DEPARTMENT OF ENVIRONMENT

KOOTENAY
AIR AND WATER QUALITY STUDY
PHASE I

WATER QUALITY IN REGION 5, THE KOOTENAY LAKE BASIN

WATER RESOURCES SERVICE

WATER INVESTIGATIONS BRANCH

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SUMMARY

This report is an evaluation of the data available up to the end of 1974 on the water quality of the Kootenay Lake basin. It is one of a series of 12 reports which assess air and water quality in the Kootenay region. These reports constitute Phase I of the Kootenay air and water quality study.

Kootenay Lake is considered to be in the mesotrophic, or moderately productive range, due mainly to nutrients from the Kootenay River, a major tributary of the lake. The Kootenay River contains a significant amount of phosphorus that originates mainly from Cominco's fertilizer operations at Kimberley. These operations discharge effluent into tributaries of the river, over two hundred miles upstream from the lake.

At the moment the productivity of Kootenay Lake appears to be in reasonable balance. The lake supports an important sports fishery which has benefited from the introduction of shrimp as well as nutrients. Algal blooms have occurred during some summers but were of short duration and created aesthetic problems. The recently completed Libby Dam in Montana, which is located on the Kootenay River approximately midway between the fertilizer operations and the lake, will tend to trap river sediments. This will increase light penetration into the lake and hence increase algal growth. On the other hand the Libby Dam will also remove phosphorus which will decrease algal growth in Kootenay Lake. The reduction in the discharge of phosphorus from Cominco,by over 90 percent by the end of 1977, will have a similar effect.

Man's activity in the Kootenay Lake basin has had a relatively small effect on water quality. There were some localised problems caused by municipal and industrial solid waste dumps and by municipal effluents. We have recommended a short one year monitoring program to clarify these problems. Monitoring of Kootenay Lake and its major tributaries will also be continued to document the effects of the Libby Dam and the reduction in the discharge from fertilizer plant operations. Results will be presented in a Phase II report for the area.

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

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1. DESCRIPTION OF THE REGION

1.1 Introduction

The Kootenay Lake Basin has an area of 5045 square miles and drains the western slope of the Purcell Mountains and the eastern slope of the Selkirk Mountains. The Purcell Trench divides the region into two halves with the Purcell Mountains occupying the eastern half and the Selkirk Mountains occupying the western half. The Purcell Trench has a north-south orientation and lies mainly between 2,500 and 1,750 feet. A map of the Kootenay Lake Basin is shown in Figure 5-1.

1.2 Climate

The mountainous topography of this region exerts a dominating influence on the climate. The warmest and driest portion of the region lies along the bottom of the Purcell Trench and along the West Arm of Kootenay Lake. The surrounding mountain ranges however, are colder because of their higher elevation, and wetter because they cause the eastward moving Pacific air masses to rise and release most of their moisture over the mountainous uplands.

The Purcell Trench receives about 760 mm of precipitation per year with the exception of the portion south of Kootenay Lake which receives 500 mm per year. Precipitation averages about 1000 mm per year in the southern Purcells and Selkirks, while the northern Purcells and Selkirks receive 1500 to 2000 mm per year. Snowfall follows a similar pattern,with the Purcell Trench receiving around 200 to 250 cm per year, while the Purcells and Selkirks receive from 250 to over 500 cm per year.

The average temperature in July is about 18^{o}C over most of the region with the exception of the northern Purcells and Selkirks which average about 15.5^{o}C. The mean January temperatures are -4^{o}C along the Purcell Trench from Kaslo to the border and along the West Arm of Kootenay Lake to Nelson, -7^{o}C in the southern Selkirks and -12^{o}C in the Purcells and northern Selkirks. Similarly, the average frost-free period is about 120 days over most of the Purcell Trench and the West Arm of Kootenay Lake, but is only 80 days in the Selkirks and 60 days in the Purcells[1].

1.3 Geology

The eastern half of the region is occupied by the Purcell Mountains which are a north-westerly trending group of peaks composed of thick quartzite, argillaceous quartzite, argillite and limestone beds with large granitic intrusions. In the northern part of the region, the Purcells are extremely rugged with peaks to 11,000 feet, and then gradually diminish in height to about 7,000 feet with comparatively subdued topography at the international boundary. Westward drainage from the Purcells is by short, steep streams, flowing in narrow, deep, east-west valleys. The Purcells were glaciated to a height of 7,000 to 8,000 feet, and active glaciers are still present on some of the highest peaks[2].

The Selkirk Mountains occupy the western half of the region. These mountains comprise a number of individual ranges which trend northeastward in the south, northward at and north of Nelson, and northwestward in the north[2].

The Selkirk Mountains contain a complex variety of rocks including gneiss, schist, argillite, slate, andesite, granite, argillaceous quartzite and erosion resistant quartzites and limestones which form many of the highest peaks[2,3]. The ranges north of Trout Lake are extremely rugged with peaks to over 11,000 feet and numerous icefields and glaciers. The ranges south of Nelson are more subdued than those of the north and contain practically no glaciers[2]. The Kokanee Glacier, in the Slocan Ranges north of Nelson has an area of more than two square miles[3].

The Purcell Trench, which forms the boundary between the Selkirks and the Purcells, is a longitudinal valley which varies in width from seven miles to less than one mile. The Kootenay River, Kootenay Lake, Duncan Lake and the Duncan River occupy the bottom of the Purcell Trench[2].

South of Kootenay Lake, the Trench is filled with fluvio-glacial material, deposited by retreating glacial ice[4], while in Kootenay Lake itself, sediments at least 700 feet thick have been reported[5].

1.4 Soils and Vegetation

Valley bottom soils of the Kootenay Lake Basin have developed on alluvial fans and floodplains and on glacial and post-glacial till, outwash, lacustrine, and terrace deposits. Coarse textures are common. Douglas fir forests predominate at elevations below 2500 feet. Western hemlock, western white pine, western red cedar, Douglas fir, larch and lodgepole pine are common on the till, colluvial, and shallow soils of the valley walls between 2500 and 5000 feet elevation. Cooler, moister climates, shallow soils, and exposed bedrock occur above 5000 feet. These areas, which comprise a major portion of Region 5, support stands of Engelmann spruce and subalpine fir. Pockets of alpine vegetation occur above 7000 feet[3].

1.5 Hydrology

1.5.1 Streamflow

The Kootenay River enters the Purcell Trench at Bonners Ferry, Idaho, 30 miles south of the international boundary. From there, it follows a sluggish, meandering course for 50 miles along the bottom of the Trench to Kootenay Lake. This reach of river is actually a delta, where the river deposits its sediment load in a large alluvial plain that is encroaching on Kootenay Lake at the rate of 15 feet per year. Much of the river has been dyked along this reach to reclaim the alluvial plain for agriculture[6]. The flow in this portion of the Kootenay River has been regulated since 1972 by the Libby Dam in Montana. The Kootenay River supplies roughly 60 percent of the inflow to Kootenay Lake, while the Duncan River supplies another 20 percent and the remaining 20 percent is contributed by the numerous small tributaries of Kootenay Lake. The outlet of Kootenay Lake is located at the Corra Linn Dam, which controls the level of the lake, except under high flow conditions[6]. The Corra Linn Dam has arbitrarily been selected as the boundary between Regions 5 and 6 for the purposes of this study.

A brief summary of the streamflow in the Kootenay, Lardeau, Duncan and Goat Rivers is contained in Table 5-1.

1.5.2 Lakes

The major lakes within the region are Kootenay Lake and Duncan Lake.

The main body of Kootenay Lake is a long, relatively narrow body of water which occupies the bottom of the Purcell Trench at an elevation of about 1745 feet. It is 65 miles long, has a maximum width of 4 miles, and a mean depth of 335 feet. The West Arm of Kootenay Lake, which drains the lake westwards toward the Columbia River, is 22 miles long with a maximum width of about one mile and a mean depth of 43 feet. The total area of the lake is 161 square miles. The theoretical retention times in the lake are 1.5 years in the main body of the lake and 5.5 days in the West Arm[7].

The outlet of Kootenay Lake is on the West Arm at the Corra Linn Dam, which has controlled the water level of Kootenay Lake since 1939. More recently, the Duncan and Libby dams, which were completed in 1967 and 1972, respectively, have affected the water levels in Kootenay Lake by the storage of spring flood waters in their reservoirs. A more detailed account of the effects of the Corra Linn, Libby and Duncan dams on Kootenay Lake is given in section 3.6.

Duncan Lake is located in the Purcell Trench, approximately five miles north of the northern end of Kootenay Lake. With the closure of the Duncan Dam in 1967, Duncan Lake was flooded to form the reservoir of the dam. The area of the lake was increased from about 13 square miles to 28.8 square miles (at normal full pool elevation) by flooding nearly 16 square miles of land along the shores of Duncan Lake and the Duncan River.

At normal full pool elevation the reservoir has a length of 28 miles and a maximum width of 1.5 miles[8,9]. The lake levels are now regulated for the purposes of flood control and downstream power generation[10]. Further details regarding Duncan Lake are given in section 3.6.3.

1.5.3 Groundwater

Information regarding groundwater in the region is limited mainly to data submitted voluntarily by well drilling companies. It has been estimated that between 50 and 75 percent of the wells drilled have been recorded in this manner[11]. A review of these data indicated that only 55 wells have been recorded in Region 5. Twelve of these wells are at Creston, 10 are in the Willow Point-Macdonalds Landing area on the West Arm of Kootenay Lake and six are at Nelson. The remaining wells are scattered throughout the region as shown in Table 5-2.

Flows of 50 to 500 GPM per well are generally available in the Purcell Trench south of Kootenay Lake and along the West Arm of Kootenay Lake[12].

1.5.4 Dams

The major dams within Region 5 are the Corra Linn Dam on the Kootenay River, the Duncan Dam on the Duncan River, and the Goat Dam on the Goat River. The Libby Dam on the Kootenay River at Libby, Montana, lies outside of the region, but does exert an effect on Kootenay Lake. A discussion of these dams and their effects is presented in section 3.6.

1.6 Water Uses

1.6.1 Water Licenses

An analysis of the water licenses issued in the region by the Water Rights Branch[13] shows that water usage is allocated as follows:

Consumptive Uses	Acre-Feet Per Year	
Domestic	20,570	
Industrial	510	
Irrigation	16,800	(12,000 acres irrigated)
Mining	4,805	
Conservation	53,820	
Bathing	152	(swimming pools)
Power	214,760	

The cities of Nelson and Cranbrook, the Town of Creston and the Village of Kaslo account for about 83 percent of the licensed domestic water usage. (Cranbrook receives water diverted from the Moyie River). The balance is distributed among numerous small users throughout the region. Approximately 70 percent of the irrigation water usage (and acreage irrigated) is concentrated in the Creston Flats area, while the remaining 30 percent is distributed among numerous very small users scattered throughout the arable lands of the region. The conservation projects in the Creston Valley Wildlife Management Area account for over 93 percent of the water licensed for conservation purposes. The water license for the Goat River Dam represents two-thirds of the water licensed for power generation.

The major sources of water supply within the region are shown as a summary of water licenses in Table 5-3. Only those sources with a licensed water usage of more than 40 acre-feet per year (30,000 GPD) are included.

1.6.2 Water Availability

Generally, good quality water sources are adequate to meet water supply needs. In some areas however, increasing population and development are imposing heavy demands on the water sources. These areas include Creston Flats (especially on the east side of Kootenay River), and areas in the vicinity of the City of Nelson. The water sources which are limited in these and other areas of the region are summarized in Table 5-4.

1.7 Settlements and Industrial Centres

The major settlements within the region are the City of Nelson, the Town of Creston and the Village of Kaslo whose populations in 1971 were 9,400, 3,204, and 755, respectively[14]. The 1971 populations of other settlements within the region are listed in Table 5-5. The total population of the region in 1971 is estimated to have been about 25,000.

There are no major industrial centres within the region.

1.8 Land Use

1.8.1 Agriculture

The Creston area in Region 5 is the most important agricultural area in the Kootenays. It accounts for 50 percent of the value of all Kootenay agricultural production. About 30,000 acres are under cultivation in the Creston area, producing mainly grain (wheat, oats and barley), hay and pasture. Beef cattle (6000 head) and dairying (1200 head) are the major livestock activities. The development of irrigation water supplies could bring an additional 16,000 acres of the benchland in the Creston area into production[15].

Other areas of Region 5, suitable for agriculture, are found in scattered pockets along the Moyie River, Kootenay Lake and the West Arm of Kootenay Lake. The farms in these areas tend to be small, part-time operations, with only one farmer in ten being self-supporting[15].

1.8.2 Forestry

Forest harvesting operations in Region 5 are mainly located in the upper third of the region, north of Kootenay Lake as shown in Figures 5-2 and 5-3. Existing operations are centred around the Lardeau and Duncan rivers, Duncan Lake, and Howser and Glacier creeks. Scattered and smaller areas are being logged in the rest of Region 5 on lands drained by the Moyie River and its tributaries.

1.8.3 Mining

There was relatively little mining in the Kootenay Lake Basin during 1972 and 1973[16]. Silver Hoard Mines Ltd., located two miles northwest of Ainsworth, produced 891 tons of ore in 1973 which was trucked to the smelter at Trail. The Bluebell Mine at Riondel was shut down in December 1971, but 65 tons of lead concentrate were salvaged from Kootenay Bay in 1973. The Nor Mine, located 3 miles northwest of Ainsworth, shipped 74 tons of ore to Trail in 1973. The Crawford Creek Dolomite Quarry produced 50,000 tons of limestone building stone in 1972. A brief summary of the mineral production in the region during 1972 and 1973 is contained in Table 5-6.

Gold placer mining has occurred in the past along the Moyie River, Weaver Creek, Palmer Bar Creek and Forty-nine Creek[17]. Reports of the B.C. Department of Mines and Petroleum Resources indicate that, with the exception of some exploration on the Moyie River, no placer mining activity has taken place in Region 5 during the years 1969 to 1973, inclusive[16]. There was a proposed placer development on the Moyie River, but it was considered to be uneconomical and development in the near future is not expected[18].

1.8.4 Recreation

Kootenay Lake (165 square miles) is a focus for intensive water-orientated recreation in Region 5. Many creeks entering the lake have formed natural alluvial beaches. These locations have been assigned Canada Land Inventory (C.L.I.) ratings of class 2 and 3 for angling, camping and boating[19,20]. Examples include the mouths of Cultus, Midge, Sanca, Crawford, Campbell and Carney Creeks. However, recreational capability of the main lake body is limited by open water, wind, wave hazard to small craft, and lack of natural harbours. Crawford Bay represents the only extensive protected boating area on the main lake.

The West Arm of Kootenay Lake, between Nelson and Balfour, offers more frequent and better shore-based recreational opportunities[19], including numerous beaches, and cottaging, camping and angling. However, currents produced by drawdown on the downstream hydro dams may conflict with small craft activity. Below Nelson, most recreation is restricted by the dams, except for angling. The Grohman Narrows area, between Nelson and Taghum in particular, supports a popular concentrated fishery.

South of Kootenay Lake, Duck and Leach lakes and associated sloughs, offer canoeing, wetland wildlife viewing, and waterfowl observation and hunting. Some angling and camping is available throughout the Creston area[19]. Moyie Lake (4.5 square miles), 12 miles south of Cranbrook, has received a C.L.I. class 2 rating[15,19]. The lake provides a blend of swimming, boating, angling and a public campsite at the north end. Both the lower Moyie and Goat Rivers have canoeing and angling potential.

North of Kootenay Lake, Duncan and Lardeau River and Duncan Lake offer fairly intensive water-based recreational opportunities. Highest capabilities exist between the north and south arms of the 29 square mile Duncan Lake (boating, camping) and at the Duncan Dam[20]. The Lardeau River, offers views of spawning fish, angling, camping, and mountain scenery. Duncan River below Duncan Lake provides limited waterfowl viewing, and above Hume Creek, flows through an area with good streamside camping potential.

Streams and lakes in the region support an active fishery. Rainbow trout and Dolly Varden char to 20 lb in Kootenay Lake and to 8 lb in Moyie Lake, can be taken by trolling[15]. Kokanee to 6 lb are an important late summer catch in Kootenay Lake. Other species include mountain whitefish, cutthroat trout, Eastern brook trout (Moyie Lake), ling (Kootenay Lake), sturgeon (Kootenay River at Creston) and bass (Duck and Leach Lakes near Creston).

Special attractions associated with Kootenay Lake include Ainsworth Hot Springs, Cody Caves (north of Balfour), and historical sites at Kaslo. Provincial parks and wilderness areas in Region 5 are listed in Table 5-7[15,21].

Intensive recreational use of the upland is restricted by adverse climate. Numerous small subalpine and alpine lakes and watercourses in the Selkirk and Purcell ranges have limited recreational capability. Areas of note include 64,000 acre Kokanee Glacier Provincial Park (skiing, glacier scenery), Toad and Dominion Mountains south of Nelson (skiing), Glacier Creek headwaters (skiing) and Cooper and Monroe Lakes west of Moyie Lake (angling, camping)[19,20].

1.8.5 Wildlife

Snow depth, particularly above 3500 feet elevation, is the main factor limiting wildlife distribution in Region 5. Highest Canada Land Inventory (C.L.I.) wildlife capability ratings (class 2 and 3) are given to winter range territory below 4000 feet in the main valleys. Areas below 6000 feet provide class 6 summer range for a variety of wild ungulates[22,23].

Wildlife winter range is fairly restricted in extent. Small areas of class 2 range are located on the west side of Kootenay Lake around the mouths of Cultus and Midge creeks, and Kaslo River. The rest of Kootenay Lake margin, the West Arm, Duncan Lake margin, lower Goat River, and Kootenay River flood plain south of Kootenay Lake to the international boundary are a mixture of class 3W and 2W winter range[22,23].

Mule deer are the only wild ungulates in abundance. Their preferred habitat is on south and west facing slopes below 4000 feet, particularly along the east side of Kootenay Lake and north side of the West Arm[15]. Scattered herds of elk occur in the Purcells, and mountain caribou are found at high elevations in the Moyie Range and in Kokanee Glacier Provincial Park. Moose are the least abundant ungulate in the region.

Upland game birds found in the region include blue, spruce and ruffed grouse in wooded cover, sharp-tailed grouse in mixed grassland-forest, and ptarmigan on open alpine slopes. The Creston flats support a large population of ring-necked pheasants, which feed on grain stubble[15].

Waterfowl production throughout most of the region is limited by adverse topography and climate[24,25]. There is little marsh edge available or water is too deep. The outstanding exception is the Kootenay River floodplain, south of Kootenay Lake, which is one of the most significant waterfowl migratory staging and production areas in the B.C. Interior[15,24]. These wetlands are rated by the C.L.I. as a mixture of class 2, 3S and 3M[24]. There is some habitat limitation due to seasonal flooding. Part of the Creston wetlands have been jointly acquired by the Federal and Provincial governments as a planned waterfowl management area.

Marshes between Duncan and Kootenay lakes and above Duncan Lake are also important for waterfowl production. However, this importance has been reduced by flooding caused by the Duncan Dam. Damming of the Duncan River has resulted in the West Arm of Kootenay Lake being increasingly used as a wintering area[25].

2. INDUSTRIAL EFFLUENTS AND SOLID WASTES

2.1 Silver Star Mines Limited (N.P.L.)

2.1.1 Description

A mill to concentrate lead zinc ore was established south of Ainsworth in 1950 and operated until 1970. About 500,000 tons of ore was processed during this time and 90 percent of the ore was processed during the first 10 years. The mill started up again in early 1975. The location of the mill is denoted in Figure 5-2, by its Pollution Control Permit number, 3564.

The ore comes from a mine 14 miles northwest of the mill, and mill processing consists of size reduction, classification and flotation. The concentrates are shipped to Trail. A simplified process flow diagram is shown in Figure 5-4.

Effluents are mainly from thickeners, filters and zinc flotation. Untreated liquid wastes are discharged 150 feet below the surface of Kootenay Lake which is considered to be below the level of any significant biological action in the lake. A bubble capture system has been designed to prevent wastes from floating to the surface.

The Company obtained Pollution Control Permit number PE-3564 for the discharge on October 21, 1974. The permit allows the discharge of a maximum of 30,000 GPD and a maximum of 50 tons per day of ground rock solids into Kootenay Lake[29]. The concentrations of cyanide and heavy metals in the effluent must meet level A of the Mining Objectives[30]. Further permit details are given in Table 5-8.

2.1.2 Effluent Data

Effluent monitoring has just begun and an evaluation of all data collected will be given in our Phase II report.

2.2 Canadian Pacific Railway Company (Nelson)

2.2.1 Description of Effluent Discharges

The Canadian Pacific Railway Company has a railway station, transport terminal, telecommunications building, diesel locomotive service shop and car repair shop in Nelson. The C.P.R. first applied for a Pollution Control Permit (application number AE-2293) on August 22, 1972. However, this application did not meet certain requirements of the Pollution Control Branch. The latest application from the Company, AE-4294, was submitted April 19, 1976 and is currently being assessed. A general description of the application is given in Table 5-9 with further details presented in Table 5-10. The location of the C.P.R. facilities is denoted in Figure 5-5, by its Pollution Control application number, 4294.

The C.P.R. has applied for seven effluent discharges. Six of the effluents, containing domestic sewage, boiler water and cooling water are discharged untreated to Cottonwood Creek. The seventh effluent, from the diesel locomotive service shop, is discharged to the ground. The Company is considering removing the six effluents from Cottonwood Creek and discharging them to the Nelson sewer system. The diesel locomotive service shop effluent may also eventually be discharged to the Nelson sewer system after adequate pretreatment, although the shop is used now only to carry out repairs on running stock[31].

2.2.2 Evaluation of Effluent monitoring Data and Recommendations

The effluent data contained in Table 5-10 were given by the CPR in their application for a Pollution Control permit. The values generally appear to be reasonable, although the suspended solids and BOD_5 concentrations of the domestic sewage discharges may be unrealistically low.

Cottonwood Creek is a small stream which drains about 25 square miles in the Bonnington Range south of Nelson. Only a few flow measurements have been made on Cottonwood Creek, but two of its tributaries, Selous and Giveout Creeks, which comprise nearly one-half of the Cottonwood Creek basin, have been gauged. Spring freshet flows of up to 800 CFS have been observed in Cottonwood Creek[32]. The lowest flows occurred from mid-August through February. Based on the flow records for Selous and Giveout Creeks and the water licenses in the Cottonwood basin, we estimate that seven day average low flows in the order of one to two CFS could occur once every two or three years[13,33]. Cottonwood Creek also receives storm water from at least five storm sewers in the City of Nelson[34].

According to their permit application, the C.P.R. is discharging an average of 40,000 GPD (0.075 CFS) of effluent to Cottonwood Creek. Of this flow, 22,500 GPD (0.042 CFS) is cooling water, which is City of Nelson tap water that has been heated to 32 to 35°C. The cooling water has only a moderate thermal effect which is not considered significant. The remaining 17,500 GPD (0.033 CFS) contains raw domestic sewage, boiler blowdown and return condensate. These effluents have high concentrations of BOD_5, suspended solids, total solids and fecal coliforms and high pH levels. However, dilution available in Cottonwood Creek at low flows (one to two CFS) is in the order of at least 30 to one. Thus, apart from public health hazards associated with the discharge of raw sewage, the effluents should not seriously impair the water quality of Cottonwood Creek. Since these effluents are discharged between 800 and 1200 feet from the point where Cottonwood Creek enters the West Arm of Kootenay Lake, the large dilution available in Kootenay Lake means that only the lower 1200 feet of the Creek should be affected.

The C.P.R. also discharges an average of 6,000 GPD of effluent to the ground in an exfiltration pond located 200 feet from Cottonwood Creek and 800 feet from Kootenay Lake. The effluent is unacceptable for discharge to surface waters since it contains appreciable concentrations of oil and grease. The exfiltration pond is located on the alluvial fan formed by Cottonwood Creek as it enters Kootenay Lake. A second oil exfiltration pond, not mentioned in the C.P.R. application, is located near the first exfiltration pond and overflows to the large deposit of woodwastes adjacent to the C.P.R. property.

Down-gradient from the oil exfiltration ponds are deposits of municipal refuse located beneath the Nelson Airport. The groundwater beneath the airport is contaminated with oil and grease (section 3.2.3). Oil has been observed seeping out along the foreshore of Kootenay Lake opposite the airport[35]. It is quite probable that a portion of the contaminants in the groundwater beneath the airport originate from the oil exfiltration ponds.

Another danger with the first exfiltration pond is from accidental spills in the diesel service shop which have caused the pond to overflow to Cottonwood Creek. This pond has been in use since 1954 and has apparently worked adequately except when spills and clogging of the bottom of the pond have caused overflows[32].

We have not recommended a specific monitoring program since the discharges appear to have a relatively small impact. The two stations on Cottonwood Creek, which are recommended in the monitoring program for the City of Nelson landfill, (section 3.2.3) should also be adequate in assessing the effects of the C.P.R. discharges.

2.2.3 Description of Solid Waste Disposal

Canadian Pacific Railway conducts rail-car cleaning operations on a spur near the West Arm of Kootenay Lake in Nelson. Solid wastes from these cleaning operations have been deposited in a landfill along the spur adjacent to Kootenay Lake for many years. In March, 1973, C.P.R. applied for a permit (application number AR-2294) to discharge 10 cubic yards of solid waste per day to this landfill. The Pollution Control Branch advised C.P.R. that the landfill site was unsuitable, and C.P.R. closed the landfill in May, 1973. Since then, C.P.R. was to have used the City of Nelson municipal landfill (PR-1663), which is located immediately adjacent to the C.P.R. landfill[36]. On January 15, 1976 the Company submitted a second application to use their landfill (AR-4295).

Since the C.P.R. landfill is in such close proximity to the larger City of Nelson municipal landfill the two are discussed together under the City of Nelson landfill in section 3.2.3. A summary of pertinent information regarding the landfill is contained in Table 5-11 and its location is denoted in Figure 5-5 by its Pollution Control Branch application number, 4295.

2.3 Kootenay Forest Products Limited (Nelson)

2.3.1 Description of Effluent Discharges

Kootenay Forest Products Limited operates a plywood plant, a sawmill and a planer mill in the City of Nelson. The complex is located on the shore of the West Arm of Kootenay Lake at the mouth of Anderson Creek, as shown in Figure 5-5. The Company applied for a Pollution Control Permit (application number AE-2705) for effluent discharged from the plant on September 14, 1973. Details regarding the application are contained in Table 5-9.

A simplified process flow diagram showing major sources of effluents and solid wastes is given in Figure 5-6. Logs are delivered to the log holding pond in Kootenay Lake by tug or truck and are mechanically debarked and trimmed before proceeding to either plywood or lumber production. In plywood production, the logs are soaked for 8-10 hours in conditioning vats, and peeled on lathes to produce veneer. The veneer is then dried, glued and pressed to form rough plywood sheets. The rough plywood is trimmed and sanded to make finished plywood for market. In lumber production, the logs are sawn into rough lumber which is dried in a kiln, and planed to produce finished lumber for market.

The effluents originating from the complex include cooling waters from pumps and compressors, boiler blowdown, log conditioning vat overflows, conditioning water tank clean-out, veneer dryer washdown, washdown from maintenance shop, and domestic sewage. Most of the log conditioning vat water and all of the glue spreader washdown water (phenolic resin base glue is used) are recycled. The storage of logs in Kootenay Lake contributes wood, bark and leachates to Kootenay Lake. Domestic sewage from the complex is discharged either to the City of Nelson sewer system or to septic tanks and tile fields. The rest of the effluents are discharged untreated to Kootenay Lake or Anderson Creek as shown in Figure 5-6.

The quantity of each effluent discharged is not known, but Kootenay Forest Products applied to discharge an average of 34,000 GPD (0.063 CFS) and a maximum of 40,000 GPD (0.074 CFS). Kootenay Forest Products is negotiating with the City of Nelson to discharge its effluents (except cooling water) to the City's sewer system.

2.3.2 Evaluation of Effluent Monitoring Data

Effluent quality data are presented in Table 5-12 and were obtained by the Pollution Control Branch from miscellaneous samples taken in 1973 and 1974. The flow data in Table 5-12 were provided by Kootenay Forest Products Limited staff and were reasonable estimates of actual flows.

The two most potentially harmful effluents from the plant are the glue spreader washdown and the log conditioning vat water. The glue spreader washdown water is completely recycled (solids are landfilled) and the log conditioning water is recycled with the exception of overflows and the weekly cleanout of the conditioning water recycle tank. These practices follow the recommendations given in the Pollution Control Objectives for the Forest Industry[37]. Generally the discharge of boiler blowdown, log conditioning vat water, veneer dryer washdown and maintenance shop washdown is not allowed without treatment. Cooling water can usually be discharged untreated.

