MINISTRY OF ENVIRONMENT
PROVINCE OF BRITISH COLUMBIA

UPPER COLUMBIA RIVER

TOBY CREEK, SINCLAIR CREEK, THE COLUMBIA RIVER FROM TOBY CREEK TO EDGEWATER, AND THE SPILLIMACHEEN RIVER

WATER QUALITY ASSESSMENT AND OBJECTIVES

TECHNICAL APPENDIX

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November, 1985

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1. PREFACE

The assessment of water quality in the Upper Columbia River area (Figure 1) was divided into two reports. A separate report deals with the headwaters of the Columbia River and includes Columbia Lake, Windermere Lake and the Columbia River between the lakes. This report deals with the Columbia River further downstream. It includes the Columbia River between Toby Creek and Edgewater and three tributaries to the Columbia River including Toby Creek, Sinclair Creek and the Spillimacheen River (Figure 2).

The purpose of this report is to assess the state of water quality and develop water quality objectives where designated water uses are threatened, either now or in the future.

The sub-basins studied include: Toby Creek which enters the Columbia River from the west just downstream from Windermere Lake; a 20 km stretch of the Columbia River between Toby Creek and Edgewater; Sinclair Creek which enters the Columbia River from the east about 10 km downstream from Toby Creek; and the Spillimacheen River, entering the Columbia River from the west about 30 km downstream from Edgewater (Figure 2).

These sub-basins were chosen as priority areas for study because water uses could be affected by waste discharges. An assessment of the water quality in each sub-basin is presented and is followed by a summary of provisional water quality objectives and proposed monitoring programs.

An overview of the data collected prior to August 1975, and between August 1975 and May 1978 was provided as part of the Kootenay Air and Water Quality Study[3,4]. This report summarizes the data collected since then and up to February 1983.

2. TOBY CREEK

2.1 INTRODUCTION

Located on the eastern slopes of the Purcell Mountains, Toby Creek drains an area of 622 km² before flowing into the Columbia River just north of Lake Windermere. The two population centers are the Village of Invermere (1981 population of 1970) near the confluence with the Columbia River, and the Panorama Ski Resort just below Hopeful Creek (Figure 3).

2.2 HYDROLOGY

The Toby Creek streamflow gauge at Athalmer near the mouth (Figure 3) has recorded maximum daily flows of 106 m^3/s during spring freshet (June) and minimum daily winter flows of 1.3 m^3/s (February)[10]. One-in-ten-year monthly low flows for Toby Creek occur during the winter and are 1.48 m^3/s at Athalmer, 1.3 m^3/s at Panorama, and 0.72 m^3/s immediately below the confluence with Jumbo Creek near the headwaters[9].

2.3 WATER USES

There are three water licenses in the Toby Creek basin, including an irrigation license on Toby Creek itself, a waterworks license on Taynton Creek, and an industrial license on Jumbo Creek (Table 3 and Figure 3). It is improbable that Toby Creek will be used as a future source of domestic water supply for Invermere[11]. Goldie Creek, which flows into Windermere Lake, is the present source of domestic supply for Invermere. The improvements being made in the supply system to maximize the water license should ensure adequate supply for 6000, the population projection for 1992-2001. If Toby Creek water were used, it would be withdrawn from above the Panorama Ski Resort sewage ground disposal, necessitating high transfer costs. Windermere Lake is a more likely source of future water supply than Toby Creek[11], and has been recommended by the Ministry of Health[14].

A fishery of moderate value exists for cutthroat trout and Dolly Varden above Invermere during the summer, and year-round for mountain whitefish near the confluence with the Columbia River. Recreational use of Toby Creek has been classified from medium(29) to high(1) with kayaking and rafting important activities in addition to fishing.

Although use surveys for Toby Creek have not been undertaken, the Columbia-Windermere Lakes Tourism Study(29) predicted a two to four-fold increase in recreational visitors to the area over the next 10 years. Increased recreational demand on Toby Creek will follow the growth of Invermere and condominium development at Panorama Ski Resort.

2.4 WASTE DISCHARGES

Permitted waste discharges to the Toby Creek sub-basin are shown in Figure 3 and summarized in Table 1. They include the treated domestic sewage from the Village of Invermere and the Panorama Ski Resort, as well as tailings pond effluent from the Mountain Minerals barite concentrating plant just downstream from Jumbo Creek. Logging, both past and present, is a diffuse source of nutrient input. Two abandoned mining operations have not been included in this discussion. These are: 1) the Jackpine concentrator, located just downstream from Panorama, which has no apparent environmental impact; and 2) the Mineral King mine, located at the junction of Jumbo and Toby Creeks, which contributes insignificantly to the zinc loadings of Toby Creek from its tailings pile(4).

2.4.1 VILLAGE OF INVERMERE

a) Description of Discharge

Invermere (1981 population 2000) is located on Toby Creek near its confluence with the Columbia River. Before March of 1981, treated domestic sewage from the Village of Invermere was discharged to Toby Creek. Sewage treatment consisted of two aeration lagoons, chlorination, a 20-day aerated holding lagoon, and the outfall. Pollution Control Permit PE 3094 was ammended in March of 1981 to allow ground disposal through two infiltration basins located about 250 m from Toby Creek with direct discharge to the creek permitted on an emergency basis only. This change was to remedy algal growth problems in Toby Creek downstream from the outfall, attributed by Waste Management Branch to the biologically available phosphorus in the effluent.

b) Present Waste Loads

Effluent monitoring required by Pollution Control Permit PE 3094 prior to March, 1981, included continuous flow measurement and sampling every 3 months for suspended solids and BOD_5. The effluent monitoring data in Table 4, which update results reported in the Phase II Kootenay Study[4], were collected only until the permit was amended to ground disposal in March of 1981. Since that date, however, problems have occurred with the treatment system including clogged infiltration basins. This necessitated frequent use of the permitted emergency discharge to Toby Creek, but no effluent monitoring was done. Not until the system is discharging to ground on a continuous basis, and all relevant sites are monitored (effluent, groundwater observation wells, and Toby Creek ambient sites) can the effectiveness of the ground disposal system be evaluated. The minimum dilution in Toby Creek is 65:1, assuming a low creek flow of 1.48 m^3/s together with the maximum recorded effluent flow of 1975 m^3/d (Table 2). The algal problems that have occurred in the past, under conditions of greater dilution, should not occur once the disposal to ground is fully operational. This conclusion assumes that (1) the groundwater flows to Toby Creek, (2) the setback of the infiltration basins (250 m) together with the retention capability of the soil are effective in removing phosphorus before the groundwater reaches Toby Creek, and (3) that the wastewater introduced to the groundwater system does not re-emerge as surface flow before being stripped of phosphorus and entering Toby Creek.

PE 3094 allows a maximum effluent flow of 1710 m^3/d with BOD_5 and suspended solids of 45 and 60 mg/L, respectively. Effluent monitoring results (Table 4) between April 1978 and March 1981 (the date of permitted change to ground disposal) show that the effluent was not quite as good as reported in the Phase II Kootenay Study(4) prior to 1978, when only effluent quantity was beyond permitted limits. The frequency of noncompliance was low, however, occurring for BOD_5 on 3%, suspended solids on 6%, and flow on 0.5% of the sampling dates. Only suspended solids were significantly above the 60 mg/L permitted: 118 mg/L on December 12, 1978 and 114 mg/L on January 3, 1979, both during winter low flows. However, even at a minimum dilution of 65:1, only minor increases in suspended solids (about 2 mg/L) would have occurred in Toby Creek.

c) Future Waste Loads

Projected waste loadings to 1992 for BOD_5, suspended solids and nutrients are presented in Table 7. Calculations are based on a 50-100 percent increase in the 1981 population. This prediction is based on future development in the Windermere Lake area being concentrated at Invermere because it is serviced. Projected loadings assume that future effluent will be in compliance with permit conditions. Provided that the effluent continues to be discharged to ground, no adverse effects on Toby Creek are expected as a result of increasing waste loads. A continuing monitoring program to assess the effectiveness of the ground disposal system should be conducted as outlined in Section 2.5.6. Because the phosphorus capacity of soils is finite, this monitoring program would show the eventual phosphorus breakthrough which would allow inputs to Toby Creek. If the residential development on the northeast shore of Lake Windermere is serviced, discharge to the Invermere sewage treatment plant would increase the load to the ground disposal system and accelerate the inevitable phosphorus breakthrough. The ongoing problems being experienced with the sewage treatment plant discharge to ground may eventually require extension of the outfall to the Columbia River.

2.4.2 PANORAMA SKI HILL CO. LTD.

a) Description of Discharge

Panorama is a skiing and condominium resort located on Toby Creek about 16 km upstream from Invermere. Authorized by Pollution Control Permit PE 5193, the discharge is domestic sewage which receives secondary treatment with rotary drum filters, rotating biological contactors, clarifiers, multimedia filters, and a 10-day emergency storage lagoon, then is discharged to tile fields located a minimum of 35 m from Toby Creek. The original permit was amended (September 14, 1979) to allow greater effluent flow (1090 m^3/d), but higher effluent quality with BOD_5 and suspended solids of 10 mg/L rather than the originally permitted 45 mg/L and 60 mg/L, respectively. This effluent quality is better than that required by the 1975 Pollution Control Objectives[5] for discharges direct to receiving waters. This was considered necessary at the time because of the potential use of Toby Creek downstream as a source of domestic water (now discounted, see section 2.3) and the potential for algal growth such as occurred when the Invermere STP discharged directly to Toby Creek. As a further precaution, the permit stipulates that Panorama must provide additional treatment works for removal of phosphorus and/or nitrogen should algae become a problem. The permit prohibits discharge of effluent which has bypassed any portion of the treatment works.

b) Present and Future Waste Loads

Monitoring of the effluent quality (data summarized in Table 6) and of groundwater observation wells (data Table 14) has not been carried out long enough to determine the adequacy of the existing system or to evaluate any proposed expansion. The treatment plant went into operation in the early fall of 1980, but has only been lightly loaded as the resort is in the initial occupancy stage. The maximum recorded flow was 161.4 m^3/d, although 1090 m^3/d is permitted. The minimum dilution ratio for Panorama effluent in Toby Creek is 103:1 (Table 2), assuming a low creek flow of 1.3 m^3/s and the permitted effluent discharge of 1090 m^3/d. The minimum dilution ratio gives a conservative indication of the effluent effects on Toby Creek because a further reduction of contaminants occurs in the ground between the tile field and the creek.

Present and future waste loadings to ground for Panorama are presented in Table 7. Future waste loadings assume that the design capacity of the treatment plant will be met and concentration of effluent characteristics will be within permitted limits. In any event, because the Panorama waste load is discharged to ground the amount of waste reaching Toby Creek will depend on treatment plant efficiency and the ability of the soil to remove contaminants. Further monitoring is recommended in Section 2.5.6 to evaluate the effectiveness of the ground disposal system and the influence on Toby Creek.

2.4.3 MOUNTAIN MINERALS LTD.

Mountain Minerals Ltd. operated a barite (barium sulphate) concentrating plant near the confluence of Jumbo and Toby Creeks. The plant discontinued operation on September 30, 1980, with no firm plans for re-opening. It was reprocessing the tailings from the old Mineral King silver-lead-zinc mine in the same location.

The Phase II Kootenay Study[4] determined that acid drainage from the old Mineral King mine was not a problem. Elevated zinc levels were identified in the mine drainage in 1976 but did not contribute significantly to the zinc loadings of Toby Creek.

Permit PE 315 (Mountain Minerals) authorized an average daily discharge of 1310 m^3/d of tailings pond supernatant to Toby Creek from May 15 to November 15. Table 5 summarizes the effluent characteristics as compared to the permitted limits, and the Pollution Control Objectives for mining, smelting and related industries[2].

The Phase II Kootenay Study[4] identified only sulphate as exceeding permit limits. Since May of 1978, sulphate continued to exceed the permit limit with high frequency (71% of samples), and other characteristics began to exceed the permit limits as the mine closure date approached: iron (10%), lead (50%), zinc (20%), and suspended solids (40%). Nickel levels, not specified in the permit, increased from those reported in the Phase II Kootenay Study, but were still well below the Pollution Control Objectives[2]. Barium levels, identified as approaching the maximum acceptable limit for drinking water (1.0 mg/L) in Toby Creek in the Phase II Kootenay Study, were not monitored in the effluent or the creek since 1978.

The minimum dilution available for the Mountain Minerals tailings pond effluent was about 48:1, assuming a minimum stream flow (10-year return period) of 0.72 m^3/s and discharge flows within the permit limit (Table 2). Although historically the discharges had frequently exceeded the permit limit, the period of permitted discharge (May to November) was when creek flows were significantly greater than the minimum flow. A 48:1 dilution would reduce all the maximum contaminant concentrations in the tailings pond effluent (Table 5) to below water quality criteria for all water uses, including aquatic life. Monitoring of Toby Creek downstream from the Mountain Minerals operation indicated that water quality continued to be good (Section 2.5). Should Mountain Minerals re-open, further monitoring is recommended in Section 2.5.6.

2.4.4 LOGGING

Logging has been conducted in the headwaters of Toby Creek as reported in the Phase I Kootenay Study[3], and selective logging continues on a small scale. Although the water quality of Toby Creek is generally good, logging (both past and present) may be contributing to the high levels of suspended solids and turbidity (see Section 2.5). Toby Creek drains numerous ice fields and glaciers which are also likely sources of suspended solids. The source(s) of suspended solids in Toby Creek has yet to be determined.

2.5 WATER QUALITY

2.5.1 PRESENTATION OF DATA

Water quality has been monitored at 6 sites on Toby Creek. These sites are described in Table 8 and shown in Figure 3. Data are summarized in Tables 9, 10, 11 and 12. Site 1190075 on Jumbo Creek has been discontinued. Groundwater monitoring wells have been established for Invermere and Panorama's ground disposal systems, and the data are summarized in Tables 13 and 14.

2.5.2 UPPER TOBY CREEK (MOUNTAIN MINERALS)

Although no hardness data have been collected from upper Toby Creek since the Phase II Kootenay Study(4), that report showed the water to be hard and suitable for domestic purposes(6).

Turbidity continued to be high near the headwaters as reported in the Phase II Kootenay Study(4), with values exceeding drinking water guidelines for use without treatment (5 NTU)(6) on both sampling dates (see Table 9). Suspended solids exceeded certain guidelines for maximum protection of aquatic life (25 mg/L)(8) on June 22, 1978, although the values are probably typical for freshet periods. Levels were higher upstream from Mountain Minerals (site 0200055) than downstream (site 0200054), probably the result of dilution from Jumbo Creek. The numerous ice fields and glaciers drained by Toby Creek are likely sources of suspended solids.

Levels of metals (Cu, Fe, Pb, Zn) in Toby Creek were low, although only 2 samples were analysed. This is in agreement with the Phase I and II Kootenay studies (3,4) where monitoring had not shown a problem. Zinc is the major contaminant in the Mountain Minerals effluent, but zinc levels continued to be suitable for aquatic life(24).

The Phase II Kootenay Study[4] showed increased barium levels between sites upstream and downstream from Mountain Minerals, approaching the maximum permissible limit for drinking water (1.0 mg/L)[6]. Although the Mountain Minerals operation is indefinitely shut down, the recommendation made in the Phase II Kootenay Study, to monitor barium levels prior to domestic consumption, still applies. Total barium should be monitored because $BaSO_4$ is highly insoluble[7].

2.5.3 MIDDLE TOBY CREEK (PANORAMA)

Because the resort is only in the initial occupancy stage, waste loadings from Panorama have been low. Although a minimal effect of the effluent on Toby Creek water quality would be expected at this stage, assessments cannot be made with the available data. Too few samples (1-5 depending on the characteristic) were collected at the wrong time of year to monitor effects on Toby Creek of groundwater from the tile fields. Sampling occurred during high spring and summer flows (high dilution), whereas the maximum effluent discharges from the ski resort are from December to March when flows in Toby Creek are at winter lows (low dilution). The data that were collected during high dilution conditions showed no change from upstream to downstream from Panorama.

