DEPARTMENT OF ENVIRONMENT
WATER RESOURCES SERVICE

James A. Nielsen, Minister
B. E. Marr, Deputy Minister

KOOTENAY
AIR AND WATER QUALITY STUDY
PHASE I

ASSESSMENT OF INFORMATION AVAILABLE TO THE END OF 1974

WATER QUALITY IN REGION 2, THE ELK RIVER BASIN

WATER RESOURCES SERVICE
G. E. Simmons
Assistant Deputy Minister

WATER INVESTIGATIONS BRANCH
P. M. Brady
Director

February 1976
File No. 0322512-1

ACKNOWLEDGEMENTS

Thanks are due to the following for supplying data and information: Cominco Ltd., Fording Coal Ltd., Kaiser Resources Ltd., B.C. Research, Environment Canada, the B.C. Fish and Wildlife Branch, the B.C. Department of Mines and Petroleum Resources, the B.C. Department of Health, the B.C. Forest Service, the B.C. Department of Economic Development, the Pollution Control Branch, the Water Rights Branch, the Water Investigations Branch and the Environmental Laboratory of the B.C. Water Resources Service.

R.J. Rocchini, P.Eng.
Study Co-ordinator
Environmental Studies Division

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

AUTHORS AND CONTRIBUTORS

R.J. Rocchini	Study Co-ordinator
J.C. Arber	Biologist
R.J. Duff	Engineer
J.J. Feddes	Agriculturalist
G.W. Giles	Engineer
L.A. Gregory	Biologist
R.N. Nordin	Biologist
D.C. Parsons	Pedologist
L.W. Pommen	Engineer
D.W. Dony	Draftsman
L.E. Smith	Typist

SUMMARY

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

The major sources of water pollution in the Elk River basin are mining exploration, coal mining and related operations such as coal washing and coking. A large amount of water sampling has been conducted in the region. However, the sampling programs were not always co-ordinated with exploration activity, effluent analyses, river flow regime and biological sampling. As a result we have found it difficult in some cases to distinguish between the effects of natural runoff and man-made disturbances. It is also not always possible to relate effluent quality with receiving water quality and biological effects.

Water quality parameters that most often exceeded recognized standards were suspended solids and turbidity. Increases in these parameters were usually associated with coal mining operations and were most pronounced during the spring runoff period. There was no evidence of acid mine drainage or of the discharge of toxic materials in significant amounts. These results were confirmed by a limited amount of aquatic biology data. The data indicated the presence of a relatively undisturbed population of invertebrates and a good fishery. However no aquatic biology data were available after 1972.

Exploration and mining will increase in the future, possibly creating greater silt loads to the rivers and deterioration in water quality. We have recommended that comprehensive water quality studies be undertaken in areas where mining is scheduled to take place. We have also recommended a one-year monitoring program in the region. This program will collect baseline data in areas now undisturbed and will also relate more accurately mining activity and water quality. In particular, we require more information on sediments and aquatic biology to predict future trends and to recommend corrective measures if necessary. The results of the monitoring program will be presented in a Phase II report for the region, and will include a chapter on water availability problems.

TABLE OF CONTENTS

TABLE OF CONTENTS Continued

TABLE OF CONTENTS Continued

TABLE OF CONTENTS Continued

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES Continued

1. DESCRIPTION OF THE REGION

1.1 Introduction

The Elk River Basin is located in the southeast corner of the province adjacent to Alberta as shown in Figure 2-1. The region is extremely mountainous, lying entirely within the Front and Border Ranges of the Rocky Mountains. The region has an area of 1772 square miles and is drained by the Elk River and its major tributaries, the Wigwam and Fording Rivers and Michel Creek. The Elk River valley runs the entire length of the region, varying in width from 1 to 4 miles with elevations of 5500 feet near the headwaters and 2400 feet at the mouth.

The major economic activities in the region are coal mining and forestry.

