DEPARTMENT OF ENVIRONMENT

KOOTENAY
AIR AND WATER QUALITY STUDY
PHASE I

WATER QUALITY IN REGION SEVEN
THE UPPER COLUMBIA RIVER BASIN

WATER RESOURCES SERVICE

WATER INVESTIGATIONS BRANCH

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SUMMARY

This report is an evaluation of the data available up to September, 1975, on the water quality of the Upper Columbia River Basin. It is one of a series of 12 similar reports which assess air and water quality in the Kootenay region. These reports constitute Phase I of the Kootenay air and water quality study.

The Columbia River originates in this region at Columbia Lake, and travels north through the region via Windermere Lake and the Columbia River Flats. Industry in the area consists of small, numerous logging operations, four small mines, and tourism.

Man's activity has generally had little influence on water quality and aquatic biology of the Columbia River system in the region. The possible diversion of part of the Kootenay River into the Columbia River at Canal Flats, after 1984, could increase water turbidity and flooding. The total impact of the diversion is being studied by B. C. Hydro.

Since water quality is generally good no extensive monitoring is planned. Localised problems associated with runoff from mining areas will be investigated and a better documentation of Columbia Lake water quality will be obtained. Results will be reported in a Phase II report for the area.

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Copies of this report may be obtained from the Environmental Studies Division, Water Investigations Branch, Water Resources Service, Parliament Buildings, Victoria, B.C.

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1. DESCRIPTION OF THE REGION

1.1 Introduction

The Upper Columbia River Basin has an area of 1970 square miles and is located in the north-eastern part of the Kootenay Study region. The region is mountainous, with the Purcell Mountains on the west and the Kootenay Ranges of the Rocky Mountains on the east. The Purcells and Rockies are separated by the Rocky Mountain Trench which varies in width from two to eight miles. The Trench lies mainly between the elevations of 2600 to 3400 feet and the mountains rise steeply on each side to alpine summits of 7500 to 10,500 feet(1). The drainage area of the basin forms the headwaters of the Columbia River. A map of the Upper Columbia River Basin is shown in Figure 7-1.

1.2 Climate

The Purcell and Rocky Mountains strongly influence the climatic pattern of the region. They act as barriers to the easterly movement of moist Pacific air masses, causing them to rise and release their moisture over the mountainous uplands. The heaviest falls of rain and snow occur on the western slopes(2).

The warmest and driest portion of the region lies along the Rocky Mountain Trench, which receives about 400 mm of precipitation annually, including 130 cm of snow per year. Temperatures average about 18°C in July and -9.5°C in January, while the frost-free period averages from 80 to 100 days(2).

To the east and west of the trench, the climate becomes progressively cooler and wetter as the slopes of the Rockies and Purcells are ascended. Precipitation in the Purcells can range up to an average of 1500 mm per year, including over 500 cm of snow. The Kootenay Ranges are drier, receiving up to 750 mm of precipitation annually, including up to 200 cm of snow. Mean temperatures in both the Purcells and Rockies are about 15.5°C in July and -12°C in January, but the frost-free period is longer in the Kootenay Ranges, averaging 80 days, compared to 60 days in the Purcells[2].

1.3 Geology

The Kootenay Ranges (Brisco and Stanford Ranges) of the Rocky Mountains occupy a narrow band, four to six miles wide, along the eastern boundary of the region. These ranges consist of a single northwesterly trending ridge, ranging in height from 5000 to 9000 feet, and characterized by geologic structures of great complexity[3]. The Stanford Range is composed mainly of limestone, limestone conglomerate, shale and phyllite[3,4], with a large gypsum deposit east of Windermere[1].

The Purcell Mountains occupy roughly two-thirds of the region, and form the western boundary of the drainage basin. They are a northwesterly trending group of peaks composed of thick quartzite, argillaceous quartzite, argillite and limestone beds with large granitic intrusions. The Purcells are extremely rugged in this area, with peaks of 9000 to 11,000 feet, many of which are capped with glaciers or icefields[3]. Minerals commonly found in the Purcells include lead, zinc, silver, copper, gold and barite ($BaSO_4$)[1].

The Rocky Mountain Trench, which lies between the Purcells and the Rockies, varies in width from two to eight miles and has the appearence of a wide, eroded valley with an uneven bottom[2]. The trench is essentially a longitudinal depression filled with very thick sedimentary, glacial and alluvial deposits[4]. The Columbia River occupies an almost flat-bottomed channel about one mile wide along the bottom of the Trench. The whole region has been strongly glaciated, resulting in sculptured bedrock, U-shaped main valleys and extensive deposits of glacial drift[5].

1.4 Soils and Vegetation

The soils in the region are mostly derived from glacial deposits. In the Rocky Mountain Trench, the channel of the Columbia River is flanked by stratified glacial lake silts between Canal Flats and Spillimacheen. Above the Columbia River channel, the surface of the Trench is comprised chiefly of lime-rich glacial till deposits with a rolling surface. The till on the east side of the Trench has been modified by large alluvial fans[1]. The gentler slopes of the valley walls are covered by glacial till, while on steeper slopes material eroded from the mountain sides covers the till or bedrock. Exposed bedrock predominates above 6500 feet[5,6].

Vegetation in the Rocky Mountain Trench below 3500 feet is generally typified by scattered stands of Douglas fir and small semi-open grasslands. Fire has resulted in the establishment of large tracts of lodgepole pine in some areas. Cottonwoods, aspen and white spruce are found on the floodplains and moist alluvial fans along the Columbia River. Climax forests of Engelmann spruce and alpine fir occur above 4000 feet and extend to the timberline at 6500 to 7000 feet. Transitional stands of lodgepole pine dominate in areas where logging or fire has occurred[5,6].

1.5 Hydrology

1.5.1 Streamflow

The Columbia River originates in Columbia Lake, and follows a very sluggish, meandering course northward along the bottom of the Rocky Mountain Trench, leaving the Kootenay Study Area just downstream from Spillimacheen. The reaches of the Columbia from Columbia Lake to Windermere Lake and from Windermere Lake to Spillimacheen and beyond are bordered by one-half to one mile of swamps and flood meadows known as the Columbia River Flats. These reaches are very nearly flat, with a gradient that seldom exceeds one foot per mile, and are flooded each year during the spring freshet[1].

The major left bank tributaries of the Columbia are Dutch Creek, Toby Creek, Horsethief Creek, Bugaboo Creek and the Spillimacheen River, which drain the eastern slope of the Purcells. The right bank tributaries of the Columbia drain small basins on the western slopes of the Kootenay Ranges which are not comparable in size to the left bank tributaries[8]. These tributaries transport sediments (fine, sandy and silty rock flour) derived from cirque glaciers in the high Purcells and Rockies. The sediments give the Columbia River its grayish, muddy colour[1].

The seasonal flow pattern of the Columbia is characterized by spring flood peaks during June and July, followed by a steady decline in flow during summer and fall. The minimum flows occur from December to March. Almost three-quarters of the annual flow in the Columbia occurs during May, June, July and August. The average annual flow in the Columbia River leaving the region at Spillimacheen is estimated to be above 4300 CFS (including the Spillimacheen River). The flows in the Columbia River at Fairmont Hot Springs, Edgewater and Golden are illustrated in Figure 7-2.

1.5.2 Lakes

Columbia Lake and Windermere Lake are the only major lakes in the Upper Columbia River Basin. These lakes are located in an old river channel that was probably eroded by the Kootenay River flowing northward in the Rocky Mountain Trench during the last glacial period. The channel is roughly one mile wide and 75 feet deep. The alluvial fans of the Kootenay River and Dutch Creek have dammed the old channel at Canal Flats and at Fairmont Hot Springs, creating Columbia Lake. Similarily, Windermere Lake was formed by the damming of the channel by the alluvial fans of Dutch Creek at Fairmont Hot Springs and Toby Creek at Athalmer[1].

Columbia Lake is nine miles long with a maximum width of one and one-half miles and an average width of about one mile. The lake has an area of ten square miles and a volume of 60,700 acre-feet at an elevation of 2652 feet. The lake is very shallow with a mean depth of nine and one-half feet and a maximum depth of 17 feet[9]. The lake level is about ten feet lower than the Kootenay River level at Canal Flats, and in the 1800's the Kootenay River did at times flow into Columbia Lake during the freshet[10]. A navigation canal with locks was built in the late 19th century to join Columbia Lake and the Kootenay River, but was abandoned one year later[10,11]. The level of Columbia Lake normally varies between the elevations of 2652 and 2657 feet.

Windermere Lake normally varies between the elevations of 2620 and 2625 feet and is nearly 11 miles long. The width of the lake is about two-thirds of a mile for much of its length. The area of the lake is about seven square miles (4500 acres) and the volume about 58,000 acre-feet at an elevation of 2623.5 feet. The lake is very shallow, with a maximum depth of 24 feet and an average depth of 12 feet[12,13].

1.5.3 Groundwater

The portion of the Rocky Mountain Trench which lies in Region 7 is reported to be an area in which groundwater flows of 50 to 500 gallons per minute are generally available[14]. The Trench contains numerous alluvial and glaciofluvial deposits which are likely to be sources of groundwater supply.

The records of the Groundwater Section of the Water Investigations Branch indicate that there are 182 groundwater wells in the region (50-75 percent of groundwater wells are on record with the Groundwater Section)[15]. All of these wells are located in the Rocky Mountain Trench adjacent to Columbia and Windermere Lakes, the Columbia River and its tributaries. Over half of the wells are located around Windermere Lake in the Invermere-

Athalmer-Windermere areas, and the rest of the wells are scattered along the Rocky Mountain Trench. The distribution of the wells in the region is shown in Table 7-1.

1.5.4 Dams and Diversions

The only major water resource project in the Upper Columbia River Basin is the Spillimacheen River Development which is owned by B.C. Hydro[16]. This project consists of an intake dam and powerhouse (installed capacity of 4 MW[16]) on the Spillimacheen River plus a diversion dam on Bugaboo Creek to divert it into the Spillamacheen River above the intake dam. The construction of the project began in 1953 and was completed in 1956[17]. The location of the project is shown in Figure 7-1.

Two potential water resource projects in the region involve diversions of the Kootenay River into the headwaters of the Columbia River. These diversions can increase power production since the potential head of the Columbia River power plants exceeds the head of the Kootenay River powerplants by 649 feet[18]. One project involves the diversion of up to 1,500,000 acre-feet of water per year from the Kootenay River into Columbia Lake at Canal Flats[18]. Under the Columbia River Treaty, Canada can make this diversion after September, 1984[18,19]. Another provision of the Columbia River Treaty allows for an additional diversion, in 2024, of the Kootenay River into the Columbia River[20], on condition that the flow of the Kootenay River at the Canada-U.S. border is not reduced below the lesser of 2,500 CFS or the natural flow.

Further details regarding these water resource projects are presented in section 3.2.3.

1.6 Water Uses

1.6.1 Water Licences

The water licences issued in the region by the Water Rights Branch of the B.C. Water Resources Service[21] indicate that licensed water usage is allocated as follows:

Water uses	Acre-feet per year
Domestic	4,440
Irrigation	17,190 (7360 acres irrigated)
Industrial	1,000
Power generation	260,700

The Village of Invermere, the Westside Improvement District, Luxor Creek Utilities, and the settlements of Windermere and Edgewater account for 87 percent of the licensed domestic water usage. The balance is distributed among many small users. Three mining operations: Mountain Minerals Ltd., Bariod of Canada Ltd., and Western Gypsum Ltd. account for over 98 percent of the licensed industrial water usage in the region. Water licenses on the Spillimacheen River and Bugaboo Creek, held by B.C. Hydro for its Spillimacheen River Development, represent 90 percent of the water usage allocated to power generation. The remaining 10 percent is accounted for by two small installations on Forster and Sinclair Creeks. All of the water licensed for irrigation purposes is used on lands that lie along the bottom of the Rocky Mountain Trench. The largest sources of irrigation water supplies in the region are Windermere, Shuswap, Frances, Kindersley, Tatley, Madias and Sophy Creeks.

The major sources of water supply within the region are shown in Table 7-2 which summarizes the water licenses for each major source. Only those sources with a licensed usage of 10,000 GPD (13 acre-feet per year) or more are included in the Table.

1.6.2 Water Availability

Since there is limited population and development in most areas, the supply of good quality water is usually adequate. In several scattered areas however, certain water sources have been fully recorded, which means that no more water is available from these sources. As shown in Table 7-3, these sources include Goldie, Ellenvale, Prust, Wilmer, Dry Gulch and Palmer Creeks[21]. A more detailed account of the water availability problems in Region 7 will be presented in the Phase II report of the Kootenay Study.

1.7 Settlements and Industrial Centres

The major settlements within the region are the Villages of Invermere, Windermere, Radium Hot Springs, and Edgewater. Their populations in 1971 were 1065, 421, 393, and 346, respectively[22,23]. The 1971 populations of other settlements within the region are listed in Table 7-4. The total population of the region in 1971 was estimated at 4000.

There are no major industrial centres within the region.

1.8 Land Use

The economy of the region depends on the forest industry, with lesser but important contributions made by tourism, agriculture and mining. The main forestry endeavors are production of lumber, and Christmas trees. The greatest tourist attractions are Kootenay National Park, Radium Hot Springs, Windermere Lake and Columbia Lake. Ranching and mixed farming are the major agriculturel activity[5].

1.8.1 Agriculture

Agriculture in the region is confined to the Rocky Mountain

Trench, and it is not extensive. Ranching is the main agricultural enterprise, with dairying, and the production of vegetables, potatoes and small fruits making lesser contributions. Most of the cultivated land is used for irrigated farming of hay and alfalfa. Agricultural potential in the region is limited by the small amount of arable land, lack of grazing land, and the short frost-free period in valleys other than the Rocky Mountain Trench[5].

Future agricultural expansion in the region could include utilization of natural range areas for grazing, and irrigation of valley soils in the Rocky Mountain Trench to produce winter feed, vegetables and small fruits. Future expansion will depend on the development of irrigation water supplies[5].

1.8.2 Forestry

The logging activities are confined to numerous, relatively small areas scattered throughout the region. The locations of existing logging operations are shown in Figure 7-3. Drainage basins which contain considerable areas of logging include Jumbo, Windermere, Horsethief, Forster, and Bugaboo Creeks[24].

1.8.3 Mining

Mining activity is relatively light in the Upper Columbia River Basin with only four producing mines at the present time. Three of these mines are owned by Mountain Minerals Ltd. and include: a barite concentrating plant on Toby Creek that is reprocessing the tailings of the old Mineral King mine; a small underground barite mine and surface quarry located between the Templeton River and Dunbar Creek, two and one half miles west of Brisco; and a shale quarry located two miles west of Canal Flats at the bottom of Thunder Hill. The remaining mine is a gypsum quarry located eight miles east of Windermere on the north side of Windermere Creek. It is owned by Western Gypsum Ltd.[25]

There are nine old mines in the region which were in production at various times between 1899 and 1967. Minerals produced included silver, lead, zinc, copper, cadmium, gold and barite. The largest producing mines were Mineral King and Paradise located along Toby Creek[26]. These two mines have abnormal drainage and are discussed in more detail in section 3.2.1.

The mineral potential of the region has been assessed by the B.C. Department of Mines and Petroleum Resources[26]. The region does not contain any areas with high mineral potential (Class 1), but does contain several areas with moderate potential (Class 2) for medium and small mineral deposits. The location of these areas and the minerals are: east of Lake Windermere (gypsum, copper, silver, lead, zinc and barite); between Toby and Horsethief Creeks (zinc, lead, silver, and copper); between the headwaters of Forster and Frances Creeks (molybdenum and copper); upper Frances Creek (silver, lead, zinc); between Dunbar Creek and Templeton River (magnesite); and in the post glacial outwash gravels along Bugaboo and Forster Creeks (niobium and uranium).

1.8.4 Recreation

a) The Rocky Mountain Trench

The area surrounding Columbia and Windermere Lakes is the most important for intensive water-oriented recreation in Region 7. North of Windermere Lake, most of the Rocky Mountain Trench has low recreational capability except for certain lakes and lower portions of Columbia River tributaries. Highway 95 provides the main access between Canal Flats and Golden.

Columbia and Windermere Lakes receive heavy recreational use because of their large size, central location and high scenic quality.

However, natural recreational capability is only moderate, due to fluctuating water levels, rough water, shallowness, limited number of sandy beaches, and aquatic plant infestations[27,28]. There is limited access and frontage along the west side of both lakes because of the Canadian Pacific Railway line. Activities concentrated around the north and east sides of both lakes include camping, cottaging, boating and angling. Of the two lakes, Windermere is more suitable for intensive recreational use, since it possesses more beaches and warmer waters.

Other localities with moderate recreational capability ratings include Fairmont Hot Springs (thermal spring), Whitetail Lake (boating, cottaging, angling), and other lakes such as Enid, Lillian and Cartwright (predominantly angling)[28]. Except for Windermere Lake, swimming is limited by cool water temperatures. Streams draining the eastern slopes of the Purcell Mountains provide scenic corridors into the upland. Lower sections of Spillimacheen River and Bugaboo, Forster and Dutch Creeks have good potential for streamside camping and angling, as well as local attractions such as hoodoos, waterfalls and canyons. However, boating is limited to the Columbia River

Most of the low-elevation lakes are fished and several have been stocked[29]. Species caught include trout (cutthroat, rainbow), char (Dolly Varden, eastern brook trout) and whitefish. There is a popular winter fishery for ling (freshwater cod) on Windermere and Enid Lakes. A list of important fishery locations is given in Table 7-5.

Provincial parks include Dry Gulch (72 acres) near Radium Junction and Thunder Hill (109 acres) near Canal Flats[30]. A corner of Kootenay National Park, centering on Sinclair Creek and extending to Radium Hot Springs, is contained in Region 7. This park was described in the phase I report for Region 3[31].

b) The Upland

Cool summers and heavy snowfall prevent intensive recreational use of the upland. Activities include camping, hiking, skiing, hunting and viewing of wildlife and mountain scenery. Glaciers are common in the Purcell Range.

Highly-rated upland in the Purcells include the headwaters of Bugaboo Creek below Bugaboo Glacier (including 655 acres of Bugaboo Glacier Provincial Park), upper Vowell Creek and tributaries below the Conrad Icefield, and Lake of the Hanging Glacier at the upper end of Horsethief Creek. Upper Fraling Creek in the Brisco Range is noted for wildlife viewing opportunities[28].

Several areas have good skiing potential but facilities are generally undeveloped. Developed skiing areas are located at Fairmont Hot Springs and Panorama Mountain.

1.8.5 Wildlife

Snow depth, particularly above 3500 feet, is the main factor determining wildlife distribution in Region 7. Highest C.L.I. capability ratings[32] are given to valleys below 4000 feet and to south-facing slopes. The Rocky Mountain Trench is the major wildlife-producing area. Ungulate species, in order of decreasing abundance, include deer, mountain goat, elk, moose and bighorn sheep. Black bear are common. Grizzly bear occur in remote areas. Ruffed, blue and Franklin grouse, and ptarmigan are upland game birds found in the region.

Small areas of Class 1 (C.L.I. rating) ungulate winter range are situated along the Kootenay National Park border south of Radium Hot Springs, around Columbia Lake, and to the east of Canal Flats. Ecological Reserve No. 20 is located near the southeast end of Columbia Lake. An important area of Class 2 ungulate (deer, elk) winter range extends along western slopes of the Brisco Range to Fairmont Hot Springs, the lower portion of Dutch Creek, and the west side of Columbia Lake. Other

Class 2 winter range (deer, elk, moose) is situated on the western and southern slopes of Steamboat Mountain, and near the confluences of Spillimacheen River and Horsethief Creek with the Columbia River. The rest of the Rocky Mountain Trench contains Class 3 winter range. Important Class 3 summer range at higher elevation is found along upper parts of Toby and Dutch Creeks, and the alpine meadows of the Brisco Range.

Upper Columbia River marshlands, ponds and lakes provide significant nesting or staging areas for migratory ducks, geese and swans[33]. In general, the floodplain is utilized for both production and migratory stop-over, with some limitation due to seasonal flooding. Windermere and Columbia Lakes and an area of floodplain near Fairmont Hot Springs, are used mainly as stop-over or feeding areas, and are less important for waterfowl production. Most of the smaller lakes along the west side of the Trench have moderate to low production capability because of small size, depth and restricted marsh edge[33].

2. INDUSTRIAL SOURCES OF EFFLUENT AND SOLID WASTE

The industrial sources of effluent in Region 7 are the mining operations of Mountain Minerals Ltd. on Toby Creek, and the sawmill-planer operation of Crestbrook Forest Industries Ltd. at Canal Flats. Mountain Minerals Ltd. is the only significant source of effluent and is discussed in section 2.1. Purcell Development operated an ore-dressing plant on Toby Creek during 1974-75, but this plant is now closed. Its operation is discussed briefly in section 2.2. Information regarding these effluent sources is summarized in Table 7-6.

The industrial sources of solid waste in Region 7 are several small sawmill-planer operations. These solid waste sources are discussed in section 2.3 and the information regarding their solid waste disposal sites is summarized in Table 7-8.