Future sampling should be carried out during periods of high effluent discharge and low creek flows to maximize the chances of identifying groundwater effects on Toby Creek water quality. A continuing monitoring program for the effluent, the groundwater wells, and Toby Creek should be conducted to assess the effectiveness of the ground disposal system in preventing water quality deterioration in Toby Creek as the Panorama resort grows. A monitoring program is recommended in Section 2.5.6.

2.5.4 LOWER TOBY CREEK (INVERMERE)

No water quality data from Lower Toby Creek have been collected since November of 1978. The data collected since the Phase II Kootenay

Study[4] (April to November 1978) are presented in Table 11. They show water quality above and below the Invermere outfall, before the change to ground disposal.

Lower Toby Creek water was alkaline (Table 11). Although no data on hardness have been collected since the Phase II Kootenay Study, that report showed the water to be hard, and consequently good to fair in its suitability for domestic purposes[6].

Turbidity remained high (up to 42 NTU, see Table 11), with values exceeding the maximum acceptable limit for drinking water (5 NTU)[6] during the summer months. Suspended solids were also high during the same period, exceeding certain guidelines for maximum protection of aquatic life (25 mg/L) on a few sampling dates, but usually at levels that ensure good to moderate (<80 mg/L) protection[8]. Suspended solids below the Invermere sewage treatment plant (Table 11) appeared to be more than twice the levels upstream, but this was not actually the case; the 226 mg/L value at the downstream site on June 22, 1978, came from an isolated sample with no upstream equivalent (see Table 12). This single high value corresponds to high freshet flows with naturally high levels of suspended sediments, at least partly due to icefields and glaciers in the Toby Creek headwaters. All 5 paired upstream and downstream samples were essentially equal, with no addition of suspended solids evident from the sewage treatment plant. Suspended solids would have to be removed from Toby Creek water during spring and summer should it be used for drinking.

Nutrients in Lower Toby Creek were generally low. With regard to total phosphorus, Table 11 is misleading. The high 92 µg/L value (June 22) at the downstream site from the Invermere sewage discharge came from an isolated sample with no upstream equivalent. High total phosphorus was probably associated with high suspended solids during freshet, most existing as particulate phosphorus. The 6 paired samples in Table 12 show that total phosphorus was increased by the effluent on April 5, and that ammonia was increased on the same date, as well as on July 27. Although effluent flows are not available for April 5 when both characteristics were increased, low flows in Toby Creek during that period with resulting low dilution could account for the significantly higher nutrient concentration downstream from the discharge. Algal problems attributed by Waste Management Branch to phosphorus have occurred under similar loading conditions in the past; no data are yet available for the new discharge to ground to evaluate the soil's effectiveness in removing phosphorus.

2.5.5 WATER QUALITY OBJECTIVES FOR TOBY CREEK

Provisional water quality objectives are proposed for Toby Creek. The objectives are based on preliminary working criteria for water quality and on available data on ambient water quality, waste discharges, water uses and river flows. The objectives will remain provisional until receiving water monitoring programs provide adequate data, and the Ministry has established approved water quality criteria for the characteristics of concern.

The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified water bodies. For example, they can be used to draw up waste management permits and plans, regulate water use or plan fisheries management. They can also provide a reference against which the state of water quality in a particular water body can be checked.

Water quality objectives have no legal standing and their direct enforcement would not be practical. This would be due to the difficulty of accurately measuring contaminants in receiving water and attributing the contamination exceeding the objective to particular sources for legal purposes, and thus of proving violations and their causes. Hence, although water quality objectives should be used when determining effluent permit limits, they should not be incorporated as part of the conditions in a waste management permit.

Depending on the circumstances, water quality objectives may already be met in a water body, or may describe water quality conditions which can be met in the future. To limit the scope of the work, objectives are only being prepared for waterbodies and for water quality characteristics which may be affected by man's activity, now and in the foreseeable future.

The proposed designated water uses for Toby Creek include recreation and fishery throughout, as well as irrigation downstream from Invermere. Toby Creek is not presently used for drinking water supply, and the potential use for this purpose appears low (see Section 2.3). However, because the water appears to be suitable for drinking following suspended solids removal and disinfection, it would seem reasonable to maintain the future option to use the water for drinking. It is therefore proposed that drinking water supply also be a designated water use.

Characteristics of Concern:

a) Fecal Contamination from Panorama and Invermere

This is indicated by fecal coliforms. Drinking water criteria can be interpreted as <10 MPN/100 mL (90th percentile) for raw water treated by disinfection only, 10-100 MPN/100 mL (90th percentile) for water receiving partial treatment, and >100 MPN/100 mL (90th percentile) for water which receives complete treatment[6]. Water contact recreation criteria are 200 (geometric mean) to 400 (90th percentile) MPN/100 mL[12]. Irrigation and livestock watering criteria are 1000 (geometric mean) to 4000 or 5000 (maximum) MPN/100 mL[38]. There are no appropriate criteria for fresh water aquatic life.

The recommended provisional objective for fecal coliforms is <10 MPN/100 mL (90th percentile of the samples in any 30-day period) throughout Toby Creek to protect drinking water use after only disinfection, based on the guidelines of the Ministry of Health[6]. The available data suggest that this objective was being met above and below the Invermere sewage discharge in 1978, but there are no recent data from these sites or any data from near the Panorama discharge. However, because Invermere and Panorama discharge to ground, it is reasonable to assume that the objective can be met. Monitoring should be conducted downstream from both Panorama and Invermere's discharges to ground to assess whether the objective is being met. Samples should be taken three times during the winter at Panorama, every two months year-round at Invermere, and more frequently (for example, 10 samples per 30-day period) if the objective is exceeded, or if Invermere discharges directly to Toby Creek.

b) Nuisance Periphyton Growth Downstream from Panorama and Invermere

As mentioned previously, Toby Creek is very sensitive to phosphorus inputs as indicated by the periphyton blooms downstream from the Invermere sewage treatment plant discharge. Because the minimum phosphorus level required to prevent nuisance periphyton growth is not known, the present policy of Waste Management Branch to prevent phosphorus discharge to Toby Creek should be continued.

The recommended provisional objective for Toby Creek to protect recreation is that total periphyton growth 100 m downstream from the point of nutrient input should not exceed the upstream periphyton growth by more than 25 percent. The periphyton growth should be measured as total biomass per unit area at sites subject to similar light and water flow conditions. Initially, visual observation at the Invermere sites (0200223, 0200224) should be used every two months year round to assess whether this objective is being met. This would be replaced by a sampling program three times a year during low flows should any of the following occur: 1) a noticeable increase in periphyton occurs; 2) phosphorus breakthrough occurs from the tile fields; or 3) there is direct discharge of sewage effluent from the treatment plant to Toby Creek.

c) Particulate Matter

The criteria for protecting aquatic life in British Columbia from excessive particulate matter due to anthropogenic sources are expressed in terms of turbidity and suspended solids[15]. Induced turbidity should not exceed 5 NTU over background when background turbidity is ≦50 NTU, nor should induced turbidity be more than 10% of background when background is >50 NTU. Induced suspended solids should not exceed 10 mg/L over background when background levels are ≦100 mg/L nor should induced suspended solids be more than 10% of background when background is >100 mg/L. The British Columbia drinking water standard of 5 NTU[6] is frequently exceeded in Toby Creek, and the recommendation has been made in section 2.5.4 to remove some of the suspended solids and turbidity before drinking to protect this use.

The provisional objectives for turbidity and suspended solids for Toby Creek are recommended to be the above mentioned aquatic life criteria. Compliance should be checked two times a year during low flow (i.e. during worst conditions) at Mountain Minerals (0200055, 0200054) should the mine re-open, three times per year at Panorama (sites 0200333, 02000334), and three times per year at Invermere (sites 0200223, 0200224) but only if there is phosphorus breakthrough from the tile fields or direct discharge of sewage effluent to Toby Creek.

Historically, turbidity levels were below this objective at Invermere, whereas levels of suspended solids were higher than the objective in two out of nine samples taken while the sewage treatment plant discharged directly to Toby Creek. The objective should be easily met with the current disposal to ground.

Although there are no historical data for suspended solids or turbidity in Toby Creek at Panorama, the sewage disposal to ground should prevent the objective from being exceeded. The objective could be exceeded, however, if construction activities at Panorama ski resort are contributing to suspended solids and turbidity loadings of Toby Creek.

Historical levels of turbidity at Mountain Minerals monitoring sites were within the objective. Levels of suspended solids exceeded the objective in three out of five samples due to the mine discharge although levels in the discharge were within permitted limits. Should the mine re-open, a treatment system may be required to remove some of the suspended solids from the effluent at least during low flows in Toby Creek to prevent the objective from being exceeded.

d) Ammonia

Studies have shown that the un-ionized ammonia molecule and not the ammonium ion is the form of ammonia toxic to fish(17). The proposed provisional objectives for un-ionized ammonia nitrogen in Toby Creek are based on the criteria developed by Pommen(47) from a study in British Columbia: an average of 0.007 mg/L or less over 30 days and a maximum of 0.030 mg/L at any one time. Compliance should be checked three times a year including low flow at Invermere (sites 0200223, 0200224), but only if there is phosphorus breakthrough from the tile fields or direct discharge of treated effluent to Toby Creek. Compliance should also be checked three times during the winter at Panorama (sites 0200333, 0200334). Although there is insufficient historical Toby Creek data to indicate whether the appropriate ammonia objective had been met at Invermere, it was easily met downstream from the Panorama sewage disposal to ground in the four samples since 1978.

e) Nitrite

The British Columbia drinking water standard for nitrite is 1.0 mg/L(6). This standard was developed to protect infants from methemoglobinemia which occurs when nitrite combines with hemoglobin, reducing the oxygen carrying capacity of the blood[7]. Aquatic life criteria reflect the high toxicity of nitrite to fish, including cutthroat trout[19], a species found in Toby Creek. B.C. Research[20] recommends 0.020 mg/L nitrite-N as the maximum level acceptable for salmonids for prolonged periods. The U.S. Environmental Protection Agency[7] found 0.060 mg/L as the maximum level to have no mortality to fish after 10 days.

A provisional objective for nitrite nitrogen is proposed for Toby Creek to protect fisheries. The objective is 0.020 mg/L nitrite-N (an average not to be exceeded over a period of 30 days) and a maximum of 0.060 mg/L at any one time. Sites 0200223 and 0200224 at Invermere should be checked three times annually, but only if there is phosphorus breakthrough from the tile fields or direct discharge of treated effluent to Toby Creek. Sites 0200333 and 0200334 at Panorama should also be checked three times a year at low flow to see whether this objective is being met. There are no historical data for these monitoring sites on Toby Creek to show whether these objectives were met in the past.

f) Barium, Zinc, Lead, Copper and Cadmium

Although objectives for these metals are set below, it is recommended that these variables only be monitored twice per year, October to November, should the Mountain Minerals mine or some other similar operation open in the future.

Barium. The criterion for total barium is 1.0 mg/L to protect drinking water[6], and ranges from 1 mg/L for invertebrates, plants and algae to 5-10 mg/L for fish[13]. The recommended provisional objective to protect these uses (drinking water and aquatic life) in Toby Creek downstream from the Mountain Minerals mine is 1.0 mg/L maximum at any time. There are no historical barium data from the monitoring sites upstream or downstream from Mountain Minerals (0200055, 0200054) to show whether this objective was met while the mine was in operation.

Zinc. The criterion for drinking water, industrial, irrigation, and recreational water use is 5 mg/L total zinc[24]. The aquatic life criterion is 0.05 mg/L total zinc[24]. The recommended provisional objective for total zinc to protect aquatic life is 0.05 mg/L maximum at any time. The available data show that this objective was being met above and below the Mountain Minerals mine while it was in operation.

Lead. The criterion for drinking water, recreation, and industry is 0.05 mg/L total lead[6,21]. The irrigation criterion is 5 mg/L[21]. The aquatic life criterion is the most stringent at 0.01 mg/L total lead when hardness is >95 mg/L, and 0.005 mg/L total lead when hardness is <95 mg/L. The recommended provisional objective for lead is 0.01 mg/L or 0.005 mg/L maximum at any time, depending on hardness, to protect aquatic life. This objective was being met both above and below the mine discharge at Mountain Minerals while it was in operation.

Copper. The British Columbia drinking water standard for copper is 1.0 mg/L[6]. The irrigation criterion for crops not sensitive to copper is 1 mg/L[22]. The recreation and industrial criterion is 0.05 mg/L total copper, and the aquatic life criterion is 0.002 mg/L total copper[22]. The recommended provisional objective for Toby Creek is a maximum of 0.002 mg/L dissolved copper to protect aquatic life. If background levels exceed this, then sites downstream from permitted discharges should not exceed 0.010-0.020 mg/L dissolved copper on a short term basis (for hardness 50-100 mg/L, as taken from E.P.A. Water Quality Criteria, 1976[7]). Data from sites 0200054 and 0200055 are too few to determine whether this objective was being met when the mine was open.

Cadmium. The British Columbia drinking water standard for total cadmium is 0.005 mg/L[6]. Environment Canada has set the aquatic life criterion at 0.0002 mg/L, and the irrigation, recreation, and industrial criteria at 0.01 mg/L[23]. The recommended provisional objective for total cadmium in Toby Creek is 0.0002 mg/L maximum at any time to protect aquatic life. Toby Creek sites 0200054 and 0200055 were not monitored for cadmium while the mine was operational, so neither background levels nor the effect of the mine discharge on water quality can be determined.

2.5.6 MONITORING

The monitoring for the Toby Creek sub-basin recommended in Table 21 is to assess the effects of waste discharges on water quality, and to determine whether water quality objectives are being met. Recommendations are made from a technical perspective and the extent of monitoring will be determined by the overall priorities and monitoring resources available for the province. Additional monitoring to assess permit compliance, and to quantify waste loads may be necessary. Areas recommended for monitoring include the permitted discharges at Mountain Minerals, Panorama and Invermere, together with the associated groundwater observation wells and Toby Creek water quality sites. It is recommended that monitoring of the Mountain Minerals operation be carried out only if the mine re-opens. Other than the visual monitoring for periphyton every two months, monitoring of the Toby Creek sites at Invermere should be carried out only if the treatment plant discharges directly to the creek or if groundwater wells indicate phosphorus breakthrough from the disposal to ground. Barium should be monitored before Toby Creek water is used for domestic supply (Section 2.5.2).

An optional program would see expansion of the above program to include year-round sampling for metals at the Mountain Minerals Mine, should it re-open, to establish natural levels which may exceed water use criteria. This optional program would also include re-checking of the old Mineral King and Paradise mines for leaching of old tailings piles with subsequent water quality impacts on Toby Creek.

All monitoring data collected by the Ministry and the permittees should meet Ministry quality control criteria and be placed in the Ministry's computer data bank.

3. SINCLAIR CREEK

3.1 INTRODUCTION

The Sinclair Creek Basin, an eastern tributary of the Columbia River, drains about 94 km^2 mostly within the southeast corner of Kootenay National Park. The Brisco and Stanford Ranges traverse the basin from north to south. The development at Radium Hot Springs, near the mouth of Sinclair Creek and the junction of Provincial Highways 93 and 95 (see Figure 4), is a major recreational center serving thousands of tourists annually. It consists of a golf course, motels, the Radium Hot Springs Lodge, and the hot springs swimming pools located about 1.6 km east of the highway junction within Kootenay National Park.

Drinking water for Kootenay National Park comes from a tributary, John McKay Creek. Drinking water for Radium Hot Springs comes from Forster Creek which flows into the Columbia River from the west; the Kootenay National Park water supply is used when turbidity levels in Forster Creek are unsuitable for domestic use. All licensed water use for Sinclair Creek is below the hot springs swimming pools. Licenses include one for domestic use, one for domestic/irrigation use, one for domestic/industrial use and one for industrial use (see Figure 4, Table 15). Flows near the mouth at the Columbia River have ranged from 0.14 m^3/s during winter lows to 11 m^3/s during spring freshet[10]. There is a cutthroat trout fishery within Kootenay National Park[1], and a limited number have been stocked successfully behind the dam on John McKay Creek[25].

