MINISTRY OF ENVIRONMENT
PROVINCE OF BRITISH COLUMBIA

THOMPSON-BONAPARTE AREA
BONAPARTE RIVER
WATER QUALITY ASSESSMENT AND OBJECTIVES
TECHNICAL APPENDIX

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

LIST OF TABLES

LIST OF FIGURES

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To these people, my thanks are expressed.

1. INTRODUCTION

1.1 BACKGROUND

The Ministry of Environment is preparing water quality assessments and objectives in priority water basins. This technical appendix describes the water quality within the Bonaparte River watershed, based upon data collected to about December 1983. The Bonaparte River is only one of two major rivers in the Thompson-Bonaparte area (Figure 1); the water quality of the Thompson River will be described in another technical appendix[1].

Some of the data are summarized as a range and 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 author has used whichever of these two statistics had more meaning. Median values are always reported for coliforms and pH.

1.2 ORGANIZATION

The Bonaparte River originates at Bonaparte and Bridge Lakes, from where it flows south-westerly through Young Lake. From its confluence with Clinton Creek, it flows in a southerly or south-easterly direction, passing the Town of Cache Creek just prior to its confluence with the Thompson River. The Bonaparte and Thompson Rivers meet just north from the Town of Ashcroft. A major tributary to the Bonaparte River is Loon Creek, which is discussed in this technical appendix. A second major tributary, Hat Creek, will not be discussed since plans for a major development by B.C. Hydro on the creek have been postponed indefinitely, and there are no major point sources of wastewater discharging to the creek.

1.2.1 LOON CREEK

Loon Creek originates as an outflow from Upper Loon Lake. It flows south-westerly to Loon Lake, and continues on to join the Bonaparte River downstream from Clinton Creek. It has a drainage area of about 480 km². There are no major settlements in this area except at Loon Lake Provincial Park. On the shores of Loon Lake are about 250 cottages and eight resorts.

1.2.2 BONAPARTE RIVER

The watershed area of the Bonaparte River is about 5 100 km². Major settlements include Clinton with a population in 1981 of about 1300 and Cache Creek, with a population of about 1000.

1.3 PROVISIONAL WATER QUALITY OBJECTIVES - BASIC PHILOSOPHY

Water quality objectives are established in British Columbia for waterbodies on a site-specific basis(2). The 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(2). 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(2).

Water quality objectives are based upon working water quality criteria which are characteristics of water, biota, or sediment(2) that must not be exceeded to prevent specified detrimental effects from occurring to a water use(2). The working criteria upon which the proposed provisional objectives are based come from the literature, and are referenced in the following chapters. The B.C. Ministry of Environment is in the process of developing specific criteria for water quality characteristics throughout British Columbia, to form part of the basis for permanent objectives.

As a general rule, objectives will only be set in reaches 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 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 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 dilution zones in which water quality objectives may be exceeded. The extent of dilution zones and the severity of conditions within them are controlled by permits issued pursuant to the Waste Management Act. 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, volatilization, photolysis, 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.

2. LOON CREEK

Loon Creek enters the Bonaparte River from the east about ten km downstream from Clinton Creek. It flows in a southwesterly direction, from Upper Loon Lake and through Loon Lake. Loon Lake has well established recreational facilities, with about 250 cottages and eight resorts along its north shore.

2.1 HYDROLOGY

Limited flow data exist for Loon Creek. A station at the mouth, 08LF071 (Figure 3) has been operated for varying periods during five years. Mean monthly flows ranged from 0.141 m^3/s to 1.27 m^3/s [3]. Freshet occurs from April through July. Outflows from Loon Lake ranged from 0.12 m^3/s to 0.18 m^3/s in the period 1970 to 1974 [18].

Loon Lake has a 960 ha surface area, shoreline perimeter of 28 970 m, a length of 13 km, a width from 0.4 to 0.8 km, mean and maximum depths of 27 m and 65 m, respectively, and a 262 550 dam^3 volume. It has a flushing rate of 0.064 times/year (15.6 year retention).

2.2 WATER USES

Water uses in Loon Lake include recreation, domestic water supply, and the preservation and protection of sensitive aquatic life. In total, about 165 m^3/d is withdrawn for a domestic water supply from Loon Lake. The lake has a provincial park situated on its shores. Spawning in the lake takes place at the creek mouths. Loon Lake is a major rainbow trout producer, heavily utilized, with no stocking.

Loon Creek is used for irrigation water (825 dam^3/year) between Upper Loon Lake and Loon Lake. Downstream from Loon Lake, Loon Creek is used for irrigation (437 dam^3/year), domestic water supply (10 m^3/d), and for the preservation and protection of sensitive aquatic life. The Loon Creek fish hatchery is located near the mouth of Loon Creek. Loon Creek is considered to be a class 1 spawning creek, with salmonid enhancement occurring in its upper reaches.

2.3 WASTE DISCHARGES

2.3.1 LOON CREEK HATCHERY

B.C. Buildings Corporation (actually the B.C. Fisheries Branch) operates a fish hatchery on Loon Creek, just upstream from its confluence with the Bonaparte River. A receiving water study, including work on periphyton, was undertaken by the Waste Management Branch in 1985 to determine existing impacts.

Rainbow trout are held at the hatchery during a 3-week period in May and September, in four 15 m by 3 m by 1 m concrete raceways. The fish are held for release, not fed for two days prior to arrival at Loon Creek, and not fed while at the Loon Creek hatchery. This section of the hatchery should contribute only minor quantities of contaminants. There are also three eight-metre diameter tanks to rear steelhead and chinook salmon. The major discharge is from January to April when these species are reared and fed.

The water used in the raceways and tanks comes from a natural spring (called Hatchery Creek). Effluent is discharged to a concrete settling pond (6 m x 12 m x 1 m), divided into two channels with solids collection in troughs. Permit PE 2388 allows the discharge of 7 500 m^3/d to Loon Creek, and increases in the effluent over background of 10 mg/L BOD_5, 5 mg/L suspended solids, 0.5 mg/L ammonia nitrogen, 0.5 mg/L nitrate nitrogen, and 0.15 mg/L phosphate (as P).

An effluent data summary is in Table 1. The data show that the effluent generally met the permit levels. This is confirmed in Tables 2 and 3, which show levels of characteristics at the inlet to the hatchery (Table 2) and at the inlet to the settling pond (Table 3). Although a true indication of compliance is not possible using data for the inlet to the settling pond, an approximation is possible.

2.3.2 DIFFUSE SOURCES

The locations of cattle in the Loon Creek watershed are shown on Figure 3. These locations have been ascertained by three methods. Actual numbers of cattle were obtained from the Ministry of Agriculture's Beef Assurance Program. Wintering locations were derived by observations of the number of cattle in the general area by staff of the Waste Management Branch, Kamloops. In addition, Tautz et al.(18) provided some information from the early 1970's.

Septic tanks located along the shores of Loon Lake would also contribute to the nutrient loading. Tautz et al. estimated that the lake development supported 40 150 person days, and that most septic tanks were at least 30.5 m from the shoreline(18). Based upon the age and proximity of the septic fields to the lake, it was estimated that 23 kg/year phosphorus and 9 kg/year nitrogen would reach the lake(18). The actual quantity would depend upon the types of soils in which the septic fields were placed and their adsorption capacity.

2.3.2.1 Upstream from Loon Lake

Tautz et al. indicated that Loon Creek, just upstream from Loon Lake, flowed through a large cattle ranch (647 ha of non-irrigated grassland and 162 ha of irrigated grassland)(18). "The number of animals grazing at various times of the year was difficult to determine since many cattle were moved between feed lots and pasture, additional calves were purchased, etc. However, the normal pattern of operation consisted of keeping cows and calves on winter range near the inlet of Loon Lake during the early spring, moving them to summer range (forest and open range areas) during summer and early fall, and back to winter range during late fall"(18). This method of operation resulted in the animals being in the area adjacent to the stream when soil was frozen and during peak runoff(18). Tautz et al. estimated that 800 cows, 325 yearlings and 30 bulls would be on winter range for 270 days each, while the 325 calves would be on winter range for

90 days each[18]. Although Tautz et al. estimated the contributions of nitrogen and phosphorus, to Loon Lake from the cattle, these have not been included here. The estimates of Bangay[22] were used here to calculate maximum potential nitrogen and phosphorus contributions from cattle.

Kg of N and P Produced by
Cattle on Winter Range

	P kg/year	N kg/year
Cows	4 687	40 241
Calves	18	145
Yearlings	774	9 592
Bulls	104	1 509
	5 583	51 487

The potential loading of phosphorus is only about 55% of that assumed by Tautz et al.[18], which had been estimated as being 30% of the phosphorus in Loon Creek. The estimated phosphorus loadings calculated here still account for a maximum of 17% of the phosphorus loadings in the creek.

Tautz et al. estimated that the contribution from chemical fertilizers used on this one cattle ranch could be 57 kg of phosphorus and 672 kg of nitrogen[18]. These loadings are only about one percent of the loadings from cattle calculated in this report.

Large percentages of the total phosphorus and nitrogen loadings contributed from diffuse sources likely remain in Loon Lake. This could have, and may have had, a great effect on the productivity of the lake. This is discussed in Section 2.4.1.3.

2.3.2.2 Downstream From Loon Lake

Information from the Ministry of Agriculture indicated that there were 28 cows at a site downstream from Loon Lake. This location coincided with an observed wintering location considered by visual observations as being of minor significance. However, downstream from this site, there was a second observed wintering location of minor significance. If it is assumed that approximately the same number of head are at each site, about 50 cows could over-winter along this reach of the creek. It also will be assumed that these cattle will remain there for 270 days (i.e. September to May, inclusive).

Using the nutrient coefficients from Bangay[22], it is calculated that the 50 head could contribute a maximum of nearly 300 kg of phosphorus and 2 500 kg of nitrogen to the creek. This is based upon waste accumulation for 270 days. The potential impact on the creek would depend upon the release period, the creek flow, and soil transmission coefficients. If the transmission coefficient was 100%, the following are the maximum potential increases in phosphorus which might occur in Loon Creek, assuming release occurs between March and May for periods ranging from one to four weeks.

	Increase in Phosphorus (mg/L) in Loon Creek		
	Release Period		
Creek Flow	1 week	2 weeks	4 weeks
0.24 m^3/s (March)	2.07	1.04	0.52
0.40 m^3/s (April)	1.24	0.62	0.31
1.3 m^3/s (May)	0.38	0.19	0.10

It is likely that as the creek flow increased, the turbidity, velocity and depth would also increase, and therefore the impact of these nutrients at high spring flows would not be great.

2.4 AMBIENT WATER QUALITY AND PROPOSED WATER QUALITY OBJECTIVES

2.4.1 LOON LAKE

The morphology of Loon Lake has been described in Section 2.1. Loon Lake demonstrates a dimictic pattern of thermal stratification with a thermocline at [illegible] m from July to September, with a peak epilimnetic temperature of 23°C during late July and early August[18].

Loon Lake was sampled at several sites in 1976 and 1977. Thereafter, samples were occasionally collected at Site 0603051, at its outlet (Figure 3). The data are summarized in Table 4. Site 0600050 was located at the inlet to Loon Lake (Table 5).

2.4.1.1 pH and Alkalinity

Loon Lake had a high acid buffering capacity, with alkalinity values exceeding 250 mg/L at all sites. The inlet to Loon Lake also had high alkalinity (434 mg/L). This high buffering capacity is also reflected in very high pH values, in the range from 8.3 to 9.1. The highest pH values could be caused by algal growth. Working water quality criteria for pH are as follows: for the protection of aquatic life 6.5 to 9.0[4], and for use of the water for drinking 6.5 to 8.5[5]. Therefore any operations which might discharge alkaline wastes should not be located near this water body.

2.4.1.2 Hardness and Metals

Loon Lake would be classified as having hard water, with all recorded values being greater than 200 mg/L in the lake and its inlet (Tables 4 and 5). Water supplies with hardness greater than 200 mg/L are considered poor with respect to domestic use[5].

High hardness values reduce acute toxicity to aquatic life from metals. Metal data were collected only at Site 0603051, at the lake outlet. All metal values were below detection limits except iron, lead, and molybdenum. Some selected working water quality criteria applicable for water of this hardness are 0.3 mg/L for iron, 0.01 mg/L for lead, and 0.01 mg/L for molybdenum[6]. Since the maximum recorded values are well below these working water quality criteria, no problems are expected in the lake from metals.

2.4.1.3 Nutrients

Phosphorus and nitrogen values have been recorded at three sites near the centre of the lake, Sites 0603050, 0603049 and 0603048 (Figure 3). The lake was thermally stratified when these data were collected.

Phosphorus values (total) were fairly high, ranging from 0.018 mg/L at Site 0603049 to 0.116 mg/L at Site 0603050. The highest values typically were associated with samples from the greatest depth. One phosphorus value for the lake inlet was 0.084 mg/L (Table 5). These values are typical of a lake with fairly high productivity. This is confirmed by the chlorophyll-a data collected on one occasion (October 1975) at several depths (Table 4). Lower total phosphorus values of about 0.06 mg/L (maximum) were measured at Site 0603047 at the lake inlet, and at Site 0603051 at the lake outlet. Although data for phosphorus were not collected at spring overturn, the values were such that the lake likely would be considered mesotrophic, approaching eutrophy, if it isn't already eutrophic. Regional Waste Management Branch staff indicate there is little doubt that the lake is eutrophic. More data need to be collected at spring overturn so that the trophic state of the lake can be determined and a provisional water quality objective developed.

Tautz et al.[18] examined the remains of diatoms in sediments to determine when shifts in trophic states may have occurred. Specifically, Tautz et al.[18] examined the ratio of Araphidales abundant in some situations in increasing numbers as eutrophication proceeds, to the number of Centrales abundant in oligotrophic conditions, but less so as eutrophication proceeds. Using an assumed average sediment build-up rate of 0.25 cm/year from the literature, Tautz et al.[18] determined that two increases in eutrophication rates had taken place. The first occurred in the 1930's, followed by a second in about 1960.

Nitrogen values were fairly high, with ammonia values as high as 0.087 mg/L at Site 0603050. This value was recorded at a 30 m depth in October 1976. Coincident pH and temperature values were 8.3 and 6°C, respectively. These conditions would result in about 0.002 mg/L un-ionized ammonia nitrogen, which is within the working water quality criterion of 0.007 mg/L for un-ionized ammonia as an average value[7]. The one total ammonia nitrogen value at the lake inlet was 0.049 mg/L (Table 5).

Nitrate/nitrite nitrogen values reached 0.36 mg/L at Site 0603048. Maximum values at the lake inlet and outlet were 0.03 mg/L (Table 5) and 0.16 mg/L (Table 4), respectively.

2.4.1.4 Dissolved Oxygen and Oxygen-Consuming Materials

A limited number of dissolved oxygen measurements were made in 1976 (Table 4). These showed high levels and percent saturation values in surface waters, but values as low as 1.4 mg/L, corresponding to 11.6% saturation, at the 30 m depth at Site 0603050. These depressed oxygen levels in the hypolimnion can prevent important cold water fish species from using deeper water during the warm summer months. These low values were typical of values at Sites 0603048, 0603049, and 0603050, collected in October 1976 when the lake was thermally stratified. These values are also indicative of eutrophic conditions.

Dissolved oxygen values (n=2) at the lake inlet were high, 11.2 mg/L and 12.2 mg/L, both corresponding to 110% saturation. Values at the outlet were all greater than 7.0 mg/L, with percent saturation values ranging from 53 to 108%.

To maintain the lake quality for cold-water species such as rainbow trout, a provisional water quality objective is proposed for dissolved oxygen. The objective is that the hypolimnetic dissolved oxygen should be greater than or equal to 5.0 mg/L. It is recognized that this objective is presently not always met in all areas of the hypolimnion, but it is proposed as a long-term goal for the future. The objective applies to all areas of the hypolimnion, 5 m above the sediment-water interface, except initial dilution zones of effluents. For lakes, this excluded initial dilution zone will extend up to 100 m horizontally in all directions around any point of discharge.

2.4.1.5 Solids

Dissolved and suspended solids (filterable and non-filterable residue, respectively) were not measured directly. However, turbidity measurements were made at all five sites, with the maximum recorded value being 2.1 NTU at the lake inlet, Site 0603047 (Table 4). These values met the water quality criterion of 5 NTU for a drinking water supply[21]. This value is low, and would indicate suspended solids levels of <5 mg/L. This is low, but typical of a lake situation.

Total solids values were recorded at all five sites. Maximum recorded total solids values were between 334 mg/L and 340 mg/L at Sites 0603048, 0603049 and 0603050. Thus, by subtracting the assumed suspended solids value of <5 mg/L, dissolved solids in the lake can be estimated to be about 335 mg/L. This is within the working water quality criterion of 500 mg/L to protect drinking water supplies[5].

2.4.1.6 Bacteriological Quality

The bacteriological quality of the lake would be expected to be fairly good. Fecal coliform values from samples collected at 19 locations along the north shore of the lake in May 1977 were all ≤5 MPN/100 mL. More data are required. Two fecal coliform values at the lake inlet (Site 0300050) were <2 and 350 MPN/100 mL (Table 5). In the absence of any specific point source of fecal contamination in the lake itself, it can probably be assumed that the water will usually be of sufficiently high quality to permit primary-contact recreation and drinking with little or no treatment other than disinfection. Since diffuse sources of coliforms exist upstream from the lake, the bacteriological quality will have to be maintained for drinking water and swimming. Therefore, <u>a dual objective is proposed. Near water intakes, fecal coliforms should be less than or equal to 10 MPN/100 mL. This is a 90th percentile value to allow drinking of the lake water with disinfection only. At bathing beaches, the fecal coliforms should be less than or equal to 200 MPN/100 mL as a geometric mean, or 400 MPN/100 mL as a 90th percentile value. All these values are to be calculated from samples collected once per week for five weeks in a period no longer than 30 days</u>. The drinking water objective applies year-round, while the recreation objectives apply only during the recreation season.

2.4.2 LOON CREEK

Data were available for two sites downstream from Loon Lake, at Site 0600297 above the hatchery, and Site 0600336 near the creek mouth (Figure 3). These data are summarized in Table 5.

2.4.2.1 pH and Alkalinity

The pH of Loon Creek downstream from Loon Lake was slightly more acidic than the lake itself. Values were between 8.2 and 8.7 at Site 0600336 (Table 5), while the range at Site 0603051 (Table 4) was from 8.3 to 9.1. The median pH value at Site 0603051 was 8.5. Applicable working water quality criteria for pH are 6.5 to 8.5 for drinking water supplies[5], and 6.5 to 9.0 for the protection of aquatic life[6]. Since livestock wastes entering the creek would contain ammonia and the formation of the toxic un-ionized portion is pH dependent, and since pH values exceeding 8.5 are of concern with regard to the fouling of plumbing fixtures, <u>a provisional water quality objective is proposed for pH in Loon Creek</u>. The objective would apply to Loon Creek between Loon Lake and the confluence with the Bonaparte River, exclusive of initial dilution zones of effluents described in Section 2.4.2.4. <u>The objective is that the pH should be in the range 6.5 to 9.0</u>. This range takes into account the high pH water entering the creek from the lake.

Alkalinity values were also lower in Loon Creek than in Loon Lake, with the one measured value being 166 mg/L at Site 0600336 (Table 5). Thus, Loon Creek is highly buffered to acidic discharges.

2.4.2.2 Hardness and Metals

The hardness of the creek also decreased downstream from the lake. At the lake outlet, the range of values was 209 to 217 mg/L (Table 4), but in the creek the range was 132 to 204 mg/L. The creek water would still be classified as being hard.

Measurements for total metal contents were made only on one occasion, during 1982. All values were below detection limits except aluminum (0.28 mg/L), iron (0.49 mg/L) and manganese (0.03 mg/L). Such levels occur naturally in British Columbia and may not be important if metals are associated with particulate matter. The values for aluminum and iron exceed working water quality criteria for the protection of aquatic life of 0.1 mg/L[8] for aluminum and 0.3 mg/L for iron. The iron criterion also applies for drinking water[6,8]. More data should be collected to see if these criteria are consistently met in the creek.