2.1 Mountain Minerals Ltd.

2.1.1 Description

Mountain Minerals Ltd. has operated a 360 ton/day barite concentrating plant at the confluence of Toby and Jumbo Creeks, 25 miles west of Invermere, since the spring of 1970[34]. The location of Mountain Minerals Ltd. is denoted in Figure 7-1 by its Pollution Control Permit No. 315. Purcell Development Ltd. operated a 200 ton/day silver-lead-zinc ore dressing plant on the same site as the Mountain Minerals operation during 1974-75 (Refer to section 2.2).

The barite concentrating plant reprocesses the tailings from a tailings pile left by the old Mineral King silver-lead-zinc mine. The old tailings pile is located one mile southwest of the plant adjacent to Toby Creek. A simplified flow diagram of the barite concentrating plant is shown in Figure 7-4. The old tailings are hauled to the plant by truck. A loading hopper feeds approximately 360 tons/day of old tailings to a mixing tank where it is slurried by adding 200 GPM of water. The slurry is pumped to a distributor and then passed over 15 Deister deck concentrating tables which separate the barite from the tailings by gravity. The middlings are reprocessed through the mixing tank and Deister tables. The barite concentrate is filtered and stockpiled for shipment. No milling reagents are introduced in the barite concentrating process[(34)].

The waste tailings from the Deister tables are pumped to a tailings impoundment located on top of an old Mineral King Mine tailings pond. The supernatant from the tailings impoundment is decanted under the tailings dam and into Toby Creek at an average rate of 288,000 GPD. Mill wash-down waters flow to a small settling pond adjacent to the plant. There is no positive discharge from this settling pond[(34)].

Pollution Control Permit No. PE-315 was issued to Mountain Minerals Ltd. on December 4, 1969 and subsequently amended on September 17, 1975. The amended permit authorizes the discharge to Toby Creek of an average of 288,000 GPD of tailings pond supernatant from May 15 to November 15. The effluent characteristics specified by the permit are summarized in Table 7-6. The permit also authorizes the discharge of an average of 50 GPD of typical wash-down water to a settling pond with no positive discharge[(34)].

Another source of effluent to Toby Creek is from the old Mineral King mine tailings pile adjacent to Toby Creek. The old tailings pile contains about 750,000 tons and extends right to the edge of Toby Creek for a distance of about one-quarter mile. Surface runoff from snowmelt and heavy rains has eroded the tailings pile in several locations, washing considerable amounts of tailings into Toby Creek[(34)]. The old tailings are not acidic (pH of 6.6 to 7.1)[(35)]. It has been reported that fine sediments, that could be tailings, have coated the bottom of Toby Creek near its mouth[(36)]. The Pollution Control Branch has asked Mountain Minerals Ltd. to review the situation at the old tailings pile and to make recommendations on how they propose to prevent the erosion of tailings into Toby Creek[34].

There have been no water licenses issued on Toby Creek. The Village of Invermere has filed an application for a water license for 10 million GPD from Toby Creek for a domestic water supply system[37].

2.1.2 Presentation of Effluent Sampling Data

The effluent from the Mountain Minerals Ltd. tailings pond has been sampled five times by the Pollution Control Branch between June 1973 and June 1975. The results of these samplings are summarized in Table 7-9. Effluent flow measurements were not made. A sample of the runoff from the old tailings of the Mineral King Mine, taken by the Water Investigations Branch on June 17, 1975, contained 0.44 mg/l total zinc. Runoff flow was 15 GPM.

The Pollution Control Branch has also sampled Toby Creek upstream (site 0200055) and downstream (site 0200054) from Mountain Minerals Ltd. These data are presented and discussed in Chapter 4 on water quality.

2.1.3 Discussion and Recommendations

Effluent sampling data in Table 7-9 indicate that the effluent quality was equivalent to or better than Level A of the Mining Objectives[38], with the exception of zinc, manganese and sulphate which lay between Levels A and B. The effluent characteristics were within the limits specified by PE-315 (as amended on September 17, 1975). The only effluent characteristic of potential concern was dissolved zinc (0.43-2.5 mg/l). At a flow rate of 288,000 GPD the quantity of dissolved zinc entering Toby Creek was relatively small (1.2-7.2 lb/day). The effect of the discharge on the water quality of Toby Creek is discussed in Chapter 4.

The tailings pond effluent was not the only source of zinc entering

Toby Creek in this area. The runoff from the old Mineral King tailings contained 0.44 mg/l total zinc (which is believed to have been mostly in the dissolved form), but the flow was only 15 GPM on June 17, 1975. During snowmelt and heavy rains, the rate of flow would be much greater and tailings would be eroded into Toby Creek, thus increasing the zinc loading to Toby Creek. Underground drainage from the old Mineral King Mine also contributed dissolved zinc to Toby and Jumbo Creeks (refer to section 3.2.1).

We recommend that the tailings pond effluent and the runoff from the old Mineral King tailings be sampled during the low flow period (October to April) and during the snowmelt-freshet period (May and June). The samples will help us to determine more accurately the zinc loadings to Jumbo and Toby Creeks and the resulting zinc concentrations in these creeks. The following parameters should be measured:

alkalinity, total	pH
barium, total and dissolved	solids, dissolved
conductance, specific	solids, total
flow	zinc, dissolved and total

2.2 Purcell Development Ltd.

Purcell Development operated a 200 ton/day silver-lead-zinc ore dressing plant at the confluence of Jumbo and Toby Creeks during 1974 and 1975. The plant began operation in the summer of 1974 and ceased operations on March 3, 1975 because of financial difficulties. The plant processed ore salvaged from the old Mineral King Mine located one mile to the west and tailings from the old Paradise Mine located along Toby Creek, 15 miles downstream from Purcell Developments Ltd.[39]. Mountain Minerals Ltd. operates a 360 ton/day barite concentrating plant on the same site as the Purcell Development Ltd. operation (see section 2.1).

Effluent from the ore dressing plant was discharged to a tailings impoundment, and the supernatant from the tailings impoundment was recycled to the process. There was no discharge from the tailings impoundment except for a tailings spill caused by a break in the tailings pipeline. This spill did not reach Toby Creek. There was no seepage from the tailings impoundment. The Purcell Development operation was issued Pollution Control Permit No. PE-3441, on November 5, 1974[39]. The permit conditions are summarized in Table 7-6. The location of the operation is denoted in Figure 7-1 by its permit number, 3441.

Sources of effluent associated with the Purcell Development Ltd. operation are mine drainage from the old Mineral King and Paradise mines which Purcell was reworking[39]. These sources of effluent are discussed in Section 3.2.1.

2.3 Industrial Solid Waste

There are no major sources of industrial solid waste in the region. A review of Pollution Control Branch files indicated that there are six small industrial refuse disposal sites under permit or application in the region. Four of these sites have been closed while two are still active. All of these sites have been used for the disposal of woodwastes from small sawmill-planermill operations located in the Rocky Mountain Trench. A description of each site is presented in Table 7-8 and the location of each site is denoted in Figure 7-1 by its Pollution Control Permit or Application number.

The two active sites (PR-3069 and PR-3070) are located at Edgewater. Considering the excess of evapotranspiration over precipitation, the great depth of the water table, and the great distance to surface waters or wells, it is very unlikely that these sites will adversely affect surface waters or groundwaters[40].

The four closed sites (AR-2344, AR-3418, AR-2663 and AR-1953) all have one feature in common: each is located on the flood plain of a stream

(Columbia River, Toby Creek) and thus is subject to inundation and high water tables during part of the year[41]. The potential for leaching at such sites is high, but in view of the small size of the sites and the relatively large flows in the Columbia River and Toby Creek the possibility of leachates significantly affecting these streams is negligible.

3. MUNICIPAL AND MISCELLANEOUS SOURCES OF EFFLUENT AND SOLID WASTE

3.1 Municipal Sources of Effluent and Solid Waste

The major sources of municipal-type effluent in Region 7 are the Village of Invermere, Radium Hot Springs and Fairmont Hot Springs Resort Ltd. Details regarding each discharge are summarized in Table 7-6.

There are also eight other minor municipal-type discharges in Region 7 which are not considered to be environmentally significant. Information regarding these minor discharges is summarized in Tables 7-6 and 7-7. The locations of the minor discharges are denoted in Figure 7-1 by their Pollution Control Permit or Application numbers. Some residents dispose of their domestic sewage to the ground via private septic tank and tile field systems authorized by the British Columbia Department of Health.

There are several small sources of municipal solid waste in Region 7. These sources are discussed in section 3.1.4 and information on their solid waste disposal sites is summarized in Table 7-10.

3.1.1 Village of Invermere

a) Description

The Village of Invermere is located on the northwest corner of Windermere Lake (Figure 7-1) and has a population of approximately 1200. At present, sewage from the village is disposed of in individual septic tanks followed by discharge to the ground in tile fields. However, a sewer system and sewage treatment facilities are being built[36].

The sewage treatment facilities will include a comminutor, two aerated lagoons in series, chlorination facilities, an aerated holding lagoon and an outfall pipe to Toby Creek. The discharge will enter Toby

Creek about one and one-quarter miles upstream from the confluence with the Columbia River[36].

The Pollution Control Branch issued Permit PE-3094 to the Village of Invermere on November 7, 1974. The permit allows the discharge of a maximum of 375,000 GPD of effluent with a BOD_5 of 45 mg/l and a total suspended solids of 60 mg/l. No discharge is allowed during that period of the year when flow reversal occurs in the Columbia River at the outlet of Lake Windermere[36]. The location of the discharge is denoted in Figure 7-1 by its Pollution Control Permit number 3094.

The maximum discharge rate of 375,000 GPD (250,000 GPD average) allowed by the permit is based on a design population of 3000 people. Since the present population of Invermere is about 1200, the actual discharge rate should be less than half of that authorized by the permit. The minimum dilution available for the treated effluent in Toby Creek is 67:1 assuming the maximum discharge rate of 375,000 GPD and the lowest recorded flow in Toby Creek of 45 CFS. If a water license is issued to the Village of Invermere for 10 million GPD the minimum dilution ratio could be reduced to 37:1[36].

b) Presentation of Effluent Sampling Data

There are no data available since the sewer system and sewage treatment facilities have not yet been completed. Once the sewage treatment facilities are in operation, the effluent will be monitored by the permittee and the Pollution Control Branch.

The Pollution Control Branch will also monitor Toby Creek at sampling stations located upstream and downstream from the effluent discharge[36].

c) Discussion and Recommendations

Water quality deterioration downstream from this discharge is not expected since the treatment works should produce an effluent of good quality, and the dilution available in Toby Creek and the Columbia River is large. No additional monitoring, other than routine Pollution Control Branch monitoring, is recommended.

3.1.2 Radium Hot Springs

a) Description

Radium Hot Springs is located eight miles north of Lake Windermere at the confluence of Sinclair Creek and the Columbia River as shown in Figure 7-1. The permanent population of Radium Hot Springs was estimated to be about 600 in 1975, but the tourist population in the area gives Radium Hot Springs an equivalent population of about 1000 during the winter and 3200 during the summer. The larger summer population is due to the influx of tourists using the recreational facilities in Radium Hot Springs and in neighbouring Kootenay National Park[42,44].

Sewage from the Radium Sewerage District and Kootenay National Park has been collected and treated since 1966 in a two-cell waste stabilization pond located adjacent to Sinclair Creek. Effluent from the pond is discharged to Sinclair Creek about two and one-half miles upstream from its confluence with the Columbia River[42]. The discharge was authorized by Pollution Control Permit PE-132, which was issued on June 22, 1965 and expired on June 22, 1970. Permit details are contained in Table 7-6, and the location of the discharge is denoted in Figure 7-1 by permit number 132. The Radium Sewerage District applied for an amendment to PE-132 on October 5, 1970, but the application was rejected since it did not meet Pollution Control Branch regulations. At present, the waste stabilization ponds are heavily overloaded, especially during the summer when the population increases due to tourism[42,43]. Until recently the Radium Sewerage District did not have sufficient funds to make the necessary improvements to the sewage treatment facilities[43].

The Radium Sewerage District and the Radium Waterworks District were amalgamated on May 15, 1975 to form the Radium Waterworks District which was given the responsibility for sewage collection and disposal[45]. The Radium Waterworks District submitted an application (AE-4422) to the Pollution Control Branch on January 20, 1976 to discharge an average of 250,000 GPD (460,000 GPD maximum) of treated effluent to the Columbia River. Proposed treatment includes biological oxidation, clarification, chlorination and discharge via a submerged outfall. Sludge from the treatment system will be discharged to sludge drying beds. Construction of the treatment works is scheduled to begin in May 1976. Details of the application are summarized in Table 7-7[57].

The sewage collection and treatment system proposed by the Radium Waterworks District eliminates the present effluent discharge to Sinclair Creek. The new system will collect and treat sewage from Kootenay National Park and the old Radium Sewerage District. It will also serve the business and residential section of the Radium Waterworks District, Canyon Campgrounds and the Revelstoke subdivision which currently dispose of their sewage in individual septic tank and tile field systems[42,44].

b) Presentation of Effluent Sampling Data

A summary of the Pollution Control Branch sampling data for the effluent discharged to Sinclair Creek from the two-cell waste stabilization pond and the conditions of PE-132 are presented in Table 7-11. Sewage flows were estimated to average 85,600 GPD during the summer and 21,700 GPD during the winter[42]. The Pollution Control Branch also monitors Sinclair Creek upstream (site 0200053) and downstream (site 0200094) from the effluent discharge. The water quality data for Sinclair Creek are discussed in Chapter 4.

c) Discussion and Recommendations

The sampling data in Table 7-11 reflect the inadequacy of the waste stabilization ponds. Suspended solids were frequently high (87-156 mg/l), exceeding the permit limit (50 mg/l) for 50 percent of the six samples taken. BOD_5 analyses (27-68 mg/l) met the permit limit (80 mg/l) for all six samples, but only one out of six samples met the level AA for BOD_5 of 30 mg/l which is now required for discharges of this type[60]. The fecal coliform concentrations in the effluent were high (54,000 to >240,000 MPN/100 ml) since there are no chlorination facilities at the waste stabilization ponds. The estimated average summer flow to the ponds was almost triple the discharge rate allowed by PE-132. The analysis of the water quality data for Sinclair Creek in Chapter 4 indicates that the major effect of this discharge was fecal contamination of Sinclair Creek.

We do not recommend a monitoring program for this discharge during Phase II since the discharge will be eliminated upon completion of the new sewage treatment and collection system.

3.1.3 Fairmont Hot Springs Resort Ltd.

a) Description

The Fairmont Hot Springs Resort Ltd. complex is located adjacent to Fairmont Creek, approximately one mile upstream from the confluence of Fairmont Creek and the Columbia River (see Figure 7-1). The 246 unit resort complex consists of a lodge, cabins, trailer parks, campgrounds and hot spring swimming pools. Effluent discharges from the resort consist of domestic sewage and effluent from the hot spring swimming pools [46,47].

The domestic sewage and effluent from the smaller hot spring swimming pool are treated in a septic tank and discharged to a natural limestone sink hole that is underlain by sand and gravel. The sink hole is located 250 feet north of Fairmont Creek and the bottom of the sink hole is 16 feet above the bed of Fairmont Creek. The discharge consists of an average of 20,000 GPD of domestic sewage and 10,000 GPD of swimming pool effluent. The discharge is authorized by Pollution Control Permit PE-1619 which allows an average annual daily discharge of 30,000 gallons of typical septic tank and swimming pool effluent[46]. The location of the discharge is denoted in Figure 7-1 by Pollution Control Permit number 1619. Permit details are summarized in Table 7-6.

The water for the large swimming pool is taken from a natural hot spring upstream from the pool, chlorinated, circulated through the pool and discharged to Fairmont Creek. Normally, the hot spring water would flow across the ground and be reabsorbed in the soil or flow into Fairmont Creek. This discharge is authorized by Pollution Control Permit PE-2057 which allows the discharge of a maximum of 300,000 GPD to typical flow-through hot spring swimming pool effluent. The Letter of Transmittal specifies that a chlorine residual between 0.3 and 1.3 mg/l must be maintained in the effluent at all times[47]. The location of the discharge is denoted in Figure 7-1 by its Pollution Control Permit number 2057. Permit details are summarized in Table 7-6.

b) Presentation of Effluent Sampling Data

A summary of the Pollution Control Branch sampling data for the effluent discharged to the natural sink hole (site PE-1619) and to Fairmont Creek (site PE-2057) is presented in Table 7-12.

The flow rates of the effluents were not measured. The Pollution Control Branch sampled Fairmont Creek upstream (site 0200122) and downstream (site 0200123) from the resort complex, and the Columbia River upstream (site 0200124) and downstream (site 0200125) from Fairmont Creek. In addition, the Branch conducted a detailed sampling survey on Fairmont Creek, Cold Spring Creek and the Columbia River on May 25, 1972, to assess the effect of the discharges. The data are discussed in Chapter 4 on water quality.

c) Discussion and Recommendations

The septic tank effluent discharged to the sink hole was of better quality than that normally expected for septic tank effluent (Table 7-12). This result was probably due to the dilution provided by the effluent from the small swimming pool. The high dissolved solids and specific conductance of the septic tank effluent were due to the presence of the highly mineralized swimming pool effluent. The quantity of contaminants reaching Fairmont Creek from this discharge is not known. Since the discharge is small and passes through at least 250 feet of sand and gravel to reach Fairmont Creek, the loading to the creek is expected to be small.

The sampling data for the large swimming pool effluent (PE02057) show the highly mineralized nature of hot spring water (Table 7-12). The dissolved solids of the effluent averaged 1452 mg/l and contained appreciable concentrations of calcium, magnesium, sulphate, sodium, potassium and chloride. As a result of the heavy mineralization, the hardness and alkalinity of the effluent were high. The concentrations of organic matter (BOD_5 and organic carbon), nitrogen, phosphorus, fecal coliforms and heavy metals were very low. The temperature of the effluent was high (24.5-31^{o}C), reflecting the high temperature of the natural hot springs (42^{o}C). The effluent imposes a heavy thermal and dissolved mineral load on Fairmont Creek, particularly during the low flow period. We consider however, that these are the natural properties of the hot spring water, and that under natural conditions, at least part of the hot spring water would flow into Fairmont Creek.

No further monitoring of the effluents, other than routine monitoring, is recommended.

3.1.4 Municipal Sources of Solid Waste

The populations of the settlements in the Upper Columbia River Basin are relatively small and thus there are no major sources of municipal solid waste in the region. A review of Pollution Control Branch files indicated that there were seven small municipal refuse disposal sites under permit or application in the region[48]. A description of each site is presented in Table 7-10 and the location of each site is denoted in Figure 7-1 by its Pollution Control permit or application number.

The possibility that leachates from these refuse sites may adversely affect adjacent groundwaters or surface waters is remote. This is due to the relatively small quantity of refuse deposited, the excess of evapotranspiration over precipitation, the considerable depth to the groundwater table, the lack of surface runoff and flooding problems, and the great distance to surface waters and wells[48].

3.2 Miscellaneous Sources of Effluent and Solid Waste

3.2.1 Mining

The two former mining operations which may have an influence on water quality are the old Mineral King and Paradise mines located along Toby Creek, as shown in Figure 7-1.

a) Mineral King Mine

The Mineral King mine operated between 1953 and 1968, producing over two million tons of ore[39]. Minerals extracted from the ore included copper, cadmium, zinc, lead, silver and barite[26]. The mine was reworked during 1974-75 by Purcell Development Ltd. (section 2.2). The two sources of effluent from the mine are runoff from the old tailings deposits and drainage from the underground workings. The runoff from the tailings deposits is discussed in section 2.1 dealing with Mountain Minerals Ltd. Mine drainage from the underground workings flows to Toby Creek (from mine portal at No. 7 level) and to Jumbo Creek (from mine portal at No. 9 level). The rate of discharge fluctuates seasonally from 15,000 GPD during the winter to over 150,000 GPD in May. The mine drainage is alkaline since the host rock is dolomite (magnesium limestone). The mine drainage is not presently covered by a Pollution Control permit but it will be evaluated in Phase II of the study.

The mine drainage water from the old Mineral King mine was analyzed once by an engineering consultant retained by Purcell Development Ltd. The results of the analyses are given in Table 7-13. The results show that the drainage contained relatively high concentrations of dissolved zinc (0.7 and 2.0 mg/l). At a flow range of 15,000 to 150,000 GPD, the quantity of dissolved zinc entering Jumbo and Toby Creeks would be relatively small (0.3-3.0 lb/day). Other sources of zinc entering Toby Creek in the area include the effluent from the Mountain Minerals Ltd. tailings pond and runoff from the Mineral King tailings (see section 2.2).

To assess more accurately the quantity of zinc entering Jumbo and Toby Creeks, we recommend that the two drainage streams from the Mineral King mine (No. 9 and No. 7 levels) be sampled several times during the low flow period (October to April) and twice during the snowmelt-freshet period (May and June) for the following parameters:

alkalinity, total	solids, dissolved
conductance, specific	solids, total
flow	zinc, dissolved
pH	

b) Paradise Mine

The Paradise Mine operated between 1901 and 1952, producing lead, zinc, silver, cadmium and gold[26]. Purcell Development Ltd. attempted to reprocess the tailings of the Paradise mine during 1974-75. The tailings and drainage from the mine are acidic with a pH of 2.2 to 2.5[35]. There was no drainage entering Toby Creek from this source on June 17, 1975, but there was evidence that a small amount of drainage and erosion of tailings into Toby Creek had occurred previously.