The boiler blowdown had high pH, temperature, colour, and dissolved solids, but the flow was only 2,000 GPD and thus the quantity of contaminants discharged to Kootenay Lake was small. Similarly, the conditioning vat water had a low pH, high temperature, colour, suspended solids, organic carbon, BOD_5, and tannins and lignins, but the flow was relatively small. A maximum of 6,000 gallons of conditioning vat water was discharged once per week during the cleanout of the vat water recycle tank. Vat water was also discharged occasionally when yard runoff entering the vats caused the vats to overflow to Kootenay Lake.

The quality and quantity of the veneer dryer washdown and maintenance shop washdown have not been measured. Data from other plywood mills[38], indicate that veneer dryer washdown has a high pH and high concentrations of total solids, suspended solids, BOD_5 and tannins and lignins. The washdown may also contain high concentrations of caustic cleaner used to remove pitch on the veneer dryer. The veneer dryers at Kootenay Forest Products are washed down once per week and the volume of washdown produced could range between 3,000 and 15,000 gallons. The maintenance shop washdown contains oils and greases and probably has a high solids content. This discharge is probably relatively small and intermittent.

The effluents are discharged to the West Arm of Kootenay Lake and to Anderson Creek. The seven day average low flow in the West Arm of Kootenay Lake, with a ten year recurrence interval, is 6,000 CFS[33]. The average seven day low flow in Anderson Creek is one CFS every year and 0.5 CFS every other year[33]. The dilution available in Kootenay Lake at low flow is in the order of 65,000:1, assuming 50,000 GPD or 0.092 CFS discharged to Kootenay Lake. The dilution in Anderson Creek at low flow is about 25:1, assuming 10,000 GPD or 0.02 CFS discharged to Anderson Creek. With these dilutions it is improbable that the effluents could adversely effect Kootenay Lake. There could be some localized water quality deterioration at the mouth of Anderson Creek and along the shore of Kootenay Lake in front of the mill. The area of Kootenay Lake in front of the mill is also used for log storage which probably contributes more contaminants to Kootenay Lake than the effluents do. Kootenay Lake water quality data obtained at stations upstream and downstream from Kootenay Forest Products Limited indicate that there was no detectable change in water quality from upstream to downstream (refer to section 4.3.5 for a discussion of water quality in the West Arm of Kootenay Lake).

A site investigation and receiving water monitoring program has been recommended for the landfill and log storage area at Kootenay Forest Products Limited (section 2.3.4). This program will serve to assess the extent of any localized water quality deterioration in Kootenay Lake due to the effluent discharges, the landfill and the log storage area.

2.3.3 Description of Solid Waste Disposal

Solid wastes from the Kootenay Forest Products Limited complex have either been burned in a wood-waste burner or deposited in a landfill located on the foreshore of the West Arm of Kootenay Lake. At present, most of the wood-wastes from the complex are deposited in a landfill operated by the City of Nelson (PR-3703) (section 2.4). In June 1973, Kootenay Forest Products Limited applied for a permit (application number AR-2704) to discharge 20 cubic yards of solid waste per day to their foreshore landfill. The Company has proposed to construct a dyke along the foreshore and to fill the area between the dyke and shore with solid wastes[39].

The quantity of solid wastes present in the existing landfill is not known, but solid wastes deposited in the landfill have included wood-wastes, ashes, clinkers, log pond dredgings, and sludges from the glue spreader sump (phenolic resin base glues used) and log conditioning vats (Figure 5-7).

The landfill is located on the foreshore of Kootenay Lake and is subject to flooding. A summary of pertinent information regarding the landfill is contained in Table 5-11 and its location is denoted in Figure 5-5 by its Pollution Control application number, 2704.

2.3.4 Evaluation of Landfill Site and Recommendations

Groundwater contamination is not of concern at this landfill since it is located on the lakeshore and there are no wells nearby. The main concern is leaching from the landfill to Kootenay Lake via flooding, surface runoff and groundwater flow from beneath the landfill. Of particular concern are the phenolic glue residues which have been deposited in the landfill.

The foreshore and lake adjacent to the landfill are extensively used for log booming and storage. These log booming areas are known to contribute contaminants to water which are similar to those which may be leached from wood-waste landfills. Thus, the detection of leaching from the landfill to Kootenay Lake will be hampered by the presence of the booming grounds.

Kootenay Lake water quality data obtained at stations upstream and downstream from the Kootenay Forest Products complex indicate that there was no detectable difference in water quality from upstream to downstream (refer to section 4.3.5 for a discussion of water quality in the West Arm of Kootenay Lake). It is probable that leachate from the landfill or the log booming grounds is rapidly diluted beyond detection in the West Arm of Kootenay Lake. There could be some localized water quality deterioration in the lake near the landfill and booming grounds before mixing occurs with the main body of the West Arm.

We recommend that a monitoring program be undertaken to determine the effect of the landfill and booming grounds on the water quality of the lake near the Kootenay Forest Products complex.

Samples should be collected at four sites located on the West Arm of Kootenay Lake near the Kootenay Forest Products complex. These sites should be sampled four times (spring, summer, fall and winter) for the following parameters:

alkalinity, total	pH
carbon, organic	phenol
colour	phosphorus, total
conductance, specific	tannins and lignins
nitrogen, total	temperature
oxygen, dissolved	turbidity

Field observations should include the direction and speed of currents, the occurrence of floating wood-wastes, the area occupied by the booming grounds, and the extent of bark and wood deposits on the lake floor.

2.4 City of Nelson Industrial Landfill Site

2.4.1 Description of Solid Waste Disposal

The City of Nelson initiated a landfill operation along the West Arm of Kootenay Lake in Nelson in early 1975 using wood-wastes from the Kootenay Forest Products Limited complex located in Nelson. The landfill was undertaken to enable the phasing out of Kootenay Forest Products' wood-waste burner and to raise the foreshore for a marina and park development. The landfill is authorized by Pollution Control Permit number PR-3703 which allows the discharge of 1200 cubic yards per day (160 tons per day) of wood-wastes. A summary of the pertinent information regarding the landfill is presented in Table 5-11. The location of the landfill is denoted in Figure 5-5 by its Pollution Control permit number, 3703.

The landfill will be separated from Kootenay Lake by a gravel dyke lined with six mil polyethylene sheeting and six inches of silt or clay. The site is underlain by at least 10 feet of relatively impervious clayey silt. Most of the landfill site lies below the level of high water on Kootenay Lake. The estimated life of the landfill is one year, and up to 58,400 tons (438,000 cubic yards) of wood-wastes could be deposited on the site. The City of Nelson wishes to extend the area of fill in the future. Four groundwater monitoring wells have been installed around the landfill.

2.4.2 Evaluation of Landfill Site

Groundwater contamination is not of concern at this landfill since it is located on the lakeshore and there are no wells nearby. The main concern at the site is leaching from the landfill to the lake. On June 19, 1975 the landfill was leaching through a 300-foot unlined section of the dyke, discolouring Kootenay Lake for a distance of about 30 feet into the lake. There did not appear to be any leaching through lined sections of the dyke.

Based on research conducted at the University of British Columbia[40], it is estimated that an absolute maximum of: 1,580 tons of COD, 470 tons of BOD_5, 380 tons of tannin-like compounds, 11,680 lb. of nitrogen and 2,570 lb. of phosphorus could be leached to Kootenay Lake from the 58,400 tons of wood-wastes that are to be deposited in the landfill. In practice, it is unlikely that all of these contaminants will be leached to the lake, and in any event they will be leached out at a slow rate over a relatively long period of time.

Any leachate that does reach Kootenay Lake would quickly be diluted beyond detection because of the large flow (mean annual flow is 28,300 CFS) in the West Arm of Kootenay Lake. For example, if the entire 1,580 tons of leachable COD entered Kootenay Lake in a one-year period, then the resulting average increase in COD concentration in the lake would only be 0.06 mg/l, assuming complete mixing. The landfill is not considered to be a significant source of nitrogen or phosphorus.

There could be some localized water quality deterioration along the foreshore of the landfill before mixing with the main body of the West Arm occurs. Mixing with the main body of the lake may be slow due to the presence of a large back eddy which flows west to east along the south shore of the lake in Nelson.

2.4.3 Recommendations

We recommend that a monitoring program be undertaken to assess the effect of the landfill on the water quality of Kootenay Lake adjacent to the landfill.

Water samples should be collected at four sites located on the West Arm of Kootenay Lake adjacent to the landfill. These sites should be sampled four times (spring, summer, fall and winter) for the same 12 parameters listed in section 2.3.4. Field observations should be made on the direction and speed of currents.

2.5 Wynndel Box and Lumber Company Limited (Wynndel)

2.5.1 Description of Solid Waste Disposal

The Wynndel Box and Lumber Company Limited operates a sawmill-planer complex on the Creston Flats near Wynndel. The mill has been in operation since 1913. Wood-wastes from the mill have been disposed of in a landfill near Wynndel for many years. In 1973, Wynndel Box applied to the Pollution Control Branch for a permit (application number AR-2369) to discharge 74 cubic yards per day of wood-wastes to this landfill. The Pollution Control Branch considered this landfill site to be unsuitable, and Wynndel Box submitted a second application in February, 1975 (AR-4318) for an alternate site. A summary of the pertinent information regarding the landfills is presented in Table 5-11. The locations of the landfills are denoted in Figure 5-11 by their Pollution Control application numbers, 2369 and 4138. The Company is also negotiating with a local food processor for disposal of the wood-wastes in a hog fuel boiler.

The existing landfill is located on the alluvial floodplain of the Kootenay River and the underlying soils are poorly drained, silt loam with a high organic content. The site has a high water table and parts of it are subject to flooding. Some of the land drainage channels near the site have been filled with wood-wastes. It is estimated that the landfill occupies an area of eight to nine acres. The volume of wood-wastes present in the landfill is not known. Open-burning of the wood-wastes was practiced in the past and thus the landfill probably contains considerable amounts of ash.

The proposed site is 200 feet east of the existing site and is currently zoned for agricultural use only. Suitability of the site is being assessed by the Pollution Control Branch.

2.5.2 Evaluation of the Existing Landfill Site

Leaching from the landfill to the surrounding waters is certain to occur because of the high water table, and because of the flooding of wood-wastes deposited in and near drainage channels. Leaching to groundwater is not considered to be a problem since the underlying soils are poorly drained, fine-grained soils which tend to retard and rapidly attenuate leachate movement. In any case, there are no groundwater wells in the area and the groundwater is probably of poor quality because of the high organic content of the soils.

Leaching of the wood-wastes deposited in and near the drainage channels by surface waters appears to be the main problem. The main drainage channel eventually flows to Duck Lake which is located 3.3 miles downstream from the landfill.

2.5.3 Recommendations

We recommend that a monitoring program be undertaken to determine the effect of the landfill on the water quality of the drainage channel to Duck Lake.

Samples should be collected at four sites located along the drainage channel between the landfill and Duck Lake. These sites should be sampled four times (spring, summer, fall and winter) for the same 12 parameters listed in Section 2.3.4. Field observations should include measurement of the flow in the drainage channel and the occurrence of floating wood-wastes.

2.6 Kootenay Forest Products (Harrop)

2.6.1 Description of Solid Waste Disposal

Kootenay Forest Products operates a log sorting operation near Harrop on the West Arm of Kootenay Lake (Figure 5-3). Logs are towed in booms along

Kootenay Lake to the log sorting area, where they are taken from the water, sorted by species, bundled, returned to the water and towed to the Kootenay Forest Products complex in Nelson. Wood-wastes from the log-sorting area are deposited in a landfill along the West Arm of Kootenay Lake. The landfill is authorized by Pollution Control Permit number PR-2395, issued in January, 1974, which allows the discharge of 1000 cubic yards of wood-wastes per year. A summary of pertinent information regarding the landfill is contained in Table 5-11. The location of the landfill is denoted in Figure 5-3 by its Pollution Control Permit number 2395.

2.6.2 Evaluation of the Landfill and Recommendations

The potential for leaching at this site is low because the site is above the high water level on Kootenay Lake, and surface streams have been diverted around the landfill. Precipitation may penetrate the landfill and leach contaminants to Kootenay Lake via the permeable sands and gravels underlying the site, but since the landfill is small the quantity of leachate should be small. Two groundwater monitoring wells are required at the site to assess this possibility.

The area of Kootenay Lake adjacent to the landfill is used for log booming and thus detection of leachate in Kootenay Lake would be hampered by the presence of contaminants leached form the boomed logs. We believe that more contaminants are leached from the logs boomed in the lake than from the landfill.

Kootenay Lake water quality data obtained at sites upstream and downstream from Kootenay Forest Products at Harrop indicate that there was no detectable difference in water quality from upstream to downstream. (Refer to section 4.3.5 for a discussion of water quality data in the West Arm of Kootenay Lake). Any leachate from the landfill and booming grounds is probably rapidly diluted beyond detection in the West Arm of Kootenay Lake.

There may be some localized water quality deterioration in the lake near the Kootenay Forest Products log-sorting operation before mixing with the main body of the West Arm occurs.

We do not recommend a specific monitoring program for this site during Phase II of this study.

2.7 Crestbrook Forest Industries Limited (Creston)

2.7.1 Description of Solid Waste Disposal

Crestbrook Forest Industrids Limited operates a sawmill in the Town of Creston, near Deadhorse (Dodd) Creek. Wood wastes from the mill are disposed of in a landfill located in the ravine of Deadhorse Creek. Deadhorse Creek flows inside a series of concrete and steel culverts beneath the landfill. The landfill is authorized by Pollution Control Permit number PR-1748, issued in April, 1974, which allows the discharge of 24 cubic yards per day of wood-wastes. A summary of pertinent information regarding the landfill is presented in Table 5-11. The location of the landfill is denoted in Figure 5-11 by its Permit number, 1748.

2.7.2 Evaluation of the Landfill Site and Recommendations

Groundwater contamination does not appear to be a problem at this site since the soils are relatively impermeable and there are no wells within a half mile of the site. Leachate from the landfill site could enter the culvert system beneath the site and thus contaminate Deadhorse Creek. Deadhorse Creek is very small, with a drainage area of about four square miles at the landfill, and probably carried no more than one to two cubic feet per second during low flow periods.

We recommend that Deadhorse Creek be sampled at one site upstream and at one site downstream from the landfill to determine if leachate is entering the creek. Samples should be taken twice (spring and summer) and analysed for the same 12 parameters listed in section 2.3.4. The flow in Deadhorse Creek should also be measured during sampling.

2.8 Minor Industries

2.8.1 Effluents

A review of Pollution Control Branch files indicated that there were nine sources of industrial effluent in Region 5 other than those which have already been discussed. These sources included: two abattoirs at Creston (AE-2528 and PE-3949), two laundromats, one at Yahk (PE-1519) and one at Kaslo (PE-2372), two vegetable washing plants at Wynndel (PE-2237 and PE-2276), a concrete truck washout operation at Creston (PE-2206), a swimming pool at Ainsworth (PE-2519), and a limestone quarry at Crawford Bay (PE-2783). Additional details regarding each of these effluent sources can be found in Tables 5-8 and 5-9 under the Pollution Control permit or application number. Their locations are shown in Figures 5-2, 5-3 and 5-11 by their Pollution Control permit or application numbers.

These effluents are not discussed in detail since a review of the information regarding each discharge indicates that their potential for adversely affecting groundwater or surface water is negligible.

2.8.2 Solid Waste

A review of Pollution Control Branch files indicated that there were five industrial refuse sites under application or permit in Region 5 besides the ones previously discussed. These sites are located at Erickson (PR-2636), Kaslo (PR-2726), Creston (AR-2629) and Wynndel (PR-2277 and PR-2238). It is judged that the potential for these sites to adversely affect groundwater or surface water is negligible. A summary of pertinent information regarding these five sites is contained in Table 5-11. The locations of the sites are shown in Figures 5-2 and 5-11 by their Pollution Control permit or application numbers.

3. MUNICIPAL AND NONPOINT SOURCES OF EFFLUENTS AND SOLID WASTES

3.1 Town of Creston

3.1.1 Description of Effluent Discharges

The town of Creston is located on the east side of the Kootenay River midway between Kootenay Lake and the international boundary. The town is the major centre in this agricultural area, and had a population of 3,204 in 1971[14]. The town has an area of 960 acres[14] and is serviced by sanitary, storm and combined sewers. The sewer system was designed to collect septic tank effluent and a septic tank was required for each connection prior to discharge to the sewer[41]. The sewer system collects septic tank effluent from a population of about 3,500 people, and industrial effluent from Columbia Brewing Company Limited, and Crestbrook Forest Industries Limited. Up to April 30, 1976 the effluent from the sewer system was discharged untreated to Deadhorse Creek which flows into the Goat River which in turn flows into the Kootenay River. Since April 30, 1976, treated effluent is discharged to the Kootenay River. The location of the discharge is denoted in Figure 5-11 by its Pollution Control permit number, 1161.

The town applied for a Pollution Control permit on December 17, 1971. A permit (PE-1161) was issued on July 10, 1972 allowing the discharge of an average of 1,000,000 GPD of treated effluent to the Kootenay River. Treatment consists of comminution, grit removal, extended aeration and chlorination prior to discharge. Sludge from the plant is sent to drying beds[41]. Additional details regarding the permit are presented in Table 5-8.

The sewage treatment plant started operating on April 30, 1976. The town is considering the upgrading of the sewer system by adding more storm sewers and larger pipes, by disconnecting the septic tanks, and by improving pipe grades[41,42].

The industrial effluent from Crestbrook Forest Industries Limited's sawmill and veneer plant has an average flow of about 8,000 GPD. This includes 4,500 GPD from log steaming vats, 860 GPD of septic tank effluent from 85 workers and 2,500 GPD of boiler blowdown[43].

Columbia Brewing Company Limited produces 20,000 GPD of beer in a batch process. Corn and malt are formed into a mash and then brewed with hops. The liquor is then fermented, stored, filtered and bottled. Effluent originates from washdowns, spent grain draining and bottle washing, and averages about 100,000 GPD. Solid wastes from the process include spent grain, yeast, diatomaceous earth and hops. The diatomaceous earth and hops are mulched while the grain and yeast are used for cattle feed[41,42].

3.1.2 Evaluation of Effluent Data and Recommendations

Effluent data were available only from applications for permit submitted by the town and industry. These data, and the resultant daily loadings in lb/day, are listed in Table 5-13. The characteristics of the domestic sewage and brewery effluent are presented separately from the effluent from Crestbrook Forest Industries Ltd. The characteristics and loading of the combined effluent were obtained by addition and should describe approximately the untreated effluent that was discharged by Creston to Deadhorse Creek.

The data in Table 5-13 indicate that the characteristics of the combined effluents were within the range normally expected for raw domestic sewage. Nutrient concentrations were not measured. Assumiming a per capita nutrient contribution of 0.02 lb/day of total nitrogen and 0.0055 lb/day of total phosphorus[44], we estimated that the 3,500 people in Creston contributed 70 lb/day of total nitrogen and 20 lb/day of total phosphorus. The quantity of nutrients contributed by the brewery and lumber mill is not known.

The discharge of untreated effluent to Deadhorse Creek caused deterioration of water quality in the lower two thirds of a mile of the Creek. The effect was particularly severe during low flow when we estimate that the creek flow was one to two cubic feet per second.

Treated effluent is now discharged to the Kootenay River. The seven day average low flow in the Kootenay River, with a ten year return period, is about 2,100 CFS[33]. At an effluent flow of one million GPD (two CFS), dilution is at least 1,000 to one. Assuming a nutrient loading of 70 lb/day of nitrogen and 20 lb/day of phosphorus, the nutrient loading would be 0.25 percent of the total nitrogen and phosphorus loading in the river at Porthill. We conclude that the effluent should not have a measurable effect on water quality of the Kootenay River. No special monitoring is recommended other than routine monitoring of the effluent required of the permittee. These data will be presented in our Phase II report on the region.

3.2 City of Nelson

3.2.1 Description of Effluent Discharges

The City of Nelson is located at the western end of the West Arm of Kootenay Lake as shown in Figure 5-3. The City was incorporated in 1897 and now functions as a service centre for the Kootenay region. The population of the City was 9,400 in 1971[14]. The City has an area of 1,897 acres of which 1,400 acres has separate sanitary and storm sewers[45].

Industry in Nelson includes the Kootenay Forest Products Limited sawmill-planer-plywood plant and the Canadian Pacific Railway service centre. The industrial effluents are not discharged to the City sewer system. (The Kootenay Forest Products complex is discussed in section 2.3 and the C.P.R. service centre is discussed in section 2.2). Further industrial development is not expected within the City boundaries. Notre Dame University is located in Nelson, and is the largest post-secondary educational institute in the area. Effluent from the University is mostly domestic sewage[45].

The City of Nelson discharged raw sewage to Kootenay Lake until June 1973 when their primary sewage treatment plant began operation. Prior to the start-up of the sewage treatment plant, the raw sewage discharges were creating health hazards at the local beaches which resulted in beach closures. The suitability of the Kootenay River as a source of drinking water was also being questioned. Inadequate dispersion of sewage and back eddies carried relatively undiluted sewage to the beaches[34].

The City's sewage treatment now consists of comminution, grit removal, settling, chlorination and discharge to Grohman Narrows on the West Arm of Kootenay Lake. (The location of the discharge is denoted in Figure 5-5 by its Pollution Control Permit number, 291). The plant began operation in June 1973, but has experienced such problems as[34]:

- hydraulic overloading due to storm water inflow and groundwater infiltration
- inadequate grit removel
- unreliable lift station pumps
- digester upsets
- erratic chlorine feed
- equipment freezing
- improperly calibrated flow measuring devices
- flooding of pump station by Kootenay Lake.

Most of these problems have been corrected, but hydraulic overloading still occurs. Dry weather flow is 800,000 GPD, but the flow can increase to 2,000,000 GPD during wet weather. Such high inflows result in decreased settling times and higher overflow rates in the settling tanks, thus decreasing treatment efficiency.

The City applied for a Pollution Control permit on May 13, 1969. Permit PE-291 was issued on July 31, 1969 allowing the discharge of an average of 1,250,000 GPD of settled and chlorinated sewage. Permit effluent quality limits were 100 mg/l of suspended solids, 140 mg/l of biochemical oxygen demand, and a coliform bacteria count of 150,000 MPN/

100 ml. Further details regarding the permit are presented in Table 5-8. The permit expired on July 31, 1972 and the City applied for a time extension on November 15, 1973. Negotiations with the City to remedy the hydraulic overloading problems are still in progress.

The City of Nelson also discharges untreated storm water to Kootenay Lake, Cottonwood Creek and Anderson Creek via storm sewers as shown in Figure 5-5[34]. Storm water flows are known to carry significant contaminant loads, but no data are available on the quantity and quality of the storm water flows in Nelson.

3.2.2 Evaluation of Effluent Data and Recommendations

The effluent data for the City of Nelson's primary sewage treatment plant are summarized in Table 5-14. The samples were taken between August 1973 and November 1974. The Pollution Control Branch took about 75 percent of the samples analysed, and the City of Nelson took the remaining 25 percent. Table 5-14 also contains a comparison of the effluent concentrations with the Pollution Control Permit limits, and the calculated average effluent loadings (lb/day). Total nitrogen and total phosphorus were not measured and concentrations of 25 mg/l for nitrogen and 8 mg/l for phosphorus were assumed in calculating these loadings. An average effluent flow of 1.25 MGPD was used to calculate all loadings.

The effluent flow data were submitted by the City of Nelson and reflect the effluent flows for the month of August 1974. Data on the efficiency of the Nelson sewage treatment plant in removing suspended solids and biochemical oxygen demand are presented in Table 5-15.

The effluent data in Table 5-14 show that the City of Nelson has consistently met the requirements of their Pollution Control Permit with regard to BOD_5 and suspended solids. The limit for total coliforms has also been met, but only two samples were taken. The permit limits for flow were met during August 1974, but due to the problems encountered with groundwater and storm water inflow, flow limits were apparently exceeded during wet weather[34].

The data in Table 5-15 indicate that the efficiency of the Nelson sewage treatment plant for removal of suspended solids ranged between 38 and 87 percent with an average of 57 percent. BOD_5 removal efficiency ranged between 26 and 77 percent with an average of 51 percent. Normally, average removal efficiencies for primary sewage treatment plants are 65 percent for suspended solids and 45 percent for BOD_5[46]. The lower treatment efficiencies occurred during periods of hydraulic overloading. The efficiency of the Nelson plant thus appears to have been satisfactory except during periods of hydraulic overloading.

The effluent loadings in Table 5-14 were calculated using an assumed flow and assumed nitrogen and phosphorus concentrations. Consequently, the loadings are order of magnitude values. The seven day average low flow in the Kootenay River at Corra Linn, with a recurrence interval of 10 years, is about 6,000 CFS[33]. Assuming complete mixing of the effluent and river water, the resultant concentration increases in the river due to the effluent loadings would be:

	Concentration increase (mg/l)	Background Concentration in Kootenay River (mg/l)
Suspended solids	0.02	3
Total solids	0.09	80
BOD_5	0.03	not measured
Total nitrogen	0.01	0.17
Total phosphorus	0.003	0.03

Thus, the increases in concentrations in the river due to the City of Nelson's effluent are negligible even under very low flow conditions. The nutrients added to the Kootenay River by the City of Nelson's effluent represent about two percent of the total phosphorus and one percent of the total nitrogen carried annually by the Kootenay River at Nelson.

The Senior Health Inspector for the area reported that there have been no beach closings at Nelson since the sewage treatment plant began operation. Health hazards have occurred downstream from the plant during abnormal treatment conditions, upsets or hydraulic overloading, but these were of short duration with acceptable quality being quickly restored when normal plant conditions resumed[47]. Decreasing the infiltration to the sewer system and improving plant operation should minimize this problem.

The water quality in the Kootenay River downstream from the sewage treatment plant was satisfactory (section 4.3.5) and adverse affects on aquatic life are not anticipated. The major concern is the possible public health hazard in the Kootenay River downstream from the plant during abnormal conditions. We recommend that routine surveillance monitoring of the effluent and the Kootenay River be maintained especially for total and fecal coliforms.

There are no data available regarding the quantity and quality of storm sewer flows in Nelson, but studies elsewhere[48,49] indicate that the contaminant loading from storm runoff could be about one quarter of that discharged from the Nelson sewage treatment plant. Contaminant concentrations in storm sewer flows are generally an order of magnitude lower than those in primary treated sewage[50]. It would be useful to quantify the contaminant loading discharged from the storm sewers in Nelson, but a relatively elaborate sampling program and study would be required[50]. Since the water quality in the West Arm of Kootenay Lake is satisfactory, a monitoring program for the Nelson storm sewers is not recommended at this time.

3.2.3 Description of Solid Waste Disposal

Solid wastes from the City of Nelson and the surrounding area (contributing population of 15,000) are disposed of in a landfill located along the West Arm of Kootenay Lake in Nelson. The landfill operation is authorized by Pollution Control Permit number PR-1663, amended June 1974, which allows the discharge of 80 cubic yards per day of municipal refuse (excluding toxic wastes) to the site. The location of the site is denoted in Figure 5-5 by its permit number, 1663. The Pollution Control Branch considers the site to be unsatisfactory since it is located immediately adjacent to Kootenay Lake and is subject to flooding and a high water table. The permit was valid until July 31, 1976. The City is considering using an incinerator to handle the wastes and has requested an extension of their permit to July 1977. A summary of pertinent information regarding the landfill site is contained in Table 5-16.

The practice of depositing solid wastes (municipal refuse, woodwastes, slag, etc.) and inert fill materials along the shore of Kootenay Lake in the City of Nelson has been conducted for many years. There is a shortage of usable land in Nelson, and thus depositing solid wastes and inert fills along the foreshore not only disposes of these unwanted materials, but also creates usable land along the lakeshore.

The landfill authorized by Pollution Control Permit PR-1663 is located on the alluvial fan formed by Cottonwood Creek as it enters Kootenay Lake. The fan is low-lying, flood-prone land which has been used for municipal refuse disposal at least since 1935. The Nelson Airport is located on a portion of the fan that was formerly used for refuse disposal [51]. Other deposits of solid waste on the alluvial fan include: a landfill operated by the C.P.R. for car-cleaning refuse (Pollution Control Application AR-4295, section 2.2.3), a large deposit of wood-wastes left on the site of an old sawmill adjacent to C.P.R. property, and slag deposits left by old mining operations. Other solid waste deposits along Kootenay Lake in Nelson include: the wood-waste landfill authorized by Pollution Control Permit PR-3703 (section 2.4.1), old deposits of municipal refuse adjacent to wood-waste landfill authorized by PR-3703, and the woodwaste landfill and log booming grounds operated by Kootenay Forest Products Limited (Pollution Control Application AR-2704, section 2.3.3). The locations of these landfills are denoted in Figure 5-5 by their Pollution Control permit and application numbers or by an appropriate label.