2.4.2.3 Nutrients

Total phosphorus values in Loon Creek at Site 0600336 (Table 5) have been as high as 0.228 mg/L, and as high as 0.238 mg/L at Site 0600297 above the fish hatchery. Total dissolved phosphorus values were as high as 0.196 mg/L, therefore the high total phosphorus values in the creek were not associated with suspended solids. Although these data were collected during a different time period than were those at Loon Lake, a considerably higher phosphorus concentration was present in the creek than in the lake (Table 4). Maximum recorded values at the lake outlet were about one-third those measured at the creek mouth (Table 5). Thus, it is suspected that a source of phosphorus was present along the creek, possibly cattle or excess fertilizer from agricultural lands. However, no algal blooms are known to have occurred in Loon Creek[9]. This is likely due to the steep gradient and resulting high creek velocity at this location.

The maximum ammonia nitrogen value of 0.14 mg/L was recorded at Site 0600336 in January, 1981. The pH was 8.5, but the temperature was not measured. If a temperature of 5°C is assumed, 3.77% of the ammonia would be available in the un-ionized form[10]. Thus, the un-ionized ammonia nitrogen concentration would be 0.005 mg/L, which is within the working water quality criterion of 0.007 mg/L[7] for protection of aquatic life.

To protect aquatic life in Loon Creek from the formation of high levels of un-ionized ammonia, a provisional water quality objective is proposed for un-ionized ammonia. The objective, applicable in Loon Creek from its confluence with the Bonaparte River to Loon Lake, except in initial dilution zones of effluents described in Section 2.4.2.4, is that the average un-ionized ammonia nitrogen value should be ≤0.007 mg/L, and the maximum value should not exceed 0.03 mg/L. The average value is to be calculated from samples collected once per week for five weeks in a period no longer than 30 days.

Nitrate/nitrite values increased slightly from the Loon Lake outlet (Table 4) to Loon Creek at its mouth (Table 5). However, the maximum Kjeldahl nitrogen value approximately doubled between the lake and the creek mouth.

2.4.2.4 Dissolved Oxygen and Oxygen-Consuming Materials

Dissolved oxygen values were measured only during 1979 and only at Site 0600336 (Table 5). All were high, exceeding 10 mg/L. Percent saturation values were also high, ranging from 92% to 123%. Values in excess of about 120% could be reason for concern about possible stress to aquatic life, which could compound other stress factors present. The maximum percent saturation value is probably not high enough to be of concern.

Davis[19] has recommended a minimum 7.75 mg/L dissolved oxygen in freshwater for salmonids, including steelhead. The Department of Fisheries and Oceans has recommended minimum dissolved oxygen levels in rearing areas of 11.2 mg/L when eggs are in the "eye" to hatch stage, and 8.0 mg/L when fish eggs and/or larvae or alevin are present[20].

To protect fish which may be released from the hatchery and salmonids naturally present in the system, an objective is proposed for dissolved oxygen as follows: 11.2 mg/L minimum when eggs are in the "eye" to hatch stage; 8.0 mg/L minimum when fish eggs and/or larvae or alevin are present;

and 7.75 mg/L minimum at all other times. This objective applies to Loon Creek, from Loon Lake to the confluence with the Bonaparte River, except in initial dilution zones of effluents. These excluded initial dilution zones are defined as extending up to 100 m downstream from the discharge point, and up to 50% across the width of the stream, from the surface to the bottom.

BOD_5 values were measured at sites 0600297 and 0600336 (Figure 3). All values were <10 mg/L, indicating a clean creek system.

2.4.2.5 Solids

Suspended solids (non-filterable residue) values ranged from 2 to 32 mg/L at Site 0600336, and from 1 to 30 mg/L at Site 0600297 (Table 5). Suspended solids values of less than 25 mg/L usually ensure no effects on sensitive aquatic life(11).

To maintain the present low suspended solids concentrations in Loon Creek, and guard against suspended solids which can enter the creek from the one point discharge and diffuse sources (cattle), a provisional water quality objective is proposed for suspended solids in Loon Creek, from Loon Lake to the confluence of Loon Creek with the Bonaparte River. The Provincial criterion states that induced suspended solids levels should not exceed 10 mg/L when background levels are <100 mg/L, nor should induced suspended solids be of more than 10% of background when background is >100 mg/L (21). These criteria will be the proposed provisional objective:

i.e. 10 mg/L maximum increase if upstream ≤100 mg/L, or
10% maximum increase if upstream > 100 mg/L

The proposed objective for suspended solids addresses the aspect of physical damage to aquatic life. Turbidity addresses the aspect of aesthetics and light attenuation. Turbidity measurements have been made only at Site 0600050, at the inlet of the creek to Loon Lake, and only on one occasion.

The Provincial criteria are that induced turbidity should not exceed 5 NTU when background levels are ≤50 NTU, nor should induced turbidity be more than 10% of background when background is > 50 NTU[21]. These criteria will be the proposed provisional objective for turbidity in Loon Creek, from Loon Lake to its confluence with the Bonaparte River:

i.e. 5 NTU maximum increase if upstream ≤ 50 NTU, or
10 % maximum increase if upstream ≥ 50 NTU.

These increases (in NTU, mg/L, or %) are over levels measured at a site upstream from a discharge or series of discharges and as close to them as possible, and apply to downstream levels. The objectives do not apply to initial dilution zones of effluents, described in Section 2.4.2.4.

Dissolved solids (filterable residue), determined by subtracting suspended from total solids, ranged from about 215 mg/L to 285 mg/L at Site 0600336 at the mouth of Loon Creek (Table 5). This was about 50 to 100 mg/L less than at the outlet to Loon Lake (Section 2.4.1.5). This level is well within the maximum acceptable concentration of 500 mg/L for drinking water [5], the desirable level of 500 mg/L for livestock[11], and the value of 500 mg/L for irrigation waters, below which no detrimental effects will be noted[4].

2.4.2.6 Bacteriological Quality

Coliform (total) values were measured during 1979 only at Site 0600336 near the mouth of Loon Creek, once in 1983 just above the fish hatchery in Loon Creek at Site 0600297, and twice during 1977 at Site 0600050, above Loon Lake. Values in the creek ranged from 17 MPN/100 mL to 1 600 MPN/100 mL (Table 5). These values are less than the maximum working water quality criterion for fecal coliforms in irrigation water of 4 000 MPN/100 mL [6], but would likely require the partial treatment of the drinking water (consisting of filtration or equivalent and disinfection) according to the guidelines for the treatment of raw water supplies[5].

It is suspected that these higher bacteriological values arise from wastes associated with cattle operations located along Loon Creek. More sampling is required to determine accurately the bacteriological regime in the creek.

Although there is a lack of ambient data, it is proposed that a provisional water quality objective should be established for fecal coliforms in Loon Creek, from Loon Lake to the confluence of the creek with the Bonaparte River. The objective will take into account the need for good quality water for irrigation purposes, but will also recognize that higher quality water will be required at water intakes, most of which are located nearer to Loon Lake than to the Bonaparte River. It is assumed that some reduction in values will have to take place so that only partial treatment (filtration or equivalent plus disinfection) of the water will be required before it can be used as drinking water supply. Recognizing that at least partial treatment of the water will be required for drinking water supplies, the 90th percentile fecal coliform value should not exceed 100 MPN/ 100 mL. This objective applies along the length of Loon Creek, except in initial dilution zones of effluents described in Section 2.4.2.4. These values are to be calculated from samples collected once per week for five weeks in a period no longer than thirty days. Drinking water objectives apply year round.

2.5 SUMMARY OF DESIGNATED WATER USES AND PROPOSED PROVISIONAL WATER QUALITY OBJECTIVES

Designated water uses proposed for reaches of the Loon Creek system are as follows:

1) Loon Creek from Upper Loon Lake to Loon Lake - designated water uses are for protection of aquatic life and wildlife, for irrigation and for livestock watering.

2) Loon Lake - designated water uses are drinking water (disinfection only), primary-contact recreation (i.e. swimming), aquatic life and wildlife.

3) Loon Creek from Loon Lake to the Bonaparte River confluence - designated water uses are the same as in reach (1) above, plus drinking water with partial treatment (filtration or equivalent and disinfection).

To protect these designated uses, provisional objectives are proposed for reaches 2 and 3 above, while monitoring is recommended in reach 1 to develop water quality objectives. No objectives are proposed for Loon Creek between Loon Lake and Upper Loon Lake because the data base on water quality is insufficient in this reach of Loon Creek.

	Reach 2 (Loon Lake)	Reach 3 (Loon Creek)
Dissolved Oxygen (minimum)	5 mg/L in hypolimnion (minimum five metres above the sediment-water interface)	11.2 mg/L when eggs are in "eye" to hatch 8.0 mg/L when eggs and/or larvae or alevin present 7.75 mg/L at all other times
pH	-	6.5 - 9.0
Fecal Coliforms	<10 MPN/100 mL (90th percentile at or near water intakes; ≤200 MPN/100 mL (geometric mean) and ≤400 MPN/100 mL (90th percentile) at bathing beaches.	≤100 MPN/100 mL (90th percentile)
Un-ionized Ammonia Nitrogen	-	≤0.007 mg/L average 0.03 mg/L maximum
Suspended Solids	-	10 mg/L maximum increase if background ≤100 mg/L, or 10% maximum increase if background >100 mg/L
Turbidity	-	5 NTU maximum increase if background ≤50 NTU, or 10% maximum increase if background > 50 NTU

2.6 RECOMMENDED MONITORING

Monitoring is recommended for two purposes: to verify that proposed objectives are achieved, and to develop future objectives. To achieve the first purpose, the following are proposed.

Loon Lake: Monitor dissolved oxygen and temperature (profiles) twice per year in July and August at mid-lake. Monitor fecal coliforms weekly in a 30-day period at bathing beaches and water intakes during the summer.

Loon Creek (reach 3): Monitor dissolved oxygen, pH, chlorophyll-*a*, ammonia, nitrite, total and dissolved forms of aluminum, iron, manganese, and fecal coliforms in April, July and October near the creek mouth (Site 0600336), and suspended solids and turbidity upstream and downstream from the fish hatchery.

To achieve the second purpose, the following are proposed.

Loon Lake: Total and total dissolved phosphorus values at spring overturn at mid-lake for at least three years.

Loon Creek (upstream from Loon Lake): Fecal coliforms, pH, ammonia, nitrite, chlorophyll-*a*, dissolved oxygen, suspended solids, turbidity, dissolved solids and total and total dissolved phosphorus, a minimum of three times between April and October.

Any monitoring actually undertaken will depend upon resources available and other Regional priorities.

2.7 CONCLUSIONS

The one operation in this watershed discharging directly to a water course is the Loon Creek fish hatchery. It had no measurable effect on the water quality of the creek downstream from the hatchery; however, this is being re-assessed by field studies. It is suspected that cattle located along Loon Creek are increasing phosphorus, nitrogen and fecal coliform values in the creek and Loon Lake. Septic tanks located near the shoreline of Loon Lake also are estimated to be increasing nitrogen and phosphorus concentrations in the lake.

Loon Lake is mesotrophic, and possibly eutrophic. It has a high acid buffering capacity, would be classed as having hard water, with low metal values, high nitrogen and phosphorus values, good dissolved oxygen levels except in deeper parts of the hypolimnion, low suspended solids, and moderate levels of dissolved solids.

Loon Creek downstream from Loon Lake has a high acid buffering capacity and hard water, but both are slightly less than Loon Lake. All metal values were low and below working water quality criteria, except aluminum and iron which naturally exceeded criteria for the protection of sensitive aquatic life. Iron also exceeded the drinking water criterion. Phosphorus and nitrogen values were higher in Loon Creek downstream from Loon Lake than in the lake itself, suggesting some contribution of these nutrients downstream from the lake. However, these higher values are not known to have caused algal blooms, possibly due to the high velocity of the water in the creek.

Calculated un-ionized ammonia values were below levels toxic to aquatic life. Dissolved oxygen levels in the creek were good. Suspended solids were at levels which would not impair sensitive aquatic life, while dissolved solids were slightly lower than in Loon Lake. Fecal coliform values, based upon limited data, appear to be at levels which would require at least partial treatment of the raw water before drinking, but were low enough to permit irrigation.

3. BONAPARTE RIVER

The Bonaparte River flows from Bonaparte Lake to its confluence with the Thompson River, just upstream from Ashcroft, after passing through Cache Creek. The drainage area of the river is about 5 100 km^2. Forestry operations in the watershed generally take place upstream from the confluence of Clinton Creek(12). Major tributaries to the Bonaparte River are Hat, Clinton and Loon Creeks with drainage areas of about 660 km^2, 250 km^2, and 480 km^2, respectively.

3.1 HYDROLOGY

Flows in the Bonaparte River increase from an annual mean of about 3 m^3/s at Site 08LF062 near the source (Figure 3) to 5.9 m^3/s near its mouth at Site 08LF002. Freshet occurs from April through July. Other mean annual flows were as follows: 0.344 m^3/s in Clinton Creek near its mouth at Site 08LF064, 0.535 m^3/s in Loon Creek at Site 08LF071 and 0.816 m^3/s in Hat Creek at Site 08LF015 (Figure 3).

The 7-day average low flow with a 10-year return period was calculated to be 1.64 m^3/s for Site 08LF002 on the Bonaparte River near Cache Creek, and 0.27 m^3/s for Site 08LF015 on Hat Creek. The data base was not sufficient for Clinton or Loon Creeks to determine comparable low flows.

3.2 WATER USES

The Bonaparte River and its tributaries are important resident rainbow trout, steelhead, and chinook salmon habitat. A dam located three km upstream from the Thompson River confluence prevents all species of salmon from spawning in the upper reaches. "A fish ladder and removal of the unused dam would open up considerable spawning areas for all species of salmon. Before the dam was built, this stream had salmon populations in the upper reaches"(13).

Since 1980, juvenile chinook salmon which were reared at the Loon Creek Hatchery have been outplanted to the Bonaparte River, downstream from Young Lake. Between 50 000 and 85 000 chinook fry have been outplanted each year. These fish likely would distribute themselves in the river system, using tributaries such as Hat and Clinton Creeks. They would overwinter in the Bonaparte system before migrating seaward.

In 1984 and 1985, 50 and 30 adult chinook, respectively, were transplanted into the Bonaparte River near its confluence with Hat Creek. These fish later spawned in the Bonaparte River, upstream from Hat Creek.

Figure 3 also indicates where water is withdrawn from the Bonaparte River for domestic, irrigation, and industrial use. Below Cache Creek, there are 20 withdrawals for 9 120 m^3/d domestic use, 9.1 m^3/d industrial use, and 2 495 dam^3/year irrigation use. Between Cache Creek and the confluence of Clinton Creek, there are 39 withdrawals for 55 m^3/d domestic use and 4 212 dam^3/year irrigation. Above the Clinton Creek confluence, there are eight withdrawals for 9 m^3/d domestic use and 851 dam^3/year irrigation use.

There are thirteen licensed water withdrawals along Clinton Creek, seven downstream from the Clinton lagoon system. Permitted withdrawals are for 9 m^3/d domestic, 1 552 m^3/d waterworks, and 172.3 dam^3/year irrigation above the lagoon. Below the lagoon, withdrawals are for 9 m^3/d domestic and 832 dam^3/year for irrigation. These large withdrawals from the creek were shown to decrease the flow in Clinton Creek from 0.102 m^3/s upstream from the Clinton lagoons to 0.025 m^3/s near the mouth on August 20, 1979(14).

3.3 WASTE DISCHARGES

The Village of Cache Creek (1981 population of 1308) discharges treated domestic sewage to the Bonaparte River, while the Village of Clinton (1981 population of 857) discharges treated domestic sewage to Clinton Creek. Two refuse sites, which are well removed from watercourses, are also located in the area. These sites are described in the following sections.

3.3.1 REFUSE SITES

Two active refuse sites exist in the area. The Corporation of the Village of Ashcroft operates a site for the disposal of refuse and septic tank sludge. Permit PR 3041 issued pursuant to the Waste Management Act allows the disposal of an average 30.5 m^3/d of domestic and commercial refuse, which is to be compacted and covered twice per week from May through September and once per week from October through April. There are no nearby watercourses which can be affected by leachate from the site. This arid area would minimize or prevent leachate production.

The Regional District of Thompson-Nicola operates a refuse site near Clinton, which serves approximately 3000 persons, about 850 of whom live in Clinton. Permit PR 4463 allows the disposal of an average 11.5 m^3/d of municipal-type refuse, which is to be covered once per week from May through September and once every two weeks from October through April. The nearest watercourse is Clinton Creek, located approximately one kilometre west from the site. Due to the small volume of waste, the arid climate which would minimize or prevent leachate production, and the distance to the creek, it is not expected that any leachate generated at the site would affect the water quality of Clinton Creek.

3.3.2 VILLAGE OF CLINTON

An assessment of the impact of the Clinton sewage treatment works on Clinton Creek was prepared by Little and Holmes in 1980[14]. They described the treatment works as consisting of two 0.2 ha anaerobic cells operated in parallel, followed in series by two facultative cells with surface areas and volumes of 2.2 ha and 33 500 m^3, and 2.8 ha and 42 800 m^3, respectively. Total maximum retention time in the two facultative cells, based upon a discharge of 360 m^3/d, is over 200 days[14]. Permit PE 170, issued pursuant to the Waste Management Act allows the discharge of an average 454.6 m^3/d at maximum concentrations of 30 mg/L suspended solids and 20 mg/L BOD_5.

Little and Holmes described the area surrounding Clinton Creek as consisting of forested hills and gullies upstream from Clinton, and grazing lands, hobby farms, and cattle ranches downstream from Clinton[14].

The assessment by Little and Holmes found that the discharge had "its greatest influence on Clinton Creek during the winter portion of the low flow period"[14]. These influences were noted in considerably increased nutrients, fecal coliforms, and algal growths due to reduced effluent quality and creek flows, and increased effluent flow rates[14].

A summary of the effluent quality is in Table 6. Maximum recorded values were: flow of 727 m^3/d, fecal coliforms of 1 100 000 MPN/100 mL, ammonia nitrogen of 19.4 mg/L, BOD_5 of 60 mg/L and suspended solids of 104 mg/L. Mean values were 380 m^3/d, 495 MPN/100 mL (median), 4.4 mg/L, 21 mg/L and 26 mg/L, respectively. These characteristics are discussed in more detail in the following sections.

3.3.2.1 Flows

Effluent flow rates exceeded 360 m^3/d about fifty percent of the time that measurements were made. The higher flows occurred in July or August or January and February. Increased flows in the latter period were likely the result of people leaving taps running to prevent water lines from freezing. The winter is of most concern due to the low flow at that time in Clinton Creek. The maximum effluent flow of 727 m^3/d occurred in February 1979.

The annual mean flow in Clinton Creek at the mouth was 0.344 m^3/s. The data were too few to permit an average 10-year 7-day low flow to be calculated. The ratios of the average 10-year 7-day low flow to the annual mean annual flows in two nearby watercourses, Hat Creek and the Bonaparte River, were 0.33 (0.27 m^3/s ÷ 0.816 m^3/s) and 0.28 (1.64 m^3/s ÷ 5.9 m^3/s), respectively. Therefore the 10-year 7-day average low flow on Clinton Creek at the mouth has been assumed to be 0.30 of the annual mean flow, or 0.1 m^3/s (0.3 x 0.344 m^3/s). Flows at Clinton further upstream would be less than this. Based upon the drainage areas for the creek at Clinton (77.7 km^2) and at the mouth (252 km^2), the low flow at Clinton would be 30% (0.03 m^3/s) of the low flow at the mouth. Available dilution of minimum creek flows would be 3:1 at maximum effluent discharge rate and 7:1 at average effluent discharge rate. The configuration of the creek downstream from the outfall likely results in complete mixing of the effluent and the creek within a short distance (30 m) downstream.

3.3.2.2 Fecal Coliforms

Fecal coliform values in the effluent exceeding 495 MPN/100 mL (median recorded value, Table 6) were generally recorded during the winter months, from December through March for several years. Little and Holmes(14) have indicated that the effluent was not chlorinated due to concerns of the B.C. Fish and Wildlife Branch (now Fisheries Branch) about chlorine toxicity to resident trout. Values lower than 495 MPN/100 mL likely occur as a result of natural ultraviolet radiation reducing fecal coliform concentrations during open water periods. This disinfection process is not available under ice cover.