We recommend that the old Paradise Mine site be inspected once during the low flow period (October or November) and twice during the snowmelt-freshet period (May and June) to determine if drainage from the mine and tailings is entering Toby Creek. If drainage is occurring then it should be sampled for the following parameters:

alkalinity, total	manganese, dissolved
cadmium, dissolved	nickel, dissolved
conductance, specific	silver, dissolved
copper, dissolved	solids, dissolved
cyanide, total	solids, total
lead, dissolved	zinc, dissolved

3.2.2 Agriculture

a) Introduction

Agricultural activity in this region is limited. Agricultural census data(49) were available only for three of the eight enumeration areas in the region since five of the enumeration areas contained less than the ten farms required for inclusion in the census. The farms are generally not as large as those found in other areas in B.C. such as the Kamloops-Merritt area. The cropland acreages are generally between 50 and 100 acres. The livestock is predominantly beef cattle and less than 50 cows per farm is common. The agricultural activity in the region is most intensive on the northwest corner of Windermere Lake. Other agricultural activity in the region is in the vicinity of Edgewater, Brisco, Spillimacheen and Harrogate. Water licenses issued by the Water Rights Branch(21) indicate that approximately 800 acres of land can be irrigated in the Windermere Lake-Wilmer area and 1600 acres can be irrigated between Edgewater and Harrogate. The 1971 census data indicate that the cultivated land in the region is primarily used for hay production.

Water licenses have been issued for the irrigation of 800 acres between Canal Flats and Windermere Lake, and 2800 acres on the east side of Windermere Lake(21). Since there are less than 10 farms in either of these areas, we assumed that some of the water licenses issued for irrigation were not being used and that the ones being used applied to acreages not considered as farms. The water licenses issued for irrigation purposes on the east side of Windermere Lake were included in a calculation of nutrient loadings for the Windermere Lake area.

b) Nutrient Loadings From Agricultural Activities

Annual nutrient loadings to the Columbia River system between Windermere Lake and Harrogate were estimated for fertilized, irrigated cropland and for livestock operations (Table 7-14). All other agricultural sources of nutrients were considered to be relatively insignificant.

Nutrients From Irrigated Cropland:

To calculate nutrient contributions from irrigated cropland, we assumed that all acreage licensed to be irrigated was fertilized. This gave a high estimate since the 1971 Agricultural Census indicated that only 50 percent of the existing cropland was fertilized. Also, the water licenses tended to indicate the potential irrigated acreage which was greater than the actual irrigated acreage reported by the Census. The nutrient contribution from fertilizer applied on non-irrigated land was assumed to be negligible.

Nutrients from irrigated, fertilized cropland were assumed to be transported to the receiving waters via groundwater flow. However, during a fast spring thaw, surface runoff may remove a substantial portion of the fertilizer granules which have been applied during the frost period. The surface runoff contribution of nutrients was not considered to have a major influence on the receiving waters due to the number, size and location of the farms. We assumed annual fertilizer application rates of 50 lb. nitrogen and 10 lb. phosphorus per acre. The method used to estimate the fraction of the applied fertilizer ultimately reaching the receiving water was based on results derived in the Okanagan Basin Study[50]. In this study, lysimeter tests were used to derive the fraction of nutrients reaching the groundwater. These fractions were 0.168 of the nitrogen applied as fertilizer and 0.021 of the phosphorus applied as fertilizer. We then assumed that 80 percent of the nitrogen and phosphorus reaching the groundwater would enter the receiving water.

Fertilized, irrigated cropland was thus assumed to contribute the following amounts of nutrients per year to the receiving waters:

Nitrogen: $50 \times 0.168 \times 0.8 = 6.7$ lb/(acre year)

Phosphorus: $10 \times 0.021 \times 0.8 = 0.17$ lb/(acre year)

The calculated nitrogen and phosphorus loadings from fertilized, irrigated cropland are presented in Table 7-14. The total nitrogen and phosphorus loadings to the Columbia River from cropland were calculated to be 37,990 lb. N/year and 960 lb. P/year.

Nutrients From Livestock:

Nutrient contributions from livestock activity were estimated using the method derived in the Okanagan Basin Study[50]. The total potential loading from each animal per year was assumed to be 140 lb/year of nitrogen and 11 lb/year of phosphorus. The fraction of the total potential loading which reached the receiving water was assumed to be 0.07 for nitrogen and 0.022 for phosphorus. The nutrient loading to the receiving water from livestock was thus assumed to be:

Nitrogen: $140 \times 0.07 = 9.8$ lb N/(animal year)

Phosphorus: $11 \times 0.022 = 0.242$ lb P/(animal year)

An estimate of the number of livestock in the region was obtained from the 1971 Agricultural Census[49]. The calculated loadings are presented in Table 7-14 and show that total loadings to the Columbia River from livestock sources were 13,230 lb/year of nitrogen and 324 lb/year of phosphorus.

The most common cattle enterprises in the region were cow-calf operations. Nutrients from these operations were contained in surface runoff from cattle wintering areas. We assumed that the nutrients would reach the receiving waters only during spring runoff. Nutrients from animal wastes transported by groundwater were expected to be minimal.

Cattle that have access to streams can disturb the stream bed and possibly contaminate the stream directly.

c) Discussion

To assess the influence of the estimated nutrient loadings from agricultural activities on the Columbia River system, we assumed that the total annual loadings in Table 7-14 reached the Columbia River during the growing season (May to August, inclusive). The resulting nitrogen and phosphorus concentrations in the Columbia River from these loadings are presented in Table 7-15. The actual nitrogen and phosphorus concentrations in the Columbia River are also included in Table 7-15 for comparison.

The calculated nutrient concentrations in Table 7-15 are very low and represent only about one-tenth of the actual nutrient concentrations in the Columbia River. The calculated nutrient loadings are an overestimate and tend to reflect the potential nutrient loading rather than the actual nutrient loading. We therefore conclude that the agricultural nutrient input is not significant in this region.

Localized problems of excessive nutrient inputs to small streams may occur where poor waste management is practised. Such practises include wintering cattle near streams or in drainage paths, allowing cattle access to streams, or allowing runoff from feedlots or animal waste storage facilities to intercept streams.

3.2.3 Dams and Diversions

a) Spillimacheen River Development

The Spillimacheen River Development is owned by B.C. Hydro and is located near the mouth of the Spillimacheen River as shown in Figure 7-1. The project consists of an intake dam and powerhouse (installed capacity of 4 MW)[16] on the Spillimacheen River plus a diversion dam on

Bugaboo Creek to divert water into the Spillimacheen River above the intake dam[17]. Water licenses held by B.C. Hydro authorize the use of up to 300 CFS from the Spillimacheen River and up to 25 CFS from Bugaboo Creek for power generation[37].

The intake dam is about 30 feet high and is located at the top of a steep reach of the Spillimacheen River which drops 220 feet in less than one mile. Water is conveyed to the powerhouse located at the bottom of this reach by a 3,800 foot penstock. There is virtually no storage capacity behind the intake dam. The construction of the intake dam and powerhouse began in 1953 and was completed in 1955[17,51]. The Bugaboo diversion dam is about 35 feet high and is located about six miles from the mouth of Bugaboo Creek. The purpose of the diversion is to augment the low winter flows in the Spillimacheen River. Storage capacity behind the dam is limited, providing only pondage. The diversion was constructed during 1955 and 1956[17,52]. Because of the limited storage capacity behind the dams the Spillimacheen River Development may be classed as a run-of-the river project. A summary of information regarding the Spillimacheen River Development is contained in Table 7-16.

A report by R.G. McMynn of the B.C. Game Commission, prepared prior to the construction of the Spillimacheen River Development, indicated that the Spillimacheen River was not considered to be important from a sport fishery standpoint[51]. Fish were known to inhabit the Spillimacheen River above and below the intake dam and powerhouse, but it was believed that few, if any, migratory fish ascended the Spillimacheen River in the vicinity of the dam and powerhouse. Bugaboo Creek was not considered to be an important sport fishery area and it was believed that only a few migratory fish utilized the lower reaches. The report concluded that clearing of the reservoir area would provide adequate compensation for the loss of stream habitat to the migratory fish populations of the streams.

b) Proposed Kootenay Diversion at Canal Flats

The Columbia River Treaty permits the diversion of up to 1,500,000 acre-feet of water per year after September 1984 from the Kootenay River at Canal Flats to the headwaters of the Columbia River (Columbia Lake). The maximum diversion flow would be between 4000 and 6000 CFS and the diversion would not be allowed to reduce the flow of the Kootenay River below the lesser of 200 CFS or the natural minimum flow. The average diversion flow would be about 2000 CFS. The proposed diversion would be accomplished by a low dam across the Kootenay River at Canal Flats, a gated concrete intake structure on the right bank, and a 7000 foot canal to Columbia Lake[18].

A map reserve has been registered on the land affected by the proposed diversion[20], and the Provincial Power Study prepared for the British Columbia Energy Board recommends construction of the diversion by 1984[53]. The diversion is advantageous for power generation since the potential head of the Columbia River powerplants exceeds that of the Kootenay River powerplants by 649 feet, thus producing a net gain of 90 average MW[18].

The environmental impact of the proposed diversion is currently being investigated by B.C. Hydro and its consultants. Some of the potential effects of the diversion on the Upper Columbia River Basin that are being investigated include:

i) Increased flooding along the Columbia River downstream from Canal Flats due to increased flows. At present, there is considerable flooding of the valley bottom during freshet flows due to the flatness of the valley slope from Athalmer downstream to Golden[54]. The maximum daily recorded flows in the Columbia River are: 3010 CFS at Fairmont Hot Springs; 9800 CFS at Edgewater; and 22,500 CFS at Golden[7]. The addition of up to 6000 CFS to these flows would represent a substantial increase in discharge and would aggravate the present flooding problem.

ii) Loss of land for other uses, including land used for structures and construction activities and land alienated from present uses (i.e., settlements, agriculture, waterfowl, wildlife, transportation routes, recreation, etc.) due to increased flooding.

iii) Destruction of habitats for aquatic and terrestrial wildlife and waterfowl due to increased flooding along the Columbia River. The Canada Land Inventory[33] has designated the Columbia River Marshes as Prime Waterfowl areas. These marshes are important staging and resting areas for the seasonal migration of waterfowl and also have a moderately high capability for waterfowl production. The main limitation of these marshes is the hazard to nesting caused by spring floods. The increased flows caused by the diversion may serve to limit further the nesting capability of these wetlands, unless artificial means are used to protect nesting sites from flooding.

iv) Possible changes in water quality due to increased flooding, erosion, sediment transport and the inflow of Kootenay River water with different physical and chemical characteristics (the water quality aspects of the diversion are discussed in section 4.2.3).

v) Possible loss of fisheries habitat and spawning areas in Columbia Lake, Windermere Lake and the Columbia River due to increased erosion and sedimentation.

vi) Possible blockage of fish migration routes by the proposed diversion dam on the Kootenay River.

c) Proposed Kootenay Diversion at Bull River

Another provision of the Columbia River Treaty allows the additional diversion, in 2024, of the Kootenay River on condition that the flow at the Canada-U.S.A. border is not reduced below the lesser of 2,500 CFS or the natural flow. No reserves have been registered.

lands affected by this potential development[20].

The environmental impact of such a diversion would be large, with widespread effects in the Kootenay and Columbia systems. The diversion at Bull River would be several times the magnitude of the proposed diversion at Canal Flats and the environmental impacts would be correspondingly more severe. The benefits of such a project must be carefully balanced against the need to preserve the valley lands for other purposes.

4. WATER SAMPLING DATA

4.1 Introduction

The waters of the Upper Columbia River basin have been sampled by Provincial and Federal agencies and by consultants retained by industry. Since 1968, the Pollution Control Branch of the B.C. Water Resources Service has collected approximately 180 samples involving a total of 5200 analyses. The results of these analyses are discussed in this chapter, together with data from other sources. Samples were collected on the Columbia River, Columbia Lake, Windermere Lake, Lillian Lake, and on three triburaries of the Columbia River: Toby, Sinclair and Fairmont Creeks. To facilitate the presentation and discussion of the data we have divided the Region as follows:

- Columbia River including Columbia and Windermere Lakes
- Toby Creek
- Sinclair Creek
- Fairmont Creek
- Lillian Lake

4.2 The Columbia River Including Columbia and Windermere Lakes

4.2.1 Presentation of Data

The Columbia River originates in Columbia Lake and follows a meandering course for six miles to Windermere Lake. From Windermere Lake, the Columbia follows a sluggish, meandering course through the Columbia River marshes for 35 miles until it leaves the Kootenay Study region near Harrogate, 40 miles south of Golden.

Figure 7-5 shows the locations of the Pollution Control Branch and Water Investigations Branch sampling sites. These sites are described in detail below, proceeding from upstream to downstream.

Site 1100641:	Columbia Lake, south end of lake, close to west shore (1100 feet south of large point on west shore).
Site 1100645:	Columbia Lake, north end, midlake.
Site 0200124:	Columbia River, 20 feet upstream from the confluence with Fairmont Creek.
Sites 0200049: and 1100646	Columbia River, at the Highway 95 bridge south of Fairmont Hot Springs (Downstream from Fairmont Creek).
Site 0200125:	Columbia River, approximately 0.2 miles west of Highway 95 bridge south of Fairmont Hot Springs (Downstream from Fairmont Creek).
Site 0200050:	Windermere Lake, midlake, 2.6 miles from south end of lake opposite Johnston Creek.
Site 0200051:	Windermere Lake, midlake, 5.7 miles from south end of lake opposite Windermere Stolen Church.
Site 0200052:	Windermere Lake, midlake, 0.22 miles south of Invermere opposite Abel Creek.
Site 0200009:	Columbia River at Highway 95 bridge at Athalmer.
Site 0500018:	Columbia River upstream from Golden (Nicholson Road bridge, 4.5 miles south of Golden).

Summaries of the data collected at these sites, up to September 1975, are presented in Tables 7-17 to 7-20 inclusive. Table 7-20 also contains a summary of the water quality data for the Kootenay River at Canal Flats. These data are used to assess the effects of diverting the Kootenay River into the Columbia River at Canal Flats. The Windermere Lake data collected by the Pollution Control Branch (Table 7-19) have been summarized for all sampling depths since the lake was not stratified when it was sampled and there was little variation with depth. Since the lake is shallow and it is often windy, the lake is thouroughly mixed during the ice-free season[66]. The Water Investigations Branch has conducted limnological studies of Windermere Lake and these studies are discussed in Chapter 5 on aquatic biology.

Site 0500018 (Table 7-20), although outside of the Kootenay Study region, was included in our study since it is the first sampling site on the Columbia River downstream from Athalmer.

4.2.2 Discussion of Data From Columbia System

The data in Tables 7-17, 7-18, 7-19 and 7-20 show that the water quality of Columbia Lake, Windermere Lake and the Columbia River downstream to Golden was similar for most parameters. These waters were all low in phosphorus, nitrogen, fecal coliforms, colour and heavy metals such as cadmium, chromium, copper, iron, lead, manganese, mercury, and zinc. The average concentrations of dissolved copper and zinc for site 0500018 in Table 7-20 were higher than for the other sites because these averages had been distorted by one abnormally high value. Normally, the zinc and copper concentrations at this site were low (0.001 mg/l dissolved copper, 0.005 mg/l dissolved zinc). The Columbia Lake, Windermere Lake and Columbia River sites were also low in suspended solids ($\leq$ 42 mg/l) and turbidity ($\leq$ 10 J.T.U.) with the exception of site 0500018 near Golden which did reach values of 268 mg/l for suspended solids and 115 J.T.U. for turbidity during freshet. Erosion of silt cliffs along the eastern side of Windermere Lake during storms has also caused turbid conditions in the whole eastern side of the lake[66].

Parameters which showed variations in average concentrations between sites included dissolved solids (143-201 mg/l), sulphate (20-45 mg/l) and hardness (128-169 mg/l). These were considered to be natural variations since there were no significant discharges in the region. Fairmont Creek, which received a discharge from hot spring swimming pools, caused small increases in the average concentrations of hardness (140 to 160 mg/l), sulphate (20 to 33 mg/l) and dissolved solids (163 to 187 mg/l) between sites 0200124 and 0200125. These increases were within the range of the natural variations which occurred along the Columbia system. Fairmont Creek has had no effect on the temperature or fecal coliform density in the Columbia River between sites 0200124 and 0200125. (Refer to section 4.5 for a discussion of Fairmont Creek water quality).

With an average hardness ranging from 128 to 169 mg/l the water of the Columbia system can be described as moderately hard[55] or as of fair quality for hardness[56]. The water quality data indicate that the water was safe for aquatic life and wildlife, and should be suitable as a raw water supply for all purposes. (The B.C. Department of Health recommends that all drinking water supplies should at least be effectively chlorinated before consumption[62]).

4.2.3 Effect on Water Quality of the Kootenay River Diversion at Canal Flats

Under the terms of the Columbia River Treaty, British Columbia can, after September 1984, divert up to 1,500,000 acre feet of water per year (2000 CFS average) from the Kootenay River at Canal Flats into the Columbia River via Columbia Lake (section 3.2.3 b). To assess the water quality implications of this diversion, we have compared the water quality of the Kootenay River at Canal Flats (site 0200020, Table 7-20) with the water quality of Columbia Lake (sites 1100641 and 1100645, Table 7-17), Windermere Lake (sites 0200050, 0200051 and 0200052, Table 7-19), and the Columbia River (sites 0200124, 0200049, 1100646, 0200125, 0200009 and 0500018, Tables 7-18 and 7-20).

The comparison shows that for most parameters, the water quality of the Kootenay and upper Columbia rivers was essentially the same. Both systems were low in phosphorus, nitrogen, colour, fecal coliforms and heavy metals. The average concentrations for total and dissolved phosphorus for the Kootenay River (Site 0200020) in Table 7-20 were higher than for the Columbia sites. These averages were distorted because two of the 68 values recorded were abnormally high. Normally, the phosphorus concentrations in the Kootenay River were very low (0.004 mg/l, dissolved and 0.01 mg/l, total) and were comparable to those in the Columbia system).

The average concentrations of dissolved solids, hardness and sulphate in the Kootenay River were generally higher than in the Columbia system, except for the site on the Columbia River at Athalmer (0200009) which was very similar to the Kootenay River for these three parameters. Average chloride concentrations in the Kootenay River (6.4 mg/l) were higher than those in the Columbia system (0.9 to 2.2 mg/l). Suspended solids (up to 256 mg/l) and turbidity (up to 100 J.T.U.) in the Kootenay River were substantially higher than those in the Columbia system from Fairmont Hot Springs to Athalmer (suspended solids $\leq$ 42 mg/l and turbidity $\leq$ 10 J.T.U.), particularly during freshet. However, at site 0500018 on the Columbia River near Golden, the suspended solids (up to 268 mg/l) and turbidity (up to 115 J.T.U.) were comparable to those for the Kootenay River at Canal Flats.

The difference in dissolved solids, sulphate, hardness and chloride would not be expected to cause deleterious changes in the water quality of the Columbia system. The higher suspended solids and turbidity levels in the Kootenay River during freshet could cause increased turbidity in Columbia Lake, Windermere Lake and the Columbia River at least as far downstream as Athalmer. There probably would be increased sedimentation in Columbia Lake as the coarser fractions of the Kootenay's sediment load settled out in the lake. The finer fractions of the Kootenay's sediment load do not settle out easily and thus the Kootenay's turbidity could be carried through Columbia Lake, the Columbia River and Windermere Lake. Increased erosion due to increased flows and increased water levels caused by the diversion could also serve to increase the turbidity in the Columbia system.

For a further discussion of the Kootenay diversion, refer to section 3.2.3 b. B.C. Hydro and their consultants are currently studying the environmental impact of the Kootenay diversion.

4.2.4 Recommendations

We recommend that a water quality sampling program be initiated on Columbia Lake. This is necessary because the Kootenay River may be diverted into Columbia Lake at Canal Flats and the water quality of the lake has not yet been adequately characterized (only two samples have been analyzed). The sampling program should be started during Phase II of the Kootenay Study, and continued until 10 to 15 samplings have been obtained. Three sites are recommended on Columbia Lake, sites

1100642, 1100643 and 1100645. The Kootenay River at Canal Flats (0200020) should also be sampled at the same time to obtain a direct comparison of the water quality in the two systems. The recommended parameters, sampling times and frequencies are listed in Table 7-21.

The data show that Fairmont Creek has not had a significant effect on Columbia River water quality, and thus Columbia River site 0200124 upstream and site 0200125 downstream from Fairmont Creek are no longer necessary. Site 0200049, downstream from Fairmont Creek, is preferred for routine surveillance since it is readily accessible. The recommended parameters, sampling times and frequencies for routine surveillance are listed in Table 7-21.

We recommend that the Pollution Control Branch continue to sample Windermere Lake (sites 0200050, 0200051 and 0200052) and the Columbia River at Athalmer (site 0200009) for surveillance purposes. Windermere Lake should be sampled once per year and the Columbia River at Athalmer should be sampled four times per year. Recommended parameters and sampling times are listed in Table 7-21.