1.2 Climate

The mountainous nature of the terrain causes the climate to vary considerably within the region. The warmest and driest part of the region is in the lower Elk Valley near Elko, with the climate generally becoming cooler and wetter in the central and upper portions of the Elk Valley. The mean annual precipitation is 500 mm. at Elko (elevation 3080), 920 mm. at Fernie (elevation (3305)[(1)], and may reach 1500 mm. at high elevations[(2)]. Mean annual snowfall varies from 140 cm. at Elko[(1)], to 360 cm. at Fernie[(1)], and to over 500 cm. at higher elevations[(2)]. Mean temperatures in July and January are respectively: 18^oC and -7^oC at Elko; 17^oC and -8^oC at Fernie; and 13^oC and -15^oC near Sparwood[(3)]. The average frost-free period varies from 100 days at Elko, to 80 days at Fernie, and to 60 days near Sparwood[(4)].

1.3 Geology

Twenty percent of the region is occupied by the Wigwam River basin which lies between the Galton and Macdonald Ranges in the southern part of the region. The Galton Range on the west, is a north-westerly trending line of peaks about 7,000 feet high and composed mainly of argillaceous rocks. The Macdonald Range on the east, consists of north-westerly trending, parallel ridges of argillite, siltstone, sandstone and limestone reaching elevations up to 7500 feet[5].

The northern eighty percent of the region lies within the Front Ranges which are northerly trending, parallel ridges of thick limestone, 7000 to 9500 feet high. Between the Front Ranges lies the Fernie Basin through which the Elk River valley runs. The Fernie Basin is 65 miles long, extending from Morrissey to the upper Fording River, and has a maximum width of 15 miles near the southern end. It is underlain by the easily eroded sandy and shaly rocks of the Fernie formation and by the coal-bearing Kootenay formation which gives rise to the coal deposits of the region[5][6].

1.4 Soils and Vegetation

Lands of the Elk River Basin, like most of the Kootenay Region, were subjected to intense glaciation which modified the bedrock and topography and left deposits of glacial materials at elevations up to about 7,000 feet. Most of the glacial till which was deposited on the steep hillsides has been eroded, leaving bedrock exposed, or has been covered with material eroded from the mountain sides. Englemann spruce and alpine fir are most common at high elevations on these slopes. Site productivity is low due to the short, cool growing season and shallow, rocky soils. Douglas fir and lodgepole pine are found on the more gentle slopes at lower elevation where the climate is warmer and drier and the soils are deeper and more productive.

Soils derived from glacial till and glacial river and lake deposits occur in the valley bottoms, supporting grassland, ponderosa pine, lodgepole pine and Douglas fir. These lands, below 5000 feet, generally have the highest capability for forest production in the region.

1.5 Hydrology

1.5.1 Streamflow

The region is drained by the Elk River and its major tributaries, the Wigwam, the Fording, and Michel Creek. The Elk has its headwaters in the Front Ranges at the northern end of the basin and flows south and southwest for about 110 miles to its confluence with the Kootenay River in the Rocky Mountain Trench. The Fording River drains the northeast part of the basin, Michel Creek drains the central eastern portion and the Wigwam River drains the southern portion.

The seasonal flow patterns of the Elk and its tributaries are characterized by spring flood peaks in May and June due to snowmelt, followed by a steady decline in discharge during the summer and fall. The minimum flows occur during the winter months of December through March.

The discharges of the Elk and its major tributaries are summarized in Table 2-1. At Elko the Elk river has a mean annual discharge of 2100 cubic feet per second (CFS) with a daily maximum of 22,600 CFS and a daily minimum of 66 CFS.

1.5.2 Lakes

There are no major lakes in the region.

1.5.3 Groundwater

Little is known about the groundwater resources of the region(7). Groundwater has not been a major source of water supply in the region, probably due in part to the adequacy of surface water supplies. Data compiled by the Groundwater Section of the Water Investigations Branch, indicate that there are 13 actively producing wells in the region, 12 at Elko and one at Morrissey. (It is estimated that 50 to 75% of all wells drilled are on record with the Groundwater Section). These wells supply minor amounts of water for domestic purposes(8), and are located in the alluvial deposits of the Elk River valley.

1.5.4 Dams and Diversions

The only major dam in the region is the Elko dam on the Elk River,

½ mile downstream from the village of Elko. The dam and power plant are now owned by B.C. Hydro and are relatively small installations by today's standards. The original development of the Elko site was in 1906 by the East Kootenay Power Company Ltd. Further expansions which were completed in 1924 and 1950 have brought the development to its present day capacity[9].