3.2 WATER QUALITY

The Radium sewage lagoon discharge to Sinclair Creek (Permit PE 132) was supplanted in December of 1976 by a treatment plant discharging directly to the Columbia River. This discharge (Permit PE 4422) is described in Section 4.4. One sample collected downstream from the old lagoons (water quality site 0200094) showed that the sanitary quality of Lower Sinclair Creek continued to be as good (fecal coliforms of 7 MPN/100 mL or less) as previously identified in the Phase II Kootenay Study[4]. The Phase II study also indicated that lower Sinclair Creek water was very hard due primarily to hot springs water and considered poor for most domestic purposes.

Data collected by Environment Canada from 1975 to 1976[26,27] showed turbidity levels in Sinclair Creek to exceed the British Columbia drinking water standard (5 NTU)[6] during freshet with a maximum of 12 NTU on May 3, 1975. An anomalously high level of 28 NTU occurred on February 23, 1976. Although the data are few, it appears that some turbidity needs removal prior to domestic use to prevent aesthetic problems. These Environment Canada data also show that in one sample dissolved sodium exceeded the British Columbia drinking water standard's alert level of 20 mg/L for people on restricted sodium diets[6]; this one sample was 44 mg/L on March 3, 1975. Out of 15 additional samples, only one taken at about the same time of year in 1976, approached the alert level; the level was 16.5 mg/L dissolved sodium on February 23.

Five hot springs are used for the two swimming pools at the Aquacourt, which discharge a total of 1.7 m^3/minute (0.029 m^3/s) to Sinclair Creek. Parks Canada chlorinates the water and attempts to maintain a level of between 0.8 and 1.0 mg/L total residual chlorine in the pools with sample checks four times a day. Bacteriological sampling is done once per week. To assess the potential impact of these two characteristics (residual chlorine and coliforms) on Sinclair Creek water quality, a minimum dilution of 5:1 is used; this is based on 0.029 m^3/s of pool discharge together with the lowest recorded flow in Sinclair Creek of 0.142 m^3/s (on March 20, 1974). The analysis shows the following, with respect to:

(i) Total coliform data from the Aquacourt pools over the last several years. Levels have been between 0-5 MPN/100 mL[28]. The theoretical incremental addition of <u>fecal</u> coliforms to Sinclair Creek, under worse case conditions, would be very low (0-1 MPN/100 mL). Although background data for Sinclair Creek are old (1975-1976), fecal coliform levels were low (<2 MPN/100 mL at Canyon Campground; n=9) and appear to be within British Columbia drinking water standards with disinfection, the minimum treatment[6]. The addition of the chlorinated pool discharge water would not be expected to change the drinking water suitability of Sinclair Creek with respect to fecal coliforms.

(ii) Total residual chlorine levels in the Aquacourt pool discharge. The highest concentration during 1983 was 1.75 mg/L (average of the two pools) on June 15[28]. This discharge could theoretically result in 0.35 mg/L total residual chlorine in Sinclair Creek, with complete mixing. This exceeds the 0.002 mg/L criterion for total residual chlorine to protect salmonids[7].

A study conducted by Environment Canada in 1979[25] identified naturally high levels of arsenic in Sinclair Creek. The principal sources were diffuse groundwater discharges (up to 0.8 mg/L arsenic) located between the tributaries of Kimpton and Redstreak Creeks, and the discharges at Radium Hot Springs and the Aquacourt pools (up to 0.3 mg/L). Although arsenic is present in both surface water and groundwater throughout the Sinclair Creek Basin, only Sinclair Creek below the hot springs and the two water wells serving the Canyon Campgrounds just outside the park contain occasional arsenic levels approaching or in excess of the British Columbia drinking water standard (0.05 mg/L)[6]. Maximum levels occur during the winter when flows are low, and the ratio of groundwater to surface water is greatest. No arsenic contamination was found in John Mckay Creek, the major drinking water supply.

3.3 RECOMMENDATIONS

Drinking water use from the lower Sinclair Creek basin should be restricted due to naturally high arsenic levels. It is recommended that approval be sought from the Ministry of Health before any surface water and groundwater in the lower Sinclair Creek basin is used for drinking.

Some removal of turbidity from drinking water may be required to meet Ministry of Health requirements. Users of drinking water should be alerted of potentially high sodium levels.

It also appears that there may be a problem with levels of total residual chlorine in Sinclair Creek downstream from the Aquacourt pools. Parks Canada should be informed that further investigation may be required. If there is a significant cutthroat trout fishery below the pool discharge, a dechlorination facility may be needed to reduce levels of total residual chlorine in Sinclair Creek to less than the 0.002 mg/L criterion to protect the fishery.

4. COLUMBIA RIVER: TOBY CREEK TO EDGEWATER

4.1 INTRODUCTION

This reach of the Columbia River between Toby Creek and Edgewater is about 20 km long. Sinclair Creek enters the Columbia River from the east near Radium Hot Springs, and Horsethief Creek enters from the west, about 5 km downstream from Toby Creek (Figure 4).

4.2 HYDROLOGY

Daily flows in the Columbia River near Edgewater have ranged from 280 m^3/s during freshet to 11.3 m^3/s during the winter[10]. The average flow during May to November, which is the permitted period for discharge from the sewage treatment plant at Edgewater, is 15.5 m^3/s (one-in-10-year monthly low flow estimate)[9]. One-in-10-year monthly low flows for the Columbia River at Radium Hot Springs are 7.2 m^3/s during the winter (October-April) and 80 m^3/s during the summer (August).

4.3 WATER USES

There are three licensed water withdrawals on this reach of the Columbia River (Figure 4, Table 16). Two are industrial withdrawals for the processing of gypsum and watering lawns on the golf course. The other is a domestic and industrial (food preparation and lawn watering) withdrawal which used to be for a restaurant located just north of Horsethief Creek. Currently the site is a children's amusement park, with the water used only for domestic purposes.

This reach of the Columbia River has high recreational value for boating, angling and viewing [29,31,32]. Marshes are extensively used by waterfowl. The Canadian Wildlife Service holds a reserve on Wilmer Slough (located between Toby and Horsethief Creeks) for waterfowl and ungulate winter range preservation.

There is a low to moderate fishery for Dolly Varden and rainbow trout in this reach of the Columbia River. Spawning is expected to be minimal, restricted to the few clean gravel bars. There is a low to moderate fishery for mountain whitefish during the summer, however, populations are concentrated in the fans and lower reaches of Toby and Horsethief Creeks throughout the year. Mountain whitefish spawn in the gravel bars of inflowing creeks, not in the Columbia River[39].

4.4 WASTE DISCHARGES

Permitted waste discharges are shown in Figure 4 by their permit numbers, and are described in Table 1. They include the effluents from the sewage treatment plants at Radium Hot Springs and Edgewater.

4.4.1 SEWAGE TREATMENT PLANT AT RADIUM HOT SPRINGS

a) Description of Discharge

Radium Hot Springs (1982 permanent population of 465[34]) is located on the Columbia River at the confluence with Sinclair Creek. Before December 1976, sewage was treated in lagoons next to Sinclair Creek (discontinued permit PE 132) and individual septic tanks and tile fields. This system was replaced by a sewage treatment plant consisting of a winter and summer oxidation chamber, a clarifier, an outfall to the Columbia River and sludge drying beds (permit PE 4422). Chlorination of the effluent is not required because dilution is high (300:1, Table 2) and there is no domestic water use downstream. The sewage treatment plant was designed to treat effluent from a population of 1 600 in winter and 4 400 in summer. The population increase reflects the large numer of tourists that visit Radium Hot Springs.

b) Present Waste Loads

The permittee is required to monitor PE 4422 twice per month, for BOD_5 (45 mg/L permitted), suspended solids (60 mg/L permitted) and fecal coliforms. Maximum permitted effluent flow is 2 090 m^3/d. Effluent monitoring data collected since those summarized in the Phase II Kootenay Study[4] are compiled in Table 4. Although a record of effluent flows is required by permit, only recently has the flow meter been operating properly; therefore, the accuracy of the flow measurements in Table 4 is "... questionable"[40].

As in the Phase II Kootenay Study[4], levels of suspended solids and BOD_5 exceeded permit limits on a regular basis (40% of samples), and were usually highest during the summer when the number of tourists and corresponding effluent loadings were greatest. Permitted levels of BOD_5 and suspended solids could more easily be attained with the addition to the treatment plant of a properly designed flow equalization system. Fecal coliform levels were generally low (2 300-33 000 MPN/100 mL; n=8), although one high value was measured (330 000 MPN/100 mL on November 12, 1980). The minimum dilution (worst case) for this effluent in the Columbia River after complete mixing is about 300:1 during the winter and 3 300:1 during the summer (see Table 2). These dilution estimates assume the maximum permitted effluent flow (2 090 m^3/d) together with low Columbia River flows (one-in-10-year monthly low flow estimates)[9] of 7.2 m^3/s during the winter low tourist period and 80 m^3/s during the summer (August) high tourist period. Actual present dilutions are greater as the sewage treatment plant is not loaded to capacity; the estimates of the 1982 population and volume of sewage flow presented in Table 2 yield dilutions of about 1 800:1 (7.2 $m^3/s \div 350\ m^3/d$) during the winter and 6 200:1 (80 $m^3/s \div 1\ 110\ m^3/d$) during the summer. These dilutions might be reduced by diurnal peaks typically associated with sewage flows. However, these peak conditions would exist for only short periods of time during the day. As well, the worst case condition is already an extreme situation which is unlikely to occur.

Waste loadings, both permitted and present (actual), are summarized in Table 17. Because effluent flow data from the sewage treatment plant are unreliable, the flow has been calculated using an estimate of the present population (965 winter, 3 085 summer in 1982)[33,34], and assuming

0.36 m^3/d of effluent per person (80 gallons of effluent/person/day). Both winter and summer loading estimates have been made to reflect the significantly higher summer tourist population. BOD_5 and suspended solids loadings were within permitted limits for both winter and summer if average concentrations for the two characteristics were used (from Table 4), but exceeded permitted loadings for BOD_5 when worst case summer concentrations were used.

The effects of present (1982) waste loads on Columbia River water quality are summarized in Table 18. Incremental increases in concentration above background levels are calculated for both the Columbia River low flow winter period (November) as well as the peak tourist use summer period (August). Effluent dilution is higher during the summer than winter (6 200 vs. 1 800:1) despite higher tourist effluent loadings because of the much greater river flow (80 vs. 7.2 m^3/s). The incremental loadings of fecal coliforms (40-130 MPN/100 mL) predicted in Table 18 are reflected in the receiving environment data of Table 20 (sites 0200232, 0200233). The increases are within fecal coliform guidelines for primary contact recreation (swimming) of 200-400 MPN/100 mL[6]. The highest additions to background from the sewage effluent are during the winter when there is no recreational use. The small increases in BOD_5, suspended solids, nitrogen and phosphorus in the Columbia River as predicted in Table 18 are in agreement with water quality section 4.5.2 which concludes that the impact of the sewage discharge on these aspects of water quality is not significant.

c) Future Waste Loads

Projected flows, together with projected loads for BOD_5 and suspended solids, are shown in Table 17. Conservative 1991 population estimates (1 300 summer, 6 300 winter)[33] were used to estimate flows, assuming 0.36 m^3/d of effluent per person (80 gallons of effluent/person/day). Loading calculations assumed permit compliance for concentrations of BOD_5 and suspended solids. Flows, as well as loadings for BOD_5 and suspended solids, will exceed permitted levels during the summer by 1991. Because past performance of the treatment plant has indicated that poor effluent quality may be expected, non-compliant loadings of BOD_5 and suspended solids may occur on a frequent basis before that date.

The predicted effects of future (1991) waste loads on Columbia River water quality are presented in Table 18. Assuming that the Radium Hot Springs sewage treatment plant discharge will be within permit limits, effluent dilution will still be high (1 300 to 3 000:1) and the impact on the receiving environment low. Predicted future increases in fecal coliforms (80-190 MPN/100 mL) are still within primary-contact recreation guidelines (200- 400 MPN/100 mL)(6) with the greatest loads occurring in the winter when there is no swimming.

4.4.2 SEWAGE TREATMENT PLANT AT EDGEWATER

a) Description of Discharge

Edgewater is a small community (1981 population 345) on the Columbia River about 8 km north of Radium Hot Springs. Municipal sewage is held in lagoons (one for aeration, one for storage) before being discharged to the Columbia River for two periods of two weeks each between May 1 and November 30. The discharge is permitted under permit PE 4802, as described in Table 1. The permitted effluent flow to the Columbia River is 2 615 m^3/d. The allowed BOD_5 and suspended solids are 30 mg/L each. Chlorination of the effluent is not required because of the high dilution (minimum 510:1, Table 2) and the absence of downstream water licenses for domestic use.

b) Present and Future Waste Loads

There are few data available on effluent quality or flows, although permit PE 4802 requires the effluent to be sampled each time the storage lagoon is discharged to the Columbia River. The only available information concerning PE 4802 is the following: 1) the first discharge was in 1980 although there are no records of discharge volume or effluent quality; 2) there was no discharge in 1981; and 3) 276 m^3/d of effluent was discharged to the Columbia River during March of 1982, with BOD_5 of 61 mg/L, and total suspended solids of 31 mg/L(35). Because the storage pond was not emptied during the 1982 discharge period, the actual rate of effluent production for Edgewater cannot be determined. The effluent flow has therefore been estimated in Table 17 to be 1 635 m^3/d, using the estimated 1981 population (345) and assuming 0.36 m^3/d of effluent per person (80 gallons of effluent/person/day). Levels of suspended solids and BOD_5 have each been estimated at 50 kg/d, assuming that concentrations have been within permit limits. Flows and loadings should be similar to present levels by the year 1991 as the population projection is for limited or no growth.

No significant impact on Columbia River water quality is expected from the sewage treatment plant at Edgewater if permit levels are met. The restriction on the permitted period of effluent discharge (May to November) assures high dilution; from the freshet flows in May through to the lowest flows of the period in November, there is still a minimum dilution of about 510:1 (see Table 2). Negligible changes in the concentration of BOD_5 and suspended solids (30 mg/L÷510 or 0.06 mg/L in the river after complete mixing) are to be expected if permit limits are met. It is for this reason that receiving environment monitoring of this discharge has not been done by the Ministry of Environment.

4.5 WATER QUALITY

4.5.1 PRESENTATION OF DATA

The Ministry of Environment monitored three sites in this reach of the Columbia River from 1976 to 1978. Site 0200225 is located between Toby and Horsethief Creeks, and sites 0200232 and 0200233 are located upstream and downstream from the sewage treatment plant at Radium Hot Springs. These sites are shown in Figure 4 and described in Table 8. Data collected since those presented in the Phase II Kootenay Study[4] are compiled in Table 19, and all the historical sampling data for specific characteristics (fecal coliforms, suspended solids, turbidity, and phosphorus) are presented in Table 20.

4.5.2 DISCUSSION OF DATA

Suspended solids and turbidity were quite high during the July 1978 freshet in this reach of the Columbia River, up to 157 mg/L and 50 NTU, respectively (Tables 19,20). At this time, levels of suspended solids were above minimum criteria for protection of aquatic life[8], and turbidity exceeded certain recreation guidelines (25-50 NTU)[36,37]. These were probably naturally occurring levels, however, due to inflowing Toby and Horsethief Creeks. Suspended solids and turbidity would have to be removed prior to drinking-water use. The sewage treatment plant discharge at Radium Hot Springs did not appear to affect these or other water quality characteristics significantly, although the number of paired samples (sites 0200232 and 0200233) was small (4 to 9 depending on the characteristics).