4.3 Toby Creek

4.3.1 Presentation of Data

Toby Creek is a glacier-fed mountain stream which rises in the Purcell Mountains and flows northeast to join the Columbia River just north of Invermere. It has a drainage area of 240 square miles[7].

The Pollution Control Branch has sampled two sites on Toby Creek since May 1971. These sites are located upstream and downstream from the mining operations of Mountain Minerals Ltd. and Purcell Development Co. Ltd. to assess the effect of these operations on the water quality of Toby Creek. These sites are approximately 25 miles upstream from the Columbia River near the confluence of Toby and Jumbo Creeks as shown in

Figure 7-5. A more detailed description of the two sites is given below.

Site 0200055: Toby Creek, upstream from the tailings deposits located near the old Mineral King Mine. Approximately one mile upstream from the Jumbo Creek confluence.

Site 0200054: Toby Creek, at the first road bridge crossing downstream from Mountain Minerals Ltd. Approximately 2.5 miles downstream from Jumbo Creek.

At their confluence, Toby and Jumbo Creeks each have a drainage area of about 60 square miles and thus their combined area is equal to one half the drainage area of the entire Toby Creek basin. Both creeks are glacier-fed. Logging activities have occurred in the headwaters above their confluence (Figure 7-3). There are no water licenses issued on Toby Creek, but the Village of Invermere has filed an application with the Water Rights Branch for 10 million GPD for a public water supply.

A summary of the data collected at the two sites between May 1971 and June 1975 is presented in Table 7-22. Data collected by a consultant to Purcell Development Co. Ltd. and by the Water Investigations Branch are presented in Table 7-23.

4.3.2 Discussion and Recommendations

The water quality data in Table 7-22 for Toby Creek upstream from the mining operations (site 0200055) indicate that the water was relatively low in dissolved solids (64-134 mg/l) and alkalinity (51-89 mg/l). We expect that the water would be relatively soft, but hardness was not measured. The concentrations of heavy metals were very low, usually below the detectable limit. Suspended solids and turbidity reached values as high as 144 mg/l and 27 J.T.U. respectively, during freshet, but it is not known whether the values were natural or attributable to erosion related to logging. The values were not high enough to be a threat to aquatic life, but would make the water unsuitable for use as a public water supply, unless the water was settled or filtered during the freshet period.

The water quality data in Table 7-22 for Toby Creek downstream from the mining operations and for Jumbo Creek were virtually identical to the upstream data. This indicates that the water quality in Jumbo Creek and Toby Creek was very similar and that the mining operations had little effect on the water quality. One of the six samples analyzed for dissolved zinc contained 0.032 mg/l, whereas the concentrations in Toby Creek were normally 0.005 mg/l or less. The high zinc value may have been caused by the discharge from Mountain Minerals Ltd. and drainage from the old Mineral King mine and tailings which are known sources of zinc (section 2.1, 2.2 and 3.2.1).

A dissolved zinc concentration of 0.032 mg/l is not of immediate concern. The lowest level of zinc found to cause reproductive impairment in the cladoceran, daphnia (water flea) is approximately 0.1 mg/l[58], although avoidance reaction in rainbow trout has been reported at concentrations as low as 0.0056 mg/l dissolved zinc[59]. The acceptable limit for zinc in drinking water is 5.0 mg/l[56]. The fact that the elevated zinc concentration occurred during freshet indicates that substantial amounts of zinc may have been entering Toby Creek at that time.

The water quality data collected by consultants (Table 7-22) differ from the data collected by the Pollution Control Branch in that elevated dissolved zinc concentrations were measured in Jumbo Creek (0.078-0.21 mg/l) and Toby Creek (0.031 mg/l) upstream of the known zinc sources. The consultant's data also show higher concentrations of dissolved copper and lead. It is possible that the consultant's data may not be accurate or that there are natural sources of zinc (and other heavy metals) upstream from the mining operations, which the Pollution Control Branch sampling did not detect.

We recommend that sites 0200055 and 0200054 and a new site on Jumbo Creek upstream from the drainage from the old Mineral King mine be sampled during Phase II. These sites should be sampled several times during the low flow period (October to April) and twice during freshet

(May and June) for the following parameters:

alkalinity, total	pH
conductance, specific	solids, dissolved
copper, dissolved	solids, total
hardness	temperature
lead, dissolved	turbidity
oxygen, dissolved	zinc, dissolved

The sampling program should be performed at the same time as the sampling program for the zinc sources recommended in sections 2.1 and 3.2.1.

4.4 Sinclair Creek

4.4.1 Presentation of Data

Sinclair Creek originates in the Rocky Mountains and flows southeast to join the Columbia River at Radium Hot Springs. It has a drainage area of 35 square miles[(7)] and there are no glaciers or ice-fields in its drainage. Highway 93 follows Sinclair Creek from the mouth to the headwaters. Almost all of the Sinclair Creek drainage is located in Kootenay National Park and there has been no logging in its watershed.

The Pollution Control Branch has sampled two sites on Sinclair Creek since March 1972. These sites are located upstream and downstream from the sewage lagoon discharge of the Radium Sewerage District. The location of the sites is shown in Figure 7-5 and a more detailed description is given below:

Site 0200053: Sinclair Creek, at outlet of culvert where Highway 95 crosses Sinclair Creek. (2.5 miles from Columbia River).

Site 0200094: Sinclair Creek, 500 feet downstream from Radium sewage lagoons west of Highway 95. (2.4 miles from Columbia River).

A summary of the data collected at these two sites between March 1972 and June 1975 is presented in Table 7-24.

Two water licenses (F.L. 4231 and F.L. 4232) issued on Sinclair Creek have points of diversion downstream from the sewage lagoon discharge. These water licenses are for irrigation and domestic purposes[21].

4.4.2 Discussion and Recommendations

The water in Sinclair Creek upstream from the sewage lagoon discharge (site 0200053) was relatively high in dissolved solids (164-308 mg/l) and alkalinity (131-188 mg/l). With an average hardness of 217 mg/l it could be described as very hard water[55] or as of poor quality with respect to hardness[56]. The water was low in suspended solids (2-32 mg/l) and turbidity (0.4-12 J.T.U.) which may be due to the relatively undisturbed state of its watershed. Nutrient concentrations were relatively low with total nitrogen averaging 0.2 mg/l and total phosphorus averaging 0.014 mg/l. Fecal coliforms were normally not detectable (less than 2/100 ml), indicating that there were no sources of sewage above the site. The water upstream from the sewage lagoon appeared to be suitable for most purposes, although its hardness lessened its desirability for domestic use. The arsenic concentration in Sinclair Creek (0.01 mg/l) was higher than that normally found in the Kootenay Region (less than 0.005 mg/l), but it was below the maximum permissible limit (0.05 mg/l) for drinking water[56] and the safe level for aquatic life (0.05 mg/l)[61]. However, only one sample was taken during June when dilution of groundwater (the probable source of the arsenic) by surface runoff was greatest. Abnormal arsenic concentrations have been measured in the Radium Hot Springs swimming pools by the B.C. Department of Health. We recommend that the arsenic concentrations (total and dissolved) of Sinclair Creek be measured several times during Phase II.

Downstream from the sewage lagoon discharge (site 0200094) there were slight increases in turbidity, total nitrogen and total phosphorus

(Table 7-24). However these increases were too small to be of concern. The major concern was the high fecal coliform densities. Four out of eight samples taken had fecal coliform densities of 2400 or more per 100 ml. The four other samples had densities ranging between 79 and 1600 per 100 ml, but three of these samples were taken during the spring freshet when dilution was greatest.

The maximum permissible limit for fecal coliform densities in raw drinking water, prior to coagulation, sedimentation, filtration and disinfection, is 1000/100 ml. in 90 percent of the samples taken in any consecutive 30 day period(56). Water Quality Criteria 1972(61) states that irrigation water with a fecal coliform density less than 1000/100 ml. should contain sufficiently low concentrations of pathogenic micro-organisms so that no health hazards to animals or man result from their use or from consumption of raw crops irrigated with such water. The recommended standards for bathing, swimming and recreation in British Columbia specify a median total coliform density of less than 1000/100 ml. with not more than 20 percent of the samples exceeding 2400/100 ml(62).

In view of these coliform standards, use of the water in Sinclair Creek below the sewage lagoon discharges should be restricted. It should not be used for domestic purposes, bathing, swimming, recreation, or for irrigation of dairy pastures or crops that are eaten raw until the effluent quality is improved or the discharge terminated. The Radium Waterworks is planning to construct new sewage collection and treatment facilities which will discharge to the Columbia River (section 3.1.2). This will end the present discharge to Sinclair Creek and the sanitary quality of Sinclair Creek below the sewage lagoons will return to the satisfactory level found upstream from the lagoons.

We do not recommend a monitoring program for Sinclair Creek during Phase II. The present water quality of Sinclair Creek has been well documented and the water quality will improve markedly when the effluent is no longer discharged.

4.5 Fairmont Creek

4.5.1 Presentation of Data

Fairmont Creek originates on Fairmont Ridge of the Stanford Range and flows west to join the Columbia River at Fairmont Hot Springs. It has a length of four or five miles and a drainage area of about four square miles. There has been no logging activity in its watershed, but land has been cleared to construct the Fairmont Hot Springs Resort Ltd. complex which includes a lodge, cabins, trailer parks, campgrounds, swimming pools, golf course and ski hill.

The Pollution Control Branch has sampled two sites on Fairmont Creek since February 1973. These sites are located upstream and downstream of the effluent discharges from the Fairmont Hot Springs Resort Ltd. complex to assess the effect of the discharges on Fairmont Creek. The location of these sites is shown in Figure 7-5 and a detailed description of the sites is given below:

Site 0200122: Fairmont Creek, upstream from Fairmont Hot Springs Resort Ltd. (500 feet above culvert in road to trailer park).

Site 0200123: Fairmont Creek, at the confluence with the Columbia River.

A summary of the data collected at these two sites between February 1973 and May 1975 is presented in Table 7-25. A detailed water quality survey was conducted by the Pollution Control Branch on May 25, 1972 with regard to the discharges from Fairmont Hot Springs Resort Ltd. This survey sampled five sites on Fairmont Creek, two sites on Cold Spring Creek, and three sites on the Columbia River. The results of the survey are presented in Table 7-26.

Four water licenses have been issued on Fairmont Creek for irrigation and domestic purposes, but all points of diversion are located upstream of the Fairmont Hot Springs Resort Ltd. discharges[21].

4.5.2 Discussion and Recommendations

The data in Table 7-25 indicate that the water in Fairmont Creek, upstream of the Fairmont Hot Springs Resort Ltd. discharges, was of good quality, and would be suitable for most purposes. With a hardness ranging between 140 to 268 mg/1, the water may be classed as moderately hard to very hard[55]. Fecal coliforms were not detectable (less than 2/100 ml), indicating that there were no sources of sewage upstream from the resort.

Downstream from the Fairmont Hot Springs Resort there were increases in dissolved solids (from 171 to 830 mg/1), specific conductance (from 314 to 1040 μmho/cm), temperature (up to 11°C increase), total alkalinity (from 139 to 215 mg/1), chloride (from 0.9 to 15.6 mg/1), hardness (from 160 to 587 mg/1), sulphate (from 21 to 363 mg/1), and sodium (from 1.2 to 12 mg/1). These increases were caused by the discharge of the heavily mineralized hot spring water from the resort's swimming pools. The water in Fairmont Creek downstream from the resort was probably unsuitable for domestic and industrial purposes due to its extreme hardness (463-684 mg/1)[56]. The maximum temperature increases (up to 11°C) could be harmful to aquatic life, but apparently there were no fish in Fairmont Creek because of its steep gradient[47]. Dissolved minerals in the hot spring water have precipitated out as carbonates in Fairmont Creek, coating the bottom of the creek and rendering it unsuitable as habitat for fish or benthic organisms. These changes in Fairmont Creek downstream from the resort's discharges are considered to be natural phenomena. The changes are due to the natural properties of the hot spring water which flowed into Fairmont Creek before the advent of the resort complex.

The data in Table 7-25 also indicate that there was a small increase in the fecal coliform density downstream from the resort complex, but increases observed to date were too small to be of concern. The data from the detailed sampling survey conducted on May 25, 1972

(Table 7-26) indicate that there were no significant differences in fecal coliforms, total organic carbon or total phosphorus on Fairmont Creek, Cold Spring Creek and the Columbia River due to the discharges from the resort complex.

A chlorine residual may exist in Fairmont Creek during low flow periods. The large swimming pool at the resort discharges a maximum of 300,000 GPD (0.56 CFS) of effluent with a chlorine residual of 0.3 to 1.3 mg/l. The minimum flow recorded in Fairmont Creek was 1.2 CFS in August 1966[47]. Thus, at minimum flow, the dilution ratio is only 2:1 and a chlorine residual of 0.15-0.65 mg/l could theoretically exist in Fairmont Creek. The Pollution Control Branch measured the chlorine residuals in the swimming pool effluent and Fairmont Creek on June 6, 1975 using the orthotolidine method. The effluent had a free chlorine residual of 0.15 mg/l and a total chlorine residual of 0.35 mg/l. One hundred feet downstream from the swimming pool discharge, Fairmont Creek had a free chlorine residual of 0.075 mg/l, while one-quarter mile downstream neither free chlorine or total chlorine could be detected. The flow in Fairmont Creek was estimated to be about four CFS[47].

Servizi[63] reported that acute toxicity or sublethal toxic conditions for fish are likely when chlorine residuals exceed 0.02 mg/l measured by the amperometric method. Water Quality Criteria 1972[61] states that aquatic life should be protected where the concentration of residual chlorine in the receiving system does not exceed 0.05 mg/l for a period up to 30 minutes in any 24 hour period.

We conclude that levels of chlorine toxic to aquatic life may exist in Fairmont Creek. This is not considered to be significant because Fairmont Creek does not appear to be capable of supporting aquatic populations due to its steep gradient and the precipitation of carbonates on the streambed.

We recommend that the Pollution Control Branch continue routine monitoring for total chlorine residual and fecal coliforms in Fairmont Creek downstream from the resort's discharges.

4.6 Lillian Lake

4.6.1 Presentation of Data

Lillian Lake is a small lake (65.8 acres) located in the Rocky Mountain Trench about two miles west of Invermere (Figure 7-5). The lake has a drainage area of 4.34 square miles, a maximum depth of 39 feet, a mean depth of 17 feet and volume of 1100 acre-feet. The Water Investigations Branch conducted a study of Lillian Lake during 1973 in response to residents' concern of increasing population and development around the lake. The residents were particularly concerned about the effect on the lake of subsurface disposal of sewage, water removals from the lake, and the use of outboard gasoline engines on the lake[68,69].

Thirteen water samples were taken at five sites on the lake between June 1973 and September 1973. A summary of the data for the five sites (sites 1100615, 1100616, 1100618, 1100619 and 1100620) is presented in Table 7-27. The data from all five sites and all sampling depths were combined in Table 7-27, since there were no significant variations with depth or between stations for most parameters.

4.6.2 Discussion and Recommendations

The data in Table 7-27 indicate that the water in Lillian Lake was of good quality and would be suitable for most purposes. The water contained a considerable amount of dissolved minerals as shown by the values for specific conductance (472-688 μmho/cm), alkalinity (288-370 mg/l) and hardness (290-420 mg/l). The water may be classed as very hard[55] or as of poor quality with respect to hardness[56], which makes its use for domestic purposes less desirable. The concentrations of heavy metals such as cadmium, copper, iron, lead, mercury, nickel and zinc were very low. The values for turbidity and extinction depth indicated that the water was clear and relatively free of suspended matter.

The study of Lillian Lake[68] concluded that the lake was in a mesotrophic state, tending toward eutrophy. For this reason, the lake was considered to be very sensitive to nutrient additions of any kind. The population density in the Lillian Lake watershed was considered to be near the tolerance level of the lake. To prevent eutrophication of the lake, it was recommended that further increases in population within the watershed be minimized, or that the sewage be disposed of outside the watershed.

A monitoring program for Lillian Lake is not recommended during Phase II.

5. AQUATIC BIOLOGY

5.1 Sources of Information

Current data on the aquatic biology of the upper Columbia River and its tributaries are not extensive. Fairly detailed limnological surveys have been carried out on Columbia, Windermere, Whitetail, Lillian and Enid Lakes[64,65,66,67,68,69]. Qualitative estimates of fish production for many of the smaller lakes are available from the Fish and Wildlife Branch[64]. Windermere Lake has received particular attention because excessive weed growth in parts of the lake interferes with recreation, and it was the subject of a 1971-73 Water Investigations Branch study[66]. Surface water quality data collected intermittently since 1968 at stations on Columbia River, Toby Creek, Sinclair Creek and Fairmont Creek by the Pollution Control Branch provide some indication of aquatic environmental quality in this region.

5.2 Lake Survey Data

Lakes in this part of the Rocky Mountain Trench are typically small, shallow, stratified, alkaline, low in organic nutrients but have relatively high total dissolved solids and moderately hard water [65,71]. Some have marl formations (e.g., Enid Lake, Lillian Lake). Fish production is moderate. Excluding Columbia and Windermere Lakes, most of the lakes have small drainage areas, restricted outflows and long flushing times, and hence could accumulate deleterious substances. Future development resulting in discharges to these lakes should be closely monitored[70]. One such lake, Lillian Lake, was studied by the Water Investigations Branch[68,69] which concluded that to prevent eutrophication of the lake, the population in the lake's watershed must be limited or that sewage must be disposed of outside of the watershed (section 4.6).

Windermere Lake water quality was monitored by the Pollution

Control Branch and the Water Investigations Branch. Results were similar to background levels in Columbia River above and below the lake (Chapter 4). Water Investigations Branch reports on Windermere Lake[66,67] indicated satisfactory water quality and no evidence of cultural eutrophication promoting the weed growth. The volume of Windermere Lake is small compared to the annual flow through the lake and thus the water in the lake is completely changed several times per year (3-7 times/year), effectively preventing accumulation of nutrients. At present, Windermere Lake is probably immune to eutrophication caused by urban development[67]. Aquatic weeds (mostly Potamogeton natans) are a major nuisance to swimmers and boaters during the July-September period in parts of the lake. However, the area affected has apparently not increased during the past 20 years of waterfront development. The manipulation of water levels to control excessive weed growth was considered to be impractical.

5.3 Biological Impacts

Indications are that the existing pattern of settlement and land use does not seriously affect aquatic biological resources in Region 7. There are no major industrial or municipal discharges (Chapters 2 and 3), and surface water quality results were within recommended criteria for aquatic life (Chapter 4).

Timber harvesting in the Rocky Mountain Trench north of Canal Flats may have local effects on stream drainage and ecology, warranting individual appraisal and control by responsible agencies where necessary. Logging has conflicted with recreational use of some areas in the past (e.g., upper Bugaboo Creek)[27]. Small-scale mining operations near Windermere Lake (gypsum), Spillimacheen (barite) and on Toby Creek (barite) may raise turbidity and suspended solids in adjacent waters; however, effects on Toby Creek, for which monitoring data are available, were not significant[70] (Chapter 4).

All municipalities in the region provide secondary treatment or equivalent before discharging to receiving waters, or else discharge to ground (Chapter 3). Contribution of nutrients to surface waters by municipal sewage is small. Coliform tests on Windermere Lake during 1972, conducted by the East Kootenay Health Unit[70], showed no sewage contamination of the lake waters which would prevent recreational use. However, increasing tourism and resulting campground wastes will probably require an increase in controlled disposal facilities to prevent contamination of water supplies.

Future water management schemes affecting aquatic biology in this region include possible development of storage reservoirs for irrigation, and possible diversion of 1,500,000 acre-feet per year from the Kootenay River to the Columbia River at Canal Flats, under terms of the Columbia River Treaty (sections 1.5.4, 3.2.3b, and 4.2.3). Biological impacts cannot be assessed with the existing data base.

5.4 Recommendations

Present intensity of land use and development in Region 7 does not seriously affect aquatic biological resources. A special biological study in addition to the water quality sampling recommended in Chapter 4 is not considered necessary at the present time, with the exception of periodic reassessment of aquatic weed infestation in Columbia and Windermere Lakes.

Specific development plans for the region will require comprehensive environmental impact assessment when tendered. The environmental impact assessment of the Kootenay River diversion at Canal Flats is currently being studied by B.C. Hydro and its consultants.