Calculations in Table 6 indicate that under a worst-case scenario (winter conditions) of high effluent flow, high fecal coliform concentrations and low creek flow, the fecal coliform concentration could increase by as much as 92 500 MPN/100 mL in Clinton Creek after complete mixing. Data in Table 7 show that an increase of this magnitude between Sites 0600503 and 0600505 (100 m downstream) was not recorded during sampling periods. Complete mixing of effluent and creek water would be expected. However, some appreciable increases in fecal coliform concentrations, to as high as 5 000 MPN/100 mL, were noted. Increases of this magnitude may be of concern for downstream water users.

3.3.2.3 Ammonia Nitrogen

This characteristic is of concern since its un-ionized form can be toxic to aquatic life. More un-ionized ammonia is present at higher pH and temperature. This would likely correspond to periods during the summer when flows were higher in Clinton Creek, but when ammonia values were lower. The highest ammonia nitrogen value of 19.4 mg/L in the effluent was recorded in March 1976, with a corresponding pH of 7.5 and 3°C temperature. The calculated un-ionized ammonia nitrogen concentration in the effluent would be 0.076 mg/L, however dilution in the creek would reduce the increase to 0.006 mg/L in the receiving water after complete mixing. The pH and temperature of the creek may have been different than the effluent. If the pH in the creek were the median 8.4 (Table 10), the maximum calculated potential increase in total ammonia nitrogen of 1.64 mg/L would correspond to an increase of 0.049 mg/L in un-ionized ammonia nitrogen in the creek.

Ammonia nitrogen values tended to increase downstream from the Clinton Creek discharge at Site 0600505. The largest recorded downstream value, 0.585 mg/L, would correspond to an un-ionized ammonia nitrogen value of about 0.007 mg/L, a level safe for aquatic life. Little and Holmes found the maximum theoretical un-ionized ammonia nitrogen value in the creek at the outfall to be 0.018 mg/L(14), below the maximum criterion of 0.03 mg/L(7). Therefore, problem ammonia levels resulting from this discharge have not been measured to date in Clinton Creek, but ammonia is of concern because of the potential for high levels during low flows.

Nitrite values in the creek could increase by 0.013 mg/L under worst case conditions, with complete mixing (Table 6). These values could be as much as three times higher if the ten-year seven-day low flow was 0.03 m^3/s instead of 0.1 m^3/s used in Table 6.

3.3.2.4 Dissolved Oxygen and Oxygen-Consuming Materials

Values for BOD_5 in the effluent ranged from <10 to 60 mg/L (Table 6). The 75th percentile value of 28 mg/L is typical of a BOD_5 value from a well operating lagoon system. Values which exceeded this level occurred generally in the January through March period.

Calculations in Table 6 show that under worst-case situations which would occur in winter of high effluent flow, maximum BOD_5 values, and low creek flows, the BOD_5 could increase by 5.1 mg/L in the creek after complete mixing. However, the data in Table 7 do not show any real trend of increasing or decreasing dissolved oxygen values in the creek, going from Site 0600503 downstream to Site 0600505. Any oxygen depletion would occur well downstream, perhaps not until the Bonaparte River confluence. Therefore BOD_5 and dissolved oxygen are not a major concern related to this discharge.

3.3.2.5 Suspended Solids

Values for suspended solids in the effluent ranged from 4 to 104 mg/L (Table 6). The mean value of 26 mg/L and the 75th percentile value of 37 mg/L are typical of a well operated lagoon system. Higher values typically occur in lagoon systems during the summer, due to algal growths in the lagoons. However, such was not the case here, with values exceeding the 75th percentile being recorded in most months of the year.

Calculations in Table 6 show that for a worst-case situation at high effluent flow, high suspended solids concentrations and low creek flow, the suspended solids in the creek could be increased by nearly 9 mg/L after complete mixing. This potential increase is about as large an increase as would be tolerable from any one discharge or series of discharges to protect aquatic life and drinking water supplies.

Values measured in the creek increased by as much as 60 mg/L (Table 7) on one occasion.

3.3.2.6 Total Phosphorus

Total phosphorus values ranged from 0.082 to 7.55 mg/L in the effluent (Table 6). The highest recorded values were in winter months, generally between January and March, a time when maximum effluent flows would enter the creek during minimum creek flows. Calculations in Table 6 indicate phosphorus in the creek under such worst-case conditions could increase by 0.64 mg/L after complete mixing.

Data in Table 7 show that on all but one date (78 06 06), phosphorus values increased downstream in Clinton Creek. Only on one occasion was the increase as large as predicted under the worst-case scenario (74 04 10).

Little and Holmes have indicated that there were large concentrations of algal growths in Clinton Creek, downstream from the lagoons[14].

3.3.2.7 Effluent Toxicity

Static 96 h LC50 acute toxicity tests carried out on the effluent in 1976 indicated that the effluent was not acutely toxic since no mortalities occurred at 100% effluent concentration[17].

3.3.2.8 Future Options

The Village of Clinton has received a $5 000 Provincial grant for a consultant, Urban Systems Ltd., to conduct a study of the best method of sewage disposal[15]. The study will be a refinement of schemes put forth in an Associated Engineering Services Ltd. report[16]. One option, a rapid infiltration system, would not be practical for the Village due to slopes and soil types in the area. A second option, spray irrigation, is impractical due to piping costs and the land areas required[15].

A third option would be to deepen the existing lagoon to 3.3 m depth to provide retention during low creek flows (October to May)[15]. Releases could be made during freshet when Clinton Creek is turbid, but only a 15:1 dilution ratio could be achieved[15]. High quantities of phosphorus from cattle wastes already may be entering the creek at that time. Algal problems would not be as severe in freshet due to the creek turbidity, greater depths, and higher stream velocities. If the population of Clinton suddenly were to increase, diffusers could be added to the bottom of the facultative lagoon to provide aeration[15], thereby improving treatment.

3.3.3 VILLAGE OF CACHE CREEK

The Cache Creek STP services a population of about 1 000 persons. The plant is a secondary-activated-sludge type, with two sets of aeration tanks and secondary clarifiers designed to be operated in parallel. However, only one side of the plant is being used[15] to get good effluent quality due to lower than design plant loadings. Overflow from the clarifiers is disinfected using chlorine, with subsequent dechlorination (after November 1985). Sludge from the plant is treated in two aerobic digesters prior to drying in sludge drying beds. The Village of Cache Creek wishes to discontinue chlorination after October 1984[15].

Permit PE 264 issued pursuant to the Waste Management Act in August 1984, allows the discharge of an average 800 m^3/d to the Bonaparte River, with concentrations of 60 mg/L suspended solids and 30 mg/L BOD_5. In addition, the effluent is to receive a minimum one-hour chlorine contact time and to be discharged with no chlorine residual. Chlorination of the effluent is required due to a concern for the downstream water withdrawal by the Village of Ashcroft from the Thompson River. Dechlorination of the effluent is required since the British Columbia Fisheries Branch have released fish into the Bonaparte River since about 1981. However, the dechlorination facilities at the plant have never really worked[15]. The Village wishes to discontinue chlorination and evaluate alternatives, including ground disposal via rapid infiltration through the existing sludge drying bed areas[15].

3.3.3.1 Flows

Flows from the Cache Creek STP generally exceeded the permitted level of 800 m^3/d during the summer months from July through October, when a large influx of tourists occurs. High flows have also occurred in the December through February period, likely associated with people leaving faucets open to prevent water pipes from freezing.

The 10-year 7-day average low flow for the Bonaparte River measured near Cache Creek was 1.64 m^3/s. The maximum recorded effluent flow would receive a dilution of about 150:1 in this low river flow after complete mixing. The configuration of the river downstream from the outfall likely results in complete mixing of the effluent and the river within a short distance (30 m) downstream.

3.3.3.2 Fecal Coliforms

Values for fecal coliforms in the effluent have exceeded 2 000 MPN/100 mL on 50% of the dates samples were collected. These high values have occurred in all months of the year. The 75th percentile value was 17 000 MPN/100 mL and the 90th percentile value was 92 000 MPN/100 mL.

Calculations in Table 8 show results for a worst-case scenario involving the maximum fecal coliform concentration being discharged at the maximum effluent flow rate into the 10-year 7-day average low flow in the Bonaparte River. Under these conditions the fecal coliform values could increase by about 2 300 MPN/100 mL, after complete mixing.

Data in Table 9 show actual increases from upstream to downstream (100 m) from the Cache Creek STP. Although values generally increased from upstream to downstream, only on two dates (74 11 07 and 75 07 14) did values increase by at least the 2 300 MPN/100 mL predicted by the worst-case scenario. Such increases are of concern for downstream water users.

3.3.3.3 Ammonia Nitrogen

The maximum recorded ammonia nitrogen value in the effluent was 29.8 mg/L (Table 8). However, in recent years, between 1980 and 1983, the maximum recorded value was 22.8 mg/L. This latter value had a corresponding pH and temperature of 7.8 and 20°C, respectively. Under these conditions, 0.559 mg/L of un-ionized ammonia nitrogen would be in the effluent. This would be present prior to any mixing. Dilution with river water would modify the pH and lower the total ammonia concentration. With the minimum

150:1 dilution, the resulting increase in concentration in the river, based upon un-ionized ammonia nitrogen in the effluent, would be 0.004 mg/L. Dilutions higher than 150:1 would be available in warm weather. As well, the actual un-ionized ammonia concentration in the river depends upon the pH and temperature of the river water. The higher pH in the river (median 8.2) would result in slightly more un-ionized ammonia.

The calculated maximum potential increase in ammonia nitrogen, in Table 8 was 0.197 mg/L, assuming complete mixing of the effluent with the receiving water. At the maximum recorded pH and temperature in the river below the Cache Creek STP of 8.5 and 21°C, respectively, this would amount to an increase of 0.023 mg/L. This is below the maximum allowable level of 0.03 mg/L[7].

The maximum measured increase in total ammonia nitrogen occurred in January, 1979, when the value rose from 0.029 mg/L upstream to 0.24 mg/L downstream. Corresponding pH and temperature values were 8.1 and 2.5°C, respectively. The resultant un-ionized ammonia concentrations in the river under such conditions would be about 0.003 mg/L, well below the recommended criterion for an average value of 0.007 mg/L[7].

Therefore, un-ionized ammonia is of moderate concern in relation to the impact of this discharge on the Bonaparte River.

Nitrite values in the river could increase by 0.036 mg/L under worst-case conditions, with complete mixing (Table 8). This value would exceed the 0.02 mg/L average criterion to protect aquatic life, but would be less than the 0.06 mg/L maximum criterion[7].

3.3.3.4 Dissolved Oxygen and Oxygen-Consuming Materials

In terms of BOD_5 elimination, a design parameter for sewage treatment plants, the Cache Creek STP performed generally well, with a 75th percentile BOD_5 in the effluent of 44 mg/L. This is probably high compared to recent values, since modification of the existing treatment modules has improved plant performance.

Calculations in Table 8 show that for a worst-case scenario the BOD_5 in the Bonaparte River should increase by a maximum 1.4 mg/L, after complete mixing of the effluent and receiving water.

The data in Table 9 for dissolved oxygen show that, in 1978 and 1979, no appreciable change could be seen in dissolved oxygen values going from upstream to downstream from the sewage treatment plant. An oxygen sag would not be apparent in the river for a considerable distance downstream, and likely wouldn't be evident before the confluence with the Thompson River. Therefore BOD_5 and dissolved oxygen are not major concerns related to this discharge.

3.3.3.5 Suspended Solids

The 75th percentile suspended solids concentration in the effluent was 35 mg/L in the period 1971 to 1983. It is expected that this percentile may even be lower now that the mode of operation of the sewage treatment plant has been changed.

Calculations in Table 8 show that under a worst-case scenario, suspended solids would increase by less than 1 mg/L in the river after complete mixing. Therefore this characteristic is not a major concern in this discharge.

Data in Table 9 show that although these small increases (1 mg/L) have been recorded in the river in the past, comparable decreases have also been recorded.

3.3.3.6 Total Phosphorus

Total phosphorus concentrations as high as 17.3 mg/L have been recorded in the effluent (Table 8). This is typical of effluent from a secondary sewage treatment plant. It has been calculated that, for a worst-case scenario, this could increase levels in the river by 0.114 mg/L (Table 8) after complete mixing.

The data in Table 9 for sites located upstream and downstream from the Cache Creek STP indicate that such a large increase has never taken place. The largest recorded increase has been 0.044 mg/L. However, phosphorus values have increased consistently going from upstream to downstream from the discharge.

3.3.3.7 Residual Chlorine

Residual chlorine in the effluent can be toxic to aquatic life. Calculations in Table 8 show that chlorine residual concentrations can increase by 0.019 mg/L in the river, after complete mixing, in a worst-case situation. Values in the mixing zone would be higher.

The United States Environmental Protection Agency (EPA) has developed a criterion of 0.002 mg/L residual chlorine to protect freshwater aquatic life(4). Thus the potential exists for chlorine toxicity in the river. Therefore, if the effluent continues to be disinfected using chlorine, the chlorine toxicity problem will have to be addressed to protect aquatic life.

3.3.3.8 Effluent Toxicity

Toxicity testing attempted in 1981 using rainbow trout as the test species was not fully successful since equipment problems did not allow proper solution mixing to be attained in the test tanks. The 96 h LC50 was > 100% (i.e. only about 10% of test species died), which indicates that there is little chance of acute toxicity in the river because of the multifold dilution. Plant modifications since that time have likely caused improvements to effluent quality so that toxicity would now be less than was evident in 1981.

3.3.4 DIFFUSE SOURCES

The locations of cattle in the Bonaparte River watershed are shown on Figure 3. These locations have been determined by two methods. Actual numbers of cattle were determined from statistics of the Beef Assurance Program of the B.C. Ministry of Agriculture. Wintering locations were derived from observations by the Waste Managment Branch in Kamloops of cattle in general areas. The estimates for nutrient coefficients proposed by Bangay[22] were used to calculate maximum potential nutrient contributions from cattle.

3.3.4.1 Bonaparte River From Bonaparte Lake to Clinton Creek

Only those cattle situated along the main arm of the Bonaparte River, or on a tributary immediately adjacent to the Bonaparte River, were considered in the following calculations.

It is estimated that there are at least 600 cows and 260 calves (no yearlings) in this reach of the Bonaparte River. The cattle would generate approximately 4 800 kg of phosphorus and 41 250 kg of nitrogen in 365 days. The potential impact from these cattle on the river would depend upon the release period, the river flow, transmission coefficients, and the length of time the cattle are adjacent to the river. If the transmission coefficient is assumed to be 100%, and the length of time the cattle are adjacent to the creek is assumed to be 270 days, the following are the maximum potential increases in phosphorus which might occur in the Bonaparte River if the release occurs between March and May. Actual increases are discussed in Section 3.4.2.3.

Maximum Potential Increase in Total Phosphorus (mg/L) in Bonaparte River

Flow (m^3/s)	Release Period		
(Site 08LF065)	1 week	2 weeks	4 weeks
1.99 (March)	2.95	1.48	0.74
5.95 (April)	0.99	0.50	0.25
34.8 (May)	0.17	0.09	0.04

These calculated values show that cattle in the watershed potentially can increase phosphorus values in the river considerably, depending upon the period of release. Nitrogen values could increase about eight times more than these calculated phosphorus increases.

3.3.4.2 Clinton Creek

A large number of cattle are located along Clinton Creek, with an almost equal number upstream and downstream from Clinton.

In total, it is estimated that there are about 400 cows, 225 calves, and 840 yearlings along the creek or its tributaries. In a one year period, about 5 900 kg of phosphorus and 61 100 kg of nitrogen would be generated. The potential impact of these cattle on Clinton Creek based on accumulation for 270 days is detailed below. Actual recorded increases are discussed in Section 3.4.1.3.

Maximum Potential
Increase in Phosphorus (mg/L) in Clinton Creek

Flow (m^3/s) (Site 08LF064)	Release Period: 1 week	2 weeks	4 weeks
0.265 (March)	27.2	13.6	6.8
0.371 (April)	19.5	9.7	4.9
0.379 (May)	19.0	9.5	4.8

These calculated increases are potentially very significant, with slightly over fifty percent of this increase taking place downstream from Clinton.

3.3.4.3 Bonaparte River From Clinton Creek to Mouth

Not as many cattle are located on the Bonaparte River downstream from Clinton Creek as there are upstream. It is estimated that there are 415 cows, 220 calves and 220 yearlings along the river. However, these numbers may be low, considering the number of cattle observed wintering along the river. Regardless, these cattle could produce 4040 kg of phosphorus and

37 400 kg of nitrogen. The potential impact of these cattle on phosphorus concentrations in the Bonaparte River based upon a period of accumulation of 270 days are detailed below. The actual impact on the Bonaparte River is discussed in Section 3.4.2.3.

Flow (m^3/s) (Site 08LF002)	Maximum Potential Increase in Phosphorus (mg/L) in Bonaparte River, Release Period: 1 week	2 weeks	4 weeks
2.93 (March)	1.69	0.84	0.42
5.53 (April)	0.90	0.45	0.22
16.7 (May)	0.30	0.15	0.07

These increases in phosphorus could be significant, depending upon the river flow and the release period.

3.4 AMBIENT WATER QUALITY AND PROPOSED PROVISIONAL WATER QUALITY OBJECTIVES

3.4.1 CLINTON CREEK

The water quality of Clinton Creek will be discussed in relation to three monitoring sites, Site 0600503 just upstream from the Clinton lagoon system, Site 0600505 just downstream from the lagoons, and Site 0600009 near the mouth of the creek (Figure 3). A large number of cattle were located between the two latter sites.

Designated water uses are recommended to be protection of aquatic life and wildlife, and use for drinking, irrigation, and livestock watering.

3.4.1.1 pH and Alkalinity

The pH of Clinton Creek ranged from 8.1 to 8.6, with no apparent trend along the length of the creek (Table 10). Working water quality criteria for pH for the protection of aquatic life, and for the use of the water for drinking water supplies, are 6.5 to 9.0[4] and 6.5 to 8.5[5], respectively. Since it is desirable to minimize the amount of un-ionized ammonia which might result in the creek from the discharge of treated sewage from the Clinton lagoons or from cattle wastes, a provisional objective is proposed for pH. Those who utilize the creek water for a drinking water supply require a lower pH water which will not cause fouling of plumbing pipes. A lower upper limit for pH also would reduce considerably the amount of un-ionized ammonia which could form in the creek. The 90th percentile pH value at Site 0600503, upstream from the lagoon system, was 8.5 (only one value measured higher, 8.6). It is therefore proposed that the pH in the creek, as measured at any point along Clinton Creek exclusive of initial dilution zones of effluents, should be maintained between 6.5 and 8.5. If natural (e.g. upstream) levels exceed this range, there should be no further change in pH due to waste discharges. The excluded initial dilution zones are described in Section 2.4.2.4.

The waters of Clinton Creek have a high acid buffering capacity, with all total alkalinity values exceeding 250 mg/L (Table 10).

3.4.1.2 Hardness and Metals

Clinton Creek would be classified as having hard water, with all recorded values being greater than 200 mg/L and usually greater than about 300 mg/L (Table 10). "Water supplies with hardness greater than 200 mg/L are considered poor"[5].

High hardness values can help to prevent acute toxicity to aquatic life from metals. Metal data were collected only at Site 0600009 (Figure 3) near the mouth of Clinton Creek.

The maximum recorded total copper and lead values were 0.02 and 0.029 mg/L, respectively. Both values were recorded in May 1972, but were not associated with suspended matter in the creek (suspended solids: 4 mg/L). No values of this magnitude have been recorded since then. Criteria for copper and lead for the protection of aquatic life are the most restrictive, compared to other uses. Criteria proposed by Inland Waters Directorate were 0.002 mg/L and 0.01 mg/L (hardness > 95 mg/L), respectively[6]. Draft criteria published subsequently by the EPA would allow an average of 0.02 mg/L of copper and 0.06 mg/L of lead at a hardness of 200 mg/L[23]. Other than the maximum values recorded, all other total copper and lead values have been ≤0.005 mg/L.