Fecal coliform levels continued to be low at site 0200225 below Toby Creek (see Tables 19,20), as reported in the Phase II Kootenay Study[4] and were within primary-contact recreation criteria (200 MPN/100 mL geometric mean to 400 MPN/100 mL 90th percentile)[12]. The data available are few and old (seven samples, 1976-1978) but do suggest that at that time disinfection (plus removal of suspended solids and turbidity) was adequate prior to domestic use (90th percentile <10 MPN/100 mL)[6]. More data are required to prove that this level of treatment is currently adequate to protect the domestic water use in the children's amusement park (Table 16), located downstream from the Invermere sewage treatment plant which has discharged frequently to Toby Creek. Small increases in fecal coliform levels were evident further downstream in the Columbia River because of the sewage treatment plant discharge at Radium Hot Springs; recorded levels were from 2 to <20 MPN/100 mL above the discharge (site

0200232) to 5 to 240 MPN/100 mL below the discharge (site 0200233; Table 20). There are no domestic water licenses below the sewage treatment plant, and water quality at the sites sampled was well within recreation criteria (200 MPN/100 mL geometric mean to 400 MPN/100 mL 90th percentile [12]). All three sites on this reach of the Columbia River (0200225, 0200232, 0200233) had levels of fecal coliforms well within criteria for irrigation purposes (1 000 MPN/100 mL geometric mean to 5 000 MPN/100 mL maximum)[38].

Nutrient levels up to 1978 continued to be low (see Table 20) as reported in the Phase II Kootenay Study[4]. A significantly higher total phosphorus level occurred at the site downstream from the sewage treatment plant (0200233) compared to the upstream site (0200232) on one occasion, April 26, 1977 (135 vs 9 μg/L; see Table 20). This anomalously high value was probably not due to the sewage treatment plant because at a dilution of 1 800:1 the sewage treatment plant effluent concentration would have to have been about 240 mg/L total phosphorus, whereas the range for most secondary treatment plants is 5-15 mg/L. The effluent may not have been completely mixed, however. Higher levels of phosphorus occurred at both sites June 21 and July 22, 1978, probably due to the phosphorus content of the suspended solids during freshet.

4.5.3 WATER QUALITY OBJECTIVES

The proposed designated water uses for the Columbia River from Toby Creek to Edgewater include primary-contact recreation, aquatic life, and wildlife throughout, as well as drinking water upstream from the sewage treatment plant at Radium Hot Springs. The only characteristic of concern at the present time is fecal contamination from Invermere (Toby Creek Sub-basin), Radium Hot Springs, and Edgewater. Criteria are 200 MPN/100 mL (geometric mean) to 400 MPN/100 mL (90th percentile) for primary-contact recreation[12], 1 000 MPN/100 mL for irrigation[38], and <10 MPN/100 mL (90th percentile) for drinking water before disinfection[6]. There are no appropriate criteria for fresh water aquatic life.

The most sensitive of these water uses downstream from the sewage treatment plant at Radium Hot Springs to Edgewater is primary-contact recreation. The recommended provisional objective for fecal coliform is that the fecal coliform density should not exceed a running log mean of 200 MPN per 100 mL, calculated from at least 5 weekly samples taken during the recreation season, nor should more than 10% of samples during any 30-day period exceed 400 MPN per 100 mL. The most sensitive use upstream from the Radium sewage treatment plant to Toby Creek is drinking water. The recommended provisional objective is that the fecal coliform density should not exceed 10 MPN/100 mL in 90 percent of creek or river water samples taken in any consecutive 30-day period for water that would then require disinfection before domestic use. It is also recommended that suspended solids and turbidity be removed before domestic use.

As fecal coliforms is the only characteristic of concern at this time, it is the only characteristic for which an objective is proposed and for which monitoring is recommended (section 4.5.4) to ensure that the objective is being met. Objectives for additional characteristics may be developed if future developments endanger the designated water uses.

4.5.4 MONITORING

The recommended effluent and water quality monitoring for this reach of the Columbia River is summarized in Table 21. Recommendations are made from a technical perspective and the extent of monitoring will be determined by the overall priorities and monitoring resources available for the province. Effluent and receiving water monitoring should be conducted on the same day so that cause-effect relationships can be determined.

Effluent monitoring of the sewage treatment plants at Radium Hot Springs and Edgewater should be conducted to form a reference for receiving water monitoring, to accurately estimate effluent loadings, and additionally as required by permit from Waste Management Branch to assess permit compliance.

It is also recommended that upstream and downstream water quality stations be established around the Edgewater sewage treatment plant.

Coordinated monitoring of sites 0200225 (downstream Toby Creek) and 0200232 (upstream Radium Hot Springs) will show whether the <10 MPN/100 mL fecal coliform objective for drinking water is being met. Coordinated monitoring of sites 0200233 (downstream Radium Hot Springs) and the two sites near Edgewater would show whether the 200-400 MPN/100 mL fecal coliform objective for primary-contact recreation is being met.

All monitoring data collected by the Ministry and permittee (Regional District of East Kootenay) should meet quality control standards and be placed in the Ministry's computer data bank.

It is assumed that the Edgewater sewage treatment plant would discharge to the Columbia River once during May, with the effluent stored during the winter, and once during November, the end of the permitted period of discharge. The timing of the recommended monitoring in Table 21 for all Columbia River sites would be adjusted to coordinate with the last sewage discharge period at Edgewater (November).

If monitoring resources are available, the monitoring program at Radium Hot Springs (PE 4422 and associated Columbia River sites) as outlined in Table 21 should be expanded. More frequent sampling, such as every two months, would monitor objective compliance with a higher degree of confidence.

5. SPILLIMACHEEN RIVER

5.1 INTRODUCTION

The drainage area of the Spillimacheen River basin is 1 360 km^2. It flows into the Columbia River at the town of Spillimacheen, located about 35 km north of Radium Hot Springs (Figure 5).

5.2 HYDROLOGY

Flows in the Spillimacheen River at the mouth (Water Survey of Canada station 08NA011) have ranged from 312 m^3/s during freshet (June 15, 1918) to 3.0 m^3/s during the winter (November 23, 1970)(10). The minimum 7-day average low flow (33 years of record) is 11 m^3/s(41).

5.3 WATER USES

There are 3 water licenses in the Spillimacheen River basin, including one for irrigation, one for power generation (B.C. Hydro), and one for campsite drinking water and mining (Ruth Vermont Mines Ltd.) in the Vermont Creek headwaters. These are summarized in Table 22 and shown in Figure 5. There is a winter fishery for burbot and mountain whitefish and a spring-summer fishery for rainbow trout and Dolly Varden. Neither the importance of fisheries nor recreational use have been evaluated.

5.4 WASTE DISCHARGES

5.4.1 RUTH VERMONT MINES LTD.

This company, formerly Consolidated Columbia River Mines, operated a lead-zinc ore dressing plant on Vermont Creek, which then flows into Bobbie Burns Creek, a tributary of the Spillimacheen River (see Figure 5). Ore processing water was held in two tailings ponds before being discharged to Vermont Creek. The discharge was authorized by Waste Management Branch permit PE 448 for a maximum flow of 1 310 m^3/d.

The plant has been shut down since 1975, although a small amount of work was done in 1981. Effluent monitoring results and permit limits are summarized in Table 23. Cyanide, used in milling of the ore, was frequently above the permit limit of 0.04 mg/L. Because cyanide is a potential threat to the fisheries resource, the Waste Management Branch will not allow the mine to re-open unless the new effluent characteristics outlined in Table 23 can be met. It has been recommended that cyanide levels in the effluent be reduced by milling the ore without cyanide or treating the tailings to remove cyanide[42].

5.4.2 BAROID OF CANADA LTD.

Effluent from the tailings impoundment of this barite concentrating plant was discharged to the Spillimacheen River just downstream from the junction with Bobbie Burns Creek (see Figure 5). Maximum effluent flow of 2 070 m^3/d is authorized by Waste Management Branch permit PE 2080. Although the ore has run out and the mine closed, the operation for some time had consisted of reprocessing the old tailings. There has been no permitted discharge to the Spillimacheen River since about 1979.

Permit PE 2080 requires effluent monitoring four times per year for the characteristics summarized in Table 26. Data over the one year sampling period (1972-1973) show that characteristics were within permitted limits except for lead and zinc. One out of six lead values and four out of six zinc values exceeded permit limits.

5.5 WATER QUALITY

5.5.1 PRESENTATION OF DATA

The Ministry of Environment monitored four sites in the Spillimacheen River basin, including two sites near the Ruth Vermont mine discharge on Vermont Creek (0500086, 0500087) and two sites near the Baroid of Canada mine discharge at the confluence of the Spillimacheen River and Bobbie Burns Creek (0500428, 0500429; see Figure 5). Data are summarized in Tables 24, 25, and 27.

5.5.2 UPPER SPILLIMACHEEN: VERMONT CREEK

Detectable concentrations of total cyanide were recorded downstream from the Ruth Vermont mine at site 0500087 on two out of nine sampling dates (0.02 mg/L on October 16, 1975; 0.03 mg/L on October 20, 1976). These corresponded to high total cyanide discharges from the mine (1.3 mg/L on October 16, 1975; 2.7 mg/L on October 20, 1976, in the mine effluent). Fresh water aquatic life criteria are 3.5[43] to 5[44] µg/L for free cyanide, which is the most toxic form. The maximum 30 µg/L total cyanide measured at site 0500087 included both free cyanide and complexed forms. Although these data do not show with certainty that the criteria were being exceeded, this may have been the case because of the high total cyanide levels. Should the mine re-open, analyses should be done for strong- and weak-acid dissociable cyanide so that the potential impact on aquatic life can be determined.

Total copper levels were from <1 to 8 µg/L at site 0500086 upstream from the Ruth Vermont mine, naturally exceeding aquatic life criteria (2 µg/L total copper)[22] on three out of six sampling dates (see Table 25). Naturally high levels are not uncommon in British Columbia because of widespread copper mineralization. Effluent from the Ruth Vermont mine increased total copper levels at downstream site 0500087 on four out of six sampling dates, to a maximum of 40 µg/L on October 20, 1976. These dates corresponded to high total copper levels in the mine effluent (1.48 to 4.83 mg/L). Data are inadequate to determine whether high total copper levels were the result of dissolved or particulate forms.

Levels of zinc upstream from the mine discharge (site 0500086) frequently exceeded criteria for aquatic life[24], including the 50 µg/L criterion (at hardness 0-120 mg/L) and the 100 µg/L criterion (at hardness 120-180 mg/L; see Table 25). Hardness in Vermont Creek could be significantly higher than the 91 mg/L single value recorded during freshet (May 10, 1973; see Table 24). The maximum zinc level recorded at site 0500086 was 510 µg/L on May 17, 1976. Zinc levels were higher only irregularly at the site downstream from the mine discharge (0500087). These high copper and zinc levels should be investigated, in particular because of the possible synergistic effect on aquatic life[46].

Levels of lead upstream from the mine (site 0500086) exceeded the criterion for aquatic life (10 µg/L at hardness >95 mg/L)[21] on five out of six sampling dates. Lead levels were higher downstream from the mine discharge (site 0500087) on only two out of six sampling dates (Table 25). These high levels of lead and zinc cannot be attributed to high suspended sediments in Vermont Creek (a relatively low 4-16 mg/L suspended solids during freshet), suggesting localized lead-zinc mineralization.

Iron levels exceeded the drinking water criterion of 0.3 mg/L[6] on May 17, 1976 (1.2 mg/L total) at upstream site 0500086. The criterion was also exceeded at downstream site 0500087 on June 18, 1979 (0.4 mg/L), although this could not be attributed to the Ruth Vermont mine discharge.

A single sample was taken July 14, 1983, by Waste Management Branch at site 0500087, downstream from the permitted discharge point of the closed mine[35]. This was because of a report that tailings pond decant water was flowing into the Spillimacheen River. As there was no corresponding sample taken at upstream site 0500086, no inferences about the quality of the discharge water can be made. Sample analyses did show levels of metals (0.012 mg/L total copper, >0.015 mg/L total lead, and >0.03 mg/L total zinc) and arsenic (0.084 mg/L) as high as when the mine was in operation. Because no follow-up operation has occurred, further monitoring is required to ensure that the mine is not impacting Vermont Creek and the Spillimacheen River.

5.5.3 LOWER SPILLIMACHEEN

Water quality sites established to monitor the Baroid of Canada mine discharge (0500428 upstream, 0500429 downstream) were sampled only from 1972 to 1973. Sampling was coordinated with sampling of the mine discharge. Data are shown in Table 27.

Suspended solids were higher at the downstream site (0500429) on all five sampling dates, presumably due to the mine discharge. All results were within certain guidelines for maximum protection of aquatic life (25 mg/L)[8], with the exception of one sample taken during freshet with predictably higher levels (46 mg/L; June of 1973). The concentrations of the other characteristics in Table 27 were not significantly different above or below the mine discharge.

Levels of some characteristics in the Lower Spillimacheen upstream from the Baroid of Canada Mine but downstream from Bobbie Burns Creek (site 0500428) exceeded aquatic life criteria. These characteristics include:

Dissolved Lead: Levels ranged from <3 to 400 µg/L, exceeding even the least stringent aquatic life criterion (30 µg/L)[21] on four out of five sampling dates. The data from Vermont Creek site 0500087 do not support the assumption that these high levels were the result of the Ruth Vermont (lead-zinc ore) mine discharge upstream. Eight samples from site 0500087 contained a maximum 100 µg/L total lead, with an average of 24 µg/L. Subsequent dilution would produce concentrations at site 0500428 which are unlikely to exceed the 30 µg/L dissolved lead aquatic life criterion. It appears that there may be a source of lead on the Spillimacheen River other than the Ruth Vermont mine.

Dissolved Copper: Dissolved copper levels exceeded the aquatic life criterion (2 µg/L)[22] in two out of five samples at site 0500429 (up to 50 µg/L). High detection limits (20 and 50 µg/L) for two samples may have masked other values exceeding the criterion. It is unlikely that high copper levels were the result of the Ruth Vermont mine upstream; although no effluent or water quality data are available for the mine between 1972-1973, dilution between the point of discharge and the sites on the lower Spillimacheen River should have reduced levels below those recorded in Table 27. It is possible that copper mineralization continues in this part of the watershed, as postulated for the upper Spillimacheen.

Cyanide: Total cyanide concentrations at both sites on the lower Spillimacheen River (0500428, 0500429) ranged from <10 to 20 µg/L. High cyanide concentrations may have been the result of discharge from the Ruth Vermont mine upstream which used cyanide in the milling process for the lead-zinc ore (see Section 5.4.1). Dilution between the Ruth Vermont mine and the water quality sites in the lower Spillimacheen River (0500428, 0500429) should have reduced the cyanide to levels lower than those detected, however. It is possible that: 1) high cyanide levels were discharged in the mine effluent upstream, but for some reason came down in a slug without mixing; 2) the cyanide was accumulated in the sediments of the Spillimacheen River downstream from the mine and came down in a slug following a rainfall; or 3) the samples were contaminated. As mentioned for the Vermont Creek sites 0500086 and 0500087, fresh water aquatic life criteria are 3.5[43] to 5[44] µg/L free cyanide whereas the samples were analysed for total cyanide which includes both free and complexed forms. Because the high total cyanide values could indicate that the criteria were exceeded in the lower Spillimacheen, analyses should be made for both the strong- and the weak-acid dissociable cyanide if the mine re-opens.

5.6 WATER QUALITY OBJECTIVES AND MONITORING

No water quality objectives are proposed at this time for the Spillimacheen River sub-basin because the two mines are closed and are unlikely to re-open[45]. No monitoring is recommended. An optional monitoring program would include:

1) A study to investigate the high background level of metals measured in the past that have exceeded water use criteria. Data from this study would form the basis for future objectives for metals.
2) A study to determine whether mine drainage or acid generation from waste rock at the two closed mines is impacting Vermont Creek or the Spillimacheen River.