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FIGURE 7-1
REGION 7, THE UPPER COLUMBIA RIVER BASIN

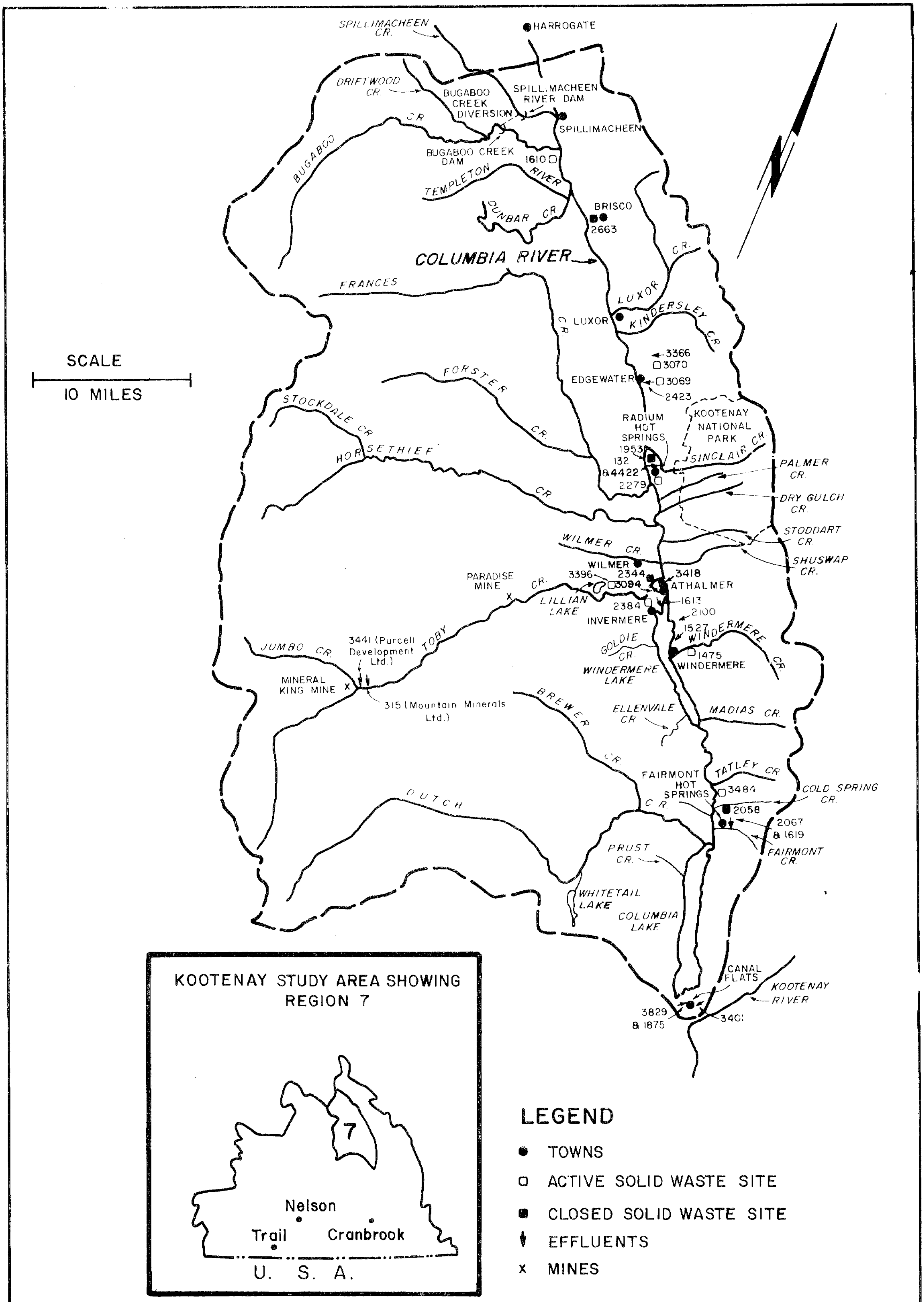

FIGURE 7-2

MEAN MONTHLY DISCHARGE IN THE COLUMBIA RIVER AT FAIRMONT HOT SPRINGS, EDGEWATER AND GOLDEN

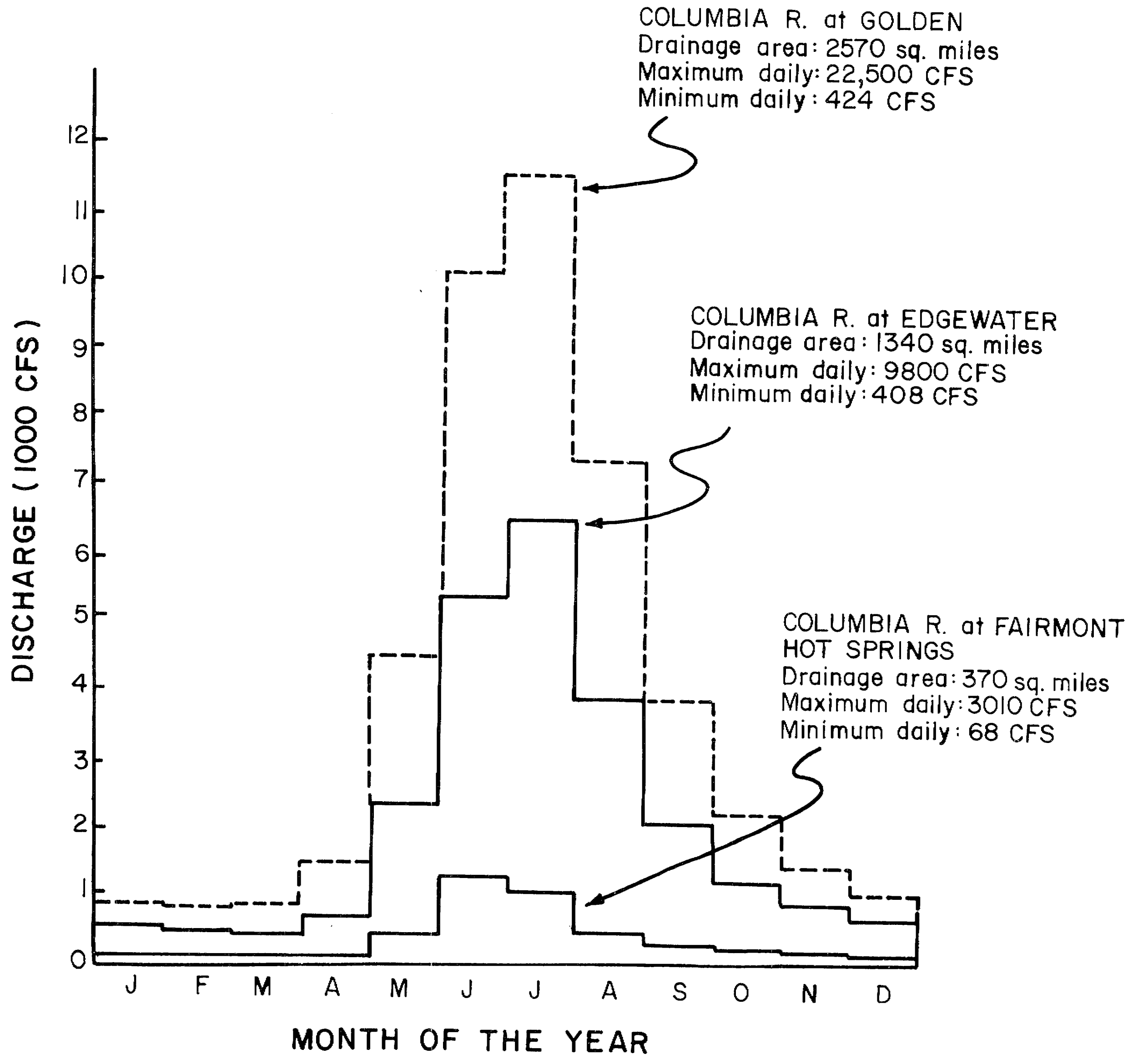

FIGURE 7-3
EXISTING FOREST HARVESTING OPERATIONS IN REGION 7

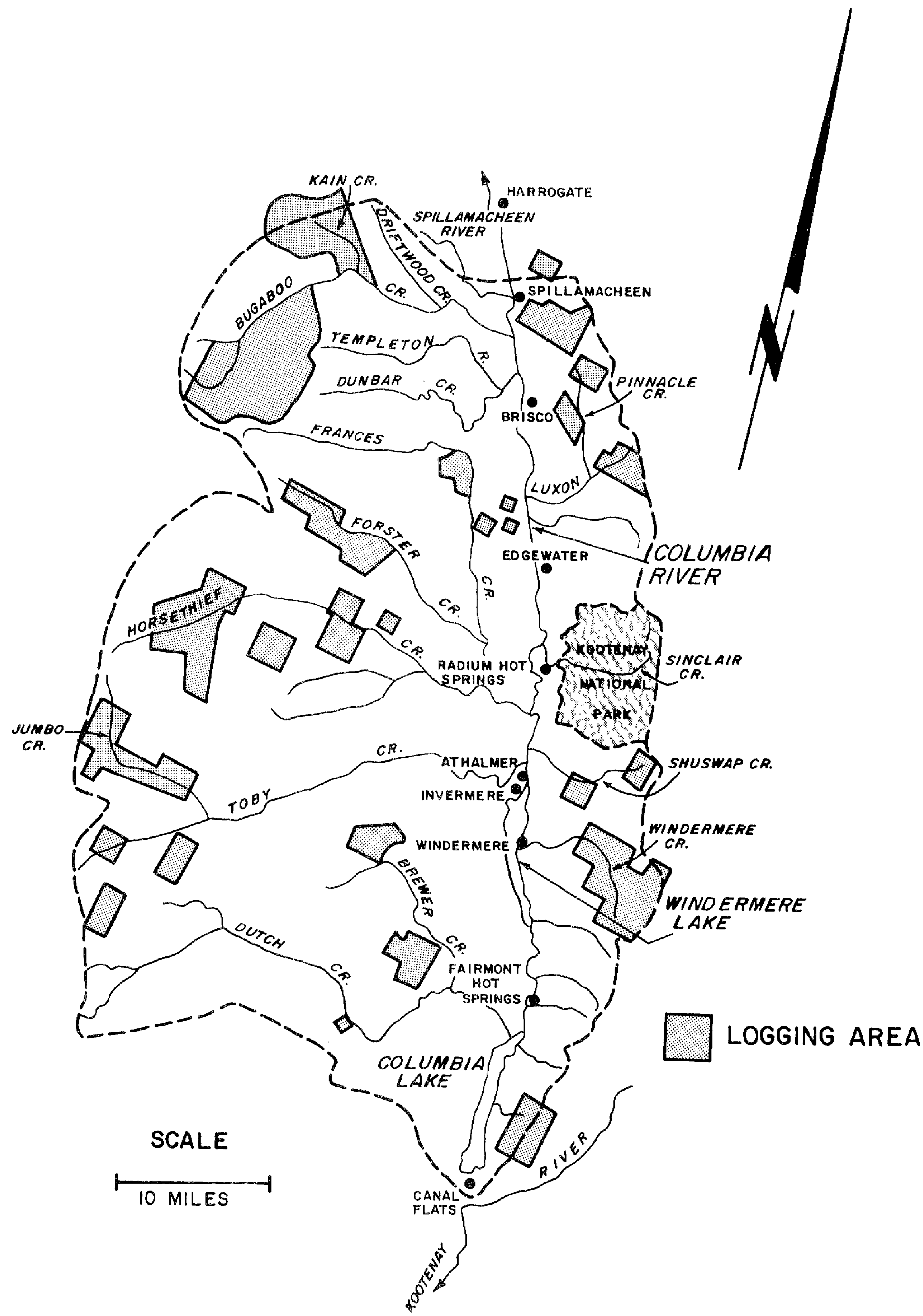

FIGURE 7-4
MOUNTAIN MINERALS LTD
SIMPLIFIED FLOW DIAGRAM OF BARITE CONCENTRATING PLANT

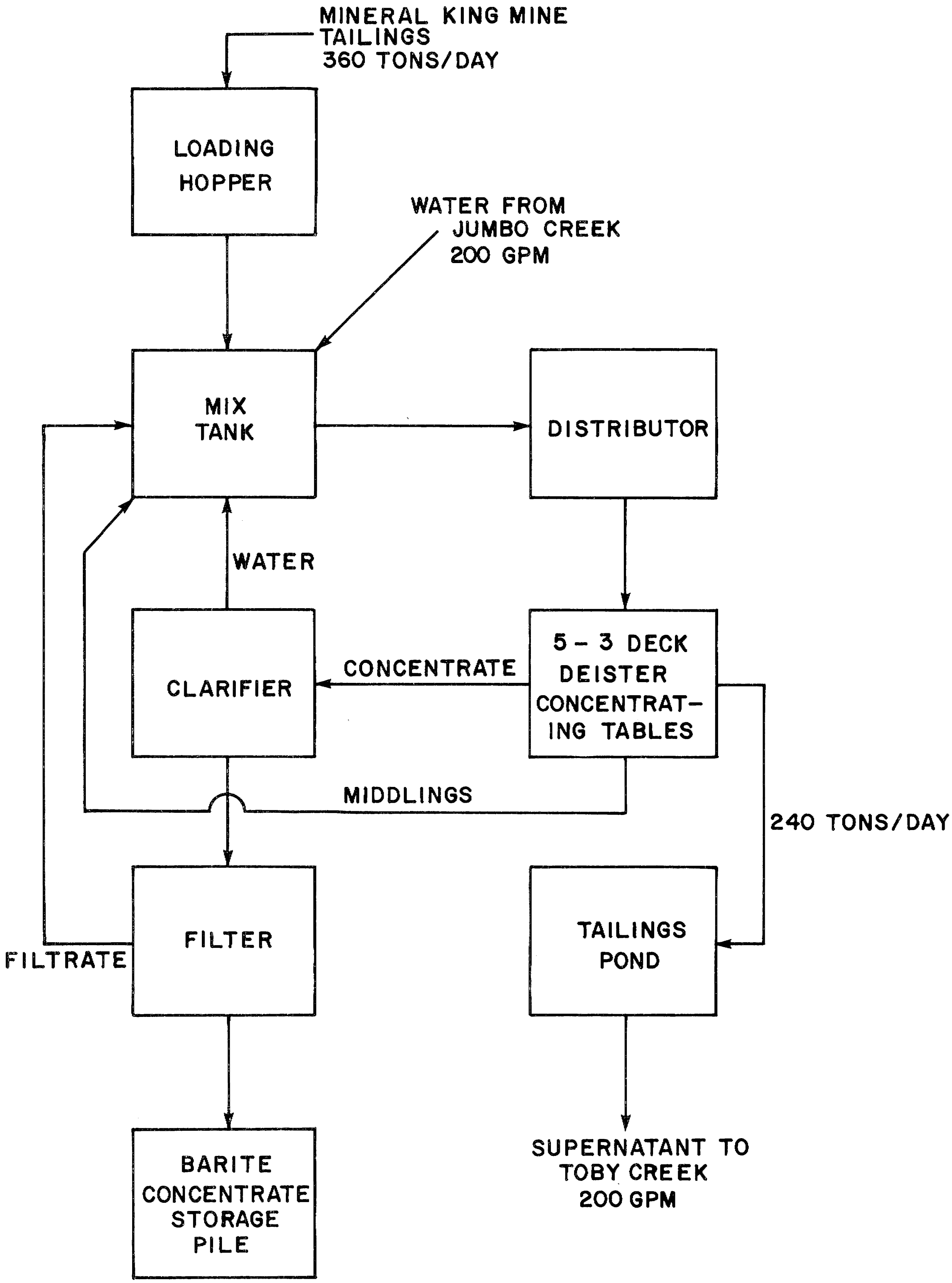

FIGURE 7—5
WATER QUALITY SAMPLINGS SITES IN REGION 7

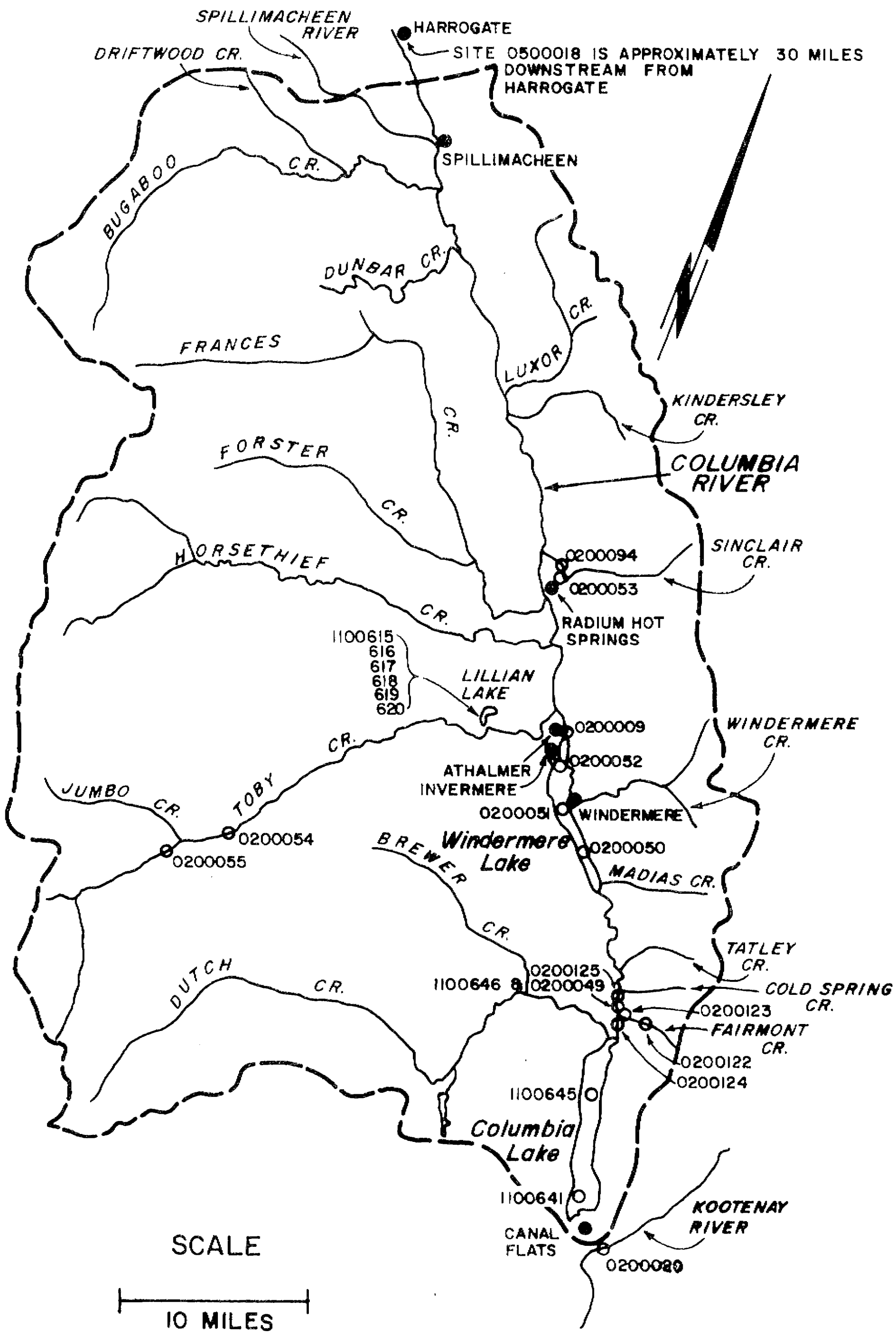

TABLE 7-1

DISTRIBUTION OF GROUNDWATER WELLS IN REGION 7

Location	Number of Wells
Windermere area	39
Athalmer area	38
Canal Flats	23
Indian Reserve No. 3 (east side of Windermere Lake)	14
Invermere area	13
Edgewater	13
Fairmont Hot Springs area	10
Thunder Hill Park (west side of Columbia Lake)	5
Dry Gulch Creek area	5
Brisco	5
Wilmer	4
Shuswap Indian Reserve (east of Columbia River at Athalmer)	4
Spillimacheen	4
Radium Junction	3
Stoddart Creek area	2
	TOTAL 182

TABLE 7-2

SUMMARY OF WATER LICENSES IN REGION 7

Source	No. of Licenses	Quantity	Purpose	Owner	Location*	Comments
Brady Cr.	5	228 AF** 1000 GPD***	irrigation domestic		L.21 (West side of Windermere Lake)	91 acres irrigated Application made for 320 AF to irrigate 82 acres.
Bruce Cr.	1	500 AF	irrigation	Wilmer Water-works Dist.	Wilmer	200 acres irrigated (estimated assuming 2.5 AF/acre)
Bugaboo Cr.	1	13.45×10^{6} GPD	power	B.C. Power Commission	D.L. 11454 (Spilli-macheen)	25 CFS+
Cedar Cr.	1	55 AF	irrigation		D.L. 349	22 acres irrigated
Cold Spring Cr.	11	475 AF 66,000 GPD	irrigation domestic		Fairmont Hot Springs	200 acres irrigated
Columbia R.	1 1 1	137,000 GPD 221 AF 2000 GPD 3000 GPD 10 AF	industrial irrigation domestic industrial industrial	Director of Indian Affairs	L.1, Shuswap I.R. L.2563 L.8208 & L.8995	Western Gypsum Ltd. 130 acres irrigated Botts Channel
Downey Pond	6	27 AF	irrigation		L.450 (north end of Columbia Lake)	11 acres irrigated (estimated assuming 2.5 AF/acre)
Dry Gulch Cr.	30	1.2 AF 38,500 GPD	irrigation domestic		L.8208 (east of Columbia R. between Wilmer & Radium)	fully recorded
Dunbar Cr.	2	69 AF 500 GPD	irrigation domestic		D.L.'s 9568, 2563 (Brisco)	27 acres irrigated
Dutch Cr.	3	502 AF 1000 GPD	irrigation domestic		Fairmont Hot Springs	200 acres irrigated

*All lots are located in the Kootenay Land District. ** AF: Acre-feet *** GPD: Imperial gallons per day
+CFS: Cubic feet per second

