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PHASE I

WATER QUALITY IN REGION 9, THE KETTLE RIVER BASIN

WATER INVESTIGATIONS BRANCH

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1. DESCRIPTION OF THE REGION

1.1 Introduction

The Kettle River Basin has an area of 3,200 square miles and is located in the southwest corner of the Kootenay Study Region. The eastern part of the basin is mountainous, with the Monashee Mountains rising to elevations of up to 7,700 feet. West of the Kettle River the more subdued topography of the Okanagan Highland marks the transition between the Monashees and the Interior Plateau. A map of the Kettle River Basin is shown in Figure 9-1.

1.2 Climate

Topography exerts a strong influence on the climatic pattern of the region. The uplands are cooler and wetter than the valleys because, with increasing altitude, precipitation increases and temperatures decline[1].

The warmest and driest parts of the region are the southern valleys of the Kettle, West Kettle, and Granby Rivers and Boundary Creek. Precipitation averages about 350 - 450 mm annually, including 120 - 150 cm of snow per year. Temperatures average about 18^{o} C in July and -7^{o} C in January, while the frost-free period averages from 80 to 130 days[1,2].

Outside of the valleys and in the northern two-thirds of the basin, the climate becomes progressively cooler and wetter with increasing altitude. Average precipitation increases to 750 mm in the Okanagan Highlands and to 750 - 1000 mm in the central and northern Monashees. Mean annual snowfall increases to the 200 to 500 cm range. Temperatures average 15.5^{o} C in July and -9.5^{o} C in January, while the average frost-free period drops to 60 days[1,2].

1.3 Geology

The Monashee Mountains occupy the half of the basin lying east of the Kettle River. They consist of three northerly trending ranges: the Rossland, Christina and Midway Ranges. Elevations range up to 7,700 feet, with maximum relief of about 5,000 feet. The Monashees are largely underlain by gneissic rocks. The valleys were intensely glaciated, resulting in U-shaped valleys, hanging tributary valleys, and a widespread mantle of glacial drift[3,4].

The Okanagan Highland occupies the half of the basin west of the Kettle River, and is a transition zone between the Monashee Mountains and the Interior Plateau. The Okanagan Highland includes rounded mountains and ridges and gentle open slopes on an upland surface reaching 7,603 feet at Big White Mountain. Much of the area is underlain by gently dipping gneisses. The highland was glaciated, but erosion was not great. There was some rounding of surfaces and a widespread mantle of drift was deposited[3].

1.4 Soils and Vegetation

The soils in the basin are mostly derived from glacial deposits. In many areas, the mantle of glacial drift deposited over the basin forms the parent materials on which present soils have developed. On steep slopes, the drift has washed or slid off leaving extensive areas of exposed rock in mountainous regions. Soils have also developed on outwash sands and gravels, eskers, glacial lake deposits, and alluvial terraces and fans. Most of the soils suitable for agriculture lie in the Kettle, West Kettle and Granby River valleys, and in the Boundary Creek Valley[4].

Open grasslands and semi-open Dry Forest occur along the Kettle Valley and on south-facing slopes between Bridesville and Grand Forks. Light to moderate stands of yellow pine, Douglas fir, and larch form a prominent cover on the low slopes, while deciduous species, including willow, cotton-

wood, and birch fringe the main river. At higher elevations, tree-cover becomes thicker, yellow pine and larch being gradually replaced by a mixture of fir, spruce and hemlock. The alpine zone lies mostly on scattered peaks above the tree-line, which is generally around 6,000 to 6,500 feet above sea-level[1].

1.5 Hydrology

1.5.1 Streamflow

The streams in the Kettle Basin mainly follow the north-south trend of the mountain ranges. The Kettle River is about 180 miles long. From its headwaters in the Monashees, it flows southward to Rock Creek, then southeastward to Midway and into the United States. It recrosses the border south of Grand Forks where it flows eastward to Cascade. At Cascade it flows south and crosses the border at Laurier and continues into the reservoir of the Grand Coulee Dam on the Columbia River in Washington State. The drainage area of the Kettle River is about 3,800 square miles at Laurier. Of this area 3,200 square miles are in British Columbia and 600 square miles are in Washington State. The West Kettle and Granby Rivers are the major tributaries of the Kettle.

The seasonal flow pattern of the Kettle and its tributaries is characterized by spring flood peaks in May and June due to snowmelt and spring rains, followed by a steady decline during summer and early fall. There is an occasional minor peak in October-November due to fall rains. Minimum flows occur during August through March. Three-quarters of the annual flow occurs during April, May and June. The flows in the Kettle and its tributaries are summarized in Table 9-1 and Figure 9-2.

1.5.2 Lakes

The three main lakes in the Kettle Basin are Christina Lake, Jewel Lake and Conkle Lake.

Christina Lake is the major lake in the Kettle Basin and is located in the southeast corner of the basin as shown in Figure 9-1. The lake is long (11.5 miles) and narrow (about 1 mile) with an area of 9.7 square miles[7], and a tributary drainage area of about 180 square miles. The lake is fairly deep, with a maximum depth of 177 feet and a mean depth of 118 feet[7]. The volume of the lake is 733,600 acre-feet[7]. Water levels fluctuate over a 7 foot range (1,459 to 1,466 feet), with maximum levels occurring during the freshet in May and June, and minimum levels occurring in October and November[8].

Jewel Lake is located about six miles northeast of Greenwood. It is a small lake, about 1.8 miles long, 0.2 miles wide, with an area of about 0.3 square miles. It has a U-shaped cross-section, a maximum depth of 50 to 60 feet, and a few littoral areas[9]. The lake lies at an elevation of about 3,750 feet and drains an area of about 2.8 square miles.

Conkle Lake is located about 10 miles northeast of Bridesville. It is small, about 1.8 miles long, 0.3 to 0.4 miles wide, with an area of 0.5 square miles. The lake lies at an elevation of about 3,500 feet and drains an area of about 12 square miles.

1.5.3 Groundwater

The Kettle, Granby and West Kettle valleys are areas in which groundwater flows of 50 to 500 gallons per minute are generally available. Wells producing more than 100 gallons per minute are located at Grand Forks and Midway[10].

The records of the Groundwater Section of the Water Investigations Branch indicate that there are 305 groundwater wells in the Kettle Basin (50 to 75 percent of wells are on record with the Groundwater Section). Eighty percent of the wells are located along the Kettle River valley in the alluvial and glacial deposits which blanket the valley bottom. Most of the other wells are located along the valleys of the West Kettle River, Boundary Creek, and Beaverdell Creek.

Over half of the wells are located in the Kettle valley in the vicinity of Grand Forks. An analysis of 33 wells in Grand Forks showed that they ranged in depth from 14 to 135 feet, yielded from 2 to 1,076 gallons per minute, and that the water was very hard[11]. The locations of the wells in the Kettle Basin are given in Table 9-2.

1.5.4 Dams and Diversions

There are no major dams or diversions in the Kettle River Basin. A dam and hydro-electric power plant were constructed on the Kettle River near Cascade in 1900, but the plant was closed in 1920. Topographic maps show that the dam still remains. A dam and power plant were also built on the Granby River, two and one-half miles upstream from the Kettle River in the 1890's. The reservoir of the dam was called Smelter Lake and occupied 670 acres. The power plant was dismantled in 1919, and topographic maps show that the dam no longer exists[4,12].

There are diversions of relatively small quantities of water from the northwestern part of the West Kettle River to the Okanagan Basin for irrigation purposes. About 5,000 acre-feet per year is diverted from Stirling Creek, Affleck Creek, Howard Lake, Haynes Lake and Pear Lake. The Southeast Kelowna Irrigation District has also applied to divert 6,200 acre-feet per year from Kallis Creek to the Okanagan Basin[14].

1.6 Water Uses

1.6.1 Water Licences

The water licences issued in the Kettle River Basin by the Water Rights Branch of the Ministry of the Environment [14] indicate that licenced water usage is allocated as follows:

Water Uses	Acre-Feet Per Year
Domestic	7,050
Irrigation	46,600 (19,000 acres irrigated)
Industrial	
-Mining	2,770
-Lumber Manufacture	990
-Fish Culture	11
Conservation	1,310

The total licenced water usage is about 58,000 acre-feet per year or 80 cubic feet per second.

Irrigation is the major water use, accounting for 80 percent of the total water used. Approximately 19,000 acres are covered by irrigation water licences, mainly along the Kettle, West Kettle, Granby and Boundary valleys. Actual irrigated acreage is less, as explained in Chapter 3, section 3.3. The Kettle River supplies 42 percent of the irrigation water, with the Granby River (6 percent), Stirling Creek (5.5 percent), Myers Creek (3.8 percent), West Kettle River (3.5 percent), July Creek (2.8 percent), Boundary Creek (2.2 percent), and numerous smaller sources (34 percent) supplying the balance of the water. Eleven percent of the irrigation water used is diverted to the Okanagan Basin for use in the Southeast Kelowna Irrigation District.

Ninety-six percent of the domestic water used is licenced to the cities of Grand Forks and Greenwood, the Village of Midway, the Christina and Sutherland Waterworks Districts and the Southeast Kelowna Irrigation District. The balance is distributed among many small users.

Mining, lumber manufacture, fish culture and conservation account for nine percent of the water usage. Water has been used for hydro-electric generation in the past, but there are no hydro-electric facilities at the present time.

The major sources of water supply in the Kettle Basin are shown in Table 9-3 which summarizes the water licences for each major source. Only those sources with a licenced usage of 10,000 GPD (13 acre-feet per year) or more are included in the Table.

1.6.2 Water Availability

There is a relatively small population and limited development in the Kettle Basin and thus the supply of water is adequate in most parts of the basin. However, in the dry, southern valleys, the use of water for irrigation has caused water shortages on several streams. Streams which are fully committed or on which there is a possible water shortage include: Aquarius Brook, Baker Creek, East Baker Creek, Biggs Creek, Hoas Creek, Hulme Creek, Jolly Jack Creek, July Creek, May Creek, Moody Creek, Morrissey Creek, Motherlode Creek, Myers Creek, Nicholson Creek, McKinney Creek, Rice Creek, Sutherland Creek, Texas Creek and Volcanic Creek[14].

A more detailed account of the water availability problems in the Kettle Basin will be presented in the Phase II report of the Kootenay Study.

1.7 Settlements and Industrial Centres

The major settlements in the Kettle Basin and their 1976 populations are the City of Grand Forks (3,020), the City of Greenwood (919) and the Village of Midway (592)[15]. The 1971 populations of other settlements in the region are listed in Table 9-4. We estimate that the total population of the Kettle Basin was about 9,500 in 1976[15].

1.8 Land Use

The economy of the Kettle Basin depends largely on the forest industry, with lesser but important contributions made by mining, agriculture and tourism.

1.8.1 Agriculture

Cultivation is concentrated on the relatively flat land bordering the Kettle River from Westbridge to Midway and Grand Forks to Christina Lake. Small pockets of cultivated land are also found around Greenwood and

up the Granby River north of Grand Forks. Large acreages of forage crops occupy south-facing slopes between Anarchist Mountain and Rock Creek. In 1966, a total of 33,000 acres was improved for crops, including 17,000 acres in pasture, 10,000 acres in hay, 2,500 acres in grains, and 2,500 acres in vegetables. Livestock production centres around beef cattle with about 13,000 head in the region[1,14].

1.8.2 Forestry

Logging and wood processing are very important to the economy of the Kettle Basin. Approximately 1,000 people are directly engaged in these activities. Fir, larch, spruce and yellow pine are the chief species cut and are obtained mainly from the higher slopes in the Kettle, West Kettle and Granby valleys, and east of Christina Lake. Figure 9-1 shows the locations of existing and proposed logging operations in the Kettle Basin.

1.8.3 Mining

Mining activity is relatively light in the Kettle Basin with only two major producing mines at the present time. The Phoenix Mine near Greenwood is the larger of the two, milling one million tons of ore and shipping 14,395 tons of copper concentrates in 1974. The Highland Bell Mine at Beaverdell milled 37,000 tons of ore and shipped 1,414 tons of lead, zinc and silver concentrates in 1974[13]. There are several other very small producers in the regions and their 1973 and 1974 production is summarized in Table 9-5.

Exploration was conducted at about 30 mining properties in the Kettle Basin during 1974. Activity centred mainly around Greenwood and in the headwaters of the Kettle River[13].

1.8.4 Recreation

Region 9 has a moderately low capability to support outdoor recreation[20]. Areas capable of supporting intensive recreation are limited

to a few lakes, portions of the main valleys, and certain local features and attractions. In general, these areas are found in the southern or border portion of Region 9. Access to the north, particularly into the Monashee Mountains, is limited.

Christina Lake, 14 miles northeast of Grand Forks, is the focus for water-oriented recreation[1]. The lake has developed shoreline access and lodging facilities adjacent to Highway 3. There are opportunities for boating, angling, swimming and family beach activities. Christina Lake is variously rated by the Canada Land Inventory at Class 2-4 recreational capability[20], with higher ratings applied to the more developed south end.

Similarly, Jewel Lake, 25 miles northwest of Grand Forks has a Class 3 rating[20], with angling, camping and boating opportunities. A small lake north of Bridesville also has Class 3 status. Other lakes in Region 9 have received Class 4 or lower rating. Myers Lake southwest of Kettle Valley provides angling and wetland wildlife viewing opportunities. The upland between Kettle and West Kettle Rivers west of the community of Christian Valley contains numerous small lakes (such as Martin, Maloney, Buck and Joan Lakes) noted for angling, camping and wetland wildlife viewing opportunities.

Lower portions of the Kettle, West Kettle and Granby River Valleys provide Class 4 capability for camping, angling and wildlife viewing and hunting[20]. Headwater areas of these rivers, together with their tributary valleys and portions of the main valleys at higher elevations, have been given Class 5 ratings for dispersed activities such as hiking and camping. The remaining upland throughout Region 9 generally has a low, Class 6, capability. However, Big White Mountain in the West Kettle River headwaters has Class 2 capability as a consequence of developed downhill skiing facilities. There is access to the area from Kelowna. Other ski areas in Region 9 are located near Bridesville and Greenwood[1,20].

The region is not outstanding for hunting, but several big game and upland bird species are available (section 1.8.5). Most of the accessible lakes sustain moderate angling[1]. The most important sport fish are rainbow trout (to 10 lb.) and Kokanee (to 16 inches). Dolly Varden char occur in the Kettle River drainage, small mouth bass are found in Christina Lake, and brook trout frequent the numerous mountain streams.

Provincial parks in Region 9[1] include Kettle River Recreation Area three miles north of Rock Creek on Highway 33, 93 acre Johnstone Creek Park 7 miles east of Bridesville on Highway 3, and Boundary Creek Park 3 miles southwest of Greenwood on Highway 3.

1.8.5 Wildlife[21,22]

Region 9 contains three main biotic zones: natural grasslands, Montane Forest and Columbia Forest. Natural grasslands occupy the Kettle and Granby River valleys, with willow, cottonwood and birch bordering the main rivers. However, there are no extensive areas of flat land. Dry Montane Forest occurs along the valley slopes, particularly those with southern aspect. This habitat is characterized at lower elevations by an open canopy of ponderosa pine with bunchgrass, and at higher elevations by Douglas fir, larch and yellow pine.

Columbia Forest habitat, consisting of dense stands of western hemlock and western red cedar, are found below 4000 feet, while at higher elevations Engelman spruce and alpine fir of the Subalpine Forest Region predominate. These highlands provide summer forage for ungulates, but deep snow forces game to winter below 4000 feet in the main valleys, mostly on south and west facing slopes.

Mule deer are the most abundant and widely dispersed wild ungulates throughout the region. White-tailed deer have moderate populations in the Kettle and Granby River valleys, and exhibit a preference for semi-open

Montane Forest habitat. Both species are found on open south-facing slopes in winter and early spring. Mountain goat are scattered throughout the Monashee Mountains, but are most numerous north of Christina Lake. Small numbers of moose are found in the northern half of Region 9. Black bear are common, but grizzly bear are confined to wilderness upland areas. Other furbearers encountered include cougar, lynx and wolverine.

Climatic factors such as snow depth and soil moisture deficiency are the main factors determining ungulate distribution. Highest Canada Land Inventory ratings are given to lower south and west facing elevations along the Kettle and Granby valleys, and above the northeast shore of Christina Lake. These areas are rated predominantly 2W with some 1W. They form significant wintering areas for deer because they remain snow-free and provide adequate food and cover. The east facing slopes of the Kettle and Granby valleys, together with other tributaries such as Boundary Creek and West Kettle River, are rated 3W. The headwaters of Granby River near Galloping Mountain are considered an important (Class 3) summer range area for deer. However, most other upland areas in Region 9 have fairly low capability as summer range and no significant wintering capability, and are rated by the C.L.I. as Class 4 ungulate habitat.

Cultivated valley bottoms and open grassy hillsides provide natural habitat for several upland bird species. These include the introduced ring-necked pheasant and Hungarian partridge in drier areas, and the indigenous blue grouse, willow grouse, Franklin's grouse, quail and ptarmigan. The indigenous species, except for ptarmigan, are associated with forest habitat.

Ecological reserves in Region 9 include a 307 acre reserve north-east of Little White Mountain (order-in-council 2761, August 10, 1973) and a 2,350 acre reserve near Big White Mountain (order-in-council 1166, March 24, 1972).

Region 9 has a low C.L.I. capability rating (Class 6 and 7) for seasonal waterfowl production. Most of the country consists of timbered upland. The few small lakes in the region, including Christina Lake, lack marsh edge and are too deep to provide optimum waterfowl habitat.

Spot locations affording some capability include Myers Lake southwest of Kettle Valley (Class 2), and several small lakes and ponds near Grand Forks including Xenia and Jewel lakes (Class 3-5). Large concentrations of waterfowl are seldom encountered.

2. INDUSTRIAL SOURCES OF EFFLUENT AND SOLID WASTES

There is no one major industry in Region 9. There are however two mines, a copper-ore dressing plant (Granby Mining Corp.), a silver-lead-zinc concentrator (Teck Corp. Ltd.), two sawmill-planer mills (Pope and Talbot Ltd.), a sawmill (Sandner Brothers Ltd.) and an abrasives plant (Pacific Abrasives). These industries are described in this chapter and data on effluents and solid wastes are discussed. Other small miscellaneous discharges are mentioned and details of the Pollution Control permits are given.

2.1 Granby Mining Corporation

The company operates the Phoenix mine situated approximately 3.5 miles east of Greenwood, between the Twin Creek and July Creek watersheds. Its location is marked in Figure 9-3 by its permit No. PE-210. Underground and open-pit mining have been carried out intermittently since the early 1900's. However, the present operation consists only of an open-pit mine and a 3000 ton per day copper ore dressing plant. Chalcopyrite ($CuFeS_2$) is the major copper ore in the deposits and there are minor amounts of gold and silver. Mining is expected to continue until sometime in 1977 and milling until slightly beyond 1978.

The overburden from the open-pit mine (Granby Mine-Ironside Pit) is dumped in old mined areas. Little leaching of metals is expected and thus these refuse piles do not require a Pollution Control Permit. The mined ore is trucked to the mill site.

2.1.1 Description of the Mill Process

A simplified flow diagram of the milling process is given in Figure 9-4. There are four basic operations involved: dry crushing, wet grinding, rough and clean flotation, and water reclamation. The only effluent discharged is the tailings or underflow from rough flotation, and this is covered under Pollution Control Permit PE-210.

The dry crushing operation involves passage of the ore through a jaw crusher, screening, re-crushing in cone and gyratory crushers, and re-screening to obtain particles less than 0.5 inches in diameter.

The wet grinding stage further reduces the ore size in rod mills and ball mills. Particles of less than 200 mesh are separated in cyclones from the oversize which is returned to the ball mills. The fine particles are passed to the rough flotation cells. During wet grinding and flotation the following agents are used: lime to control the pH, aerofloat to act as a collector, cyanide to depress the pyrite (FeS_2), pine oil to act as a frother and xanthate to act as a promoter and collector.

The rough flotation cells separate the mineral from the gangue (tailings). The mineral and attached impurities are separated from the gangue by agitation, flotation, and skimming. Aerofloat, pine oil, xanthate and sodium sulphite (to sulphidize mineral oxides making them more easily depressed) are again added to augment the separation. The overflow (minerals and attached impurities) goes either directly to the clean flotation cells or to another set of ball mills and cyclones for regrinding and reclassification. The underflow, or gangue, is thickened to remove water then piped to the tailings impoundment.

In the clean flotation cells, the mineral is removed from the attached impurities in three banks of cells. The overflow from the first two cells is passed into the third cell for final flotation. The underflows from all cells are recycled through the various grinding circuits. Lime and aerofloat are added to the second cell to improve separation.

The overflow (cleaned mineral) from the third clean flotation cell is de-watered in a thickener and a disk filter then dried in a rotary drier. The dry concentrate is stored or shipped to a refinery.

The water removed from the cleaned mineral and tailings in the thickeners is recycled within the plant.

2.1.2 Description of the Tailings Impoundment

Until mid-1967, the tailings were piped across the July Creek drainage to an impoundment in the Fisherman Creek drainage (Figure 9-3). During the winter of 1966-67, the pipe broke and melting occurred in May depositing approximately 40,000 tons of tailings in July Creek. Pollution was reduced by the diversion of July Creek around the tailings accumulation. In December, 1967, Pollution Control Permit No. PE-210 was issued allowing the disposal of 756,000 GPD (gallons per day) of tailings to a new impoundment behind a rockfill dam in the Twin Creek Valley (Figure 9-3). A concrete catchment weir just below the dam contained the seepage water which was pumped back to the pond or mill. Excess water in the catchment weir during spring was discharged into Twin Creek and excess supernatant in the tailings impoundment was pumped to Providence Lake, although these discharges were not specified in the Permit.

In September, 1969 a failure of the piping at the base of the tailings dam resulted in the release of 2,000 GPM (gallons per minute) into Twin Creek for about five hours. Twin Creek passes through Greenwood via a culvert and the excess flow containing water and tailings tore out the culvert, washed out the street overlying the culvert, broke watermains and flooded basements and septic tanks. To prevent a re-occurrence of the flooding a system of dykes, interceptor dams and diversion dams was built.

The excess water discharged into Twin Creek and Providence Lake was authorized by an amendment to the Permit, issued in April, 1973. The amendment details are given in Table 9-6. However, to assure the stability of the tailing dam, the company was granted special permission during the springs of 1974 and 1975 to discharge into Twin Creek quantities in excess of the permit stipulation. To prevent runoff water from entering the tailing impoundment a system of drainage ditches was built around the impoundment.

In December, 1975, a second major amendment to the Permit was issued allowing the tailings to be pumped to the Ironsides Pit instead of to the

Twin Creek impoundment (Table 9-6). The Ironsides Pit is located between the mill and the Twin Creek impoundment and thus any seepage will drain into the tailings impoundment. To maintain the water level in the Twin Creek impoundment, a spillway was constructed on the south abutment

2.1.3 Effluent Sampling Data

The data collected by the Pollution Control Branch and the Granby Mining Corporation are summarized in Tables 9-7, 9-8 and 9-9. The data are from a limited number of samples collected between 1973 and 1975.

The overflow to Providence Lake showed some high values during spring runoff (Table 9-9). Copper reached a maximum concentration of 0.245 mg/l compared to the permit limit of 0.03 mg/l, cyanide a maximum of 0.19 mg/l compared to a limit of 0.03 mg/l, and total solids a maximum of 1850 mg/l compared to the limit of 1500 mg/l. The overflow from the weir below the dam to Twin Creek was however within permit limits.