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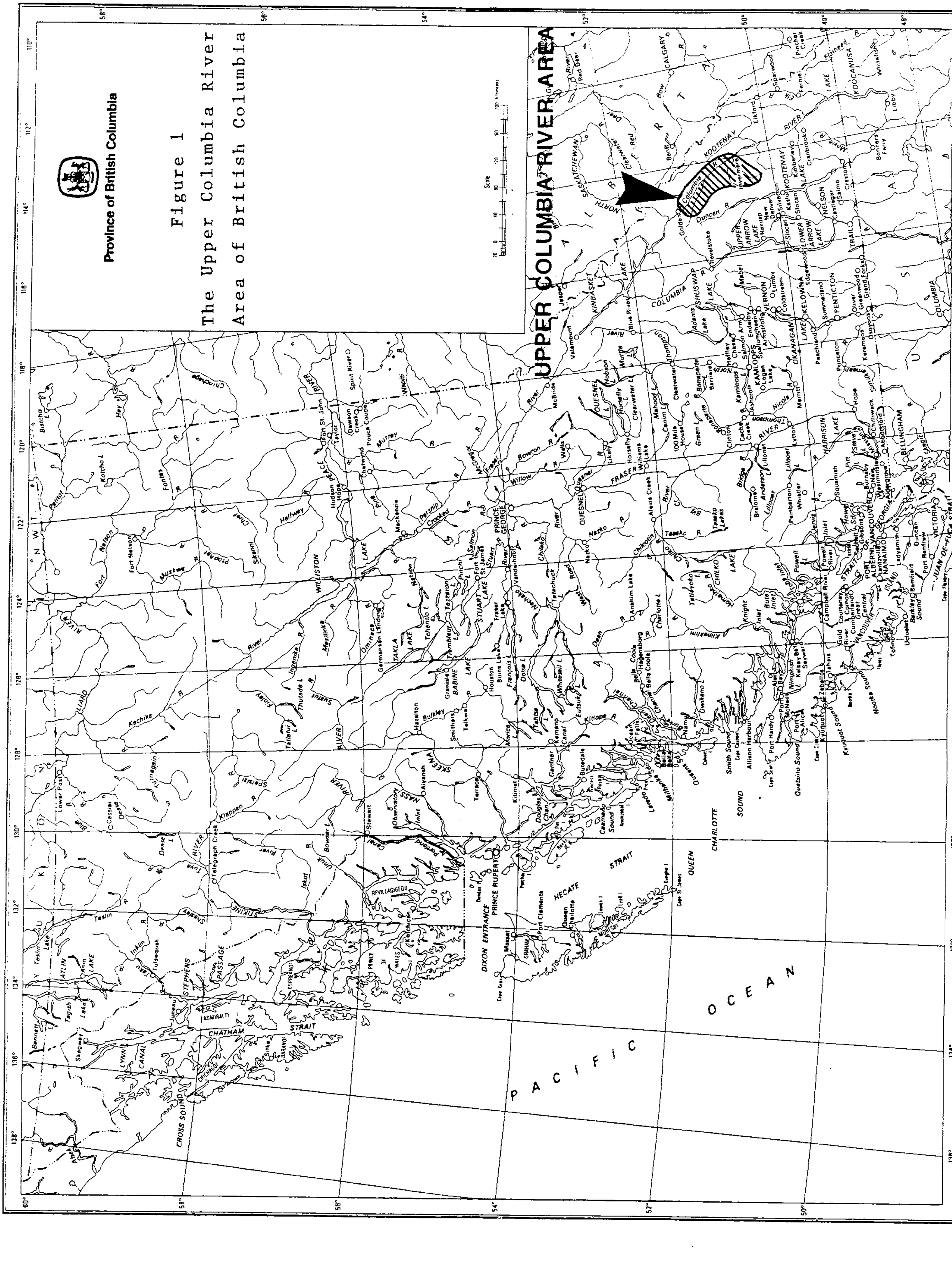