TABLE 7-2 Continued

SUMMARY OF WATER LICENSES IN REGION 7

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Ellenvale Cr.	1	60 AF 10,000 GPD	irrigation domestic	Diversified Holdings	W½ of W½ of L.346 (W. side of Windermere Lake)	30 acres irrigated, fully recorded
Enid Lake	1	235 AF 1000 GPD	irrigation domestic		S.L's 7,8&10 of D.L. 378 (Wilmer)	94 acres irrigated
Fairmont Cr.	4	233 AF 10,000 GPD	irrigation domestic		Fairmont Hot Springs	93 acres irrigated (estimated assuming 2.5 AF/acre)
Forster Cr.	5	675 AF 5.92×10^6 GPD	irrigation power		D.L.'s 700,701,702 & 4348 (Radium)	720 acres irrigated
Fraling Cr.	14	565 AF 6000 GPD	irrigation domestic		Spillimacheen	243 acres irrigated
Frances Cr.	2	870 AF	irrigation		D.L.'s 7907,7908, 7907&7911. (Steamboat Mountain)	348 acres irrigated
Geary Cr.	2	10,000 GPD	domestic		Fairmont Hot Springs	
Goldie Cr.	1 1 4	1,500,000 GPD 200,000 GPD 393 AF	domestic domestic irrigation	Village of Invermere Westside Improvement Dist.	West side of Windermere Lake	Fully recorded 157 acres irrigated (estimated assuming 2.5 AF/acre)
Hardie & South Hardie Cr's.	18	98 AF 10,000 GPD 10,000 GPD	irrigation industrial domestic		West side of Columbia Lake	39 acres irrigated (estimated assuming 2.5 AF/acre)
Hatch Cr.	2	34 AF	irrigation		T.P.23, R.18, Section 22	14 acres irrigated

TABLE 7-2 Continued

SUMMARY OF WATER LICENSES IN REGION 7

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Hurst & W. Hurst Cr's.	2	250 AF 1000 GPD	irrigation domestic		L.7907 & L.7908 (Steamboat Mtn.)	100 acres irrigated
Jane Cr.	1	10 AF 25,500 GPD	irrigation domestic		L.8	5 acres irrigated
Johnston Cr.	3	170 AF 1500 GPD	irrigation domestic		L.'s 107,5118 &S.L. 16 of D.L. 4596	108 acres irrigated
Jumbo Cr.	1	288,000 GPD	industrial	Mountain Minerals Ltd.	L.16126 (Confluence of Jumbo & Toby Cr's)	mining, ore processing
Kindersley Cr.	2	850 AF 2000 GPD	irrigation domestic		L.'s 348,352,353, 7569,7580,7581,9040, 9051 & 10716.	350 acres irrigated. Application made for 750 AF irrigation & 25,000 GPD domestic
Kreuter Cr.	1	250 AF	irrigation		L.'s 9196,9197 & S.L. 4 of D.L. 4596	100 acres irrigated
Lame Joe Cr.	1	50 AF	irrigation	Indian Affairs Branch	Lower Columbia Lake I.R. #3	24 acres irrigated
Luxor Cr.	4	534 AF 75,500 GPD	irrigation domestic	Luxor Cr.Util.	D.L.'s 5117,9008,448, 7571 & 9574 (Luxor)	240 acres irrigated
Macaulay Cr.	9	288 AF 203,000 GPD	irrigation domestic		Edgewater	124 acres irrigated
Marion Cr.	2	410 AF 2000 GPD	irrigation domestic		L.'s 287,663 & 664. (W. side of Columbia Lake)	164 acres irrigated
McKay Cr.	1	92 AF 1500 GPD	irrigation domestic	Kirk Ltd.	L.673	36 acres irrigated

TABLE 7-2 Continued

SUMMARY OF WATER LICENSES IN REGION 7

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
McMurdo Cr.	7	376 AF 1000 GPD	irrigation domestic		D.L.'s 1090,1088, 10733 & 1089	186 acres irrigated
Neave Cr.	1	77 AF	irrigation		L.'s 120 & 123 of D.L.4096(Invermere)	31 acres irrigated
Pratt Cr.	2	71 AF	irrigation		T.P.23, R.18,Sec. 28 & 32	59 acres irrigated
Prust Cr.	2	64 AF 1500 GPD	irrigation domestic		D.L.7548 (W.side of Columbia Lake)	26 acres irrigated Fully Recorded
Pye Cr.	1	14,500 GPD	domestic & industrial	Timber Springs Inv.Corp.Ltd.	S.L. 19 of D.L.4596	
Shuswap Cr.	5	1412 AF 11,500 GPD	irrigation domestic		Windermere	702 acres irrigated
Sinclair Cr.	4	237 AF 1500 GPD 13.45×10^6 GPD	irrigation domestic power		Radium Hot Springs	120 acres irrigated
Sixty-two Mi.Cr.	10	64,500 GPD	domestic		Edgewater	
Soles Cr.	2	93 AF 500 GPD	irrigation domestic		T.P.23, R.18, Sec.14	37 acres irrigated
Spillimacheen R.	1 1	300,000 GPD 161×10^6 GPD	industrial power	Bariod of Can. B.C. Power Com.	Spillimacheen Dam	mining, milling 300 CFS
Squaw Point Cr. & Pirie Cr.	2	105 AF	irrigation		D.L. 1903	42 acres irrigated
Stoddart Cr.	27	239 AF 64,000 GPD	irrigation domestic		D.L.'s 288,5353 & 9248	146 acres irrigated

TABLE 7-2 Continued

SUMMARY OF WATER LICENSES IN REGION 7

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Sunlight Cr.	1 5	250,000 GPD 1,750 GPD 279 AF	domestic domestic irrigation	Village of Invermere	Invermere	122 acres irrigated
Tatley Cr., Madias Cr. & Sophy Cr.	1	2,900 AF 15,000 GPD	irrigation domestic	Indian Affairs Branch	Lower Columbia Lake I.R. #3	1160 acres irrigated
Taynton Cr.	1	36,500 GPD	domestic	Panorama Ski Hill Co.	L.'s 4690 & 16352	
Templeton R.	5	273 AF 500 GPD	irrigation domestic		D.L.350 & 11385 (Brisco)	128 acres irrigated
Thorold Cr.	1	91 AF 1000 GPD	irrigation domestic	Royal Antler Ranch	S.L.'s 3 &114 of D.L. 4596(Dutch Cr.)	36 acres irrigated
Wilmer Cr.	4	396 AF 2000 GPD	irrigation domestic		L.376 (Wilmer)	158 acres irrigated (estimated assuming 2.5 AF/acre) fully recorded
Wilmer Lake	1	29 AF	irrigation	Wilmer Water-works Dist.	Wilmer	12 acres irrigated (estimated assuming 2.5 AF/acre)
Windermere Cr.	37	2282 AF 9300 GPD	irrigation domestic		Windermere	936 acres irrigated (estimated assuming 2.5 AF/acre)
Windermere Lake	11	120 AF 656,000 GPD	irrigation domestic	Windermere Improvement Dist. Parr Util.Ltd. Terravista Services Ltd.	Windermere Lake	37 acres irrigated

In addition to those previously listed, there are numerous sources of water supply for domestic and irrigation purposes which are smaller than those listed. Only those sources providing 10,000 GPD (13 AF) or more are listed.

TABLE 7-3

AREAS IN REGION 7 WITH LIMITED WATER AVAILABILITY

Location	Limited Sources of Water Supply	Comments
West side of Windermere Lake Invermere	Goldie Creek	Fully recorded, supplies Village of Invermere and Westside Improvement District.
S.W. of Windermere Lake	Ellenvale Creek	Fully recorded
West side of Columbia Lake	Prust Creek	Fully recorded
Wilmer	Wilmer Creek	Fully recorded
Radium Hot Springs	Dry Gulch Creek Palmer Creek	Fully recorded Fully recorded, tributary of Dry Gulch Creek

TABLE 7-4

POPULATIONS OF SOME SETTLEMENTS IN REGION 7[22,23]

Settlement	1971 Population
Invermere	1065
Windermere	421
Radium Hot Springs	393
Edgewater	346
Athalmer (Lake Windermere)	255
Wilmer	200
Spillimacheen	82
Brisco	77
Fairmont Hot Springs	62

TABLE 7-5

SOME IMPORTANT FISHING LOCATIONS IN REGION 7[64]

Lake or Stream	Size	Location	Fish Species, Size Caught
Blue Lakes	3 small lakes	east of Windermere	cutthroat trout to 6 inches
Cartwright Lk.	½ x ½ mile	30 miles N.of Wilmer	rainbow trout to 8 lb.
Clelland Lake	½ x 1 mile	6 miles W.of Brisco	rainbow trout to 6 lb.
Columbia Lake	10 x 2 mile (6360 acres)		whitefish to 1 lb. rainbow trout to 2.5 lb.
Dunbar, Twin, Bott, Fish Lks.	65 acres or	near Wilmer	cutthroat trout to 3 lb.
Dutch Creek		enters N.W. Columbia Lake	whitefish, cutthroat trout, rainbow trout to 4 lb. Dolly Varden to 10 lb.
Enid Lake	55 acres	3 miles W.of Wilmer	Eastern brook trout to 2 lb.
Hall Lakes	2 small lakes	22 miles N.of Wilmer	cutthroat trout to 10 inches
Halgrove Lake	½ x ¼ mile	20 miles N.of Wilmer	cutthroat trout to 4 lb.
Jade Lake		7 miles W.of Brisco	rainbow trout to 2 lb.
Lillian Lake	67 acres	4 miles W.of Inver-mere	rainbow trout to 5 lb. Eastern brook trout
Munn Lake		½ mile from Wilmer	Eastern brook trout to 2 lb.
Toby Creek		enters west side of Windermere Lake	cutthroat trout Dolly Varden char whitefish to 4 lb.
Whitetail Lake	3½ x ¼ mile (400 acres)	18 miles W. of Canal Flats	rainbow trout Dolly Varden char whitefish
Windermere Lake	10 x 1 mile (4490 acres)		rainbow trout to 5 lb. Dolly Varden char

TABLE 7-6

SUMMARY OF POLLUTION CONTROL BRANCH EFFLUENT PERMITS IN REGION 7

Permit Number	PE-315	PE-3441	PE-3401	PE-3366
Permittee	Mountain Minerals Ltd.	Purcell Development Co. Ltd.	Crestbrook Forest Ind. Ltd.	H. More
Date Issued	Dec. 4, 1969	Nov. 5, 1974	Aug. 8, 1974	July 24, 1974
Location	Confluence of Toby & Jumbo Cr.	Confluence of Toby & Jumbo Cr.	Canal Flats	Edgewater
Type of Effluent	barite concentrating plant effluent	Lead-zinc-silver ore dressing plant effluent	boiler blowdown & cooling water	septic tank pumpage
Quantity of Effluent Allowed	288,000 IGPD (tailings pond supernatant) 50 IGPD (wash-down water)	180,000 IGPD (maximum)	515 IGPD	2000 IGPD
Quality of Effluent Allowed	tailings pond supernatant: SS:50 mg/l DS:2,500 mg/l SO_4:250 mg/l pH:6.5-8.5 Cu,diss:0.05mg/l Pb,diss:0.05mg/l Zn,diss:3.0mg/l Fe,diss:0.3mg/l washdown water: typical wash-down water	typical lead-zinc-silver ore dressing tailings	typical boiler blowdown & uncontaminated cooling water	typical septic tank pumping
Type of Treatment	Tailings impoundment, decant structure. wash-down water settling pond.	tailings impoundment, reclaim works, seepage return works	exfiltration sump	exfiltration/ evaporation trenches
Discharged To	tailings pond supernatant-Toby Creek Washdown water-no positive discharge (refer to sec. 2.1.2)	no discharge (refer to sec. 2.2)	ground	ground

TABLE 7-6 Continued

SUMMARY OF POLLUTION CONTROL BRANCH EFFLUENT PERMITS IN REGION 7

Permit Number	PE-2423	PE-1613	PE-132	PE-2057
Permittee	Campgrounds of Canada	Mr. Madson	Radium Sewerage District	Fairmont Hot Springs Resort Ltd.
Date Issued	Mar. 29, 1974	Sept. 25, 1972	June 22, 1965 Expired June 22, 1970	July 17, 1973 Amended Jan. 3, 1974
Location	Edgewater	Invermere	Radium Hot Springs	Fairmont Hot Springs
Type of Effluent	domestic	laundromat & domestic	domestic	swimming pool effluent
Quantity of Effluent Allowed	18,000 IGPD (maximum)	3000 IGPD	45 GPM(max.) 30,000 GPD (average)	300,000 IGPD (max.)
Quality of Effluent Allowed	BOD_5:45mg/1 SS :60mg/1	combined laundromat & domestic effluent	BOD_5:80 mg/1 SS :50 mg/1 coliform bacteria M.P.N.: $1x10^6$/100 ml	typical flow-through hot spring swimming pool effluent, Chlorine residual:0.3tol.3mg/1
Type of Treatment	lagoons, chlorination facilities, outfall pipe	lint interceptor screen, septic tanks, tile field	2-cell waste stabilization pond	chlorination, outfall to creek
Discharged To	Columbia River	ground	Sinclair Creek (refer to sec. 3.1.2)	Fairmont Creek (refer to sec. 3.1.3)

TABLE 7-6 Continued

SUMMARY OF POLLUTION CONTROL BRANCH EFFLUENT PERMITS IN REGION 7

Permit Number	PE-3829	PE-1875	PE-1619	PE-1527
Permittee	Mr. R. Belcher	Cal's Service Station Ltd.	Fairmont Hot Springs Resourt Ltd.	Nu West Development Corporation Ltd.
Date Issued	Jan. 15, 1975	June 11, 1973	Nov. 29, 1972	June 8, 1972
Location	Canal Flats	Canal Flats	Fairmont Hot Springs	Windermere (condominium complex)
Type of Effluent	laundromat & domestic	laundromat	domestic & swimming pool	domestic
Quantity of Effluent Allowed	1200 IGPD	1000 IGPD	30,000 IGPD (average) (20,000 IGPD domestic & 10,000 IGPD swimming pool)	25,000 IGPD (maximum)
Quality of Effluent Allowed	typical laundromat effluent & domestic sewage effluent	typical laundromat effluent & domestic wastewater	typical septic tank and swimming pool effluent	BOD_5: 30 mg/l SS : 50 mg/l
Type of Treatment	lint interceptor screen, septic tank, tile field	lint interceptor screen, septic tank, tile field	septic tank and ground disposal	extended aeration package treatment plant, tile fields
Discharged To	ground	ground	ground (natural sink hole) (refer to sec. 3.1.3)	ground

TABLE 7-6 Continued

SUMMARY OF POLLUTION CONTROL BRANCH EFFLUENT PERMITS IN REGION 7

Permit Number	PE-3094
Permittee	Village of Invermere
Date Issued	Nov. 7, 1974
Location	Invermere
Type of Effluent	Domestic
Quantity of Effluent Allowed	375,000 IGPD (maximum) 250,000 IGPD (average)
Quality of Effluent Allowed	BOD_5: 45 mg/l SS : 60 mg/l
Type of Treatment	comminution, aerated lagoons, chlorination, aerated holding lagoon, outfall
Discharged To	Toby Creek (refer to sec. 3.1.1)

TABLE 7-7

SUMMARY OF POLLUTION CONTROL BRANCH

EFFLUENT APPLICATIONS IN REGION 7

Application Number	AE-2100	AE-4422
Application Date	Sept. 16, 1974	Jan. 29, 1976
Location	Windermere	Radium Hot Springs
Type of Effluent	treated domestic sewage	treated domestic sewage
Proposed Quantity of Effluent	25,000 IGPD during June, July and Aug. 1,000 IGPD for remainder of year	250,000 IGPD (average) 460,000 IGPD (maximum)
Proposed Quality of Effluent	BOD_5 < 30 mg/1 SS < 30 mg/1 TS < 500 mg/1	BOD_5 < 45 mg/1 SS < 60 mg/1 TS < 500 mg/1 pH: 6.5-8.5 temperature: 32-80^{o}F
Proposed Treatment	aerated lagoons, evaporation pond	oxidation ditch, clarifier, chlorination facilities, submerged outfall, sludge drying beds
Proposed Discharge Point	no discharge, evaporation pond	Columbia River

TABLE 7-8

DESCRIPTION OF INDUSTRIAL SOLID WASTE DISPOSAL SITES IN REGION 7

Pollution Control Branch Application Or Permit Number	PR-3069	PR-3070	AR-2344
Operator And Location	H. Seel, Edgewater (Airport Site)	H. Seel, Edgewater (Mill Site)	J. Kirsch Sawmills Ltd. Invermere
Status Of Refuse Disposal Site And Level Of Operation**	active site level C**	active site level C	site closed
Quantity And Type Of Refuse	combined total of 16 cu. yd./day of wood-wastes		3 cu. yd./day wood-wastes
Site Suitability Factors: Depth To Groundwater Table (feet)	50	50	0 (when Toby Creek floods)
Site Suitability Factors: Underlying Soils	gravel, clay	gravel clay	sand, gravel
Site Suitability Factors: Surface Runoff or Flooding	no	no	flooding by Toby Creek
Site Suitability Factors: Distance to Surface Water (feet)	4000	5000	0 (when Toby Creek floods)
Site Suitability Factors: Distance to Wells (feet)	3500	2500	2500
MAP/PE*	16/20	16/20	16/20
Potential For Adverse Effects On Groundwater or Surfacewater	Groundwater: nil Surfacewater: nil	Groundwater: nil Surfacewater: nil	Groundwater: nil Surfacewater: negligible (site is very small and closed)
Comments	estimated life of 10 years	estimated life of 6 months	site unsuitable, application withdrawn, Mill closed 6/73.

*MAP/PE: Mean annual precipitation/average potential evapotranspiration.

** As defined in the Operational Guidelines for the Discharge of Refuse on Land, Pollution Control Branch, October 1971.

TABLE 7-8 Continued

DESCRIPTION OF INDUSTRIAL SOLID WASTE DISPOSAL SITES IN REGION 7

	Pollution Control Branch Application Or Permit Number	AR-3418	AR-2663	AR-1953
	Operator And Location	North Star Planing, Athalmer	Brisco Saw-Mills, Brisco	Revelstoke Sawmill Ltd., Radium Hot Springs
	Status Of Refuse Disposal Site And Level Of Operation **	site closed	site closed	site closed
	Quantity And Type Of Refuse	2 cu. yd./day wood-wastes	1 cu. yd./day wood-wastes	16 cu. ft./day wood-wastes
Site Suitability Factors	Depth To Groundwater Table (feet)	0 (when Columbia River floods)	0 (when Columbia River floods)	0 (when Columbia River floods)
	Underlying Soils	clay, silt sand	silt, clay	gravel
	Surface Runoff Or Flooding	flooding by Columbia R., site 1 ft. below high water mark	flooding by Columbia River	flooding by Columbia River
	Distance To Surface Water (feet)	300	2500	5000
	MAP/PE *	16/20	16/20	16/20
	Potential For Adverse Effects On Groundwater or Surfacewater	Groundwater: nil Surfacewater: negligible (site is small and closed)	Groundwater: nil Surfacewater: negligible (site is small)	Groundwater: nil Surfacewater: negligible (site is small and closed)
	Comments	site unsuitable, application withdrawn, wood-wastes to be burned.	applicant requested to find another site, refuse stockpiled at present. Unresolved 11/4/75.	site closed 5/74. wood-wastes to be burned or hauled to PR-2297.

TABLE 7-9

MOUNTAIN MINERALS LTD.

POLLUTION CONTROL BRANCH MONITORING RESULTS FOR THE TAILINGS POND EFFLUENT

Site Number	PE-00315			
Sampling Period	June 1973 - June 1975			
Parameter \ Type of Value	Maximum	Minimum	Average	No. of Values
Alkalinity, Total mg/l	130	49	94	5
Cadmium, Dissolved mg/l	0.0054	0.0005	0.0023	4
Calcium, Dissolved mg/l	60	60	60	1
Chloride, Dissolved mg/l	0.9	<0.5	0.6	5
Chromium, Dissolved mg/l	<0.005	<0.005	<0.005	1
Conductance, Specific μmho/cm	680	310	484	8
Copper, Dissolved mg/l	0.01	0.003	0.005	5
Fluoride, Dissolved mg/l	<0.1	<0.1	<0.1	4
Hardness, Total Dissolved mg/l	207	207	207	1
Iron, Dissolved mg/l	<0.1	<0.04	0.08	5
Lead, Dissolved mg/l	0.06	0.005	0.029	5
Magnesium, Dissolved mg/l	14	14	14	1
Manganese, Dissolved mg/l	0.37	0.07	0.15	5
pH	8.2	7.6	7.9	9
Solids, Dissolved mg/l	562	174	319	5
Solids, Suspended mg/l	20	1	7	5
Solids, Total mg/l	566	176	326	5
Sulphate, Dissolved mg/l	311	20	136	5
Zinc, Dissolved mg/l	2.5	0.42	1.0	5

TABLE 7-10

DESCRIPTION OF MUNICIPAL SOLID WASTE DISPOSAL SITES IN REGION 7

	Pollution Control Branch Application Or Permit Number	AR-2058	PR-1475	PR-1610	PR-2384
	Operator And Location	Fairmont Hot Springs Resort	Regional Dist. of East Kootenay, Windermere	Regional Dist. of East Kootenay, Brisco-Spillimacheen	Village of Invermere
	Status of Refuse Disposal Site and Level Of Operation **	site closed	active site level C**	active site level C	active site level B (May 1 to Sept.30) level C (Oct.1 to April 30)
	Quantity And Type Of Refuse	24 cu.yd./day (May-Sept.) 12 cu.yd./day (Oct.-Apr.) municipal	2 tons/day municipal (includes septic tank sludge)	10 cu.yd./day municipal	10 cu.yd./day (1200 people) municipal (includes septic tank sludge)
Site Suitability Factors	Depth To Groundwater Table (feet)	400	not a problem	not a problem	300
Site Suitability Factors	Underlying Soils	clay, gravel	silty sand	gravelly till, sandy loam	bedrock, sandy loam
Site Suitability Factors	Surface Runoff or Flooding		no	no	no
Site Suitability Factors	Distance to Surface Water (feet)	400	4000	2500	1000
Site Suitability Factors	Distance to Wells (feet)			1000	18,000
	MAP/PE*	16/22	16/20	16/20	16/20
	Potential For Adverse Effects On Groundwater or Surfacewater	Groundwater: nil Surfacewater: nil	Groundwater: nil Surfacewater: nil	Groundwater: nil Surfacewater: nil	Groundwater: nil Surfacewater: nil
	Comments	Closed 5/74 due to bear problem. Now use PR-3484			Permit expired 31/12/74, site too small. Many suitable sites in the area.