3.2.4 Evaluation of Landfill Site and Recommendations

It is very probable that leachates from refuse deposited on the fan are entering Kootenay Lake via groundwater flow and via flooding of the site by Kootenay Lake. The groundwater table beneath the fan is close to the surface and rises and falls through the deposited refuse as the level of Kootenay Lake fluctuates. The site has also been completely flooded in the past by high water on Kootenay Lake. (The operation of the Duncan and Libby storages now reduce the possibility of flooding). The annual precipitation (average of 760 mm) at Nelson exceeds the annual evapotranspiration (average of 560 mm). Thus there is an excess of moisture that can percolate downward through the refuse to join the groundwater flow , if it does not run off as surface flow.

Monitoring results for the Nelson landfill consist of data from two groundwater wells located within the landfill. Data are presented in Table 5-17. The wells are situated near the western end of the runway at Nelson Airport in an area which contains refuse which was burned and buried over 10 years ago.

The data from the wells indicate that the groundwater beneath the landfill was polluted. High concentrations of organic carbon, oil and grease, biochemical oxygen demand, nitrogenous compounds, tannins and lignins, and heavy metals have been measured. The quality and quantity of the groundwater that actually enters Cottonwood Creek or Kootenay Lake is not known. The flow of groundwater from beneath the landfill site is considered to be very small in comparison to the flow in the West Arm of Kootenay Lake at Nelson. The minimum daily discharge recorded for the lake is 3680 CFS and thus the dilution of groundwater is high.

The results from water quality stations located on the West Arm of Kootenay Lake indicate that the water quality upstream from the landfill (Pollution Control Branch sites 163 and 164) was the same as the water quality downstream from the landfill (Pollution Control Branch site 141). (Refer to section 4.3.5 for an evaluation of the water quality in the West Arm of Kootenay Lake). Thus, we concluded that the landfill is not adversely affecting the water quality of Kootenay Lake. There may be some localized water quality deterioration near the landfill before water mixes with the main body of the West Arm. Mixing with the main body of the lake may be slow due to the presence of a large back eddy which flows from west to east along the south shore in Nelson.

We recommend that a monitoring program be undertaken during Phase II of our study to measure water quality near the landfill.

The program will require four sites located on the West Arm of Kootenay Lake and two sites on Cottonwood Creek, one at the mouth and one upstream from the C.P.R. effluent discharges. (These sites will also be used to assess the effect of the C.P.R. discharges, see section 2.2.2). The sites should be sampled four times (spring, summer, fall and winter) for the following parameters:

- alkalinity, total
- carbon, organic
- coliforms, fecal
- colour
- conductance, specific
- iron, total and dissolved
- lead, total and dissolved
- oxygen, dissolved
- pH
- phenols
- phosphorus, total
- tannins and lignins
- temperature
- turbidity
- zinc, total and dissolved

Field observations should include direction and speed of currents in Kootenay Lake, measurement of the flow in Cottonwood Creek and the occurrence of floating material and oil slicks.

3.3 Miscellaneous Sources of Municipal Effluent and Solid Waste

3.3.1 Effluent

A review of Pollution Control Branch files indicated that there were seven sources of municipal-type effluent in Region 5 in addition to those which have already been discussed. These miscellaneous sources included: septic tank sludge discharges to the ground at Sirdar (PE-1867), Lister (AE-3324) and Creston (AE-3362), septic tank effluent discharges to the ground at Creston (AE-3913), and La France Creek (PE-1848), and secondary treated domestic discharges to the ground at Balfour (PE-1649) and to Kootenay Lake at Nelson (PE-1892). Details regarding each of these effluent discharges are given in Tables 5-8 and 5-9. Their locations are denoted in Figures 5-2, 5-3, 5-5 and 5-11 by their Pollution Control permit or application numbers.

These miscellaneous sources of municipal effluent are not discussed in detail since a review of the information regarding each discharge indicates that their potential for adversely affecting groundwater or surface water is negligible.

3.3.2 Solid Waste

A review of Pollution Control Branch files indicated that there were five municipal refuse sites in Region 5 under permit or application other than those discussed previously. The sites at Creston (PR-1416), Lister (PR-3916) and Balfour (PR-3889) have Pollution Control permits. The potential for adverse effects on groundwater or surface water at these three sites is judged to be nil.

The sites at Kaslo (AR-4070) and Crawford Bay (AR-4069) are covered by recent Pollution Control applications. There is not sufficient information available at the present time to make a complete evaluation of these sites, but considering their small size and location it is expected that their potential for adversely affecting groundwater and surface water will be negligible.

A summary of pertinent information regarding these five sites is contained in Table 5-16. The locations of the sites are denoted in Figures 5-2, 5-3 and 5-11 by their Pollution Control permit or application numbers.

3.4 Effects of Agriculture

This region supports the main agricultural activity in the Kootenays. Only a small fraction of the total region is used for agriculture and these areas are intensively farmed. The farms, which are near watercourses leading to the Kootenay River, are located on the Moyie River, the Goat River, the Kootenay River south of Kootenay Lake, the south-east shore of Kootenay Lake, the West Arm of Kootenay Lake and the northern half of Kootenay Lake.

The best soil for agriculture is found on the Kootenay River flats near Creston. Farms are situated on Class 2 and 3 sites[15] which have moderate limitations such as moisture holding capacity and topography. The land is used mainly for crops of grain or hay and generally must be irrigated. Livestock production is predominantly beef cattle. In the Creston area feedlots are becoming more common because of the local grain production. The main sources of nutrients to the receiving waters are livestock and fertilized, irrigated cropland.

3.4.1 Nutrients From Irrigated Cropland

The acreage and location of irrigated lands were obtained from water licences[13]. We assumed that all irrigated land was fertilized, although this is probably an overestimate according to the 1971 Agricultural Census[52]. Fertilizer applied to non-irrigated land was believed to contribute a negligible amount of nutrients to creeks and rivers.

To calculate potential source loadings of nutrients we assumed a fertilizer application rate of 50 lb. nitrogen per acre and 10 lb. phosphorus per acre. The method used to estimate the fraction of applied nutrient ultimately reaching the receiving water was based on results derived in the Okanagan Basin Study[53]. In this study lysimeter tests were used to obtain the fraction of nutrients reaching the groundwater. These fractions were 0.168 of the nitrogen applied as fertilizer and 0.021 of the phosphorus applied as fertilizer.

We then assumed that 80 percent of the nitrogen and phosphorus reaching the groundwater would enter the receiving water. Therefore each irrigated acre was assumed to contribute the following amount of nutrient per year to the receiving water:

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

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

Table 5-18 gives nutrient loadings to the receiving water from irrigated crop lands, based on the above assumptions and calculations. All calculated values in Table 5-18 were rounded off. The results show that irrigated crop land could contribute in the order of 78,500 lb/year of nitrogen and 2,000 lb/year of phosphorus to the Kootenay River.

3.4.2 Nutrients From Livestock

The major contribution from livestock was considered to occur during winter. During the summer, cattle graze over wide areas away from watercourses. The nutrient contribution from this activity was considered to be negligible. However, beef cattle are often wintered near streams because of the natural shelter and water supply provided. A significant amount of animal waste can thus accumulate near the streams. When the spring thaw occurs the runoff can flush this waste into the streams.

The method used to derive nutrient loadings to the river from livestock operations was also based on results from the Okanagan Basin Study[53]. The total potential loading from each animal per year was assumed to be 137 lb/year of nitrogen and 9.1 lb/year of phosphorus. The fraction of the total potential loading which reached the river was assumed to be 0.07 for nitrogen and 0.022 for phosphorus. An estimate of the number of farms and livestock was obtained from the 1971 agricultural census[52]. Results are presented in Table 5-18 and show a total yearly potential contribution from livestock of 41,000 lb. of nitrogen and 850 lb. of phosphorus.

3.4.3 Evaluation of Results

To evaluate the effect of agricultural operations on the Kootenay River system we calculated some theoretical nutrient concentrations which would occur. We assumed that the total contributions calculated in Table 5-18 reached surface waters during a five month period, from April to August. The daily load was therefore calculated by dividing the annual load by 150. The resulting concentrations of nitrogen and phosphorus were calculated for the Moyie River, the Goat River and the Kootenay River, during high and low flow. Results are presented in Table 5-19. Calculated concentrations of phosphorus did not exceed 0.01 mg/l. Calculated concentrations of nitrogen were 0.4 mg/l in the Goat River and 0.12 mg/l in the Moyie River at low flow.

Due to the large number of simplifying assumptions made in this analysis we can only derive order of magnitude values for nutrient loading and concentrations. On an annual basis the loadings are considered to be small. The concentrations which could result in the rivers over a five month period are also considered small except for nitrogen in the Moyie and Goat Rivers. These higher values will occur for short times during low flow and are not at levels which would be considered toxic to aquatic life. Since phosphorus concentration was generally quite low eutrophication effects would not be expected.

3.5 Effect of Mining

As outlined in section 1.8.3 and Table 5-6, very little mining activity has taken place in Region 5 during 1972 and 1973. There was no placer mining activity during the period 1969 to 1973, inclusive[54].

There are numerous closed mines within the region. Mines where effluent or drainage may cause a local pollution problem include:

- Molly Gibson Mine west of Ainsworth (Kokanee Creek)
- Yale Lead and Zinc Co. Mine near Ainsworth
- Western Mine near Ainsworth
- Scranton Mine north-west of Ainsworth
- Bluebell Mine south of Riondel
- St. Eugene Mine beside Moyie Lake
- Silver King Mine south of Nelson
- Queen Victoria Mine near Nelson
- Granite Poorman Mine near Nelson
- Caledonia Mine on Kaslo River near Blaylock
- Cork-Province Mine on Keen Creek
- Whitewater Mine on Whitewater Creek (Kaslo River)

No data are available regarding the effect that drainage from these mines may be having on water quality in the region. A visual survey of the mines should be carried out and, if judged necessary, samples of drainage and adjacent surface waters should be analysed for heavy metals.

3.6 Effect of Dams

3.6.1 Columbia River Treaty

The water resources of the Kootenay Study Area are strongly influenced by the water resource projects constructed under the terms of the Columbia River Treaty. In view of its importance, the essential features of the treaty are outlined below[55].

a) Canada will provide 15.5 million acre-feet of usable storage by constructing dams near Mica Creek (7 million acre-feet), the outlet of Arrow Lakes (7.1 million acre-feet) and Duncan Lake (1.4 million acre-feet) in British Columbia.

b) The United States will maintain and operate hydro-electric power facilities included in the base system, and any new main-stem projects, to make the most effective use of improved stream flow resulting from operation of the Canadian storage. Canada will operate the storage in accordance with procedures and operating plans specified in the Treaty.

c) The United States and Canada will share equally the additional power generated in the United States as a result of river regulation by upstream storage in Canada.

d) At the start of the storage operations the United States will make payments to Canada totalling $64.4 million (U.S. funds) for flood control provided by Canada.

e) The United States has the option of constructing a dam on the Kootenay River near Libby, Montana. The Libby Reservoir would extend some 42 miles into Canada and Canada would make the necessary Canadian land available for flooding.

f) Both Canada and the United States have the right to make diversions of water for consumptive uses and, in addition, after September 1984, Canada has the option of making specific diversions of the Kootenay River into the headwaters of the Columbia River, for power purposes.

g) Differences arising under the Treaty which cannot be resolved by the two countries may be referred either to the International Joint Commission, or to arbitration by an appropriate tribunal as specified by the Treaty.

h) The Treaty shall remain in force for at least 60 years from its date of ratification, September 16, 1964.

Canada's share of downstream power benefits, resulting from the first 30 years of scheduled operation of each of the storage projects, was sold in advance to a group of electric utilities in the United States, known as the Columbia Storage Power Exchange, for $253.9 million (U.S. funds)[55].

All of the projects called for under the Columbia River Treaty are now operational. These projects became operational on the following dates: Duncan Dam: July 31, 1967; Hugh Keenlyside Dam (Arrow Lakes):

October 10, 1968; Mica Dam: March 29, 1973; and Libby Dam: April 17, 1973[55].

The locations of the Columbia River Treaty projects and other major water resource projects, existing or under construction, are shown in Figure 5-7.

3.6.2 Corra Linn Dam

The Corra Linn Dam is located on the Kootenay River, about seven miles downstream from the City of Nelson as shown in Figure 5-7.

The primary purposes of the dam are power generation and water storage in Kootenay Lake (for power generation). It is also used to divert Kootenay River water into the Kootenay Canal[56]. The dam is owned and operated by Cominco Ltd. and has an installed capacity of 40.5 MW[57]. A summary of pertinent information regarding the Corra Linn Dam is contained in Table 5-20.

Corra Linn was completed in 1931 and was operated on a run-of-the-river basis with no storage in Kootenay Lake until 1939. In 1939, the International Joint Commission allowed West Kootenay Power and Light Co. Ltd. to enlarge Grohman Narrows and to store six feet of water (about 800,000 acre-feet) in Kootenay Lake. The regulation of Kootenay Lake by Corra Linn Dam is governed by a rule curve prescribed by the International Joint Commission in 1938. The rule curve is shown in Figure 5-8 and has been adhered to since 1939 except during 1941-1944 and 1949-1952 when eight feet of water storage was permitted. The level of Kootenay Lake is controlled at Corra Linn Dam except under high flow conditions when natural channel constrictions in the West Arm restrict the flow and thus control the lake level[6].

The Corra Linn Dam has affected fish and flooding. The storage of water floods the narrows in the West Arm from late summer to early spring, and the flooding may affect the spawning and egg survival of

Rainbow trout and other salmonids which spawn in the narrows[58]. The enlargement of Grohman Narrows and the operation of Corra Linn has protected lands bordering Kootenay Lake and the Kootenay River from flooding by reducing the level of Kootenay Lake from one to four feet (minimum) during the spring freshet[6].

A discussion of the effects of Corra Linn Dam on the Kootenay River downstream from the dam is included in our Phase I report on Region 6.

3.6.3 Duncan Dam

The Duncan Dam is located on the Duncan River, about five miles upstream from the north end of Kootenay Lake, as shown in Figure 5-7. The dam was built by the B.C. Hydro and Power Authority under the terms of the Columbia River Treaty. The primary purpose of the dam is the storage of water for flood control on the Columbia River in the United States. The dam may also provide some regulation for power generation at downstream plants over the long term, but there are no power generation facilities at the dam[10]. Construction of the Duncan Dam was started in 1965 and completed in 1967. A summary of pertinent information regarding the Duncan Dam is contained in Table 5-20.

The operation of the 1.4 million acre-feet of storage behind the dam for flood control is based on flood forecasts made during each winter. If required for flood control, the reservoir must be evacuated to provide 700,000 acre-feet of storage by April 1 and up to 1,270,000 acre-feet by May 1. Unless otherwise agreed to by Canada and the United States, the average weekly outflow from the dam is not to be less than 1,000 CFS[10].

The Duncan Lake reservoir is generally full (el. 1,892) or nearly full by late July to early August and remains full until drawdown begins in November or December. Drawdown during December, January and February lowers the reservoir level by as much as 92 feet (to elevation 1,800) by March. The reservoir then remains at this low level until spring runoff during May, June and July brings it back to full pool elevation by August[59].

This mode of operation has substantially altered the flow conditions in the Duncan River downstream from the dam. As a result of the storage of water during spring runoff, the flood peaks have been decreased in size and now occur in late July and August instead of in June. Low or very low flow now occurs in May and June, which were formerly months of high flow. Winter drawdown of the reservoir during December, January and February has changed this period from a time of low flow to a time of high flow. Before the completion of the dam, the minimum daily flow in the Duncan River was 268 CFS whereas minimum flows of 100 CFS and less are now common[26].

The creation of the reservoir flooded approximately 15.6 square miles of land along the shores of Duncan Lake and the Duncan River. About 3.5 square miles was cleared prior to flooding, while the remaining 12.1 square miles was flooded without clearing[8,9].

Several authors have commented on possible adverse effects of the Duncan project on the Duncan Lake-Duncan River-Kootenay Lake system. These possible effects include:

- Loss of spawning grounds in the Duncan River[58,60].
- Blocking of fish migration routes in the Duncan River[9,61].
- Disturbance of migration patterns of fish caused by altered flow and water temperature regimes in the Duncan River downstream from the dam[58,60].
- Alteration of limnological conditions in Kootenay Lake by altering the flows, water temperatures, and sediment content of the lower Duncan River[58,60].
- Changes in the temperature characteristics of both Duncan Lake and the Lower Duncan River. The surface waters of the reservoir will tend to be warmer while the water in the lower Duncan River will tend to be colder during spring, summer and fall because water released from the dam will be drawn from the hypolimnion. Winter water temperatures in the lower Duncan should increase[60].
- Increased sedimentation in the Duncan Lake reservoir resulting

in less turbid conditions in the reservoir and lower Duncan River. Increased sedimentation could damage benthic populations by smothering, while less turbid conditions could lead to increased primary productivity through increased light penetration[60].

- Decreased dissolved oxygen content in epilimnion of reservoir due to increased water temperatures[60].
- Possible increased acidity in the reservoir and lower Duncan River due to leaching of newly flooded acidic forest soils. A change in pH of the water may alter the species composition of the reservoir[60].
- Temporary increases in dissolved solids and nutrients in the reservoir and lower Duncan River due to leaching of newly flooded land[60].
- Increased primary production in the reservoir during first few years of impoundment due to increased nutrient content, and increased clarity due to improved settling[60].
- Decreased benthic population in the reservoir due to increased water depths, smothering effect of sedimentation, and seasonal flooding and drying of littoral areas[60].
- Rapid erosion of the steep-sided banks of the reservoir[60].
- Possible increase in benthic populations of lower Duncan River due to decreased turbidity. This may be offset by a reduction in water temperatures and sudden water releases and level fluctuations below the dam[60].
- Initial increases in fish productivity in the reservoir due to increased primary productivity and the availability of terrestrial flood organisms. After a few years game fish such as rainbow trout, Dolly Varden char and mountain whitefish will decline due to loss of food and restriction of the spawning grounds. Non-game fish species may increase in numbers in the reservoir[60].
- Algal blooms in the North Arm of Kootenay Lake, due to the outflow of nutrient rich water from the newly flooded Duncan Lake reservoir[62].

- Increased concentration of metal ions (eg., Fe, Mn) in solution due to low pH and redox potential caused by anaerobic conditions in the reservoir[9].
- Destruction of habitats for aquatic and terrestrial wildlife and birds[9].
- Loss of land for other users[9].
- Increased boating and aircraft hazard, and interference with angling and net-fishing due to drowned trees and floating debris[9].
- Altered hydraulic equilibrium downstream from the dam due to change in downstream flow conditions[9].
- Decreased reservoir recreation potential due to fluctuating levels and reduced accessibility[9].
- Moderate supersaturation of dissolved gases downstream[63].

3.6.4 Goat Dam

The Goat Dam is located on the Goat River, about seven miles upstream from its confluence with the Kootenay River as shown in Figure 5-7. The dam and powerhouse are owned by the West Kootenay Power and Light Company, and were completed in 1933. Power generation was the sole purpose of the project. The dam was heavily damaged by the flood of 1956, and the powerhouse is rarely used anymore, with only minor amounts of water being passed through the turbines during spring and fall maintenance procedures. The balance of the flow in the Goat River at the dam is allowed to spill continuously over the spillway[56]. A summary of pertinent information regarding the Goat Dam is contained in Table 5-20.

Originally, the Goat dam was a run-of-the-river plant with only a small reservoir. The reservoir is now filled with sediment and debris to the crest of the spillway so that, in effect, the dam merely acts as a waterfall[56].

No studies of the environmental impact of the Goat Dam have been done. The only adverse effects on the Goat River which are expected are:

1) Possible blocking of fish migration routes. (If indeed, fish did migrate upstream from the dam before its construction).
2) Possible dissolved gas supersaturation downstream from the dam, due to the continuous spilling of water over the 73 foot high spillway.

3.6.5 Libby Dam

The Libby Dam is located on the Kootenay River near Libby, Montana, about 100 miles upstream from the British Columbia boundary. Despite the remoteness of the dam from British Columbia, it is expected to have a considerable effect on Kootenay Lake and the Kootenay River in Region 5. Data regarding the Libby Dam and reservoir were summarized in our water quality report on Region 4, the Lower Kootenay River basin [64].

The following is a brief summary of the downstream effects of the Libby project which have been predicted or observed:

- Changes in the flow characteristics downstream from the dam [65]. Generally the flow will be about 15,000 CFS higher than the unregulated flow during the November through mid-March period and will be about the same as natural conditions during late March and most of April. During May and June, the regulated flow will be about 35,000 CFS less than in an average year without regulation, while, during August, September and October it will be about equal to the natural discharge [66]. The minimum flows at the damsite prior to impoundment have been estimated to be about 1,650 CFS during the period of October to March, while the minimum allowable flow with the dam is 2,000 CFS [55].

- Daily river level fluctuations downstream from the dam during winter, due to variable power demands. This may result in decreased angler use, destruction of aquatic food organisms and stranding of fish in shallow water [65]. A reregulating dam, downstream from Libby Dam, scheduled to be completed in 1982, will average the flows released from Libby on a daily basis. This dam will reduce the downstream fluctuation at the town of Libby to a gradual rise and fall within a three foot range during the course of a week [66].
- Changes in the water temperature characteristics of the Kootenay River downstream from the dam. It was calculated, in 1964, that Kootenay River water temperature would decrease by as much as 3.5^{o}C in spring and summer and 1.6^{o}C in fall at the international boundary (Porthill, Idaho) due to the release of colder water drawn from the hypolimnion of the reservoir. The moderating effect of the reservoir will increase winter water temperatures in the Kootenay River downstream from the dam [65]. The addition of a selective withdrawl structure to the dam in 1975 will maintain normal river temperatures during mid-May through September. However, during October to March, river water will be warmer than normal, while during April to mid-May it will be colder than normal [66].
- Nitrogen supersaturation of river water downstream from the dam [65,66]. The dissolved gas concentrations diminish to levels which are unlikely to effect fish by the time the downstream waters pass back into British Columbia [67]. In addition, with the installation of four additional units at Libby and the construction of the reregulating dam, nitrogen gas concentrations are not expected to exceed safe levels (110 percent saturation), except on rare occasions [66].
- A reduction in the nutrient levels in Kootenay Lake because the Libby reservoir may act as a nutrient trap [65,68].
- A reduction in the turbidity in the Kootenay River and in Kootenay Lake because the Libby reservoir will act as a sediment trap. This may lead to algal blooms in the southern

part of Kootenay Lake, due to increased light penetration[65,68]. Phytoplankton production has been restricted by poor light penetration due to the inflow of highly turbid Kootenay River water[68]. It has been estimated that 90 percent of the suspended sediment load will be retained in the reservoir throughout the year[69].

- Changes in the circulation system of Kootenay Lake caused by changes in the physical and chemical characteristics of the inflowing Kootenay River water[65].
- Reduction in pH from a range of 7.4-8.3 to near neutral (7.0) and a reduction in hardness[65].
- Creation of an impassable barrier to fish migration[65].
- Delays in spawning and reduction of spawning and feeding areas of fishes such as rainbow trout from Kootenay Lake due to reduced spring flows[65].

The Libby project has also created at least two important downstream benefits for British Columbia. The operation of the Libby storage provides flood control on the Kootenay River and Kootenay Lake. This was evident in the spring of 1974, when the peak level of Kootenay Lake was about 10 feet lower than it would have been had the Libby and Duncan reservoirs not been in use[57]. The operation of the Libby reservoir increases the amount of power which can be generated at the power plants on the lower Kootenay River[57].

3.6.6 Libby Reregulating Dam

This dam is scheduled to be completed by 1982 and will be located 10 miles downstream from the Libby Dam. The dam will have a small amount of installed generating capacity (44 MW), but its main purpose will be to average, on a daily basis, the fluctuations in flow downstream from Libby Dam caused by the operation of Libby for peaking power generation. It will also eliminate or minimize dissolved gas supersaturation in the water released from the Libby Dam[66,67].

4. WATER SAMPLING DATA

For the purpose of evaluating water quality data we have divided the region into five sections. These are: the Moyie River, the Kootenay River from the international border to Kootenay Lake, Kootenay Lake, the West Arm of Kootenay Lake to the Corra Linn dam and the Kaslo, Duncan and Lardeau Rivers.

4.1 Location of Sampling Sites

There are 22 river and lake sampling sites which have been monitored regularly by the Pollution Control Branch. Site locations are shown in Figures 5-2, 5-3, 5-5 and 5-11 and are described below.

4.1.1 Moyie River Sites

Site 22: downstream from Moyie Lake, approximately 31 miles from the international border

Site 99: immediately north of the international border at Kingsgate

Site 23: in Idaho, approximately one half a mile south of the international border

4.1.2 Kootenay and Goat River Sites

Site 14: on the Kootenay River at Porthill in Idaho, approximately five miles from the international border

Site 13: on the Kootenay River at highway 3 bridge west of Creston, approximately 10 miles north of the international border

Site 56: on the Goat River, 2.4 miles upstream from its confluence with the Kootenay River and 1.4 miles upstream from its confluence with Deadhorse Creek

4.1.3 Kootenay Lake Sites

Site 31: Midlake, 14 miles downstream from site 13 and 0.8 miles north of Shaw Creek

Site 32: midlake, west of Columbia Point and 10 miles downstream from site 31

Site 33: midlake, west of Lockhart Creek and seven miles downstream from site 32

Site 34: midlake, between Cape Horn and Sun Point, six miles downstream from site 33

Site 35: midlake, two miles north of Kootenay Bay

Site 57: midlake, east of Kaslo, 15 miles upstream from site 35

4.1.4 West Arm Sites

Site 12: midlake, at Fraser Rapids west of Balfour

Site 163: north side of lake, 800 feet upstream from Nelson bridge and 19 miles downstream from site 12

Site 164: north side of lake, 800 feet downstream from Nelson bridge

Site 141: midlake, 2000 feet upstream from Nelson's sewage outfall and two miles downstream from site 164

Site 142: midlake, 1000 feet downstream from Nelson's sewage outfall

Site 143: midlake, one mile downstream from Nelson's sewage outfall

Site 11: at Taghum, five miles upstream from the Corra Linn Dam

4.1.5 Kaslo, Lardeau and Duncan River Sites

Site 58: on Kaslo River at Kaslo, 0.4 miles from the mouth

Site 59: on Duncan River, one quarter of a mile below Duncan dam

Site 60: on Lardeau River at Marblehead, one mile from the mouth

4.2 Presentation of Data

Over 870 river and lake samples were collected at the Pollution Control Branch sites between 1969 and 1974. Each sample was analysed for approximately 26 parameters. The resulting 23,000 analyses are summarized in three Tables (5-21 to 5-23).

Concentrations appeared to depend on flow for many parameters and thus concentrations were considered for both the high and low flow period. The high flow period was considered to occur between May and August and the low period during the remaining months. The values presented are those which were judged to be most representative and were therefore close to the median values for the high and low flow periods. Parameters presented in Tables 5-21 to 5-23 were selected either on the basis of relationship to effluent discharges near the sites, or as indicators of change in natural water quality.

Certain parameters were below or near the concentrations recommended for drinking water, and did not appear to change significantly within the region. Typical values for these parameters are presented in Table 5-24, at sites 14 and 11, where most of the water enters and leaves the region.

Dissolved gas data collected in the region are presented in Table 5-25. The data were collected by the Fish and Wildlife Branch, the U.S. Army Corps of Engineers, and the Pollution Control Branch [63]. The purpose was to assess the downstream effects of the Libby Dam and the Duncan Dam.

Monitoring is currently being carried out by the Water Quality Branch of Environment Canada as part of a nutrient budget study on Kootenay Lake. Their preliminary data appear to be in agreement with Pollution Control Branch data presented in Tables 5-21 to 5-23. We expect to discuss the Federal data in more detail in our Phase II report on the region.

4.3 Discussion and Recommendations

4.3.1 Moyie River

The water of the Moyie River had low solids, metals and nutrient content, which is fairly typical of natural runoff water (Table 5-21). There was no apparent decrease in water quality between sites 22 and 23 and 99, which is to be expected considering the low population and marginal land use along this section of the river. In section 3.4 we predicted the possibility of higher nitrogen concentrations due to agricultural operations. High nitrogen values were not recorded, due possibly to the fact that higher nitrogen loadings occurred over a very short time period during the spring thaw. There also appeared to be no effect at site 22 from logging near the headwaters of the Moyie River.