The maximum recorded total iron value of 0.4 mg/L exceeded the criteria of 0.3 mg/L for the protection of aquatic life and drinking water supplies[5,6,]. All other values met the working water quality criteria.

Recorded values for other trace metals met the working water quality criteria[6].

3.4.1.3 Nutrients

In section 3.3.2.6, it was predicted that, based upon a worst-case scenario, total phosphorus from the lagoon system could increase concentrations in the creek by 0.64 mg/L. It was also stated that this increase had been measured on one occasion. Data in Table 10 indicate that total phosphorus values measured at Site 0600505 downstream from the lagoons, and at Site 0600009 near the creek mouth, were comparable. Therefore the significant increases in total phosphorus from diffuse sources, predicted in Section 3.3.4, have not been measured downstream from Clinton. However, flows near the mouth may be three to four times greater than at Clinton during periods when irrigation is not taking place, and thus diffuse sources may have helped maintain high phosphorus and nitrogen concentrations.

Similarly, ammonia and Kjeldahl nitrogen values have shown no measurable increase between Sites 0600505 and 0600009. However, it was indicated in Section 3.3.2.3 that un-ionized ammonia levels could increase due to the discharge from the lagoon system, and the predicted increase had been measured just downstream from the lagoons. Therefore a provisional water quality objective is proposed for un-ionized ammonia in Clinton Creek. The objective, applicable to Clinton Creek, but exclusive of initial dilution zones of effluents described in Section 2.4.2.4, is that the average un-ionized ammonia nitrogen concentration should be ≤0.007 mg/L and the maximum value should not exceed 0.03 mg/L. The average value is to be calculated from samples collected once per week for five weeks over a period of no longer than 30 days.

Nitrite nitrogen values were all less than 0.005 mg/L above the lagoon discharge at Site 0600503, but were as high as 0.012 mg/L at Site 0600505 just downstream, and as high as 0.016 mg/L at Site 0600009 at the mouth of Clinton Creek (Table 10). These levels were below the working water quality criteria to protect aquatic life of 0.020 mg/L as an average value, and 0.060 mg/L as a maximum value[7]. Ammonia nitrogen in the lagoon effluent, when oxidized, can form nitrite. This can be a concern if oxidation of the nitrite to nitrate is inhibited. Therefore, to protect aquatic life from a build-up of nitrite nitrogen in Clinton Creek, a provisional water quality objective is proposed. The objective, applicable to Clinton Creek except in initial dilution zones of effluents described in Section 2.4.2.4, is that the average nitrite nitrogen concentration should be ≤0.020 mg/L and the maximum value should not exceed 0.060 mg/L. The average value is to be calculated from a minimum of five weekly samples collected over a period of 30 days.

Periphyton chlorophyll-a values were measured only in 1978, upstream and downstream from the lagoon discharge using artificial substrates (three plates per site)[14]. Maximum values increased from 153 mg/m^2 at Site 0600503 to 168 mg/m^2 at Site 0600505; however, the mean values for each of the sets of three plates were 123 mg/m^2 and 125 mg/m^2, respectively. Working water quality criteria for chlorophyll-a as set by the B.C. Ministry of Environment are 50 mg/m^2 for recreation and aesthetics, and 100 mg/m^2 for aquatic life[24]. Values upstream from Clinton do not always meet the criteria for aquatic life. A long-term goal for this system should be to meet the criteria for aquatic life. However, consideration also will have to be given to the wide range of values possible for chlorophyll-a measurements at the same site. Therefore, to protect aquatic life, the following provisional objective is proposed for chlorophyll-a in Clinton Creek, except in initial dilution zones of effluents described in Section 2.4.2.4: the average periphyton chlorophyll-a value for at least five replicates from natural substrates should not exceed 100 mg/m^2. If the average value measured upstream from a discharge or series of discharges already exceeds this value, the average downstream value should not be more than 120% of upstream. This percentage is meant to reflect no detrimental increase in periphyton growth, but is also meant to reflect on randomness of sampling and vagaries of measurements.

3.4.1.4 Dissolved Oxygen and Oxygen-Consuming Materials

In Section 3.3.2.4, it was stated that there was no real trend in dissolved oxygen values from upstream to downstream from the lagoon system due to the proximity of the two sites. This generally was also the pattern for values between Sites 0600503 and 0600009; however, decreased dissolved oxygen levels between the sites (≥0.5 mg/L) were noted on four of 18 coincident samplings. The largest decrease was 1.1 mg/L, in June and July, 1978.

The lowest recorded dissolved oxygen value was 6.1 mg/L at Site 0600009 in November 1973. This likely coincided with a period when the efficiency of treatment in the lagoon system was decreasing. Generally, the minimum 7.75 mg/L dissolved oxygen criterion for salmonid populations[19] was met in the creek.

The Department of Fisheries and Oceans has recommended minimum dissolved oxygen levels in rearing areas. These are 11.2 mg/L when eggs are in the "eye" to hatch stage, and 8.0 mg/L when fish eggs and/or larvae or alevin are present[20].

To protect the natural fish population, a provisional objective is proposed for dissolved oxygen as follows: 11.2 mg/L minimum when eggs are in the "eye" to hatch stage; 8.0 mg/L minimum when fish eggs and/or larvae or alevin are present; and 7.75 mg/L minimum at all other times. This objective applies to Clinton Creek, except in initial dilution zones of effluents described in Section 2.4.2.4.

3.4.1.5 Solids and Turbidity

Suspended solids values were from 2 to 50 mg/L at Site 0600503, 4 to 68 mg/L at Site 0600505, and 3 to 22 mg/L at Site 0600009. Most values at Site 0600503 were below 25 mg/L, while most values at Site 0600505 were less than 35 mg/L (Table 10). Suspended solids levels less than 25 mg/L should have no effect on aquatic life, while levels between 25 and 80 mg/L should have a moderate effect on aquatic life[11].

To prevent excessive suspended solids concentrations in Clinton Creek, and to allow for suspended solids entering the creek from the one point discharge and diffuse sources, a provisional water quality objective is proposed for suspended solids. The provincial criteria for suspended solids are that induced levels should not exceed 10 mg/L when background levels are ≤100 mg/L, nor should levels be more than 10% of background when background is >100 mg/L[21]. Therefore these provincial criteria will be the proposed provisional objective:

i.e. 10 mg/L maximum increase if upstream ≤ 100 mg/L, or
10% maximum increase if upstream > 100 mg/L.

The increase (in mg/L, or %) is over levels measured at a site upstream from a discharge or series of discharges and as close to them as possible, and applies to downstream levels. The objectives do not apply to initial dilution zones of effluents described in Section 2.4.2.4.

The maximum turbidity measurements going in a downstream direction were 3.6 NTU at Site 0600503, 6.7 NTU at Site 0600505, and 16 NTU at Site 0600009 (Table 10). Turbidity is an important characteristic for drinking water sources and aquatic life because it limits light penetration, while suspended solids can cause physical damage.

The provincial criteria for turbidity are that induced turbidity should not exceed 5 NTU when background levels are ≤ 50 NTU, nor should induced turbidity be more than 10% of background when background is > 50 NTU[21]. Therefore, the following provisional objective is proposed for turbidity, in Clinton Creek except in initial dilution zones of effluents, described in Section 2.4.2.4: if background turbidity levels are ≤50 NTU, the maximum increase should be ≤5 NTU; however, if background turbidity levels are > 50 NTU, the maximum increase should be ≤10% of background. The increase (in NTU or %) is over levels measured at a site upstream from a discharge or series of discharges and as close to them as possible.

Dissolved solids ranged to as high as about 425 mg/L at Site 0600503, 465 mg/L at Site 0600505, and 485 mg/L at Site 0600009. These maximum values meet the working water quality criterion of 500 mg/L (maximum acceptable) for drinking water(5), 500 mg/L (desirable level) for livestock watering(11), and 500 mg/L for irrigation purposes(4). Dissolved solids in the effluent from the lagoons can exceed 500 mg/L (Table 6). The effluent could raise present high dissolved solids levels even further and thereby impair use of the creek water. This is not considered highly probable. However, it is proposed that the maximum dissolved solids value in Clinton Creek should not exceed 500 mg/L. The objective applies to Clinton Creek, except in initial dilution zones of effluents described in Section 2.4.2.4.

3.4.1.6 Bacteriological Quality

Fecal coliform values were as high as 920 MPN/100 mL in Clinton Creek above the lagoons, 5 400 MPN/100 mL at Site 0600505 below the lagoons, and 2 400 MPN/100 mL near the mouth at Site 0600009 (Table 10). The upstream values meet the working water quality criteria for maximum concentration in irrigation water of 4 000 MPN/100 mL(6), but would likely require that complete treatment of drinking water (consisting of coagulation, sedimentation, filtration and disinfection) be undertaken, according to the guidelines for the treatment of raw water supplies(5). Some downstream values did not meet the criterion for irrigation.

It is suspected that the high upstream values were associated with cattle operations located along Clinton Creek and its tributaries. Downstream increases may also have been related to cattle, as well as discharges from the sewage treatment facility.

High levels of fecal coliforms exist and water quality in the creek should be upgraded for all water users. A provisional water quality objective therefore is proposed for fecal coliforms in Clinton Creek. The objective will take into account the need for good quality water for irrigation purposes, but will also recognize that higher quality water will be required at water intakes. Recognizing that at least partial treatment of water will be required for drinking water supplies, (median values at all sites were less than 100 MPN/100 mL) the 90th percentile fecal coliform value should not exceed 100 MPN/100 mL at any point outside initial dilution zones of effluents. These values are to be calculated from at least five weekly samples taken in a period of thirty days. Drinking water objectives apply year-round.

Values for colour in the creek at times exceeded the working criteria of 15 TCU for drinking water supplies[5]. Thus, the water at times may not be aesthetically desirable from a drinking water perspective.

The effluent from the Clinton lagoons currently is not disinfected. The possibility exists that at sometime in the future, this could be undertaken. The EPA recommend that to protect aquatic life, the chlorine residual value should be $\leq$ 0.002 mg/L[4]. A provisional water quality objective is proposed for residual chlorine in Clinton Creek in case the lagoon effluent is chlorinated. The objective, applicable along the length of Clinton Creek exclusive of initial dilution zones of effluent described in Section 2.4.2.4, is the maximum total residual chlorine value should be 0.002 mg/L. Since the objective is less than the minimum detectable concentration, it will be necessary to estimate the receiving water concentration using effluent load and stream flow.

3.4.2 BONAPARTE RIVER

Data for the Bonaparte River have been collected at sites from just above Clinton Creek (Site 0600017) to near its confluence with the Thompson River (Site 0600329). Data for these several Bonaparte River sites, as well as data for sites on Cache Creek and Hat Creek near their confluences with the Bonaparte River, are summarized in Table 11.

Designated water uses recommended for the Bonaparte River are use by aquatic life and wildlife, and use for drinking, irrigation, recreation and aesthetics, and livestock watering.

3.4.2.1 pH and Alkalinity

Values for pH have ranged between 7.8 and 8.3 above Clinton Creek (Table 11) to 8.2 to 8.8 just upstream from the Thompson River. The increasing pH values seem to arise from inputs from tributaries such as Hat Creek (pH range: 8.0 to 8.7), Cache Creek (pH range: 7.6 - 8.7) (Table 11), and Clinton Creek (pH from 8.2 to 8.6) (Table 10). However, the highest values were evident downstream from Cache Creek. The maximum pH value at all sites other than Site 0600329 above the Thompson River was 8.5.

Working water quality criteria for pH are 6.5 to 9.0 for the protection of aquatic life(4), and 6.5 to 8.5 for the use of the water for water supplies(5). Since it is desirable to minimize the amount of un-ionized ammonia which might be formed at higher pH in the creek from the discharge of either treated sewage from Cache Creek or of cattle wastes, a provisional objective is proposed for pH. Those consumers who use the river water as a drinking water supply require a lower pH water which will not cause fouling of plumbing pipes. A lower upper limit for pH also would reduce the amount of un-ionized ammonia which could form in the creek. The higher pH levels are naturally occurring. It is therefore proposed that the pH in the Bonaparte River, from Cache Creek to its headwaters at Bonaparte Lake, should be maintained between 6.5 and 8.5. In the river reach from

Cache Creek to the confluence of the Thompson River, the pH should be maintained between 6.5 and 9.0. The pH ranges are not applicable in initial dilution zones of effluents described in Section 2.4.2.4. The latter objective recognizes that some fouling of plumbing systems may occur for water users downstream from Cache Creek.

The Bonaparte River is moderately to well buffered to acid inputs, with all alkalinity values exceeding 70 mg/L (Table 11).

3.4.2.2 Hardness and Metals

The hardness of the Bonaparte River increases in a downstream direction. At Site 0600017 above Clinton Creek, the river is of moderate hardness (65 to 163 mg/L) (Table 11). However, these values increase along the length of the river so that the range is from 195 to 221 mg/L at Site 0600329. "Water supplies with hardness greater than 200 mg/L are considered poor"[5]. High hardness values can help to prevent acute toxicity to aquatic life from metals.

Total copper values as high as 0.03 mg/L were recorded at Site 0600008 below Cache Creek (Table 11). A maximum dissolved copper concentration (taken at a different time) of 0.06 mg/L was also recorded at this site. Values of total copper as high as 0.09 mg/L have been recorded in Cache Creek. At Site 0600008, the minimum hardness was 116 mg/L. Recent draft criteria by the EPA relating permitted copper levels to hardness would allow 0.011 mg/L as an average copper value and 0.016 mg/L as a maximum value at a hardness of 100 mg/L[23]. A criterion for copper published prior to these by the Inland Waters Directorate was 0.002 mg/L. Thus median or mean copper values met the EPA criteria, but not necessarily those of the Inland Water Directorate. Some maximum values met neither of the criteria; however, these levels were naturally occurring or erroneous.

Values for lead were generally low, although some higher values have been recorded. For example, the maximum lead value was 0.029 mg/L at Site

0600017 above Clinton Creek, and 1.2 mg/L at Site 0600186 above Hat Creek. These higher values exceeded criteria put forth by Inland Waters Directorate of 0.01 mg/L[6] and those of the EPA of 0.003 mg/L as an average and 0.064 mg/L as a maximum[23] value. However, they were naturally occurring high values. Most median and mean values were ≤0.003 mg/L.

High iron values occurred along the length of the river, with many values exceeding the water quality criteria of 0.3 mg/L for use as drinking water and protection of aquatic life[6,5]. Zinc values, except for the maximum recorded value of 0.1 mg/L at Site 0600008 below Cache Creek, met the criterion of 0.05 mg/L for the protection of sensitive aquatic life[6].

Other metals generally met the working water quality criteria. No water quality objectives will be proposed for metals since there are no anthropogenic activities which discharge metals to the river.

3.4.2.3 Nutrients

Total phosphorus values generally increased going in a downstream direction. Minimum, mean, and maximum values between a site upstream from Clinton Creek (Site 0600017) and a site near the mouth of the Bonaparte River (Site 0600329) increased approximately four-fold. These higher values could cause algal growths which in turn could cause taste and odour problems in drinking water supplies.

Periphyton chlorophyll-a values have been measured on artificial substrate above and below the Cache Creek STP discharge and near the confluence of the Bonaparte River with the Thompson River. The maximum recorded values were 52 mg/m² at Site 0600506, 45 mg/m² at Site 0600508, and 87 mg/m² at Site 0600329. All values met the working water quality criterion of 100 mg/m² for the protection of aquatic life but the value at Site 0600329 did not meet the criterion of 50 mg/m² for the preservation of aesthetics[24]. To ensure that periphyton growth does not become a problem, a provisional objective is proposed for the Bonaparte River, from Bonaparte Lake to its confluence with the Thompson River, except in initial dilution zones of effluents described in Section 2.4.2.4. The objective is that the average of at least five periphyton chlorophyll-a values from natural substrate should not exceed 50 mg/m².

In section 3.3.3.3, it was determined that the discharge from the Cache Creek STP increased ammonia values in the Bonaparte River. The data for Cache Creek (Table 11, Site 0600074) indicate that the maximum recorded ammonia levels in Cache Creek exceeded the maximum recorded at most other sites. This suggests that livestock wastes may be raising ammonia values in the creek, and possibly in the Bonaparte River. The maximum ammonia nitrogen value of 0.133 mg/L in Cache Creek corresponded to an un-ionized ammonia nitrogen concentration of 0.002 mg/L, which is less than the working criterion to protect aquatic life of ≤0.007 mg/L as an average(7).

Ammonia values increased between a site upstream from Clinton Creek and the mouth of the Bonaparte River (Sites 0600017 and 0600329). The highest values, other than those measured adjacent to the sewage discharge at Cache Creek, were at Site 0600008 downstream from Cache Creek. The maximum value of 0.26 mg/L corresponded to an un-ionized ammonia nitrogen value of 0.008 mg/L, which is greater than the working water quality criterion to protect aquatic life of ≤ 0.007 mg/L as an average, but less than the criterion of 0.030 mg/L for a maximum value(7).

To protect aquatic life in the Bonaparte River, the following provisional water quality objective is proposed for un-ionized ammonia: the average un-ionized ammonia nitrogen concentration should be ≤0.007 mg/L, and the maximum concentration should not exceed 0.03 mg/L. The objectives apply to the Bonaparte River, from its confluence with the Thompson River to Bonaparte Lake, exclusive of initial dilution zones of effluents described in Section 2.4.2.4. The average value is to be calculated from samples collected once per week for five weeks during a period no longer than 30 days.

Nitrite nitrogen values measured upstream from the Cache Creek STP discharge were generally ≤ 0.005 mg/L (Table 11). Maximum values downstream from the discharge were 0.027 mg/L at Site 0600508, 0.028 mg/L at Site 0600008, and 0.005 mg/L at Site 0600329 above the confluence with the Thompson River. The higher values exceeded the working criterion to protect aquatic life of ≤0.02 mg/L as an average, but were less than the criterion for a maximum of 0.06 mg/L[7]. Consequently, a provisional objective is proposed. The objective applicable to the Bonaparte River, except in dilution zones of effluents described in Section 2.4.2.4, is as follows: the average nitrite-N value should not exceed 0.02 mg/L, and the maximum nitrite-N value should not exceed 0.06 mg/L. The average should be calculated from samples collected once per week in a 30-day period.

3.4.2.4 Dissolved Oxygen and Oxygen-Consuming Materials

In Section 3.3.3.4, it was stated that no appreciable change in dissolved oxygen could be noted in going from upstream to ownstream from the Cache Creek STP. This was also the case for mean and maximum values at the different sites along the Bonaparte River; however, minimum recorded values

The minimum recorded dissolved oxygen values at the different sites ranged from 4.7 mg/L at Site 0600329, just upstream from the Thompson River, to 6.5 mg/L at Site 0600017, above Clinton Creek. Thus, the working criterion of a minimum 7.75 mg/L for salmonid populations[19] was not met at all times in the Bonaparte River.

These recorded low values correspond to percent saturation values in the order of 40%, which can make aquatic life susceptible to stress from other contaminants. The maximum percent saturation value of nearly 165% at Site 0600017, above Clinton Creek, may also cause stress. The wide range of percent saturation values at this site may be due to algal blooms at some times of the year.

Although oxygen levels do not always meet the working water quality criteria for dissolved oxygen, it is important to maintain a high oxygen level in the river for migration, rearing, spawning, and possible future enhancement projects. Therefore a provisional objective is proposed for dissolved oxygen as follows; 11.2 mg/L minimum when fish eggs are in the "eye" to hatch stage; 8.0 mg/L minimum when fish eggs and/or larvae or alevin are present[8]; and 7.75 mg/L minimum at all other times[19]. This objective applies to the Bonaparte River, from its confluence with the Thompson River to Bonaparte Lake, except in initial dilution zones of effluents described in Section 2.4.2.4.

3.4.2.5 Solids and Turbidity

Suspended solids levels can be fairly high in the Bonaparte River. Maximum values of greater than 80 mg/L have been recorded at most sites along the river. Median values were considerably lower, generally less than 25 mg/L. Water with less than 25 mg/L will not affect aquatic life, between 25 and 80 mg/L the water will have a moderate effect, and above 80 mg/L the water can be considered poor for aquatic life[11]. Thus, little effect on aquatic life is expected over fifty percent of the time, but there are times when suspended solids in the Bonaparte River could be of concern. These high levels are associated with freshet conditions, and arise from inputs from tributaries. The maximum values in tributaries were 1 024 mg/L in Hat Creek and 1 660 mg/L in Cache Creek.