There are no diversions of the major rivers and creeks in the Elk River Basin. However, Elco Mining Ltd. (formerly Emkay-Scurry) plans to divert the Elk River between Cadorna and Weary Creeks in order to mine the coal beneath the river bed.

1.6 Water Uses

The licenced water usage in the Elk River Basin is distributed as follows[10]:

Domestic	24.2 CFS*
Industrial	19.8 CFS
Irrigation	2.6 CFS (1300 acres under irrigation)
Power production	900 CFS (Elko dam)

*The City of Fernie has a water licence for 22.4 CFS, but actual water usage is estimated to be about 1 CFS.

A summary of the water licences issued in the region is contained in Table 2.2 [10]. The water licences are listed in alphabetical order. Also listed are the quantity, purpose, ownership, and location of the water licences. Sources providing minor quantities of water are listed in alphabetical order at the end of Table 2-2.

The water licence specifies the maximum rate of diversion of water and thus does not give a completely accurate picture of present water use. The quantity of water actually used may be less than the licence allows or the water may not be used at all. There also may be some unlicenced users of water, but these would generally be small users and would not appreciably effect the total water usage.

1.7 Settlements and Industrial Centres

The terrain of the region is very mountainous and thus settlement has tended to take place along the relatively flat valley of the Elk River. The major settlements in the Elk Valley are Fernie (4422)[14], Sparwood (2990)[14], Elkford (605)[14], Elko (196)[15], and Hosmer (165)[15]. Two small settlements, Michel (21)[15], and Natal (158)[15] are located in the lower reaches of Michel Creek. Population figures are for the 1971 census. Present population is somewhat higher, especially in Elkford (1975 estimate of 2500). The balance of the population of the region is scattered throughout the Elk Valley on farms and in small rural settlements.

The major transportation routes through the region are Highway 3 and the Canadian Pacific Railway which enter the region from Alberta via the Crowsnest Pass, and parallel Michel Creek and the Elk River until they leave the region near Elko.

The major sources of municipal effluent and solid waste in the Elk River Basin are the City of Fernie, the District of Sparwood, and the Village of Elkford.

The major sources of industrial effluent and solid waste in the region are the coal mining and processing operations of Kaiser Resources Ltd. in the Sparwood-Michel area, and Fording Coal Ltd. in the upper Fording River valley.

1.8 Land Use

1.8.1 Agriculture

Agricultural activity in the Elk River Basin is limited. Agriculture is generally confined to the areas of the Elk Valley between Sparwood and the confluence of the Elk and Fording Rivers, and between Morrissey and Olson. Fertilizer application on irrigated cropland, and livestock are the primary agricultural sources of nutrients entering the Elk River. Ranching is the chief agricultural enterprise and other livestock and cash crops make lesser contributions. The agricultural potential of the region is limited by the small area of arable land and the short frost-free period.

1.8.2 Forestry

Logging activities in Region 2 are limited to river valleys. There are a few operations in the south along the Wigwam River and its tributaries (which supply logs to sawmills at Elko), and a few operations in the far north, particularly along the Fording River and upper Line Creek.

1.8.3 Mining

The major mining developments within the region are the operations of Kaiser Resources Ltd. in the Michel area and of Fording Coal Ltd. in the Fording River valley.

Kaiser Resources Ltd. has the major coal reserves in the Fernie Basin, and operates several open pit mines at Harmer Ridge and two underground mines at Michel. Associated with these mines are a coal preparation plant (Elkview) and a coal by-products plant (coke and tar) at Michel. A preparation plant at Michel was phased out in 1973. Production from the mines in 1972 was 6.3 million tons of raw coal[6].

The Fording Coal Ltd. operation consists of three open pit mines (Greenhills, Clode, and Repeat 4 Pits) and a coal preparation plant which is located in the upper Fording River Valley. Fording Coal Ltd. began production in 1971 and produced 2.7 million tons of raw coal in 1972[6].