In future routine monitoring, bacteriological monitoring should be included to determine the effects of recreation on Moyie Lake. Site 23 can be discontinued since it is close to site 99.

4.3.2 Kootenay River and Goat River

There was no significant change in the water quality of the Kootenay River between the international border (site 14) and Kootenay Lake (site 13). Such a result is consistent with the lack of activity in the area other than agriculture. The effect of agriculture was predicted in section 3.4 to be minimal.

The effect of the Libby Dam on site 14 and changes in concentrations and loadings between site 100 in Region 4 and site 14 in Region 5, are shown in Table 5-26. Values of concentration were taken from Table 5-21 at site 14 for the pre and post impoundment periods. Site 100 is on the Kootenay River in Canada just before it enters Montana. Concentration values were obtained from the water quality report on Region 4[64]. The concentration and flow values in Table 5-26 were yearly averages obtained by taking a weighted average of concentrations and flows for the low and high flow periods. Loadings in lb/day, were calculated by multiplying the concentration, in mg/l, by the flow, in CFS, and by a factor of 5.4.

The effect of the Libby Dam on site 14 was to cause a loss of from 30 to 60 percent in heavy metals, fluoride and total phosphorus. The turbidity was reduced by more than 50 percent. These results indicate that the dam retained a portion of the sediment load and that much of the metal and total phosphorus was in the insoluble form. There were losses of less than 30 percent in ammonia and dissolved phosphorus and there was a gain of 11 percent in nitrate nitrogen. Considering the error involved in the calculations these changes were minor.

Although there was a net decrease in loadings of heavy metals, fluoride and certain nutrients at site 14 after impoundment, the loadings were generally higher at site 14 than at site 100. For certain parameters, such as nitrate nitrogen and organic nitrogen the increases were particularly large and may have been caused by agricultural operations. Loadings of other parameters may have been increased by natural contributions from tributaries and runoff, which also increased the river flow between site 100 and 14. Since we are dealing with quite large flows and very low concentrations, usually a fraction of a mg/l, there is a certain degree of uncertainty associated with the calculations. Also, the flow at site 100 was only estimated and was not known accurately. We recommend that further samples and flow measurements be taken during Phase II of the study to confirm the results.

The water quality at sites 14 and 13 generally met all drinking water standards (listed in Table 5-21 for comparison) except for turbidity during the high flow period. We can assume that fecal coliform contamination would also be present. The concentrations of heavy metals, fluoride and nutrients were usually well below levels which would be toxic to aquatic life. A summary of sublethal and lethal toxicity values for fresh water organisms is given in Table 5-27, drawn primarily from Clarke[71].

The water quality in the Goat River was good at site 56, approximating generally that of the Kootenay River (Table 5-21). Higher nitrate nitrogen values due to agriculture were predicted as a possibility in section 3.4 but did not show up in the analyses. Deadhorse Creek, which flows into the Goat River just before its confluence with the Kootenay

River, was, until recently, contaminated with untreated sewage from the town of Creston (section 3.1).

4.3.3 Kootenay Lake

The water quality of Kootenay Lake from 1969 to 1974 was very similar to that of the Kootenay River. This result was expected because the lake has a high flushing rate (1.5 years) and the Kootenay River is 60 percent of the inflow. The distribution of heavy metals, dissolved solids, colour and turbidity was fairly uniform throughout the lake. Values of these parameters, shown in Table 5-22, were low, well within drinking water standards[70], and were below levels considered toxic to aquatic life (Table 5-27).

Fluoride levels at 0.25 mg/l tended to decrease in value from south to north (Table 5-22), reflecting the influence of the Kootenay River on the lake. The fluoride was thought to originate partly from fertilizer operations at Kimberley. Effluent from these operations entered the Kootenay River several hundred miles upstream from Kootenay Lake, as described in our report on water quality in Region 4[64]. Fluoride concentrations in the lake met drinking water standards and were below levels considered toxic to aquatic life.

Dissolved phosphorus from 1969 to 1974 was in the range of 0.02 mg/l to 0.03 mg/l and decreased from south to north. Much of the phosphorus was believed to originate from the fertilizer operations in Kimberley as discussed in our report on Region 4[64]. The phosphorus concentration of 0.02-0.03 mg/l and the nitrate nitrogen concentration of 0.10-0.14 mg/l (Table 5-22), were in a range which can be expected to cause increased productivity in the lake. The effect of nutrients on phytoplankton, and other productivity indicators, is discussed in detail in Chapter 5 which deals with aquatic biology. Nutrient data, such as phosphorus concentrations, listed in Table 5-22, were averaged at each site over several depths. The concentration actually varied with depth and also with the time of year and these variations were related to algae production, as shown in Chapter 5.

4.3.4 Kaslo, Duncan and Lardeau Rivers

Most water quality parameters measured in these rivers met drinking water standards and were at levels which were not toxic to aquatic life. The major exception was zinc, which, in the Kaslo and Duncan Rivers, was well within drinking water standards but at concentrations which could cause avoidance reaction in rainbow trout (Table 5-27). The zinc from these rivers probably caused the higher zinc concentrations at the north end of Kootenay Lake (Table 5-22).

There are several old mines in the Kaslo and Duncan river basins which could contribute zinc. The metal may also be picked up by runoff or groundwater passing through certain types of soil. Further samples will be collected from the river sites to up-date our information.

4.3.5 West Arm of Kootenay Lake

Results listed in Table 5-23 show no significant change in water quality through the West Arm of Kootenay Lake. Generally the concentrations of parameters were similar to those in the main body of Kootenay Lake, or slightly lower, due perhaps to the dilution effect from higher quality tributaries to the lake. Water samples were taken at mid-lake points and at these locations there was no noticeable effect from effluents or solid waste discharged by industries and municipalities in the Nelson area. For example, the difference in water quality between site 141, upstream from Nelson's sewage treatment plant discharge and site 142, downstream from the discharge, was negligible. Throughout the West Arm the fecal coliform count ranged from 2 to 100 MPN/100 ml, suggesting that there may be some localised fecal coliform contamination at certain inshore points.

4.3.6 Dissolved Gas Data

The dissolved gas values reported in Table 5-25 were all at satisfactory levels. Although high values have occurred below the Libby Dam in Montana, the situation returned to normal at the Idaho-British Columbia border.

5. AQUATIC BIOLOGY

Most of the biological studies have been conducted in the main basin of Kootenay Lake. The West Arm of the lake has a much smaller volume than the main basin (0.41 Km^3 compared to 42.2 Km^3). The water exchange rate in the West Arm is therefore approximately 100 times that in the main basin and a noticeable current is produced. This chapter deals exclusively with the main lake basin.

5.1 Presentation of Data

A bibliography by the Canada Centre for Inland Waters serves as an excellent listing of material on Kootenay Lake[72]. Biological studies in the lake have centred either on fisheries or on productivity indicators such as algal and zooplankton populations.

5.1.1 Fisheries Data

The aspect of biology of Kootenay Lake most thoroughly documented is fisheries. The sports fishery has been established as being of economic importance[73,74] and has been the subject of many studies.

An important sport fish is Kokanee (*Oncorhynchus nerka*). Before the early 1950's it never exceeded 0.25 Kg in weight. Now, fish of 2 Kg are not uncommon[75]. The increase in weight is attributed to the planned introduction of *Mysis*, a freshwater shrimp, into the lake[75], and to the increase in lake productivity, which in turn is believed to be due to the fertilizer plant effluent from Kimberley[58]. According to Vernon[76] three separate races of Kokanee exist in the lake. Population estimates have been carried out[77].

More detailed investigations have been carried out on the biology of Rainbow trout (*Salmo gairdneri*)[78,79,80,81,82,83,84]. Dolly Varden (*Salvelinus malma*) and mountain whitefish (*Prosopium williamsoni*) both support minor fisheries[85]. A large mortality of mountain whitefish occurred in 1969[79,86]. Carbon dioxide was cited as a possible cause [87] but data collected in 1970-1971[88] discounted this theory.

The effect of dams and other man-made changes on fish have been discussed[60,65,89]. Also, excellent overviews of Kootenay Lake fisheries and limnology have been prepared by Northcote[7,68,90].

5.1.2 Lake Productivity Data

In sections 4.3.2 and 4.3.3 we discussed the water quality of the Kootenay River and Kootenay Lake. The data indicated that the fertilizer plant at Kimberley, several hundred miles upstream from the lake, was a major source of phosphorus entering the lake. The phosphorus increased the productivity of the lake, as manifested by an increase in fish size and the formation of algal blooms. A detailed report on algal and zooplankton populations is in preparation[91] but the main findings are summarized in this section.

From 1972 to 1974 the Pollution Control Branch collected monthly samples from March to November at six stations on Kootenay Lake. The stations were numbered 31, 32, 33, 34, 35 and 57. Their location is shown on Figures 5-2 and 5-3 and is described in section 4.1.3. The samples were analysed for algal counts, chlorophyll-a, carbon-14 estimates of productivity, zooplankton and water quality parameters.

Phytoplankton were collected at depths of 1, 5, 10, 15 and 20 metres, and composited into a single sample. The number of cells per millilitre was converted to biomass using the method described by Vollenweider[92]. The results are expressed in Table 5-28 as algal biomass in mg/m^3 for each month sampled in 1973 at each site. Similar results obtained from the Great Lakes and from Swedish lakes are also presented in Table 5-28 for comparison.

Chlorophyll-a was measured in algae collected at various depths. Data obtained from samples composited from depths of 1 to 20 metres, and from samples at 1 metre, are presented in Table 5-29. The data are expressed as mg/m^3 of chlorophyll-a, for each month sampled in 1974 at each site. Similar results obtained from the Great Lakes are also given in the table.

Photosynthesis, as measured by Carbon-14 uptake rate by phytoplankton, was measured at each site, once a month from March to November. Results are listed in Table 5-30 as mg $C/(m^2$ day) for each site and each month in 1973 and 1974. The method used to obtain the data will be described in a more detailed technical report(93). Comparative data obtained in the Great Lakes are also given in Table 5-30.

The horizontal distribution of orthophosphate in the lake is presented in Table 5-31. Results are expressed as mg/l of phosphorus at a depth of one metre at each site for the spring of 1972, 1973 and 1974. The vertical distribution of orthophosphate is shown in Table 5-32. The concentration of phosphorus is given for various depths, ranging from 1 to 127 metres, for selected sites and months in 1972, 1973 and 1974.

A summary of zooplankton collected in 1972, 1973 and 1974 at each station is given in Table 5-33. The results are expressed as mean number of organisms per square centimetre of lake surface collected at each site, each year. Procedures used will be documented in a more comprehensive report(91). Data obtained by Zyblut(94) in 1949 and 1964 are also presented in Table 5-33 along with data from Okanagan Lake and the Great Lakes.

Some of the data given in Tables 5-28 to 5-33 are presented graphically. In Figure 5-9 nutrient concentrations are plotted against time of year for site 31 in 1973. The variations of light penetration and primary productivity rate with time are shown in Figure 5-10 for 1973 and 1974.

5.2 Discussion of Data

5.2.1 Phytoplankton

The data in Table 5-28 show that at all sites the growth of phytoplankton reached a peak in the spring around June, declined, then reached another peak in the fall, in September. The peak growths were mostly diatoms (Asterionella formosa, Fragilaria crotonensis) and the mid-summer dominants were blue-green algae (Anabaena, Oscillatoria). In terms of biomass the blue-green algae were of minor importance but were very visible when they accumulated at the surface. The amount of algal biomass produced was comparable to that found in moderately productive lakes (Table 5-28).

The chlorophyll-a data show a similar trend. Peaks occurred at all sites in May-June and again in September (Table 5-29). Actual values were similar to those formed in mesotrophic or moderately productive lakes. The primary productivity data in Table 5-30 also give the same pattern of peaks in spring and late summer. The carbon uptake rate again classifies the lake in roughly the mesotrophic range.

The pattern of phytoplankton growth can be explained by the availability of nutrients and the occurrence of turbidity. The data in Table 5-31 show that there was an horizontal gradient of phosphorus at a depth of one metre from south to north in early spring. At this time of year the lake water was fairly well mixed vertically and the inflowing Kootenay River produced relatively high concentrations, up to 0.03 mg/l, at the southern end of the lake. The higher phosphorus concentration caused algal growth which spread northward across the lake. The algae removed phosphorus and nitrogen from the upper layers of the lake and thus produced a vertical gradient of nutrient concentrations as indicated in Table 5-32. The dissolved phosphorus concentration was much greater at depths of 100 metres than near the surface. In the fall, cooling of surface waters could cause relatively deep water to circulate to the surface, and thereby increase the concentration of phosphorus in surface waters again. This phenomenon would produce the second peak of algal growth. The variation of nutrient concentration in surface waters, and the corresponding variation in algal growth, as measured by carbon uptake rate, is illustrated in Figure 5-9.

The peak turbidity usually occurred in late spring or early summer. Since light, as well as nutrients, is required for growth of algae, turbidity may be another reason for the termination of the spring algal growth. Figure 5-10 shows how phytoplankton varied in proportion to light penetration.

5.2.2 Zooplankton

Organisms were collected in 1972 and 1973 in similar quantities to those collected by Zyblut[94] in 1964 (Table 5-33). The quantity was roughly double the amount collected in 1949, before operation of the fertilizer plant at Kimberley. This result demonstrates the effect of nutrients on zooplankton productivity. This productivity was similar to that occurring in Okanagan Lake and to other lakes considered oligotrophic, such as Lake Huron. In 1974, the number of organisms in Kootenay Lake declined, although phytoplankton productivity did not. The reason for the decline is unclear although it may be due to increased *Mysis* population, as *Mysis* was not collected in the sampling.

5.3 Conclusions and Recommendations

The present condition of the Kootenay Lake fisheries appears to have been created by the introduction of shrimp and nutrients into the lake. The shrimp, *Mysis relicta*, were introduced to provide food for rainbow trout which were also introduced into the lake. The shrimp has played a part in increasing the growth rate and maximum size of Kokanee, mountain whitefish as well as trout. Nutrients, discharged as effluent by the fertilizer plant in Kimberley, have increased primary productivity in the lake. This has resulted in increased zooplankton and fish production.

The Libby Dam, which went into operation in 1972, is expected to act as a sediment trap for the Kootenay River. This should increase light penetration into the lake and thus increase phytoplankton productivity. However, the reservoir behind the dam may also act as a sink for phosphorus, which would decrease productivity in the lake. By the end of 1977 the fertilizer plant at Kimberley will have reduced its discharge of phosphorus by approximately 90 percent[64]. This action should also decrease phytoplankton growth. Owing to the rapid flushing rate of Kootenay Lake, changes in phosphorus input should have a noticeable effect within a few years.

The productivity of the lake appears currently to be in reasonable balance. Algal blooms occurred during some summers but they were of relatively short duration and created aesthetic problems. Both increases or decreases in productivity could have adverse effects. Increases would cause algal blooms. Nitrogen is thought to be the limiting nutrient so that higher primary productivity might take the form of blue-green algae which fix atmospheric nitrogen. These algae are poor sources of food for lake herbivores hence the added productivity would not increase zooplankton and fish production directly. The death and decay of algal blooms could create an oxygen demand in the bottom of the lake which might adversely affect both fish and Mysis which require abundant dissolved oxygen. A decrease in productivity from the current state would be reflected through the food chain and result in lower fish production.

The dam is expected to cause changes in the mixing and circulation patterns in the lake. Depending on whether cold (hypolimnetic) or warm (epilimnetic) water is discharged from the dam, the Kootenay River will flow into the lake either at some subsurface level or at the surface. The temperature of incoming water will also affect heating and cooling of the lake and hence its internal current patterns. The altered flow regime of the river has an unknown effect on the circulation pattern of the lake.

We recommend that biological sampling of Kootenay Lake be continued to document the effect of the dam and the reduction in the discharge of fertilizer plant effluent. Data on the distribution and quantities of *Mysis relicta* would be especially useful. Also, a comprehensive study of the physical structure of the lake would be necessary to determine water movement patterns. A survey of this type is being carried out by the Inland Waters Directorate of Environment Canada.

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100. McKee, J.E., Wolf, H.W., Water Quality Criteria, 2nd Reprint, Publication 3-A, California State Water Resources Control Board, June 1, 1974.

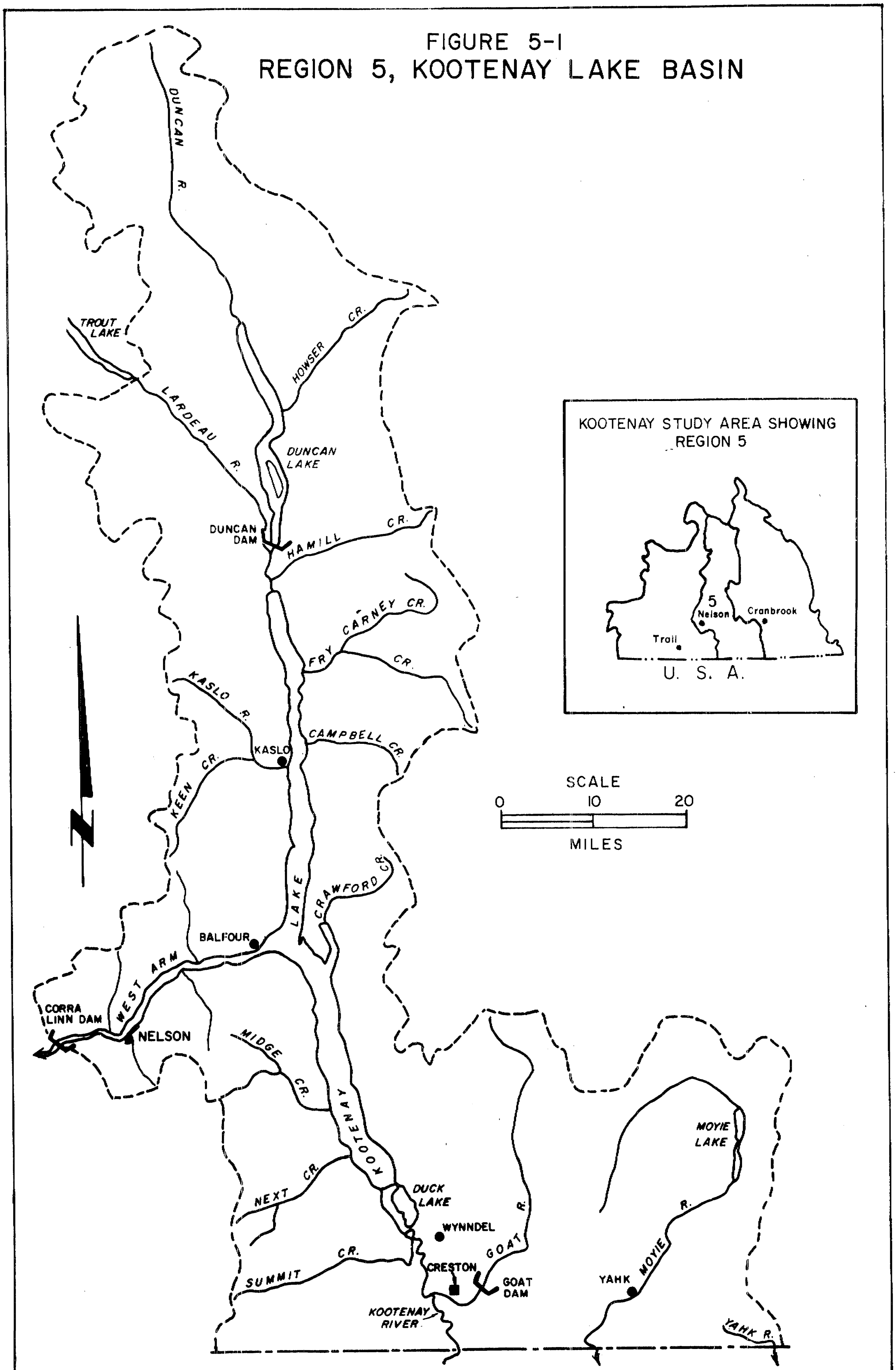

FIGURE 5-1
REGION 5, KOOTENAY LAKE BASIN

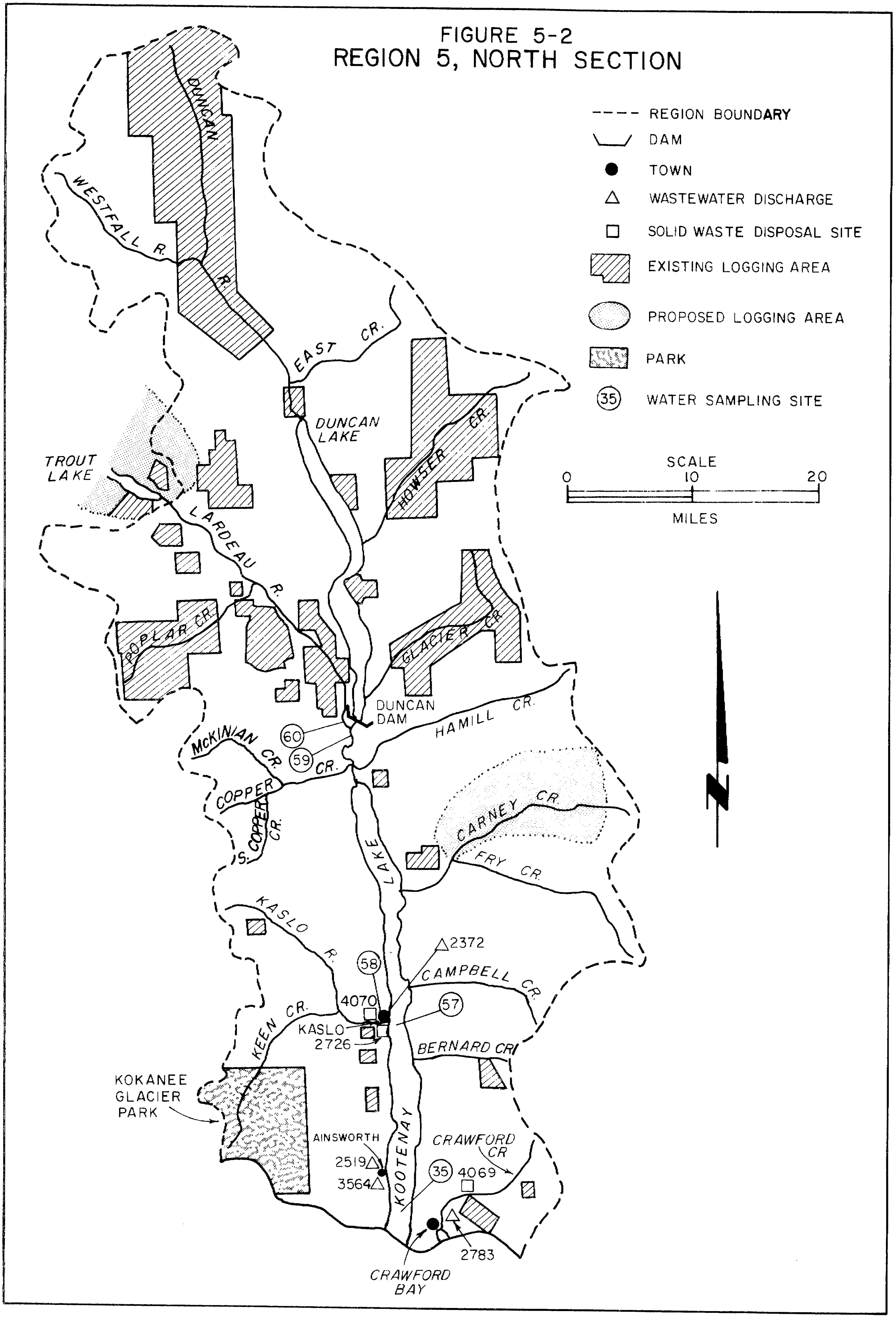
FIGURE 5-2
REGION 5, NORTH SECTION
REGION BOUNDARY
DAM
TOWN
WASTEWATER DISCHARGE
SOLID WASTE DISPOSAL SITE
EXISTING LOGGING AREA
PROPOSED LOGGING AREA
PARK
35
WATER SAMPLING SITE
SCALE
0
10
20
MILES
DUNCAN
WESTFALL R.
R.
EAST CR.
DUNCAN LAKE
TROUT LAKE
LARDEAU R.
HOWSER CR.
POPLAR CR.
GLACIER CR.
DUNCAN DAM
HAMILL CR.
60
59
McKINIAN CR.
CR.
COPPER
S. COPPER CR.
CARNEY CR.
FRY CR.
LAKE
KASLO R.
58
2372
CAMPBELL CR.
57
4070
KEEN CR.
KASLO
2726
BERNARD CR.
KOKANEE GLACIER PARK
AINSWORTH
2519
3564
KOOTENAY
CRAWFORD CR
35
4069
2783
CRAWFORD BAY