Although it was calculated in Section 3.3.3.5 that the Cache Creek STP would increase suspended solids concentrations by less than 1 mg/L, suspended solids should not be increased unnecessarily by other anthropogenic activities. Upsets in the biological treatment may, at some time, cause abnormally high suspended solids concentrations to be discharged. Therefore, to prevent excessive suspended solids concentrations in the Bonaparte River due to anthropogenic activities, a provisional water quality objective is proposed. The objectives, based upon the provincial criteria[21], are as follows:

10 mg/L maximum increase if upstream ≤100 mg/L, or
10% maximum increase if upstream >100 mg/L.

Turbidity is an important characteristic for drinking water sources and for aquatic life because of its effect on light penetration. Suspended solids can cause physical damage. The maximum turbidity values were 54 NTU above the Cache Creek STP discharge at Site 0600506, and 70 NTU just above Cache Creek at Site 0600008. The provincial criteria for turbidity are that induced turbidity should not exceed 5 NTU when the background is ≤50 NTU, nor should induced turbidity be more than 10% of background when background is > 50 NTU[21]. A provisional objective is proposed for turbidity in the Bonaparte River, except in initial dilution zones of effluents described in Section 2.4.2.4. The objective is that if background turbidity levels are ≤50 NTU, the maximum increase should be ≤ 5 NTU; however, if background turbidity levels are >50 NTU, the maximum increase should be ≤ 10% of background. The increase (in mg/L, NTU or %) is over levels measured at a site upstream from a discharge or series of discharges and as close to them as possible, and applies to downstream levels.

Dissolved solids levels ranged from between about 100 to 250 mg/L at Site 0600017, upstream from Clinton Creek to 180 to 338 mg/L at Site 0600329, upstream from the Thompson River (Table 11). Some higher maximum dissolved solids levels were recorded (Table 11) in Hat Creek (428 mg/L), Cache Creek (412 mg/L) and in Clinton Creek (480 mg/L-Table 10). All these values are below the working water quality criteria of 500 mg/L to protect drinking water (maximum acceptable)[5], livestock watering (desirable level)[11], and irrigation[4]. The values in the Bonaparte River are well below the 500 mg/L level, and the Cache Creek STP will not have a considerable impact on these values. Therefore no objective is proposed for dissolved solids in the Bonaparte River.

3.4.2.6 Bacteriological Quality

Fecal coliform values were as high as 920 MPN/100 mL above the Cache Creek STP discharge at Site 0600506, 5 400 MPN/100 mL just below the discharge at Site 0600508, and as high as 16 000 MPN/100 mL at Site 0600008, below Cache Creek (Table 11). The values upstream from the Cache Creek STP discharge met the working water quality criterion for irrigation water[6] of a maximum concentration of 4 000 MPN/100 mL, while the maximum values downstream from the discharge did not always meet the criterion. The median value at Site 0600008 was 110 MPN/100 mL. Based upon these data, it is likely that at least partial treatment of drinking water supplies (consisting of filtration or equivalent and disinfection) would be required[5].

The maximum recorded fecal coliform values in Clinton Creek (Site 0600009), Hat Creek (Site 0600073), and Cache Creek (Site 0600074) were 2 400 MPN/100 mL, 130 MPN/100 mL, and 170 MPN/100 mL, respectively. Thus the high fecal coliform values do not necessarily originate from tributaries. It is suspected that the high and increasing fecal coliform values originate from cattle operations, as well as from the Cache Creek STP discharge. The maximum recorded fecal coliform value at Site 0600329 just upstream from the Thompson River was 920 MPN/100 mL, while the median value was 33 MPN/100 mL. The impact of these levels on the water intake at Ashcroft will be made in an assessment of the Thompson River[1].

High levels of fecal coliforms exist at times in the river, and water quality in the river should be upgraded for all users. A provisional water quality objective is proposed for fecal coliforms in the Bonaparte River. The objective will take into account the need for good quality water for irrigation, but will also recognize that higher quality water will be required at water intakes. Recognizing that at least partial treatment of water will be required for drinking water supplies, (most median values <100 MPN/100 mL), the 90th percentile fecal coliform value should not exceed 100 MPN/100 mL at any point in the river outside initial dilution zones of effluents. These values are to be calculated from samples collected once per week for five weeks in a period no longer than 30 days. Drinking water objectives apply year-round.

Values for colour in the Bonaparte River at times exceeded the working water quality criterion of 15 TCU for drinking water supplies(5). Thus the water may be aesthetically undesirable at certain times for drinking water purposes.

An assessment is currently being made by the Village of Cache Creek as to whether the Cache Creek STP effluent needs to be disinfected. The EPA recommends that to protect aquatic life, the chlorine residual should be ≤0.002 mg/L(4). A provisional water quality objective is proposed therefore for chlorine residual in the Bonaparte River. The objective, applicable along the length of the Bonaparte River, except in initial dilution zones of effluents described in Section 2.4.2.4, is that the maximum total chlorine residual values should be 0.002 mg/L. Since the objective is less than the minimum detectable concentration, it will be necessary to estimate the receiving water concentration from effluent load and stream flow.

3.5 SUMMARY OF DESIGNATED WATER USES AND PROVISIONAL WATER QUALITY OBJECTIVES

Designated water uses proposed for Clinton Creek and the Bonaparte River are:

1. Clinton Creek - use by aquatic life and wildlife, and for irrigation, livestock watering, and drinking water with at least partial treatment.

2. Bonaparte River - same as Clinton Creek, plus recreation and aesthetics.

To protect these designated uses, provisional objectives are proposed as follows:

	Clinton Creek and Bonaparte River
pH	6.5 - 8.5 6.5 - 9.0 (Bonaparte River from Cache Creek to the Thompson River)
Un-ionized Ammonia (N)	≤0.007 mg/L (average) 0.03 mg/L (maximum)
Nitrite (N)	≤0.02 mg/L (average) 0.06 mg/L (maximum)
Chlorophyll-a	100 mg/m^2, or 120% of upstream in Clinton Creek (if upstream >100 mg/m^2) 50 mg/m^2 in Bonaparte River
Dissolved Oxygen	11.2 mg/L (minimum): eggs are in "eye" to hatch stage 8.0 mg/L (minimum): eggs and/or larvae or alevin present 7.75 mg/L (minimum): all other times
Suspended Solids	10 mg/L maximum increase (upstream ≤100 mg/L) 10% maximum increase (upstream >100 mg/L)
Turbidity	5 NTU maximum increase (upstream ≤50 NTU) 10% maximum increase (upstream >50 NTU)
Dissolved Solids	≤ 500 mg/L (Clinton Creek only)
Fecal Coliforms	100 MPN/100 mL (90th percentile): year round
Total Residual Chlorine	0.002 mg/L (maximum)

3.6 RECOMMENDED MONITORING

To verify that the proposed objectives are achieved, it is proposed that pH, dissolved oxygen, ammonia, nitrite, chlorophyll-a, temperature, fecal coliforms, suspended solids, turbidity and total residual chlorine (estimated) be monitored at the mouths of Clinton Creek (Site 0600009) and the Bonaparte River (Site 0600329), as well as just upstream and downstream from the sewage treatment facilities (Sites 0600503 and 0600505 on Clinton Creek and Sites 0600506 and 0600508 on the Bonaparte River). Appropriate monitoring of waste discharges should also be conducted at the same time as receiving water monitoring. Ideally, replicate samples (minimum of three) would be taken to determine variability.

This monitoring should be undertaken five times per month during two periods, once during freshet and once during low flow for one year. Thereafter, depending on the results of the first year, only infrequent spot checks need be made unless modifications are made to the sewage treatment facilities, their mode of operation, or to any other anthropogenic activities in the basin.

Monitoring should be undertaken at Site 0600329 on a regular basis to detect any trends in Bonaparte River water quality. Sampling at this site will integrate everything that has happened upstream, will delete anomalies associated with small flows, and will encompass seasonal variability. It is recommended that such sampling be undertaken on a minimum frequency of monthly, year-round for a minimum of five years. This is the minimum monitoring effort needed for trend detection. Analyses which should be performed include pH, temperature, fecal coliforms, dissolved and suspended solids, TAC colour, turbidity, dissolved oxygen, total hardness, ortho and total phosphorus, periphyton chlorophyll-a (during open water period), ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, and Kjeldahl nitrogen.

The contribution of nutrients from cattle wastes to levels in Clinton and Loon Creeks, and the Bonaparte River, needs to be studied. This study should initially look at phosphorus concentrations upstream and downstream from selected cattle operations, to determine any increase. Sampling should occur at least weekly at selected sites from April through mid-June. Analyses should include field measurements for pH, temperature, and dissolved oxygen, and laboratory measurements for total and orthophosphorus, periphyton chlorophyll-a, nitrite nitrogen, nitrate nitrogen, ammonia nitrogen, Kjeldahl nitrogen, turbidity, suspended solids, and fecal coliforms. Any streams entering these water bodies from lands near cattle operations in between the upstream and downstream sites should also be monitored for these same characteristics. Streamflows should be measured where practical to determine nutrient loadings from cattle operations. Replicate samples should be considered to determine sample variability.

Any monitoring programs actually undertaken will depend on resources and Regional priorities.

3.7 CONCLUSIONS

Two operations discharge treated domestic sewage directly to Clinton Creek and the Bonaparte River. These are the lagoon system at Clinton and the sewage treatment facility at Cache Creek.

Calculations indicated that fecal coliforms, ammonia, suspended solids, and total phosphorus in the Clinton lagoon effluent could affect values in Clinton Creek. Increases due to this effluent have been measured in the creek. Additional treatment may be required.

Calculations and field measurements revealed that the Cache Creek STP discharge increased levels of fecal coliforms, ammonia nitrogen, and total phosphorus.

Locations of cattle in the watershed are shown in Figure 3. Estimates show that these cattle could increase phosphorus values in Clinton Creek and the Bonaparte River. Other related characteristics such as ammonia and nitrite nitrogen, BOD_5, and fecal coliforms in these water bodies could be affected by cattle.

Clinton Creek is highly buffered, has "hard" water, with some naturally high copper, iron, and lead values, some high phosphorus values, fairly good dissolved oxygen levels, and suspended solids levels which should not affect aquatic life. Dissolved solids levels were high but were still low enough not to impair use of the water, and fecal coliform values were high enough to require that drinking water supplies receive at least partial treatment.

The Bonaparte River is moderately to well buffered, is of moderate hardness, with some naturally high copper, iron, and lead values and some high total phosphorus values. Ammonia values increased along the length of the river, but they were not sufficiently high to cause a problem to aquatic life. Dissolved oxygen and percent saturation values ranged widely and could cause stress to aquatic life. Some suspended solids concentrations were so high that they could affect aquatic life. Dissolved solids levels were lower than in Clinton Creek but no water uses would be impaired. Fecal coliform values increased along the Bonaparte River in a downstream direction, and some maximum values recorded below Cache Creek would exceed criteria for irrigation water.

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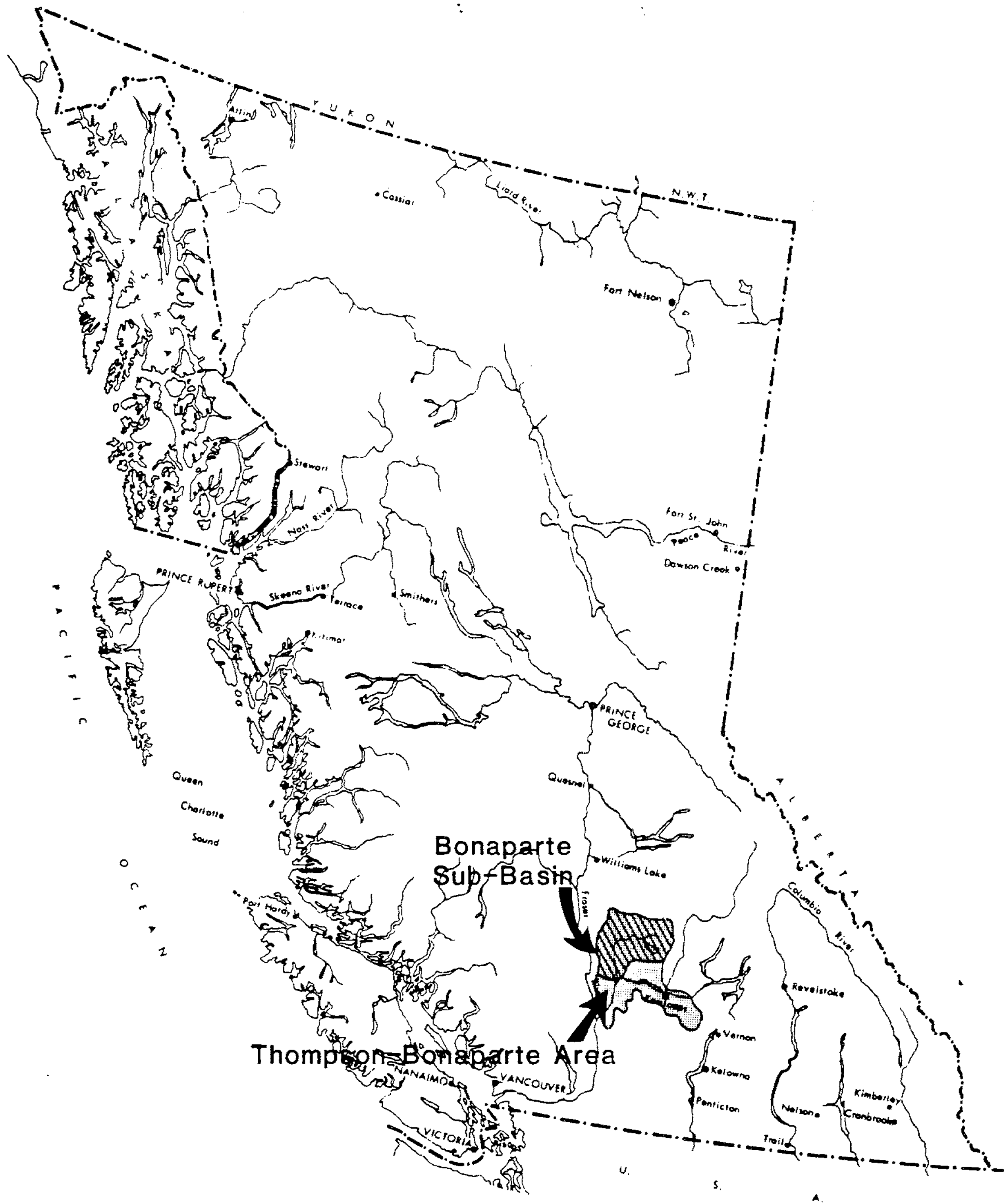

Figure 1 Location Map

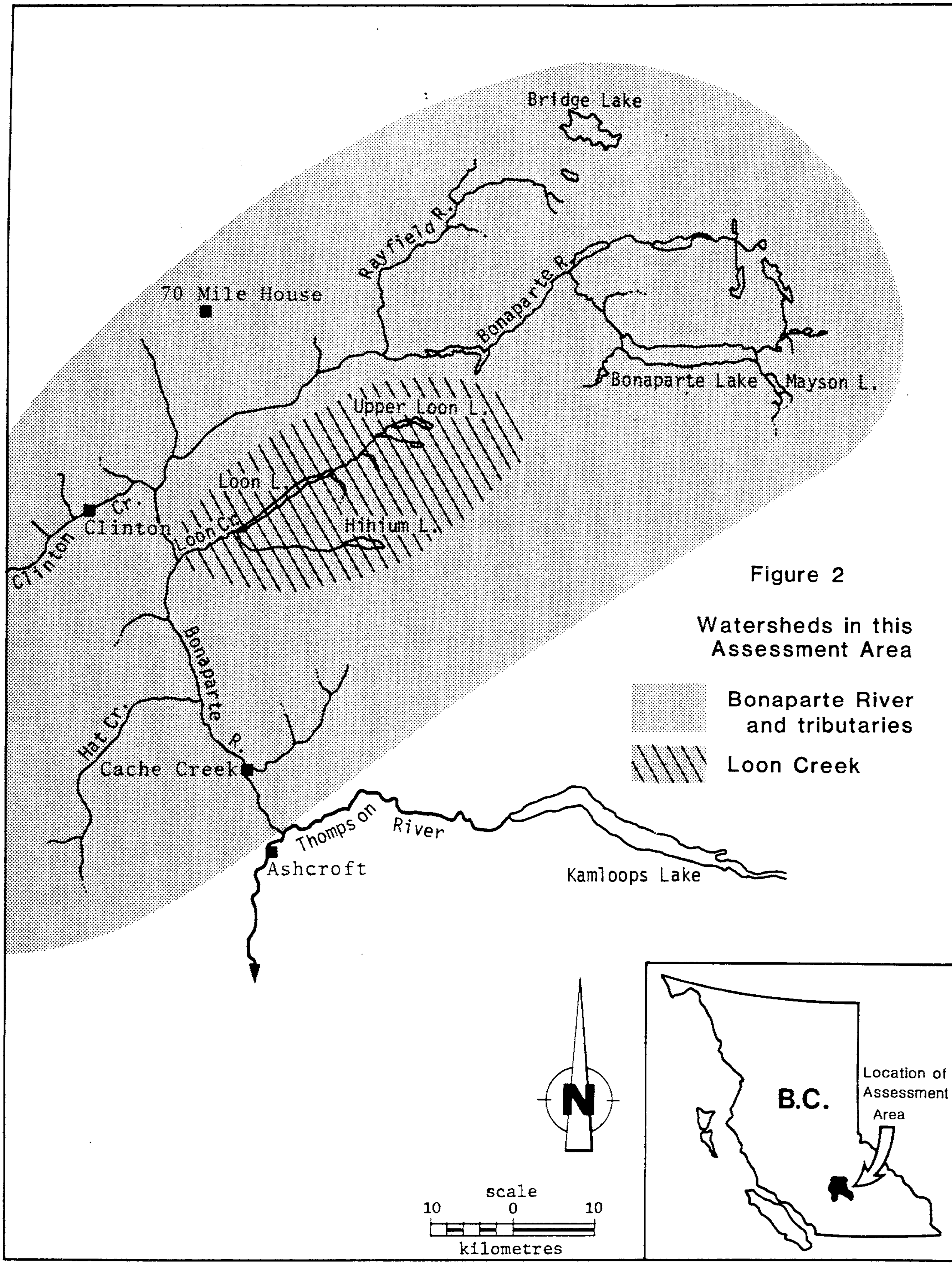

Figure 2

Watersheds in this Assessment Area

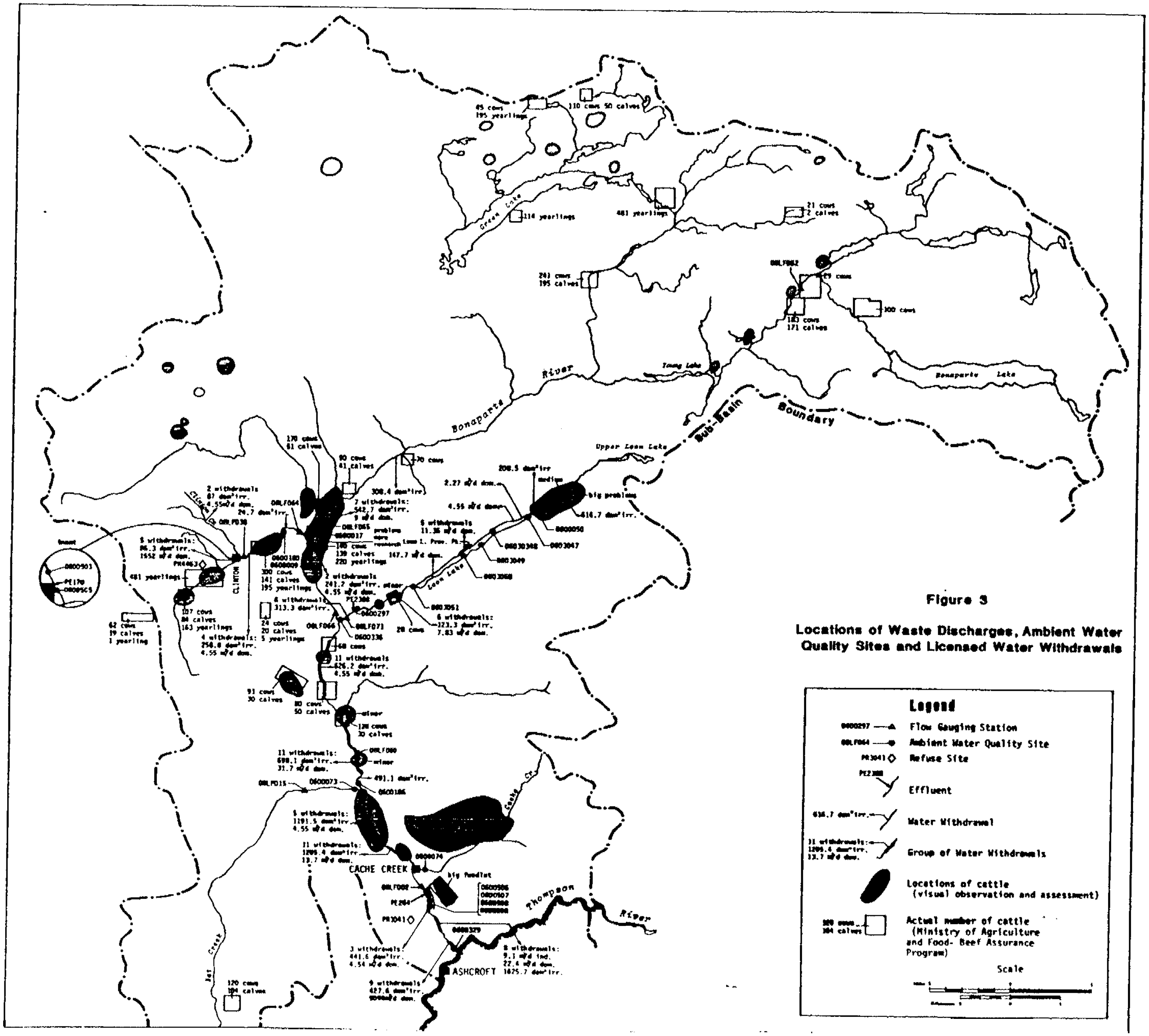

Figure 3

Locations of Waste Discharges, Ambient Water Quality Sites and Licensed Water Withdrawals