TABLE 7-10 Continued

DESCRIPTION OF MUNICIPAL SOLID WASTE DISPOSAL SITES IN REGION 7

	Pollution Control Branch Application Or Permit Number	PR-2279	PR-3484	AR-3396
	Operator And Location	Regional Dist. of East Kootenay, Radium Hot Springs	Regional Dist. of East Kootenay, Fairmont Hot Springs	Eastlake Campground Invermere (Lillian Lake)
	Status of Refuse Disposal Site and Level Of Operation **	site active level C	active site level C	
	Quantity And Type Of Refuse	10 cu.yd./day (2 tons/day) (600 people) municipal	4 cu.yd./day (800 people) municipal	3/4 cu.yd./day municipal
Site Suitability Factors	Depth To Groundwater Table (feet)	8	not a problem	
	Underlying Soils	silt loam	silt loam (well drained)	silt, gravel
	Surface Runoff or Flooding	no (50-75 ft. above Columbia River)	no	
	Distance to Surface Water (feet)	1000	1000	2000
	Distance to Wells (feet)	3000	1000	3000
	MAP/PE*	16/20	16/22	16/20
	Potential For Adverse Effects On Groundwater or Surfacewater	Groundwater: nil Surfacewater: nil	Groundwater: nil Surfacewater: nil	Groundwater: nil Surfacewater: nil
	Comments		possible bear & raven problems	Application withdrawn, site will be operated under Litter Act until policy re. small dumps is established.

*MAP/PE: Mean annual precipitation/average potential evapotranspiration.
** As defined in the Operational Guidelines for the Discharge of Refuse on Land, Pollution Control Branch, October 1971.

TABLE 7-11

RADIUM HOT SPRINGS

POLLUTION CONTROL BRANCH MONITORING RESULTS FOR

THE WASTE STABILIZATION POND EFFLUENT

Site Number	PE-00132				
Sampling Period	April 1972 - June 1975				
Type of Value / Parameter	Maximum	Minimum	Average	No. of Values	Permit Conditions
Carbon, Organic mg/l	99	19	54	6	
Coliforms, Fecal M.P.N./100 ml	>240,000	54,000	178,000	3	
Coliforms, Total M.P.N./100 ml	>240,000	>240,000	>240,000	1	$<1 \times 10^6$
Conductance, Specific µmho/cm	760	580	684	4	
Flow					30,000 IGPD (average) 45 IGPM (max.)
Oxygen, Biochemical Demand, mg/l	68	27	50	6	<80
Oxygen, Dissolved mg/l	4.4	0.4	2.8	4	
pH	8.3	7.3	7.8	10	
Solids, Suspended mg/l	156	17	68	6	<50
Solids, Total mg/l	470	350	424	5	

TABLE 7-12

FAIRMONT HOT SPRINGS RESORT LTD.

POLLUTION CONTROL BRANCH MONITORING RESULTS FOR THE EFFLUENT DISCHARGES

Site Description	Septic Tank Effluent				Large Swimming Pool Effluent			
Site Number	PE-01619				PE-02057			
Sampling Period	February 1973- May 1975				August 1973 - May 1975			
Type of Value / Parameter	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No. of Values
Alkalinity, Total mg/l					461	328	419	7
Cadmium, Dissolved mg/l					<0.005	<0.0001		6
Calcium, Dissolved mg/l					318	265	294	7
Carbon, Organic mg/l	61	<1	28	7	65	1	14	7
Chloride, Dissolved mg/l					26.4	23.1	25.0	4
Chlorine, Residual mg/l					0.15	0.15	0.15	1
Chromium, Dissolved mg/l					0.027	0.027	0.027	1
Coliforms, Fecal M.P.N./100 ml	1.6×10^6	>2400	398,200	7	<20	<2		8
Conductance, Specific μmho/cm	2120	1870	2010	6	1850	1100	1628	12
Copper, Dissolved mg/l					0.012	<0.001	0.004	7
Fluoride, Dissolved mg/l					0.97	0.73	0.82	7
Hardness, Total Dissolved mg/l					1140	979	1056	7
Iron, Dissolved mg/l					0.10	<0.04	0.09	7
Lead, Dissolved mg/l					0.007	<0.001	0.003	7
Magnesium, Dissolved mg/l					84	75	78	7
Manganese, Dissolved mg/l					0.02	<0.01	0.017	7
Nickel, Dissolved mg/l					0.03	0.03	0.03	1
Nitrogen, Ammonia mg/l	13.4	0.4	7.0	7	0.01	<0.005	0.008	7
Nitrogen Kjeldahl mg/l					0.09	<0.01		4

TABLE 7-12 Continued

FAIRMONT HOT SPRINGS RESORT LTD.

POLLUTION CONTROL BRANCH MONITORING RESULTS FOR THE EFFLUENT DISCHARGES

Site Description	Septic Tank Effluent				Large Swimming Pool Effluent			
Site Number	PE-01619				PE-02057			
Sampling Period	February 1973 - May 1975				August 1973 - May 1975			
Parameter / Type of Value	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No. of Values
Nitrogen, Nitrate mg/l	0.02	<0.02	0.02	7	0.11	0.08	0.10	7
Nitrogen Nitrite mg/l	0.02	<0.005	0.007	7	<0.005	<0.005	<0.005	7
Nitrogen, Organic mg/l					0.09	<0.01	0.03	7
Nitrogen, Total mg/l					0.18	0.10	0.13	7
Oxygen, Biochemical Demand mg/l	54	<10	30	8	22	<10	12	7
pH	8.0	7.0	7.6	13	7.7	6.8	7.2	13
Phosphorus, Total mg/l	4.4	4.4	4.4	1	0.023	0.005	0.012	7
Potassium, Dissolved mg/l					3.7	3.2	3.4	4
Sodium, Dissolved mg/l					19.3	17.0	18.3	7
Solids, Dissolved mg/l	1946	1041	1609	8	1560	1349	1452	7
Solids, Suspended mg/l	67	2	21	8	3	<1	1	7
Solids, Total mg/l	1948	1108	1630	8	1562	1350	1453	7
Sulphate, Disolved mg/l					679	543	606	7
Temperature °C					31	24.5	28	7
Turbidity, J.T.U.					7	0.24	1.5	6
Zinc, Dissolved mg/l					0.08	0.08	0.08	1

TABLE 7-13

MONITORING RESULTS FOR MINERAL KING MINE DRAINAGE

Source Of Data	E. R. Higgins Engineering Ltd.	
Site Description	Portal #9 Level	Portal #7 Level
Sampling Date / Parameter	September 6, 1974	September 6, 1974
Copper, Dissolved mg/l	0.005	0.006
Iron, Total mg/l	0.06	0.30
Lead, Dissolved mg/l	0.007	0.012
Nickel, Dissolved mg/l	0.011	0.021
pH	7.8	8.2
Solids, Dissolved mg/l	726	1120
Solids, Suspended mg/l	0	0
Solids, Total mg/l	726	1120
Sulphate, Total mg/l	298	556
Zinc, Dissolved mg/l	0.70	2.0

TABLE 7-14

ANNUAL NUTRIENT CONTRIBUTION TO THE COLUMBIA RIVER

FROM LIVESTOCK AND FERTILIZED, IRRIGATED CROPLAND

	Windermere Lake - Wilmer	Columbia R. Downstream Windermere Lake	Totals
Irrigated Cropland (acres)[1]	4070	1600	5670
Nitrogen contribution[2] to the river from irrigated cropland (calculated lb N/year)	27270	10720	37990
Phosphorus contribution[3] to the river from irrigated cropland (calculated lb P/year)	690	270	960
Number of cattle[4] (older than 1 year)	389	961	1350
Nitrogen contribution[5] to the river from cattle (calculated lb N/year)	3810	9420	13230
Phosphorus contribution[6] to the river from cattle (calculated lb P/year)	94	230	324
Total nutrient contributions to the river from irrigated cropland and cattle.			
Nitrogen (lb N/year)	31080	20140	51220
Phosphorus (lb P/year)	784	500	1284

1. Water Rights Branch, Licensing Division. Water Register, Golden Water District, Fairmont, Windermere and Spillimacheen Precincts. B.C. Water Resources Service, Victoria, B.C.
2. 6.7 lb N/acre/year
3. 0.17 lb P/acre/year
4. 1971 Census of Agriculture, Statistics Canada, Census Division, Ottawa, Canada.
5. 9.8 lb N/animal/year
6. 0.242 lb P/animal/year

TABLE 7-15

EFFECT OF AGRICULTURAL NUTRIENTS ON NUTRIENT CONCENTRATIONS IN THE COLUMBIA RIVER

	Columbia River At Wilmer	Columbia River At Spillimacheen
Nitrogen Loading (lb)	31080	51220
Phosphorus Loading (lb)	784	1284
Flow (CFS)	2700*	8530*
Calculated Concentrations		
Nitrogen (mg/l)	0.018	0.009
Phosphorus (mg/l)	0.0004	0.0002
Actual Concentrations		
Total Nitrogen (mg/l)	0.15-0.2	0.15-0.2
Dissolved Phosphorus (mg/l)	0.003	0.003
Total Phosphorus (mg/l)	0.01-0.02	0.01-0.02

*Average flow, May to August, inclusive.

TABLE 7-16

STATISTICS FOR THE SPILLIMACHEEN RIVER DEVELOPMENT

	Spillimacheen Intake Dam	Bugaboo Diversion Dam
Dam		
Height (feet)	30	35
Crest length (feet)	136	145
Spillway capacity (CFS)	35,000	8,000
Spillway height (feet)	30	17
Spillway type	overflow	side-channel
Powerhouse		
Installed capacity (MW)	4	not applicable
Hydraulic capacity (CFS)	300	not applicable
Reservoir		
Usable storage capacity (acre-feet)	nil	pondage only
Area (acres)	15.25	--
Length (miles)	--	--
Maximum width (miles)	--	--
Watershed area (miles^2)	580	144
Normal range of water levels (feet) H.W.	2951	3388
L.W.	2932	3380

TABLE 7-17

SUMMARY OF WATER QUALITY DATA FOR COLUMBIA LAKE

Site Number	1100641	1100645
Site Description	Columbia Lake, South End, West Side	Columbia Lake, North End, Mid-Lake
Sampling Date	Sept. 23, 1973	Sept. 23, 1973
Sampling Depth / Parameter	1 foot	1 foot
Alkalinity, Total mg/l	126	106
Cadmium, Total mg/l		0.0001
Calcium, Total mg/l	29.0	23.5
Carbon, Inorganic mg/l	32	26
Carbon, Organic mg/l	6	5
Conductance, Specific μmho/cm	310	170/234
Copper, Total mg/l		<0.001
Hardness, Total Dissolved mg/l	142	118
Iron, Total mg/l		0.08
Lead, Total mg/l		<0.001
Magnesium, Dissolved mg/l	17.0	15.3
Mercury, Total mg/l		<0.00005
Nickel, Total mg/l		<0.01
Nitrogen, Ammonia mg/l	<0.01	0.02
Nitrogen, Nitrate/Nitrite mg/l	<0.02	<0.02
Nitrogen, Organic mg/l	0.16	0.15
Nitrogen,Total mg/l	0.16	0.17
pH	8.4	8.5
Phosphorus, Total mg/l	0.007	0.004
Phosphorus, Total Dissolved mg/l	0.003	<0.003
Temperature °C		13.5
Turbidity J.T.U.	1.1	0.6
Zinc, Total mg/l		<0.005

All data are from the Water Resources Service data bank (EQUIS)

TABLE 7-18

SUMMARY OF WATER QUALITY DATA FOR THE COLUMBIA RIVER

Site Number	0200124				0200049 & 1100646				0200125			
Site Description	Columbia River Upstream Fairmont Creek				Columbia River Downstream Fairmont Cr. (Hwy 93/95 Bridge)				Columbia River Downstream Hwy 93/95 Bridge			
Sampling Period	Feb. 1973 - May 1975				June 1971 - June 1973				Feb. 1973 - May 1975			
Type of Value / Parameter	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No. of Values
Alkalinity, Total mg/1	149	96	124	10	136	85	111	6	153	101	131	15
Cadmium, Dissolved mg/1					0.0024	<0.0001	0.001	3	<0.0005	<0.0001		14
Calcium, Dissolved mg/1	38	20	30	10	33	22	27	6	44	24	35	14
Carbon, Total Organic mg/1	22	<1	5	10	9	9	9	1	20	<1	5	14
Chloride, Dissolved mg/1	2.7	1.5	2.0	10	2.0	1.0	1.5	5	3.6	1.2	2.2	14
Chromium, Dissolved mg/1					0.005	<0.005		5				
Coliforms, Fecal MPN/100ml	5	<2	2	9					70	<2	8	12
Colour, True-Colour Units					5	<5		5	5	<5		14
Copper, Dissolved mg/1					0.01	<0.001	0.007	5	0.005	<0.001	0.001	14
Fluoride, Dissolved mg/1					<0.1	<0.1	<0.1	5	0.11	<0.1	0.10	14
Hardness, Total Dissolved mg/1	170	103	140	10	158	102	128	6	198	116	160	14
Iron, Dissolved mg/1					0.08	0.02	0.05	4	<0.10	<0.04		14
Iron, Total mg/1												
Lead, Dissolved mg/1					0.012	<0.003	0.005	5	0.001	<0.001	0.001	14
Magnesium, Dissolved mg/1	20	11	16	10	14	12	13	2	21	12	18	14
Manganese, Dissolved mg/1					0.01	<0.01	0.01	5	0.02	<0.01	0.015	14
Nitrogen, Ammonia mg/1					0.04	<0.01	0.016	5	0.04	<0.005	0.012	13
Nitrogen, Kjeldahl mg/1	0.2	0.04	0.12	4	0.13	0.13	0.13	1	0.21	0.03	0.13	5

TABLE 7-18 Continued

SUMMARY OF WATER QUALITY DATA FOR THE COLUMBIA RIVER

Site Number	0200124				0200049 & 1100646				0200125			
Parameter / Type of Value	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No. of Values
Nitrogen, Nitrate/ Nitrite mg/l	0.05	<0.02	0.04	10	0.11	0.02	0.05	6	0.07	<0.02	0.05	14
Nitrogen, Organic mg/l					0.23	0.06	0.12	5	0.23	0.02	0.09	14
Nitrogen, Total mg/l	0.25	0.04	0.15	4	0.29	0.08	0.18	5	0.26	0.05	0.15	13
Oxygen, Dissolved mg/l					12.2	9.6	10.5	5	12.0	8.8	10.4	12
Oxygen, % Saturation									106	86	92	9
pH	8.6	8.0	8.3	18	8.4	7.8	8.1	11	8.6	8.0	8.2	26
Phosphorus, Dissolved Ortho Phosphate mg/l					0.003	<0.003	0.003	5	<0.003	<0.003	<0.003	14
Phosphorus, Total mg/l	0.01	0.005	0.008	10	0.03	0.004	0.013	5	0.01	0.003	0.007	14
Solids, Dissolved mg/l	196	122	163	10	186	103	147	5	230	130	187	14
Solids, Suspended mg/l	28	2	10	10	42	2	17	5	14	2	7	14
Solids, Total mg/l	204	132	173	10	216	118	165	5	236	142	194	14
Sulphate, Dissolved mg/l	25	15	20	10	24	14	20	5	50	16	33	14
Temperature °C	15	0		9	9	2		5	12	1		13
Turbidity J.T.U.					5.6	3.6	4.7	3	5.9	1.0	2.9	15
Zinc, Dissolved mg/l					0.04	<0.005	0.017	5	0.01	<0.005	0.005	14

All information is from the Water Resources Service data bank (EQUIS)

TABLE 7-18 Continued

SUMMARY OF WATER QUALITY DATA FOR THE COLUMBIA RIVER

Site Number	0200009			
Site Description	Columbia River At Athalmer			
Sampling Period	August 1968 - May 1975			
Parameter \ Type of Value	Maximum	Minimum	Average	No. of Values
Alkalinity, Total mg/l	196	88	126	47
Cadmium, Dissolved mg/l	<0.001	<0.0001		18
Calcium, Dissolved mg/l	51	25	37	35
Carbon, Total Organic mg/l	21	<1	5	14
Chloride, Dissolved mg/l	6.3	0.5	1.8	35
Chromium, Dissolved mg/l	<0.005	<0.005	<0.005	9
Coliforms, Fecal MPN/100 ml	13	<2	5	7
Colour, True-Colour Units	5	<5		27
Copper, Dissolved mg/l	0.01	<0.001	0.003	22
Fluoride, Dissolved mg/l	0.85	<0.1	0.13	35
Hardness,Total Dissolved mg/l	225	114	169	35
Iron, Dissolved mg/l	<0.10	0.02	0.07	20
Iron, Total mg/l	0.25	0	0.08	13
Lead, Dissolved mg/l	0.014	<0.001	0.002	20
Magnesium, Dissolved mg/l	25	12	19	29
Manganese, Dissolved mg/l	1.63	<0.01	0.02	32
Nitrogen, Ammonia mg/l	0.25	0	0.032	35
Nitrogen, Kjeldahl mg/l	0.19	0.09	0.15	5
Nitrogen,Nitrate/Nitrite mg/l	0.17	<0.02	0.03	34
Nitrogen, Organic mg/l	0.32	0.03	0.13	35
Nitrogen, Total mg/l	0.38	0.06	0.19	33
Oxygen, Dissolved mg/l	12.9	7.4	10.3	32
Oxygen, % Saturation	117	76	97	10
pH	9.1	7.2	8.2	70
Phosphorus, Dissolved Ortho Phosphate mg/l	<0.02	<0.001	0.003	31
Phosphorus, Total mg/l	0.14	<0.001	0.014	34
Solids, Dissolved mg/l	281	84	201	33
Solids, Suspended mg/l	28	1	7	33
Solids, Total mg/l	309	105	208	34
Sulphate, Dissolved mg/l	81	17	45	36
Temperature ^{o}C	19	0		35
Turbidity, J.T.U.	5.0	0.3	1.4	32
Zinc, Dissolved mg/l	0.03	<0.005	0.007	21

TABLE 7-19

SUMMARY OF WATER QUALITY DATA FOR WINDERMERE LAKE

Site Number	0200050				0200051				0200052			
Site Description	Windermere Lake, South End, Midlake				Windermere Lake, Middle, Midlake				Windermere Lake, North End, Midlake			
Sampling Period	June 1971 - July 1975				June 1971 - July 1975				June 1971 - July 1975			
Parameter / Type of Value	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No. of Values
Alkalinity, Total mg/1	198	52	104	18	135	51	95	18	132	94	105	15
Cadmium, Dissolved mg/1	0.0007	<0.0001	0.0005	3	0.0011	<0.0001	0.0006	3	0.0005	<0.0001	0.0004	3
Calcium, Dissolved mg/1	41	22	28	14	46	20	30	14	46	24	30	13
Carbon, Total Organic mg/1	8	<1	4	9	8	<1	5	9	8	<1	5	9
Chloride, Dissolved mg/1	2.7	0.9	1.5	12	1.8	0.7	1.2	14	2.0	0.7	1.2	13
Chromium, Dissolved mg/1	0.005	<0.005		6	0.005	<0.005		6	0.005	<0.005		5
Colour, True-Colour Units	10	<5	5.4	14	10	<5	5.7	14	10	<5	5.4	13
Copper, Dissolved mg/1	0.07	<0.001	0.008	14	<0.01	<0.001		14	<0.01	<0.001		13
Depth, Extinction feet	15	3.5	8.6	8	15	7.1	11.1	9	17	4	11.4	9
Fluoride, Dissolved	<0.10	<0.10	<0.10	14	0.10	<0.10	0.10	14	<0.10	<0.10	<0.10	13
Hardness, Total Dissolved mg/1	191	100	132	14	209	95	140	14	210	115	137	13
Iron, Dissolved mg/1	<0.10	0.02	0.06	14	<0.10	<0.02		14	<0.10	<0.02		13
Lead, Dissolved mg/1	0.004	<0.001	0.002	14	0.004	<0.001	0.002	14	0.004	<0.001	0.002	13
Magnesium, Dissolved mg/1	17	11	14	9	18	11	15	9	18	13	15	9
Manganese, Dissolved mg/1	<0.02	<0.01		13	<0.02	<0.01		14	<0.02	<0.01		13
Nitrogen, Ammonia mg/1	0.03	0.005	0.013	13	0.04	0.006	0.017	13	0.07	0.006	0.016	12
Nitrogen, Nitrate/Nitrite mg/1	0.15	<0.02	0.03	14	0.04	<0.02	0.024	14	<0.02	<0.02	<0.02	12
Nitrogen, Organic mg/1	0.25	0.08	0.15	13	0.27	0.06	0.16	13	0.24	0.10	0.15	12