Since the tailings are now discharged to the mined area instead of the impoundment, the discharge to Providence Lake has ceased. The construction of ditches to prevent runoff from entering the impoundment should reduce the concentration of contaminants in the weir overflow.

2.1.4 Recommendations

Monitoring of the overflow from the catchment weir should continue. The discharge rate should be measured and samples collected at least once during both high and low runoff periods. The samples should be analysed as follows:

- alkalinity - total
- copper - total and dissolved
- cyanide - total
- iron - total and dissolved
- hardness
- pH
- solids - total and suspended
- specific conductance
- sulphate - dissolved
- turbidity

2.2 Teck Corporation Ltd.

Teck Corporation Ltd. operates an underground mine, the Highland Bell, and a silver-lead-zinc concentrator near Beaverdell on the West Kettle River. Its location is marked in Figure 9-3 by its permit No. PE-444. The mine, from which ore was first shipped in 1916, is the oldest continuously operating mine in B.C. The concentrator, first built in 1950 to handle 50 tons per day, now produces approximately 120 tons per day.

The underground mine is situated east of Beaverdell and the West Kettle River. Mining is done by open stope methods and the overburden is dumped into old underground workings or trammed to the surface and dumped near the adit entrance. Water for mining is obtained from surface seepage and underground diamond drill holes and is recycled. The mined ore is trucked to the mill site (west of Beaverdell and the West Kettle River) and dumped into the coarse ore bin.

2.2.1 Description of the Plant Process

A simplified flow chart of the milling process is shown in Figure 9-5. The mined ore from the coarse ore bin is first picked through by hand to remove waste rock and then crushed, screened and if necessary, re-crushed to obtain particles less than 0.5 inches in diameter. These particles are further reduced in size to approximately 70 percent less than 200 mesh, by wet grinding in a ball mill. Lime, thiocarbanilide, zinc sulphate, cyanide and aerofloat are added with the ore to the ball mill. They control the pH and act as conditioners, collectors and depressants to augment the removal of impurities during flotation.

Following wet grinding, the ore is passed to the duplix jig which produces a jig concentrate, high in silver content, and jig middlings. The concentrate is filtered and stored. The middlings are screened and passed with copper sulphate to the conditioner for lead flotation.

There are three lead flotation cells. The overflow from the cells is clean lead concentrate which is filtered and stored. The underflow is conveyed to zinc flotation. Lime, Dowfroth, xanthate and copper sulphate are added in zinc flotation to promote removal of impurities. The overflow from the single zinc flotation cell is the clean concentrate which is filtered and stored. The underflow, or tailings, is sent to the tailings pond. These tailings are the only discharge and are covered under Pollution Control Permit No. PE-444, issued February, 1974.

2.2.2 Description of the Tailing Impoundment

The tailing pond covers approximately 6.5 acres and has a centrally located decant structure over which the supernatant flows into the exfiltration ditch (0.42 acres). There is no positive discharge from the pond or exfiltration ditch to the West Kettle River. Permit details (PE-444) are outlined in Table 9-10.

Since 1950 when the concentrator was built, Teck Corporation Ltd. (formerly Leitah Mines Ltd.) has filled three tailing ponds. The first two cover approximately 15 acres and are eight to ten feet deep. The third was active when the company first applied for a permit in 1970. It had frequent leaks, most of which were contained within an earthern dyke although some slimes did reach the Kettle River. No spills have been recorded since the summer of 1972.

2.2.3 Effluent Sampling Data

The data collected by the Pollution Control Branch and Teck Corporation Ltd. are summarized in Table 9-11. The mean daily discharge per day to the tailing pond was within permit limits except in May 1974. The limit was exceeded by three percent due possibly to spring runoff water.

The Pollution Control Branch sampled the water in the exfiltration ditch only once because water is seldom present in the ditch. This sample showed a pH value of 12.2, which is greater than the permit maximum of 8.5 but all other parameters were within permit limits.

Effects on the Kettle River were minimal, as discussed in Chapter 4. All of the data submitted by Teck Corporation Ltd. on the exfiltration pond supernatant were within the permit requirements.

Monitoring of parameters listed in the permit should be continued and total solids should be included.

2.3 Pope and Talbot Ltd.

Pope and Talbot Ltd. (formerly Boundary Forest Products) operates a 500,000 fbm (board feet) per day sawmill-planer mill complex in Midway and a 70 million fbm per year complex in Grand Forks. The Midway operation has applied for a Permit to discharge effluent to the Kettle River (Application No. AE-2224) and has two refuse disposal sites under Pollution Control Permits No. PR-1950 and PR-3649. The Grand Forks operation is similar except that no effluent is discharged and there is only one refuse site. The site is covered by Pollution Control Permit No. PR-3767. The application and permits are summarized in Table 9-12.

2.3.1 Midway Mill

a) Description of the Mill Process

A simplified flow diagram of the sawmill-planer mill process is shown in Figure 9-6. The logs are trucked to the mill site and moved within the mill grounds over land. Before 1974, the logs were transported on a log pond, but the pond has been drained and is now used as a refuse disposal site.

The logs are first sorted for size and species and then debarked and bucked to length. The bark and wastes are conveyed to the teepee burner and the logs are passed to one of the two chip 'n' saws or the edger.

The chip 'n' saws produce sawdust which goes to the teepee burner and edges, which are further processed into chips and lumber. The chips are either classified in cyclones and then sold to pulp mills or are used in the boilers. Excess chips are trucked to one of the refuse sites. The lumber is dried in kilns and planed, with the planer ends going to the chipper or refuse site and the shavings and sawdust to the teepee burner. Steam used in the kilns is generated in the boilers from deionized Kettle River water. The steam condensate is recycled. Boiler blowdown water is combined with the edger cooling water and constitutes the effluent discharged to the Kettle River. To decrease the suspended solids and the BOD_5, the effluent is passed over a screen conveyor and through a multiple chamber settling sump. A submerged outfall with a slide screen are to be installed to further reduce the suspended wood material and the BOD_5.

The largest logs go to the edgers which are water cooled saws. The resulting edger cooling water contains pitch and sawdust. It is combined with the boiler blowdown effluent and treated as described above. The edges are conveyed to a chipper and the chips are classified in a cyclone and stored for sale to pulp mills. The squared logs are cut into lumber, dried and planed.

b) Effluent Sampling Data and Recommendations

There are no data available since the installation of the screen and settling sump. An analysis on December 6, 1974 before this installation showed a BOD_5 of 290 mg/l and a total solids of 508 mg/l. The discharge rate should be measured weekly and samples analysed quarterly for oil and grease, tannins and lignins, BOD_5, total solids and suspended solids.

c) Refuse Disposal Sites

The Midway operation has two refuse disposal sites: site no. 2 under Pollution Control Permit No. PR-3649 and the former log pond under Pollution Control Permit No. PR-1950. The permit details are outlined in

Table 9-12. Each site receives approximately five cubic yards of refuse per day. The refuse consists of bark, branches and broken logs from the log yard, ashes and clinkers from the teepee burner and boilers, scrap metal and packaging from the maintenance shop, waste paper from the offices and mill chips and shavings from the mill area cleanup operations.

Site no. 2 covers an area of approximately 1.5 acres west of the mill site, between the railway tracks and the Kettle River. A scarp about 10 feet high separates the disposal area from the area adjacent to the river which is subject to seasonal flooding. In October, 1973, the refuse caught fire and was allowed to burn rather than cause excess smoke from smothering. Since the Pollution Control Permit was issued the ashes and clinkers are separated from the combustible material and at regular intervals the refuse is covered with gravel.

The log pond was drained in November, 1974 and a site inspection revealed that with some fill in the south section, the area would be relatively impermeable and suitable for a refuse site. The bottom is above groundwater, except during freshet, however it is thought that the drainage is away from the Kettle River. Monitoring wells were installed late in 1975 to ascertain the drainage direction. As with site no. 2, the ashes and clinkers are separated from the combustible material and the refuse is covered with gravel at regular intervals.

No data are yet available from the monitoring wells. Samples should be collected at least four times per year, including high and low runoff periods. Analyses should include:

alkalinity, total	pH
carbon, organic	solids, total and suspended
copper, total and dissolved	specific conductance
hardness	tannins and lignins
iron, total and dissolved	turbidity.

2.3.2 Grand Forks Mill

The sawmill-planer mill complex in Grand Forks is similar to the one in Midway except that no effluent is discharged. There is one refuse disposal site under Pollution Control Permit No. PR-3767. The permit is summarized in Table 9-12.

The refuse disposal site is a triangular shaped area covering approximately 2.5 acres west of the mill site. It is bounded on the south by a railway embankment, on the east by the mill and a residential area and on the north and west by a bank of trees adjacent to the Kettle River. For aesthetic reasons and bank stabilization the trees are not to be encroached upon or damaged.

The permit requires that the site be operated as an improved dump. The ashes and clinkers are separated from the combustible material and if they are used as intermediate cover material they must be cooled to ambient temperatures and oiled. The wastes are covered with sand and gravel a minimum of 12 times per year.

The site is approximately seven feet above ground water and little leaching to the Kettle River is expected to occur.

2.4 Sandner Brothers Lumber Co.

Sandner Brothers Lumber Co., a sawmill, is situated southeast of Christina Lake (Figure 9-3). Refuse is discharged under Pollution Control Permit No. PR-3942 to a site near Christina Creek at the south end of the lake. Permit details are outlined in Table 9-13.

Between 1969 and 1973 a site adjacent to Christina Lake was used but in 1973 an application for a Pollution Control permit was refused due to the potential leaching of tannins and lignins to the lake. The company was ordered by the Pollution Control Branch to cover the site and to improve

the dykes along the lake's edge. This was done in 1974-75. The present site was then chosen and Pollution Control Permit No. PR-3942 was issued in March, 1975.

Christina Creek flows south past the present site and is approximaterly 30 feet from the southern section of the area which is already filled. The area remaining, approximately two acres, is higher than the stretch of land east of the site and adjacent to the river and is not subject to flooding or groundwater surfacing. Old highway no. 395 borders the west side of the refuse site, and gravel from a pit just west of highway no. 395 is used periodically to cover the refuse.

Monitoring wells have not been installed as leaching to Christina Creek is not expected. Operation of the site should be continued as stipulated in the permit with regular coverings.

2.5 Pacific Abrasives and Supply Ltd.

Pacific Abrasives and Supply Ltd., a slag handling plant, is situated in Grand Forks (Figure 9-3). A simplified flow diagram of the plant process is given in Figure 9-7. The slag from an old mine north of Grand Forks is trucked to the plant site and conveyed to the kiln. In the kiln the slag is heated to remove impurities and to prepare it for screening. The kiln vents to a wet scrubber which washes out particulate material entrained in the gas. The cleaned gas is exhausted via a stack and the underflow, or solid wastes, are trucked to the refuse disposal site. Water used in the wet scrubber is recycled. From the kilns the slag is passed via a bucket elevator to the shaking screen which separates the slag into the required particle sizes.

The refuse disposal site is under Pollution Control Permit No. PR-1755, the details for which are given in Table 9-13. The site is an old railway excavation situated north of the plant site. The company was for a short period also disposing of solid wastes at a landfill site

east of the plant, however, they were ordered by the Pollution Control Branch on June 18, 1975, to discontinue doing so.

To prevent the inert slag at the disposal site from blowing, it is covered a minimum of twenty times per year. Leaching is not expected to be a problem and thus monitoring wells have not been installed.

2.6 Miscellaneous Sources of Industrial Wastes

There are four minor industries discharging wastes in Region 9. These include a placer mine on Boundary Creek (PE-3151), a vegetable washing and packing plant (PE-1927), a car wash (PE-2390) and a laundromat (PE-2962). The permit details for these miscellaneous industries are outlined in Table 9-14.

No monitoring data are available but no adverse effects on the groundwater or creeks are expected.

3. MUNICIPAL AND NON POINT SOURCES OF EFFLUENT AND SOLID WASTES

3.1 Municipal Sources of Effluent

The largest municipal centres in the region are the City of Grand Forks (population 3,173 in 1971), the City of Greenwood (population 868 in 1971) and the Town of Midway (population 502 in 1971)[16]. These three municipalities have sewage treatment plants under Pollution Control Permit which are discussed below. The remaining areas encompass a 1971 population of 3,837[16] and rely primarily on septic tanks and tile fields for sewage disposal.

3.1.1 The City of Grand Forks

The Corporation of the City of Grand Forks operated a sewage treatment plant consisting of a single oxidation pond up to 1970. The pond was then split into an aeration cell and a settling lagoon. A provisional three year permit, No. PE-280, was issued June 13, 1969 and the aeration cell was operational in February, 1970. The provisional permit was amended to include chlorination facilities and the amended permit was issued January 3, 1973. The permit details are outlined in Table 9-15.

A 25 HP surface aerator is used in the aeration cell which has a capacity of 473,000 ft^3 and a retention time of 9.5 days. The settling lagoon has a retention time of 18.5 days. The chlorination facilities are to provide one hour contact time during average flow rates and a free residual chlorine level between 0.1 and 1.0 mg/l. The effluent is discharged to the Kettle River.

A complaint concerning the sewage treatment plant in the past was "poor housekeeping". This included aquatic weed growth in the ponds, poor operating records, no flow measuring device, and icing of the aerator in the winter.

The effluent data collected by the Pollution Control Branch from June, 1972 to November, 1975 are summarized in Table 9-16. These data were obtained before chlorination but after installation and operation of the aeration cell. The BOD_5 (12-24 mg/1) and suspended solids (7.2-23 mg/1) were well within the permit requirements of 45 mg/1 and 60 mg/1 respectively. Coliform values were high and variable but should be reduced when the chlorination facilities are installed. The effluent flow was not measured and thus loadings cannot be calculated. However, a dilution of at least 70 times is expected at maximum effluent discharge and lowest river flow. Chlorination will reduce the coliform levels, but residual chlorine should be monitored carefully. After dilution the level of chlorine in the river should not be allowed to exceed 0.002 mg/1 to protect most aquatic organisms [23].

3.1.2 The City of Greenwood

The Corporation of the City of Greenwood used septic tanks and tile fields up to 1975. Since contamination of the groundwater was occurring a sewage treatment plant was built consisting of an oxidation ditch, clarifier, sludge drying bed, chlorine contact chamber and two percolation ditches to handle 100,000 GPD of municipal sewage. Chlorination was later considered unnecessary as it would enhance clogging in the percolation basins. Pollution Control Permit No. PE-4113 was issued on November 21, 1975 as summarised in Table 9-15. It requires that the chlorination contact chamber be installed but that chlorination commence only if coliform levels in Boundary Creek warrant it. The plant is situated adjacent to Boundary Creek and the exfiltrate from the percolation basins passes via the groundwater to Boundary Creek. The shortest distance between the percolation basins and the creek is 130 feet and the soil is quite permeable, consisting of alluvial sands, silts and gravels. Contamination of Boundary Creek is not expected, however a well is to be installed for sampling the groundwater.

No effluent data were available to the end of 1975.

3.1.3 The Village of Midway

The Village of Midway built a sewage treatment plant in 1971 to replace old septic tanks which were causing groundwater contamination. The plant included two facultative stabilization ponds, a chlorine contact chamber, a gravel filter bed and discharge of treated effluent to the Kettle River. The stabilization ponds could handle 55,000 GPD and the filter bed and discharge pipe could handle 167,000 GPD. Pollution Control Permit No. PE-394 was issued April 7, 1971 as summarized in Table 9-15.

The collected municipal sewage flows into the stabilization ponds (organic loading 27 lb/day/acre) where there is a retention time of up to 98 days. The partially treated sewage is then chlorinated (1.5 hour contact time) and passed through a gravel bed to a 10 inch outfall pipe.

The stabilization ponds were operational in 1972 but chlorination did not begin until late 1975.

The effluent data collected by the Pollution Control Branch are summarized in Table 9-16. The four values for BOD_5 (up to 111 mg/l) and two of the three values for suspended solids (up to 82 mg/l) exceeded the permit requirements. Fecal coliform levels were high and variable (2000 to 2.4 million MPN/100 ml) but were obtained before chlorination started. The samples were collected before the effluent passed through the gravel bed and therefore the effluent reaching the river should be of better quality. Also, at maximum effluent discharge a dilution with Kettle River water of 1:100 is expected. A monitoring well in the gravel bed, close to the Kettle River, should be installed to check the quality of effluent discharged.

3.2 Municipal Refuse Disposal Sites

There are eight municipal refuse disposal sites in Region 9, three of which are under Pollution Control Permit or Application. These three

sites are at Grand Forks, Greenwood and Midway and are described below. The areas with sites not under permit or application include Beaverdell, Bridesville, Christina Lake, Rock Creek and Westbridge. Only the site at Christina Lake is considered to be in an unacceptable location but in 1976-77 a new site will be developed [24]. Also in 1976-77, the sites at Beaverdell, Bridesville and Westbridge will be phased out and the refuse will be trucked to an improved site at Rock Creek [24].

3.2.1 The City of Grand Forks

The Grand Forks disposal area is under Pollution Control Permit No. PR-1770 which is summarized in Table 9-17. It encompasses an area of approximately 5 acres on a bench of land just northwest of Grand Forks (Figure 9-3). The eastern boundary is a steep rocky hillside which permits little runoff onto the bench. The Granby River is about 2000 feet to the west and although drainage is to the west, no leaching to the river is expected. The surrounding soil, which consists of silts, sands and gravels, is used to cover the site three times per week.

3.2.2 The City of Greenwood

The Greenwood refuse disposal site is under Pollution Control Permit No. PR-2984 which is summarized in Table 9-17. The site (approximately one acre) is located just west of Greenwood (Figure 9-3), in a depression beside an old railway embankment. Rocky hills lie to the east and north of the area and the railway embankment to the west and south. Motherlode Creek is about 300 feet west of the site. To prevent runoff water from the disposal area from entering Motherlode Creek, a diversion ditch from the rocky hills to Motherlode Creek was constructed.

3.2.3 The Village of Midway

The Midway disposal site is under Pollution Control Permit No. PR-2985 which is summarized in Table 9-17. The area is a flat gulley on the south side of an old railway embankment approximately two miles west of Midway. Some accumulation of water is expected during spring runoff.

However little leaching to the Kettle River, which lies about 3000 feet north, is likely. The scarcity of suitable cover material in this rocky area has prompted an application for some burning at the site.

3.3 Effects of Agriculture

Agricultural activities in Region 9 are on numerous small-scale farms, many of which are not self-supporting. The major block of arable land is along the Kettle River in the Grand Forks area where in 1971 the Agricultural Census reported 75 farms with cropland [25]. The remaining 110 farms were, according to the census, scattered along the rivers: 79 were located on the Kettle River upstream from Grand Forks and some were by the Granby River and Boundary Creek.

The agricultural emphasis is upon beef cattle in the form of cow-calf operations. The cultivated land is used primarily for the production of hay crops.

The contribution of nutrients to the Kettle River from agriculture was calculated for the irrigated and fertilized cropland and for livestock confinement areas. Other sources were considered negligible. The irrigated acreage obtained from the Water License data [14] exceeded that reported from the Agricultural Census (Table 9-18) probably because many of the small farms were becoming uneconomical and discontinuing operation.

3.3.1 Nutrients From Irrigated Croplands

The water license data, which reflect the potential rather than the actual irrigated acreage, were used to determine the potential nutrient loadings. It was assumed that all of the irrigated area was fertilized, that nutrients from acreage not irrigated were negligable and that nutrients reached the river via groundwater.

The results from the Okanagan Basin Study [26] were used for the calculations. This involved three assumptions. First, the fertilizer was applied at a rate of 50 lb nitrogen and 10 lb phosphorus per acre per year. Second, the fractions of nutrients reaching the goundwater were 0.168 of nitrogen applied as fertilizer and 0.021 of the phosphorus applied as fertilizer. Third, 80 percent of the nitrogen and phosphorus reaching the groundwater entered the receiving water (Kettle River). Using these assumptions, the contribution of nutrients from each acre to the Kettle River were calculated as follows:

Nitrogen: 50 x 0.168 x 0.8 = 6.7 lb/year/acre

Phosphorus: 10 x 0.021 x 0.8 = 0.17 lb/year/acre

The nutrient loadings to the Kettle River, based on the above assumptions and calculations, are summarized in Table 9-18.

3.3.2 Nutrients From Livestock

The results from the Okanagan Basin Study [26] were also used to calculate the nutrient loadings from livestock to the Kettle River. This involved two assumptions. First, the potential loading from each animal per year was 137 lb nitrogen and 9.1 lb phosphorus. Second, the fraction of the total potential loading which reached the river was 0.07 for nitrogen and 0.022 for phosphorus. The contribution from each animal per year was thus 137 x 0.07 or 9.6 lb nitrogen and 9.1 x 0.022 or 0.2 lb phosphorus. An estimate of the number of livestock was obtained from the 1971 Agricultural Census [25] and is given in Table 9-18. Also in the Table are the potential loadings of nutrients from livestock to the Kettle River.

3.3.3 Discussion

The effect of agricultural operations on the water quality of the Kettle River were based on estimates which gave only order of magnitude values. The total loadings given in Table 9-18 reached the river primarily during the spring and summer months (April to August) and thus the daily load was calculated by dividing the total by 150. The resulting values of 970 lbs/day for nitrogen and 23 lbs/day for phosphorus are considered low. The low levels of nutrients in the Kettle River (Chapter 4) suggest that the

agricultural activities were not having any discernable effect on the water quality of the river.

3.4 Effects of Mining

The two largest mines in the region, Phoenix Mine and Highland Bell Mine, are sources of ore for Granby Mining Co. Ltd. and Teck Corporation Ltd. respectively. These operations were discussed in sections 2.1 and 2.2 and some details concerning the mines are given in Table 9-5. In 1973, Providence Mine and Fur, Flo (Doorn) Mine were also being worked but on a small scale (Table 9-5) [13].

There are numerous small mineral-ore mines in the region which are not presently being worked. Certain mines including Greyhound Mine, Wellington Mine and Union Mine may be discharging some contaminated effluent [27]. Greyhound Mine is situated 1.5 miles northwest of Greenwood on Motherlode, Deadwood, Greyhound and Boundary Creeks [15]. A 2000 ton per day copper concentrator was completed at this mine in August, 1970. However the mine closed at the end of 1970. No data are available on the water quality of the creeks, except Boundary Creek, which is discussed in Chapter 4.

Wellington Mine is a silver-lead-zinc mine situated one mile east of Beaverdell on Wallace Mountain. No data or information concerning the mine are available from 1969 to 1973. A site inspection should be made.

Union Mine, a gold-silver mine, is situated 46 miles north of Grand Forks in an area known as Franklin Camp. It has been idle for many years, but the owners left a small mill and 200,000 tons of tailings which contain some gold and silver. To recover the gold and silver, a cyanide process plant was erected and a closed-circuit leaching process started. The operation proved uneconomical and was closed within a few months. A site inspection of the tailings pile should be made to determine whether water sampling is required.

A gold-silver mine on Jewel Lake, six miles northeast of Greenwood, has operated intermittently since 1895 and still has a tailings pile adjacent to Jewel Lake. Following a complaint by a local resident, the lake water, sediment and fish tissues were examined to ascertain whether the tailings were entering the lake and having any detrimental effects. No problems were found although the lead values in the sediment in the vicinity of the tailings pile were higher than in some other British Columbia lakes [9].