TABLE 1

HATCHERY EFFLUENT DATA SUMMARY

PE 2388

B.C. BUILDINGS CORPORATION (Clinton)

SETTLING POND OUTLET

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
BOD_5	1974-1984	16	<10	<10	<10
Flow	1980-1981	4	2 153	103	1 426
Nitrogen-ammonia	1978-1984	13	0.35	0.069	0.201
-nitrate/nitrite	1975-1984	18	0.27	0.12	0.22
-organic	1974-1984	13	0.45	0.1	0.28
-Kjeldahl	1978-1984	12	2	0.17	0.61
pH	1977-1984	16	8.5	8.1	8.2+
Phosphorus-total diss.	1978-1984	13	0.264	0.081	0.125
-total	1978-1984	22	0.486	0.085	0.137
Solids-suspended	1974-1984	22	13	1	3.6
-total	1974-1984	19	318	266	290
Specific Conductivity	1974-1984	20	499	409	481
Temperature	1974-1984	8	10.8	6	9.3

+ Median value

* All values are as mg/L except:
  (1) Flow as m^3/d
  (2) pH
  (3) Specific Conductivity as µS/cm
  (4) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 2

AMBIENT WATER QUALITY DATA SUMMARY

SITE 0600291

LOON CREEK HATCHERY INLET

(HATCHERY CREEK)

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Nitrogen - ammonia	1980-1984	10	0.011	<0.005	0.007
- nitrite/nitrate	1980-1984	10	0.27	0.22	0.24
- organic	1981-1984	8	0.09	0.02	0.05
- Kjeldahl	1981-1984	8	0.1	0.02	0.06
- total	1981-1984	8	0.32	0.25	0.29
Oxygen - BOD_5	1983-1984	3	<10	<10	<10
pH	1980-1984	10	8.5	8.2	8.4+
Phosphorus-total diss.	1981-1984	9	0.076	0.067	0.072
-total	1980-1984	10	0.077	0.071	0.073
Solids-suspended	1980-1984	10	3	1	2
-total	1980-1983	8	300	288	291
Specific Conductivity	1980-1984	10	499	483	489
Temperature	1983-1984	3	9.5	9	9.2

+ Median value

* All values are as mg/L except:

(1) pH

(2) Specific Conductivity as µS/cm

(3) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 3

EFFLUENT DATA SUMMARY

SITE 0601059

LOON CREEK HATCHERY SETTLING POND INLET

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Nitrogen - ammonia	1980-1984	10	0.326	0.052	0.212
- nitrite/nitrate	1980-1984	10	0.27	0.12	0.23
- organic	1981-1984	9	1.13	0.19	0.42
- Kjeldahl	1981-1984	9	1.43	0.24	0.64
- total	1981-1984	8	1.68	0.46	0.86
Oxygen - BOD_5	1983-1984	3	<10	<10	<10
pH	1980-1984	10	8.4	8.1	8.3+
Phosphorus-total diss.	1981-1984	9	0.143	0.086	0.114
-total	1980-1984	10	0.247	0.087	0.146
Solids-suspended	1980-1984	10	8	1	4.5
-total	1980-1984	9	308	258	292
Specific Conductivity	1980-1984	10	499	408	482
Temperature	1983-1984	3	10.5	8.5	9.3

+ Median value

* All values are as mg/L except:

(1) pH

(2) Specific Conductivity as µS/cm

(3) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 4
AMBIENT WATER QUALITY DATA SUMMARY FOR LOON LAKE
SITE 0603051
LOON LAKE AT OUTLET

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity - total	1976-1981	7	314	262	294
Carbon - organic	1976-1977	3	8	6	6.7
Cyanide (total)	1978	2	<0.01	<0.01	<0.01
Hardness - calcium	1976-1981	4	23.8	21.1	22.9
- magnesium	1976-1977	3	38.6	37.3	37.8
- total	1976-1981	4	217	209	213
Metals and metalloids:					
Arsenic (total)	1978-1981	3	<0.005	<0.005	<0.005
Boron (diss)	1978	2	<0.1	<0.1	-
Cadmium (total)	1978-1981	3	<0.0005	<0.0005	<0.0005
Chromium (total)	1978-1981	3	<0.005	<0.005	<0.005
Iron (total)	1978-1981	4	0.1	<0.1	<0.1+
Lead (total)	1978-1981	3	0.003	<0.001	0.002
Manganese (total)	1978-1981	3	<0.02	<0.02	<0.02
Mercury (total)	1978-1981	3	<0.00005	<0.00005	<0.00005
Molybdenum (total)	1978-1981	3	0.0016	0.0009	0.0012
Nickel (total)	1978-1981	3	<0.01	<0.01	<0.01
Zinc (total)	1978-1981	3	<0.005	<0.005	<0.005
Nitrogen - ammonia	1976-1978	5	0.036	0.023	0.026
- nitrite/nitrate	1976-1979	6	0.16	<0.02	0.06
- organic	1976-1977	3	0.56	0.49	0.52
- Kjeldahl	1976-1977	3	0.58	0.51	0.55
- total	1976-1977	3	0.69	0.51	0.59
Oxygen - dissolved	1976-1981	5	10.9	7.2	10
- % saturation	1976	5	108	53	94.8
pH	1976-1981	7	9.1	8.3	8.7+
Phosphorus-diss. ortho	1976-1977	3	0.05	<0.003	0.019
-total diss.	1976-1978	4	0.075	0.013	0.039
-total	1976-1981	5	0.064	0.013	0.029
Solids-total	1976-1977	7	348	320	329.7
Specific Conductivity	1976-1977	7	540	480	518
Temperature	1976-1981	6	13.5	1.5	10.8
Turbidity	1976-1977	3	1.1	0.6	0.9

+ Median value
* All values are as mg/L except:
  (1) Oxygen - % saturation as %
  (2) pH
  (3) Specific Conductivity as µS/cm
  (4) Temperature as °C
  (5) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 4
AMBIENT WATER QUALITY DATA SUMMARY FOR LOON LAKE (CON'T)
SITE 0603050
LOON LAKE AT ROCK BLUFF

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity - total	1976-1977	7	297	293	294.4
Carbon - organic	1976-1977	4	7	5	5.8
Chlorophyll-a	1977	4	0.0053++	0.0039++	0.0046++
Hardness - calcium	1976-1977	7	24	23	23.4
- magnesium	1976-1977	7	38.4	37.4	37.8
- total	1976-1977	7	216	212	213.9
Nitrogen - ammonia	1976-1977	7	0.087	0.022	0.039
- nitrite/nitrate	1976-1977	7	0.29	<0.02	0.011
- organic	1976-1977	7	0.65	0.36	0.52
- Kjeldahl	1976-1977	7	0.68	0.45	0.56
- total	1976-1977	7	0.8	0.52	0.67
Oxygen - dissolved	1976	3	11 **	1.4**	7.4**
- % saturation	1976	3	108.4**	11.6**	71.7**
pH	1976-1977	7	8.9	8.3	8.6
Phosphorus-diss. ortho	1976-1977	7	0.107	<0.003	0.044
-total diss.	1976-1977	7	0.114	0.011	0.052
-total	1976-1977	7	0.116	0.024	0.06
Solids-total	1976-1977	7	340	320	330
Specific Conductivity	1976-1977	7	542	509	527
Temperature	1976-1977	6	13.2	4.8	8.3
Turbidity	1976-1977	7	1.2	0.4	0.8

\+ Median value
++ Samples collected at depths of 0, 2.1, 5.2 and 10.1 m
* All values are as mg/L except:
(1) pH
(2) Specific Conductivity as µS/cm
(3) Temperature as °C
(4) Turbidity

** Samples collected at depths of 0, 13.1 and 30.2 m
Data Source: B.C. Ministry of Environment

TABLE 4
AMBIENT WATER QUALITY DATA SUMMARY FOR LOON LAKE (CON'T)
SITE 0603049
LOON LAKE OFF GOVERNMENT CAMPGROUND

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity - total	1976-1977	4	295	291	293
Carbon - organic	1976-1977	4	6	2	3.8
Chlorophyll-a	1976	4	0.0096++	0.0038++	0.0069++
Hardness - calcium	1976-1977	4	24	23	23.6
- magnesium	1976-1977	4	37.4	36.9	37.3
- total	1976-1977	4	213	211	212
Nitrogen - ammonia	1976-1977	4	0.032	0.019	0.025
- nitrite/nitrate	1976-1977	4	0.35	<0.02	0.12
- organic	1976-1977	4	0.60	0.42	0.50
- Kjeldahl	1976-1977	4	0.63	0.44	0.52
- total	1976-1977	4	0.82	0.52	0.64
Oxygen - dissolved	1976	3	11.4**	1.8**	5.6**
- % saturation	1976	3	113	14.9	59.3
pH	1976-1977	4	8.9	8.3	8.5+
Phosphorus-diss. ortho	1976-1977	4	0.093	<0.003	0.049
-total diss.	1976-1977	4	0.094	0.009	0.055
-total	1976-1977	4	0.105	0.018	0.064
Solids-total	1976-1977	4	334	324	328
Specific Conductivity	1976-1977	4	530	510	523
Temperature	1976	3	13.5**	5.9**	8.9**
Turbidity	1976-1977	4	1.2	0.4	0.75

\+ Median value
++ Samples collected at depths of 0, 2.1, 5.2, and 10.1 m
* All values are as mg/L except:
(1) pH
(2) Specific Conductivity as µS/cm
(3) Temperature as °C
(4) Turbidity as NTU

** Samples collected at depths of 0, 13.1, and 30.2 m

Data Source: B.C. Ministry of Environment

TABLE 4
AMBIENT WATER QUALITY DATA SUMMARY FOR LOON LAKE (CON'T)
SITE 0603048
LOON LAKE OFF WHITE MOOSE

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity - total	1976-1977	5	295	291	293
Carbon - organic	1976-1977	5	8	<1	4.6
Chlorophyll-a	1976	4	0.0069**	0.0046**	0.0059**
Hardness - calcium	1976-1977	5	23.9	23.1	23.5
- magnesium	1976-1977	5	37.7	36.8	37.3
- total	1976-1977	5	214	211	212
Nitrogen - ammonia	1976-1977	5	0.03	0.021	0.025
- nitrite/nitrate	1976-1977	5	0.36	<0.02	0.09
- organic	1976-1977	5	0.61	0.37	0.52
- Kjeldahl	1976-1977	5	0.64	0.39	0.54
- total	1976-1977	5	0.75	0.48	0.63
Oxygen - dissolved	1976	3	11.5++	1.9++	5.9++
- % saturation	1976	3	112.7++	15.5++	60.3++
pH	1976-1977	5	8.9	8.3	8.7+
Phosphorus-diss. ortho	1976-1977	5	0.092	<0.003	0.044
-total diss.	1976-1977	5	0.094	0.008	0.050
-total	1976-1977	5	0.099	0.019	0.064
Solids-total	1976-1977	5	334	330	331
Specific Conductivity	1976-1977	5	532	510	525
Temperature	1976	3	13++	5.5++	9++
Turbidity	1976-1977	5	1.3	0.3	0.82

\+ Median value
++ Samples collected at depths of 0, 13.1, and 30.2 m
* All values are as mg/L except:
(1) pH
(2) Specific Conductivity as μS/cm
(3) Temperature as °C
(4) Turbidity as NTU

** Samples collected at depths of 0, 2.1, 5.2 and 10.1 m

Data Source: B.C. Ministry of Environment

TABLE 4
AMBIENT WATER QUALITY DATA SUMMARY FOR LOON LAKE (CON'T)
SITE 0603047
LOON LAKE AT INLET

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity - total	1976-1977	3	295	293	294
Carbon - organic	1976-1977	3	6	5	5.3
Hardness - calcium	1976-1977	3	23.9	23.4	23.6
- magnesium	1976-1977	3	37.6	37.3	37.5
- total	1976-1977	3	214	212	213
Nitrogen - ammonia	1976-1977	3	0.029	0.022	0.026
- nitrite/nitrate	1976-1977	3	0.03	<0.02	<0.02+
- organic	1976-1977	3	0.67	0.54	0.59
- Kjeldahl	1976-1977	3	0.7	0.56	0.62
- total	1976-1977	3	0.7	0.56	0.63
Oxygen - dissolved	1976	2	12.2	11.2	11.7
- % saturation	1976	2	109.8	109.8	109.8
pH	1976-1977	3	8.9	8.7	8.9+
Phosphorus-diss. ortho	1976-1977	3	0.034	<0.003	<0.003+
-total diss.	1976-1977	3	0.044	0.005	0.020
-total	1976-1977	3	0.06	0.021	0.037
Solids-total	1976-1977	3	338	324	329
Specific Conductivity	1976-1977	3	530	510	517
Temperature	1976	2	13	13	13
Turbidity	1976-1977	3	2.1	1.2	1.6

+ Median value
* All values are as mg/L except:
  (1) Oxygen-% saturation as %
  (2) pH
  (3) Specific Conductivity as µS/cm
  (4) Turbidity as NTU
  (5) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 5
AMBIENT WATER QUALITY DATA SUMMARY FOR LOON CREEK
SITE 0600336
LOON CREEK NEAR MOUTH

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity - total	1982	1	166	-	-
Carbon - organic	1979	9	11	<1	5.3
Coliform - total	1979	7	1 600	17	240+
Hardness - calcium	1979-1982	3	31.5	22.8	27.2
- magnesium	1979-1982	3	30.5	18.2	24.9
- total	1979-1982	3	204	132	170
Metals and metalloids:					
Aluminum (total)	1982	1	0.28	-	-
Arsenic (total)	1982	1	<0.25	-	-
Cadmium (total)	1982	1	<0.01	-	-
Chromium (total)	1982	1	<0.01	-	-
Copper (total)	1982	1	<0.01	-	-
Iron (total)	1982	1	0.49	-	-
Lead (total)	1982	1	<0.1	-	-
Manganese (total)	1982	1	0.03	-	-
Molybdenum (total)	1982	1	<0.01	-	-
Nickel (total)	1982	1	<0.05	-	-
Zinc (total)	1982	1	<0.01	-	-
Nitrogen - ammonia	1979-1984	20	0.14	<0.005	0.032
- nitrite/nitrate	1979-1984	21	0.27	0.04	0.13
- organic	1979-1984	20	1.06	0.14	0.39
- Kjeldahl	1979-1984	21	1.07	0.14	0.41
- total	1979-1984	20	1.19	0.27	0.52
Oxygen - dissolved	1979	6	14.8	10.1	11.8
- % saturation	1979	5	123	92.2	101.5
- BOD_5	1983-1984	3	<10	<10	<10
pH	1979-1984	22	8.7	8.2	8.5+
Phosphorus-diss. ortho	1979	1	0.065	-	-
-total diss.	1979-1984	21	0.196	0.06	0.09
-total	1979-1984	21	0.228	0.078	0.107
Solids -suspended	1979-1984	15	32	2	11
-total	1979-1984	18	316	216	261
Specific Conductivity	1979-1984	22	489	315	417
Temperature	1979-1984	13	15	3	8.8

+ Median value
* All values are as mg/L except:
  (1) Coliform - total as MPN/100 mL
  (2) Oxygen - % saturation as %
  (3) pH
  (4) Specific Conductivity as µS/cm
  (5) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 5
AMBIENT WATER QUALITY DATA SUMMARY FOR LOON CREEK (CON'T)
SITE 0600297
LOON CREEK ABOVE HATCHERY

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Coliform - fecal	1983	1	1 600	-	-
Nitrogen - ammonia	1981-1984	8	0.08	<0.005	0.028
- nitrite/nitrate	1981-1984	8	0.17	0.04	0.10
- organic	1981-1984	8	0.61	0.15	0.34
- Kjeldahl	1981-1984	8	0.69	0.15	0.37
- total	1981-1984	8	0.81	0.31	0.46
Oxygen - BOD_5	1983-1984	3	<10	<10	<10
pH	1981-1984	8	8.6	8.4	8.5+
Phosphorus-total diss.	1981-1984	8	0.195	0.066	0.093
-total	1981-1984	8	0.238	0.077	0.107
Solids - suspended	1981-1984	8	30	1	9.4
- total	1981-1984	8	312	212	255
Specific Conductivity	1981-1984	8	480	342	404
Temperature	1983-1984	3	10	3.5	5+

+ Median value
* All values are as mg/L except:
  (1) Coliform - fecal as MPN/100 mL
  (2) pH
  (3) Specific Conductivity as µS/cm
  (4) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 5
AMBIENT WATER QUALITY DATA SUMMARY FOR LOON CREEK (CON'T)
SITĖ 0600050
LOON CREEK AT LOON LAKE INLET

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*	
			MAXIMUM	MINIMUM
Alkalinity - total	1977	1	434	-
Carbon - organic	1977	1	15	-
Coliforms - fecal	1977	2	350	<2
- total	1977	2	350	49
Hardness - calcium	1977	1	35.9	-
- magnesium	1977	1	62	-
- total	1977	1	345	-
Nitrogen - ammonia	1977	1	0.049	-
- nitrite/nitrate	1977	1	0.05	-
- organic	1977	1	0.75	-
- Kjeldahl	1977	1	0.80	-
- total	1977	1	0.85	-
pH	1977	1	8.5	-
Phosphorus-diss. ortho	1977	1	0.043	-
-total diss.	1977	1	0.049	-
-total	1977	1	0.084	-
Solids-total	1977	1	512	-
Specific Conductivity	1977	1	735	-
Turbidity	1977	1	6.3	-

+ Median value
* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) pH
(3) Specific Conductivity as µS/cm
(4) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 6
EFFLUENT DATA SUMMARY
CLINTON LAGOON OUTFALL (PE 170)