FIGURE 5-3

REGION 5, SOUTH SECTION

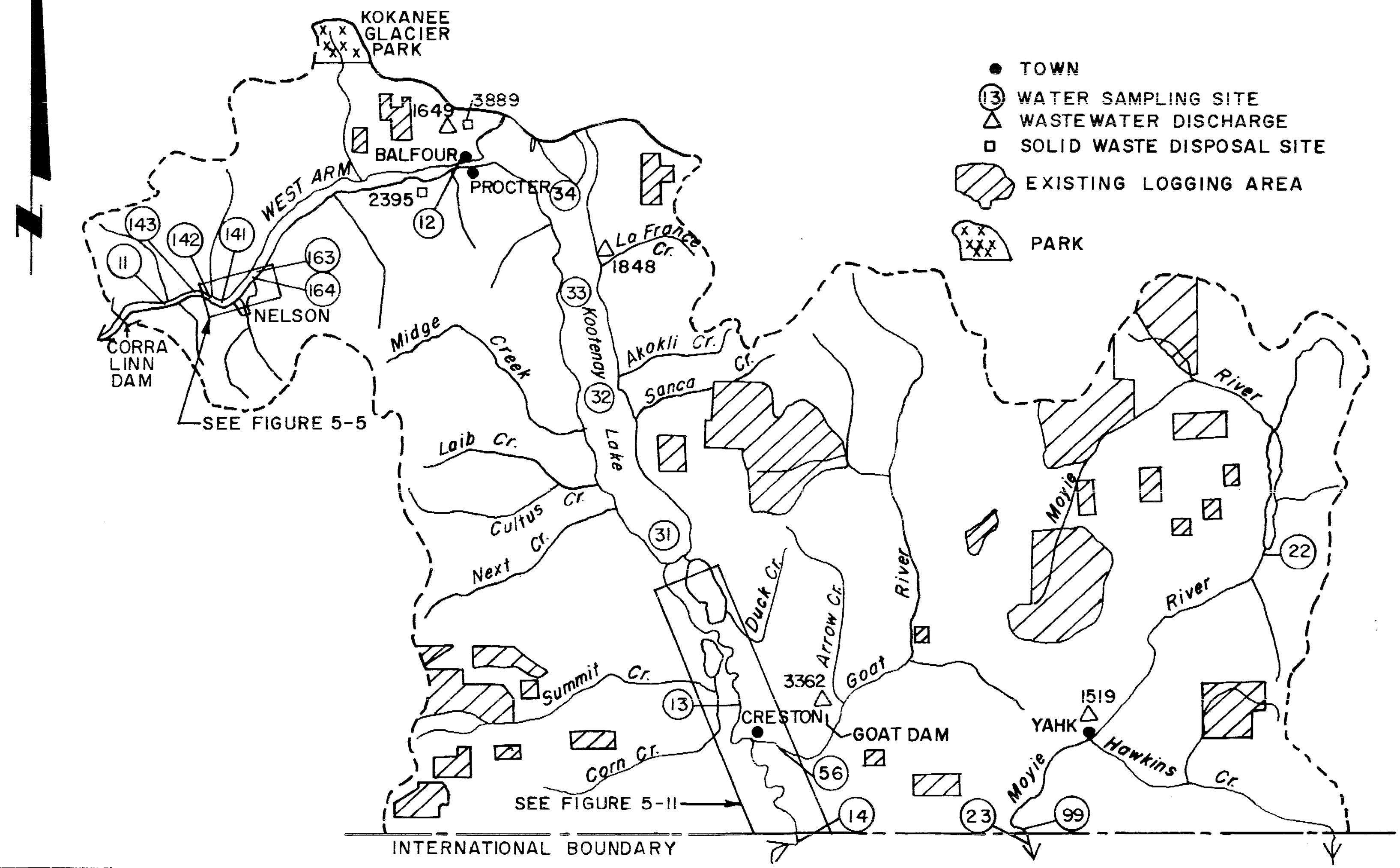

FIGURE 5-4
SIMPLIFIED PROCESS FLOW DIAGRAM FOR THE SILVER STAR MINES LTD. (N. P. L.) ORE CONCENTRATOR

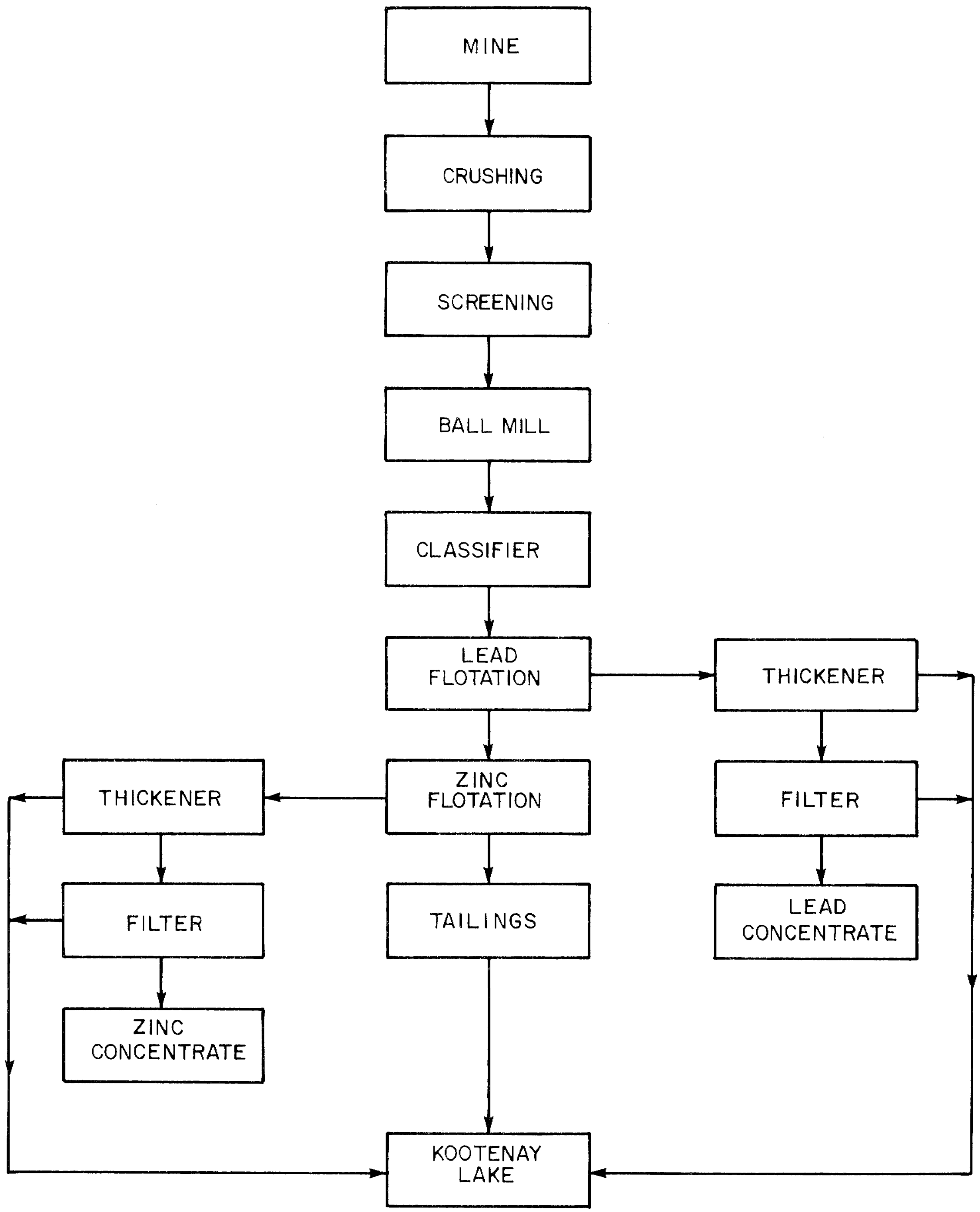

FIGURE 5-5
REGION 5, NELSON AREA

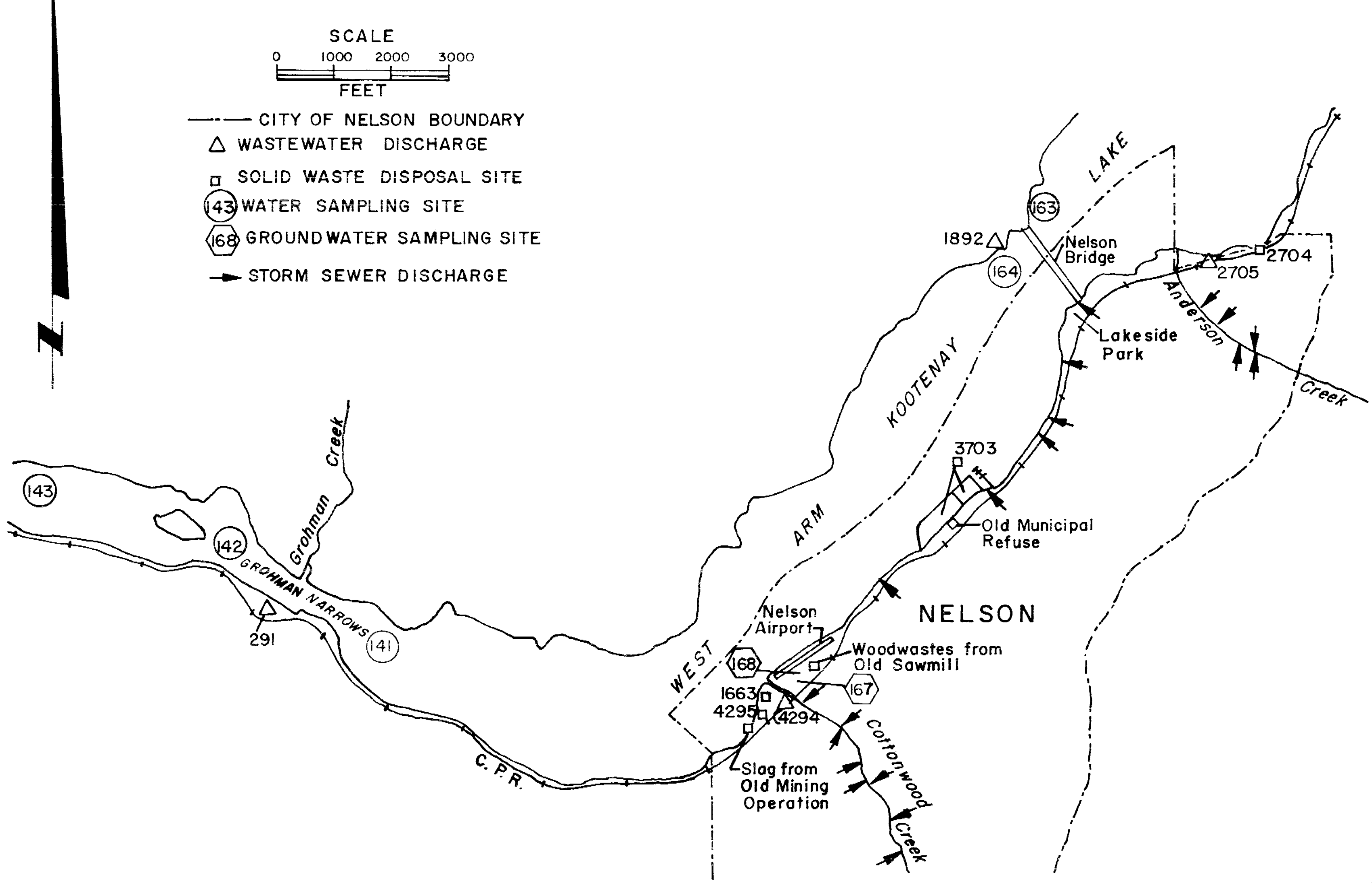

FIGURE 5-6
SIMPLIFIED PROCESS FLOW DIAGRAM FOR KOOTENAY FOREST PRODUCTS LTD. (NELSON)

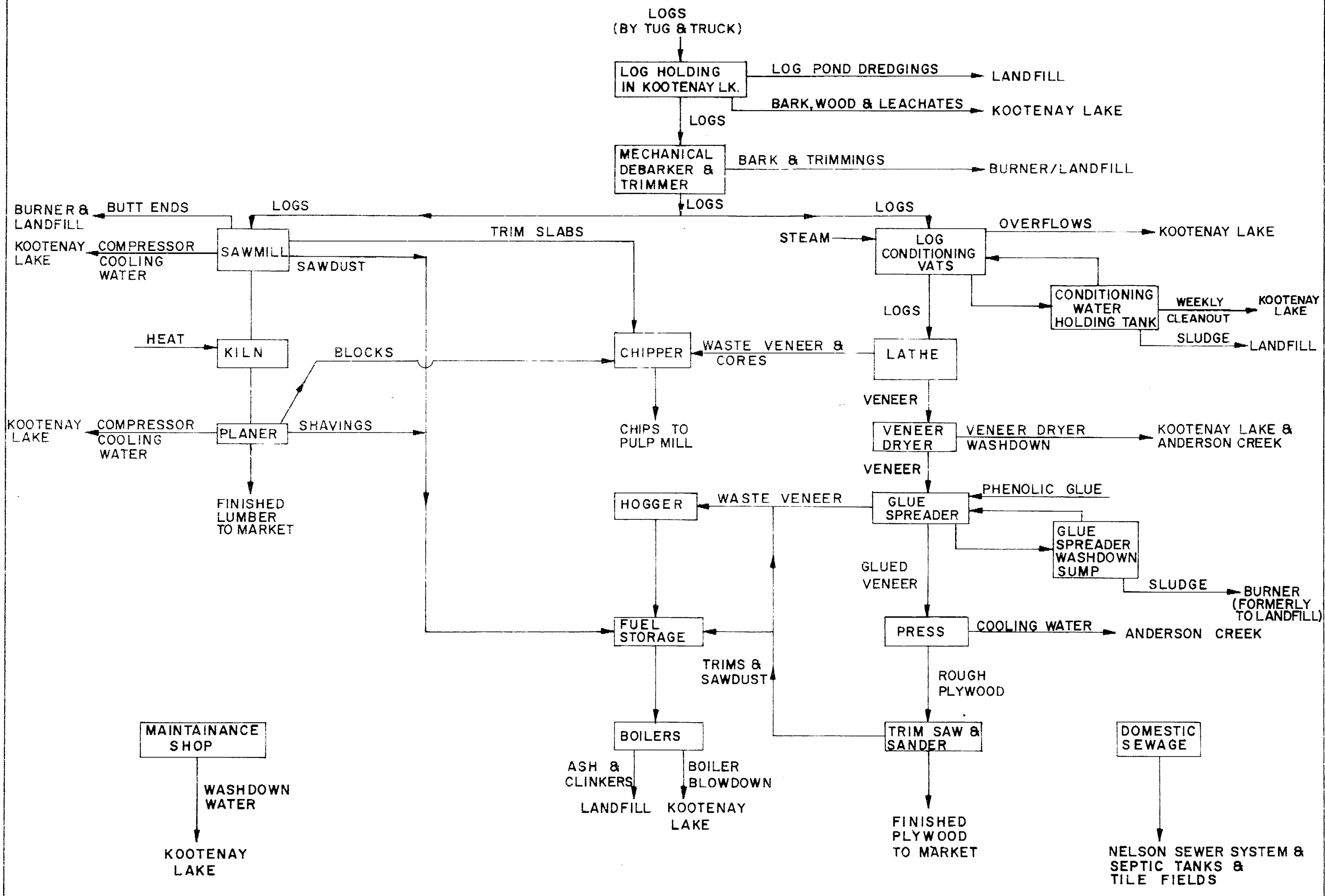

FIGURE 5-7
POWER & STORAGE PROJECTS IN THE NORTHERN COLUMBIA BASIN

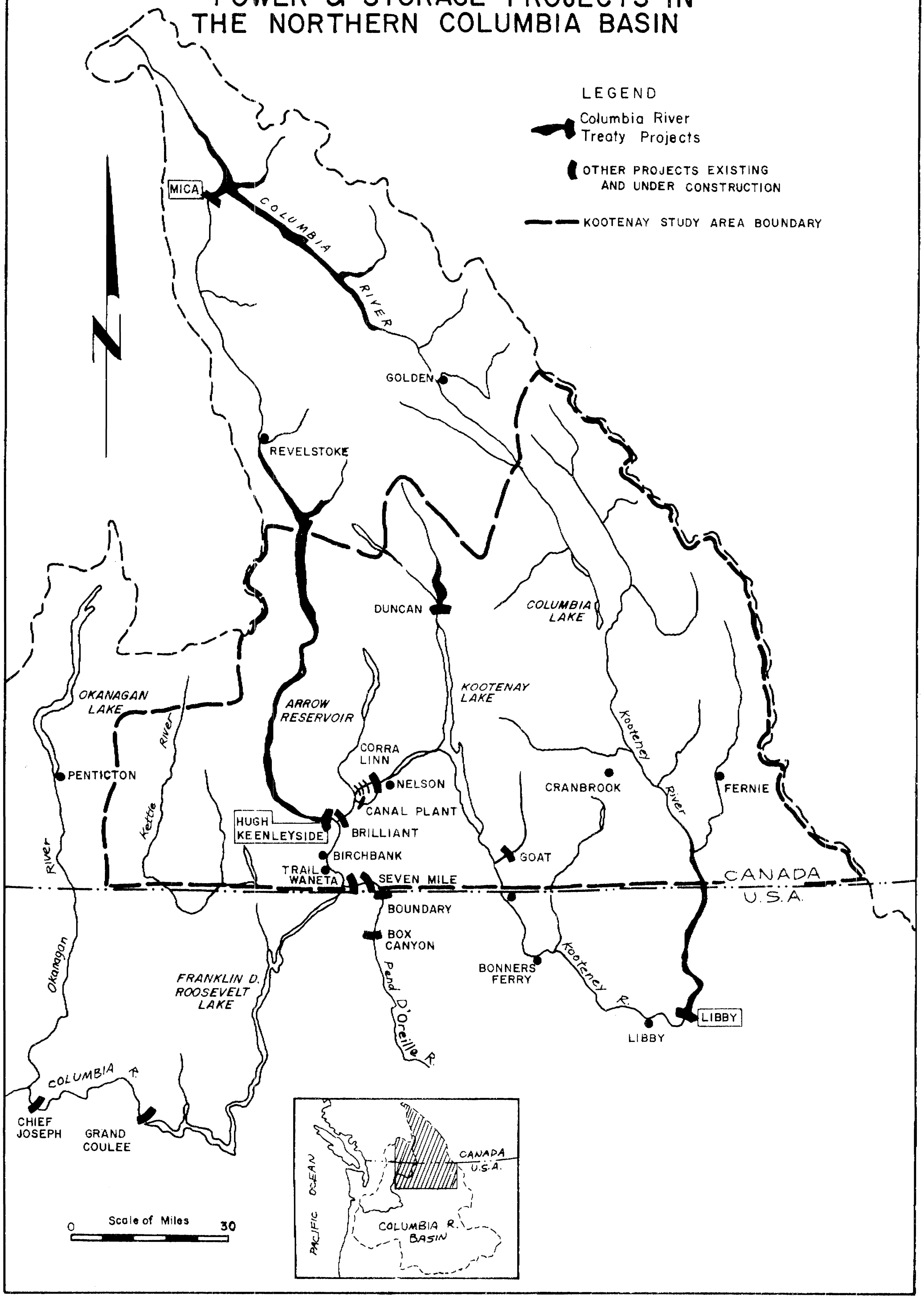

FIGURE 5-8

RULE CURVE FOR REGULATION OF KOOTENAY LAKE

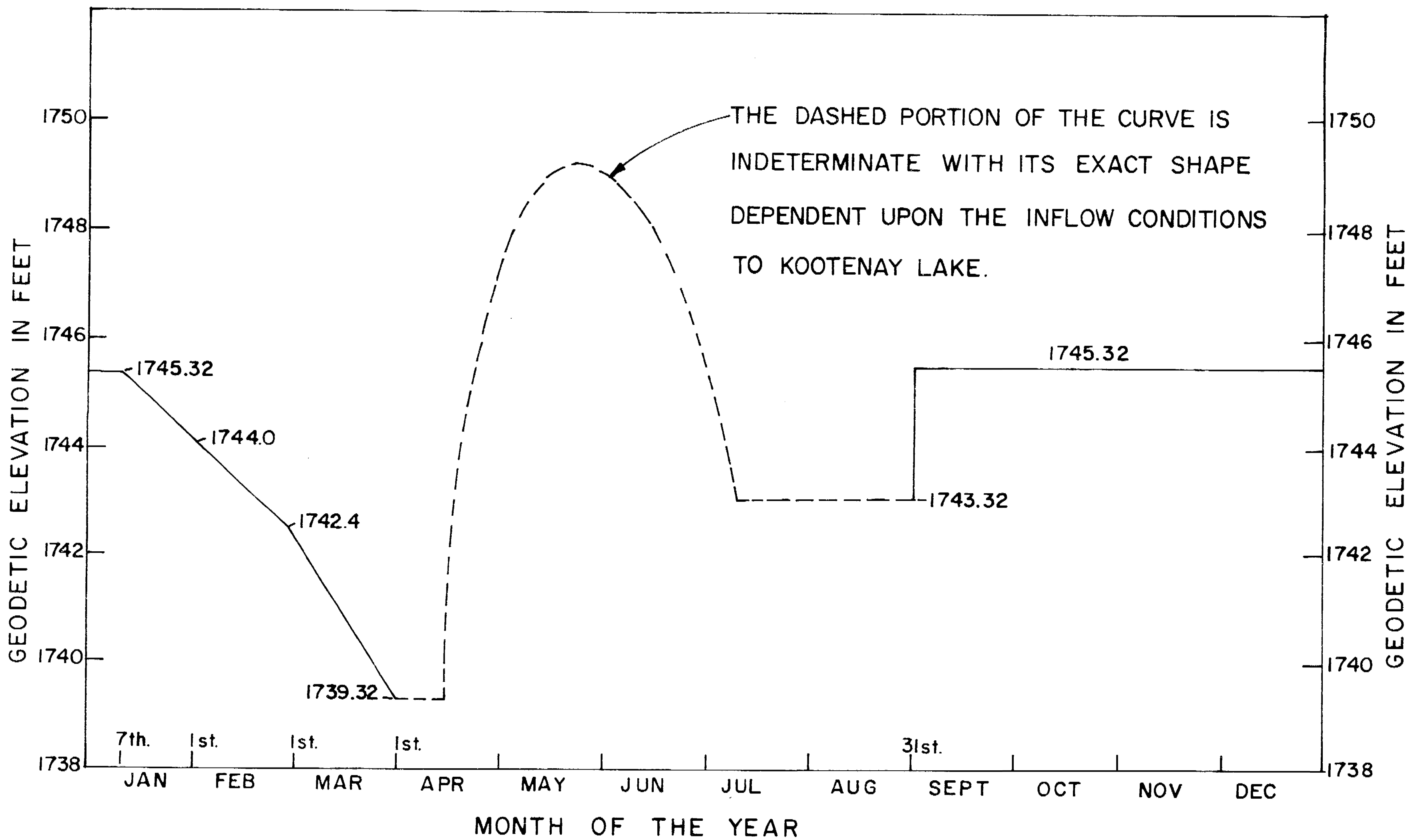

FIGURE 5-9
MONTHLY VARIATIONS OF NUTRIENT CONCENTRATIONS IN KOOTENAY LAKE AT SITE 31 IN 1973

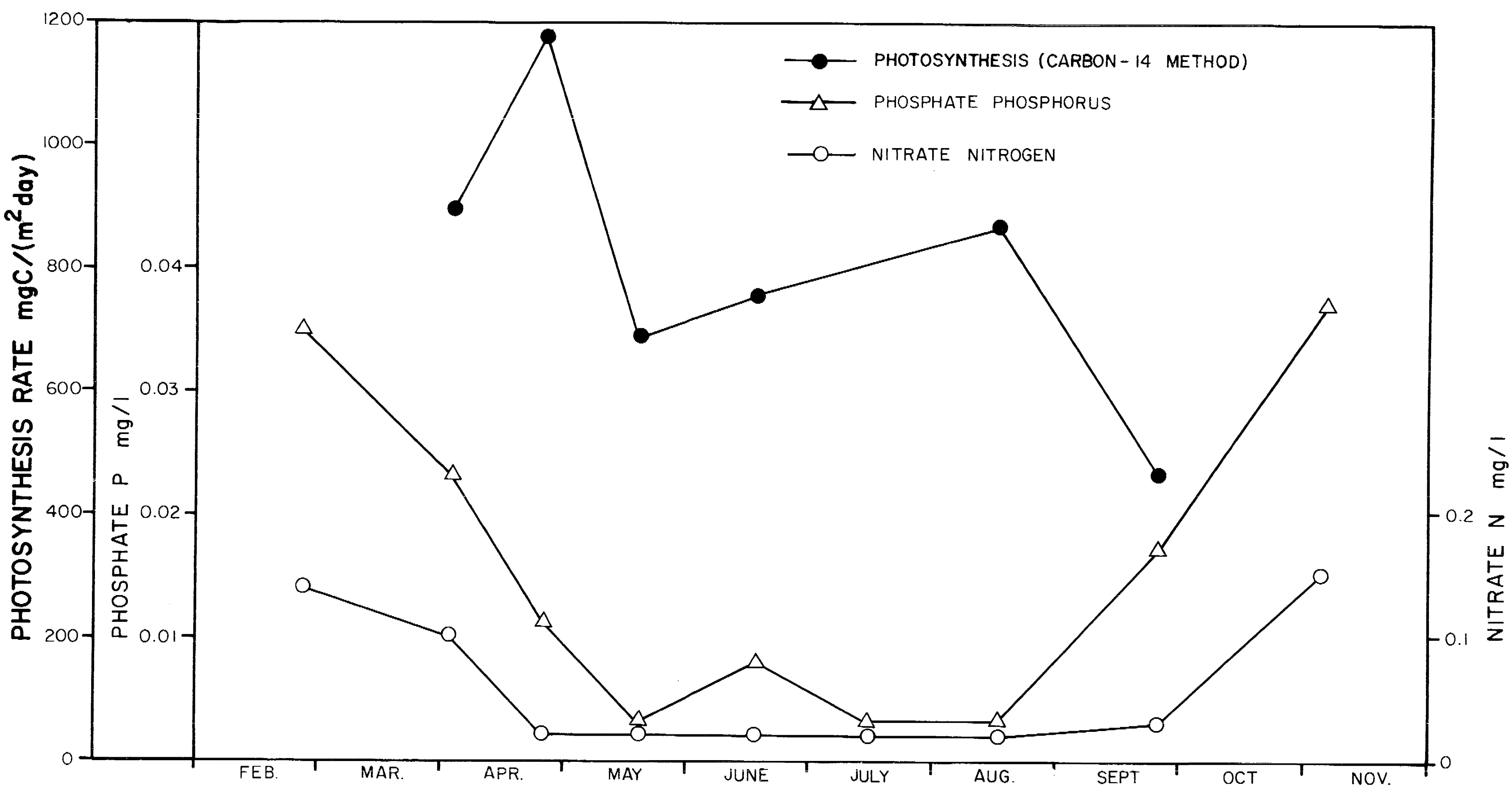

FIGURE 5-10

MONTHLY VARIATIONS OF PHOTOSYNTHESIS RATE AND LIGHT PENETRATION IN KOOTENAY LAKE AT SITE 31 IN 1973 AND 1974

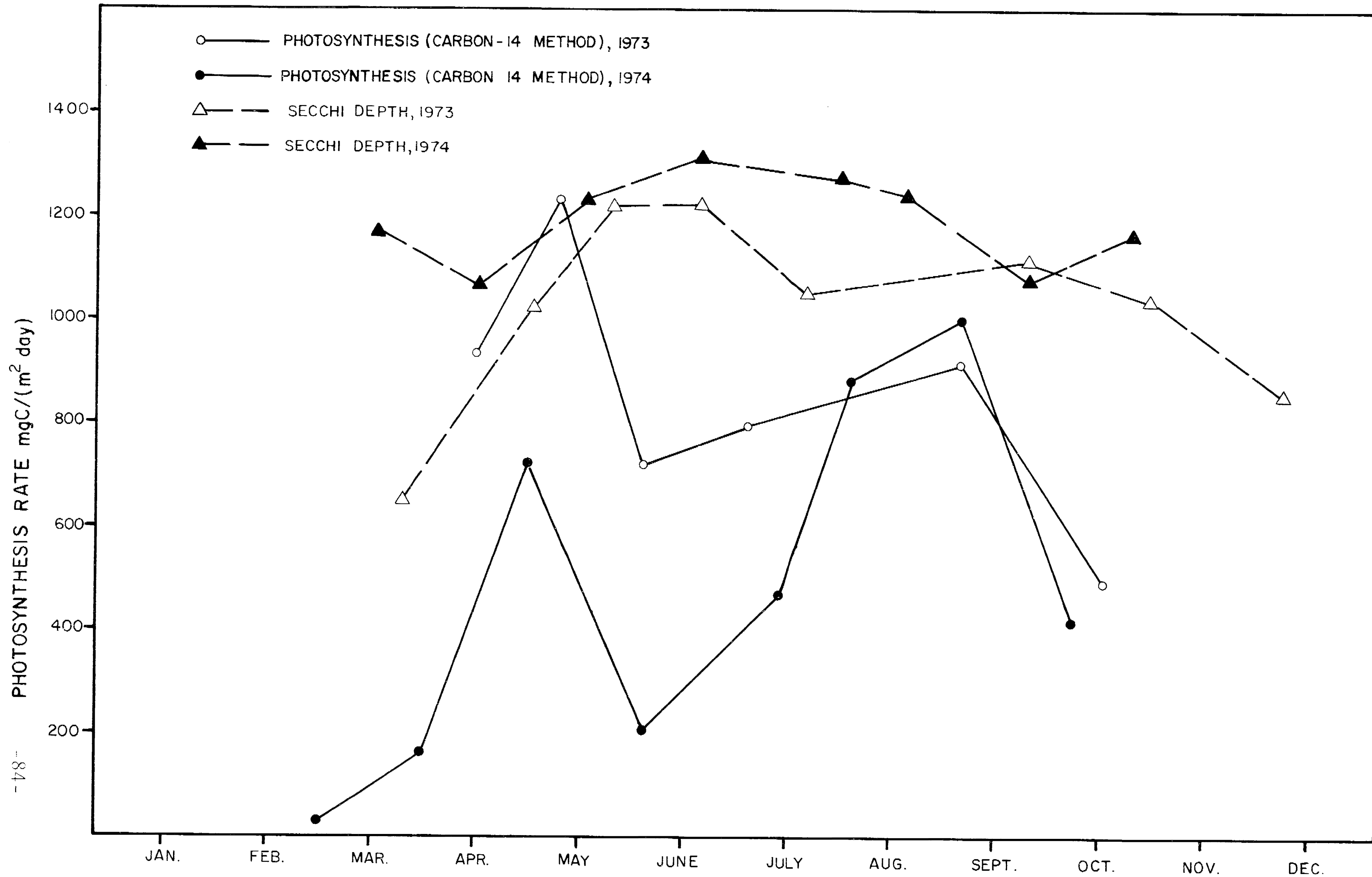

FIGURE 5-11
REGION 5, CRESTON AREA

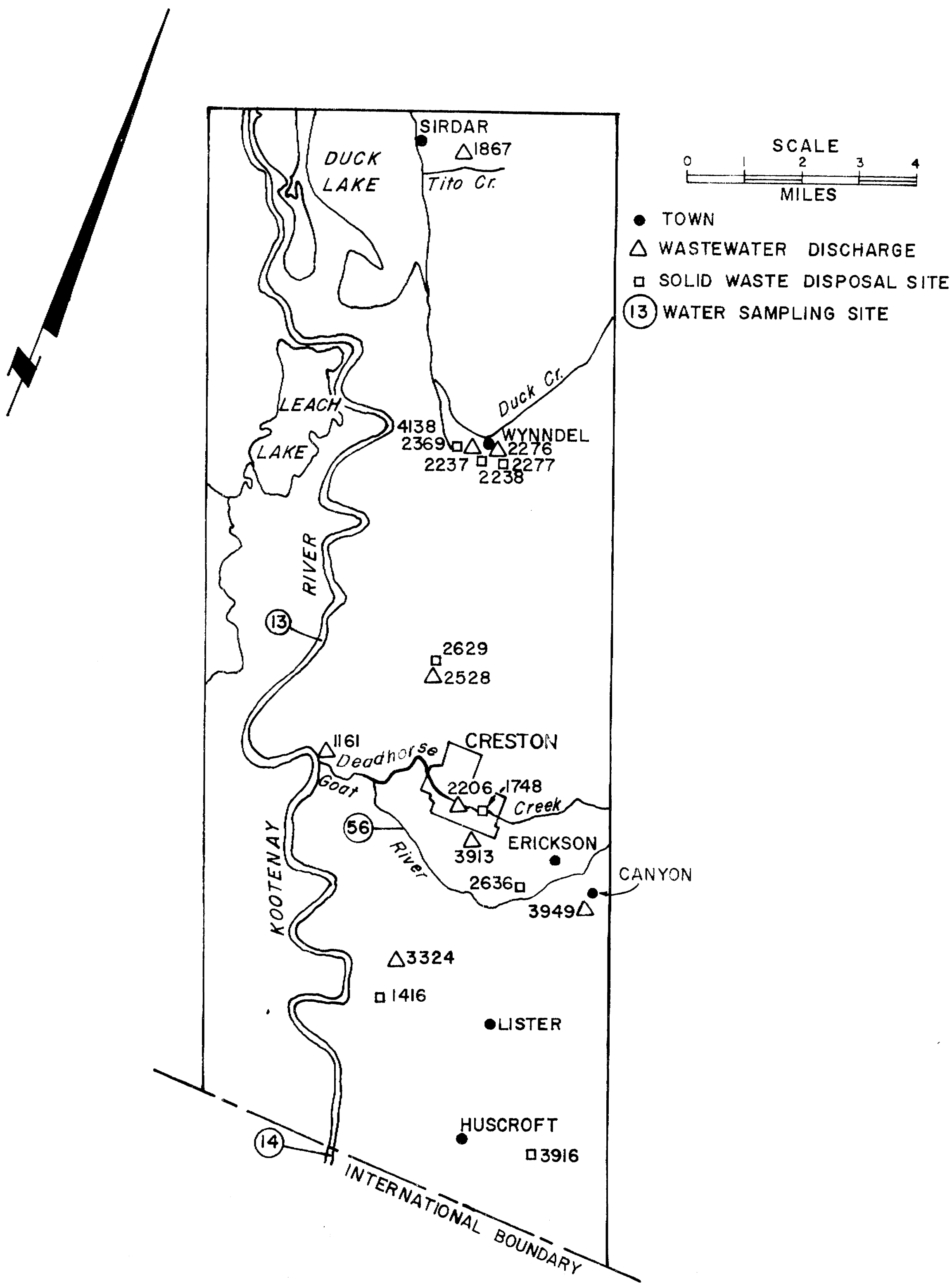

TABLE 5-1

STREAMFLOW SUMMARY TO 1970 FOR THE KOOTENAY, LARDEAU, DUNCAN AND GOAT RIVERS[8,26,27]

Stream	Drainage Area Square Miles	Mean Annual Discharge (CFS)	Maximum Daily Discharge Recorded (CFS)	Minimum Daily Discharge Recorded (CFS)
Kootenay River at Porthill* (at the international boundary)	13,700	16,000	125,000	1,380
Kootenay River at Corra Linn Dam**	Approximately 17,800	28,300	174,000	3,680
Lardeau River at Marblehead (near the mouth)	610	2,130	13,400	300
Duncan River at Duncan Dam+	925	3,600	21,400	268
Goat River near Erickson (below Goat River Dam)	430	932	15,900	40

* Regulated by the Libby Dam since 1972.
** Regulated by the Corra Linn Dam since 1939.
\+ Regulated by the Duncan Dam since 1967.