4. WATER SAMPLING DATA

Water samples from the Kettle River Basin have been collected and analyzed since 1972 by the Pollution Control Branch. Approximately 6000 analyses were carried out between 1972 and 1975. The sample sites and their location relative to the major industrial and municipal discharges are shown in Figure 9-3.

The Kettle River is joined by the West Kettle River in the western section of Region 9, and flows south to Midway and then into Washington State. Boundary Creek flows into the Kettle River immediately south of the border. The Kettle River flows east and back in to Canada near Grand Forks. It is joined by the Granby River at Grand Forks and flows east to receive the outflow from Christina Lake. It then flows south again into Washington State to join the Columbia River at the Grand Coulee Dam.

To present the data, we divided the region into three parts: the West Kettle, Kettle and Granby Rivers, Boundary Creek and Christina Lake.

4.1 West Kettle, Kettle and Granby Rivers

4.1.1 Presentation of the Data

All of the major discharges and activities in Region 9 are along the West Kettle and Kettle Rivers, except for the Granby Mining Co. and the Greenwood sewage treatment plant. There were 3 water quality sites on the West Kettle River, 9 sites on the Kettle River and one site on the Granby River. The water quality data, excluding coliform data, for these 13 sites are summarized in Tables 9-19, 9-20, 9-21, 9-22 and 9-23. The Canadian drinking water standards[28] are included in Table 9-19 for comparison. Mean colour values at 10 of the sites, during both high flow (April to July inclusive) and low flow (August to March inclusive) periods, are plotted in Figure 9-8. Available coliform data are summarized in Table 9-24. The geometric mean of the coliform values was used because of the large variation in the data.

4.1.2 Discussion and Recommentdations

The discharges and activities along the West Kettle and Kettle Rivers had little effect on the water quality (Table 9-19 to 9-24). Also, except for colour, two turbidity values and certain fecal coliform levels, the results were within permissible drinking water standards[28]. The data do not include the analyses for total iron from samples collected May 16-17, 1972. On these two days the values at all sites ranged from 0.84 to 6.6 mg/l. Such values appear to be unrealistically high and were possibly due to contamination of the samples. Dissolved and total iron should be monitored at all sites to confirm the results in the tables.

The highest colour values (Figure 9-8) and the two high turbidity levels (18 and 24 JTU) occurred during high flow periods on the upper West Kettle River at sites 88 and 89. These values were not caused by any particular discharge but were probably due to natural runoff, magnified by the logging activities in the upper West Kettle River area. Colour and turbidity should be determined at least twice a year at each of the sites.

The limited coliform data, summarized in Table 9-24, were collected before chlorination was installed at the sewage treatment plants in Midway and Grand Forks. All of the total coliform values were within the acceptable limit for raw water supplies of 1000 MPN/100 ml[28]. The geometric mean values of the fecal coliform counts were within the acceptable limit of 100 MPN/100 ml for raw water supplies[28] but certain individual values at sites on the Granby River and the Kettle River exceeded the limits. These sites were downstream from the Grand Forks sewage treatment plant (site 81), immediately upstream from the plant but downstream from the Granby River confluence (site 149) and on the Granby River (site 82). The upstream site 149 on the Kettle River was only 200 feet from the plant but close to the Granby River confluence. A temporary site should be established on the Kettle River upstream from the Granby River

confluence. The source of coliforms in the Granby River is not known and an inspection of the area should be made.

For the Phase II investigation we recommend that fecal and total coliform levels should be measured at sites 89, 88, 84, 147, 83, 149, 81, 82 and the temporary site on the Kettle River just upstream of the Granby River confluence. Two samples per week for a month should be collected, but if this is not feasible 3 to 5 samples should be collected at each site over a period of 3 to 5 days. The samples should be collected during both low and high flow periods. The results will help to establish the location of sites for routine monitoring, although much of the fecal contamination should be eliminated by chlorination of the municipal effluents.

Once chlorination commences at the sewage treatment plants of Midway and Grand Forks, residual chlorine should be determined at sites 84, 147, 149, 81, 82 and the temporary station just upstream of the Granby River confluence. The amperometric chlorine titration method should be used.

Monitoring for Phase II of the study should be carried out at sites 89, 88, 84, 147, 83, 149, 82, 81 and 80. In addition to coliforms and residual chlorine as detailed above, samples should be analysed for total alkalinity (phenolphthalein alkalinity if pH>8.3), Kjeldahl nitrogen, pH, total phosphorus and total and dissolved solids.

4.2 Boundary Creek and its Tributaries

4.2.1 Presentation of the Data

There were three water quality sites on Boundary Creek, one site on Providence Creek at the outlet of Providence Lake, and one site on Twin Creek. Providence and Twin Creeks receive excess supernatant and runoff from the tailings impoundment at Granby Mining Company. The Boundary Creek

sites were upstream and downstream of the Greenwood sewage treatment plant and at the confluence of Boundary Creek and the Kettle River. Single samples were also taken from Eholt Creek, a tributary meeting Boundary Creek north of Providence Creek, and from Boundary Creek upstream of Eholt Creek (Figure 9-3). The data obtained by the Pollution Control Branch from 1972 to 1975 are summarized in Tables 9-25 and 9-26.

4.2.2 Discussion and Recommendations

The samples from the outlet of Providence Lake to Providence Creek and from Twin Creek (Table 9-26) showed low levels of metals but high values for calcium and certain other parameters. Average values were: calcium 173 mg/l at the outlet of Providence Lake and 149 mg/l for Twin Creek, chloride 5 and 3.9 mg/l respectively, hardness 539 and 407 mg/l respectively and sulphate 408 and 332 mg/l respectively. These values were close to, or, as in the case of hardness, in excess of drinking water standards [28]. Eholt Creek, which follows the side of the mountain on which Providence Lake is situated and where Twin Creek originates, generally did not show such high values. There were also high concentrations of these parameters in the discharge to Providence Lake and the overflow from Granby Mine tailings impoundment into Twin Creek. Providence Lake and Twin Creek originate at Granby Mine and thus it was not possible to obtain upstream control samples. However, the data suggest that the high dissolved solids levels of these waters was due to the discharge of the tailings supernatant and to the run-off from the cleared area around Granby Mining Company. If this was the case, concentrations should decline in the future because excess supernatant is no longer discharged into Providence Lake, use of the tailings impoundment is being discontinued and drainage ditches to intercept the runoff water are being constructed (Chapter 2). Monitoring should continue at the outlet of Providence Lake and in Twin Creek and additional samples should be collected from the drainage ditch where it meets Twin Creek. Samples should be taken at least once during both high and low flow periods and the following para-

meters should be measured:

flow
acidity
alkalinity-total (Phenolphthalein if pH>8.3)
hardness
pH
solids-total and dissolved
sulphate - dissolved
turbidity

There were only limited data from the stations along Boundary Creek, but alkalinity, hardness, pH, total solids and sulphate appeared to increase from upstream to downstream sites (Table 9-25). These increases were probably due to the mixing of Boundary Creek with Providence and Twin Creek, which enter Boundary Creek via culverts. The location of these culverts should be established. We recommend that the Boundary Creek sites, including the site above Eholt Creek, be sampled during Phase II, and analyzed for the same parameters as listed above for Providence Lake and Twin Creek. Total and dissolved phosphorus and Kjeldahl nitrogren should be added to the analyses.

There was a slight increase in the coliform levels at the station downstream from the Greenwood sewage treatment plant, although this represented only one analysis (Table 9-24). Fecal and total coliform determinations should be made at the four stations along Boundary Creek during both high and low flow periods. During each sample period, 3 to 5 samples should be collected over a period of a week.

4.3 Christina Lake

4.3.1 Presentation of the Data

The Christina Lake Study, prepared by the Regional District of Kootenay Boundary, was designed to obtain information for future planning

of the lake area[29]. The study included the whole watershed (124,920 acres) and considered economic, social and environmental factors. The water quality data were, however, limited to some nitrate and phospate determinations, extinction depth and detailed coliform data. The coliform data were collected weekly during the summers of 1967, 1970 and 1975 by the West Kootenay Health Unit and the results are summarized in Table 9-27.

Some water quality data were collected by Provincial Government agencies. Since 1971 the Pollution Control Branch sampled the southeast corner of Christina Lake at site 78, Sutherland Creek, a tributary at the southeast corner, at site 79, and Christina Creek, the outlet at the south end, at site 77. The Water Investigations Branch obtained data from two centrally located sites on Christina Lake (Numbered 681 and 682) in July, 1974. Site locations are shown in Figure 9-3. The lake samples were taken at various depths but as little or no variation was apparent over depth, the values from the different depths were grouped together. A summary of the lake data is given in Table 9-28 and the results from Sutherland Creek and Christina Creek are given in Table 9-29. The dissolved oxygen and temperature profiles for station 681, are typical for the three lake stations and are shown in Figure 9-9.

4.3.2 Discussion and Recommendations

Christina Lake is quite deep (mean depth 118 feet) and U shaped in cross section with relatively steep littoral areas. It is clear (extinction depth 25 to 50 feet) and has a summer thermocline of about 33 feet (Figure9-9). There are numerous inlets, most of which are small with gravel-boulder substrate and dry during the summer. The only outlet is Christina Creek which is approximately 30 feet wide and has a sand-gravel substrate. Domestic water licences exist on eight of the tributaries, including McCree Creek midway up the east side of the lake, Moody Creek on the southwest side, Sutherland Creek and Christina Creek.

These creeks are the only ones which flow year-round. Moody Creek is the water source for the Christina Waterworks District serving Christina Township. Sutherland Creek is the water source for the Sutherland Waterworks District serving Lavelley Point on the southeast side of the lake[29]. Logging is presently active in the upper Moody and Sutherland Creek Basins[29], although the water quality data for Sutherland Creek suggest no adverse effects (Table 9-29).

The water quality data for Christina Lake, Sutherland Creek and Christina Creek, presented in Tables 9-28 and 9-29, represent over 1000 analyses, all of which were within the Recommended Drinking Water Standards[28]. The total and fecal coliform counts (Table 9-27) were low. The total coliform counts satisfied the Provincial Water Quality Standards for recreation waters[30] (i.e., median value less than 240 MPN/100 ml). The fecal coliform counts were within the acceptable limits for raw drinking water sources[28] (i.e., 100 MPN/100 ml). However, the coliform counts were higher during high use periods and at the south end of the lake[29]. This is not unexpected as the south end is most developed and is the major outflow area of the lake.

There do not appear to be any problems with the water quality of Christina Lake although, with the increasing development of the area, the potential for problems exists. Sampling should continue at the present Pollution Control Branch sites and on a new site on Moody Creek. Samples should be collected monthly during spring and summer and the following parameters measured:

alkalinity - Phenolphthalein at pH<8.3
nitrogen - ammonia and organic
oxygen - dissolved
pH
phosphorus - total and total dissolved
solids - total and dissolved

Routine monitoring of beaches and creeks which serve as a water supply should be continued for total and fecal coliform.

5. AQUATIC BIOLOGY

5.1 Presentation of the Data

Data are available only for Christina Lake. They include some plankton-volume determinations from 1952 and 1966[31] (Table 9-30), some data on fish from 1950 to 1969[32] (Table 9-31), and some observations and identifications of aquatic plants (Tables 9-32 and 9-33).

The Pollution Control Branch collected aquatic plants from the southeast corner of Christina Lake in September, 1970[33]. This was in response to a complaint by a local resident about increased plant growth. The plant identifications and some general comments are given in Table 9-32. In 1974, the Regional District of Kootenay Boundary expressed concern about plant growth which may result from increased use and development of Christina Lake. In July, 1974, the Water Investigations Branch mapped the relative abundance of plants in the lake and collected samples from sites numbered 683 to 687 as shown in Figure 9-10. The location and relative abundance of plants in relation to marinas, boat launches, beaches and cottages are also shown in Figure 9-10. The list of plants identified and some general comments are listed in Table 9-33.

5.2 Discussion and Recommendations

A brief description of Christina Lake was given in Sections 1.5.2 and 4.3.2. More detailed information was included in the Christina Lake Study[29]. It is a deep, clear lake and the shallow areas are restricted to the north and south ends and to some isolated areas along the sides.

The limited plankton-volume determinations in Table 9-30 suggest that Christina Lake was relatively unproductive. The low nutrient levels

in the lake (Kjeldahl nitrogren: 0.02 to 0.08 mg/l, total phosphorus: <0.003 to 0.014 mg/l, Table 9-28) indicated an oligotrophic condition and thus an unproductive lake.

The fish species gill-netted in Christina Lake from 1950 to 1969 are given in Table 9-31. The indigenous population of Kokanee is a late shore spawner (December and January) and undergoes little colour change[34]. In the 1930's and 1940's, the kokanee supported a commercial fishery. Fishing is now primarily as sport for home consumption. The decrease in the commercial fishery was due to decreased fish size, increased sports fishing (and recreation in general) and the late spawning time. Prime fishing occurred as the fish approached the spawning grounds near freeze-up. Ironically, the late spawning time was partially a result of over-fishing of the early spawning segment of the population.

An attempt has been made to improve the blood lines, or hybrid vigor, of the indigenous population and revert the population to early spawning. Kokanee from the Meadow Creek Hatchery, which spawn in September in streams, were stocked in Christina Lake. The introductions occurred sometime in the 1940's but to date there is no evidence of hybrids.

Mysis relicta, a crustacean, was introduced into Christina Lake in 1966. This was to supply a supplementary invertebrate food source for young rainbow trout and kokanee and thus promote faster fish growth. Fish and Wildlife personnel observed some mysids in the summer of 1974, but not in the quantities found in Okanagan and Kootenay Lakes where the mysids were also introduced. The increase in fish size and numbers observed in Kootenay Lake[35] has not been apparent in Christina Lake, due possibly to the low productivity of Christina Lake.

The aquatic plants in Christina Lake in July, 1974 were primarily in the downwind shallow areas where the marinas, boat launches, beaches and cottages were most prevalent (Figure 9-10). The two species lists of aquatic plants (Tables 9-32 and 9-33) show no overlap. This may be due to differences in sampling location (the 1970 samples were restricted to the southeast corner), sampling dates (July versus September) or the sampling method. It is difficult to tell from these data whether plants spread from 1970 to 1974 or whether man's activity promoted plant growth.

Initially the plants probably arrived by natural dispersion (e.g., birds) or via man (on boat propellors, shoes, etc.) and grew if the habitat was suitable. Suitable habitat depends on such factors as dissolved oxygen, clarity, suspended solids, substrate-type, exposure, nutrient content and drawdown levels which can be quite variable in shallow areas. The nutrient levels can depend on sewage disposal methods.

The plants are spread by wind or man-made breakage such as by boats or docks. Plants which float on the surface, form mats. Some large branching plants, which are submerged and not readily visible, are easily broken. Of the species in Christina Lake, Potamogeton natans and possibly Myriophyllum (species unknown) are surface floaters and Elodea canadensis is an easily broken submerged plant. Spreading can also result from new habitat being established, particularly at the mouth of streams which carry large sediment loads. Sutherland Creek fits this requirement.

Should there be futher complaints about aquatic weeds we recommend that another survey be carried out, similar to the one done in 1974. The study should establish the relative abundance of plants and whether the area affected has increased.

AUTHORS

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L.W. Pommen, P.Eng.,	Description of the Region

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FIGURE 9-1
REGION 9, THE KETTLE RIVER BASIN