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*			MAXIMUM LOADING** (Kg/d)	MAXIMUM POTENTIAL INCREASE**
			MAXIMUM	MINIMUM	MEAN		
Carbon - organic	1972-1981	44	50	1	26.4	-	-
- inorganic	1975-1981	25	157	69	123.4	-	-
Coliform - fecal	1973-1984	46	1 100 000	13	495+	-	92 560
Flow	1977-1982	25	727	203	380	-	-
Nitrogen - ammonia	1974-1983	39	19.4	0.008	4.4	14.1	1.63
- nitrite	1972-1983	44	0.155	<0.005	0.024;<0.005+	-	0.013
- nitrate/nitrite	1972-1983	41	0.71	0.019	0.087	-	-
- Kjeldahl	1972-1983	52	23	2	8.3	-	-
Oil and Grease	1974-1977	5	5.1	1.1	3.2	-	-
Oxygen - dissolved	1974-1980	41	>20	0.7	5.9	-	-
- BOD_5	1971-1983	58	60	<10	21	43.6	5.1
pH	1971-1983	64	9.2	7.5	8.5+	-	-
Phosphorus-diss. ortho	1974-1981	21	4.55	1.31	2.52	3.31	0.38
-dissolved	1975-1983	39	5.02	0.94	2.35	3.65	0.42
-total	1971-1983	59	7.55	0.082	2.84	5.49	0.64
Solids - suspended	1971-1983	57	104	4	26	75.6	8.8
- total	1971-1983	60	894	68	613	-	-
Specific Conductivity	1971-1983	67	1 250	300	927	-	-
Temperature	1971-1983	58	21.5	0	8.8	-	-
Turbidity	1974-1977	14	35	1.8	10	-	-

+ Median value
* All values are as mg/L except:
(1) Coliform as MPN/100 mL
(2) Flow as m^3/d
(3) pH
(4) Specific Conductivity as μS/cm
(5) Temperature as °C
(6) Turbidity as NTU

** Calculated using maximum recorded concentration, maximum flow rate, and assumed 10-year 7-day low stream flow of 0.1 m^3/s and complete mixing

Data Source: B.C. Ministry of Environment

TABLE 7
EFFECT OF CLINTON LAGOONS ON
SELECTED CHARACTERISTICS IN CLINTON CREEK

Date	Coliform - fecal		D.O.		Total Phosphorus		Kjeldahl N		Ammonia N	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
74 04 10	20	70	7.6	8.8	0.025	0.8	-	-	-	-
74 07 29	<20	20	-	-	0.022	0.067	0.14	0.15	0.023	0.035
74 09 03	13	22	-	-	0.023	0.043	0.18	0.23	0.006	0.011
78 02 09	110	600	13.2	13.6	0.03	0.13	0.27	0.5	-	-
78 03 15	-	-	12.2	11.9	0.048	0.211	0.44	2	-	-
78 04 05	2	350	12.3	12.4	0.038	0.155	0.27	0.67	0.031	0.137
78 04 18	13	240	12.2	12.3	0.031	0.082	0.26	0.57	0.025	0.041
78 05 10	79	1600	12.3	12.2	0.021	0.075	0.26	0.45	0.013	0.007
78 06 06	220	920	10.5	9.6	0.12	0.047	0.55	0.9	0.017	0.02
78 06 19	49	80	9.7	9.7	0.037	0.055	0.31	0.41	0.005	0.016
78 07 04	-	-	9.1	9.5	0.034	0.067	0.32	0.32	0.017	0.017
78 07 18	130	70	10.8	10.0	0.032	0.079	0.3	0.37	0.012	0.008
78 07 24	23	49	10.4	9.8	0.032	0.074	0.4	0.41	0.011	0.014
78 08 08	22	220	8.4	8.5	0.029	0.076	0.26	0.54	0.022	0.017
78 08 21	49	1300	8.7	9.5	0.036	0.088	-	-	-	-
78 09 05	130	40	9.5	9.6	0.034	0.073	0.3	0.49	0.015	0.015
78 09 18	17	79	11.3	10.9	0.019	0.061	0.2	0.29	0.012	0.004
78 10 02	13	8	10.8	11.6	0.012	0.034	0.14	0.16	0.008	0.011
78 10 16	5	22	13.1	12.9	0.014	0.039	0.05	0.2	0.011	0.012
78 10 30	2	4	12.2	13.0	0.017	0.054	0.17	0.23	0.011	0.019
78 11 15	13	14	13.4	13.4	0.027	0.06	0.21	0.27	0.013	0.057
78 12 06	79	540	13.5	13.8	0.02	0.078	0.12	0.2	0.02	0.099
79 01 11	79	540	-	-	-	-	-	-	-	-
79 02 07	49	2200	13.3	12.1	0.029	0.169	0.12	0.63	0.036	0.47
79 02 28	33	5400	13.9	13.4	0.033	0.198	0.19	2	0.047	0.585

U/S values at Site 0600503 100 m upstream
D/S values at Site 0600505 100 m downstream

Data Source: B.C. Ministry of Environment

TABLE 7 (CON'T)
EFFECT OF CLINTON LAGOONS ON
SELECTED CHARACTERISTICS IN CLINTON CREEK

Date	Suspended Solids	
	U/S	D/S
74 04 10	6	4
74 05 14	8	68
74 07 29	10	22
74 09 03	2	10
77 08 04	20	-
78 03 15	28	-
78 04 05	6	36
78 04 18	4	14
78 05 10	6	24
78 06 06	50	14
78 06 19	10	10
78 07 04	22	24
78 07 18	22	30
78 07 24	38	32
78 08 08	4	6
78 08 21	12	46
78 09 05	12	20
78 09 18	8	22
78 10 02	8	6
78 10 16	4	8
78 10 30	2	6
78 11 15	4	4
78 12 06	18	4
79 01 11	10	-
79 02 07	4	4
79 02 28	6	16

U/S values at Site 0600503 100 m upstream
D/S values at Site 0600505 100 m downstream

Data Source: B.C. Ministry of Environment

TABLE 8
EFFLUENT DATA SUMMARY
CACHE CREEK STP OUTFALL (PE 264)

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*			MAXIMUM LOADING** (Kg/d)	MAXIMUM POTENTIAL INCREASE**
			MAXIMUM	MINIMUM	MEAN		
Carbon - organic	1972-1981	53	93	7	29.7	-	-
- inorganic	1973-1981	30	105	48	70.9	-	-
Chlorine Residual	1972-1982	127	2.9	0	0.36	-	0.019
Coliform - fecal	1975-1984	59	350 000	<20	2 000+	-	2 312
Flow	1976-1982	675	936	414	675	-	-
Nitrogen - ammonia	1975-1983	54	29.8	0.039	10.1	27.9	0.197
- nitrite	1972-1983	68	5.51	<0.005	0.79	-	0.036
- nitrate/nitrite	1972-1983	53	20.5	0.02	7.6	-	-
- Kjeldahl	1971-1983	79	52	1.99	16	-	-
Oil and Grease	1971-1978	32	53	0.4	5.2	-	-
Oxygen - dissolved	1973-1983	46	5.7	0.9	2.5	-	-
- BOD_5	1971-1983	105	207	<10	35.4	193.8	1.4
pH	1971-1983	87	8.3	7	7.7+	-	-
Phosphorus-diss. ortho	1974-1982	21	8.1	2.1	4.7	7.6	0.054
-dissolved	1973-1983	55	12	2.41	5.4	11.2	0.079
-total	1971-1983	82	17.3	0.13	5.8	16.2	0.114
Solids - suspended	1971-1983	112	120	4	27	112.3	0.8
- total	1971-1983	89	850	446	612	-	-
Specific Conductivity	1971-1983	97	1 250	734	951	-	-
Temperature	1971-1983	74	23	4	13.6	-	-
Turbidity	1973-1983	26	48	5.1	14.5	-	-

\+ Median value
* All values are as mg/L except:
(1) Coliform as MPN/100 mL
(2) Flow as m^3/d
(3) pH
(4) Specific Conductivity as µS/cm
(5) Temperature as °C
(6) Turbidity as NTU

** Calculated using maximum recorded concentration, maximum effluent flow rate, and 10-year 7-day low stream flow of 1.64 m^3/s and assuming complete mixing
Data Source: B.C. Ministry of Environment

TABLE 9
EFFECT OF CACHE CREEK STP ON
SELECTED CHARACTERISTICS IN THE BONAPARTE RIVER

Date	Coliform - fecal		Dissolved Oxygen		Total Phosphorus		Kjeldahl N		Ammonia N	
	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
74 04 16	-	-	5.38	5.1	0.042	0.068	-	-	0.012	0.15
74 08 20	130	23	-	-	-	-	-	-	-	-
74 09 24	31	140	-	-	-	-	-	-	-	-
74 11 07	8	>2400	10.2	10.2	0.021	0.056	0.14	0.28	-	-
75 04 10	79	920	10.4	9.6	0.034	0.057	0.3	0.37	-	-
75 05 13	-	-	9.4	8.6	-	-	2	0.83	-	-
75 06 12	20	170	9.9	9.0	-	-	0.52	0.57	-	-
75 07 14	110	5400	8	-	0.052	0.079	0.3	0.41	-	-
75 08 14	130	50	10	10	0.018	0.062	0.14	0.31	-	-
75 09 11	49	130	10.6	11	0.018	0.036	0.23	0.25	0.014	0.02
75 10 29	79	23	12.1	11.8	0.019	0.062	0.15	0.34	0.009	<0.02
78 01 19	-	-	12.8	-	0.046	0.06	0.27	0.27	-	-
78 03 22	-	-	12.2	12.2	0.086	0.101	0.39	0.51	0.082	0.15
78 06 06	920	2200	9.2	9	0.403	0.405	0.99	1.07	0.025	0.03
78 06 19	-	-	9.4	9.3	0.082	0.088	0.42	0.44	0.012	0.03
78 07 05	-	-	9.4	9.5	0.047	0.05	0.33	0.35	0.008	<0.02
78 07 18	-	-	9.8	9.9	0.028	0.037	0.39	0.33	<0.005	0.03
78 07 24	-	-	9.8	9.9	0.023	0.035	0.4	0.35	0.006	0.02
78 08 09	-	-	9.2	9.3	0.017	0.037	0.26	0.32	0.011	0.07
78 08 22	23	130	8.7	8.8	0.019	0.039	0.24	0.27	0.008	0.05
78 09 06	-	-	9.4	9.1	0.019	0.037	0.27	0.29	0.009	0.04
78 09 19	-	-	10.4	10.8	0.021	0.042	0.35	0.22	0.058	0.06
78 10 03	-	-	10.3	10	0.023	0.049	0.2	0.25	0.009	<0.02
78 10 17	-	-	10.9	10.9	0.027	0.038	0.17	0.21	0.008	0.03
78 10 31	-	-	13.3	13.4	0.024	0.052	0.14	0.16	0.007	0.04
78 11 16	-	-	14.6	14.2	0.024	0.055	0.21	0.24	0.009	0.09
78 12 05	-	-	14	13.8	0.027	0.053	0.2	0.22	0.011	0.13
79 01 10	-	-	10.3	10.4	0.035	0.066	0.18	0.25	0.029	0.24
79 02 08	-	-	12.5	12.6	0.042	0.057	0.2	0.28	0.024	0.19
79 03 01	-	-	14	13.9	0.08	0.095	0.56	0.63	0.09	0.22

U/S values at Site 0600506 100 m upstream
D/S values at Site 0600508 100 m downstream

Data Source: B.C. Ministry of Environment

TABLE 9 (CON'T)
EFFECT OF CACHE CREEK STP ON
SELECTED CHARACTERISTICS IN THE BONAPARTE RIVER

Date	Suspended Solids	
	U/S	D/S
74 04 16	18	18
74 08 20	2	2
74 09 24	2	2
74 11 07	2	4
75 04 10	18	14
75 05 13	228	210
75 06 12	100	112
75 07 14	14	20
75 08 14	6	6
75 09 11	4	4
75 10 29	2	4
77 12 22	2	-
78 03 22	14	14
78 06 06	438	392
78 06 19	32	48
78 07 05	20	28
78 07 18	34	18
78 07 24	14	24
78 08 09	2	2
78 08 22	6	4
78 09 06	4	8
78 09 19	8	6
78 10 03	2	6
78 10 17	6	4
78 10 31	2	2
78 11 16	4	6
78 12 05	6	2
79 01 10	4	4
79 02 08	2	6
79 03 01	22	18

U/S values at Site 0600503 100 m upstream
D/S values at Site 0600505 100 m downstream

Data Soruce: B.C. Ministry of Environment

TABLE 10
AMBIENT WATER QUALITY DATA SUMMARY FOR CLINTON CREEK
SITE 0600503
CLINTON CREEK ABOVE LAGOONS

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity - total	1974-1978	10	338	251	292
Carbon - organic	1974-1979	21	37	<1	3.8
- inorganic	1974-1979	15	88	55	72.6
Chlorophyll-a	1978	12	153	0.4	41.6
Coliform - fecal	1974-1983	34	920	2	22+
Colour	1977	2	20	7	-
Hardness - calcium	1974-1978	9	81.2	60.1	69.8
- magnesium	1974-1978	5	39.2	26.7	34
- total	1974-1978	9	348	264	310
Nitrogen - ammonia	1974-1983	22	0.056	0.005	0.020
- nitrite	1974-1983	21	<0.005	<0.005	<0.005
- nitrate/nitrite	1977-1983	26	0.42	0.04	0.19
- Kjeldahl	1974-1983	28	0.55	0.05	0.25
Oxygen - BOD_5	1974	3	<10	<10	<10
- dissolved	1974-1979	26	13.9	7.6	11.3
- % saturation	1974-1979	26	113.9	67.1	97
pH	1974-1983	34	8.6	8.1	8.4+
Phosphorus-diss. ortho	1974-1978	8	0.031	0.003	0.020
-dissolved	1977-1983	26	0.038	0.005	0.020
-total	1974-1983	31	0.12	0.012	0.031
Solids - dissolved	1974-1979	26	428	278	355
- suspended	1977-1983	26	50	2	13; 8+
- total	1974-1983	27	438	288	368
Specific Conductivity	1974-1983	32	699	422	565
Temperature	1974-1983	31	17.2	0.5	8.2
Turbidity	1974	4	3.6	1.4	2

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

Data Source: B.C. Ministry of Environment

TABLE 10 (CON'T)
AMBIENT WATER QUALITY DATA SUMMARY FOR CLINTON CREEK
SITE 0600505
CLINTON CREEK BELOW LAGOONS

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity - total	1974-1978	8	376	285	331
Carbon - organic	1974-1979	21	39	<1	4.3
- inorganic	1974-1979	16	97	65	78.9
Chlorophyll-a	1978	18	168	<0.3	54
Coliform - fecal	1974-1979	29	5 400	4	70+
Colour	1974	1	10	-	-
Hardness - calcium	1974-1978	7	81.2	60.6	68.7
- magnesium	1974-1978	4	48.9	39	43.6
- total	1974-1978	7	390	295	350
Nitrogen - ammonia	1974-1979	22	0.585	0.007	0.074
- nitrite	1974-1979	20	0.012	<0.005	0.006;<0.005+
- nitrate/nitrite	1978-1979	21	0.61	0.02	0.22
- Kjeldahl	1974-1979	23	2	0.15	0.54
Oxygen - BOD_5	1974	3	<10	<10	<10
- dissolved	1974-1979	23	13.8	8.5	11.3
- % saturation	1974-1979	23	111.7	72	96.4
pH	1974-1979	27	8.6	8.1	8.4+
Phosphorus-diss. ortho	1974-1978	5	0.156	0.019	0.087
-total diss.	1978-1979	21	0.19	0.025	0.067
-total	1974-1979	26	0.211	0.034	0.087
Solids - dissolved	1974-1979	25	464	304	390
- suspended	1978	25	68	4	18; 14+
- total	1974-1979	25	472	338	409
Specific Conductivity	1974-1979	26	735	485	609
Temperature	1974-1979	27	16.8	0.5	8.4
Turbidity	1974	4	6.7	1.6	4.7

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

Data Source: B.C. Ministry of Environment

TABLE 10 (CON'T)
AMBIENT WATER QUALITY DATA SUMMARY FOR CLINTON CREEK
SITE 0600009
CLINTON CREEK NEAR MOUTH

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity - total	1972-1978	24	386	261	327
Coliform - fecal	1974-1979	24	2400	7	80+
Colour	1972-1974	15	30	5	12.7
Hardness - calcium	1973-1978	9	71.8	52.1	63.3
- magnesium	1973	9	62	30	45
- total	1973-1978	12	405	288	342
Metals: Copper - diss.	1974-1976	7	0.004	<0.001	0.002
- total	1972-1977	11	0.02	<0.001	0.005
Iron - diss.	1974-1976	7	0.1	<0.1	<0.1+
- total	1976-1977	3	0.4	<0.1	0.3+
Lead - diss.	1974-1976	6	0.002	<0.001	<0.001+
- total	1972-1976	8	0.029	<0.001	<0.003+
Manganese - total	1972-1977	10	0.03	0.01	0.02
Molybdenum total	1977	2	0.0028	0.0015	-
Zinc - diss.	1974-1976	5	0.009	<0.005	0.006
- total	1972-1977	12	0.038	<0.005	0.012
Nitrogen - ammonia	1974-1979	18	0.396	<0.005	0.079
- nitrite	1972-1979	28	0.016	<0.005	0.007;<0.005+
- nitrate/nitrite	1972-1979	25	0.78	<0.02	0.24
- Kjeldahl	1972-1979	37	2	<0.01	0.36
Oxygen - dissolved	1973-1979	29	13.9	6.1	10.7
- % saturation	1973-1979	26	135.2	43.5	90.2
pH	1973-1979	39	8.6	8.2	8.4+
Phosphorus-diss. ortho	1974-1978	5	0.122	0.023	0.065
-dissolved	1975-1979	23	0.206	0.024	0.064
-total	1972-1979	40	0.214	0.032	0.084
Solids - suspended	1972-1977	5	22	3	8.1
- total	1972-1979	40	506	336	413
Specific Conductivity	1972-1979	44	738	504	618
Temperature	1972-1979	40	15.6	0	6.6
Turbidity	1972-1977	21	16	1.2	3.5

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

Data Source: B.C. Ministry of Environment

TABLE 11
AMBIENT WATER QUALITY DATA SUMMARY FOR THE BONAPARTE RIVER
SITE 0600017
BONAPARTE RIVER ABOVE CLINTON CREEK

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity	1972-1978	20	211	70.8	119
Coliform - fecal	1972-1979	18	110	2	33+
Colour	1972-1974	13	25	5	13
Hardness - calcium	1973-1978	13	27.5	15	20.3
- magnesium	1973-1978	8	23	7	14.2
- total	1973-1978	16	163	65	99.4
Metals (total):					
Copper	1972-1977	12	0.02	<0.001	0.004
Iron	1977	3	0.9	0.1	0.4
Lead	1972-1976	10	0.029	<0.001	0.007
Manganese	1972-1977	12	0.02	<0.01	0.014
Mercury	1973	1	<0.00005	-	-
Molybdenum	1973-1977	3	0.0007	<0.0005	-
Zinc	1972-1977	12	0.03	<0.005	0.009
Nitrogen - ammonia	1978-1979	16	0.051	<0.005	0.016
- nitrite	1978-1979	26	<0.005	<0.005	<0.005
- nitrate/nitrite	1972-1979	26	0.9	<0.02	0.033
- Kjeldahl	1972-1979	36	0.39	<0.01	0.26
Oxygen - dissolved	1973-1979	25	14	6.5	10.3
- % saturation	1973-1979	25	164.7	45.9	91.8
pH	1972-1979	35	8.3	7.8	8.1+
Phosphorus-diss. ortho	1974-1978	7	0.01	<0.003	0.004
-dissolved	1975-1979	21	0.016	0.003	0.008
-total	1972-1979	37	0.103	0.006	0.019
Solids - suspended	1976-1977	4	20	4	10.8
- total	1972-1979	37	250	96	157
Specific Conductivity	1972-1979	43	408	145	224
Temperature	1972-1979	37	23	0	8.3
Turbidity	1972-1978	21	9.1	0.5	2