Figure 1
The Upper Columbia River Area of British Columbia

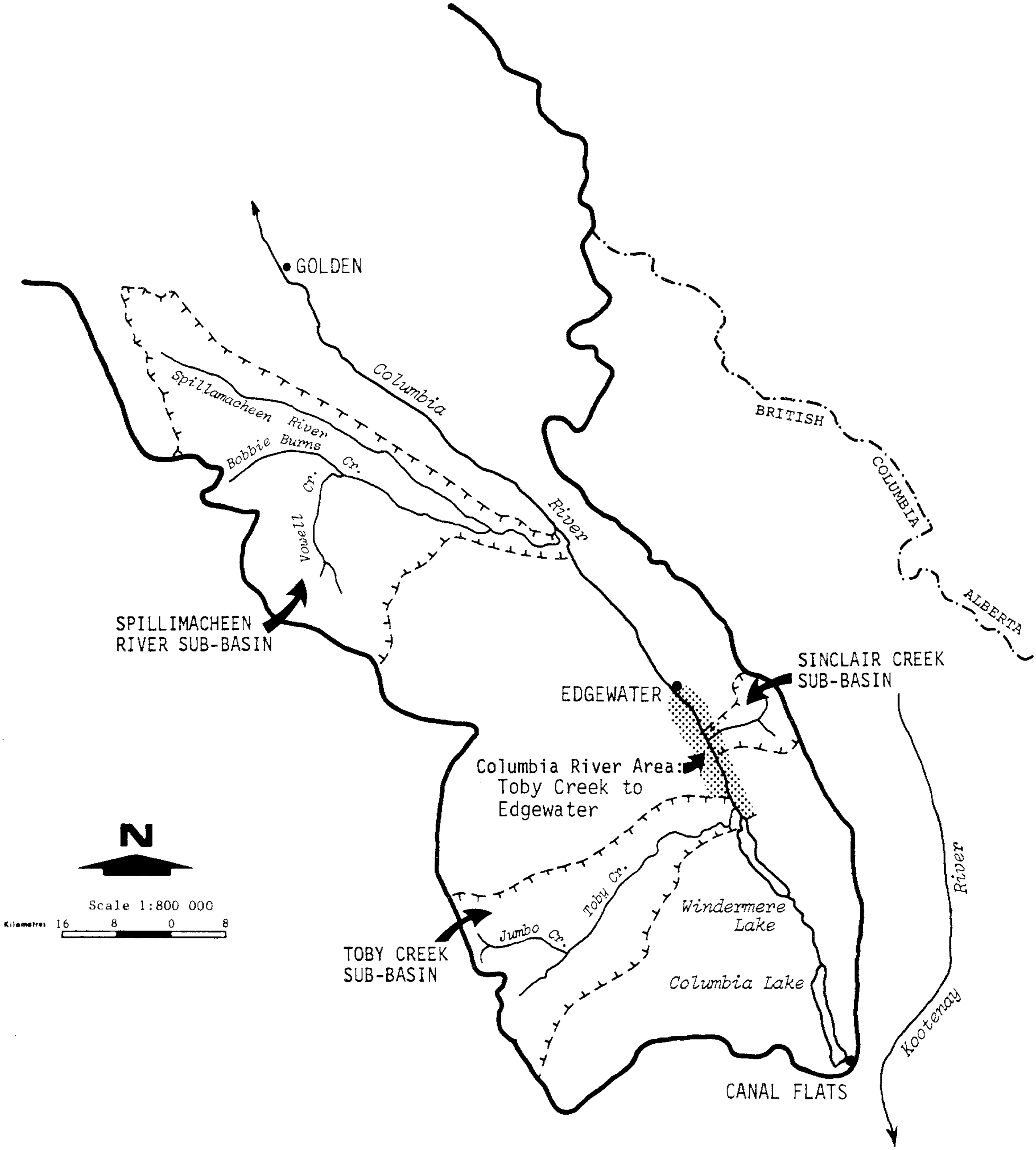

Figure 2: Priority Sub-Basins in the Upper Columbia River Area

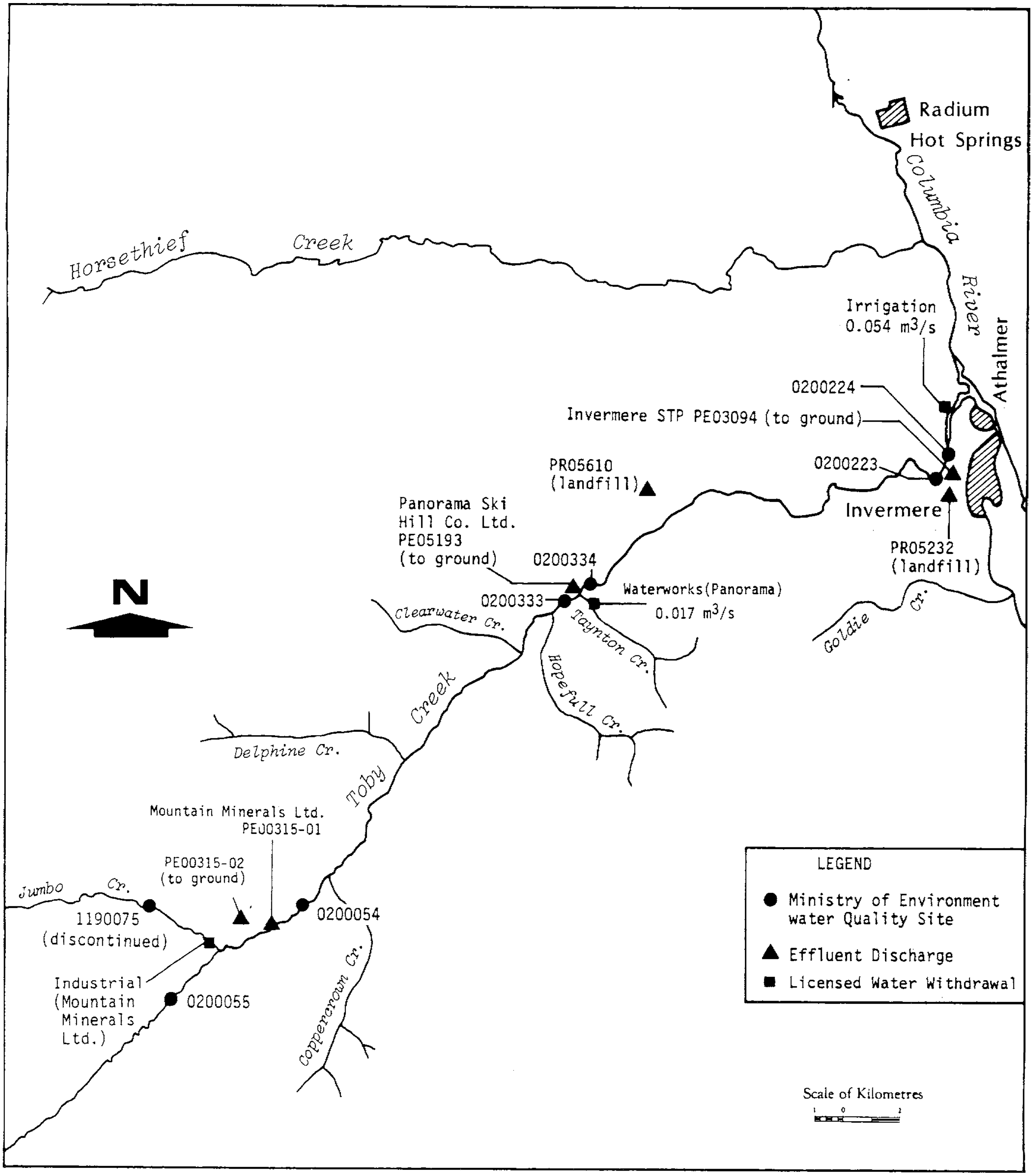

Figure 3: Toby Creek Sub-Basin

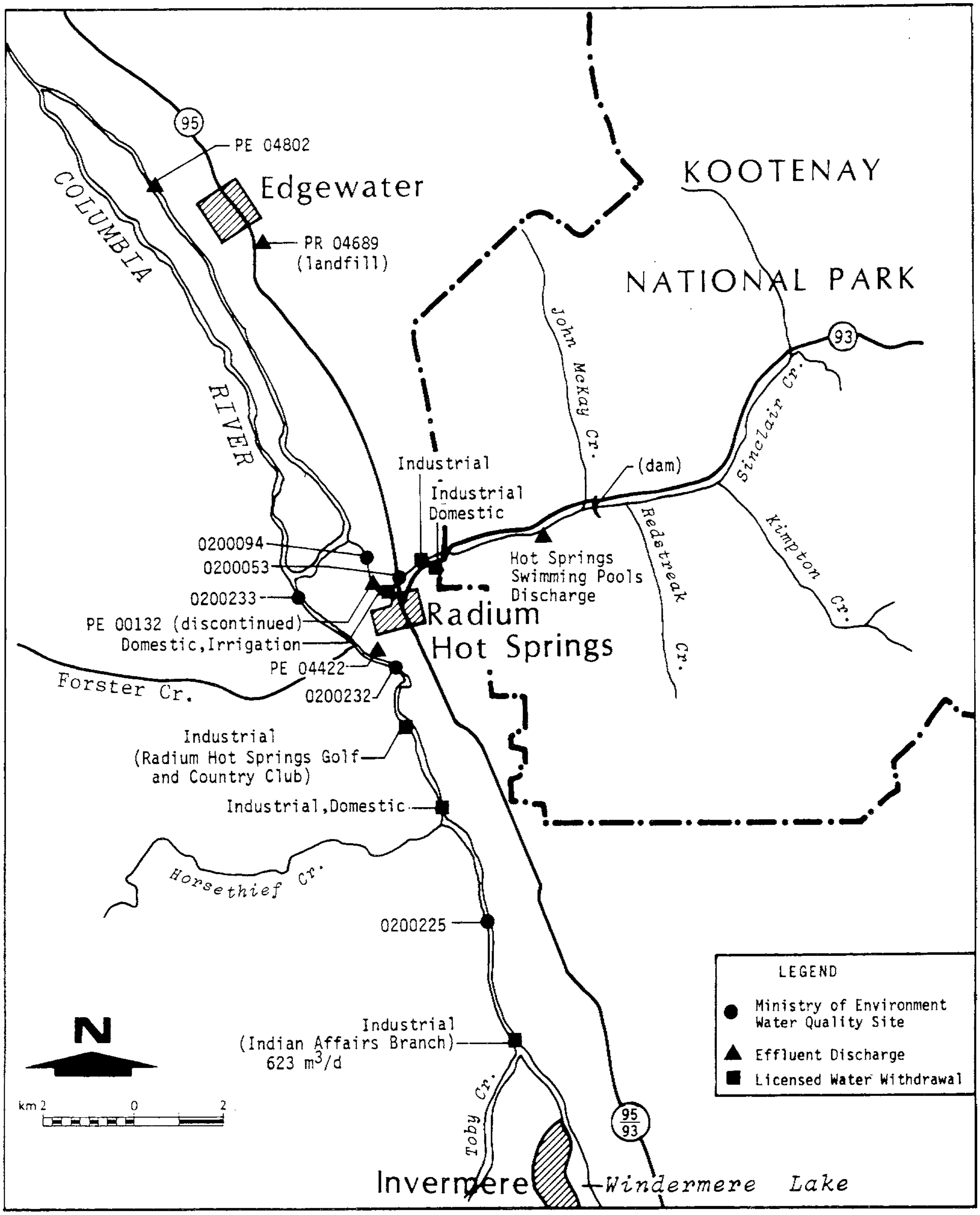

Figure 4: Columbia River (Toby Creek to Edgewater) and Sinclair Creek

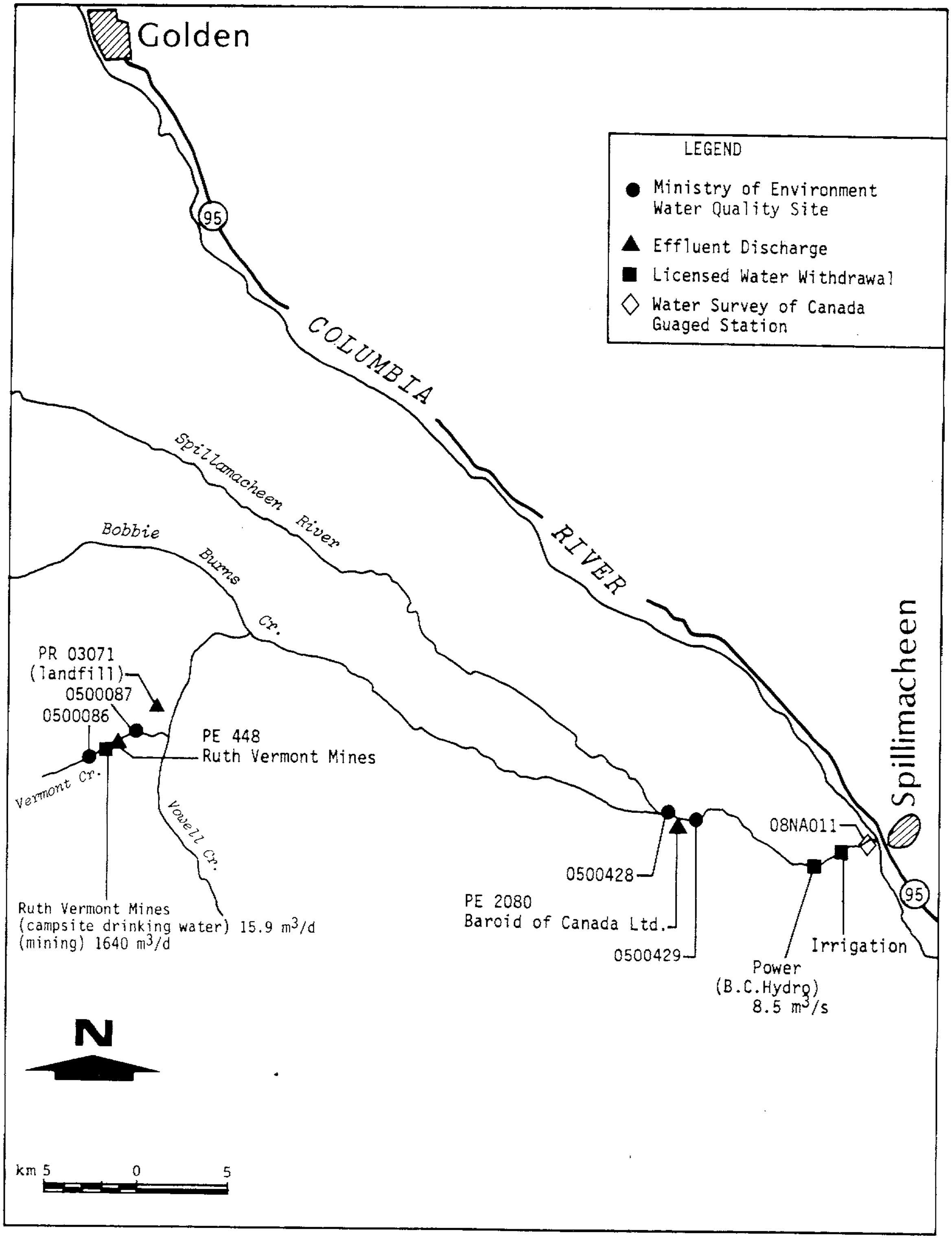

Figure 5: Spillimacheen River Sub-Basin

TABLE 1

SUMMARY OF PERMITTED EFFLUENT DISCHARGES FOR TOBY CREEK, THE COLUMBIA RIVER AND THE SPILLIMACHEEN RIVER

Permit Holder	Permit Number	Discharges To	Waste Discharge Flow (m^3/d)	Type of Discharge
1. Toby Creek Sub-basin				
Mountain Minerals Ltd.	PE 315	Toby Creek	1 310	tailings pond effluent
Panorama Ski Hill Co. Ltd.	PE 5193	ground	1 090	sewage effluent
	PR 5610	ground	-	refuse, landfill
Village of Invermere	PE 3094	ground	1 710	municipal effluent
	PR 5232	ground	-	refuse, landfill
2. Columbia River: Toby Creek to Edgewater				
Regional District of East Kootenay	PE 4422	Columbia River	2 090	sewage effluent from Radium Hot Springs
	PE 4802	Columbia River	2 615	sewage effluent from Edgewater
	PR 4689	ground	-	refuse, landfill
3. Spillimacheen River				
Ruth Vermont Mines	PE 448	Vermont Creek	1 310	tailings pond effluent
	PR 3071	ground	-	refuse, landfill
Baroid of Canada Ltd.	PE 2080	Spillimacheen R.	2 068	tailings pond effluent

TABLE 2

MINIMUM DILUTION RATIOS FOR THE MAIN EFFLUENT DISCHARGES

Permit Holder	Permit Number	Discharges To	Permitted Discharge m^3/d	Maximum Actual Discharge m^3/d	Stream Low Flow Estimate[1] m^3/s	Minimum Dilution Ratio[2]
1. Toby Creek Sub-basin						
Mountain Minerals Ltd.	PE 315	Toby Creek	1 310	2 985	0.72	21:1[5]
			(May 15-Nov. 15)			48:1[6]
Panorama Ski Hill Co. Ltd.	PE 5193	ground	1 090	161	1.3	103:1[7]
Village of Invermere	PE 3094	ground	1 710	1 975	1.48	65:1[7]
2. Columbia River: Toby Creek to Edgewater						
Regional Districts of East Kootenay/for:						
Radium Hot Springs STP	PE 4422	Columbia River	2 090	612	7.2	298:1
Edgewater STP	PE 4802	Columbia River	2 615 (May-Nov.)	assume permit compliance[4]	15.5[3]	512:1

[1] Low flow estimate, October to April minimum monthly average, 10 year return period.
[2] Minimum dilution ratios calculated from the low flow estimate together with either the permitted discharge or actual discharge, whichever is greater.
[3] Low flow estimate, May to November minimum monthly average, 10 year return period.
[4] No data for permitted period of discharge.
[5] Dilution ratio unlikely as the permitted period of discharge (May 15-November 15) is when flows in Toby Creek are significantly greater than the low flow estimate.
[6] Assumes discharge flows are in compliance.
[7] Minimum dilution ratios are irrelevant with ground disposal, unless treatment works are bypassed with direct discharge of sewage to Toby Creek.

TABLE 3

LICENSED WATER WITHDRAWALS IN THE TOBY CREEK SUB-BASIN

Location	Licensee	No. of Licenses	Category	Amount m^3/s	Duration
Toby Creek below Invermere	(farmer)	1	irrigation	0.054	summer
Taynton Creek	Panorama Ski Hill Co. Ltd.	1	waterworks	0.017	annual
Jumbo Creek	Mountain Minerals Ltd.	1	industrial	0.012	annual

TABLE 4

EFFLUENT MONITORING RESULTS FOR INVERMERE AND
RADIUM WATERWORKS DISTRICT SEWAGE TREATMENT PLANTS

Effluent		Invermere PE 3094				Radium Waterworks District PE 4422			
Sampling Period		April 1978 - March 1981				April 1978 - November 1982			
Characteristic	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N
BOD_5	mg/L	52	1	12	33	161	10	56.5	26
Chlorine Residual	mg/L	0	0	0	1	-	-	-	
Coliforms, Fecal	MPN/100 mL	14 000	0	18.7*	32	330 000	2 300	45 290*	8
Flow Rate	m^3/d	1 975	258	722	860	612	265	411	6
Nitrogen, Ammonia	mg/L	15.2	0.09	3.64	7	25.9	17.9	21.9	2
Nitrite/Nitrate	mg/L	9.4	0.04	2.50	7	0.03	<0.02	<0.025	2
Organic	mg/L	4	0.8	2.43	7	6.1	6.1	6.1	2
Total	mg/L	25.4	3.04	8.5	7	32.0	24.0	28.0	2
pH		10.4	7.9	9.1	13	7.7	7.3	7.5	10
Phosphorus, Dissolved	mg/L	5.6	0.2	3.1	7	5.1	3.3	4.2	2
Total	mg/L	5.9	0.7	3.5	7	5.7	4.5	5.1	2
Solids, Suspended	mg/L	118	3	21.9	33	209	5	47.0	26

All data are from Ministry of Environment data bank, EQUIS.
N = Number of values.
* = Geometric mean.

TABLE 5

MOUNTAIN MINERALS LTD. TAILINGS POND MONITORING RESULTS MAY 1978 TO DECEMBER 1982

Site Number		PE 315					Pollution Control
Characteristic / Type of Value		Max.	Min.	Mean	Number Of Values	Permit Limits	Objective Levels[1]
Cadmium, Dissolved	µg/L	2.5	2.4	2.45	2		10-100
Copper, Dissolved	µg/L	30	<1	<7.1	10	50	50-300
Flow Rate	m^3/d	2 985	0	1 237	260	1 310 (average)	
Iron, Dissolved	mg/L	0.39	0.02	.085	10	0.30	0.30-1.0
Lead, Dissolved	µg/L	310	4	76	10	50	50-200
Nickel, Dissolved	µg/L	58	15	36	5		200-1,000
pH		8.1	7.6	7.8	10	6.5-8.5	6.5-10
Solids, Dissolved	mg/L	1 101	399	691	5	2 500	2 500-5 000
Suspended	mg/L	73	2.8	21.1	10	50	25-75
Sulphate, Dissolved	mg/L	456	177	388	7	250	
Zinc, Dissolved	mg/L	3.08	1.02	1.90	5	3.0	0.2-1.0

Data are from Ministry of Environment's data bank, EQUIS

[1]Pollution Control Objectives for the Mining, Smelting and Related Industries of B.C. Pollution Control Board, February 1979.

TABLE 6

EFFLUENT MONITORING RESULTS, PANORAMA SKI HILL CO. LTD.
MARCH 4, 1981 TO JUNE 2, 1982

Site Number		Panorama Ski Hill PE 5193				Permit Limits
Characteristic / Type of Value		Max.	Min.	Mean	N	
pH		8.3	7.2	7.8	4	
Total Suspended Solids	mg/L	23.6	1	8.3	12	≦10
NO_2/NO_3-N	mg/L	19.5	18.1	18.8	2	
Flow	m^3/day	161.4	33.9	94.2	8	1 090
BOD_5	mg/L	22	2	9	12	≦10
Phosphorus, Ortho	mg/L	7.85	4.52	6.19	2	
Phosphorus, Dissolved	mg/L	8.0	4.67	6.34	2	
Phosphorus, Total	mg/L	8.27	4.72	6.50	2	
Fecal Coliforms	MPN/100 mL	>2 400	540	*1 300.6	4	

Data from Ministry of Environment data bank, EQUIS.
N = Number of values.
* = Geometric mean.

TABLE 7

SUMMARY OF PERMITTED, ACTUAL, AND PROJECTED FUTURE WASTE LOADS TO GROUND FOR PE 5193 (PANORAMA SKI HILL CO. LTD.) AND PE 3094 (VILLAGE OF INVERMERE)

Characteristic	Permit Conditions		Present Conditions		Projected Loading For 1992-2001 kg/d *[2]
	Level or Concentration	Loading kg/d	Maximum Level or Concentration	Maximum Present Daily Loadings kg/d *[1]	
PE 5193 Panorama Ski Hill Co. Ltd.					
Flow	1 090 m^3/d		161 m^3/d		1 090 m^3/d*[3]
BOD_5	10 mg/L	10.9	22 mg/L	3.5	10.9*[3]
Solids, Suspended	10 mg/L	10.9	23.6 mg/L	3.8	10.9*[3]
Phosphorus, Dissolved	-	-	8.0 mg/L	1.3	NA
NO_2/NO_3-N	-	-	19.5 mg/L	3.1	NA
PE 3094 Village of Invermere					
Flow	1 710 m^3/d		1975 m^3/d	-	2 960-3 950 m^3/d
BOD_5	45 mg/L	77	52 mg/L	102.7	150-210 *[3]
Solids, Suspended	60 mg/L	103	118 mg/L	233.1	350-470 *[3]
Nitrogen, Ammonia	-	-	15.2 mg/L	30.0	45-60
Organic	-	-	4.0 mg/L	7.9	12-16
Total	-	-	25.4 mg/L	50.2	75-100
Phosphorus, Total	-	-	5.9 mg/L	11.7	17.6-23.4

*[1] Calculated by multiplying maximum flow by maximum concentration; a conservative estimate of actual loadings.

*[2] Based on a projected 1992 population for:
a) PE 5193: 4 000, the design capacity of the sewage treatment plant
b) PE 3094 of 3000-4000, a 50-100% increase over the 1981 estimate.

*[3] Assuming permit compliance.

NA = not available.

TABLE 8

DESCRIPTION OF WATER SAMPLING SITES IN THE COLUMBIA RIVER, TOBY CREEK, SINCLAIR CREEK, AND THE SPILLIMACHEEN RIVER

Site Number	Description
	Columbia River Downstream from Toby Creek
0200225	Columbia River 2.5 km downstream from Toby Creek.
0200232	Columbia River just upstream from Radium Waterworks District sewage treatment plant.
0200233	Columbia River 2 km downstream from Radium Waterworks District sewage treatment plant.
	Toby Creek
1190075	Jumbo Creek upstream from old Mineral King Mine.
0200055	Toby Creek upstream from old Mineral King Mine and Mountain Minerals Ltd.
0200054	Toby Creek downstream from old Mineral King Mine and Mountain Minerals Ltd.
0200333	Toby Creek upstream from the Panorama sewage treatment plant.
0200334	Toby Creek downstream from the Panorama sewage treatment plant.
0200223	Toby Creek upstream from Invermere sewage lagoons.
0200224	Toby Creek downstream from Invermere sewage lagoons.
	Sinclair Creek
0200053	Sinclair Creek upstream from the Radium sewage lagoons at the highway 95 crossing.
0200094	Sinclair Creek downstream from the Radium sewage lagoons.
	Spillimacheen River
0500429	Spillimacheen River downstream from Baroid Mine outfall.
0500428	Spillimacheen River, upstream from Baroid Mine.
0500086	Vermont Creek, upstream from Ruth Vermont Mine.
0500087	Vermont Creek, downstream from Ruth Vermont Mine.

TABLE 9

UPPER TOBY CREEK WATER QUALITY
MAY 1978 TO SEPTEMBER 1978

Site Number		0200055				0200054			
Site Description		Toby Creek upstream Mountain Minerals				Toby Creek downstream Mountain Minerals			
Characteristic / Type of Value		Max.	Min.	Mean	N	Max.	Min.	Mean	N
Copper, Dissolved	µg/L	1	1	1	1	1	1	1	2
Total	µg/L	5	5	5	1	5	5	5	1
Iron, Dissolved	mg/L	<0.1	<0.1	<0.1	2	<0.1	<0.1	<0.1	2
Lead, Dissolved	µg/L	<1	<1	<1	2	<1	<1	<1	2
Total	µg/L	5	5	5	1	4	4	4	1
Nitrogen, Ammonia	mg/L	<0.005	<0.005	<0.005	2	0.006	<0.005	<0.005	2
Nitrite/Nitrate	mg/L	0.11	0.11	0.11	2	0.1	0.02	0.06	2
pH		8.1	8	8.05	2	8.2	8.1	8.15	2
Phosphorus, Total	µg/L	69	12	40.5	2	53	9	31	2
Solids, Suspended	mg/L	152	19	85.5	2	120	13	66.5	2
Sulphate, Dissolved	mg/L	8.1	8.1	8.1	1	8.1	8.1	8.1	1
Turbidity	N.T.U.	20	8.5	14.3	2	22	6	14	2
Zinc, Dissolved	µg/L	<5	<5	<5	1	7	5	6	2
Total	µg/L	<5	<5	<5	1	<5	<5	<5	1

N = Number of values.
Data from Ministry of Environment's data bank, EQUIS.

TABLE 10

LOWER TOBY CREEK WATER QUALITY, PANORAMA
APRIL 1978 TO NOVEMBER 1982

Site Description	Toby Creek upstream Panorama STP 0200333				Toby Creek downstream Panorama STP 0200334			
Characteristic / Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Nitrogen, Ammonia µg/L	7	<5	<5.5	4	13	<5	<8.5	4
Nitrite/Nitrate mg/L	0.23	0.06	0.14	5	0.23	0.06	0.14	5
Organic mg/L	0.19	0.01	0.08	4	0.13	0.01	0.08	4
pH	8.2	8.0	8.12	5	8.2	8.1	8.14	5
Phosphorus, Dissolved µg/L	4	4	4	1	5	5	5	1
Total µg/L	18	18	18	1	20	20	20	1

N = Number of values.
Data are from Ministry of Environment's data bank, EQUIS.