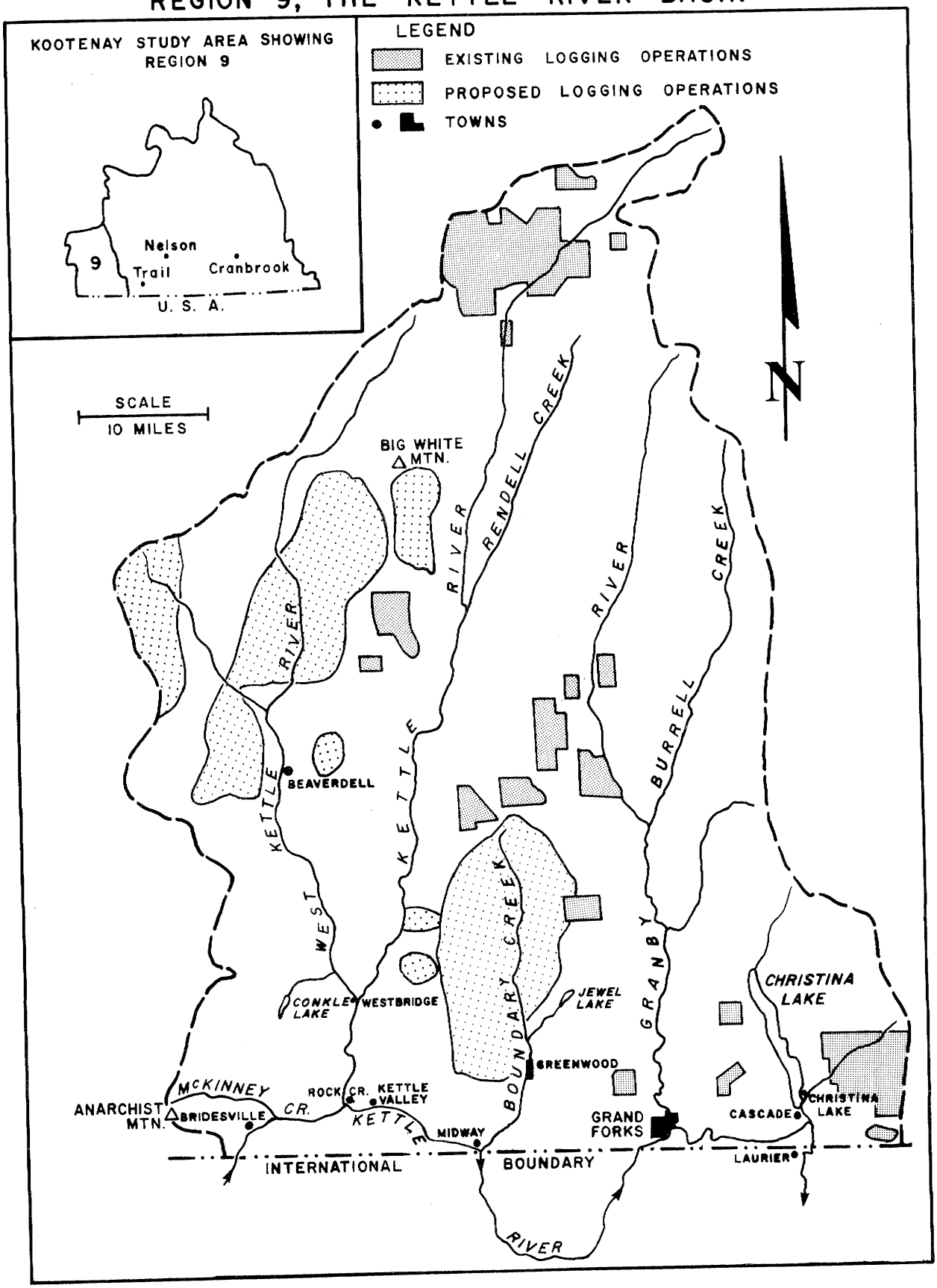


FIGURE 9-2

MEAN MONTHLY DISCHARGE IN THE KETTLE RIVER NEAR LAURIER

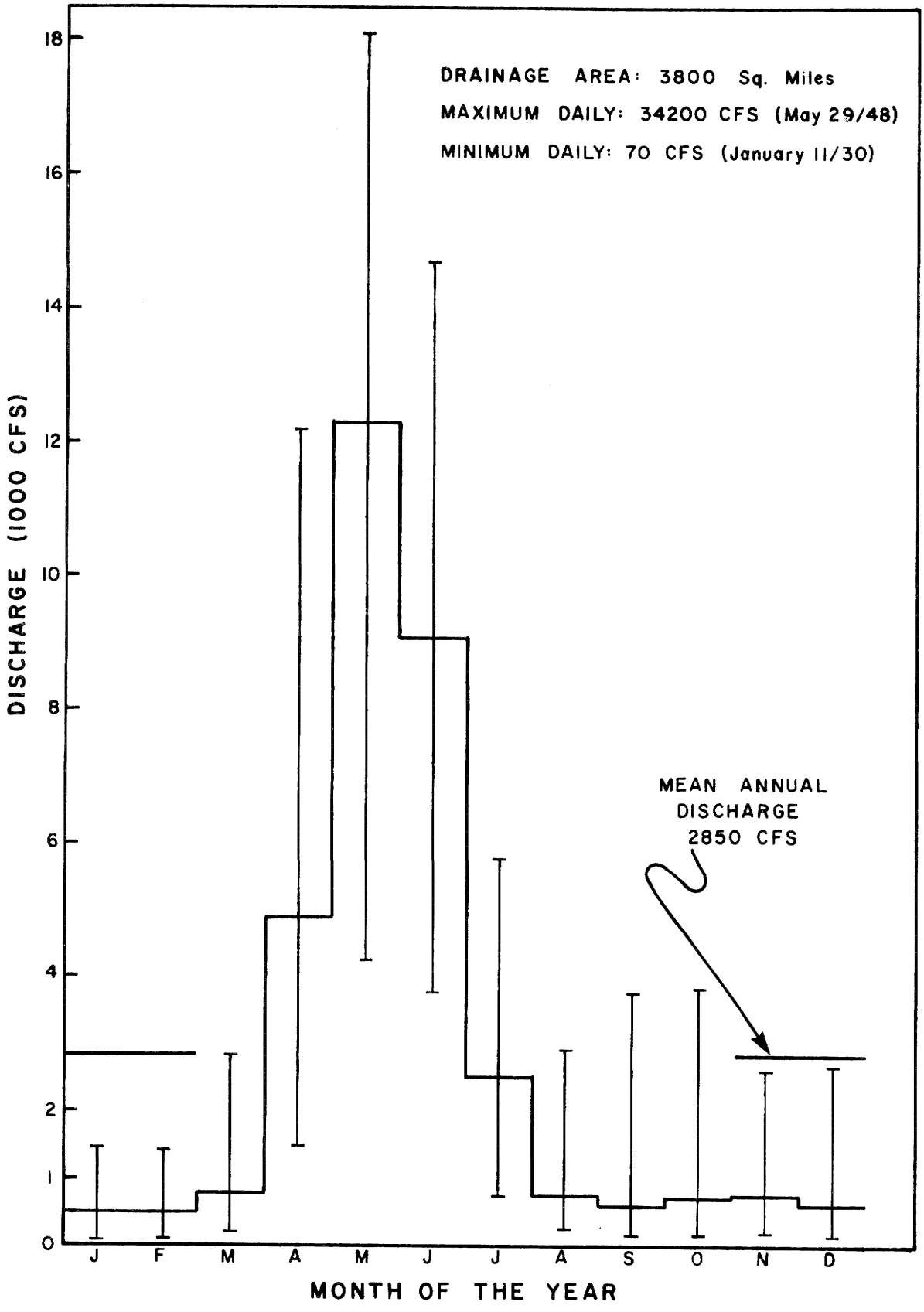


FIGURE 9-3

DISCHARGES AND SAMPLING SITES

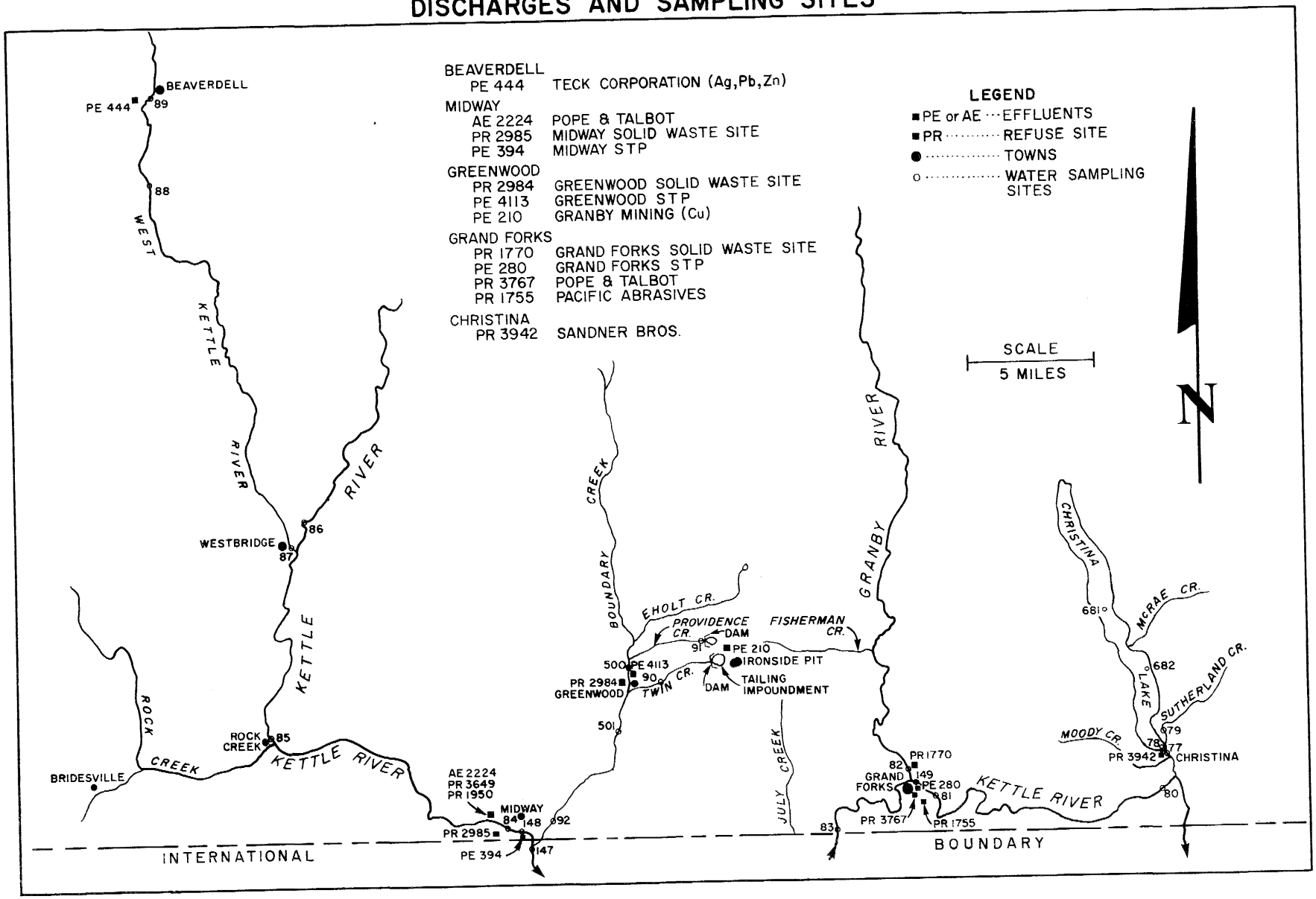


FIGURE 9-4

THE GRANBY MINING CORPORATION

SIMPLIFIED FLOW DIAGRAM OF THE COPPER ORE-DRESSING PLANT

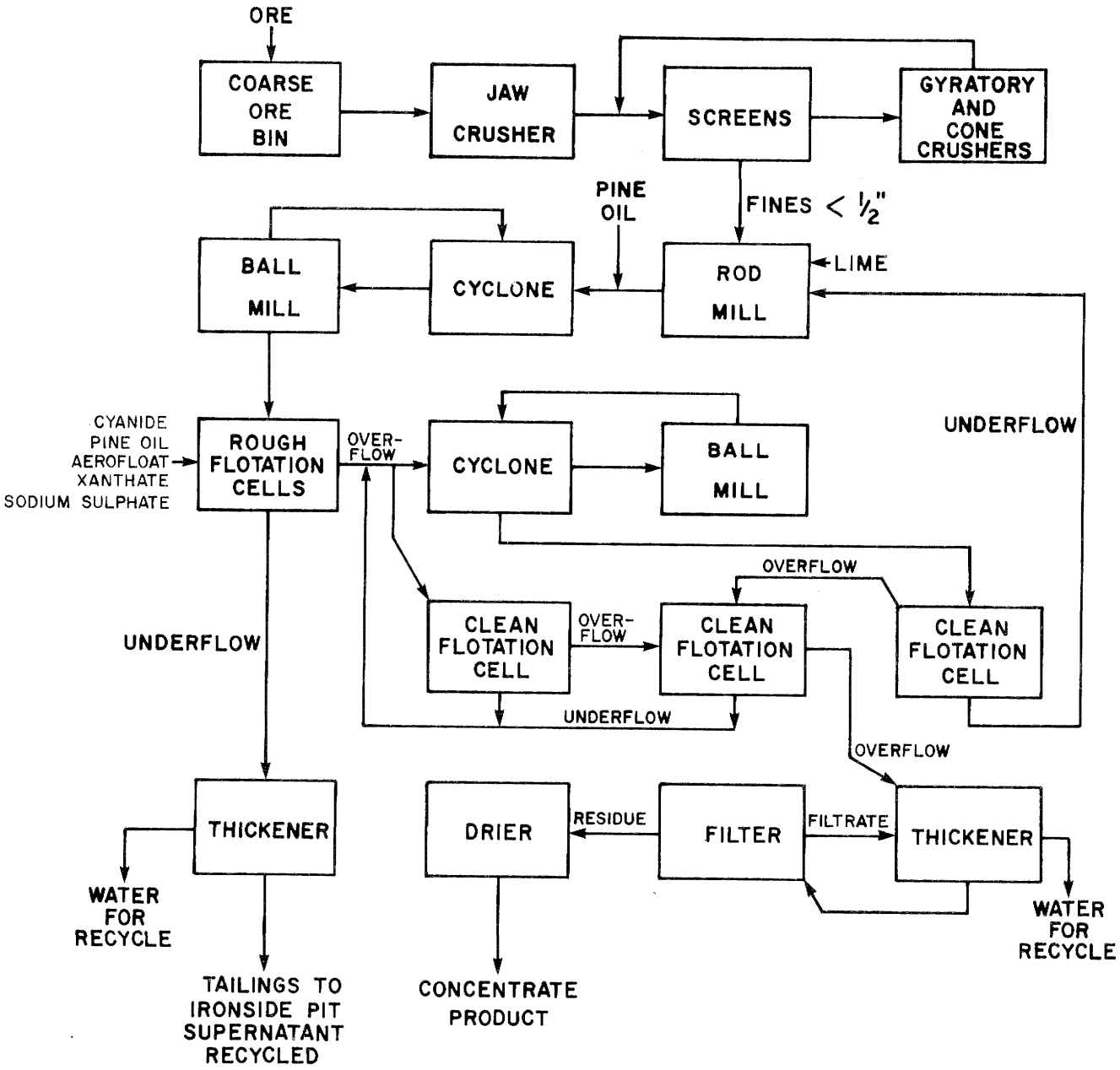


FIGURE 9-5
TECK CORPORATION
SIMPLIFIED FLOW DIAGRAM OF THE
SILVER-LEAD-ZINC CONCENTRATOR

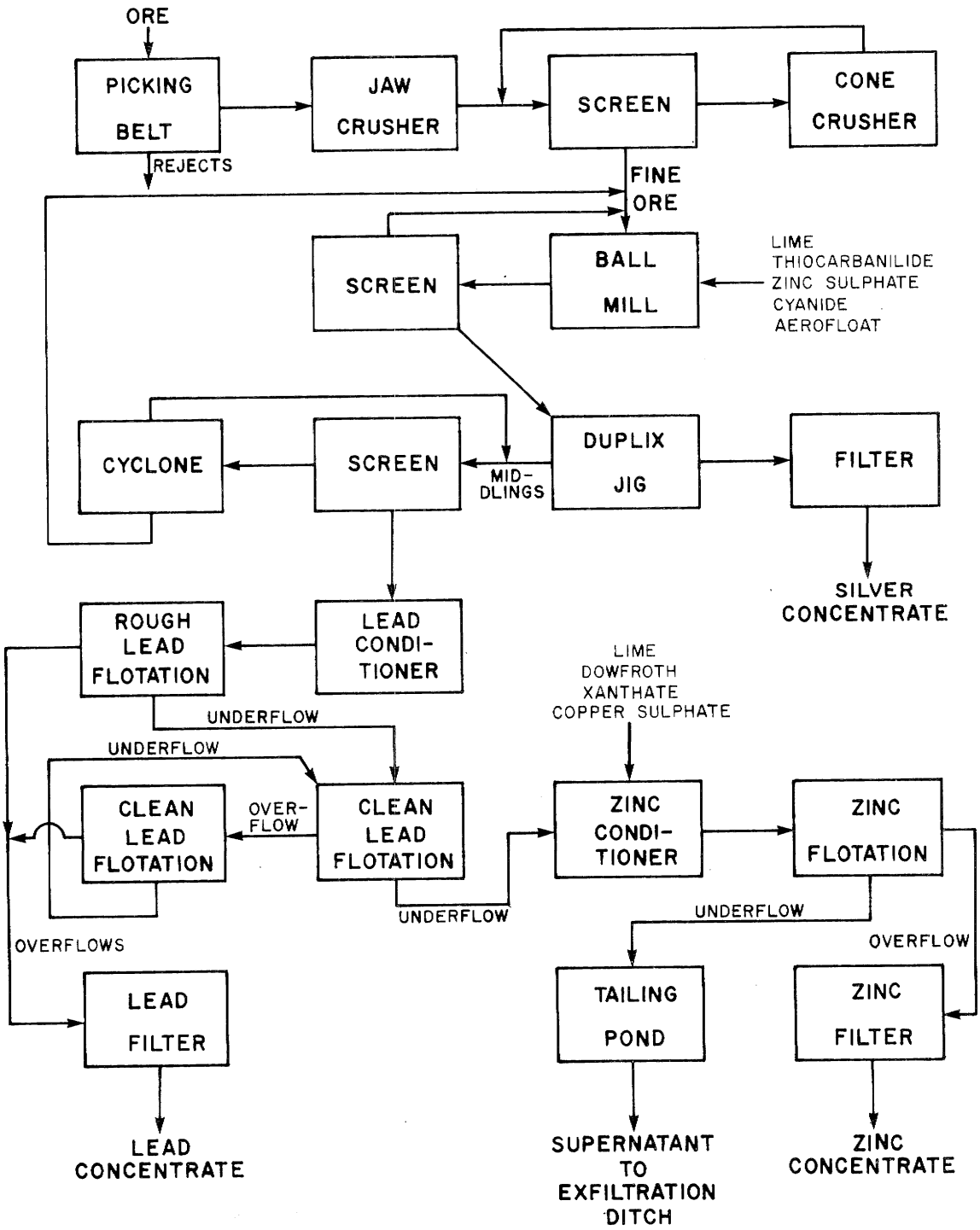


FIGURE 9-6

POPE AND TALBOT LTD.

SIMPLIFIED FLOW DIAGRAM OF THE SAWMILL-PLANERMILL AT MIDWAY

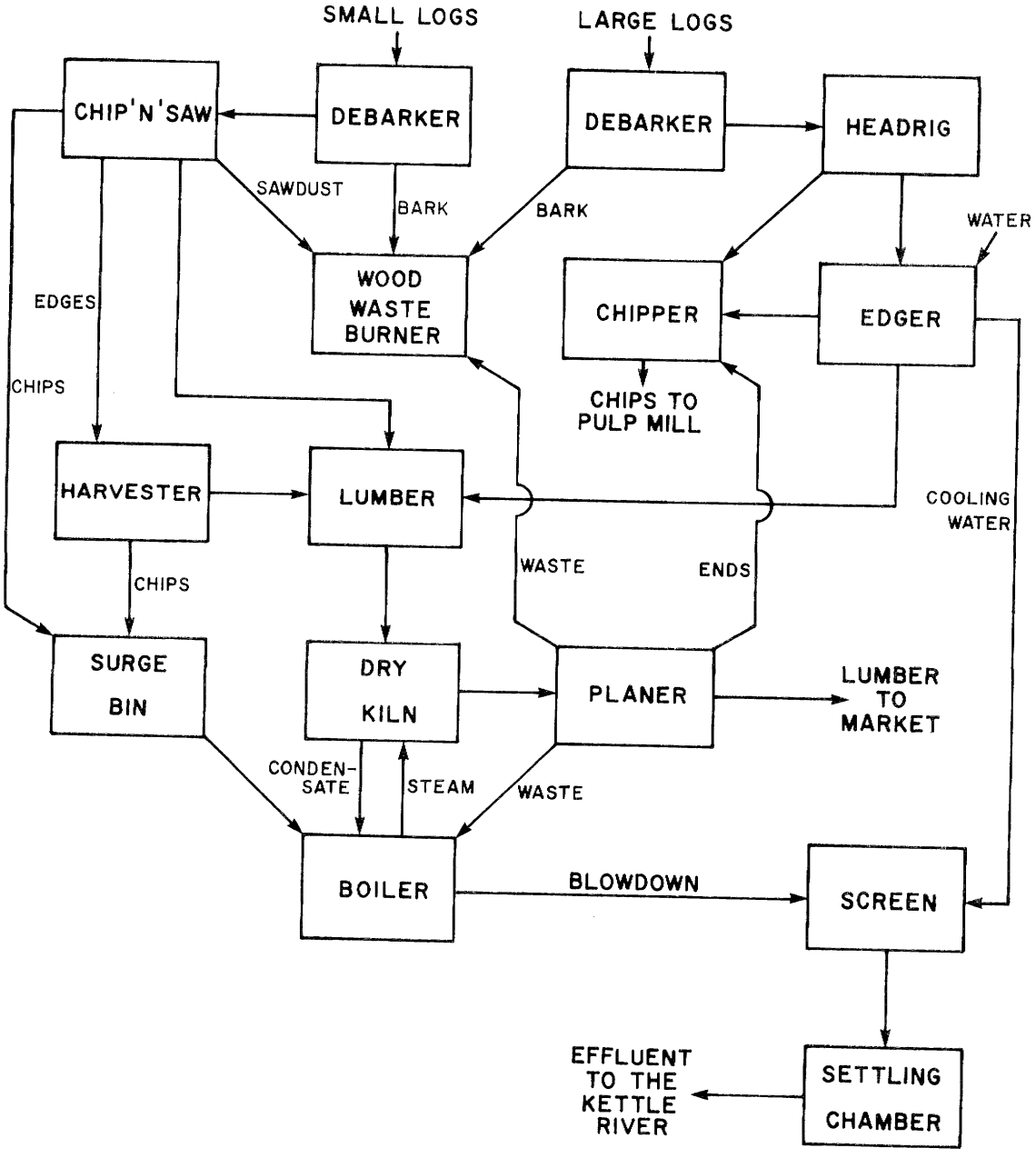


FIGURE 9-7

PACIFIC ABRASIVES LTD.
SIMPLIFIED DIAGRAM OF THE PROCESS

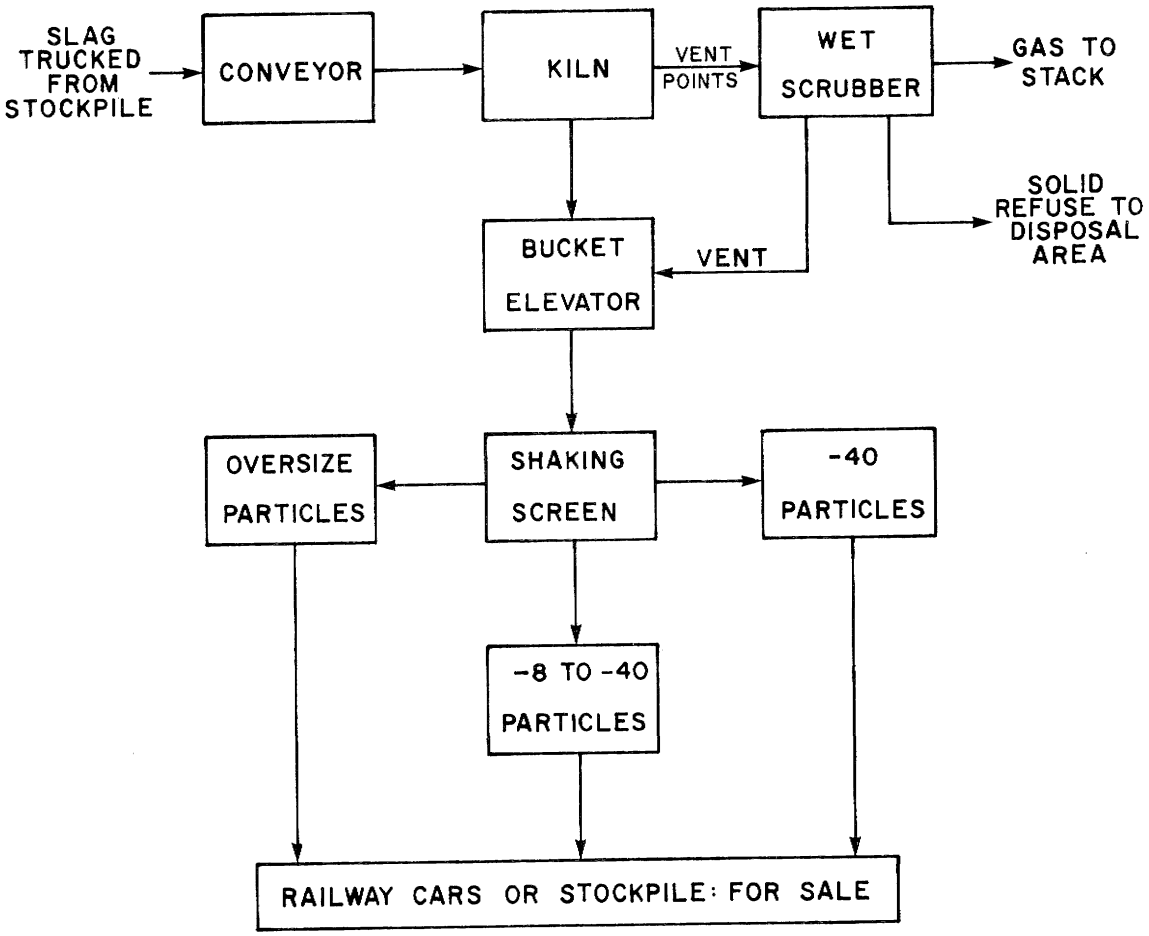
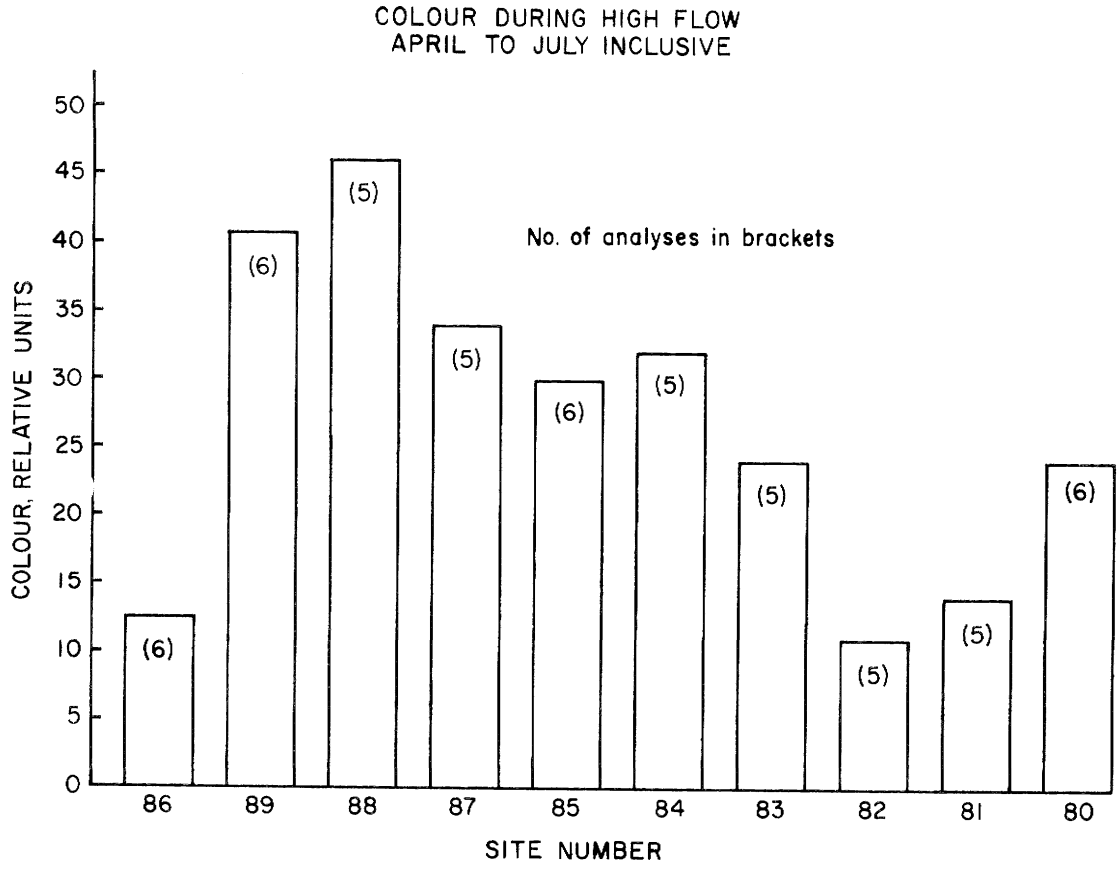