TABLE 7-19 Continued

SUMMARY OF WATER QUALITY DATA FOR WINDERMERE LAKE

Site Number	0200050				0200051				0200052			
Site Description	Windermere Lake, South End, Midlake				Windermere Lake, Middle, Midlake				Windermere Lake, North End, Midlake			
Sampling Period	June 1971 - July 1975				June 1971 - July 1975				June 1971 - July 1975			
Parameter / Type of Value	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No. of Values	Maximum	Minimum	Average	No of Values
Nitrogen, Total mg/l	0.38	0.10	0.18	13	0.33	0.07	0.18	13	0.25	0.10	0.17	11
Oxygen, Dissolved mg/l	11.8	8.8	10.3	12	11.8	9.1	10.2	12	11.4	8.7	10.2	11
Oxygen, % Saturation	125	96	111	4	122	95	107	4	111	94	102	3
pH	8.8	7.6	8.3	28	9.0	8.0	8.5	28	9.0	7.6	8.4	24
Phosphorus, Dissolved Ortho Phosphate mg/l	0.009	<0.003	0.003	14	0.004	<0.003	0.003	14	<0.003	<0.003	<0.003	13
Phosphorus, Total mg/l	0.03	<0.003	0.009	14	0.04	0.004	0.012	14	0.16	0.003	0.018	13
Solids, Dissolved mg/l	220	112	149	14	258	110	168	14	260	107	160	13
Solids, Suspended mg/l	28	2	7	14	40	2	10	14	31	2	7	3
Solids, Total mg/l	238	114	156	14	290	116	178	14	274	138	167	13
Sulphate, Dissolved mg/l	43	9	22	14	71	13	34	14	69	17	32	13
Temperature °C	21	4		14	21	2		14	21	5		13
Turbidity, J.T.U.	10	0.54	3.0	14	7.1	0.4	1.8	13	7.3	0.3	1.6	12
Zinc, Dissolved mg/l	0.03	<0.005	0.01	13	0.02	<0.005	0.006	14	0.02	<0.005	0.006	13

All information is from the Water Resources Service data bank (EQUIS)

TABLE 7-20

SUMMARY OF WATER QUALITY DATA FOR KOOTENAY RIVER AT CANAL FLATS AND COLUMBIA RIVER AT GOLDEN

Site Number	0200020				0500018			
Site Description	Kootenay River At Canal Flats				Columbia River Upstream From Golden			
Sampling Period	August 1968 - July 1975				August 1971 - August 1975			
Type of Value / Parameter	Maximum	Minimum	Average	No. Of Values	Maximum	Minimum	Average	No. Of Values
Alkalinity, Total mg/l	164	93	130	86	137	60	101	15
Arsenic, Dissolved mg/l	0.02	0	0.005	48	<0.005	<0.005	<0.005	2
Cadmium, Dissolved mg/l	<0.0005	<0.0001		28	<0.0005	<0.0001		3
Calcium, Dissolved mg/l	60	21	44	65	41	18	29	18
Carbon, Total Organic mg/l	8	<1	3	29	13	<1	4	14
Chloride, Dissolved mg/l	11.8	1.8	6.4	64	2.4	<0.3	0.9	18
Chromium, Dissolved mg/l	0.009	<0.005	0.005	48	<0.005	<0.005	<0.005	4
Coliforms, Fecal MPN/100 ml	<20	<2	5	22	5	<2	3	5
Colour, True Colour Units	15	0	4	46	20	<5	6	12
Copper, Dissolved mg/l	<0.1	<0.001	0.005	47	0.15	<0.001	0.023	9
Fluoride, Dissolved mg/l	0.26	0.08	0.12	64	0.1	<0.1	0.1	10
Hardness, Total Dissolved mg/l	215	76	165	64	178	77	129	18
Iron, Dissolved mg/l	0.2	<0.02	0.08	45	<0.1	0.03	0.06	12
Iron, Total mg/l	1.6	0	0.3	33	0.3	0.2	0.23	3
Lead, Dissolved mg/l	0.016	<0.001	0.003	46	0.006	<0.001	0.003	11
Magnesium, Dissolved mg/l	20	6	13	49	19	6	13	12
Manganese, Dissolved mg/l	0.2	0	0.02	60	0.02	<0.01	0.013	9
Mercury, Total µg/l					<0.85	<0.02	0.14	9
Molybdenum, Dissolved mg/l					<0.1	<0.1	<0.1	4

All information is from the Water Resources Service data bank (EQUIS)

TABLE 7-20 Continued

SUMMARY OF WATER QUALITY DATA FOR KOOTENAY RIVER AT

CANAL FLATS AND COLUMBIA RIVER AT GOLDEN

Site Number	0200020				0500018			
Site Description	Kootenay River At Canal Flats				Columbia River Upstream From Golden			
Sampling Period	August 1968 - July 1975				August 1971 - August 1975			
Type of Value / Parameter	Maximum	Minimum	Average	No. Of Values	Maximum	Minimum	Average	No. Of Values
Nickel, Dissolved mg/l					0.05	<0.01	0.017	9
Nitrogen, Ammonia mg/l	0.2	0	0.019	64	0.04	<0.01	0.016	9
Nitrogen, Kjeldahl mg/l	0.25	<0.01	0.08	12	0.14	0.02	0.08	12
Nitrogen, Nitrate/ Nitrite mg/l	0.5	0.03	0.13	67	0.16	0.02	0.1	18
Nitrogen, Organic mg/l	0.32	0	0.05	64	0.15	0.01	0.09	9
Nitrogen, Total mg/l	0.51	0.04	0.19	63	0.27	0.023	0.17	17
Oxygen, Dissolved mg/l	15.2	6.8	11.3	60	14.0	9.2	11.1	14
Oxygen, % Saturation	108	87	96	30				
pH	8.8	7.3	8.1	128	8.5	7.2	7.9	25
Phosphorus, Dissolved Ortho Phosphate mg/l	0.33	0	0.012	68	0.036	<0.003	0.006	12
Phosphorus, Total mg/l	0.67	0	0.026	68	0.05	<0.003	0.013	18
Solids, Dissolved mg/l	276	98	199	62	198	70	143	17
Solids, Suspended mg/l	256	0	36	62	268	1	31	18
Solids, Total mg/l	415	110	233	65	362	105	172	17
Sulphate, Dissolved mg/l	62	12	37	65	56	13	29	17
Surfactants mg/l	0	0	0	9	0	0	0	1
Tannin & Lignin mg/l	0.62	0	0.14	61	0.7	<0.1	0.3	3
Temperature °C	19	-1		72	15	0.5		16
Turbidity, J.T.U.	100	0	14.5	67	115	0.6	12.7	13
Zinc, Dissolved mg/l	0.04	<0.005	0.008	44	0.82	<0.005	0.12	10

TABLE 7-21

SUMMARY OF RECOMMENDED WATER QUALITY SAMPLING FOR

COLUMBIA LAKE, KOOTENAY RIVER, WINDERMERE LAKE AND COLUMBIA RIVER

Parameters \ Sites	Columbia Lake 1100642, 1100643 & 1100645 Kootenay River 0200020	Columbia River 0200049 & 0200009	Windermere Lake 0200050, 0200051 & 0200052
Alkalinity, Total	√	√	√
Carbon, Total Organic	√	√	√
Chloride, Dissolved	√		
Coliforms, Fecal		√	
Colour, True	√	√	√
Conductance, Specific*	√	√	√
Depth, Extinction	√		√
Hardness, Total Diss.	√	√	√
Nitrogen, Ammonia	√	√	√
Nitrogen,Nitrate/Nitrite	√	√	√
Nitrogen, Organic	√	√	√
Oxygen, Dissolved*	√	√	√
pH	√	√	√
Phosphorus, Dissolved Ortho Phosphate	√	√	√
Phosphorus, Total	√	√	√
Solids, Dissolved	√	√	√
Solids, Suspended	√	√	√
Solids, Total	√	√	√
Sulphate, Dissolved	√		
Temperature*	√	√	√
Turbidity	√	√	√
Frequency	4/year	4/year	1/year
Preferred Times	spring turn-over, freshet, summer, fall	freshet, summer, fall, winter	spring turnover

*Profiles for lake sites

TABLE 7-22

SUMMARY OF WATER QUALITY DATA FOR TOBY CREEK

Site Number	0200055				0200054			
Site Description	Toby Creek Upstream Mountain Minerals Ltd.				Toby Creek Downstream Mountain Minerals Ltd.			
Sampling Period	May 1971 - June 1975				May 1971 - June 1975			
Parameter \ Type Of Value	Maximum	Minimum	Average	No. Of Values	Maximum	Minimum	Average	No. Of Values
Alkalinity, Total mg/1	89	51	72	6	89	53	70	6
Cadmium, Dissolved mg/1	<0.0005	<0.0005	<0.0005	4	<0.0005	<0.0001		5
Carbon, Total Organic mg/1					3	<1	2	3
Copper, Dissolved mg/1	0.001	<0.001		6	0.004	<0.001		6
Fluoride, Dissolved mg/1	<0.1	<0.1	<0.1	5	<0.1	<0.1	<0.1	5
Iron, Dissolved mg/1	<0.1	<0.04		6	<0.1	<0.04		6
Lead, Dissolved mg/1	<0.003	<0.001		6	<0.003	<0.001		6
Manganese, Dissolved mg/1	<0.02	<0.01		4	<0.02	<0.01		5
Nitrogen, Nitrate Nitrite mg/1					0.13	0.1	0.11	3
Oxygen, Dissolved mg/1	13.0	13.0	13.0	1	12.8	12.8	12.8	1
pH	8.4	7.8	8.0	12	8.4	7.9	8.1	12
Phosphorus, Total mg/1					0.08	0.003	0.03	3
Solids, Dissolved mg/1	134	64	100	5	124	68	98	5
Solids, Suspended mg/1	144	2	35	5	134	2	29	5
Solids, Total mg/1	208	100	133	6	202	78	126	6
Sulphate, Dissolved mg/1	25.2	5.3	16.2	5	22.6	8.7	15.9	5
Temperature °C	6	2		7	6	2		7
Turbidity, J.T.U.	27	0.5	9.3	4	27	1.8	14.4	2
Zinc, Dissolved mg/1	0.005	<0.005		6	0.032	<0.005	0.01	6

All information is from the Water Resources Service data bank (EQUIS)

TABLE 7-23

WATER QUALITY DATA FOR TOBY CREEK AND JUMBO CREEK

Site Description	Jumbo Creek Upstream Mineral King Drainage	Jumbo Creek Upstream Mineral King Drainage	Jumbo Creek At The Mouth	Toby Creek Upstream Mineral King Tailings	Toby Creek Upstream Mineral King Tailings	Toby Creek Downstream Mountain Minerals
Source of Data	E.R. Higgins Engineering Ltd.	E.R. Higgins Engineering Ltd.	Water Investigations Branch	E.R. Higgins Engineering Ltd.	E.R. Higgins Engineering Ltd.	E.R. Higgins Engineering Ltd.
Sampling Date / Parameter	Sept. 6/74	Dec. 2/74	June 17/75	Sept. 6/74	Dec. 2/74	Dec. 2/74
Copper, Dissolved mg/1	0.002	0.018		0.005	0.005	0.002
Iron, Total mg/1	0.08	0.25		2.8	0.15	0.25
Lead, Dissolved mg/1	<0.002	0.16		<0.002	0.038	0.036
Magnesium, Total mg/1			6.0			
Manganese, Total mg/1			<0.02			
Nickel, Dissolved mg/1	<0.002	0.008		<0.002	0.004	0.006
pH	7.7	7.4		8.1	7.4	7.5
Solids, Dissolved mg/1	85	151		93	175	165
Solids, Suspended mg/1	1	0		105	0	0
Solids, Total mg/1	86	151		198	175	165
Sulphate, Total mg/1	16.4	16.0		18.2	28.0	28.0
Zinc, Dissolved mg/1	0.078	0.21		0.031	0.008	0.008
Zinc, Total mg/1			<0.005			

TABLE 7-24

SUMMARY OF WATER QUALITY DATA FOR SINCLAIR CREEK

Site Number	0200053				0200094			
Site Description	Sinclair Creek Upstream Radium Sewage Lagoons				Sinclair Creek Downstream Radium Sewage Lagoons			
Sampling Period	March 1972 - June 1975				March 1972 - June 1975			
Parameter \ Type of Value	Maximum	Minimum	Average	No. Of Values	Maximum	Minimum	Average	No. Of Values
Alkalinity, Total mg/l	188	131	167	15	191	130	167	14
Arsenic, Dissolved mg/l	0.01	0.01	0.01	1				
Calcium, Dissolved mg/l	64	41	56	12	65	41	56	11
Carbon, Total Organic mg/l	10	<1	4	9	13	<1	4	9
Coliforms, Fecal MPN/100 ml	70	<2	10	8	>2400	79	1541	8
Colour, True Colour Units	5	<5	5	15	5	<5	5	15
Hardness, Total Dissolved mg/l	254	145	217	15	252	146	219	14
Magnesium, Dissolved mg/l	25	10	19	12	25	10	20	11
Nitrogen, Ammonia mg/l	0.08	0.005	0.02	15	0.11	<0.01	0.05	15
Nitrogen, Nitrate/ Nitrite mg/l	0.19	0.08	0.12	15	0.54	0.07	0.15	15
Nitrogen, Organic mg/l	0.14	<0.01	0.06	15	0.25	<0.01	0.1	15
Nitrogen, Total mg/l	0.31	0.08	0.2	15	0.71	0.13	0.3	15
Oxygen, Dissolved mg/l	13.2	7.0	10.8	13	13.2	8.1	10.9	13
pH	9.1	8.0	8.4	28	9.1	8.0	8.4	27
Phosphorus, Dissolved mg/l	0.02	<0.003	0.007	15	0.04	0.008	0.02	15
Phosphorus, Total mg/l	0.03	0.004	0.014	15	0.07	0.014	0.03	15
Solids, Dissolved mg/l	308	164	255	15	312	162	256	15
Solids, Suspended mg/l	32	2	12	15	42	2	15	15
Solids, Total mg/l	328	184	267	15	348	198	271	15
Sulphate, Dissolved mg/l	77	17	50	15	77	17	49	15
Temperature °C	7.8	0		14	8	0		13
Turbidity J.T.U.	12	0.4	3.5	15	25	0.4	4.8	15

All information is from the Water Resources Service data bank (EQUIS)

TABLE 7-25

SUMMARY OF WATER QUALITY DATA FOR FAIRMONT CREEK

Site Number	0200122				0200123			
Site Description	Fairmont Creek Upstream Fairmont Hot Springs Resort				Fairmont Creek At The Mouth			
Sampling Period	February 1973 - May 1975				February 1973 - May 1975			
Parameter / Type of Value	Maximum	Minimum	Average	No. Of Values	Maximum	Minimum	Average	No. Of Values
Alkalinity, Total mg/l	172	125	139	10	245	193	215	10
Calcium, Dissolved mg/l	65	27	32	10	170	116	146	10
Carbon, Total Organic mg/l	19	<1	4	10	24	<1	6	10
Chloride, Dissolved mg/l	3.8	<0.5	0.9	10	21.3	11.4	15.6	10
Coliforms, Fecal MPN/100 ml	2	<2		9	350	<2		9
Conductance, Specific μmho/cm	540	260	314	16	1275	798	1040	15
Hardness, Total Dissolved mg/l	268	140	160	10	684	463	587	10
Magnesium, Dissolved mg/l	25	17	20	10	63	42	54	10
Nitrogen, Kjeldahl mg/l	0.05	<0.01	0.02	4	0.12	<0.01	0.05	4
Nitrogen, Nitrate/ Nitrite mg/l	0.14	0.09	0.12	10	0.11	0.03	0.07	10
Nitrogen, Total mg/l	0.18	0.09	0.14	4	0.18	0.09	0.12	4
pH	8.6	7.3	8.3	18	9.0	8.1	8.4	18
Phosphorus, Total mg/l	0.004	<0.003	0.003	10	0.009	<0.003	0.004	10
Potassium, Dissolved mg/l	0.8	0.3	0.45	4	2.3	2.0	2.2	4
Sodium, Dissolved mg/l	3.2	0.9	1.2	10	15	8	12	10
Solids, Dissolved mg/l	324	144	171	10	1026	622	830	10
Solids, Suspended mg/l	32	2	8	10	28	2	7	10
Solids, Total mg/l	326	154	179	10	1030	632	834	10
Sulphate, Dissolved mg/l	91	12	21	10	461	250	363	10
Temperature °C	8	0		9	18	4		9

All information is from the Water Resources Service data bank (EQUIS)

TABLE 7-26

WATER QUALITY SURVEY OF FAIRMONT CREEK, COLD SPRING CREEK AND COLUMBIA RIVER, MAY 25, 1972

Sampling Location \ Parameter	Temperature °C	Fecal Coliforms MPN/100 ml	Total Organic Carbon mg/1	Total Phosphorus mg/1
Fairmont Creek, 500 feet Upstream Fairmont Hot Springs Resort Ltd.	4.5	<20/<20/<20	4	<0.003
Fairmont Creek, 500 feet Downstream Fairmont Hot Springs Resort Ltd.	11.5	<20/<20/<20	4	0.003
Fairmont Creek, 1700 feet Downstream Fairmont Hot Spring Resort Ltd.	13.0	50/<20/<20	4	0.006
Fairmont Creek, 3200 feet Downstream Fairmont Hot Springs Resort Ltd.	12.5	<20/<20/<20	4	0.006
Fairmont Creek, At The Mouth	11.0	<20/<20/<20	3	0.006
Columbia River, Upstream Fairmont Creek	9.0	<20/<20/<20	4	<0.003
Columbia River, Downstream Fairmont Creek	8.0	<20/<20/<20	4	0.011
Cold Spring Creek, Upstream Fairmont Hot Springs Resort Ltd.	5.0	20/<20/<20	3	<0.003
Cold Spring Creek, Downstream Fairmont Hot Springs Resort Ltd.	8.0	<20/<20/<20	2	0.003
Columbia River, Downstream Cold Spring Creek	9.0	<20/<20/50	1	0.011

Data are from Pollution Control Branch file number 1619.

TABLE 7-27

SUMMARY OF WATER QUALITY DATA FOR LILLIAN LAKE[68]

Site Numbers	1100615, 1100616, 1100618, 1100619 &1100620			
Sampling Period	June 1973 - September 1973			
Type of Value / Parameters	Maximum	Minimum	Average	No. Of Values
Alkalinity, Total mg/l	370	247	288	13
Cadmium, Total mg/l	<0.0001	<0.0001	<0.0001	1
Calcium, Dissolved mg/l	76	39	48	13
Carbon, Total Inorganic mg/l	80	59	68	13
Carbon, Total Organic mg/l	21	11	17	13
Conductance, Specific μmho/cm	688	472	613	13
Copper, Total mg/l	0.002	<0.001	0.001	3
Depth, Extinction m	8	5.3	6.9	6
Hardness, Total Dissolved mg/l	420	290	361	13
Iron, Total mg/l	0.06	0.06	0.06	1
Lead, Dissolved mg/l	0.002	<0.001	0.001	3
Magnesium, Dissolved mg/l	69	37	60	13
Mercury, Total μg/l	<0.05	<0.05	<0.05	2
Nickel, Total mg/l	<0.01	<0.01	<0.01	1
Nitrogen, Ammonia mg/l	0.04	<0.01	0.02	7
Nitrogen, Nitrate/Nitrite mg/l	0.09	<0.02	<0.02	13
Nitrogen, Organic mg/l	0.57	0.12	0.45	7
Nitrogen, Total mg/l	0.70	0.12	0.54	13
Oxygen, Dissolved mg/l	9.6	3.5		5
pH	8.5	8.0	8.3	13
Phosphorus, Dissolved Ortho Phosphate mg/l	0.003	<0.003	0.003	12
Phosphorus, Total mg/l	0.013	0.005	0.008	13
Phosphorus, Total Dissolved mg/l	0.007	0.003	0.005	12
Temperature ^{o}C	19	6		13
Turbidity, J.T.U.	6.0	0.5	1.3	13
Zinc, Total mg/l	0.005	0.005	0.005	1