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

Data Source: B.C. Ministry of Environment

TABLE 11
AMBIENT WATER QUALITY DATA SUMMARY FOR THE
BONAPARTE RIVER AND SELECTED TRIBUTARIES
SITE 0600186
BONAPARTE RIVER ABOVE HAT CREEK

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity	1977-1982	9	206	90.8	157.2
Carbon - organic	1977-1978	13	13	<1	5.1
- inorganic	1977-1978	12	52	27	39.1
Coliform - fecal	1977-1982	16	230	5	41+
Colour	1977-1978	3	32	5	10+
Hardness - calcium	1977-1981	5	40.1	18.1	30.9
- magnesium	1977-1978	4	24.7	19.1	22.3
- total	1977-1981	6	202	88	149.8
Metals (total): Aluminum	1982	1	1.11	-	-
Arsenic	1978-1981	3	<0.005	<0.005	<0.005
Boron (dissolved)	1977-1978	3	<0.1	<0.1	<0.1
Cadmium	1978-1981	3	<0.0005	<0.0005	<0.0005
Cobalt	1982	1	<0.1	-	-
Chromium	1978-1981	3	0.008	0.005	<0.005+
Copper	1977-1981	4	0.003	<0.001	0.002
Iron	1977-1982	7	1.68	0.1	0.57
Lead	1978-1982	4	1.2	<0.001	-
Manganese	1977-1982	5	0.05	0.02	0.03
Mercury	1978-1981	3	<0.00005	<0.00005	<0.00005
Molybdenum	1977-1981	4	0.0015	0.0005	0.0008
Nickel	1978-1981	3	0.01	<0.01	<0.01+
Vanadium	1982	1	<0.01	-	-
Zinc	1977-1982	6	0.011	<0.005	0.007
Nitrogen - ammonia	1978-1979	17	0.037	0.006	0.013
- nitrite	1977-1979	16	<0.005	<0.005	<0.005
- nitrate/nitrite	1977-1979	22	0.16	<0.02	0.05
- Kjeldahl	1977-1979	19	0.43	0.07	0.28
Oxygen - dissolved	1977-1981	19	14.4	6.5	10
- % saturation	1977-1981	19	107.2	72.8	92.1
pH	1977-1982	26	8.4	8	8.3+
Phosphorus-diss. ortho	1978	1	0.022	-	-
-dissolved	1977-1979	20	0.03	0.009	0.018
-total	1977-1979	22	0.057	0.016	0.030
Solids - dissolved	1977-1982	24	314	127	224
- suspended	1977-1982	24	40	2	6+ ; 12
- total	1977-1982	24	316	135	230
Specific Conductivity	1977-1982	26	500	205	340
Temperature	1977-1982	22	20	0.5	10.8
Turbidity	1977-1978	2	9.4	4.4	-

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

Data Source: B.C. Ministry of Environment

TABLE 11
AMBIENT WATER QUALITY DATA SUMMARY FOR THE
BONAPARTE RIVER AND SELECTED TRIBUTARIES
SITE 0600073
HAT CREEK AT MOUTH

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity	1972-1982	21	275	142	244
Carbon - organic	1974-1978	19	24	<1	4.5
- inorganic	1974-1978	16	68	33	55.8
Coliform - fecal	1976-1979	18	130	2	13+
Colour	1972-1975	7	30	<5	9.3
Hardness - calcium	1972-1978	17	71	36.6	62.7
- magnesium	1972-1978	12	28	16.6	24.1
- total	1972-1978	18	288	137	249.9
Metals (total): Aluminum	1976-1982	7	2.4	<0.01	0.43
Arsenic	1977-1978	7	0.006	<0.005	<0.005
Boron (dissolved)	1976-1978	10	<0.1	<0.1	<0.1
Cadmium	1976-1978	8	<0.0005	<0.0005	<0.0005
Chromium	1978-1982	2	<0.01	<0.005	-
Copper - dissolved	1974-1976	8	0.003	<0.001	0.002
- total	1972-1978	14	0.005	<0.001	0.002
Iron	1976-1982	8	2.2	0.1	0.48
Lead - dissolved	1974-1976	8	0.002	<0.001	<0.001
- total	1972-1978	13	0.005	<0.001	<0.001+
Manganese	1972-1982	7	0.03	0.01	0.02
Mercury	1976-1978	8	0.00005	<0.00005	<0.00005
Molybden	1976-1978	6	0.0022	0.0009	0.0015
Nickel	1978	2	<0.01	<0.01	-
Zinc	1972-1982	11	0.02	<0.005	0.007
Nitrogen - ammonia	1978-1979	17	0.028	<0.005	0.013
- nitrite	1976-1979	28	<0.005	<0.005	<0.005+
- nitrate/nitrite	1976-1979	22	0.09	<0.02	0.03
- Kjeldahl	1972-1979	34	2	<0.01	0.25
Oxygen - dissolved	1973-1979	22	14.5	6.3	10.5
- % saturation	1973-1979	22	107.3	45.1	90.9
pH	1974-1982	36	8.7	8	8.4+
Phosphorus-diss. ortho	1974-1978	9	0.02	0.006	0.011
-dissolved	1975-1979	23	0.054	0.007	0.015
-total	1972-1979	34	0.865	0.011	0.052
Solids - dissolved	1972-1982	35	428	176	337
- suspended	1972-1982	35	1024	2	17+ ; 38
- total	1972-1982	35	1200	290	380
Specific Conductivity	1972-1982	40	670	237	518
Temperature	1972-1982	29	21.5	0	8.1
Turbidity	1972-1978	15	29	0.6	8.3

TABLE 11 (CON'T)

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
SEDIMENTS					
Arsenic	1977	1	0.003	-	-
Boron	1977	1	<0.01	-	-
Cadmium	1977	1	0.003	-	-
Copper	1977	1	0.032	-	-
Iron	1977	1	20.5	-	-
Lead	1977	1	0.02	-	-
Mercury	1977	1	<0.00005	-	-
Zinc	1977	1	0.07	-	-

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

Data Source: B.C. Ministry of Environment

TABLE 11
AMBIENT WATER QUALITY DATA SUMMARY FOR THE
BONAPARTE RIVER AND SELECTED TRIBUTARIES
SITE 0600506
BONAPARTE RIVER UPSTREAM FROM CACHE CR. STP

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity	1974-1979	15	230	110	182.1
Biomass	1978	8	138	22.5	58.4
Carbon - organic	1974-1978	24	18	<1	4.7
- inorganic	1974-1978	22	57	28	44.3
Chlorophyll-a	1977-1978	34	52	<0.3	5.3
Colour	1975-1978	6	27	3	10.2
Coliform - fecal	1974-1979	30	920	8	60+
Hardness - calcium	1974-1979	15	51.8	24.3	38.3
- magnesium	1978-1979	4	25	20.7	23.4
- total	1974-1979	15	238	106	180
Metals (dissolved): Copper	1974	1	0.004	-	-
Iron	1974	1	<0.1	-	-
Lead	1974	1	<0.001	-	-
Zinc	1974	1	0.008	-	-
Nitrogen - ammonia	1974-1979	23	0.09	<0.005	0.022
- nitrite	1974-1976	26	0.005	<0.005	<0.005+
- nitrate/nitrite	1975-1979	23	0.19	<0.02	0.06
- Kjeldahl	1974-1979	31	2	0.14	0.35
Oxygen - dissolved	1974-1979	29	14.6	5.4	10.6
- % saturation	1974-1979	27	112.9	46.9	95.3
pH	1974-1979	39	8.5	7.9	8.2+
Phosphorus-diss. ortho	1974-1978	10	0.057	0.003	0.019
-dissolved	1975-1979	21	0.069	0.01	0.025
-total	1974-1979	30	0.403	0.017	0.046
Solids - dissolved	1974-1979	30	326	164	254
- suspended	1974-1979	30	438	2	6+ ; 34
- total	1974-1979	30	620	208	288
Specific Conductivity	1974-1979	39	520	231	386
Temperature	1974-1979	33	21	0	9.5
Turbidity	1974-1975	11	54	0.7	9.2

+ Median value
* All values are as mg/L except:
(1) Biomass as mg
(2) Chlorophyll-a as mg/m²
(3) Colour - TAC
(4) Coliform as MPN/100 mL
(5) Oxygen % saturation as %
(6) pH
(7) Specific Conductivity as µS/cm
(8) Temperature as °C
(9) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 11 (CON'T)
AMBIENT WATER QUALITY DATA SUMMARY FOR THE
BONAPARTE RIVER AND SELECTED TRIBUTARIES
SITE 0600507
BONAPARTE RIVER AT CACHE CREEK

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity	1974-1978	14	229	109	182
Biomass	1978	8	6.4	1.2	3.6
Carbon - organic	1974-1978	24	17	<1	4.9
- inorganic	1974-1978	22	57	28	44.7
Chlorophyll-a	1977-1978	38	70	<0.3	<0.3+ ; 4.4
Colour	1975-1978	7	26	7	11.6
Coliform - fecal	1974-1979	28	9 200	2	79.5+
Hardness - calcium	1974-1979	12	51.7	24.1	38.3
- total	1974-1979	12	239	103	179
Metals (dissolved): Copper	1974	1	<0.001	-	-
Iron	1974	1	<0.1	-	-
Lead	1974	1	<0.001	-	-
Zinc	1974	1	0.006	-	-
Nitrogen - ammonia	1974-1979	23	1.6	0.009	0.163
- nitrite	1974-1979	26	0.793	<0.005	0.005+
- nitrate/nitrite	1975-1979	23	2.35	<0.02	0.45
- Kjeldahl	1974-1979	31	2	0.15	0.56
Oxygen - dissolved	1974-1979	29	14	4.8	10.4
- % saturation	1974-1979	28	128.8	41.8	96.1
pH	1974-1979	39	8.5	7.9	8.2+
Phosphorus-diss. ortho	1974-1978	13	0.086	0.015	0.045
-dissolved	1975-1979	20	1.1	0.03	0.26
-total	1974-1979	32	1.15	0.031	0.24
Solids - dissolved	1974-1979	29	386	160	264
- suspended	1974-1979	29	358	2	10+ ; 38
- total	1974-1979	29	542	212	298
Specific Conductivity	1974-1979	39	596	226	400
Temperature	1974-1979	35	22	0	10.1
Turbidity	1974-1975	11	52	0.9	9.5
SEDIMENTS					
Copper	1977	1	0.039	-	-
Zinc	1977	1	0.068	-	-

\+ Median value
* All values are as mg/L except:
(1) Biomass as mg
(2) Chlorophyll-a as mg/m²
(3) Colour - TAC
(4) Coliform as MPN/100 mL
(5) Oxygen % saturation as %
(6) pH
(7) Specific Conductivity as μS/cm
(8) Temperature as °C
(9) Turbidity as NTU
(10) Sediments as mg/g (dry-weight)

Data Source: B.C. Ministry of Environment

TABLE 11 (CON'T)
AMBIENT WATER QUALITY DATA SUMMARY FOR THE
BONAPARTE RIVER AND SELECTED TRIBUTARIES
SITE 0600508
BONAPARTE RIVER BELOW CACHE CREEK STP (100 m)

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity	1974-1979	14	228	108	172.9
Biomass	1978	8	2.6	<1	1.5
Carbon - organic	1974-1978	23	14	<1	4.6
- inorganic	1974-1978	20	59	26	44.9
Chlorophyll-a	1977-1978	35	45	<0.3	<0.3+ ; 6.6
Colour	1975-1978	7	27	6	10.8
Coliform - fecal	1974-1979	11	5 400	23	140+
Hardness - calcium	1974-1979	13	52.1	23.7	36.9
- magnesium	1974-1978	3	25	12.9	17.1
- total	1974-1979	13	239	102	172
Metals (dissolved): Copper	1974	1	<0.001	-	-
Iron	1974	1	<0.1	-	-
Lead	1974	1	<0.001	-	-
Zinc	1974	1	0.006	-	-
Nitrogen - ammonia	1974-1979	24	0.137	<0.005	0.042
- nitrite	1974-1979	27	0.027	<0.005	0.005+
- nitrate/nitrite	1975-1979	23	0.24	<0.02	0.08
- Kjeldahl	1974-1979	31	1.07	0.16	0.36
Oxygen - dissolved	1974-1979	27	14.2	5.1	10.5
- % saturation	1974-1979	26	114.1	44.5	94.3
pH	1974-1979	39	8.5	7.9	8.2+
Phosphorus-diss. ortho	1974-1978	12	0.157	0.012	0.048
-dissolved	1975-1979	22	0.149	0.019	0.045
-total	1974-1979	32	0.405	0.028	0.079
Solids - dissolved	1974-1979	30	330	160	248
- suspended	1974-1979	30	392	2	6+ ; 36
- total	1974-1979	30	570	204	284
Specific Conductivity	1974-1979	39	520	226	387
Temperature	1974-1979	34	21	0	9.6
Turbidity	1974-1975	12	50	1	9.8

+ Median value
* All values are as mg/L except:
(1) Biomass as mg
(2) Chlorophyll-a as mg/m²
(3) Colour - TAC
(4) Coliform as MPN/100 mL
(5) Oxygen % saturation as %
(6) pH
(7) Specific Conductivity as µS/cm
(8) Temperature as °C
(9) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 11 (CON'T)
AMBIENT WATER QUALITY DATA SUMMARY FOR THE
BONAPARTE RIVER AND SELECTED TRIBUTARIES
SITE 0600074
CACHE CREEK NEAR MOUTH

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity	1972-1977	15	268	47.4	205
Carbon - organic	1974-1978	19	38	<1	6.5
- inorganic	1974-1978	17	69	18	52.2
Coliform - fecal	1976-1979	16	170	2	26.5+
Colour	1972-1974	6	100	5	22.5
Hardness - calcium	1972-1978	15	58.2	11.8	40.9
- magnesium	1972-1978	8	31	18	21.5
- total	1972-1978	15	265	47.4	186.4
Metals:					
Copper - dissolved	1974-1975	5	0.004	<0.001	0.003
- total	1972-1976	8	0.09	<0.001	0.002+;0.013
Iron - dissolved	1974-1975	5	1.8	<0.1	<0.1+
Lead - dissolved	1974-1975	5	0.002	<0.001	<0.001+
- total	1972-1973	4	0.004	<0.001	0.002
Manganese - total	1972-1977	5	0.03	<0.01	0.02
Molybdenum- total	1974-1977	3	0.0061	0.0024	0.0044
Zinc - total	1972-1977	8	0.2	<0.005	0.006+
Nitrogen - ammonia	1978-1979	17	0.133	<0.005	0.016
- nitrite	1976-1979	27	0.026	<0.005	0.005+
- nitrate/nitrite	1976-1979	21	0.18	<0.02	0.047
- Kjeldahl	1972-1979	32	3	<0.01	0.27
Oxygen - dissolved	1973-1979	24	14.2	5.8	10.1
- % saturation	1973-1979	24	111.5	43.9	90.9
pH	1973-1979	36	8.7	7.6	8.3+
Phosphorus-diss. ortho	1974-1978	7	0.196	0.091	0.12
-dissolved	1976-1979	22	0.251	0.069	0.12
-total	1972-1979	31	1.46	0.097	0.18
Solids - dissolved	1972-1979	30	412	150	289
- suspended	1972-1979	30	1 660	2	4+ ; 64
- total	1972-1979	30	1 892	156	353
Specific Conductivity	1972-1979	37	599	108	412
Temperature	1972-1979	30	20.3	1.5	9.5
Turbidity	1972-1978	14	670	0.4	2+;53

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

TABLE 11 (CON'T)
AMBIENT WATER QUALITY DATA SUMMARY FOR THE
BONAPARTE RIVER AND SELECTED TRIBUTARIES
SITE 0600008
BONAPARTE RIVER BELOW CACHE CREEK

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity	1971-1977	22	252	111	193
Carbon - organic	1973-1977	16	17	1	6.8
- inorganic	1974-1977	7	55	31	45.6
Coliform - fecal	1975-1977	5	16000	70	110+
Colour	1972-1975	14	55	<5	12.1
Hardness - calcium	1973-1977	7	51.9	35.7	42.6
- magnesium	1971-1977	5	33	20	26.3
- total	1973-1977	7	258	116	194
Metals: Copper - dissolved	1971-1976	8	0.06	<0.001	<0.002+;0.02
- total	1972-1977	14	0.03	0.001	0.003+;0.007
Iron - dissolved	1971-1976	8	<0.1	<0.02	<0.1+
- total	1977	2	1.4	0.4	0.9
Lead - dissolved	1971-1972	3	<0.003	<0.003	<0.003
- total	1972-1973	8	0.003	<0.001	<0.003+
Manganese - dissolved	1971-1972	3	0.02	0.01	0.02
- total	1972-1977	9	0.24	0.02	0.05
Molybdenum - total	1977	1	0.0005	-	-
Zinc - dissolved	1971-1976	8	0.1	<0.005	<0.005+
- total	1972-1977	12	0.02	<0.005	0.007
Nitrogen - ammonia	1973-1975	6	0.26	0.07	0.18
- nitrite	1972-1977	16	0.028	<0.005	0.010
- nitrate/nitrite	1972-1977	9	0.13	<0.02	0.04
- Kjeldahl	1971-1977	22	0.62	<0.01	0.35
Oxygen - dissolved	1973-1976	7	13.2	5.5	9.8
- % saturation	1973-1976	7	131.5	44.5	82
pH	1972-1977	19	8.4	8.1	8.3+
Phosphorus-diss. ortho	1971-1976	12	0.146	0.014	0.061
-dissolved	1975-1977	6	0.105	0.022	0.058
-total	1971-1977	24	0.294	0.039	0.105
Solids - dissolved	1972-1977	20	362	172	271
- suspended	1972-1977	24	310	2	6+ ; 28
- total	1972-1977	24	596	232	304
Specific Conductivity	1971-1977	23	580	220	422
Temperature	1971-1977	22	18	0	6.5
Turbidity	1971-1977	22	70	0.8	7.8

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

Data Source: B.C. Ministry of Environment

TABLE 11 (CON'T)
AMBIENT WATER QUALITY DATA SUMMARY FOR THE
BONAPARTE RIVER AND SELECTED TRIBUTARIES
SITE 0600329
BONAPARTE RIVER UPSTREAM FROM THOMPSON RIVER

CHARACTERISTIC	PERIOD OF RECORD	NO. OF VALUES	VALUES*		
			MAXIMUM	MINIMUM	MEAN
Alkalinity	1978	3	222	189	211
Carbon - organic	1978	12	15	<1	4.8
- inorganic	1978	11	52	32	43.7
Chlorophyll-a	1978	15	87	<0.3	25
Coliform - fecal	1978-1979	17	920	8	33+
Hardness - calcium	1978	4	46.2	40.2	42.9
- magnesium	1978	4	25.8	22.9	25
- total	1978	4	221	195	210
Nitrogen - ammonia	1978-1979	17	0.061	<0.005	0.018
- nitrite	1978-1979	17	0.005	<0.005	<0.005
- nitrate/nitrite	1978-1979	18	0.23	<0.02	0.07
- Kjeldahl	1978-1979	18	1.08	0.15	0.35
Oxygen - dissolved	1978-1979	15	14.8	4.7	10.6
- % saturation	1978-1979	15	114.6	48.2	97.1
pH	1978-1979	18	8.8	8.2	8.55+
Phosphorus-diss. ortho	1978-1979	1	0.04	-	-
-dissolved	1978-1979	15	0.061	0.016	0.033
-total	1978-1979	18	0.437	0.028	0.082
Solids - dissolved	1978-1979	18	338	180	263
- suspended	1978-1979	18	334	2	13+ ; 40.3
- total	1978-1979	18	514	242	304
Specific Conductivity	1978-1979	18	530	247	412
Temperature	1978-1979	18	23	0	9.8
Turbidity	1978	1	42	-	-

+ Median value
* All values are as mg/L except:
(1) Chlorophyll-a as mg/m²
(2) Coliform as MPN/100 mL
(3) Oxygen - % saturation as percent
(4) pH
(5) Specific Conductivity as µS/cm
(6) Temperature as °C
(7) Turbidity as NTU

Data Source: B.C. Ministry of Environment