FIGURE 9-8

MEAN COLOUR IN THE WEST KETTLE, KETTLE AND GRANBY RIVERS DURING HIGH AND LOW FLOWS



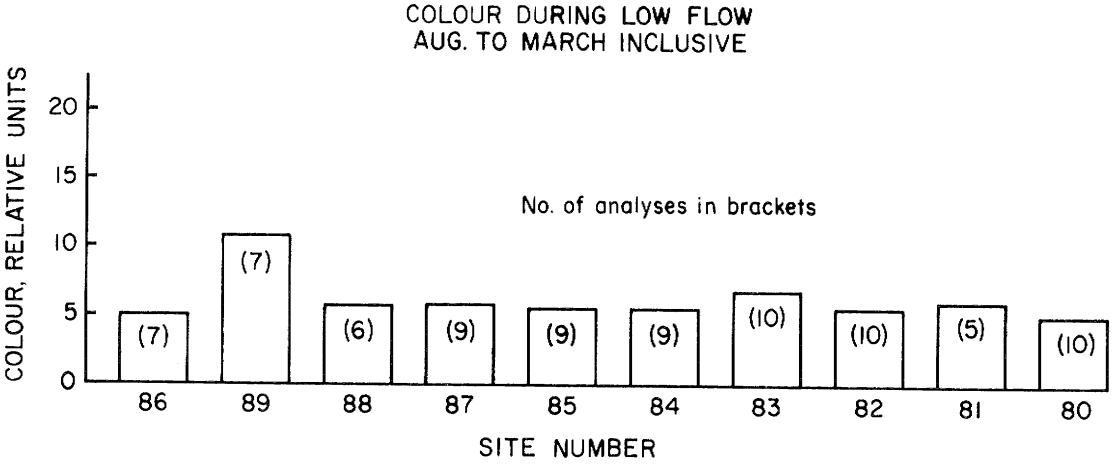


FIGURE 9-9

DISSOLVED OXYGEN AND TEMPERATURE PROFILES
IN CHRISTINA LAKE AT SITE 681

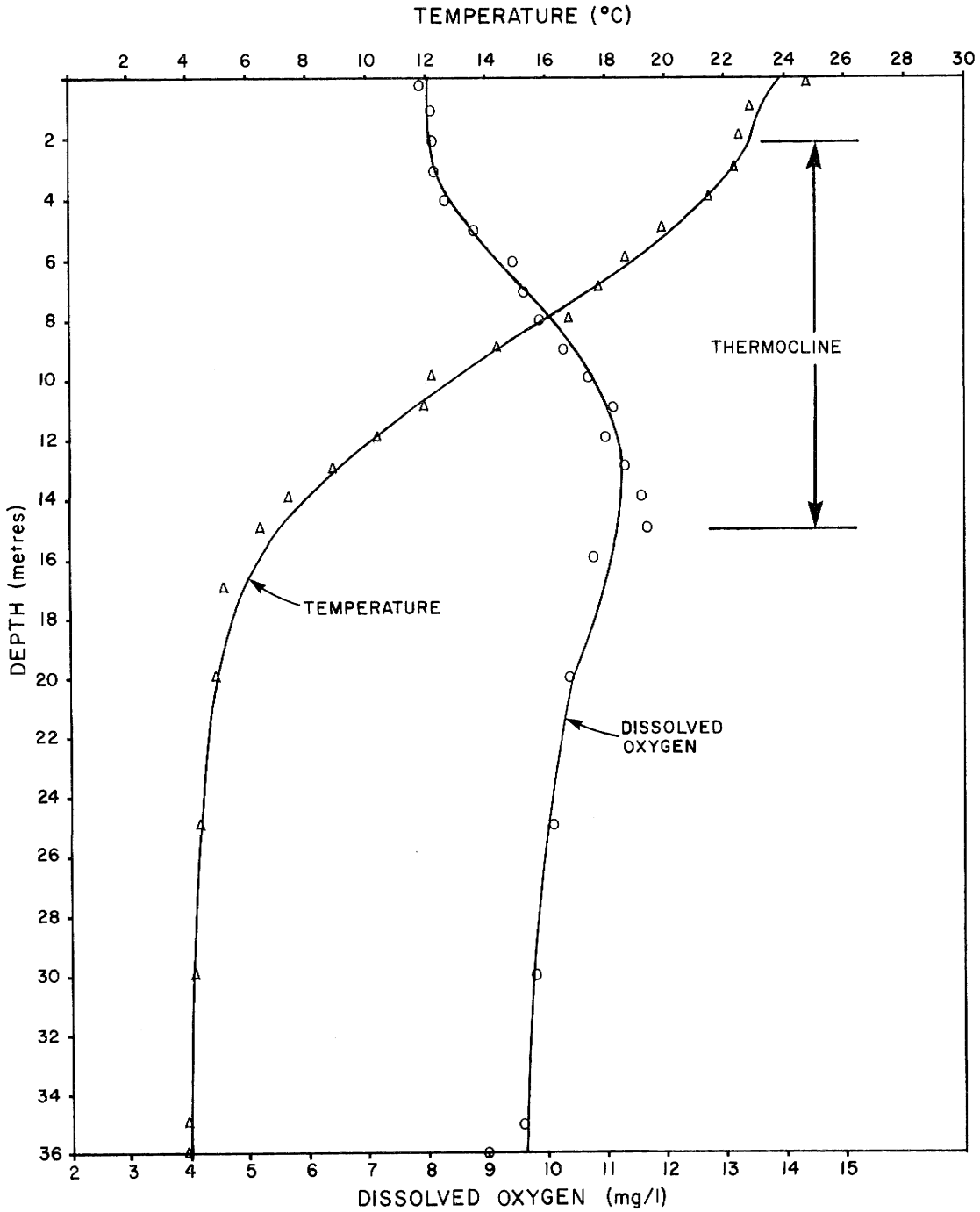


FIGURE 9-10
CHRISTINA LAKE
RELATIVE LOCATIONS OF AQUATIC PLANTS

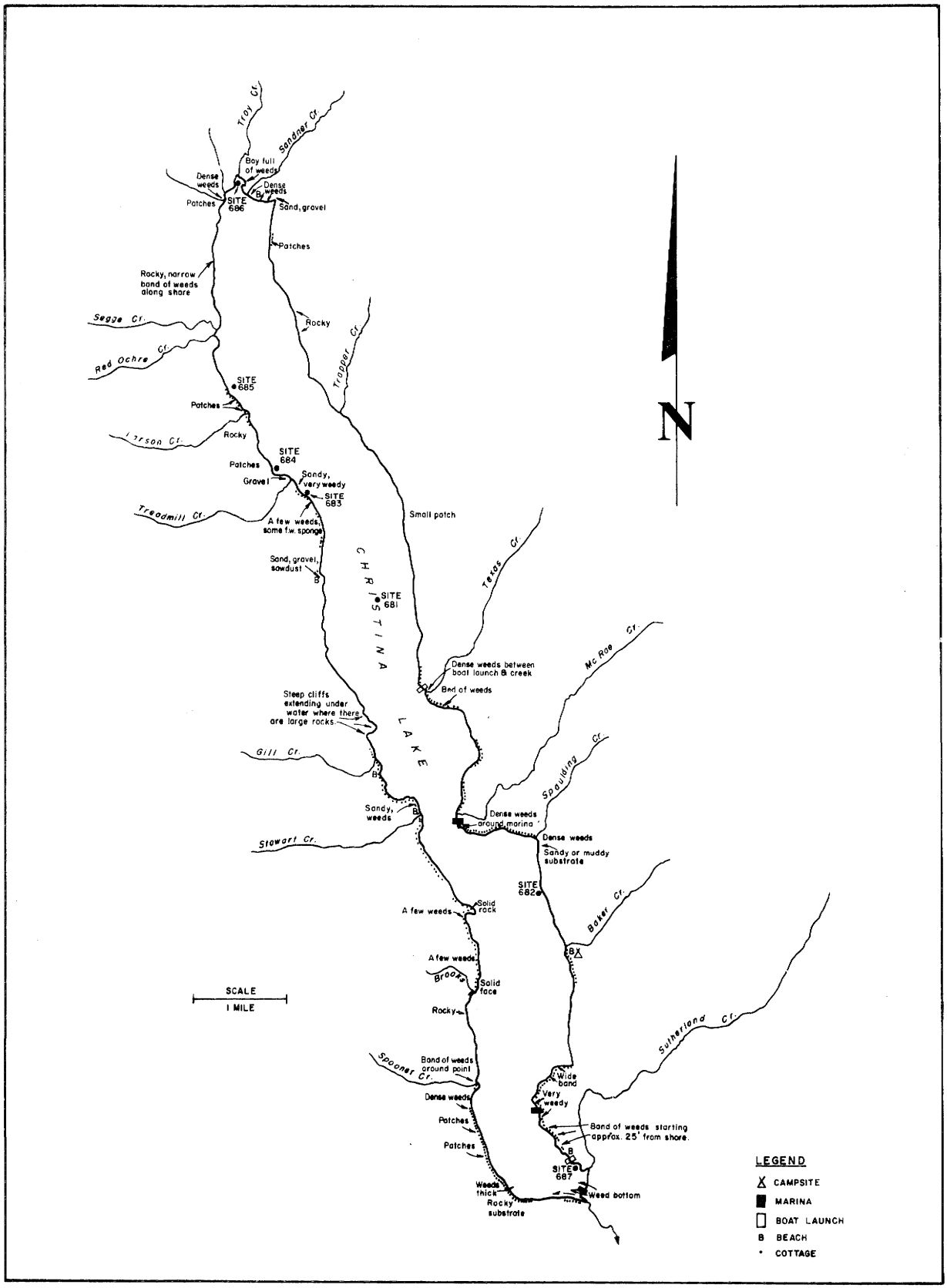


TABLE 9-1

SUMMARY OF FLOWS IN THE KETTLE RIVER AND ITS MAJOR TRIBUTARIES [5,6,18]

Stream	Drainage Area (mi^2)	Mean Annual Discharge (CFS)	Maximum Daily Discharge (CFS)	Minimum Daily Discharge (CFS)
Kettle R. near Midway	2200	1480	20300	15
Kettle R. near Laurier	3800	2850	34200	70
Granby R. at mouth	782	1070	13600	8
West Kettle R. at mouth	700	326	4770	15
Boundary Cr. at Greenwood*	164	84	1640	2.4

* Regulated flow.

TABLE 9-2

DISTRIBUTION OF GROUNDWATER WELLS IN REGION 9[19]

Location	Number of Wells
Grand Forks	161
Beaverdell	38
Midway	24
Rock Creek	18
Kettle Valley	14
Carson	12
Westbridge	8
Kettle River Valley north of Westbridge	7
Bridesville	5
West of Bridesville (Nine Mile Creek area)	5
Greenwood	3
Carmi	3
Christina Lake	2
Rhone	2
Cascade	1
Boundary Creek Provincial Park	1
Johnstone Creek Provincial Park	1
TOTAL	305

TABLE 9-3

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location *	Comments
GRAND FORKS WATER DISTRICT, CASCADE PRECINCT						
Aquarius Brook	1	40 AF***	irrigation		L.1672S (East side of Christina L.)	20 acres irrigated Possible water shortage, domestic only available
Chandler Cr.	3	1000 GPD** 50 AF 2500 GPD	domestic irrigation industrial	Sandner Bros. Lumber Co. Ltd.	Cascade	20 acres irrigated
Christina & Angelo Cr's.	1	300,000 GPD	industrial	Sandner Bros. Lumber Co. Ltd.	Cascade	fire protection
Christina Lake	1	500 GPD	domestic		West side Christina Lake	Application for 48,000 GPD & 17.7 AF (waterworks) for Wolverton Waterworks Ltd.
Kettle R.	10	6500 GPD 542 AF	domestic irrigation		L.'s 268,269,313, 349,3046,314 (Cascade)	190 acres irrigated
McRae Cr.	3	2000 GPD 79 AF	domestic irrigation		L.963 (English Point on Christina Lake)	32 acres irrigated
Moody Cr.	7	267,000 GPD 5 AF	domestic irrigation	Christina Waterworks District	Cascade	3.5 acres irrigated Possible water shortage, no water rights should be granted for irrigation

* All lots are located in the Similkameen Division of Yale Land District
** GPD: Imperial gallons per day
*** AF: Acre-feet

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Stewart Cr.	9	5000 GPD	domestic		L. 768S (Christina Lake - across from English Point)	
Sutherland, Maida & Copper Cr's.	66	110,000 GPD 115 AF	domestic irrigation	Sutherland Cr. Water-works District (108,000 GPD)	Christina Lake	Possible water short-age, water reserved for domestic purposes only. (Formerly fully committed). (Applica-tion made for 110 AF irrigation April 1975)
Swetland Springs	1	1000 GPD 40 AF	domestic irrigation		L. 1672S (East side of Christina L.)	Possible water short-age (1972) 20 acres irrigated (estimated)
Szimmer Slough	1	42 AF	irrigation		Christina Lake	14 acres irrigated
Texas Creek	3	3000 GPD	domestic		L. 2104 (East side of Christina L.)	Possible water short-age, short term licenses only on Texas Creek (1957)
GRAND FORKS, WATER DISTRICT, GRAND FORKS PRECINCT						
Balabanor Springs	1	20 AF 500 GPD	irrigation domestic		L. 3389	20 acres irrigated
Bayne, Brooke & Coles Sloughs	1	200 AF	irrigation		L. 606	100 acres irrigated
Burrell Cr.	2	555 AF	irrigation		L.'s 841S & 4026S	185 acres irrigated
Fisherman Cr.	1	38 AF	irrigation		L. 1356	15 acres irrigated
Gibbs Cr.	4	5500 GPD 150 AF	domestic irrigation	Covert Irrigation District	L. 497	272 acres irrigated

TABLE 9-3 Continues

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Gilpin Cr.	1	1000 GPD 42 AF	domestic irrigation		L. 330	16 acres irrigated
Granby R.	1	500,000 GPD	domestic	City of Grand Forks	Grand Forks	waterworks
	11	2750 GPD 2694 AF	domestic irrigation		L.'s 1357,3292,3671, 2018,333,1612,1605, 332,1494,2653,40835, 537,2007,606	1156 acres irrigated
Hardy Cr.	2	418 AF	irrigation	Sion Improvement District	L.'s 333 & 33.4 West of Grand Forks	167 acres irrigated Fully committed
Hornet Cr.	1	2500 GPD 100 AF	domestic irrigation		L. 3390 North of Grand Forks	40 acres irrigated
Hull Cr.	1	75,000 GPD	domestic	City of Grand Forks	Grand Forks	Waterworks reserved for City of Grand Forks water supply
July Cr.	5	1258 AF	irrigation	Covert Irrigation District & Son Improvement District	L.'s 497,364,365, 453,1027	675 acres irrigated Fully committed
Kettle River	39	1500 GPD 4662 AF	domestic irrigation	Grand Forks Irrigation District (2440 AF)	L.'s 1475,152,184A, 533,534,362,519, 363,153,351,1699, 530,382,330,331, 494,453. Grand Forks	3720 acres irrigated
	1	3000 GPD	industrial	City of Grand Forks		fish pond
	1	500,000 GPD	domestic	City of Grand Forks		waterworks
Line Cr.	1	40 AF	irrigation		L. 265	40 acres irrigated
Lynch Cr.	1	400 AF	irrigation		L.'s 436S & 2019 North of Grand Forks	160 acres irrigated

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
May Cr.	4	1000 GPD 13 AF	domestic irrigation		L.'s 1737	6 acres irrigated Possible water shortage. 2 licenses refused - no water
McCarthy Cr.	3	470 AF	irrigation		L.'s 2732 & 2024	401 acres irrigated
McConnel Cr.	2	2250 GPD 138 AF	domestic irrigation		L.'s 350 & 351	55 acres irrigated
Morrissey Cr.	5	493 AF	irrigation	Grand Forks Irrigation District (374 AF)	L.'s 153 & 351	68 acres irrigated Fully committed
Overton Cr.	1	325,000 GPD	domestic	City of Grand Forks	Grand Forks	waterworks reserved for City of Grand Forks water supply
Pass Creek	9	2500 GPD 195 AF	domestic irrigation		L.'s 1480,3293,3172 North of Grand Forks	77 acres irrigated
Pavan Slough & Brook	2	250 AF	irrigation		L. 1480	100 acres irrigated
Pohoda Slough	1	100 AF	irrigation	City of Grand Forks	Grand Forks L.'s 380 & 520	40 acres irrigated
Ruckle Slough	1	80 AF	irrigation	Grand Forks Irrigation District		
Sand Cr.	2	500 GPD 64 AF	domestic irrigation		L.'s 3389 & 1359, North of Grand Forks	64 acres irrigated
Toronto Cr.	1	38 AF	irrigation		L. 3009, North of Grand Forks	15 acres irrigated

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Volcanic Cr.	1	1000 GPD 13 AF	domestic irrigation		L. 1727, North of Grand Forks	4 acres irrigated Fully committed
Ward Lake	2	155 AF	irrigation		L.'s 334 & 333 (Grand Forks)	164 acres irrigated
Wiseman Cr.	1	500 GPD 33 AF	domestic irrigation		L. 828 Grand Forks	13 acres irrigated
GRAND FORKS WATER DISTRICT, GREENWOOD PRECINCT						
Bauer Cr.	1	200 GPD 13 AF	domestic irrigation		L. 471S	7 acres irrigated
Boundary Cr.	1 27	300,000 GPD 4,500 GPD 977 AF	domestic domestic irrigation	City of Greenwood	Greenwood	waterworks 478 acres irrigated
Clement Creek	2	2000 GPD 248 AF	domestic irrigation		L.'s 471S, 2983	118 acres irrigated
Daniel Cr.	1	25 AF	irrigation		L. 3284	10 acres irrigated
Eholt Creek	5	1000 GPD 62 AF	domestic irrigation		L.'s 2075,1052,638	25 acres irrigated
Gold Drop Creek	1	500 GPD 15 AF	domestic irrigation		L. 1052	6 acres irrigated
Goosmus Cr.	1	10,000 GPD	industrial	Levington Mines Ltd.	L.'s 645,1161,2013, 614,1096S,868,1095S, 595,2804,955 & 1152	diamond drilling
Hoas Cr.	2	19 AF	irrigation		L. 797	9 acres irrigation

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Jewel Creek & Lake	3	110 AF 2,000 GPD 75 AF	conservation domestic irrigation	Fish & Wildlife Branch	L. 860 L.'s 252 & 2075	44 acres irrigated
Jolly Jack Creek	2	500 GPD 104 AF	domestic irrigation		L.'s 1028 & 542	43 acres irrigated Fully committed (1974)
Kettle R.	1 8	2,600,000 GPD 6,000 GPD 87 AF	domestic domestic irrigation	Village of Midway	Midway L.'s 781, 501 & 2656	waterworks 28 acres irrigated
Lind Creek	1 2	100,000 GPD 48 AF 1,000 GPD	domestic irrigation domestic	City of Greenwood	Greenwood Sec. 32, TP. 68 & 70	waterworks 19 acres irrigated
McArthur Cr.	1	68 AF	irrigation		L. 1414	27 acres irrigated
McCarren Cr.	5	2,000 GPD 132 AF	domestic irrigation		L.'s 2083,1074S, 2084,2614 & 3305	53 acres irrigated
Motherlode Creek	2	1,000 GPD 167 AF	domestic irrigation		L. 620	78 acres irrigated Possible water shortage, 1 refusal of water, 1956 (Formerly fully committed).
Norwegian Cr.	1	135 AF	irrigation		L. 3393	90 acres irrigated
Porter Cr.	2	500 GPD 62 AF	domestic irrigation		L.C., Sec. 29, Pl. B1005	21 acres irrigated
Providence Cr. & Lake	1 1 1	50,000 GPD 200,000 GPD 8 AF	domestic mining irrigation	Granby Mining Co. Ltd. Granby Mining Co. Ltd.	L. 922 L. 1257 L. 297S	waterworks milling 4 acres irrigated

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Twin Creek	3	225,000 GPD	mining	Granby Mining Co. Ltd.	L. 922	milling, 300 AF of storage in reservoir & Providence Lake.
	1	200 AF	irrigation		L.'s 3141 & 3134	80 acres irrigated
Wallace Cr.	2	130 AF	irrigation		L.470 & E½, Sec. 20, TP. 79	52 acres irrigated
Wyder Creek	2	1,000 GPD 80 AF	domestic irrigation		L. 1020	40 acres irrigated
GRAND FORKS WATER DISTRICT, MCKINNEY PRECINCT						
Alden Lake	1	45 AF	irrigation		L. 2328	30 acres irrigated
Baker & East Baker Creeks	8	4,500 GPD 275 AF	domestic irrigation		L.'s 2529,491 & 2530	123 acres irrigated
Ballo Cr.	2	500 GPD 40 AF	domestic irrigation		L. 320S	40 acres irrigated
Brides Cr.	1	20,000 GPD	domestic	Bridesville Waterworks District	Bridesville	waterworks
Bubar Cr.	2	22 AF	irrigation		L.'s 631 & 632	9 acres irrigated
Cedro (Cedar) Cr.	1	500 GPD 16 AF	domestic irrigation		L. 2637	6 acres irrigated
Goodwin Spring Hulme Cr. Link Cr.	2	2,000 GPD 75 AF	domestic irrigation		L. 156 S	30 acres irrigated Possible water shortage, on Hulme Creek (1973)
Ingram Cr.	1	1,000 GPD 100 AF	domestic irrigation		L.'s 376 & 502	48 acres irrigated

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
James Creek & Lake	1	1,000 GPD 86 AF	domestic irrigation		L. 559	75 AF of storage in James Lake 28 acres irrigated
Johnstone Cr.	1	80 AF	irrigation		L.'s 230 & 291S	40 acres irrigated
Jolly Cr.	1 1	7 AF 3,000 GPD	industrial domestic		L. 271S	fish culture resort
Kettle R.	1	432,000 GPD	industrial	Pope & Talbot Ltd.	L.'s 2647,273,424 & 637	lumber manufacturing
	49	1,500 GPD 9,130 AF	domestic irrigation		L.'s 424,514,513, 231,683,375,631,681, 215,2455,862,559, 617S 757,632,471, 164S,2704,156S,2456, 376,2339,502,425, 637,377,501 & 423	3140 acres irrigated
McCoy Cr.	2	2,500 GPD 60 AF	domestic irrigation		NW¼ Sec. 7, TP.67, L. 684S	30 acres irrigated
McKinney & Rice Cr's.	6	18,500 GPD	domestic	Mount Baldy Recreation Ltd. (15,000 GPD)	L. 100S	waterworks
		445 AF	irrigation		L.'s 2529,1890S, 240S & 2330	180 acres irrigated
McMynn Spring	1	1,000 GPD 28 AF	domestic irrigation		L. 471	11 acres irrigated
Miller Spring	1	1,000 GPD 14 AF	domestic irrigation			9 acres irrigated
Murrays Gulch	2	500 GPD 49 AF	domestic irrigation		L.'s 671 & 377	20 acres irrigated

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Myers Creek	12	3,500 GPD 1,718 AF	domestic irrigation		L.'s 470,2453,2637, 423,604,321,345,170, 471,3280,3281,3282, 3340	823 acres irrigated Possible water shortage without accompanying storage, except for short term irrigation & domestic (1975)
Nathan Cr.	2	2,000 GPD 14 AF	domestic irrigation		L. 228	7 acres irrigated
Nicholson Cr.	4	2,750 GPD 75 AF	domestic irrigation		L.'s 311S & 2704	28 acres irrigated Possible water shortage, future applications to be refused or restricted to short term (1975). Fully recorded for irrigation after freshet (June 15)
Nine Mile & North Nine Mile Creeks	7	3,500 GPD 632 AF	domestic irrigation		L. 486S	357 acres irrigated
Pineridge Spring	1	70 AF	irrigation		L. 486S	47 acres irrigated
Portmann Cr.	1	17 AF	irrigation		L. 312S	17 acres irrigated
Rock Cr.	1	$1.6X10^6$ GPD	mining		P.M.L. 244	
	6	3,500 GPD 251 AF	domestic irrigation		L.'s 754S & 352	85 acres irrigated
GRAND FORKS WATER DISTRICT, WESTBRIDGE PRECINCT						
Affleck Cr.	1	250,000 GPD 400 AF	domestic irrigation	S.E. Kelowna Irrigation District		waterworks

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Avenzoar Cr.	1	500 GPD 14 AF	domestic irrigation		L.'s 1256S & 4042S	7 acres irrigated
Beaverdell Cr.	6	700 AF	irrigation		L.'s 1250,1466,3130, 565S & 3129	326 acres irrigated
Cochrane Cr.	1	10,000 GPD	domestic		L. 3022S	Youth camp
Conkle Cr.	2	1,000 GPD 19 AF	domestic irrigation		L. 817S	5 acres irrigated
Copperkettle Cr.	4	3,000 GPD 305 AF	domestic irrigation		L.'s 874S, 2792S, 2989S & 2993S	160 acres irrigated
Crouse Cr.	2	160 AF	irrigation		L.'s 2312 & 1322	65 acres irrigated
East Creek	1	5,000 GPD 62 AF	domestic irrigation	Parks Branch	L. 1889S	25 acres irrigated
Eugene Cr.	1	100 AF	conservation	Fish & Wildlife Branch	L. 1277S	
Fiva Cr.	2	660 AF	irrigation		L.'s 2570S & 890S	330 acres irrigated
Harrison Cr.	1	20 AF	irrigation		L. 1778	10 acres irrigated
Haynes Lake	1	1,200 AF	irrigation	S.E. Kelowna Irrigation District		
Hellroarer	2	540 AF	irrigation		L.'s 2790S & 2793S	240 acres irrigated
Horse Creek	1	500 GPD 80 AF	domestic irrigation		L. 797S	40 acres irrigated
Howard Lake	1	250 AF	irrigation	City of Penticton		

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Kettle R.	13	2,000 GPD 4,800 AF	domestic irrigation		L.'s 2912S,731S, 1488S,207A,1322,1819, 2792S,2993S,1464,890S, 2570S,730S,2361 & 632	2322 acres irrigated
LaPorte Cr.	1	1,500 GPD 40 AF	domestic irrigation		L. 3308	20 acres irrigated
Lower Arlington Lake	1	750 AF	conservation	Fish & Wildlife Branch	L. 1277S	
Ouellette & S. Fork Creeks	1	1,000 GPD 200 AF	domestic irrigation		L.'s 2625 & 3637	100 acres irrigated
Pear Lake	1	600 AF	irrigation	S.E. Kelowna Irrigation District		
Rendel Cr.	2	455 AF	irrigation		L.'s 2997,2998S & 3022S	190 acres irrigated
Steep Cr.	1	90 AF	irrigation		L.'s 1411S	30 acres irrigated
Stirling Cr.	1	2,500 AF	irrigation	S.E. Kelowna Irrigation District		
Taurus Cr. & Lake	3	350 AF 88 AF	conservation irrigation	Fish & Wildlife Branch	L. 619S	35 acres irrigated
Waddell Cr.	2	500 GPD 100 AF	domestic irrigation		L.'s 1819 & 1322	40 acres irrigated
West Kettle	9	1,604 AF	irrigation		L.'s 819S,2986S, 2133,1208S,1271S, 3309,3638,6195,1466, 2515	655 acres irrigated
	1	7,500 GPD	mining		L. 2364	milling

TABLE 9-3 Continued

SUMMARY OF WATER LICENSES IN THE KETTLE RIVER BASIN

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
Wildhorse Cr.	1	1,000 GPD 25 AF	domestic irrigation		L. 1287S	10 acres irrigated
Williamson Cr.	1	20 AF	irrigation		L. 1464	10 acres irrigated
Wilson Cr.	1	1,000 GPD 60 AF	domestic irrigation		L.'s 1256S & 4042S	30 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 9-4

POPULATIONS OF SOME SETTLEMENTS IN REGION 9[15,16,17]

Settlement	Population	
	1971	1976
Grand Forks	3173	3020
Greenwood	868	919
Midway	502	592
Christina Lake	311	*
Beaverdell	241	*
Kettle Valley	165	*
Rock Creek	162	*
Bridesville	81	*
Westbridge	46	*
Gilpin	38	*
Cascade	25	*
Carmi	8	*
Christian Valley	6	*

* 1976 population data for unincorporated places not yet available.