TABLE 5-2

DISTRIBUTION OF GROUNDWATER WELLS[28]

Location	Number of Wells
Creston	12
Willow Point-Macdonalds Landing (West Arm of Kootenay Lake)	10
Nelson	6
Aldridge	5
Taghum	5
Kokanee Point	4
Long Beach	4
Yahk	3
Harrop	3
Procter	2
Balfour	1
	Total: 55

TABLE 5-3

SUMMARY OF WATER LICENSES IN REGION 5[13]

Source +	No. of Licenses	Quantity	Purpose	Owner	Location*	Comments
CRANBROOK WATER DISTRICT, MOYIE PRECINCT						
Braunagel Cr.	2	$2.42X10^6$GPD**	power	Cranbrook Holding	D.L. 3003 & 5799	
Elmira Cr.	2	55 AF*** 2000 GPD	irrigation domestic		L's 9388 & 9104	27 acres irrigated
Glencairn Cr.	1	100,000 GPD	domestic	Moyie Water Co.		water works
Hogg Cr.	1	95 AF	irrigation		L.1086 & S.L. 2 or D.L. 4591	38 acres irrigated
Johnson Cr.	1	50 AF 500 GPD	irrigation domestic		L. 7020	20 acres irrigated
Kiakho Cr.	1	538,186 GPD	placer mining	A.A. Ablett	P.M.L. 924	
Moyie R.	6	300 AF $5.0X10^6$GPD 2,500 GPD	irrigation domestic domestic	City of Cranbrook	D.L.'s 6423, 7927, 6675,12258&12259	130 acres irrigated. City of Cranbrook has applied for an additional $10.0X10^6$GPD for domestic purposes.
Palmer Bar Cr.	2	502.5 AF 2000 GPD	irrigation domestic		L's 12530, 2304, 2804, 3066 & 5255	201 acres irrigated
Peavine Cr.	5	307 AF	irrigation		L's 5590, 7985, 9451 & 9452	123 acres irrigated fully recorded
Weaver Cr.	1	$2.15X10^6$GPD	mining		P.M.L's 1082&1083	

*All lots are located in the Kootenay Land District
**GPD: Imperial gallons per day.
***AF: Acre-feet
+ Only those sources with a licensed water usage of 40 AF/year (30,000 GPD) or more are listed in the Table.

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, CRESTON PRECINCT						
Arrow Cr.	2	2610 AF	irrigation	East Creston Irrigation District		2088 acres irrigated (estimated using duty of 1.25 AF/acre)
	2	31 AF	irrigation			25 acres irrigated
	2	1,615,360 GPD	domestic	Town of Creston	Creston	
	2	300,000 GPD	domestic	East Creston Irrigation Dist.		
	3	1500 GPD	domestic			
Bayonne Cr.	1	600,000 GPD	mining		L's 6887,6888 & 9360	
Camp Run Cr.	28	451 AF 24,900 GPD	irrigation domestic		N.W. corner of L.182 of D.L. 812 (Canyon area)	385 acres irrigated Fully recorded
Corn Cr.	1	250 AF 117.5 AF	conservation irrigation	Creston Wildlife Management Area	L.1005,L.281 &L.12548 (Wynndel Area)	94 acres irrigated
	4	4000 GPD	domestic			
Corn Cr. Marsh	1	2400 AF	conservation	Creston Valley Wildlife Management area		Leach Lake Project
Crackerjack Cr.	1	2000 AF 7500 GPD	irrigation domestic		L.16355 &S.L. 15 of L. 4592	800 acres irrigated
Deadhorse Cr.	1	65,000 GPD	industrial	Crestbrook Forest Industries Ltd.	D.L. 891, Creston	Log sprinkling

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, CRESTON PRECINCT Continued						
District Brook	2	115 AF	irrigation	North Canyon Improvement Dist.	Canyon	Fully recorded 92 acres irrigated (estimated using duty of 1.25 AF/acre
Duck Cr.	2	888.5 AF 50,000 GPD	irrigation domestic		Wynndel area	711 acres irrigated (estimated using duty of 1.25 AF/A) Possible water shortage
Ed & Jean Springs	2	600,000 GPD	domestic	Town of Creston	Creston	
Elsie Holmes Cr.	5	41.25 AF	irrigation		S.L. 2 & S.L. 31 of D.L. 4595	33 acres irrigated
Fairhead Cr.	4	38 AF 1500 GPD	irrigation domestic		D.L. 891	29 acres irrigated
Floyd Cr. & tributaries (Orde, Lister, Bond, Nygaard & Cor)	76	405 AF 392,500 GPD	irrigation domestic		Lister-Canyon Area	372 acres irrigated Fully recorded
Glaser Cr.	12	25.5 AF 14,000 GPD	irrigation domestic		L.892 (Creston)	20 acres irrigated Fully recorded
Goat R.	7	712 AF 201,500 GPD 1000 GPD 107.6×10^6 GPD	irrigation domestic industrial power	 West Kootenay Power & Light Co.Ltd.	S.L. 16 & L. 812 of D.L. 4592	543 acres irrigated (mostly East Creston Irrigation District) Goat River Dam

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, CRESTON PRECINCT Continued						
Huggard Cr.	6	50 AF 51,000 GPD	irrigation domestic		S.L.63,S.L.12 & S.L. 51 of D.L. 4595 Wynndel area)	40 acres irrigated
Jock Cr.	1	70,000 GPD 500 GPD	industrial domestic	International Marble & Stone Co.Ltd.	L.14521	
Kootenay Lake	1	25,000 AF	conservation	Dept. of Recreation & Conservation	Duck Lake	Duck Lake Project of Creston Valley Wildlife Management Area
Kootenay R.	1	500 GPD	domestic		L.1 of L.14878	
	1	500 AF	conservation	Can.Wildlife Serv.	L.9997(I.R.'s1A & 1)	
	2	7000 AF	conservation	Creston Valley Wildlife Management Area	Leach Lake	Leach Lake Project
	1	1000 AF	conservation	" "	Corn Creek Marsh	Corn Creek Marsh Project
	1	2400 AF	irrigation	Reclamation Dyking District		1920 acres irrigated (estimated using duty of 1.25 AF/Acre)
	1	3000 AF	conservation	Creston Valley Wildlife Management Area	Corn Creek Marsh	Corn Creek Marsh Project
	1	250 AF 2500 GPD	irrigation domestic	Dept. of Environment	L.15150	200 acres irrigated
Leach Lake	1	3500 AF	conservation	Creston Valley Wildlife Management Area	Leach Lake	Leach Lake Project

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, CRESTON PRECINCT Continued						
Okell Cr. & Slough	10	75 AF 4000 GPD	irrigation domestic		S.L.9, S.L.5, S.L.130 of D.L. 4592 (Arrow Creek area)	Fully recorded 65 acres irrigated
Reed & Drury Brooks	1	99 AF	irrigation		L. 362	90 acres irrigated
Rykert Cr. & tributaries (Huscroft Cr. & William Brook)	39	551 AF 19,000 GPD	irrigation domestic		Huscroft Area	507 acres irrigated Possible water shortage
Samuelson Spr.	1	50 AF 1000 GPD	irrigation domestic		L. 362	40 acres irrigated
Sullivan Cr.	23	145 AF 99,000 GPD	irrigation domestic		L. 5617,L. 812 L. 9953	115 acres irrigated
Summit Cr.	4	7550 AF	conservation	Creston Valley Wildlife Management Area	Leach Lake & Corn Cr. Marsh Projects	
	1	1000 GPD	domestic	Dept. of Highways	L.10531	
Twin Bays Cr.	29	25 AF 18,250 GPD	irrigation domestic		L. 2637 (Twin Bays)	6 acres irrigated
Urmston Cr.	5	100 AF 1500 GPD 100,000 GPD 10,000 GPD	irrigation domestic industrial industrial	Swan Valley Foods	Urmston Cr. area (West of Kootenay R.)	80 acres irrigated Possible water shortage Food processing

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, CRESTON PRECINCT Continued						
Wilds Cr.	12	63 AF 3500 GPD	irrigation domestic		S.L. 39 & D.L. 9427 (Wynndel)	47 acres irrigated Fully recorded
Wynndel Cr.	27	95 AF 13,500 GPD	irrigation domestic		S.L.'s 47,26,48,31, 2,4,44,6,43(Wynndel)	78 acres irrigated Fully recorded
NELSON WATER DISTRICT, CRAWFORD BAY PRECINCT						
Burden Cr.	13	52 AF 9500 GPD	irrigation domestic		D.L. 7615, L. 196	42 acres irrigated
Crawford Cr.	8	67 AF 6500 GPD	irrigation domestic		L's 5021, 3888, 24, 7366, & 2335	53 acres irrigated
Croasdaile Cr.	3	76.5 AF 1000 GPD 538,186 GPD	irrigation domestic power		S.L. 32 & D.L. 1489	54 acres irrigated
Crown Cr.	2	112.5 AF 1500 GPD	irrigation domestic		S.L. 41 & S.L. 87 of D.L. 4595	90 acres irrigated
Gray Cr.	9	70 AF 5500 GPD	irrigation domestic		S.L. 20, D.L. 1489 & S.L. 32	52 acres irrigated
	1	10,000 GPD	bathing			swimming pool
Holiday Cr.	15	42.5 AF 4500 GPD	irrigation domestic		D.L. 5027	35 acres irrigated
Lindsay & Wolverton Crs.	6	21 AF 5,000 GPD 12,000 GPD	irrigation domestic industrial		S.L.'s 28 & 16	33 acres irrigated

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, CRAWFORD BAY PRECINCT Continued						
McFarlane Cr.	11	200 AF 8500 GPD	irrigation domestic		S.L.'s 82, 98, 91& 55	158 acres irrigated
McGregor Cr.	6	66 AF 1000 GPD	irrigation domestic		D.L.'s 6983 & 889	63 acres irrigated
McGregor Cr.	3	43 AF 1500 GPD	irrigation domestic		L. 6936	30 acres irrigated
McGregor Lake	1	100,000 GPD	industrual		L. 13493	fish culture
Sherraden Cr.	8	58 AF 3500 GPD	irrigation domestic		S.L.'s 29,3,30 & L's 1,2,3,5, & 6	47 acres irrigated
Thomas Cr.	3	40 AF 1000 GPD	irrigation domestic		S.L. 21 of D.L. 4595	32 acres irrigated
Zimmer Cr.	2	48 AF 1000 GPD	irrigation domestic		D.L. 6937	32 acres irrigated
NELSON WATER DISTRICT, PROCTER PRECINCT						
Bagley Cr.	14	52 AF 5750 GPD	irrigation domestic		L's 4161, 3448, 7069	41 acres irrigated
Bourke Cr.	45	12.8 AF 24,350 GPD	irrigation domestic		L. 4216 (Crescent Bay area)	10 acres irrigated

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, PROCTER PRECINCT Continued						
Greenwood Cr.	6	49 AF 3000 GPD	irrigation domestic		D.L. 306 (Sunshine Bay area)	39 acres irrigated
Harrop Cr. (& Mill Cr.)	28	114 AF 11,500 GPD	irrigation domestic		L. 222 (Harrop)	76 acres irrigated
Laird Cr.	32	174.4 AF 17,000 GPD	irrigation domestic		L. 7007 & L. 337 (Balfour)	132 acres irrigated
Morley Cr.	21	28.5 AF 11,000 GPD	irrigation domestic		L. 4217 & L. 4216 (Cresent Bay)	21 acres irrigated
Narrows Cr.	26	310 AF 9,000 GPD	irrigation domestic		L.'s 306,309 (Procter)	263 acres irrigated
Procter Cr. & Spring	58	31,500 GPD	domestic		L. 309 (Procter)	
Redfish Cr. (& Rosswell Brook)	15 1	49 AF 7875 GPD 2.69×10^6 GPD	irrigation domestic conservation	 Fish & Wildlife Branch	L. 7070 & L. 1313 (Longbeach)	39 acres irrigated
Rucks Cr.	3	53 AF 1500 GPD	irrigation domestic		L. 306 (Procter)	40 acres irrigated
Slater Cr.	18	106.4 AF 20,000 GPD 134,546 GPD	irritation domestic power		L.222 & L.7365 (Harrop)	93 acres irrigated

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, NELSON PRECINCT						
Airey Cr.	30	40 AF	irrigation		L.'s 4396,4397,4398 (McDonalds Landing)	30 acres irrigated
		15,500 GPD	domestic			
Anderson & Fell Cr's.	1	1,500,000 GPD	domestic	City of Nelson	L's 97 & 183 (Nelson)	
		12,500 GPD	domestic			
	7	17 AF	irrigation			13 acres irrigated
Cottonwood Cr.	2	1,538,000 GPD	domestic	City of Nelson	Nelson	
& Tributaries	17	30,500 GPD	domestic			
(Selous, Giveout,		17.4 AF	irrigation			14 acres irrigated
Bradshaw, Towner,	1	538,000 GPD	power		L. 21 of L. 304	
Cliff & Schesnuk Creeks)		3000 GPD	bathing			swimming pool
Crystal Cr.	32	45 AF	irrigation		L. 4780 (Willow Point)	31 acres irrigated
		16,250 GPD	domestic			
Duhamel Cr.	78	301 AF	irrigation		L.787, L.788, L.6302 (McDonalds Landing)	190 acres irrigated
		132,500 GPD	domestic			
Eagle Cr.	39	117 AF	irrigation		L. 5550, L.5079, L.3266, L.6584 (blewett)	60 acres irrigated
		14,250 GPD	domestic			
Falls Cr.	6	68 AF	irrigation		(Corra Linn Dam)	52 acres irrigated
		10,000 GPD	domestic	West Kootenay Power & Light Co.	L's 6300, 7068, 7066 & 14536	Storage on Falls Cr. (100,000 GPD)
		1000 GPD	domestic			

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, NELSON PRECINCT Continued						
Five Mile Cr.	1	1,615,359 GPD	domestic	City of Nelson	Nelson	
Fortynine Cr.	24	116 AF	irrigation		L's 6306,6305,6308, 6307 & 8257	115 acres irrigated
		6,500 GPD	domestic			
	1	10,000 GPD	industrial	Cominco	L. 3333	Construction camp
	1	2,000 GPD	industrial		L. 6306	Mobile Home
Four Mile Cr.	21	23.5 AF	irrigation		L. 917 (Roberts Bay)	25 acres irrigated
		53,000 GPD	domestic			
Grohman Cr.	1	1,345,464 GPD	power		D.L. 910 (across Kootenay Lake from Nelson)	
		4,000 GPD	domestic			
	4	4 AF	irrigation			3 acres irrigated
Isaac Cr.	6	101,250 GPD	domestic		L. 372 (Nelson)	Fully recorded except for domestic use
Sandy Cr.	56	232 AF	irrigation		L. 2548 & L. 3266 (Granite)	190 acres irrigated
		41,000 GPD	domestic			
Shannon Cr.	57	82.3 AF	irrigation		L. 4780 (Willow Point)	57 acres irrigated
		33,500 GPD	domestic			
Sitkum Cr.	1	100,000 GPD	mining	Alpine Gold Ltd.	D.L. 14922 (Cresent Bay)	
	9	8,000 GPD	domestic			
		9.7 AF	irrigation			8 acres irrigated
	1	1,614,000 GPD	power		D.L. 7453	

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
NELSON WATER DISTRICT, NELSON PRECINCT Continued						
Smelter Cr.	5	45 AF 4000 GPD	irrigation domestic	Nelson Golf & Country Club	Nelson	45 acres irrigated (golf course) Fully recorded
Sproule Cr. (& Rixen Cr.)	22	77.8 AF 9500 GPD	irrigation domestic		L. 5574, L. 10427 Taghum	55 acres irrigated
Sutherland Cr.	5	91,750 GPD	domestic		L. 372, L. 370 (Nelson)	
Van Wagner Cr. (& East Van Wagner Cr.)	5	10.4 AF 69,600 GPD	irrigation domestic		L. 372 (Nelson	Fully recorded
KASLO WATER DISTRICT, KASLO PRECINCT						
Ainsworth Hot Springs	1	100,000 GPD	bathing	Ainsworth Hot Springs Ltd.	Ainsworth	mineral springs
Bjerkness Cr.	36	89 AF 18,000 GPD	irrigation domestic		L.455 & L.819 (Mirror Lake)	72 acres irrigated
Bridalveil Cr.	11	62.6 AF 2500 GPD	irrigation domestic		L.6899 (Queens Bay)	36 acres irrigated
Brooks, Clarke, & Cross Creeks	1	500,000 GPD	domestic	Village of Kaslo	Kaslo	
Clute Cr.	1 1	1,345,000 GPD 500 GPD	power domestic		D.L. 12417	

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of Licenses	Quantity	Purpose	Owner	Location	Comments
KASLO WATER DISTRICT, KASLO PRECINCT Continued						
Kaslo R.	1	300,000 GPD	domestic	Village of Kaslo	Kaslo	
Kemp Cr.	1	100,000 GPD	domestic	Village of Kaslo	Kaslo	
Murphy Cr.	1	5,380,000 GPD	power		D.L. 12417	
Shutty Cr.	11	54.4 AF 3500 GPD	irrigation domestic		S.L. 13 of D.L. 819 (Shutty Beach)	62 acres irrigated
Stenson Cr.	1	86,000 GPD 2,000 GPD	mining domestic	Iksut Silver Mines Ltd.	L. 1166	
Wing Cr.	5	78 AF 3500 GPD	irrigation domestic		S.L. 13 of L. 819 (Shutty Beach)	60 acres irrigated
KASLO WATER DISTRICT, LARDEAU PRECINCT						
Argenta Cr.	23	71.4 AF 10,500 GPD 538,000 GPD	irrigation domestic power		L. 8390, L. 527, L. 7451 (Argenta)	57 acres irrigated
Gar Cr.	11	109 AF 4,000 GPD	irrigation domestic		D.L. 6810 (Johnsons Landing)	87 acres irrigated
Hamill Cr.	2	45 AF	irrigation		L. 12852 & L. 7450 (Cooper Creek)	40 acres irrigated
Salisbury Cr.	1	5,380,000 GPD	power		D.L. 8094	
Tarr & Carter Creeks	5	127.5 AF 1500 GPD	irrigation domestic		L. 8390 & L. 1883 (Argenta)	92 acres irrigated

TABLE 5-3 Continued

SUMMARY OF WATER LICENSES IN REGION 5

Source	No. of	Quantity	Purpose	Owner	Location	Comments
KASLO WATER DISTRICT, TROUT LAKE PRECINCT						
Batys Cr.	1	40,000 GPD	domestic	Trout Lake Improvement Dist.		
Daney Cr.	1 1	538,000 GPD 1000 GPD	power domestic		L. 15703	
Ferguson Cr.	1	$26.9X10^6$ GPD	power	Columbia Metals Corp. Ltd.	D.L. 1140	
Lardeau Cr.	1	5,380,000 GPD	power		L. 769	
True Fissure Creek	1	95,000 GPD	mining	Columbia Metals Corp. Ltd.	L. 1097	

TABLE 5-4

AREAS WITH LIMITED WATER AVAILABILITY[13]

Location	Limited Sources Of Water Supply	Comments
Creston Flats		
East of Kootenay River		
Wynndel	Duck Creek	possible shortage
	Wilds Creek	fully recorded
Creston	Glaser Creek	fully recorded
	Mallampton Springs	fully recorded
Canyon	Camp Run Creek	fully recorded
	District Brook	fully recorded
Canyon-Lister	Floyd Creek & tributaries	fully recorded
Erickson	Mallandaine Spring	possible shortage
Huscroft-Rykerts	Rykert Creek & tributaries	possible shortage
West of Kootenay River	Urmston Creek	possible shortage
Goat River		
Arrow Creek	Okell Creek & Slough	fully recorded
Nelson	Issac Creek	fully recorded, except for domestic use
	Smelter Creek	fully recorded
	Van Wagner Creek	fully recorded
Cranbrook	Peavine Creek	fully recorded Most of water in Peavine Cr. is used for irrigation in Region 4, near Cranbrook.

TABLE 5-5

POPULATIONS OF SOME SETTLEMENTS

Settlement	1971 Population	Settlement	1971 Population
Nelson	9,400	Kootenay Bay	88
Creston	3,204	Willow Point	83
Kaslo	755	Shutty Bench	80
Wynndel	579	Taghum	78
Riondel	572	Sunshine Bay	74
Crawford Bay	244	Ainsworth	62
Balfour	195	Meadow Creek	60
Yahk	192	Johnsons Landing	51
Procter	183	Kitchener	49
Longbeach	136	Crescent Bay	44
Lister	134	Queens Bay	39
Gray Creek	126	Lardeau	37
Harrop	110	Sirdar	23
Canyon	107	Granite	20
Argenta	107	Howser	17
Blewett	101	Kokanee	17
Boswell	97	Sanca	15
Moyie	94	Twin Bays	14

TABLE 5-6

MINERAL PRODUCTION DURING 1972 AND 1973 [16]

Property	Location	Minerals	Ore Production	Comments
Crawford Creek Dolomite Quarry	Crawford Bay	limestone	50,000 tons (1972)	Building stone
Bluebell Mine	Riondel	lead concentrate	65 tons (1973)	salvaged from Kootenay Bay
Crown	Ainsworth	silver, lead, zinc	52 tons (1972)	shipped to Trail
General Grant	Ainsworth	silver, lead, zinc, copper	5 tons (1972)	shipped to Trail
Lavina Mine	Duncan Reservoir	silver, lead, zinc	13 tons (1972)	salvaged from mine dumps and shipped to Trail
Silver Hoard Mine	Ainsworth	silver, lead	891 tons (1973)	salvaged from mine dump and shipped to Trail
Nor	Ainsworth	silver, lead, zinc	74 tons (1973)	shipped to Trail

TABLE 5-7

PROVINCIAL PARKS IN REGION 5 [15,21]

Name	Area (acres)	Location	Feature
Cody Caves	155	Balfour	natural feature
Cottonwood Lake	20	Nelson	picnicking
Drewry Point	51	Kootenay Lake	
James Johnstone	4	Nelson	picknicking
Kokanee Creek	643	12 miles N.E. of Nelson	boat launching, beach, camping, swimming
Kokanee Glacier	64,000	N. of Nelson	alpine recreation
Kuskonook	14	Creston	picnicking
Lardeau	29	Kootenay Lake	
Lockhart Beach	7	17 miles S. of Kootenay Bay	picnicking, beach, swimming
Moyie Lake	153	12 miles S. of Cranbrook	camping, swimming, angling, boat launching
Pilot Bay	856	Kootenay Bay	picnicking, swimming
Ryan	143	Yahk	picnicking
Stagleap	2,800	Salmo-Creston Highway	picnicking, scenic
Yahk	18	on Moyie River near Yahk	picnicking, angling
Central Purcell Wilderness Conservancy	325,000	East of the northern half of Kootenay Lake	wilderness area
Fry Creek Recreation Area	1,360	On Fry Creek near Kootenay Lake	wilderness area

TABLE 5-8

SUMMARY OF POLLUTION CONTROL EFFLUENT PERMITS

Permit Number	PE-291	PE-1161	PE-1519	PE-1649	PE-1848
Permitee	City of Nelson	Town of Creston	T.J. Dickson	B.C.Dept.Highways	Mountain Shores Resort
Date Issued	July 31, 1969	July 10, 1972	Feb. 18, 1972	Oct. 6, 1972	Nov. 6, 1973
Location	Nelson	Creston	Yahk	Balfour	LaFrance Creek
Type of Effluent	domestic	domestic	laundromat	domestic from washrooms & ferries	domestic
Effluent Flow	1,250,000 GPD	Average: 1,000,000 GPD	1,960 GPD	6,250 GPD	9,000 GPD
Effluent Characteristics	SS:100 ppm BOD_5:140 ppm Total coliform: 150,000/100 ml	SS:60 mg/1 BOD_5:45 mg/1 chlorine residual: 0.1-1.0 ppm	typical laundromat effluent	SS:80 mg/1 BOD_5:45 mg/1	typical septic tank effluent
Treatment	primary comminution chlorination	comminution grit removal extended aeration chlorination sludge drying beds	lint screen septic tank tile field	extended aeration chlorination tile field	septic tank tile field
Discharge Point	Kootenay River	Kootenay River	ground	ground	ground

Note: SS = suspended solids
BOD_5 = Biochemical oxygen demand

TABLE 5-8 Continued

SUMMARY OF POLLUTION CONTROL EFFLUENT PERMITS

Permit Number	PE-1867	PE-1892	PE-2206	PE-2237	PE-2276
Permitee	R.A. Acton	Across Lake Holdings Ltd.	L. Salvador & Son Ltd.	Duck Lake Co-operative Exchange	Co-op Fruit Growers Association
Date Issued	Sept. 10, 1973	April 4, 1973	Oct. 19, 1973	Oct. 12, 1973	Sept. 6, 1974
Location	Sirdar	Nelson	Creston	Wynndel	Wynndel
Type of Effluent	septic tank sludge	domestic and swimming pool	concrete truck washout	potato wash water	vegetable wash water
Effluent Flow	Maximum: 2,000 IGPD May 1 - October 15	Maximum: 10,000 IGPD	300 IGPD	6,300 IGPD Sept. 15 - May 15	Maximum: 15,000 IGPD Sept. 15 - May 15
Effluent Characteristics	typical domestic septic tank sludge	BOD_5: 45 mg/1 SS: 60 mg/1 chlorine residual: 0.1 - 1.0 mg/1 pH: 6.5 - 7.5	SS: 50 mg/1 pH: 6.0 - 10.0	SS: 100 mg/1 BOD_5: 13 mg/1 pH: 7.0 - 7.4	BOD_5: 100 mg/1 SS: 11 mg/1
Treatment	sludge drying lagoons	extended aeration chlorination	settling basin filter bed	screening settling pond	screening settling pond
Discharge Point	ground	Kootenay Lake	Deadhorse Creek	Butterfield Creek	Butterfield Creek