TABLE 11

LOWER TOBY CREEK WATER QUALITY, INVERMERE
APRIL 1978 TO NOVEMBER 1978

Site Description		Toby Creek upstream Invermere Lagoons 0200223				Toby Creek downstream Invermere Lagoons 0200224			
Characteristic	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total	mg/L	133	52.6	91.6	7	133	52.6	86.9	7
Carbon, Total Organic	mg/L	2	<1	<1	7	2	<1	<1	7
Coliforms, Fecal	MPN/100 mL	9	<2	3*	7	<20	<2	3.6*	7
Color	T.A.C.	14	<1	<3.7	7	5	<1	<2.7	7
Nitrogen, Ammonia	µg/L	5	<5	<5	7	17	<5	7	7
Nitrite/Nitrate	mg/L	0.26	0.05	0.113	7	0.27	0.04	0.114	7
Organic	mg/L	0.07	<0.01	0.04	7	0.14	0.01	0.061	7
Total	mg/L	0.33	<0.06	0.15	7	0.41	0.05	0.18	7
Oxygen, Dissolved	mg/L	11.1	10.2	10.5	6	11.9	10.2	10.8	7
pH		8.2	8.0	8.13	7	8.2	8.1	8.17	7
Phosphorus, Total	µg/L	49	3	13.1	7	92	5	26.6	7
Solids, Dissolved	mg/L	184	184	184	1	190	190	190	1
Suspended	mg/L	105	2.0	27.7	6	226	2.0	62.8	6
Temperature	°C	9.0	3.0	6.3	6	9.0	4.0	6.6	7
Turbidity	NTU	38	0.8	9.3	7	42	4.1	14.5	7

Data are from Ministry of Environment's data bank, EQUIS.
N = Number of values.
* = Geometric mean.

TABLE 12

AMMONIA, PHOSPHORUS, SUSPENDED SOLIDS, AND TURBIDITY
IN LOWER TOBY CREEK, APRIL TO NOVEMBER 1978

Date	Total Ammonia (µg/L)		Total Phosphorus (µg/L)		Suspended Solids (mg/L)		Turbidity (NTU)	
	Site 0200223	Site 0200224	Site 0200223	Site 0200224	Site 0200223	Site 0200224	Site 0200223	Site 0200224
April 5	<5	17	5	14	-	-	1.8	2.1
May 10	<5	<5	12	10	15	12	3.3	3.3
June 22	-	<5	-	92	-	226	-	42
July 27	<5	10	49	44	105	99	38	34
August 24	<5	<5	12	13	29	26	16	14
September 27	<5	<5	7	8	12	12	4.1	4.9
October 25	5	<5	3	5	2	2	1.1	1.1
November 29	<5	-	4	-	3	-	0.8	-

Data from Ministry of Environment's data bank, EQUIS.

TABLE 13

WATER QUALITY FOR GROUNDWATER MONITORING WELLS, INVERMERE SEWAGE TREATMENT PLANT (PE 3094)

Sampling Site		0200357 (Control) NW of Infiltration Basins				0200354 SE Corner of Infiltration Basins				0200358 E of Infiltration Basins			
Characteristic	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
pH		8.2	8.1	8.15	2	8.4	8.2	8.3	2	8.3	8.1	8.2	2
Ammonia-N	mg/L	0.012	0.009	0.0105	2	0.008	0.005	0.0065	2	6.16	<0.005	<3.08	2
Nitrate/Nitrite-N	mg/L	0.19	0.17	0.18	2	0.57	0.48	0.525	2	1.48	0.43	0.96	2
Phosphorus, Ortho, Dissolved	mg/L	<0.003	<0.003	<0.003	2	<0.003	<0.003	<0.003	2	<0.003	<0.003	<0.003	2
Phosphorus, Total, Dissolved	mg/L	0.006	0.004	0.005	2	0.014	0.004	0.009	2	0.006	0.004	0.005	2
Phosphorus, Total	mg/L	0.122	0.005	0.064	2	0.138	0.006	0.072	2	0.009	0.005	0.007	2
		0200359 N of Infiltration Basins				0200360 SE of 0200358				0200361 Near 0200360			
pH		8.2	8.1	8.15	2	8.4	8.0	8.2	2	8.4	8.2	8.3	2
Ammonia-N	mg/L	4.12	0.007	2.06	2	0.008	<0.005	<0.006	2	0.01	0.007	0.0085	2
Nitrate/Nitrite-N	mg/L	0.038	0.023	0.03	2	0.46	0.25	0.36	2	0.12	0.11	0.115	2
Phosphorus, Ortho, Dissolved	mg/L	0.038	<0.003	<0.021	2	0.003	<0.003	<0.003	2	<0.003	<0.003	<0.003	2
Phosphorus, Total, Dissolved	mg/L	0.04	0.003	0.022	2	0.005	0.003	0.004	2	0.003	0.003	0.003	2
Phosphorus, Total	mg/L	0.051	0.015	0.033	2	0.012	0.009	0.011	2	0.005	0.004	0.0045	2

Data from Ministry of Environment's data bank, EQUIS.
N = Number of values.
All sites sampled March 4 and April 29, 1981.

TABLE 14

WATER QUALITY FOR GROUNDWATER MONITORING WELLS,
PANORAMA SEWAGE TREATMENT PLANT (PE 5193)
MARCH 4, 1982 TO FEBRUARY 23, 1983

Sampling Site		0200405 (Control) Below Standby Field #1				0200406 Below Center of Standby Field #2				0200407 Below East End of Standby Field #2			
Characteristic	Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
pH		8.3	7.9	8.10	3	8.1	7.9	8.0	3	7.9	7.5	7.7	3
Nitrate/Nitrite-N	mg/L	0.07	<0.02	0.038	4	16.2	4.0	10.5	4	20.2	11.3	17.5	4
Phosphorus, Ortho, Dissolved	mg/L	0.004	<0.003	-	4	<0.003	<0.003	<0.003	4	<0.003	<0.003	<0.003	4
Phosphorus, Total, Dissolved	mg/L	0.008	0.004	0.006	4	0.007	0.006	0.0065	4	0.008	0.005	0.0065	4
Phosphorus, Total	mg/L	0.105	0.010	0.035	4	0.014	0.009	0.011	4	0.114	0.006	0.047	4
Coliforms, Fecal	MPN/100 mL	<2	<2	<2	3	<2	<2	<2	3	2	<2	<2	2

Data from Ministry of Environment's data bank, EQUIS.
N = Number of values.

TABLE 15

LICENSED WATER WITHDRAWALS FROM SINCLAIR CREEK

LICENSEE	PURPOSE	AMOUNT	DURATION
Kirk Ltd.	Domestic	2.3 m^3/d	annual
Kirk Ltd.	Domestic	2.3 m^3/d	annual
	Irrigation	11 100 m^3	April 1 to Sept. 30
Canyon Campgrounds	Industrial (campground)	115 m^3/d	annual
Canyon Campgrounds	Domestic	2.3 m^3/d	annual
	Industrial (lawn watering)	12 330 m^3	April 1 to Sept. 30

TABLE 16

LICENSED WATER WITHDRAWALS IN THE COLUMBIA RIVER:
TOBY CREEK TO EDGEWATER

LICENSEE	PURPOSE	AMOUNT	DURATION	LOCATION
Indian Affairs Branch	Industrial (processing of gypsum)	623 m^3/d	annual	just north of Toby Creek
G.I. Amy*	Domestic	9.1 m^3/d	annual	just north of Horsethief Creek
	Industrial (restaurant)	13.6 m^3/d	annual	
	Industrial (watering lawns)	1.2×10^4 m^3	April 1 - September 30	
Radium Hot Springs Golf and Country Club Ltd.	Industrial (watering golf course)	1.9×10^5 m^3	April 1 - September 30	south of Radium Hot Springs

*Currently used for domestic purposes at a children's amusement park.

TABLE 17

SUMMARY OF PERMITTED, ACTUAL, AND PROJECTED WASTE LOADINGS FOR THE SEWAGE TREATAMENT PLANTS AT RADIUM HOT SPRINGS (PE 4422) AND EDGEWATER (PE 4802)

CHARACTERISTIC	PERMIT CONDITIONS		PRESENT CONDITIONS		PROJECTED LOADING FOR YEAR 1991 Kg/d
	LEVEL OR CONCENTRATION	LOADING kg/d	MAXIMUM LEVEL OR CONCENTRATION	MAXIMUM PRESENT DAILY LOADINGS Kg/d	
PE 4422 Radium Hot Springs Sewage Treatment Plant					
Flow	2090 m^3/d	--	350 m^3/d Winter[1]	--	490 m^3/d Winter[3]
			1110 m^3/d Summer[2]	--	2270 m^3/d Summer[4]
BOD$_5$	45 mg/L	94	Winter max. = 86 mg/L	Winter max. = 30	Winter = 23[5]
			mean = 41 mg/L	mean = 14	
			Summer max. = 161 mg/L	Summer max. = 180	Summer = 103[5]
			mean = 86 mg/L	mean = 96	
Solids, suspended	60 mg/L	125	Winter max. = 117 mg/L	Winter max. = 41	Winter = 30[5]
			mean = 35 mg/L	mean = 12	
			Summer max. = 105 mg/L	Summer max. = 118	Summer = 137[5]
			mean = 84 mg/L	mean = 94	
Ammonia-N	--	--	Winter max. = N.A.	Winter max. = N.A.	Winter = N.A.
			mean = N.A.	mean = N.A.	
			Summer max. = 25.9 mg/L	Summer max. = 28.7	Summer = 58/7[6]
			mean = 21.9 mg/L	mean = 24.3	
Nitrate-N	--	--	Winter max. = 0.13 mg/L	Winter max. = 0.046	Winter = 0.064[6]
			mean = 0.06 mg/L	mean = 0.021	
			Summer max. = 0.03 mg/L	Summer max. = 0.033	Summer = 0.067[6]
			mean =<0.02 mg/L	mean = <0.022	
P-ortho	--	--	Winter max. = 5.52 mg/L	Winter max. = 1.93	Winter = 2.70[6]
			mean = 4.70 mg/L	mean = 1.65	
			Summer max. = 5.07 mg/L	Summer max. = 5.63	Summer = 11.51[6]
			mean = 3.62 mg/L	mean = 4.02	
P-total	--	--	Winter max. = 6.75 mg/L	Winter max. = 2.36	Winter = 3.30[6]
			mean = 6.02 mg/L	mean = 2.11	
			Summer max. = 5.65 mg/L	Summer max. = 6.27	Summer = 12.82[6]
			mean = 4.62 mg/L	mean = 5.13	
PE 4802 Edgewater Sewage Treatment Plant					
Flow	2615 m^3/d (May 1-Nov. 30)	--	(1635 m^3/d)[7]	--	(1635 m^3/d)[8]
BOD$_5$	30 mg/L	78.5	NA	50[9]	50[8]
Solids, Suspended	30 mg/L	78.5	NA	50[9]	50[8]

[1]Estimate, based on: (1982 winter population) x 0.36 m^3 of effluent/person/day
= (965 people) x 0.36 m^3/person/day
= 350 m^3/day

[2]Estimate, based on: (1982 summer population) x 0.36 m^3 of effluent/person/day
= (3085 people) x 0.36 m^3/person/day
= 1110 m^3/d

[3]Estimate, based on: (1991 winter population) x 0.36 m^3/person/day
= (1370 people) x 0.36 m^3/person/day
= 490 m^3/d

[4]Estimate, based on: (1991 summer population) x 0.36 m^3/person/day
= (6300 people) x 0.36 m^3/person/day
= 2270 m^3/d

[5]Assumes permit compliance for levels of BOD_5 and suspended solids, together with estimated 1991 flows.

[6]Projection based on maximum recorded historic data and estimated 1991 effluent flow.

[7]Flow estimate based on: 1981 population x 0.36 m^3/person/day
= 345 people x 0.36 m^3/person/day
= 125 m^3/day or 45 800 m^3/year

Sewage is held in retention lagoons, with effluent discharge permitted for two periods of two weeks each (28 days from May to November) or 1635 m^3/day.

[8]Population projection for 1991 is for limited or no growth.

[9]Assumes permit compliance for levels of BOD_5 and suspended solids.

NA - not available

Note: (1) Population estimates used in calculations include only permanents and seasonals, not transient users such as gas station and restaurant customers.

(2) Population estimates for 1991 assume that present trends (increasing numbers of permanent residents, number of motels and private campgrounds) continue.

TABLE 18

THE EFFECT OF THE SEWAGE TREATMENT PLANT AT RADIUM HOT SPRINGS (PE 4422) ON COLUMBIA RIVER WATER QUALITY

CHARACTERISTIC	INCREMENTAL EFFECT ON COLUMBIA RIVER WATER QUALITY DURING[1]: 1982[2] WINTER (Low Flow 7.2 m^3/s)	1982[2] SUMMER (Low Flow 80 m^3/s)	1991[3] WINTER (Low Flow 7.2 m^3/s)	1991[3] SUMMER (Low Flow 8.0 m^3/s)
effluent dilution	1800:1 (actual)	6200:1 (actual)	1300:1	3000:1
BOD_5	0.048 mg/L	0.026 mg/L	0.035 mg/L	0.015 mg/L
Solids, suspended	0.066 mg/L	0.017 mg/L	0.047	0.020 mg/L
Coliforms, fecal	130 MPN/100 mL	40 MPN/100 mL	190 MPN/100 mL	80 MPN/100 mL
Ammonia-N, un-ionized	-[4]	<0.001 mg/L	-[4]	<0.001 mg/L
Nitrate-N	<0.001 mg/L	<0.001 mg/L	<0.001 mg/L	<0.001 mg/L
Phosphorus-ortho	0.003 mg/L	<0.001 mg/L	0.004 mg/L	0.002 mg/L
-total	0.004 mg/L	0.001 mg/L	0.005 mg/L	0.002 mg/L

[1] Assuming complete mixing of effluent and river water.
[2] Using actual maximum concentrations from Table 17.
[3] Assuming future concentrations within permitted limits.
[4] Insufficient data.