TABLE 9-5

MINERAL PRODUCTION DURING 1973 AND 1974[13]

Property or Mine	Location	Owner or Agent	Minerals	Ore Production 1973	Ore Production 1974
Phoenix	Phoenix	Granby Mining Corp.	copper, silver, gold	1,003,815	1,012,427
Highland Bell	Beaverdell	Teck Corporation	lead, zinc, copper, silver, gold, cadmium	37,202	37,184
Denero Grande, Jewel	Jewel Lake (Greenwood)	Colt Resources Ltd.	lead, zinc, silver, gold	0	726
Burnt Basin	Paulson (east of Christina Lake)	Alvija Mines Ltd.	lead, zinc, cadmium silver	164	302
Fur, Flo (Doorn)	Beaverdell	Argentia Mines Ltd.	lead, zinc, silver, gold	60	0
Providence	Greenwood	W. E. MacArthur	copper, lead, zinc, silver, gold	53	0
Sebac Quarries	Grand Forks	M. Astrope	dolomite & quartzite building stone	Not available	

TABLE 9-6

SUMMARY OF GRANBY MINING CORPORATION POLLUTION CONTROL PERMIT NO. PE-210

Amendment date	April 11, 1973			December 29, 1975	
	Appendix 01	Appendix 02	Appendix 03	Appendix 03	Appendix 04
Permit Holder	Granby Mining Co.Ltd.	Granby Mining Co.Ltd.	Granby Mining Co.Ltd.	Granby Mining Corp.	Granby Mining Corp.
Effluent Source	Tailings from a copper ore dressing plant	Supernatant from the tailings impoundment	Storage and settling basin below the main tailings impoundment	Storage and settling basin below the main tailings impoundment	Tailings from a copper ore dressing plant
Effluent Flow	Average annual daily discharge of 720,000 Imp. gal. and maximum daily discharge of 800,00 Imp. gal.	March to July: average daily discharge of 200,000 Imp. gal. and maximum daily discharge of 1,224,000 Imp. gal.	March to July: average daily discharge of 41,000 Imp. gal. and maximum daily discharge of 144,000 Imp. gal.	March to July: average daily discharge of 41,000 Imp. gal. and maximum daily discharge of 144,000 Imp. gal.	Average annual daily discharge of 1,125,000 Imp. gal. and maximum daily discharge of 1,300,000 Imp. gal.
Effluent Characteristics	Typical ore dressing plant tailings	Equal or better than: SS 100 mg/1 TS 1500 mg/1 pH 7.0 to 8.5 Total Cyanide 0.36 mg/1 Diss. Copper 0.2 mg/1	Equal or better than: SS 75 mg/1 TS 1500 mg/1 pH 7.0 to 8.5 Total Cyanide 0.03 mg/1 Diss. Copper 0.005 mgy1	Equal or better than SS 75 mg/1 TS 2000 mg/1 pH 7.5 to 8.5 Total Cyanide 0.03 mg/1 Diss. Copper 0.03 mg/1	Typical tailings from a copper ore dressing plant
Receiving Water	Tailings impoundment	Providence Lake	Twin Creek	Twin Creek	Ironsides Pit with a recycle system

TABLE 9-7

SUMMARY OF DATA OBTAINED FROM SAMPLING THE

SUPERNATANT OF THE GRANBY MINE TAILING IMPOUNDMENT

Location		Granby Mine Tailings Impoundment Supernatant						
Data Source		PCB Data (1974-1975)				Granby Mine Data (1974-1975)		
		n	Mean	Max.	Min.	n	Mean	Max.	Min.
Alkalinity-total	mg/l	3	145	149	140				
Cadmium	mg/l	2	<0.0005	<0.0005	<0.0005				
Calcium	mg/l	2	348	358	338				
Chloride	mg/l	1	6.6	6.6	6.6				
Colour	rel. units	2	5	5	5				
Copper-diss.	mg/l	3	0.019	0.03	0.008	4	0.103	0.245	0.006
Cyanide	mg/l	3	0.047	0.12	<0.01	4	0.077	0.105	0.034
Hardness	mg/l	2	1060	1090	1030				
Iron-diss.	mg/l	3	<0.1	<0.1	<0.1				
Lead-diss.	mg/l	3	<0.002	0.003	<0.001				
Magnesium	mg/l	2	46	47	45				
Manganese	mg/l	1	0.05	0.05	0.05				
Molybdenum	mg/l	1	0.0067	0.0067	0.0067				
Oil & Grease	mg/l	1	<1.0	<1.0	<1.0				
Oxygen-diss.	mg/l	2	8.9	9.2	8.5				
pH	pH units	3	8.1	8.5	7.7	4	7.72	8.07	7.21
Potassium	mg/l	1	11.4	11.4	11.4				
Sodium	mg/l	1	16	16	16				
Solids-diss.	mg/l	2	1591	1636	1546				
-suspended	mg/l	1	4	4	4	4	<1.3	2	<1
-total	mg/l	3	1690	1882	1552	4	1805	1870	1700
Specific Conductivity	µmho/cm	6	1666	1920	1060				
Sulphate	mg/l	2	965	1052	879	4	1022	1060	950
Turbidity	JTU	2	2.2	3.9	0.5				
Zinc-diss.	mg/l	3	<0.005	<0.005	<0.005				

Note: n = number of values

TABLE 9-8

SUMMARY OF DATA OBTAINED FROM SAMPLING THE OVERFLOW OF THE CATCHMENT WEIR BELOW THE GRANBY MINE TAILING IMPOUNDMENT

Location		Overflow From Concrete Weir Below Tailing Pond, Into Twin Creek							
Data Source		PCB Data (1973 to 1975)				Granby Mines Data (5/74 to 4/75)			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.
Alkalinity -total	mg/l	3	148	170	135				
Arsenic-diss.	mg/l								
Cadmium	mg/l	1	<0.0005	<0.0005	<0.0005				
Calcium	mg/l	1	336	336	336				
Chloride	mg/l	1	8.8	8.8	8.8				
Colour	rel. units	1	5	5	5				
Copper-diss.	mg/l	4	0.012	0.02	0.008	3	0.012	0.021	0.005
-total	mg/l	3	0.014	0.02	0.009	3	0.018	0.024	0.008
Cyanide	mg/l	4	<0.01	<0.01	<0.01	3	<0.02	<0.02	ND
Hardness	mg/l	1	1030	1030	1030				
Iron-diss.	mg/l	4	<0.07	<0.1	<0.04	3	0.006	0.013	0.002
-total	mg/l	3	0.11	0.2	0.05	3	0.13	0.3	0.029
Lead-diss.	mg/l	4	<0.001	<0.001	<0.001	3	<0.0016	<0.002	<0.001
-total	mg/l	3	<0.001	<0.001	<0.001	3	0.011	0.014	0.006
Magnesium	mg/l	1	47	47	47				
Manganese-diss.	mg/l	3	0.22	0.28	0.13	3	0.31	0.35	0.28
-total	mg/l	3	0.22	0.28	0.13	3	0.325	0.375	0.28
Mercury	µg/l	1	<0.05	<0.05	<0.05				
Oil & Grease	mg/l	2	<1.0	<1.0	<1.0				
Oxygen-diss.	mg/l	2	8.3	10.1	6.5				
pH	pH units	4	7.68	7.9	7.5				
Potassium	mg/l	1	13.4	13.4	13.4				
Sodium	mg/l	1	19.6	19.6	19.6				
Solids-diss.	mg/l	1	1630	1630	1630				
-suspended	mg/l	3	1.83	3.0	1.2	3	<2.1	4	<1
-total	mg/l	4	1398	1640	940	3	1560	1630	1480
Specific Conductivity	µmho/cm	5	1472	1790	1170				
Sulphate	mg/l	4	730	912	467	3	872	920	835
Turbidity	JTU	5	1.54	3.2	0.5				
Zinc-diss.	mg/l	4	<0.005	<0.005	<0.005	3	<0.001	0.001	<0.001
-total	mg/l	3	<0.005	<0.005	<0.005	3	0.0033	0.005	0.001

Note: n = number of Values, ND = not detectable

TABLE 9-9

MONITORING RESULTS FOR THE SUPERNATANT AT THE POINT OF DISCHARGE INTO PROVIDENCE LAKE

AND FOR PROVIDENCE LAKE

Data Source		Granby Mines Data (1974-1975)			Granby Mines Data (1974-1975)			
Location		Supernatant at Point of Discharge To Providence Lake			Providence Lake			
		May, 1973	May, 1974	April, 1975	n	Mean	Max.	Min.
Copper-diss.	mg/l	0.12	0.039	0.245	7	0.012	0.03	0.007
-total	mg/l	0.15	0.06	0.255	7	0.024	0.058	0.007
Cyanide	mg/l	0.19	0.08	0.12	7	<0.008	0.055	ND
Iron-diss.	mg/l	0.04	0.015	0.02	7	<0.028	0.1	<0.001
-total	mg/l	0.23	0.17	0.108	7	0.14	0.2	0.053
Lead-diss.	mg/l	<0.001	<0.002	<0.002	7	<0.005	0.016	<0.001
-total	mg/l	<0.001	0.01	0.012	7	<0.008	0.018	<0.001
Manganese-diss.	mg/l	0.07	0.1	0.08	7	<0.074	0.25	<0.025
-total	mg/l	0.08	0.1	0.08	7	0.11	0.25	0.025
Oil & Grease	mg/l	<1.0						
pH	pH units	7.9	7.59	7.71	7	7.75	8.27	7.19
Solids-suspended	mg/l	1.5	2	1.3	7	3.6	7	2
-total	mg/l	1408	1560	1850	7	891	920	878
Specific Conductivity	µmho/cm	1550			7	1061	1099	1050
Sulphate	mg/l	740	870	1100	7	439	506	390
Turbidity	JTU	1.6			7	1.32	2.4	0.86
Zinc-diss.	mg/l	<0.005	<0.001	<0.001	7	<0.004	0.018	<0.001
-total	mg/l	0.005	0.008	0.005	7	0.014	0.029	0.003

Note: n = number of values, ND = not detectable

TABLE 9-10

SUMMARY OF TECK CORPORATION LTD. POLLUTION CONTROL PERMIT

Permit Number	PE-444
Permit Holder	Teck Corporation Ltd.
Date of Issue	February 25, 1974
Effluent Source	Exfiltration pond supernatant from a tailings pond for a lead-zinc-silver ore dressing plant
Effluent Flow Rate	A maximum discharge of tailings of 140,000 Imperial Gallons per day
Effluent Characteristics	(Exfiltration pond supernatant) SS 150 mg/l pH 7.5 to 8.5 Total Cyanide 0.10 mg/l Diss. Arsenic 0.10 mg/l Diss. Copper 0.30 mg/l Diss. Iron 0.30 mg/l Diss. Lead 0.02 mg/l Diss. Manganese 0.05 mg/l Diss. Silver 0.10 mg/l Diss. Zinc 0.10 mg/l
Discharge point	Ground

TABLE 9-11

SUMMARY OF EFFLUENT SAMPLING DATA FOR TECK CORPORATION LTD.

Location		Supernatant From Exfiltration Pond			Mean Daily Discharge To Tailings Pond	
Data Source		PCB Data Dec. 4, 1974	Teck Corporation Data 1974-1975*		Teck Corporation Data	
			Mean	Range	Month	Gal. Per Day
Arsenic-diss.	mg/l		0.005	ND-0.01	April/74	135,956
Cyanide	mg/l	0.06			May'74	143,969
Copper-diss.	mg/l	0.04	0.037	ND-0.08	June'74	130,546
Iron-diss.	mg/l	<0.1	0.005	ND-0.02	July'74	139,727
Lead-diss.	mg/l	0.007	0.0068	0.002-0.012	Aug.'74	119,409
Manganese-diss.	mg/l	<0.02	ND	ND	Sept.'74	133,310
Oxygen-diss.	mg/l	10.5			Oct.'74	133.859
pH	rel. units	12.2	8.05	8.0-8.1	Nov.'74	115,292
					Dec.'74	123,018
Solids-total	mg/l	630	340	256-424	Jan.'75	127,336
-suspended	mg/l	3	24	24	Feb.'75	122,293
Specific Conductance	µmho/cm	1400			March'75	121,924
Sulphate	mg/l	235				
Silver-diss.	mg/l	<0.005	0.007	ND-0.02		
Zinc-diss.	mg/l	0.09	0.028	0.004-0.068		

* 4 samples, one each quarter from May 1974 to April 1975 - except pH and total suspended solids which were only sampled the first two quarters.

ND = not detectable

TABLE 9-12

SUMMARY OF POLLUTION CONTROL PERMITS AND

APPLICATION FOR PERMIT FROM POPE AND TALBOT LTD.

Description \ Permit or Application No.	Application AE-2224	Permit PR-3649	Permit PR-1950	Permit PR-3767
Permit Holder	Pope & Talbot Ltd. (Midway)	Pope & Talbot Ltd. (Midway)	Pope & Talbor Ltd. (Midway)	Pope & Talbot Ltd. (Grand Forks)
Date of Issue	May 15, 1974	August 8, 1974	May 6, 1974	October 23, 1974
Discharge Source	Sawmill-Planermill	Sawmill-Planermill	Sawmill-Planermill	Sawmill-Planermill
Type of Discharge	effluent	refuse	refuse	refuse
Quantity Discharged	145,000 GPD max.	5 cu. yd. per day	5 cu. yd. per day	5 cu. yd. per day (5 days per week)
Discharge Characteristics	BOD = 200 mg/l pH = 5.5-9.5 S.S. = 5000 mg/l T.S. = 6000 mg/l	wood scrap, bark, gravel and ashes	wood bark, waste paper, scrap metal, ashes and clinkers	wood, bark, ash and gravel
Treatment	Boiler blowdown combined with edger cooling water and through sump and over screen	-hot ashes & clinkers segregated from combustible material -covered with a suitable material as per "improved dump" objectives	-hot ashes & clinkers segregated from combustible material -covered with a suitable material as per "improved dump" objectives	-hot ashes & clinkers segregated from combustible material and let cool before being covered -leaching to Kettle R. prevented by construction of dykes and ditches
Discharge Point	Kettle River	ground	ground	ground

TABLE 9-13

SUMMARY OF POLLUTION CONTROL PERMITS FOR SANDNER BROTHERS LTD.

AND PACIFIC ABRASIVES AND SUPPLY LTD.

Permit No. / Description	PR-3942	PR-1755
Permit Holder	Sandner Brothers Lumber Co. Ltd.	Pacific Abrasives and Supply Inc.
Date of Issue	March 17, 1975	January 5, 1973
Discharge Source	Sawmill	Slag Handling plant
Type of Discharge	refuse	refuse
Quantity Discharged	120 cu. yd. per day	6 cu. yd. per day
Discharge Characteristics	sawdust, bark and yard cleanup	inert slag dust
Treatment	cover with a suitable material as per "Improved Dump" objectives	cover with a suitable material a minimum of 20 times per year -- Level "C" operation*
Receiving Area	ground	ground

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

TABLE 9-14

SUMMARY OF MISCELLANEOUS POLLUTION CONTROL PERMITS IN REGION 9

Permit No. / Description	PE-3151	PE-1927	PE-2390	PE-2962
Permit Holder	Raymond Lawrence	Leader Potato Associates Ltd.	Spalgan Holdings Ltd.	Alan Francis Cudworth
Date of Issue	November 5, 1974	January 29, 1974	September 6, 1973	December 14, 1973
Effluent Source	Placer gold sluicing operation	Vegetable washing and packaging plant	Car wash	Laundromat
Effluent Flow Rate	Maximum of 5000 IGPD	Maximum of 3300 IGPD between Aug. 1 & Mar.31	Maximum of 360 IGPD	Maximum of 1500 IGPD
Treatment	12 hour settling basin	primary settling tank and exfiltration basin	sump to catch dirt	lint interceptor and soap trap
Effluent Characteristics	suspended solids less than or equal to 50 mg/1	vegetable washer	typical car wash effluent	typical laundromat effluent
Receiving Water or Area	Boundary Creek	Groundwater	Tile Field	Tile Field

TABLE 9-15

SUMMARY OF POLLUTION CONTROL PERMITS FOR THE SEWAGE TREATMENT PLANTS AT GRAND FORKS, GREENWOOD AND MIDWAY

Description \ Permit No.	PE-280	PE-4113	PE-394
Permit Holder	The Corp. of the City of Grand Forks	The Corp. of the City of Greenwood	Village of Midway
Date of Issue	June 13, 1969 and ammended January 3, 1973	November 21, 1975	April 7, 1971
Discharge Source	sewage lagoon	percolation basin (exfiltrates via ground)	stabilization pond (filtration through gravel)
Type of Discharge	treated municipal sewage	treated municipal sewage	treated municipal sewage
Quantity Discharged	350,000 GPD	Max. 100,000 GPD	Max. 55,000 GPD
Discharge Characteristics	SS 60 mg/l BOD 45 mg/l	SS 60 mg/l BOD 45 mg/l	SS 50 mg/l BOD 30 mg/l
Treatment	-aerated lagoon, quiescent cell and chlorination*. -effluent sampling device and flow measuring device to be installed.	oxidation ditch, clarifier, sludge drying beds and exfiltration basins (chlorination contact chamber installed but no chlorination dosing apparatus)	stabilization pond and chlorination facilities
Receiving Area	Kettle River	Ground near Boundary Creek	Kettle River

* Chlorination facilities completed in 1976.

TABLE 9-16

SUMMARY OF EFFLUENT SAMPLING DATA FROM SEWAGE

TREATMENT PLANTS (STP) AT GRAND FORKS AND MIDWAY

Parameters \ Permit No. & Description		PE-280 Grand Forks STP (June, 1972 to Nov. 1975)				PE-394 Midway STP (May, 1973 to Nov. 1975)			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.
Alkalinity-total	mg/l	3	259	286	227	1	314	314	314
BOD_5	mg/l	10	18.2	24	12	4	60.5	111	35
Carbon-organic	mg/l	8	28.9	37	21	4	111.5	147	91
Chloride	mg/l	5	21.9	24.4	16.5	1	87.2	87.2	87.2
Chlorine-residual	mg/l					1	0.3	0.3	0.3
Coliforms-fecal	MPN/100 ml	6	18418	540000	1700	3		2400000	<2000
-total	MPN/100 ml	2	19200	33000	5400				
Colour	rel. units	5	36	50	20				
Nitrogen-ammonia	mg/l	2	13.9	18.6	9.1	1	4.45	4.45	4.45
-kjeldahl	mg/l	4	18.2	21	14	1	18	18	18
-nitrate	mg/l	3	0.107	0.28	<0.02	1	0.04	0.04	0.04
-nitrite	mg/l	3	0.089	0.256	<0.005				
-organic	mg/l	1	2.4	2.4	2.4	1	13.55	13.55	13.55
-total	mg/l	2	19.3	2.1	17.5				
Oxygen-dissolved	mg/l	11	5.3	13.4	2.6	2	4.9	9.2	0.5
pH	pH units	9	7.9	8.5	7.4	4	8.57	9.5	7.3
Phosphate-diss.	mg/l	4	3.75	4.76	2.84	1	4.5	4.5	4.5
-total	mg/l	5	4.52	5.28	3.6	1	6.55	6.55	6.55
Solids-dissolved	mg/l	5	396	422	346	1	648	648	648
-suspended	mg/l	6	13.7	23	7.2	3	64	82	33
-total	mg/l	8	416	450	386	2	714	740	688
Specific Conductance	µmho/cm	10	707	800	590	2	1084	939	1230
Sulphate	mg/l	2	62.6	70.5	54.6				
Turbidity	JTU	5	7.5	9.5	4.8	1	28	28	28

Note: n = number of measurements

when n = 1, sample taken Nov., 1975

TABLE 9-17

SUMMARY OF POLLUTION CONTROL PERMITS FOR MUNICIPAL REFUSE DISPOSAL SITES

Description \ Permit No.	PR-1770	PR-2984	PR-2985
Permit Holder	The Corp. of the City of Grand Forks	The Corp. of the City of Greenwood	The Corp. of the Village of Midway
Date of Issue	January 19, 1973	April 25, 1975	December 11, 1974
Type of Dicharge	Municipal (excluding toxic wastes)	Municipal (excluding toxic wastes)	Municipal (excluding toxic wastes)
Quantity Discharged	50 cu. yd. per day	50 cu. yd. per day	5 cu. yd. per day
Treatment	-operate as Level B* -fencing around entire site	-operate as Level C* -segregate car bodies and large metallic objects from other wastes -construct a diversion ditch around the site to Motherlode Cr.	-operate as Level C*
Distance to Surface Water	about 2000 ft. to Granby River	about 300 ft. to Motherlode Creek	about 3000 ft. to Kettle River
Surface Runoff or Flooding	nil	nil after diversion ditch constructed	some water during spring runoff but no problems expected

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

TABLE 9-18

NUTRIENT CONTRIBUTION TO THE KETTLE RIVER FROM

FERTILIZED AND IRRIGATED CROPLANDS AND FROM LIVESTOCK

Location / Parameters	Kettle River and Tributaries Grand Forks Area	Kettle River and Tributaries Upstream From Grand Forks
Farms reporting cropland	75	79
Cropland - acres	3188	7794
Hay - acres	2343	6229
Irrigated land area - acres		
- Agricultural Census	1070	3077
- Water License Data	7178	6825
Fertilized land area - acres	984	1382
Calculated nutrient contribution to the river from cropland		
- Nitrogen - lb/year	48,000	45,700
- Phosphorus - lb/year	1220	1160
Cattle - number older than 1 year	1166	4190
Calculated nutrient contribution to the river from livestock		
- Nitrogen - lb/year	11,200	40,000
- Phosphorus - lb/year	230	840
Total contribution		
- Nitrogen - lb/year	59,200	85,700
- Phosphorus - lb/year	1450	2000

TABLE 9-19

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH FROM 1972 TO 1975 ON THE WEST KETTLE RIVER IN THE VICINITY OF TECK CORPORATION.