TABLE 5-8 Continued

SUMMARY OF POLLUTION CONTROL EFFLUENT PERMITS

Permit Number	PE-2372	PE-2519	PE-2783	PE-3564	PE-3949
Permitee	M. C. Irwin	Ainsworth Hotsprings Ltd.	International Marble & Stone Co. Ltd.	Silver Star Mines Ltd.	M. Moore
Date Issued	August 6, 1974	July 5, 1974	January 9, 1975	October 21, 1974	December 30, 1974
Location	Kaslo	Ainsworth	Crawford Bay	Ainsworth	Creston
Type of Effluent	laundromat	Hotsprings swimming pool	dolomite limestone quarry	tailings from a lead-zinc-silver concentrator	abattoir
Effluent Flow	3,000 IGPD	34,000 IGPD	Maximum: 2,100 IGPD	Maximum 30,000 IGPD	Minimum 125 IGPD, 1 day week
Effluent Characteristics	typical laundromat effluent	typical mineral spring swimming pool effluent with chlorination	SS: 50 mg/1 oil and grease: 15 mg/1	pH: 6.0 - 10.0 dissolved Cd: 0.005 mg/1 Zn diss:0.5 mg/1 Pb diss:0.05 mg/1 Fe diss:0.3 mg/1 Cu diss:0.05 mg/1 Total CN: 0.1 mg/1 -50 tons/day of solids (ground rock) discharged	typical abbatoir effluent
Treatment	septic tank tile field	outfall	settling ponds	submerged outfall bubble return	lagoon
Discharge Point	ground	Hotsprings Creek	Willow Brook	Kootenay Lake	ground

TABLE 5-9

SUMMARY OF POLLUTION CONTROL EFFLUENT APPLICATIONS

Application Number	AE-2528	AE-2705	AE-3324	AE-3362	AE-3913	AE-4294
Application Date	Nov. 21, 1974	Sept. 14, 1973	Dec. 13, 1974	Nov. 29, 1973	Aug. 2, 1974	April 19, 1976
Applicant	H.O. Nielsen	Kootenay Forest Products Ltd.	R.A. Acton	T.C. Hayes	A.E. & D.O. Gunderson	Canadian Pacific Railway Company
Location	Creston	Nelson	Lister	Creston	Creston	Nelson
Type of Effluent	slaughter house	sawmill & plywood plant	septic tank sludge	septic tank pumpout	domestic	domestic, cooling, blowdown, service shop washdown
Quantity of Effluent	100 IGPD, one day per week	34,450 IGPD	2,000 IGPD	2,400 IGPD	maximum: 8,250 IGPD	average: 40,003 IGPD maximum: 48,360 IGPD
Proposed Quality	typical slaughter house effluent oil & grease: 350 mg/1	refer to Table 5-12	typical domestic septic tank sludge	typical septic tank pump out	typical domestic septic tank effluent	refer to Table 5-10
Proposed Treatment	lagoon	none	sludge drying lagoons	sludge drying bed	septic tanks tile fields	None except for diesel locomotive service shop effluent which passes through grit & oil separator to exfiltration pond.
Proposed Discharge Point	ground	Kootenay Lake	ground	ground	ground	Cottonwood Creek, ground

TABLE 5-10

EFFLUENT DATA FOR THE CANADIAN PACIFIC RAILWAY COMPANY IN NELSON, TAKEN FROM AE-4294

Effluent Description \ Effluent Source	Car Repair Shop	Diesel Locomotive Service Shop	Railway Station	Boiler Room			
Type of Effluent	Domestic Sewage	Wash Water	Domestic Sewage	Domestic Sewage	Compressor Cooling Water	Boiler Blowdown	Return Condensate
Discharge Point	Cottonwood Creek	Ground	Cottonwood Creek	Cottonwood Creek	Cottonwood Creek	Cottonwood Creek	Cottonwood Creek
Flow GPD	900	6,000	10,000	3	22,500	50	550
Characteristics:							
BOD_5 mg/l	<10	36	43	<10	<10	61	<10
Coliform, Fecal MPN/100 ml	22,000	2,300	130,000-240,000	<200	<2	<2	<2
Oil and Grease mg/l		318					
pH	7	7.1	7	7	10.4	14	14
Solids, Suspended mg/l	7	45.4	110	30	0	979	24
Solids, Total mg/l	68	152	263	69	0	1,867	697
Temperature ^oC	10-13	10-13	5-7	10-80	21-27	32-35	20-99

TABLE 5-11

DESCRIPTION OF INDUSTRIAL SOLID WASTE DISPOSAL SITES

Pollution Control Branch Application or Permit Number	PR-3703	AR-2369	PR-1748	AR-2704
Operator and Location	City of Nelson	Wynndel Box & Lumber Co., Wyndell	Crestbrook Forest Industries, Creston	Kootenay Forest Products Products, Nelson
Status of Refuse Disposal Site & Level of Operation*	Site is in operation, Level A	Site is in operation	Site is in operation, Level B	Site is in operation
Quantity & Type of Refuse	1,200 cu.yd./day(160 tons/day)wood-wastes	74 cu.yd./day wood-wastes	24 cu.yd./day wood-wastes	20 cu.yd./day wood-wastes and sludges
Site Suitability Factors: Depth to Groundwater Table (feet)	0 (site below high water level on Kootenay Lake)	0	0 (site located in channel of Deadhorse Creek)	0
Underlying Soils	clayey silt (relatively impervious)	alluvial silt loam with high organic content (poorly drained)	clay and loam	silt, gravel
Surface Runoff Or Flooding	surface runoff diverted, site separated from lake by dyke with clay liner	site is in low lying area subject to flooding	Deadhorse Cr. diverted through culverts beneath refuse site	flooding by Kootenay Lake
Distance to Surface Water (feet)	0 (Kootenay Lake)	0 (drainage channel to Duck Lake)	0 (Deadhorse Creek)	0 (Kootenay Lake)
Distance to Wells (feet)	none affected (lakeshore)	none affected	none within a ½ mile	none affected (lakeshore)
MAP/PE**	30/22	21/22	21/22	30/22
Potential For Adverse Effects On Groundwater or Surface Water	Groundwater:not applicable Surface Water: low (refer to sec.2.4)	Groundwater: not applicable Surface Water: high (refer to sec. 2.5)	Groundwater: nil Surface Water: moderate(refer to sec. 2.7)	Groundwater: not applicable Surface Water: moderate (refer to sec. 2.3.4)
Comments	Once completed, site to be used for park/ marina development.	Applicant seeking alternative method of disposal.		Logs are boomed in Kootenay Lake adjacent to the landfill site.

TABLE 5-11Continued

DESCRIPTION OF INDUSTRIAL SOLID WASTE DISPOSAL SITES

Pollution Control Branch Application or Permit Number	AR-4295	PR-2636	PR-2726	PR-2395
Operator and Location	Canadian Pacific Railway, Nelson	J.H. Huscroft, Erickson	T & H Sawmills, Kaslo	Kootenay Forest Products, Harrop
Status of Refuse Disposal Site & Level of Operation*	site in operation	site in operation Level C	site in operation Level C	site in operation Level C
Quantity and Type of Refuse	9.6 cu.yd./day, 90% wood, cardboard & paper, 5% inert, 3% fertilizer & grain, 2% scrap metal	5 cu.yd./day wood-wastes, ashes, bark	4 cu.yd./day wood-wastes, ashes, bark	1,000 cu.yd./year wood-wastes, bark (log sorting)
Site Suitability Factors: Depth to Groundwater Table (feet)	not known	1 during spring, 20 during rest of year (drain tiles & culverts to drain groundwater from site)	0 (during high water on Kootenay Lake)	3
Site Suitability Factors: Underlying Soils	gravelly silt	clay	alluvial gravel	sand, gravel (alluvial fan)
Site Suitability Factors: Surface Runoff Or Flooding	possible flooding by Kootenay Lake	no problem	flooding by Kootenay Lake. Landfill at elevation 1750, high water on Kootenay L. can reach elevation 1756.	Slater Cr. diverted around site. Site above high water level on Kootenay Lake (elevation 1756)
Site Suitability Factors: Distance to Surface Water (feet)	100 (Kootenay L. & Cottonwood Creek)	600 (Goat River)	200 (Kootenay L.) (Kaslo River)	50 (Kootenay Lake
Site Suitability Factors: Distance to Wells (feet)	none affected (lake-shore)	2,500	none affected (lake-shore)	none affected (lake-shore)
Site Suitability Factors: MAP/PE**	30/22	21/22	31/22	30/22
Potential For Adverse Effects On Groundwater Or Surface Water	Groundwater: not applicable Surface water: low (refer to sec.2.2.3)	Groundwater: nil Surface water: negligible	Groundwater: not applicable Surface water: negligible	Groundwater: not applicable Surface water: low (refer to sec. 2.6)
Comments	adjacent to site PR-1663			Logs are boomed in Kootenay L. adjacent to site.

TABLE 5-11 Continued

DESCRIPTION OF INDUSTRIAL SOLID WASTE DISPOSAL SITES

Pollution Control Branch Application or Permit Number	AR-2629	PR-2277	PR-2238	AR-4138
Operator and Location	A. Josephson, Creston	Co-operative Fruit Growers Association, Wynndel	Duck Lake Co-operative Wynndel	Wynndel Box and Lumber Co., Wynndel
Status of Refuse Disposal Site and Level of Operation*	site in operation	site in operation Level C	site in operation Level C	proposed site, not in use
Quantity and Type of Refuse	1,000 lb/week slaughterhouse wastes (bones, animal offal)	0.5 cu.yd./day vegetable matter & soil	0.4 cu.yd./day vegetable matter & soil	2,000 cu.ft./day bark
Site Suitability Factors: Depth to Groundwater Table (feet)	83	not known	well above water table	2
Underlying Soils	silty clay	clay	sandy clay, loam & some gravel	sandy loam and silt
Surface Runoff or Flooding	no problem	no problem	no problem	some flooding
Distance to Surface Water (feet)	10,000	800	250	400
Distance to Wells (feet)	2,500	none affected	none affected	2 miles
MAP/PE**	21/22	21/22	21/22	21/22
Potential For Adverse Effects	Groundwater: nil Surface water: nil	Groundwater: nil Surface water: nil	Groundwater: nil Surface water: nil	Groundwater: possible Surface water: moderate
Comments		refuse removed periodically for use as fertilizer		land now reserved for agricultural use

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

** MAP/PE: Mean annual precipitation/Average annual potential evapo-transpiration.

TABLE 5-12

EFFLUENT DATA FOR KOOTENAY FOREST PRODUCTS IN NELSON

Effluent Characteristics \ Effluent Source and Type	Boiler Blow-Down	Sawmill Compressor Cooling Water	Plywood Compressor Cooling Water	Plywood Press Oil Cooler	Log Conditioning Vat Overflow	Conditioning Vat Recycle Tank Clean-out	Glue Spreader Sump	Veneer Drier Washdown	Maintenance Shop Washdown
Discharge Point	Kootenay Lake	Kootenay Lake	Kootenay Lake	Kootenay Lake	Kootenay Lake	Kootenay Lake	Recycled	Kootenay Lake and Anderson Creek	Kootenay Lake
Flow GPD	2,000	10,000	12,000	2,000		6,000 G/week		washed once per week	
BOD_5 mg/1					1,590	1,600			
Carbon, total organic mg/1					1,380	1,400			
Colour, True/TAC	60/25	5/5			1,000/ 1,240	1,000/ 1,250			
Conductance, Specific μmho/cm	1,200	80			240	250	3,500		
Copper, diss. mg/1	0.04								
Iron, total/diss., mg/1	1.4/0.07								
Lead, diss. mg/1	<0.001								
Oil & grease mg/1		<1.0	<1.0						
pH	10.0	7.2	7.7		4.7	5	10.9		
Phenol mg/1			<0.004				4.0		
Potassium, diss. mg/1	7.6								
Sodium, diss. mg/1	148								
Solids, suspended mg/1	118	<1.0			671	700	4,597		
Solids, total mg/1	556	58			2,296	2,300	13,000		
Tannin & Lignin mg/1		0.2			500	500			
Temperature °C	43	12	12		49	50	35		
Zinc, diss. mg/1	<0.001								

Note: Data from P.C.B. File No. AE-2705, except for flows which were obtained directly from the Company, June 19, 1975.

TABLE 5-13

EFFLUENT DATA FOR THE TOWN OF CRESTON, COLUMBIA BREWING CO. LTD. AND CRESTBROOK FOREST INDUSTRIES LTD.

Effluent Source / Characteristic	Town of Creston and Columbia Brewing Co. Ltd.		Crestbrook Forest Industries Ltd.		Combined Effluent From Sewer System	
	Concentration	Loading lb/day	Concentration	Loading lb/day	Concentration	Loading lb/day
BOD_5	250 mg/1	1,000	690 mg/1	54	258 mg/1	1,054
Coliform, total	$30x10^6$ MPN/100 ml					
Conductance, specific			180 μmho/cm			
pH	6.0 - 8.0		5.1			
Sodium			5.7 mg/1	<1		
Solids, suspended	200 mg/1	800			<207 mg/1	<844
Solids, total	400 mg/1	1,600	564 mg/1	44	403 mg/1	1,644
Temperature ^{o}C	7.2 - 18.3					
Flow GPD	400,000 - Average dry weather flow		7,860		407,860	

Note: Data obtained from Pollution Control Applications AE-1161 and AE-1747

TABLE 5-14

CITY OF NELSON SEWAGE TREATMENT PLANT

EFFLUENT DATA OBTAINED BETWEEN AUGUST 1973 AND NOVEMBER 1974

Parameter \ Statistic	Maximum Value	Minimum Value	Mean Value	No. of Samples Analysed	Average Permit Conditions	Loadings Calculated Assuming a Flow of 1.25 MGPD
BOD_5 mg/1	129	30	85	13	140	1,062 lb/day
Chlorine Residual mg/1	0.5	0	0.3	12		
Coliform, Fecal MPN/100 ml.	>24,000	20	5,400	9		
Coliform, Total MPN/100 ml.	>24,000	16,000	20,000	2	150,000	
Conductance, Specific μmho/cm	308	271	294	6		
Flow, measured for 23 days GPM	1,600	347	618		1,875 (max)	
MGPD	1.19	0.75	0.89		1.25	
Nitrogen, Total mg/1			25 assumed			312 lb/day
Oxygen, Dissolved mg/1	9.0	4.2	6.4	12		
pH	7.6	6.4	7.1	12		
Phosphorus,Total mg/1			8.0 assumed			100 lb/day
Solids, Suspended mg/1	93	22	58	12	100	725 lb/day
Solids, Total mg/1	278	194	233	9		2,912 lb/day
Temperature ^{o}C	17.5	5.7	9.7	12		

Note: 75 percent of the data were obtained by the Pollution Control Branch and 25 percent by the City of Nelson.

TABLE 5-15

EFFICIENCY OF THE CITY OF NELSON SEWAGE TREATMENT

PLANT FROM POLLUTION CONTROL BRANCH DATA

	Influent (mg/1)	Effluent (mg/1)	% Removal	Average % Removal
Suspended Solids	117	61	48	
	92	57	38	
	187	93	50	57
	243	90	63	
	253	32	87	
BOD_5	147	92	37	
	137	101	26	
	118	69	42	51
	430	113	74	
	419	97	77	

TABLE 5-16

DESCRIPTION OF MUNICIPAL SOLID WASTE DISPOSAL SITES

Pollution Control Branch Application Or Permit Number	PR-1663	PR-1416	PR-3916	PR-3889
Operator & Location	City of Nelson	Town of Creston	Regional District of Central Kootenay, Lister	Regional District of Central Kootenay, Balfour
Status of Refuse Disposal Site & Level of Operation*	site in operation Level A	site in operation Level A	site in operation Level B	site in operation Level B during June, July & August. Level C during remainder of year.
Quantity & Type of Refuse	80 cu.yd./day municipal (contributing population of 15,000)	30 cu.yd./day municipal	40 cu.yd./day (8 tons/day) municipal (contributing population of 3,200)	12 cu.yd./day municipal (population equivalent of 1,000 & 2,000 during June, July & August.
Site Suitability Factors: Depth to Groundwater Table (feet)	0	12 (may be as great as 200 feet)	20	12 (likely much deeper)
Site Suitability Factors: Underlying Soils	silt, clay	fine grained, relatively impermeable (clay)	sand, gravel	sandy loam with gravel
Site Suitability Factors: Surface Runoff Or Flooding	flooding by Kootenay Lake, Cottonwood Cr.	surface runoff and intermittent creek diverted	no problem	no problem
Site Suitability Factors: Distance to Surface Water (feet)	0 (Kootenay L., Cottonwood Cr.)	0 (intermittent creek) 2,500 (Kootenay River)	330 (Rykerts Creek)	300 (Wyandotte Cr.) 2,500 (Kootenay Lake)
Site Suitability Factors: Distance to Wells (feet)	none affected (lakeshore)	none nearby	500	1,000 (well is above refuse site)
Site Suitability Factors: MAP/PE**	30/22	21/22	21/22	30/22
Potential For Adverse Effects On Groundwater or Surface Water	Groundwater: not applicable Surface water: low (refer to sec. 3.2.4)	Groundwater: nil Surface water: nil	Groundwater: nil Surface water: nil	Groundwater: nil Surface water: nil
Comments	monitoring wells indicate that groundwater is contaminated		there is a height of land between the site and Rykerts Creek	runoff from site flows away from Wyandotte Cr.

TABLE 5-16 Continued

DESCRIPTION OF MUNICIPAL SOLID WASTE DISPOSAL SITES

Pollution Control Branch Application Or Permit Number	AR-4070	AR-4069
Operator & Location	Regional District of Central Kootenay, Kaslo	Regional District of Central Kootenay, Crawford Bay
Status of Refuse Disposal Site & Level of Operation*	not known, Level B applied for	Level C applied for
Quantity & Type of Refuse	9,385 lb/day municipal (contributing population of 1,877)	2,500 lb/day municipal (contributing population of 500)
Site Suitability Factors: Depth to Groundwater Table (feet)	not known	not known
Site Suitability Factors: Underlying Soils	assumed to be gravel	gravel
Site Suitability Factors: Surface Runoff or Flooding	not known	not known
Site Suitability Factors: Distance to Surface Water (feet)	150 (Kaslo Creek)	500 (Crawford Creek) 600 (Preacher Creek)
Site Suitability Factors: Distance to Wells (feet)	750	500
Site Suitability Factors: MAP/PE**	31/22	35.5/22
Potential For Adverse Effects On Groundwater Or Surface Water	Groundwater: assumed to be negligible Surface water: assumed to be negligible	Groundwater: assumed to be negligible Surface water: assumed to be negligible
Comments	Application submitted 12/74	Application submitted 12/74

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

** MAP/PE: Mean annual precipitation/Average annual potential evapo-transpiration.

TABLE 5-17

RESULTS OF MONITORING CITY OF NELSON REFUSE DISPOSAL SITE (PR-1663), OBTAINED BY THE POLLUTION CONTROL BRANCH, 1973 TO 1974

Site No.	0200167				0200168			
Site Description	250 ft. S. of Kootenay Lake, 200 ft. E. of Cottonwood Cr.				400 ft. S. of Kootenay Lake, 900 ft. E. of Cottonwood Cr.			
Parameter \ Statistic	Maximum	Minimum	Mean	No. of Values	Maximum	Minimum	Mean	No. of Values
BOD_5 mg/l	6510	150	3375	13	5940	>150	1833	15
Carbon, organic mg/l	3369	372	2048	15	2895	292	1144	15
Coliform, fecal MPN/100 ml	<2	<2	2	13	110	<2	19	12
Conductivity, specific µmho/cm	6000	5000	5500	2	4000	3500	3750	2
Copper, dissolved mg/l	0.02	0.02	0.02	1	0.03	0.03	0.03	1
total mg/l	0.26	0.05	0.15	11	0.76	0.08	0.27	10
Lead, dissolved mg/l	0.002	0.002	0.002	1	0.004	0.004	0.004	1
total mg/l	0.60	0.013	0.33	10	3.4	0.055	1.07	10
Nitrogen, ammonia mg/l	17.0	2.7	6.8	6	50.0	4.1	32.6	6
Kjeldahl mg/l	136.0	31.0	78.8	9	34.0	12.0	21.9	10
nitrate,nitrite mg/l	1.77	0.03	0.21	15	0.18	0.02	0.065	15
Organic mg/l	31.0	0.14	12.2	6	58.0	6.0	21.4	5
Total mg/l	136.2	6.2	55.1	15	68.0	12.1	34.6	15
Oil and Grease mg/l	229	46	113	11	72	8	19	11
pH	7.0	5.8	6.2	9	7.1	5.8	6.6	7
Phosphorus, total phosphate mg/l	10.8	1.34	6.5	12	23.2	0.73	9.37	13
Tannins & lignins mg/l	236	49.2	105	9	291	28	79	11
Turbidity J.T.U.	120	120	120	1	130	130	130	1
Zinc, dissolved mg/l	0.13	0.13	0.13	1	0.14	0.14	0.14	1
total mg/l	0.94	0.19	0.45	10	6.3	0.88	2.75	10

TABLE 5-18

ESTIMATED NUTRIENT CONTRIBUTION TO SURFACE WATERS FROM FERTILIZED, IRRIGATED CROPLAND AND LIVESTOCK

	Moyie River	Kootenay R.: Upstream from Creston	Goat River	Lower Kootenay Lake	Upper Kootenay Lake	West Arm of Kootenay Lake	Totals
Farms Reporting Cropland	13	108	216	47	19	15	418
Cropland Area Acres	255	13,000	11,350	700		175	25,480
Irrigated Land Area - Acres	447	2,950	2,700	3,400	520	1,620	11,637
Calculated Nutrient Contribution From Irrigated Land							
N lb/year	3,000	20,000	18,000	23,000	3,500	11,000	78,500
P lb/year	80	500	460	600	90	280	2,010
Number of Head of Cattle (older than one year)	137	2,500	1,250	105	150	100	4,242
Calculated Nutrient Contribution From Cattle							
N lb/year	1,300	24,000	12,000	1,000	1,500	1,000	40,800
P lb/year	27	500	250	21	30	20	848
Total Nutrient Contribution From Irrigated Land and Cattle							
N lb/year	4,300	44,000	30,000	24,000	5,000	12,000	119,300
P lb/year	107	1,000	710	621	120	300	2,858

TABLE 5-19

CALCULATED NUTRIENT LOADINGS AND CONCENTRATIONS IN

SURFACE WATERS, FROM AGRICULTURAL OPERATIONS

Location \ Parameter	Nitrogen			Phosphorus		
	Loading lb/day	Concentration mg/1		Loading lb/day	Concentration mg/1	
		Low Flow	High Flow		Low Flow	High Flow
Moyie River	29	0.12	0.001	0.7	0.003	0.00003
Goat River	200	0.4	0.02	5.0	0.01	0.0005
Kootenay River Upstream From Creston	293	0.07	0.002	7.0	0.002	0.00004
Moyie River Flow	Low Flow: 50 CFS, High Flow: 5,000 CFS					
Goat River Flow	Low Flow: 100 CFS, High Flow: 2,000 CFS					
Kootenay River Flow	Low Flow: 8,000 CFS, High Flow: 35,000 CFS					

TABLE 5-20

STATISTICS FOR THE CORRA LINN, DUNCAN, AND GOAT DAMS

Dam	Corra Linn	Duncan	Goat
Height - feet	70	130	83
Crest length - feet	1,700	2,600	175
Spillway capacity-CFS	275,000	42,000	
Spillway height - feet	35	74	73
Spillway type	overflow at crest gates	gated chute	overflow
Sluiceway capacity-CFS		20,000	blocked-unusable
Powerhouse			
Installed capacity - MW	40.5	nil	1.28
Hydraulic capacity-CFS	12,600		
Reservoir	*		
Usable storage capacity - acre - feet	800,000	1,400,000	nil
Area - square miles	161	28.8	
Length - miles	65 & 22 (West Arm)	28	
Maximum width - miles	4	1.5	
Watershed area - square miles	17,800	925	430
Normal range of - high water	1,745	1,892	
water levels: - low water	1,739	1,800	

* Kootenay Lake is the reservoir of Corra Linn Dam.

TABLE 5-21

SUMMARY OF POLLUTION CONTROL BRANCH WATER QUALITY DATA, FROM 1969 TO 1974, FOR THE MOYIE, KOOTENAY AND GOAT RIVERS

Site Location		Moyie River			Kootenay River				Goat River	Recommended Drinking Water Standard (70)
Parameter \ Site Number		22	99	23	14 pre-impoundment	14 post-impoundment	13 pre-impoundment	13 post-impoundment	56	
Arsenic, dissolved mg/1	L				<0.005	<0.005	<0.005	<0.005		0.05
	H				<0.005	<0.005	<0.005	<0.005		
Boron, dissolved mg/1	L				<0.10	<0.10	<0.20	<0.10		5.0
	H				<0.10	<0.10	<0.20	<0.10		
Colour, true relative units	L	5	5	5	5	5	5	5	5	15
	H	10	10	5	10	8	10	9	5	
Conductivity, specific μmho/cm	L	60	60	55	250	200	210	200	75	
	H	60	50	55	200	175	150	150	75	
Copper, dissolved mg/1	L				0.002	0.002	0.005	0.001	<0.001	1.0
	H				0.002	0.002	0.005	0.001	<0.001	
Flow, 1000 CFS	L				8	15			0.43	
	H				35	20			2.0	
Fluoride, dissolved mg/1	L				0.5	0.2	0.5	0.25	<0.10	1.5
	H				0.2	0.4	0.5	0.40	<0.10	

Note: L = low flow period, H = high flow period.
Derivation of data explained p. 54, paragraph 1.