TABLE 19

COLUMBIA RIVER WATER QUALITY DOWNSTREAM FROM TOBY CREEK
JUNE 1978 TO NOVEMBER 1978

SAMPLING SITE	COLUMBIA RIVER DOWNSTREAM TOBY CREEK 0200225				COLUMBIA RIVER U/S RADIUM STP 0200232				COLUMBIA RIVER D/S RADIUM STP 0200233			
Characteristic / Type of Value	Max.	Min.	Mean	N	Max.	Min.	Mean	N	Max.	Min.	Mean	N
Alkalinity, Total mg/L	126	92.5	109.3	2	103	59	81.9	3	103	59.1	82.6	3
Carbon, Total												
Organic mg/L	2	<1	<1.5	2	1	<1	<1	3	1	<1	<1	2
Coliforms, Fecal										2		
MPN/100 mL	5	<2	<3.2*	2	<20	7	<10.4*	3	50	5	20.2*	3
Colour T.A.C.	8	4	6	2	2	1	1.7	3	5	2	1.3	3
Copper, Total µg/L	<1	<1	<1	1	--	--	--	-	--	--	--	-
Iron, Total mg/L	0.2	0.2	0.2	1	--	--	--	1	--	--	--	-
Lead, Total µg/L	<1	<1	<1	1	--	--	--	-	--	--	--	-
Manganese, Total µg/L	<20	<20	<20	1	--	--	--	-	--	--	--	-
Nitrogen, Ammonia µg/L	22	12	17	2	15	<5	<9	3	16	6	11.3	3
Nitrate/Nitrite mg/L	0.07	0.03	0.05	2	0.09	0.04	0.06	3	0.1	0.03	0.06	3
Organic mg/L	0.11	0.09	0.1	2	0.14	0.06	0.09	3	0.19	0.03	0.09	3
Total mg/L	0.20	0.13	0.17	3	0.24	0.10	0.16	3	0.3	0.08	0.17	3
Oxygen, Dissolved mg/L	8.2	8.2	8.2	1	10.6	9	9.7	3	10.6	9.2	9.8	3
% saturation	83.7	83.7	83.7	1	91.9	81.9	90.9	2	90.2	90.0	90.1	2
pH	8.2	8.2	8.2	2	8.2	8.2	8.2	2	8.3	8.2	8.25	3
Phosphorus, ortho µg/L	<3	<3	<3	2	<3	<3	<3	3	4	<3	<3.3	3
Total µg/L	11	6	8.5	2	76	10	44.7	3	64	16	44.3	3
Solids, Suspended mg/L	16	3	9.5	2	149	14	79	3	157	17	82	3
Temperature °C	12.5	12.5	12.5	1	12	5	9.2	3	12	5	9.2	3
Turbidity NTU	5.8	1.7	3.8	2	46	7.5	26.8	3	50	6.9	28.3	3
Zinc, Total µg/L	<5	<5	<5	1	--	--	--	-	--	--	--	-

Data are from Ministry of Environment's Data Bank, EQUIS
* = Geometric Mean

TABLE 20

COLUMBIA RIVER WATER QUALITY, DOWNSTREAM FROM TOBY CREEK JUNE 1976 TO NOVEMBER 1978

DATE	CHARACTERISTIC											
	Fecal Coliforms (MPN/100 mL)			Suspended Solids (mg/L)			Turbidity (NTU)			Phosphorus, Total (µg/L)		
	0200225	0200232	0200233	0200225	0200232	0200233	0200225	0200232	0200233	0200225	0200232	0200233
June 8, 1976	49	--	--	--	--	--	--	--	--	--	--	--
June 9	--	--	--	--	--	--	--	--	--	57	--	--
August 17	--	--	2	--	--	--	--	--	--	--	--	30
September 20	<2	--	2	--	--	--	--	--	--	10	--	16
January 26, 1977	<2	--	130	--	--	--	--	--	--	6	6	6
April 26	--	17	240	--	--	--	--	--	--	--	9	135
June 14	5	2	79	--	--	--	--	--	--	26	36	--
June 15	--	--	--	--	--	--	--	--	--	--	--	54
July 20	--	--	11	--	--	--	--	--	--	--	--	--
September 20	<2	--	--	--	--	--	--	--	--	9	9	9
November 8	2	--	5	--	--	--	3.1	2.8	2.4	10	9	9
December 13	--	--	31	--	4	3	--	0.9	1.9	--	9	10
February 9, 1978	--	--	--	--	--	--	1.4	--	--	9	--	--
March 15	--	2	--	--	--	--	--	3.2	3.9	--	8	11
June 21	--	<20	50	--	74	72	--	27	28	--	48	53
July 27	--	8	33	--	149	157	--	46	50	--	76	64
August 24	5	--	--	16	--	--	5.8	--	--	11	--	--
October 25	--	7	5	--	14	17	--	7.5	6.9	--	10	16
November 29	<2	--	--	3	--	--	1.7	--	--	6	--	--

Data are from Ministry of Environment's Data Bank, EQUIS

TABLE 21

RECOMMENDED ROUTINE WATER QUALITY MONITORING FOR TOBY CREEK AND THE UPPER COLUMBIA RIVER

SITES	FREQUENCY AND TIMING	CHARACTERISTICS TO BE MEASURED
TOBY CREEK		
Mountain Minerals pond effluent (PE 315)	Twice per year, October to November if mine re-opens	Flow, pH, suspended solids, temperature, Ba, Cd, Cu, Pb, Zn
Toby Creek Sites 0200055 (upstream) 0200054 (down-stream from Mountain Minerals)	Same as Mountain Minerals effluent	Same as Mountain Minerals effluent
Panorama STP effluent (PE 5193)	3 times per year in the winter	Flow, BOD_5, suspended solids, fecal coliforms, turbidity, NO_3-N, NO_2-N, NH_3-N, organic-N, dissolved ortho-P, total dissolved-P, total-P
Groundwater wells near Panorama STP	3 times per year in the winter	Fecal coliforms, NO_3-N, NO_2-N, NH_3-N, dissolved ortho-P. total dissolved-P, total-P, temperature, pH
Toby Creek Sites 0200333 (upstream) 0200334 (down-stream from Panorama)	3 times per year in the winter	Flow, suspended solids, fecal coliforms, turbidity, NO_3-N, NO_2-N, NH_3-N, dissolved ortho-P, total dissolved-P, total-P, temperature, pH
Invermere STP effluent (PE 3094)	every 2 months, year-round	Same as for Panorama STP effluent
Groundwater wells near Invermere STP	every 2 months, year-round	Same as for Panorama ground-water wells
Toby Creek Sites 0200223 (upstream) 0200224 (down-stream from Invermere)	every 2 months, year-round	Visual monitoring for peri-phyton. If P breakthrough or direct discharge then sample as for Panorama sites

...continued

TABLE 21 (Continued)

SITES	FREQUENCY AND TIMING	CHARACTERISTICS TO BE MEASURED
COLLUMBIA RIVER		
Columbia River Site 0200225 (downstream Toby Creek)	Once in winter, once in summer	Fecal Coliforms
Radium Hot Springs STP effluent (PE 4422)	Once in winter, once in summer	Flow, BOD_5, suspended solids, fecal coliforms
Columbia River Sites 0200232 (upstream) 0200233 (downstream from Radium Hot Springs STP)	Once in winter, once in summer	Fecal coliforms
Edgewater STP effluent (PE 4802)	2 times per year, May to November	Same as for Radium Hot Spring STP effluent
Columbia River Sites upstream and downstream from the Edgewater discharge	2 times per year, May to November	Fecal coliforms

Note: Sampling frequency may be changed to check objectives, depending on circumstances.

TABLE 22

LICENSED WATER WITHDRAWALS IN THE SPILLIMACHEEN RIVER SUB-BASIN

LOCATION	LICENCEE	NO. OF LICENCES	PURPOSE	AMOUNT	DURATION
Near mouth at Columbia River	S.J. Stewart	1	Irrigation	333 000 m^3	April 1 - September 30
Near mouth at Columbia River	B.C. Hydro & Power Authority	1	Power Generation	8.5 m^3/s	Annual
Vermont Ck.	Ruth Vermont Mines Ltd.	1	Industrial (campsite drinking water) Mining	15.9 m^3/d 1 640 m^3/d	Annual

TABLE 23

EFFLUENT MONITORING RESULTS, RUTH VERMONT MINES LTD.
JULY 1972 TO AUGUST 1982

SITE NUMBER			PE 448					
Characteristic			Type of Value				Permit Limits	
			Max.	Min.	Mean	N	Before July, 1981	After July, 1981*
pH			8.8	7.1	8.2	8	7.5 - 10.0	6.5 - 10
Solids	Total	mg/L	252	106	179	7		
	Suspended	mg/L	39	1	8.3	7	50.0	50.0
Oxygen	Dissolved	mg/L	9.6	3.5	6.6	2		
Alkalinity	Total	mg/L	87	47	67	6		
Chloride	Dissolved	mg/L	5.2	0.5	3.3	3		
Cyanide	Total	mg/L	2.7	<0.01	0.7	7	0.04	0.1 (dissolved)
Sulphate	Dissolved	mg/L	99.1	36.1	68.9	5		
Arsenic	Dissolved	mg/L	<0.25	<0.005	<0.09	3	0.24	0.1
	Total	mg/L	<0.25	<0.005	<0.007	4		
Boron	Dissolved	mg/L	<0.01	-	-	1		
Cadmium	Dissolved	mg/L	<0.01	-	-	1		
	Total	mg/L	<0.01	<0.0005	<0.003	4		
Calcium	Dissolved	mg/L	29.5	-	-	1		
	Total	mg/L	33	25	29	4		
Copper	Dissolved	mg/L	0.01	<0.01	<0.01	2	0.1	0.05
	Total	mg/L	4.8	<0.001	1.2	7		
Iron	Dissolved	mg/L	0.14	0.06	0.10	2		
	Total	mg/L	0.4	<0.1	0.3	7		
Lead	Dissolved	mg/L	<0.1	0.016	<0.058	2	0.2	0.05
	Total	mg/L	0.1	0.01	0.06	7		
Magnesium	Dissolved	mg/L	6.1	-	-	1		
	Total	mg/L	12.7	6.7	8.8	5		
Manganese	Dissolved	mg/L	0.06	-	-	1		
	Total	mg/L	1.07	0.09	0.6	5		
Zinc	Dissolved	mg/L	0.6	0.02	0.31	2	0.08	0.2
	Total	mg/L	0.82	<0.005	<0.23	7		
Aluminum	Dissolved	mg/L	<0.02	-	-	1		
	Total	mg/L	<0.02	-	-	1		
Cobalt	Dissolved	mg/L	<0.1	-	-	1		
	Total	mg/L	<0.1	-	-	1		
Barium	Dissolved	mg/L	<0.01	-	-	1		
Vanadium	Dissolved	mg/L	<0.01	-	-	1		
	Total	mg/L	<0.01	-	-	1		
Flow		m^3/d	-	-	-	-	1310	1310

Data from Ministry of Environment's data bank, EQUIS
N = number of values
* if the mine re-opens

TABLE 24

VERMONT CREEK WATER QUALITY
JULY 1972 TO JUNE 1979

Sampling Site / Type of Value / Characteristic			Vermont Creek, Upstream Ruth Vermont Mines 0500086				Vermont Creek, Downstream Ruth Vermont Mines 0500087			
			Max.	Min.	Mean	N	Max.	Min.	Mean	N
pH			8.1	7.7	7.9	7	8.1	7.3	7.9	10
Solids	Total	mg/L	104	60	81	7	118	46	92	9
	Dissolved	mg/L	56	-	-	1	106	52	75	3
	Suspended	mg/L	6	<1	<2.7	6	16	1	4.8	8
Temperature		°C	14	0.5	5	4	8	0.5	3.9	6
Oxygen	Dissolved	mg/L	12	6	9	2	11.2	6	8.6	2
Alkalinity	Total	mg/L	71.6	42	58.4	6	77	47	64.2	8
Cyanide	Total	mg/L	<0.01	<0.01	<0.01	7	0.03	<0.01	<0.013	9
Nitrogen	Ammonia	µg/L	-	-	-		7	<5	<6.5	2
	NO_2/NO_3	mg/L	-	-	-		0.76	0.23	0.52	3
	Organic	mg/L	-	-	-		0.18	<0.01	<0.09	2
	Total	mg/L	-	-	-		0.76	0.41	0.58	3
Phosphorus	Total	µg/L	3	-	-	1	14	<3	<7	4
Silica	Dissolved	mg/L	2.7	1.8	2.5	5	3.7	2.3	3.2	7
Sulphate	Dissolved	mg/L	19.1	9.7	14.4	5	21.7	6.8	16.0	6
Arsenic	Dissolved	µg/L	<5	<5	-	2	6	<5	<5.5	2
Calcium	Dissolved	mg/L	-	-	-		22.5	-	-	1
Copper	Dissolved	µg/L	3	-	-	1	1	<1	<1	2
	Total	µg/L	8	<1	<3	6	40	<1	<12	8
Iron	Dissolved	mg/L	<0.02	-	-	1	0.04	0.02	0.03	2
	Total	mg/L	1.2	<0.1	<0.3	6	0.6	<0.1	<0.3	8
Lead	Dissolved	µg/L	7	-	-	1	5	5	5	2
	Total	µg/L	240	8	74	6	100	3	24	8
Magnesium	Dissolved	mg/L	-	-	-		8.5	-	-	1
	Total	mg/L	7.1	4.7	6	4	9.5	5.8	7.5	5
Manganese	Dissolved	mg/L	-	-	-		0.02	-	-	1
	Total	mg/L	<0.02	<0.02	<0.02	4	0.03	<0.02	<0.024	5
Potassium	Dissolved	mg/L	.0.1	0.1	0.1	2	0.3	0.1	0.2	3
Sodium	Dissolved	mg/L	1.3	0.3	0.64	5	1.1	0.4	0.8	6
Zinc	Dissolved	mg/L	0.02	-	-	1	0.13	0.02	0.08	2
	Total	mg/L	0.51	<0.005	<0.164	6	0.18	0.04	0.10	8
Hardness	Total	mg/L	-	-	-		91.2	-	-	1

Data from Ministry of Environment's data bank, EQUIS
N = number of values

TABLE 25

COPPER, ZINC, AND LEAD IN VERMONT CREEK
JULY 1972 TO JUNE 1979

DATE	UPSTREAM FROM RUTH VERMONT MINES SITE 0500086						DOWNSTREAM FROM RUTH VERMONT MINES SITE 0500087					
	Copper (μg/L)		Zinc (μg/L)		Lead (μg/L)		Copper (μg/L)		Zinc (μg/L)		Lead (μg/L)	
	Dissolved	total	Dissolved	total	Dissolved	total	Dissolved	total	Dissolved	total	Dissolved	total
July 25, 1972	3	-	20	-	7	-	<1	-	20	-	5	-
May 10, 1973	-	-	-	-	-	-	1	-	130	-	5	-
Oct.16, 1975	-	2	-	110	-	62	-	20	-	80	-	25
May 17, 1976	-	8	-	510	-	240	-	<1	-	40	-	10
Aug. 17, 1976	-	3	-	40	-	22	-	30	-	180	-	100
Oct. 20, 1976	-	4	-	160	-	100	-	40	-	130	-	25
July 19, 1977	-	1	-	5	-	8	-	2	-	70	-	10
Oct. 19, 1977	-	<1	-	160	-	10	-	<1	-	150	-	3
May 24, 1978	-	-	-	-	-	-	-	<1	-	130	-	4
June 18, 1979	-	-	-	-	-	-	-	1	-	50	-	17

TABLE 26

EFFLUENT MONITORING RESULTS, BAROID OF CANADA LTD.
SEPTEMBER 1972 TO OCTOBER 1973

SITE NUMBER			PE 2080				Permit Limits
Characteristic / Type of Value			Max.	Min.	Mean	N	
pH			8.2	7.6	7.96	5	6.5 - 8.5
Solids	Total	mg/L	412	122	272.4	7	800
	Suspended	mg/L	91	7.3	25.3	7	100
Cyanide	Total	mg/L	0.02	<0.01	0.012	5	
Copper	Dissolved	mg/L	0.05	0.008	0.03	6	<0.05
Iron	Dissolved	mg/L	0.1	<0.03	0.06	6	<0.1
Lead	Dissolved	mg/L	0.5	0.05	0.14	6	0.1
Zinc	Dissolved	mg/L	1.7	0.2	0.84	6	0.5
Barium	Dissolved	mg/L	2.1	<0.1	0.64	5	
	Total	mg/L	1	0.2	0.63	4	
Flow		m^3/d	-	-	1125 (in 1973)	-	1680 mean 2070 max.

Data from Ministry of Environment's data bank, EQUIS
N = number of values

TABLE 27

SPILLIMACHEEN RIVER WATER QUALITY SEPTEMBER 1972 TO OCTOBER 1973

Sampling Site / Characteristic	Type of Value		Spillimacheen River Upstream Baroid Mine 0500428				Spillimacheen River Downstream Baroid Mine 0500429			
			Max.	Min.	Mean	N	Max.	Min.	Mean	N
pH			8.8	7.4	8.3	4	8.6	7.6	8.15	4
Solids	Total	mg/L	213	74	118	5	252	70	128.8	5
	Dissolved	mg/L	170	67.8	101.4	5	206	63.5	109.3	5
	Suspended	mg/L	43	6.2	16.6	5	46	6.5	19.5	5
Temperature		°C	8	-	-	1	8	6.2	7.1	2
Oxygen	Dissolved	mg/L	10.3	-	-	1	10	-	-	1
Cyanide	Total	µg/L	20	10	17.5	4	20	<10	-	4
Sulphate	Dissolved	µg/L	12	-	-	1	12	-	-	1
Copper	Dissolved	mg/L	0.05	<0.001	<0.034	5	0.05	0.001	0.034	5
Iron	Dissolved	mg/L	0.1	<0.03	<0.062	5	0.1	0.03	0.06	5
Lead	Dissolved	µg/L	400	6	115	5	400	<3	-	5
Zinc	Dissolved	µg/L	0.1	<0.02	<0.042	5	100	<5	<36	5
Barium	Dissolved	mg/L	0.2	0.1	0.175	4	0.3	<0.1	<0.2	4
	Total	mg/L	0.2	0.1	0.15	4	0.2	<0.1	<0.13	4

Data from Ministry of Environment's data bank, EQUIS
N = number of values