Parameters \ Site No. and Location		W. Kettle R. Upstream Teck Corp. Tailing Pond				West Kettle River Downstream				Max. Permissible Drinking Water Standard[28]
		n	Mean	Max.	Min.	n	Mean	Max.	Min.	
Alkalinity-total	mg/l	14	30	61	15	16	46	81	20	300-500 gen. accept.
Arsenic-dissolved	mg/l	8	<0.005	0.005	<0.005	10	<0.005	0.007	<0.005	0.05
Calcium	mg/l	14	9.2	17.0	3.45	13	15.1	28	5.8	200
Cadmium-dissolved	mg/l	2	<0.0005	<0.0005	<0.0005		<0.0005	<0.0005	<0.0005	
Carbon-organic	mg/l	13	7.8	16	2	12	7.6	16	2	
Chloride	mg/l	14	<0.76	1.2	<0.5	14	0.73	1.1	<0.5	250
Cyanide	mg/l	7	<0.01	<0.01	<0.01	10	<0.01	<0.01	<0.01	0.2
Colour	rel. unit	14	31	120	5	11	25	65	<5	15
Copper-dissolved	mg/l	13	0.0014	0.005	<0.001	15	0.001	0.002	<0.001	1.0(total)
Fluoride	mg/l	12	0.18	0.24	0.1	6	0.29	0.48	0.15	1.5
Hardness	mg/l	14	30.8	56.9	11.3	10	50	87.2	20	180
Iron-dissolved	mg/l	12	<0.085	0.18	<0.04	15	0.088	0.17	0.04	
-total	mg/l	8	0.12	0.22	<0.04	6	0.16	0.26	0.06	0.3
Lead-dissolved	mg/l	13	<0.002	0.004	<0.001	15	<0.002	0.003	<0.001	0.05
Magnesium	mg/l	14	1.82	3.5	0.66	10	2.5	4.2	1.0	150
Mercury-total	µg/l					2	<0.12	0.19	<0.05	
Nitrogen-ammonia	mg/l	13	0.013	0.02	0.005	7	0.014	0.02	0.005	0.5
-nitrate	mg/l	12	<0.04	0.10	<0.02	8	<0.05	0.09	<0.02	10
-nitrite	mg/l	12	<0.005	0.006	<0.005	8	<0.006	0.011	<0.005	
-kjeldahl	mg/l	2	0.17	0.21	0.13	4	0.23	0.27	0.17	
-organic	mg/l	12	0.15	0.39	<0.01	6	0.21	0.52	0.05	

TABLE 9-19 Continued

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH FROM 1972 TO 1975 ON THE WEST KETTLE RIVER IN THE VICINITY OF TECK CORPORATION.

Parameters \ Site No. and Location		W. Kettle R. Upstream Teck Corp. Tailing Pond				West Kettle River Downstream				Max. Permissible Drinking Water Standard[28]
		n	Mean	Max.	Min.	n	Mean.	Max.	Min.	
Oil & Grease	mg/l	4	1.08	1.3	<1	4	1.8	2.6	<1	
Oxygen-dissolved	mg/l	11	11.4	13.1	9.1	12	11.7	14	9.3	
pH	pH units	17	7.3	7.9	6.9	19	7.4	7.8	6.8	6.5-8.3
Phosphorus-dissolved	mg/l	13	0.004	0.008	<0.003	9	<0.005	0.12	<0.003	0.2
-total	mg/l	14	0.016	0.098	0.003	10	<0.021	0.09	<0.003	
Potassium	mg/l	14	0.8	1.1	0.5	8	0.96	1.4	0.6	
Sodium	mg/l	14	2.7	4.0	1.4	8	2.93	3.8	2.0	
Solids-dissolved	mg/l	14	68	90	44	16	85	120	54	
-total	mg/l	14	81	162	46	16	105	252	56	1000
Specific Conductance	µmho/cm	18	80	130	38	20	113	180	<50	
Sulphate	mg/l	14	6.8	21.6	<5	14	7.8	14	<5	500
Turbidity	TJU	12	3.5	18	0.4	14	2.4	24	0.4	5
Zinc-dissolved	mg/l	12	<0.007	0.03	<0.005	15	<0.005	<0.005	<0.005	5

Note: n = number of values

TABLE 9-20

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH TO THE END OF 1975 AT SITES 87, 86, AND 85

Parameters \ Site No. and Location		87 W. Kettle R., Just Upstream Kettle R. Confluence				86 Kettle R., Just Upstream W. Kettle R. Confluence				85 Kettle R., Just Upstream Rock Cr. Confluence			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.	n	Mean	Max.	Min.
Alkalinity-total	mg/l	14	54	87	19.5	14	42.5	70	22	15	49	79	20
Arsenic-dissolved	mg/l	8	<0.005	<0.005	<0.005	3	<0.005	<0.005	<0.005	4	<0.0053	0.006	<0.005
Calcium	mg/l	14	17.3	28	6	14	13.9	21	6.6	15	16.2	25	6.4
Cadmium-dissolved	mg/l	4	<0.0005	<0.0005	<0.0005	3	<0.0005	<0.0005	<0.0005	4	<0.0005	<0.0005	<0.0005
Carbon-organic	mg/l	12	6.4	15	2	13	4.3	10	<1	13	<5	10	<1
Chloride	mg/l	12	0.71	1.0	<0.5	14	0.5	0.6	0.3	13	<0.58	0.9	<0.5
Cyanide	mg/l	8	<0.01	<0.01	<0.01	3	<0.01	<0.01	<0.01	4	<0.01	<0.01	<0.01
Colour	rel. unit	14	16	65	<5	13	8.57	25	<5	15	<11.3	45	<5
Copper-dissolved	mg/l	14	<0.001	<0.001	<0.001	14	<0.0012	0.004	<0.001	14	<0.0011	0.002	<0.001
Fluoride	mg/l	10	0.36	0.55	0.16	11	0.16	0.23	<0.1	10	0.23	0.37	0.10
Hardness	mg/l	14	53.7	85.6	19.6	14	43	65.6	20	15	50.4	78.1	21.4
Iron-dissolved	mg/l	14	0.13	0.5	<0.04	14	<0.067	0.1	<0.04	14	<0.066	0.11	<0.04
-total	mg/l	4	0.14	0.22	<0.04	4	0.1	0.12	<0.04	4	0.08	0.14	<0.04
Lead-dissolved	mg/l	14	0.002	0.003	<0.001	14	<0.002	<0.003	<0.001	14	<0.002	0.003	<0.001
Magnesium	mg/l	14	2.48	3.8	0.97	14	1.95	3.2	0.7	15	2.31	3.8	0.83
Mercury-total	µg/l	2	<0.04	<0.05	<0.05	1	<0.05	<0.05	<0.05	2	<0.05	<0.05	<0.05
Nitrogen-ammonia	mg/l	11	0.02	0.05	0.005	12	0.016	0.05	<0.005	11	0.021	0.07	0.006
-nitrate	mg/l	12	0.04	0.1	<0.02	12	0.03	0.09	<0.02	12	<0.035	0.10	<0.02
-nitrite	mg/l	12	0.005	0.007	<0.005	12	0.005	0.008	<0.005	12	<0.0051	0.006	<0.005
-kjeldahl	mg/l	4	0.26	0.49	0.01	3	0.12	0.14	0.11	4	0.165	0.26	0.07
-organic	mg/l	10	0.15	0.34	0.02	11	<0.07	0.18	<0.01	10	0.107	0.27	0.05

Note: n = number of values

TABLE 9-20 Continued

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH TO THE END OF 1975 AT SITES 87, 86, AND 85

Parameters \ Site No. and Location		87 W. Kettle R., Just Upstream Kettle R. Confluence				86 Kettle R., Just Upstream W. Kettle R. Confluence				85 Kettle R., Just Upstream Rock Cr. Confluence			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.	n	Mean	Max.	Min.
Oxygen-dissolved	mg/l	10	11.2	12.6	8.4	10	11.1	12.7	8.9	11	10.8	12.4	8.7
pH	pH units	14	7.6	8.0	6.9	14	7.5	8.0	6.8	14	7.6	8.7	6.7
Phosphorus-diss.	mg/l	13	0.003	0.005	<0.003	13	0.003	0.003	<0.003	13	0.0032	0.004	<0.003
-total	mg/l	15	0.011	0.056	<0.003	15	0.011	0.068	<0.003	15	0.0147	0.095	<0.003
Potassium	mg/l	11	0.92	1.3	0.6	13	0.65	0.90	0.30	12	0.74	1.0	0.5
Silica	mg/l	2	14.2	14.4	14.0	1	11.6	11.6	11.6	2	13.0	13.3	12.7
Sodium	mg/l	11	3.1	4.3	1.8	13	2.59	4.1	1.2	12	2.78	4.0	1.4
Solids-dissolved	mg/l	14	88.6	118	56	14	77.3	92	56	15	80.5	108	54
-total	mg/l	14	97.4	120	70	14	69	90	44	15	87.7	116	60
Specific Conductance	µmho/cm	14	112	180	28	14	102	150	55	15	111	170	<50
Sulphate	mg/l	12	7.5	11.6	<5	14	5.6	9.5	<5	13	6.5	10.6	<5
Turbidity	JTU	10	0.85	2.2	0.4	12	0.73	2.0	0.3	12	0.71	2.3	0.1
Zinc-dissolved	mg/l	13	0.007	0.03	<0.005	14	<0.0063	0.02	<0.005	13	<0.0051	0.006	<0.005

Note: n = number of values

TABLE 9-21

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL

BRANCH TO THE END OF 1975 FROM THE THREE SITES IN THE VICINITY OF MIDWAY

Parameters \ Site No. and Location		84 Kettle R. Upstream Midway STP				148 Kettle R. Immediately Upstream Midway STP				147 Kettle R. Downstream Midway STP			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.	n	Mean	Max.	Min.
Alkalinity-total	mg/l	12	61	100	20	5	61.7	84.5	25	5	63.2	84	26
Calcium-dissolved	mg/l	14	18.3	31.0	5.2	1	22.5	22.5	22.5	2	14.65	23.2	6.1
Carbon-inorganic	mg/l					1	14	14	14	1	15	15	15
-organic	mg/l	11	4.3	9	1	4	3.5	6.0	2.0	4	3.0	6.0	1.0
Chloride	mg/l	13	<0.63	0.9	<0.5	1	0.8	0.8	0.8	2	0.8	1.0	0.6
Colour-true	rel. units	14	<11	40	5	1	5	5	5	2	17.5	30	5
Copper-dissolved	mg/l	11	<0.002	0.003	<0.001								
Fluoride	mg/l	10	0.24	0.37	0.12								
Hardness	mg/l	14	58.6	102	16	1	72.2	72.2	72.2	2	47.1	75.2	18.9
Iron-dissolved	mg/l	11	<0.06	0.110	<0.04								
-total	mg/l	4	0.125	0.28	<0.04								
Lead-dissolved	mg/l	11	<0.0023	0.005	<0.001								
Magnesium-dissolved	mg/l	14	3.02	6.0	0.76	1	3.9	3.9	3.9	2	2.54	4.2	0.88
Nitrogen-ammonia	mg/l	11	0.019	0.05	0.005	1	0.005	0.005	0.005	1	0.008	0.008	0.008
-nitrate	mg/l	10	0.045	0.110	<0.02	1	0.05	0.05	0.05	1	0.08	0.08	0.08
-nitrite	mg/l	10	<0.007	0.025	<0.005								
-kjeldahl	mg/l	1	0.17	0.17	0.17	1	0.04	0.04	0.04	1	0.23	0.23	0.23
-organic	mg/l	11	0.101	0.23	0.01	1	0.04	0.04	0.04	1	0.22	0.22	0.22

Note: n = number of values

STP = sewage treatment plant

TABLE 9-21 Continued

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL

BRANCH TO THE END OF 1975 FROM THE THREE SITES IN THE VICINITY OF MIDWAY

Parameters \ Site No. and Location		84 Kettle R. Upstream Midway STP				148 Kettle R. Immediately Upstream Midway STP				147 Kettle R. Downstream Midway STP			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.	n	Mean	Max.	Min.
Oxygen-dissolved	mg/l	11	11.5	13.5	8.4	4	11.5	13.5	8.4	5	11.4	13.4	8.4
pH	pH units	14	7.6	8.6	6.9	5	7.6	8.0	6.9	6	7.6	8.0	6.9
Phosphorus-diss.	mg/l	11	<0.003	0.003	<0.003	1	<0.003	<0.003	<0.003	1	<0.003	<0.003	<0.003
-total	mg/l	13	<0.014	0.093	<0.003	1	0.003	0.003	0.003	3	0.01	0.024	0.003
Potassium	mg/l	11	0.86	1.3	0.60	1	0.8	0.8	0.8	1	0.8	0.8	0.8
Sodium	mg/l	11	3.7	5.8	15								
Solids-dissolved	mg/l	14	87.1	136	42	4	90	116	52	5	82.4	114	46
-total	mg/l	14	96	138	64	5	94.8	120	60	6	90.3	116	62
Specific Conductance	µmho/cm	13	132.5	220	38	5	140	180	60	6	115	180	43
Sulphate	mg/l	11	8.4	14	<5								
Turbidity	JTU	12	0.95	3.5	0.2	5	1.14	2.8	0.2	6	1.22	2.4	0.2
Zinc-dissolved	mg/l	11	<0.0065	0.02	<0.005								

Note: n = number of values

STP = sewage treatment plant

TABLE 9-22

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH TO THE END OF 1975 IN THE VICINITY OF THE GRAND FORKS SEWAGE TREATMENT PLANT

Parameters \ Site No. and Location		149 Kettle R. Downstream Granby R. Confluence and Upstream Grand Forks STP				81 Kettle R. Downstream Grand Forks STP				80 Kettle R. Upstream Christina Cr. Confluence			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.	n	Mean	Max.	Min.
Alkalinity-total	mg/l	7	54.1	77	23	12	64.9	104	22	16	61.3	112	18.5
Arsenic	mg/l					1	0.01	0.01	0.01				
Calcium	mg/l	3	13.2	18.4	5.9	10	19.4	32	5.2	16	18.6	35	5.9
Cadmium	mg/l					2	<0.0005	<0.0005	<0.0005				
Carbon-inorganic	mg/l	2	15.5	16	15	1	12	12	12				
-organic	mg/l	5	3	6	1	12	<4	6.0	<1	14	<4	9	<1
Chloride	mg/l	3	0.63	0.8	0.5	10	0.73	1.3	0.4	15	0.79	1.4	<0.5
Colour	rel. units	3	13.3	30	5	10	<10	30	<5	16	<11.8	45	<5
Copper-dissolved	mg/l					7	0.0011	0.002	<0.001	11	<0.002	0.006	<0.001
Cyanide	mg/l					2	<0.01	<0.01	<0.01	1	<0.01	<0.01	<0.01
Fluoride	mg/l					5	0.236	0.31	0.13	11	0.22	0.31	0.12
Hardness	mg/l	2	55.4	61.2	49.5	9	70.2	108.3	31.6	16	61.6	120	18.4
Iron-dissolved	mg/l					7	<0.08	0.14	<0.04	11	0.55	0.11	0.02
-total	mg/l					3	<0.093	0.2	<0.04	4	0.1	0.28	<0.04
Lead-dissolved	mg/l					7	<0.002	<0.003	<0.001	11	0.002	0.005	<0.001
Magnesium	mg/l	2	3.25	3.7	2.8	9	4.2	6.9	1.4	16	3.6	8.0	0.9
Manganese	mg/l					5	<0.014	0.02	<0.01	10	<0.011	<0.02	<0.01
Mercury-total	µg/l					2	<0.05	<0.05	<0.05	1	<0.05	<0.05	<0.05

Note: n = nuber of values

STP - sewage treatment plant

TABLE 9-22 Continued

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH TO THE END OF 1975 IN THE VICINITY OF THE GRAND FORKS SEWAGE TREATMENT PLANT

Parameters / Site No. and Location		149 Kettle R. Downstream Granby R. Confluence and Upstream Grand Forks STP				81 Kettle R. Downstream Grand Forks STP				80 Kettle R. Upstream Christina Cr. Confluence			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.	n	Mean	Max.	Min.
Nitrogen-ammonia	mg/l	2	0.008	0.011	0.005	7	0.0157	0.031	0.009	14	0.021	0.06	0.009
-nitrate	mg/l	1	0.03	0.03	0.03	8	0.0925	0.29	<0.02	14	0.086	0.28	<0.02
-nitrite	mg/l	1	<0.005	<0.005	<0.005	8	<0.005	<0.005	<0.005	14	<0.0051	0.006	<0.005
-kjeldahl	mg/l	2	0.065	0.08	0.05	4	0.17	0.24	0.05	5	0.09	0.13	0.03
Oxygen-dissolved	mg/l	9	11.9	13.4	9.4	13	11.6	13.4	8.4	13	11.4	12.9	9.2
pH	pH units	6	7.8	8.2	7.0	13	7.8	8.3	6.9	11	7.7	8.7	6.9
Phosphorus-diss.	mg/l	2	<0.003	<0.003	<0.003	9	0.006	0.017	<0.003	15	<0.004	0.01	<0.003
-total	mg/l	3	0.014	0.031	0.004	10	0.015	0.028	0.005	15	<0.021	0.105	<0.003
Potassium	mg/l	2	0.95	1.0	0.9	7	0.94	1.3	0.4	11	0.96	1.4	0.5
Sodium	mg/l	1	4.4	4.4	4.4	6	4.28	6.3	2.1	11	3.86	7.0	1.3
Solids-dissolved	mg/l	7	76.3	120	40	14	89.6	150	34	14	91.1	156	38
-total	mg/l	9	90.7	124	60	15	98.9	152	60	16	104	158	58
Specific Conductance	µmho/cm	7	120.4	200	40	15	144	260	36	17	137.3	250	40
Sulphate	mg/l					6	10.5	16.5	5.2	11	<9.8	19.0	<5
Turbidity	JTU	7	1.49	3.3	0.2	13	1.4	3.6	0.3	14	1.6	4.8	0.3
Zinc-dissolved	mg/l					7	<0.005	0.005	<0.005	11	<0.0058	0.014	<0.005

Note: n = number of values

STP = sewage treatment plant

TABLE 9-23

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH TO THE END OF 1975 AT SITES 83 AND 82

Parameters \ Site No. and Location		83 Kettle River At Carson				82 Granby River Just Upstream Kettle River Confluence			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.
Alkalinity-total	mg/l	14	63.8	121	24	13	37.3	89	14
Arsenic	mg/l					1	<0.005	<0.005	<0.005
Calcium	mg/l	14	20.5	30.5	7.2	15	11.3	26.4	3.6
Cadmium	mg/l					2	<0.0005	<0.0005	<0.0005
Carbon-organic	mg/l	12	4.3	9.0	2.0	13	<3.1	9	<1
Chloride	mg/l	13	0.81	1.3	<0.5	13	<0.72	2.8	<0.5
Colour	rel. units	15	<12	45	<5	15	<7.3	20	<5
Copper-dissolved	mg/l	11	<0.0015	0.006	<0.001	14	<0.0011	0.002	<0.001
Cyanide	mg/l					1	<0.01	<0.01	<0.01
Fluoride	mg/l	11	0.23	0.36	0.10	11	0.16	0.31	<0.1
Hardness	mg/l	14	68.6	127	22.4	15	36.8	90	11.3
Iron-dissolved	mg/l	11	<0.06	0.110	<0.04	14	<0.061	0.1	<0.02
-total	mg/l	4	0.09	0.22	<0.04	4	0.11	0.18	0.05
Lead-dissolved	mg/l	11	<0.0024	0.006	<0.001	14	0.002	0.009	<0.001
Magnesium	mg/l	14	4.04	8.4	1.0	15	1.92	4.9	0.57
Manganese	mg/l	11	<0.011	<0.02	<0.01	11	<0.014	0.03	<0.01
Mercury-total	µg/l					2	<0.05	<0.05	<0.05

Note: n = number of values

TABLE 9-23 Continued

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH TO THE END OF 1975 AT SITES 83 AND 82

Site No. and Location / Parameters		83 Kettle River At Carson				82 Granby River Just Upstream Kettle River Confluence			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.
Nitrogen-ammonia	mg/l	13	0.016	0.04	0.008	12	0.018	0.05	0.008
-nitrate	mg/l	13	0.062	0.21	<0.02	14	<0.043	0.12	<0.02
-nitrite	mg/l	13	<0.005	0.005	<0.005	14	<0.005	<0.005	<0.005
-kjeldahl	mg/l	3	0.16	0.22	0.12	4	0.148	0.21	0.05
Oxygen-dissolved	mg/l	10	11.0	13.4	8.4	13	11.5	13.6	8.7
pH	pH units	13	7.9	8.9	7.1	12	7.5	8.3	6.7
Phosphorus-diss.	mg/l	13	0.0032	0.005	<0.003	14	<0.003	<0.003	<0.003
-total	mg/l	15	0.0169	0.069	<0.003	15	0.015	0.04	0.003
Potassium	mg/l	11	1.03	1.7	0.5	12	0.69	1.3	0.4
Sodium	mg/l	11	4.21	7.2	1.5	12	2.24	5.9	0.9
Solids-dissolved	mg/l	14	101.1	162	48	15	60.3	122	26
-total	mg/l	14	109.4	164	70.0	14	68.6	126	46
Specific Conductance	µmho/cm	12	153.5	222	65	12	91.3	193	40
Sulphate	mg/l	11	10.1	18.5	<5	12	<6	12	<5
Turbidity	JTU	11	1.16	3.5	0.3	12	1.39	4.0	0.3
Zinc-dissolved	mg/l	11	<0.0051	0.006	<0.005	13	<0.006	0.017	<0.005