TABLE 5-21 Continued

SUMMARY OF POLLUTION CONTROL BRANCH WATER QUALITY DATA, FROM 1969 TO 1974, FOR THE MOYIE, KOOTENAY AND GOAT RIVERS

Site Location		Moyie River			Kootenay River				Goat River	Recommended Drinking Water Standard (70)
Parameter / Site Number		22	99	23	14 pre-impoundment	14 post-impoundment	13 pre-impoundment	13 post-impoundment	56	
Iron, dissolved mg/1	L	<0.04	<0.04		0.07	0.04	0.07	0.05	<0.04	0.3
	H	<0.04	<0.04		0.07	0.04	0.07	0.04	<0.04	
Lead, dissolved mg/1	L				<0.003	<0.003	<0.003	<0.003	<0.001	0.05
	H				<0.003	<0.003	<0.003	<0.003	<0.001	
Manganese, dissolved mg/1	L	<0.01	<0.02	0.01	<0.01	<0.01	0.04	<0.02	<0.01	0.05
	H	<0.01	<0.02	0.01	<0.01	<0.01	0.04	<0.01	<0.01	
Nitrogen mg/1 ammonia	L				0.02	0.01	0.03	0.01	0.01	
	H				0.03	0.03	0.05	0.04	0.03	
nitrate	L	0.04	0.04	0.03	0.15	0.20	0.15	0.15	0.02	10.0
	H	0.03	0.02	0.03	0.15	0.10	0.10	0.10	0.03	
organic	L				0.1	0.1	0.1	0.1	0.03	
	H				0.1	0.1	0.1	0.1	0.15	
Oxygen, dissolved mg/1	L	11.0	12.5	10.3	11.5	10.0				
	H	11.0	12.5	10.3	9.5	10.0				
pH	L	7.5	7.3	7.4	8.0	8.0	7.8	8.0	7.5	6.5-8.3
	H	7.5	7.3	7.4	8.0	8.0	8.1	8.0	7.5	

Note: L = low flow period, H = high flow period

TABLE 5-21 Continued

SUMMARY OF POLLUTION CONTROL BRANCH WATER QUALITY DATA, FROM 1969 TO 1974, FOR THE MOYIE, KOOTENAY AND GOAT RIVERS

Site Location			Moyie River			Kootenay River				Goat River	Recommended Drinking Water Standard (70)
Parameter \ Site Number			22	99	23	14 pre-impoundment	14 post-impoundment	13 pre-impoundment	13 post-impoundment	56	
Phosphorus mg/1	dissolved	L	0.003	0.003	0.003	0.04	0.03	0.06	0.05	0.003	
		H	0.003	0.003	0.003	0.02	0.02	0.04	0.02	0.004	
	total	L	0.006	0.005	0.006	0.10	0.05	0.10	0.06	0.004	0.065 (inorganic)
		H	0.006	0.007	0.006	0.10	0.05	0.10	0.04	0.010	
Solids mg/1	dissolved	L	40	30	44	150	120	140	140	42	1000
		H	35	40	44	110	90	120	90	42	
	suspended	L	5	5	12	10	10	10	10	10	
		H	5	5	12	20	20	80	10	10	
Turbidity J.T.U.		L	1.0	1.0	1.5	5	5	5	5	2	5
		H	2.0	2.0	1.5	50	15	40	10	4	
Zinc, dissolved mg/1		L				<0.005	<0.005	0.01	<0.005	<0.005	5.0
		H				<0.005	<0.005	0.01	<0.005	<0.005	

Note: L = low flow regime, H = high flow regime

TABLE 5-22

SUMMARY OF POLLUTION CONTROL BRANCH WATER QUALITY DATA, FROM 1969 TO 1974, FOR KOOTENAY LAKE AND THE KASLO, DUNCAN AND LARDEAU RIVERS

Site Location		Kootenay Lake						Kaslo River	Duncan River	Lardeau River	Recommended Drinking Water Standards (70)
Parameter / Site Number		31	32	33	34	35	57	58	59	60	
Arsenic, total mg/l	L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				0.05
	H	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Boron, dissolved mg/l	L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10				5.0
	H	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10				
Colour, true relative units mg/l	L	5	5	5	5	5	5	5	5	5	15
	H	5	5	5	5	5	5	5	5	5	
Conductivity, specific μ mho/cm	L	180	175	175	175	170	165	200	120	170	
	H	180	175	175	175	170	165	110	120	125	
Copper, dissolved mg/l	L	0.001	0.002	0.002	0.002	0.002	0.002	<0.001	0.002	<0.001	1.0
	H	0.001	0.002	0.002	0.002	0.002	0.002	<0.001	0.002	<0.001	
Flow, 1000 CFS	L							0.2	1	0.8	
	H							1.2	10	5	
Fluoride, dissolved mg/l	L	0.27	0.26	0.25	0.23	0.21	0.20	0.11	<0.10	0.11	1.5
	H	0.27	0.26	0.25	0.23	0.21	0.20	0.11	<0.10	0.11	

Note: L = low flow period, H = high flow period.
Derivation of data explained p. 54, paragraph 1.

TABLE 5-22 Continued

SUMMARY OF POLLUTION CONTROL BRANCH WATER QUALITY DATA, FROM 1969 TO 1974, FOR KOOTENAY LAKE AND THE KASLO, DUNCAN AND LARDEAU RIVERS

Site Location		Kootenay Lake						Kaslo River	Duncan River	Lardeau River	Recommended Drinking Water Standards (70)
Parameter \ Site Number		31	32	33	34	35	57	58	59	60	
Iron, dissolved mg/l	L	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.1	<0.1	<0.1	0.3
	H	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.1	<0.04	<0.04	
Lead, dissolved mg/l	L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.002	0.002	0.05
	H	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.002	0.002	0.002	
Manganese, dissolved mg/l	L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.05
	H	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	
Nitrogen mg/l ammonia	L	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.01	
	H	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.04	0.01	
nitrate	L	0.10	0.12	0.13	0.12	0.14	0.13	0.08	0.10	0.15	10.0
	H	0.10	0.12	0.13	0.12	0.07	0.13	0.10	0.13	0.20	
organic	L	0.08		0.08	0.08	0.06	0.06	0.05	0.05	0.04	
	H	0.08		0.08	0.08	0.06	0.06	0.05	0.10	0.04	
Oxygen, dissolved mg/l	L	10.1	10.5	10.0	10.0	10.0	10.0	12.0	11.0	11.5	
	H	10.1	10.5	10.0	10.0	10.0	10.0	12.0	11.0	11.5	
pH	L	7.9	7.9	7.9	7.9	7.9	8.0	8.0	7.7	7.9	6.5-8.3
	H	7.9	7.9	7.9	7.9	7.9	8.0	8.0	7.7	7.9	

Note: L = low flow period, H = high flow period.

TABLE 5-24

AVERAGE CONCENTRATION OF CERTAIN PARAMETERS WHICH DO NOT ADVERSELY AFFECT WATER QUALITY IN REGION 5

(From Pollution Control Branch Data Collected 1969-1974)

Parameter \ Site Number	14	11	Recommended Drinking Water Standard (70)
Alkalinity, total,mg/l	71	62	
Calcium, mg/l	25	22	200
Carbon, organic, mg/l		3	
Chloride, mg/l	1.6	1.1	250
Hardness, total,mg/l	91	72	180
Magnesium,mg/l	6.9	4.0	150
Nitrate + nitrite nitrogen,mg/l	0.005	0.005	10.0
Potassium, dissolved,mg/l	0.66	0.64	
Silica, reactive,mg/l	6.2	3.0	
Sodium, dissolved,mg/l	2.2	1.7	
Sulphate,mg/l	14.5	12.4	500

TABLE 5-25

DISSOLVED GAS VALUES MEASURED IN REGION 5, FROM 1972 TO 1974

Site	Agency	Date	Total Dissolved Gas As % Saturation
Kootenay River At Porthill, U.S.A.	P.C.B.	Aug. 22/73	108.5
	P.C.B.	Nov. 1/73	100.1
	P.C.B.	May 31/74	103.0
	P.C.B.	June 19/74	107.0
Kootenay River At The International Border	F & W	Aug. 24/72	107.7
	F & W	Sept. 14/72	103.5
	F & W	Jan. 8/73	97.5
	F & W	Jan. 29/73	98.6
	F & W	Feb. 27/73	99.2
	F & W	March 27/73	103.8
	F & W	May 3/73	106.0
Kootenay River At Creston Indian Reserve No. 2	P.C.B.	July 27/72	106.6
Kootenay River At Creston	U.S.	June 12/72	107.5
Kootenay River At Duck Lake	F & W	Aug. 24/72	107.3
	F & W	Sept. 14/72	102.3
Duncan River At Duncan Dam Forebay	P.C.B.	July 26/72	107.0
	F & W	Aug. 23/72	107.5
	F & W	Sept. 12/72	102.8
	F & W	Jan. 5/73	96.8
	F & W	Jan 23/73	98.3
	F & W	Feb. 26/73	96.3
	F & W	March 26/73	102.7
	F & W	May 2/73	108.3
Duncan River Downstream From Duncan Dam	P.C.B.	July 26/72	104.4
	F & W	Aug. 23/72	105.9
	F & W	Sept. 12/72	104.7
	F & W	Jan. 5/73	102.5
	F & W	Jan. 23/73	102.3
	F & W	Feb. 26/73	109.6
	F & W	March 26/73	103.5
	F & W	May 2/73	106.5

TABLE 5-25 Continued

DISSOLVED GAS VALUES MEASURED IN REGION 5 FROM 1972 TO 1974

Site	Agency	Date	Total Dissolved Gas As % Saturation
Kootenay Lake At Balfour	U.S.	June 12/72	105.8
	U.S.	June 12/72	106.3
	F & W	Aug. 19/72	106.2
	F & W	Sept. 12/72	102.2
	F & W	Jan. 7/73	93.9
	F & W	Jan. 23/73	96.5
	F & W	Feb. 26/73	98.2
	F & W	March 27/73	99.0
	F & W	May 3/73	103.7
Kootenay Lake At Nelson Bridge	F & W	Aug. 25/72	110.1
	F & W	Sept. 24/72	104.8
	P.C.B.	June 19/72	110.9
Kootenay Lake At Taghum	U.S.	June 12/72	104.6
	P.C.B.	July 26/72	106.8
	P.C.B.	June 14/73	107.6
	P.C.B.	June 14/73	107.3
	P.C.B.	June 17/74	110.8
	P.C.B.	June 19/74	103.3
	P.C.B.	July 4/74	100.3

% Saturation	Approximate Potential Effects[63]
100 - 110	Satisfactory. Possible sub-lethal effects.
110 - 120	Borderline. Increased likelihood of sub-lethal effects. Some mortality especially in shallow water.
120 - 140	Unsatisfactory. Increased likelihood of significant mortality, especially if water shallower than three metres.
> 140	Critical. High probability of extensive fish mortality.

TABLE 5-26

CHANGES IN LOADINGS OF CONTAMINANTS IN THE KOOTENAY RIVER, AFTER THE RIVER PASSES THROUGH MONTANA AND IDAHO

		Concentrations And Loadings						% Gain or Loss in Loadings	
		Site 14 Pre-impoundment		Site 14 Post-impoundment		Site 100 Post-impoundment		Site 14 From Pre- To Post-Impoundment	From Site 100 to Site 14 Post-Impoundment
		mg/1	1b/day	mg/1	1b/day	mg/1	1b/day		
Copper		0.005	460	0.002	180	0.002	100	61% loss	80% gain
Flow		17,000 CFS		16,700 CFS		9,300 CFS*			
Fluoride		0.40	36,700	0.27	24,300	0.3*	15,100	34% loss	61% gain
Iron		0.07	6,400	0.04	3,600	0.3	15,100	44% loss	76% loss
Nitrogen	Ammonia	0.023	2,100	0.017	1,500	0.023	1,200	29% loss	25% gain
	Nitrate	0.15	13,800	0.17	15,300	0.03	1,500	11% gain	920% gain
	Organic	0.10	9,200	0.10	9,000	0.07	3,500	2% loss	160% gain
Phosphorus	Dissolved	0.033	3,000	0.027	2,400	0.04	2,000	20% loss	20% gain
	Total	0.10	9,200	0.05	4,500	0.06	3,000	51% loss	50% gain
Turbidity		20 J.T.U.		9 J.T.U.		6 J.T.U.			
Zinc		0.01	900	0.005	450	0.008	400	50% loss	12% gain

*=Estimated value

TABLE 5-27

SUMMARY OF SELECTED TOXICITY DATA FOR FRESHWATER AQUATIC ORGANISMS[a]

(See last page for footnotes a, b, c, d and definitions)

	Lethal Toxicity Data		Sublethal Toxicity Data	Remarks
	Fish	Invertebrates		
Arsenic	low: 1.1 mg/l, toxic to Stizostedium (walleye) in 2 days[100]	4.3 mg/l, toxic to crabs in 11 days [99]	1.73 mg/l, withstood generally by fish organisms[99]	Toxicity varies with valence state: $As^{3+} > As^{5+}$ [99] Cumulative poison[99]
	high: 60 mg/l, toxic to minnows in 16 hours [100]			
Cadmium	low: 0.008 - 0.01 mg/l, 7 day LC50, hard water, Salmo gairdneri (rainbow trout)	0.005 mg/l, 3 week LC50, soft water, Daphnia (water flea)	0.0005 mg/l, reproductive impairment, Daphnia (water flea)	toxicity varies with temperature & salanity. Toxicity varies with hardness (b) LCd = 11.5 H-150 (H<100) LCd=20 H-1000 (H>100)
	high: 73.5 mg/l, 96 hour LC50, hard water, Pimephales (fathead minnow)	25.0 mg/l, 96 hour LC50, saline water, Mytilus (mussel)		
Chromium (trivalent)	low: 1.2 mg/l incipient lethal level [c], soft water, Gasterosteus (threespine stickleback)	0.01 mg/l, 48 hour LC50, Daphnia (water flea)	0.33 mg/l, 16% reproductive impairment [d], soft water, Daphnia (water flea)	toxicity varies with hardness
	high: 76 mg/l, 96 hour LC50, hardwater, Salmo gairdneri (rainbow trout)	32.0 mg/l, 7 day LC50, softwater, Hydropsyche (caddisfly) and Acroneria (stonefly)		
Chromium (hexavalent)	low: 17.6 mg/l, 96 hour LC50, softwater, Pimephales (fathead minnow)	0.05 mg/l, 48 hour LC50, Daphnia (water flea)	0.1 mg/l, decreased viability Cyprinus (carp) Daphnia (water flea) & Paramecium (protozoan)	toxicity varies with pH & hardness, greater variability in toxicity with hexavalent compounds
	high: 133 mg/l, 96 hour LC50, hardwater, Lepomis (bluegill)			

TABLE 5-27 Continued

SUMMARY OF SELECTED TOXICITY DATA FOR FRESHWATER AQUATIC ORGANISMS[a]

	Lethal Toxicity Data		Sublethal Toxicity Data	Remarks
	Fish	Invertebrates		
Copper	low: 0.015 mg/1 incipient lethal level[c], soft water, *Gasterosteus* (threespine stickleback) high: 10.2 mg/1, interpolated 96 hour LC50, hardwater, *Lepomis* (bluegill)	0.008 mg/1, incipient lethal level[c], soft water *Gammarus* (scud) 32.0 mg/1, 2 week LC50, softwater, *Hydropsyche* (caddisfly)	0.0046 mg/1 affected completion of *Gammerus* (scud) life cycle.	toxicity varies with chemical form and chelation. Toxicity varies with hardness[b]. LCu=2.02 H + 7.87 (H<53) =1.56 H + 32.2 (H>53)
Fluoride	low: 2.3 mg/1-7.3 mg/1, 10 day LC50, softwater, *Salmo gairdneri* (rainbow trout) high: 925 mg/1, 96 hour LC50, turbid water, *Gambusia* (mosquitofish)		1.5 mg/1 affected hatching of fish eggs	toxicity varies with hardness & chloride levels
Iron	low: 0.1 mg/1, lethal to certain fish in 24 hours high: 10,000 mg/1, lethal to *Tinca* (tench) after 1 week	0.32 mg/1, 96 hour LC50, softwater, *Ephemeralla* (may fly) 16.0 mg/1, 96 hour LC50, softwater, *Acroneuria* (stonefly) & *Hydropsyche* (caddisfly)	0.52 mg/1 killed *Coregonus* (arctic cisco) spawn	Dissolved and suspended iron toxicity. Toxicity varies with pH, hardness, dissolved oxygen, & chelation. $Fe(OH)_3$ more toxic at low concentration
Lead	low: 0.1 mg/1 incipient lethal level[c], soft water, *Gasterosteus* (threespine stickleback) high: 432 mg/1, 96 hour LC50 hard water, *Pimephales* (fathead minnow)	0.3 mg/1, 3 week LC50, softwater, *Daphnia* (water flea) 64.0 mg/1, 2 week LC50, softwater, *Acroneuria* (stonefly)	0.03 mg/1, 16% reproductive impairment[d], softwater, *Daphnia* (water flea)	low solubility, toxicity varies with pH and chelation. Toxicity varies with hardness[b] LPb = 17.9 H + 585 (H<27) LPb = 10.2 H + 790 (H>27)

TABLE 5-27 Continued

SUMMARY OF SELECTED TOXICITY DATA FOR FRESHWATER AQUATIC ORGANISMS[a]

	Lethal Toxicity Data		Sublethal Toxicity Data	Remarks
	Fish	Invertebrates		
Manganese	low: 12 mg/l, lethal to *Fundulus* (killifish) in 6 days[99] high: 7850 mg/l lethal to *Orizias* in 24 hours[99]	0.005 mg/l, toxic to some algae, stimulates others (100)	6.9 mg/l, effect on acetylcholinesterase in shinerperch[99]	Permanganates are much more toxic than manganates (100) Antagonistic towards nickel toxicity[99]
Mercury	low: 0.001 mg/l, lethal to *Esox* (pike) in one season high: 0.3 mg/l, 96 hour incipient lethal level[c], *Cyprinus* (carp)	0.013 mg/l, 3 week LC50, softwater, *Daphnia* (water flea) 2.0 mg/l, 96 hour LC50, softwater, *Acroneuria* (stonefly), *Ephemeralla* (mayfly), *Hydropsyche* (caddisfly)	0.001 mg/l decreased algal growth and photosynthesis	methyl mercury accumulates in aquatic biota via the water or the food chain Toxicity not affected by hardness.
Nitrogen (ammonia)	low: 0.2 mg/l un-ionized NH_3, incipient lethal level[c] *Salmo gairdneri* fry (rainbow trout fry) high: 2.0 mg/l un-ionized NH_3, toxic level for *Cyprinus* (carp) and *Tinca* (tench)	0.66 mg/l un-ionized NH_3, 48 hour LC50, *Daphnia* (water flea)		Un-ionized ammonia is the toxic entity, therefore toxicity increases with increased pH Toxicity depends on temperature, dissolved oxygen and alkalinity
Nitrogen (nitrite nitrate)			Stimulates growth of plankton and aquatic weeds-Critical concentration below which algal blooms not troublesome 0.3 mg/l (100)	

TABLE 5-27 Continued

SUMMARY OF SELECTED TOXICITY DATA FOR FRESHWATER AQUATIC ORGANISMS[a]

	Lethal Toxicity Data		Sublethal Toxicity Data	Remarks
	Fish	Invertebrates		
pH (acid)	low: pH[c] 6.2, incipient lethal level, salmonids high: pH 4.2, 8 day LC50, Salmo gairdneri (rainbow trout) and Rutilus (roach)	pH 6.6, 50% emergence of Isogenus (stonefly) pH 2.45, 30 day LC50 Brachycentrus (caddisfly)	pH 5.0, possible reproduction impairment	pH dependent upon buffering capacity. Toxicity varies with acclimation. Effects toxicity of other poisons. Lethal amounts of CO_2 may be liberated. Basic nutrients unavailable to plants at pH<6.5 and pH>8.
pH (alkali)	low: pH[c] 9.2, incipient lethal level, salmonids high: pH[c] 10.8, incipient lethal level, Cyprinus (carp)			
Phenol	low: 0.079 mg/1, lethal to minnows in 30 minutes high: 44.5 mg/1, 48 hour LC50, Carassius (gold fish)	1.0 mg/1, incipient lethal level[c], Mytilus (mussel) 150 mg/1, incipient lethal level[c], Cyclops (copepod)	1.0 mg/1, 20% reduction in growth of Salmo gairdneri (rainbow trout) and possible avoidance reaction at 0.1 mg/1	Toxicity varies with temperature, dissolved oxygen and hardness, with Cl_2 very toxic chlorinated phenols may be formed 1-10 mg/1 taints fish flesh
Phosphorus	1090 mg/1 of Na tripolyphosphate and Na pyrophosphate lethal to fishes	126 mg/1 Na phosphate 96 hour LC50, Daphnia (water flea)	0.01 mg/1 soluble ortho phosphate associated with algal blooms. 0.005 mg/1 inhibited growth of the algae: Uroglena & Dinobryon. 1.78 mg/1 inhibited growth of the algae: Pediastrum, Staurestrum & Nitzschia (higher levels are probably toxic)	Algal blooms may reduce dissolved oxygen below critical level

TABLE 5-27 Continued

SUMMARY OF SELECTED TOXICITY DATA FOR FRESHWATER AQUATIC ORGANISMS[a]

	Lethal Toxicity Data		Sublethal Toxicity Data	Remarks
	Fish	Invertebrates		
Zinc	low: 0.3 mg/l incipient lethal level[c], softwater, *Gasterosteus* (threespine stickleback) high: 40.9 mg/l, interpolated 96 hour LC50, hardwater, *Lepomis* (bluegill)	0.1 mg/l, 48 hour LC50, unfed *Daphnia* (water flea) 32.0 mg/l, 2 week LC50, softwater, *Acroneuria* (stonefly) and *Hydropsyche* (caddisfly)	0.0056 mg/l, softwater avoidance reaction in *Salmo gairdneri* (rainbow trout)	Toxicity varies with chemical form and pH. Toxicity varies with hardness[b] $L_{Zn} = 19.5\ H + 291\ (H<46)$ $= 10.2\ H + 710\ (H>46)$

FOOTNOTES TO TABLE 5-27

LC50: concentration which results in 50% mortality (or 50% survival) within a specified time period, for example 96 hour LC50.

Lethal : causing death
Sublethal: below the level which directly causes death

a. All data taken from Clarke[71] except where indicated.

b. The hardness formulae adjust toxicity for various levels of hardness. LX is the lethal threshold for metal X in μg/l. H is total hardness as mg/l $CaCO_3$. Formulae for cadmium are based on 48 hour LC50, not on lethal threshold.

c. Incipient lethal level is the concentration at which increased mortality is observed.

d. 16% reproductive impairment means the total number of young produced is 16% less than that of controls.

TABLE 5-28

ALGAL BIOMASS IN KOOTENAY LAKE FROM SAMPLES COLLECTED BY THE POLLUTION CONTROL BRANCH

(Values Expressed in mg/m^3)

1973									
Site \ Month	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.
31	0.6	180	547.2	477.6	106.2	406.1	1703.9	335.0	15.6
32	3.6	240.6	4.8	690.0	85.2	165.7	1250.0		95.9
33	13.2	267.0	266.2	1171.8	123.8	722.5	661.9	367.8	
34	11.1	303.0	231.4	540.5	161.1	502.0	1946.9	209.4	56.0
35	43.4	134.4	88.3	832.5	167.4	122.5	1103.3	311.4	38.8
57	20.5	21.2		694.9	746.9		464.8	26.2	193.1

1974								
Site \ Month	March	April	May	June	July	Aug.	Sept.	Oct
31	9.9	10.2	69.4	2663.0	101.6	1336.8	445.0	264.1
32	14.9	27.4	101.0	373.6		261.1	3021.5	661.4
33	15.2	15.0	55.6	1310.7	882.6	1292.4	526.4	
34	23.6	7.9	27.9	547.7	776.6	488.3	604.7	
35	23.2	12.5	135.6	766.9	588.4	451.9	907.9	444.7
57	11.0	17.9	323.0	211.0	502.9		1047.6	337.3

Comparison With Other Lakes

Lake		Mean mg/m^3	Maximum mg/m^3	State
Kootenay Lake	1973	361.9	1946.9	
	1974	491.9	3021.5	
Great Lakes (95)	L. Huron (offshore)	900	1800	oligotrophic
	L. Erie (W. basin)	5300	13200	eutrophic
Swedish Lakes (96)	Gorvaln		6000	eutrophic
	Ransaren		200	oligotrophic

TABLE 5-29

CHLOROPHYLL-A IN KOOTENAY LAKE FROM SAMPLES COLLECTED BY THE POLLUTION CONTROL BRANCH IN 1974

(Values Expressed in mg/m^3)

Composite of Samples From Depths of 1, 5, 10, 15 and 20 m.

Site \ Month	March	April	May	June	July	Aug.	Sept.	Oct.
31	0.84	2.08	2.61	2.32	1.89		2.16	2.12
32	0.03	0.50		0.06	0.88		1.98	
33	3.49	1.23	1.39	3.82	3.10	2.46	3.25	
34	1.0	1.78	2.85	4.79	3.52	0.98	2.15	3.05
35	0.78	0.725	3.26		2.63	1.73	3.07	
57	1.71	0.97	11.22	9.74	2.76	1.33	4.08	

Samples From Depth of 1 m.

Site \ Month	March	April	May	June	July	Aug.	Sept.	Oct.
31	0.51	2.03	3.05	2.35	3.37	4.51	2.61	2.22
32	0.03	0.25		0.06	0.88		1.98	
33	1.27	0.83	1.21	4.32	3.81	5.46	4.07	
34	1.28	1.84	2.47	7.74	4.57	1.14	2.03	3.68
35	1.02	0.44	3.9		3.37	1.97	3.94	
57	3.20	0.59	23.56	11.05	2.66	1.39	4.50	

Comparison With Other Lakes

Lake		Range	Mean	State
Kootenay Lake	1974	0.03-11.22	2.41	
Great (95) Lakes	L. Huron (offshore)	1.4-2.2	1.7	oligotrophic
	L. Ontario (offshore)	1.8-7.9	3.8	mesotrophic
	L. Erie (W. basin)	3.3-19.3	8.9	eutrophic

TABLE 5-30

CARBON-14 ESTIMATES OF PHOTOSYNTHESIS IN KOOTENAY LAKE FROM SAMPLES COLLECTED BY THE POLLUTION CONTROL BRANCH
(Values Expressed in $mgC/(m^2\ day)$)

1973

Site \ Month	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.
31	54	892	1174	689	754		866	466	
32	78	718	1055	503	266	1257	951		
33	129	604	1530	756	218	1347		430	204
34	157	444	948	707	531	993	800	385	
35	212	538	1066	1158	590	442	699	636	400
57	125	424		1864	372	868	233	604	

1974

Site \ Month	March	April	May	June	July	Aug.	Sept.	Oct.
31	31	157	686	196	443	836	964	388
32	28	105		559	868		791	
33	35	74	484	613	522	1209	1082	
34	12	119	336	920	643		383	645
35	54	159	342	656	392	877	783	689
57	76	215	880	1098	349		615	

Comparison With Other Lakes

Lake		Range $mgC/(m^2\ day)$	State
Kootenay Lake	1973	54-1864	
	1974	12-1209	
Great (95) Lakes	Lake Ontario (offshore)	58-1443	mesotrophic
	Lake Erie (W. basin)	30-4760	eutrophic
	Lake Huron (offshore)	147-698	oligotrophic

TABLE 5-31

CONCENTRATION OF ORTHOPHOSPHATE PHOSPHORUS IN KOOTENAY LAKE, AT A DEPTH OF ONE METRE, FROM SAMPLES COLLECTED BY THE POLLUTION CONTROL BRANCH

(Values Expressed in mg/1 P)

Date / Site	1972		1973		1974	
	9-11 May	6-12 June	6-13 March	9-18 April	4-12 March	29 Apr.-7 May
31	0.033	0.019	0.035	0.023	0.031	0.022
32	0.024	0.015	0.031	0.025	0.030	
33	0.032	0.005	0.029	0.022	0.030	0.016
34	0.008		0.024	0.019	0.029	0.020
35	0.010	0.008	0.021	0.014	0.027	0.017
57	<0.003	0.006	0.019		0.025	<0.003

TABLE 5-32

CONCENTRATION OF ORTHOPHOSPHATE PHOSPHORUS IN KOOTENAY LAKE, AT VARIOUS DEPTHS, FROM SAMPLES COLLECTED BY THE POLLUTION CONTROL BRANCH

	1972			
	29 March		18 September	
	Depth m	Concentration mg/1	Depth m	Concentration mg/1
Site 31	1	0.056	1	0.007
	50	0.054	21	0.008
	100	0.058	45	0.031
			79	0.040
			102	0.040
	29 March		9 August	
	Depth m	Concentration mg/1	Depth m	Concentration mg/1
Site 32	1	0.051	1	0.006
	60	0.049	11	0.014
	125	0.055	34	0.030
			84	0.049
			127	0.052

	1973			
	13 March		5 September	
	Depth m	Concentration mg/1	Depth m	Concentration mg/1
Site 31	1	0.037	1	0.010
	61	0.038	10	0.013
	110	0.045	26	0.030
			70	0.037
			105	0.043
	6 March		12 September	
	Depth m	Concentration mg/1	Depth m	Concentration mg/1
Site 57	1	0.019	1	<0.003
	58	0.032	1	<0.003
	110	0.035	24	0.004
			72	0.036
			115	0.039

	1974			
	7 March		1 August	
	Depth m	Concentration mg/1	Depth m	Concentration mg/1
Site 31	1	0.030	1	<0.003
	74	0.030	73	0.028
	146	0.033	146	0.038
	12 March		7 August	
	Depth m	Concentration mg/1	Depth m	Concentration mg/1
Site 35	1	0.027	1	<0.003
	66	0.028	11	<0.003
	130	0.031	71	0.027
			132	0.035

TABLE 5-33

ZOOPLANKTON IN KOOTENAY LAKE COLLECTED BY THE

POLLUTION CONTROL BRANCH, FROM 1972 TO 1974

(Values Expressed in Mean Number of Organisms/cm^2 Lake Surface)

Site \ Date	May - November 1972	March - November 1973	April - November 1974
31	96.4	94.1	45.4
32	70.5	71.0	35.1
33	113.0	64.6	39.7
34	98.2	61.7	30.2
35	114.1	65.6	43.0
57	134.0	62.1	36.0
Mean	108.8	69.8	38.2

Comparison With Other Lakes

Lake	Organisms/litre	Organisms/cm^2	State
Kootenay Lake Mid-summer (July - Aug.) 1972	14.1	171.1	
1973	11.5	142.5	
1974	5.4	54.1	
Kootenay Lake (94) June-July 11 1949	7.81		
August 1964	14.68		
Okanagan Lake (97) September 1969		188	oligotrophic
August 1971		101	
Great Lakes (98) Lake Superior		43	oligotrophic
Lake Huron		167	oligotrophic
Lake Erie		400	eutrophic