Note: n = number of values

TABLE 9-24

SUMMARY OF COLIFORM DATA COLLECTED BY THE POLLUTION CONTROL BRANCH TO THE END OF 1975 FROM THE KETTLE RIVER BASIN, EXCLUDING CHRISTINA LAKE

Site No.	Site Location	Fecal Coliforms (MPN/100 ml)			Total Coliforms (MPN/100 ml)		
		n	Geometric Mean	Range	n	Geometric Mean	Range
89	W. Kettle R. upstream Teck Corp Ltd.	7	<2.8	<2 to 9			
88	W. Kettle R. downstream Teck Corp Ltd.	8	<5.6	<2 to 28			
84	Kettle R. upstream Midway STP (downstream Pope & Talbot)	3	18.2	13 to 20	2	197.7	170 to 230
148	Kettle R. immediately upstream Midway STP	4	15.5	8 to 33	3	142	80 to 210
83	Kettle R. at Carson	2	7.4	5 to 11	2	12.4	7 to 22
149	Kettle R. downstream Granby R. & upstream Grand Forks STP	6	29.4	13 to 540	1	17	17
81	Kettle R. downstream Grand Forks STP	7	76	13 to 1600	1	33	33
500	Boundary Cr. upstream Greenwood STP	1	<20	<20	1	20	20
501	Boundary Cr. downstream Greenwood STP	1	50	50	1	130	130
92	Boundary Cr. just upstream confluence Kettle R.	2	<20	<20	2	80	80
82	Granby R., just upstream confluence Kettle R.	7	18	2 to 240	1	8	8

Note: n = nuber of values
STP = sewage treatment plant

TABLE 9-25

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH TO THE END OF 1975 FROM BOUNDARY CREEK

Parameters \ Site No. and Location		Boundary Creek upstream Eholt Cr. confluence	500 Boundary Creek upstream Greenwood	
		Nov. 1975	Sept. 1975	Nov. 1975
Alkalinity-total	mg/l	48	72.9	71.3
Calcium	mg/l	14.2	23.0	24.0
Cadmium	mg/l	<0.0005		<0.0005
Carbon-organic	mg/l		2	
Chloride	mg/l	0.8	1.3	1.4
Colour	rel. units	5	5	5
Copper-dissolved	mg/l	<0.001		<0.001
Cyanide	mg/l	<0.01		<0.01
Hardness	mg/l	48.2	74.3	77.6
Iron-dissolved	mg/l	<0.1		<0.1
Lead-dissolved	mg/l	<0.001		<0.001
Nitrogen-ammonia	mg/l	0.013		0.011
-nitrate	mg/l	} 0.16	0.17	
-nitrite	mg/l		<0.005	
-kjeldahl	mg/l	0.16	0.46	0.11
Oxygen-dissolved	mg/l			14.0
pH	pH units	7.5	8.1	8.0
Phosphorus-diss.	mg/l	0.004		<0.003
-total	mg/l	0.005	0.005	0.004
Solids-dissolved	mg/l	74	113	116
-total	mg/l	76	114	118
Specific Conductance	µmho/cm	116	162	176
Sulphate	mg/l	6.7		10.6
Turbidity	JTU	0.4	0.3	0.3
Zinc-dissolved	mg/l	<0.005		<0.005

Note: n = number of values

TABLE 9-25 Continued

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH TO THE END OF 1975 FROM BOUNDARY CREEK

Site No. and Location / Parameters		501 Boundary Creek downstream Greenwood		92 Boundary Creek Just upstream Kettle River confluence			
		Sept. 1975	Nov. 1975	n	Mean	Max.	Min.
Alkalinity-total	mg/l	92	98	14	73.6	117	32
Arsenic	mg/l			6	<0.005	<0.005	<0.005
Calcium	mg/l			9	28.2	41	13.6
Cadmium	mg/l	<0.0005	<0.0005	3	<0.0005	<0.0005	<0.0005
Carbon-organic	mg/l			6	5.8	12	2
Chloride	mg/l		2	13	1.44	2.8	0.6
Colour	rel. units	5	5	15	<10	30	<5
Copper-dissolved	mg/l	0.001	<0.001	14	<0.0013	0.002	<0.001
Cyanide	mg/l	<0.01	<0.01	3	<0.01	<0.01	<0.01
Hardness	mg/l	109	112	4	107.1	138	44.2
Iron-dissolved	mg/l	<0.1	<0.1	14	<0.063	<0.1	<0.04
Lead-dissolved	mg/l	<0.001	<0.001	14	<0.002	<0.003	<0.001
Magnesium	mg/l			11	<0.01	0.01	<0.01
Mercury-total	µg/l			1	<0.05	<0.05	<0.05
Nitrogen-ammonia	mg/l	0.012	0.014	2	0.008	0.009	0.007
-nitrate	mg/l	0.36		3	0.16	0.35	0.05
-nitrite	mg/l	<0.005		3	0.011	0.022	<0.005
-kjeldahl	mg/l	0.19	0.09	3	0.313	0.38	0.24
Oxygen-dissolved	mg/l	9.5	13.7	10	11.5	13.8	8.4
pH	pH units	8.1	8.1	14	7.9	8.8	7.0
Phosphorus-diss.	mg/l	0.005	0.004	8	<0.004	0.005	<0.003
-total	mg/l	0.007	0.006	10	0.013	0.023	<0.003
Potassium	mg/l			5	1.1	1.7	0.7
Silica	mg/l			1	15.5	15.5	15.5
Sodium	mg/l			6	4.32	6.4	2.7
Solids-dissolved	mg/l	166	156	15	135.5	190	60
-total	mg/l	168	158	14	139.7	196	76
Specific Conductance	µmho/cm	234	242	15	208	370	75
Sulphate	mg/l		26.5	8	19.6	36.6	5.4
Turbidity	JTU	0.5	0.4	12	0.85	1.9	0.3
Zinc-dissolved	mg/l	<0.005	<0.005	14	<0.0061	0.02	<0.005

Note: n = number of values

TABLE 9-26

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL

BRANCH TO THE END OF 1975 FROM THREE TRIBUTARIES OF BOUNDARY CREEK

Sites 90 and 91 received discharges from Granby Mining

Parameters \ Site No. and Location		Eholt Creek Upstream Boundary Cr. Confluence	91 Providence Lake By Dam			90 Twin Creek Upstream Boundary Cr. Confluence			
		Nov. 1975	n	Mean	Max.	Min.	n	Mean	Max.	Min.
Alkalinity-total	mg/l	120	8	75.9	157	30.2	11	173	199	141
Arsenic	mg/l		1	<0.005	<0.005	<0.005	3	<0.005	<0.005	<0.005
Calcium	mg/l	43.0	5	173	195	149	8	149	198	53.4
Cadmium	mg/l		2	<0.0005	<0.0005	<0.0005				
Carbon-organic	mg/l		3	9	11	8	4	7.5	10	4
Chloride	mg/l		5	5.0	5.5	4.4	8	3.9	5.9	2.5
Cyanide	mg/l		5	<0.01	<0.01	<0.01	10	<0.01	<0.01	<0.01
Colour	rel. units	10	6	8.3	10	5	10	<5	5	<5
Copper-dissolved	mg/l		8	<0.01	0.03	<0.001	13	<0.002	0.005	<0.001
-total	mg/l		2	<0.01	0.02	<0.001	6	0.004	0.006	0.002
Hardness	mg/l	134	2	539	556	523	5	407	486	205
Iron-dissolved	mg/l		8	0.055	<0.1	0.02	13	<0.066	0.1	<0.02
-total	mg/l		3	0.303	0.71	0.07	4	0.29	0.5	0.17
Lead-dissolved	mg/l		8	<0.002	<0.003	<0.001	13	<0.002	<0.003	<0.001
-total	mg/l		2	<0.001	<0.001	<0.001	3	<0.001	0.001	<0.001
Magnesium	mg/l	6.4	5	14.0	16.7	11.0	8	20.9	26.4	17.5
Manganese-dissolved	mg/l		6	0.175	0.5	0.01	8	0.01	0.01	<0.01
Mercury-total	µg/l						1	<0.05	<0.05	<0.05

Note: n = number of values

TABLE 9-26 Continued

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL

BRANCH TO THE END OF 1975 FROM THREE TRIBUTARIES OF BOUNDARY CREEK

Sites 90 and 91 received discharges from Granby Mining

Site No. and Location / Parameters		Eholt Creek Upstream Boundary Cr. Confluence	91 Providence Lake By Dam				90 Twin Creek Upstream Boundary Cr. Confluence			
		Nov. 1975	n	Mean	Max.	Min.	n	Mean	Max.	Min.
Nitrogen-ammonia	mg/l	0.028	1	0.192	0.192	0.192	3	0.026	0.032	0.02
-nitrate	mg/l	0.31	1	3.0	3.0	3.0	2	1.98	2.3	1.67
-nitrite	mg/l	0.31	1	0.036	0.036	0.036	2	<0.005	<0.005	<0.005
-kjeldahl	mg/l	0.28	2	0.765	0.79	0.74	4	0.29	0.39	0.19
Oxygen-dissolved	mg/l		7	11.1	7.8	9.9	10	11.9	13.2	9.8
pH	pH units	8.8	8	8.2	9.1	7.4	7	8.2	8.3	8.1
Phosphorus-dissolved	mg/l	0.007	4	<0.003	<0.003	<0.003	6	0.016	0.022	0.007
-total	mg/l	0.009	6	0.01	0.013	0.006	9	0.028	0.035	0.017
Potassium	mg/l		3	9.2	10.1	7.6	5	3.06	4.3	2.3
Sodium	mg/l		4	10.9	11.6	9.6	6	9.5	11.5	8.7
Solids-dissolved	mg/l	186	6	782	882	688	9	738	950	562
-suspended	mg/l	1	2	9.6	16	3.2	4	7.7	10	2
-total	mg/l	188	8	779	886	644	13	738	960	564
Specific Conductance	µmho/cm	286	8	916	1070	750	9	879	1120	765
Sulphate	mg/l		4	408	516	308	8	332	519	221
Turbidity	JTU	0.4	7	1.8	3.4	1.0	12	1.5	3.0	0.5
Zinc-dissolved	mg/l		8	<0.007	0.017	<0.005	13	<0.005	<0.005	<0.005
-total	mg/l		2	0.013	0.02	0.006	3	<0.005	<0.005	<0.005

Note: n = number of values

TABLE 9-27

TOTAL AND FECAL COLIFORM DATA COLLECTED BY THE WEST KOOTENAY HEALTH UNIT FROM CHRISTINA LAKE, 1967 to 1975

	Median Total Coliforms (MPN/100 ml)		Log Mean Fecal Coliforms (MPN/100 ml)	
	June 12-Sept.9 1967	June 7-Aug.30 1970	June 7-Aug.30 1970	Apr. 1-Sept.30 1975*
Texas Point		4.0	1.1	1.3
Mid-lake, north of Texas Point	0	0	0	1.3
West side, north of Texas Point		4.0	1.1	
Bay, south of Texas Point		6.2	1.4	2.5
Bay, north of McCree Creek				0
English Point (Alpine Inn Beach)	7.8	9.0	1.8	2.0
East side, across from English Pt.				1.3
Between English Pt. and Cove				2.3
English Cove		4.0	1.4	1.3
Lavelley Point (Christina Lake Hotel Beach)	4.5	15	1.9	3.6
West side, across from Lavelley Pt.				1.2
Mouth of Sutherland Creek		23	2.6	4.2
North of Silver Birch Bay		23	1.6	3.7
Silver Birch Bay	13.0	9.0	1.6	5.1
South end of lake	33	15	1.5	3.5
Mouth of Christina Creek				3.8

*Values given are maximum log means over 30 days.

TABLE 9-28

SUMMARY OF WATER QUALITY DATA COLLECTED

BY PROVINCIAL AGENCIES IN CHRISTINA LAKE

Parameters	Agency and Site No.	Pollution Control Br. 1971-1974 78				Water Investigations Br. July, 1974 681		682	
		n	Mean	Max.	Min.	n	Mean	n	Mean
Alkalinity-total	mg/l	17	31.5	35.6	27.5	5	31.5	2	31.5
Calcium	mg/l	17	10	10.5	9.5	5	10	2	9.9
Cadmium	mg/l							2	<0.0005
Carbon-organic	mg/l	17	2.4	6	<1	5	1.6	2	2
Chloride	mg/l	17	0.63	1.2	<0.5				
Colour	rel.units	17	5.6	10	<5				
Copper-dissolved	mg/l	16	<0.001	0.002	<0.001				
-total	mg/l					5	0.001	2	<0.001
Extinction Depth	m	8	10.2	16	7.3	5	13.2	2	13
Fluoride	mg/l	10	<0.1	<0.1	<0.1				
Hardness	mg/l	17	31.6	35.6	29.9				
Iron-dissolved	mg/l	16	<0.06	<0.1	<0.04				
-total	mg/l	15	<0.06	0.1	<0.04	5	<0.1	2	<0.2
Lead-dissolved	mg/l	16	<0.001	<0.003	<0.001				
-total	mg/l					5	<0.001	2	<0.001
Magnesium	mg/l	16	1.45	1.6	1.25	5	1.35	2	1.3
Manganese	mg/l	16	<0.015	<0.02	<0.01				
Mercury-total	µg/l					5	<0.05	2	<0.05
Nickel	mg/l					5	<0.01	2	<0.01
Nitrogen-ammonia	mg/l	17	0.009	0.02	<0.005				
-NO_2+NO_3	mg/l	17	<0.025	0.035	<0.025	5	<0.02	2	<0.02
-kjeldahl	mg/l	6	0.055	0.08	0.02	5	<0.09	2	0.06
pH	pH units	17	7.6	8.9	6.8	5	7.15	2	7.5
Phosphorus-dissolved	mg/l	17	<0.003	0.006	<0.003	5	<0.003	2	<0.003
-total	mg/l	17	<0.006	0.014	<0.003	5	<0.0035	2	<0.0097
Potassium	mg/l	17	0.73	1.2	0.6				
Silica	mg/l	17	12.1	15	11.2				
Sodium	mg/l	17	2.0	2.5	1.7				
Solids-dissolved	mg/l	17	55	62	48				
-total	mg/l	17	57.9	64	52				
Specific Conductance	µmho/cm	17	77.8	90	70	5	71.5	2	70.5
Sulphate	mg/l	17	5.7	9.20	<5				
Turbidity	JTU	16	0.58	1.0	0.1	5	0.2	2	0.2
Zinc-dissolved	mg/l	14	0.007	0.017	<0.005				
-total	mg/l					5	<0.005	2	<0.005

Note: n = number of values

TABLE 9-29

SUMMARY OF WATER QUALITY DATA COLLECTED BY THE POLLUTION CONTROL BRANCH UP TO 1974 FROM ONE TRIBUTARY AND FROM THE OUTLET OF CHRISTINA LAKE

Site No. and Location / Parameters		79 Sutherland Cr. Just Upstream Mouth				77 Christina Cr. Just Downstream Christina Lake			
		n	Mean	Max.	Min.	n	Mean	Max.	Min.
Alkalinity-total	mg/l	13	48.1	79	20.4	13	36	71	19
Calcium	mg/l	13	15.3	32.1	6.0	13	11.4	24.0	6
Carbon-organic	mg/l	12	<3.0	9	<1	12	3.7	6.0	<1
Chloride	mg/l	11	<0.61	1.1	<0.5	10	<0.6	0.8	<0.5
Colour	rel.units	13	<8.1	20	<5	13	6.8	20	<5
Copper-dissolved	mg/l	11	<0.0011	0.002	<0.001	10	<0.0011	0.002	<0.001
-total	mg/l	1	<0.001	<0.001	<0.001				
Fluoride	mg/l	3	<0.1	0.1	<0.1	9	0.12	0.18	<0.1
Hardness	mg/l	12	48.7	95.4	20.7	13	37.0	80.5	20.1
Iron-dissolved	mg/l	11	<0.12	<0.4	<0.04	9	0.074	0.11	0.04
-total	mg/l	1	<0.1	<0.1	<0.1				
Lead-dissolved	mg/l	11	<0.0022	0.008	<0.001	10	0.0026	0.011	<0.001
-total	mg/l		<0.001	<0.001	<0.001				
Magnesium	mg/l	13	2.65	5.0	1.4	13	1.9	5	1.2
Manganese	mg/l	9	0.012	0.02	<0.01	9	0.012	0.02	<0.01
Nitrogen-ammonia	mg/l	2	0.0065	0.007	0.006	10	0.019	0.07	<0.005
-nitrate	mg/l	4	<0.03	0.06	<0.02	13	0.02	0.03	<0.02
-nitrite	mg/l	4	<0.005	<0.005	<0.005	13	<0.005	<0.005	<0.005
-kjeldahl	mg/l	4	<0.04	0.09	<0.01	5	0.09	0.12	0.02
Oxygen-dissolved	mg/l	11	10.8	12.2	8.6	12	10.7	12.9	8.5
pH	pH units	13	7.6	8.75	6.9	14	7.6	8.2	6.6
Phosphorus-diss.	mg/l	12	0.013	0.028	<0.003	12	<0.008	0.023	<0.003
-total	mg/l	13	<0.022	0.056	<0.003	13	<0.022	0.1	<0.003
Potassium	mg/l	11	0.91	1.50	0.6	11	0.84	1.3	0.5
Sodium	mg/l	11	2.25	3.3	1.4	11	2.1	3.3	1.5
Solids-dissolved	mg/l	13	81.5	132	48	13	64	120	40
-total	mg/l	13	87.1	134	52	13	67.7	124	52
Specific Conductance	µmho/cm	13	100	180	48	13	83	185	55
Sulphate	mg/l	5	<5.9	8.2	<5	11	<6.4	13.5	<5
Turbidity	JTU	12	0.7	1.7	0.1	13	1.2	5.1	0.3
Zinc-dissolved	mg/l	11	<0.0055	0.01	<0.005	10	0.007	0.02	<0.005
-total	mg/l	1	<0.005	<0.005	<0.005				

Note: n = number of values

TABLE 9-30

SUMMARY OF AVAILABLE PLANKTON DATA FROM CHRISTINA LAKE

Sampling Location	Date	Sampling Method	Net Size	n	Mean Settled Vol. of Plankton
1 mi. from S. end on E. side	June 15/52	vert. haul from 145' (total vert.)	#10	2	0.88 ml
1 mi. from S. end on E. side	June 15/52	vert. haul from 145' (total vert.)	#20	1	1.7 ml
1 mi. from S. end on E. side	June 15/52	surface tow	#10	1	3 ml
off Texas Cr. middle of lake	June 16/66	vert. tow from 50'	#10?	4	0.25 ml
off Texas Cr. middle of lake	July 14/66	vert. tow from 50'	#10?	4	0.74 ml
off Texas Cr. middle of lake	Sept. 29/66	vert. tow from 50'	#10?	4	0.8 ml
off Texas Cr. middle of lake	June 16/66	surface tow (for 2 min.)	#10?	4	0.29 ml
off Texas Cr. middle of lake	July 14/66	surface tow (for 2 min.)	#10?	4	1.48 ml
off Texas Cr. middle of lake	Sept. 29/66	surface tow (for 2 min.)	#10?	4	2.23 ml
off Baker Cr. middle of lake	June 16/66	vert. tow from 50'	#10?	4	0.2 ml
off Baker Cr. middle of lake	July 14/66	vert. tow from 50'	#10?	4	0.8 ml
off Baker Cr. middle of lake	Sept. 29/66	vert. tow from 50'	#10?	4	0.63 ml
off Baker Cr. middle of lake	June 16/66	surface tow (for 2 min.)	#10?	4	0.55 ml
off Baker Cr. middle of lake	July 14/66	surface tow (for 2 min.)	#10?	4	3.4 ml

Note: n = number of measurements

TABLE 9-31

DATA ON FISH CAUGHT BY THE FISH AND WILDLIFE BRANCH IN

GILL NETS IN THE SOUTH-WESTERN PART OF CHRISTINA LAKE

Date	Species	Number	Length (cm)	Weight (g)	Stomach Content*
July, 1950	rainbow trout	12	44.6(25.5-73.6)	1308(112-4082)	empty or not identifiable
September, 1950	kokanee	20	18.7(15-20.3)	129(112-180)	empty or not identifiable
June, 1952	bass	10	23(16.5-28)	186(65-325)	crayfish, mayfly nymphs, dytiscid larvae
June, 1952	sculpin	7			
June, 1952	kokanee	3	18.8(18.5-19)	58.3(55-60)	no data
June, 1952	Rocky Mtn. whitefish	4	30(26-31)	257.5(200-360)	caddis fly larvae, mayfly nymph, mollusk
June, 1952	squawfish	16	24(17-45)	250(60-1150)	caddis fly larvae
December, 1952	kokanee	16			
August, 1953	rainbow trout	1	76.2	6349	
May, 1969	no fish in nets: fishing poor according to local residents.				

*The stomach contents listed are those which were identifiable
Many stomachs were empty due to the time in the gill nets.

TABLE 9-32

AQUATIC PLANTS COLLECTED BY THE POLLUTION CONTROL BRANCH

FROM THE SOUTH-EAST CORNER OF CHRISTINA LAKE IN SEPTEMBER 1970

Species	Comments
Potamogetan epihydrus	- in shallow to deep water; particularly in slow streams - mainly floating leaves; entire plant 14' long
P. fluitans	- in shallow to deep water; often in flowing water - predominant plant in area of collection
P. richardsonii	- in shallow standing water - plant mainly submerged
P. (species unknown)	- main portion submerged; few leaves above the surface
Myriophyllum verticillatum	- in quiet ponds and streams; often where brackish - apicies above water, rest of plant submerged; dominant species in area of collection from 2-18' deep
M. (species unknown)	- approx. plant length 20'; dominant plant in area collected - completely occludes light to areas below
Brasenia schreberi	- in shallow ponds and sluggish streams; acid waters - only leaves above surface of water
Valisneria canadensis	- quiet waters; fresh to slightly brackish water; collected near sawmill (1-18' long)

TABLE 9-33

DATA ON AQUATIC PLANTS COLLECTED BY THE WATER INVESTIGATIONS BRANCH FROM CHRISTINA LAKE IN JULY, 1974

(Site locations in Figure 9-10)

Site	Depth	Species	Comments
683	5	Potamogetan gramineus	in standing and running waters; mostly submerged, some floating leaves.
683	3	P. illinoensis	mainly in calcareous areas in canals, streams and lakes. usually in rather deep, quiet areas. mostly submerged; some floating leaves
683	3	P. amplifolius	in lakes and streams; usually in fairly deep water. mostly submerged, some floating leaves.
684	6	P. nodosus?	in shallow to deep water; often in inlet and outlet channels of lakes. floating leaves.
685	5	P. illinoensis	mostly in calcareous areas in canals, streams and lakes. usually in rather deep, quiet areas. mostly submerged; some floating leaves.
686	3	P. gramineus	in standing and running waters; mostly submerged, some floating leaves.
686	3	P. natans	in rather shallow, usually standing water; often where brackish. floating leaves.
686	3	P. (species unknown)	filiform
686	3	Ranunculus flabellaris?	in shallow water; completely submerged.
686	3	Bidens beckii	submerged in ponds, lakes, and slow streams.
686	3	Elodea canadensis	in ditches, ponds, streams and lakes; particularly in calcareous sites. submerged.
687	3&4	Potamogetan zosteriformis	in ponds and streams, but mostly in lakes. submerged.