Other coal mines in the region include: the open pit operations of Byron Creek Collieries Ltd. on Coal Mountain just south of Corbin, and the open pit of Coleman Collieries Ltd. of Alberta, on the west side of Tent Mountain, three miles northwest of Corbin. Coal mining developments are proposed along Line Creek (Crows Nest Industries Ltd.), on Coal Mountain south of Corbin (Crows Nest Industries Ltd.), on Weary Ridge along the east side of the upper Elk River (Elco-Mining Ltd., formerly Emkay Scurry), and in the Hosmer Creek-Wheeler Creek area, east of Hosmer (Kaiser Resources Ltd)[16].

Exploration for phosphate has been conducted in the Corbin area[6].

1.8.4 Recreation

The Canada Land Inventory[17,18,19] shows that Region 4 can sustain a moderately high level of recreation. The Fording, Wigwam and particularly the Elk Rivers provide broad scenic corridors into and through the Rocky Mountains. The type of recreation available includes streamside camping, sport fishing, hiking, hunting and wildlife and landscape viewing. The intervening uplands sustain a limited range of dispersed activities such as climbing, hiking and viewing of scenery.

Opportunities for water-based recreation are limited by difficult stream access in many cases, and by the lack of sizeable lakes and developed shoreline. However, there are scattered areas with a potential for intensive recreational use (C.L.I. classes 1-3). Streamside parklands include Elko, Morrissey and Elk Valley Provincial Parks in the lower Elk Valley, and Crowsnest Provincial Park above Alexander Creek. In 1974, the 13900 acre Elk Lakes Provincial Park was established at the headwaters of the Elk River, 65 miles north of Fernie.

The major streams and many of their tributaries support extensive, successful summer fisheries[20,21] for Yellowstone cutthroat trout, Dolly Varden, mountain whitefish and lesser numbers of eastern brook trout. The streams also serve as important spawning and rearing areas for these species[21]. Big game is present throughout the region. The resource is widely used and supports several guiding operations[22]. A survey of Elk Valley, north of Sparwood, was made by the Fish and Wildlife Branch[23]. It showed that during July and August 1972, an estimated 10,000 people spent 24,000 visitor days in the region.

1.8.5 Wildlife

The Elk River Basin encompasses some of the most potentially productive big game range in British Columbia. Big game species found in the basin include elk, moose, mule deer, white-tailed deer, bighorn sheep, mountain goat, black bear, grizzly and cougar.

The main factors limiting wild ungulate abundance and distribution in the East Kootenay are the quantity and quality of low-elevation wintering areas[24]. There are three general winter range classifications[17,24]. The first classification of prime wintering areas includes the south and west slopes of Mt. Broadwood near the Elk-Wigwam River confluence, immediately west of Grave Lake, and the south-facing slopes of certain Fording River tributaries, notably Kilmarnock and Chauncey Creeks. These areas are used by elk, mule deer, and bighorn sheep.

A second classification of wintering areas, used primarily by elk and mule deer, includes portions of burned-over slopes along the west side of Sparwood Ridge, the north side of upper Coal Creek, the west side of Loop Ridge, the south and southwest side of Natal Ridge, and the terraces south of Lodgepole Creek and the Wigwam River.

The third winter range classification, used mainly by moose and elk, includes riparian habitat along portions of the upper Elk and Fording Rivers, upper Michel and Leach Creeks, Lodgepole and Bighorn Creeks and upper Wigwam River, and lower elevations at the confluence of the Wigwam and Elk Rivers. This latter area, the Wigwam-Elko-Mt. Broadwood range, is considered the most important big game winter range in the study area[24]. Elk, moose and mule deer summer within the lower tree line zone. Bighorn sheep and mountain goats summer along the upper limit of the tree line zone. Year-round use is made by elk, deer and moose of a natural mineral lick at the Fording Sulphur Springs, north of Grave Lake.

Waterfowl production is severely limited by the topography throughout the study areas, the only exception being a small area extending southeast behind Elko Dam[25,26].

2. INDUSTRIAL EFFLUENTS AND SOLID WASTES

Coal mining is the major industrial activity of the Elk River Basin. Mines are currently operated by Kaiser Resources Limited, Fording Coal Limited, and Byron Creek Collieries Limited. Crows Nest Industries, Elco Mining Company (formerly Emkay Canada National Resources Limited) and Kaiser Resources Limited have proposals for new coal mining developments.

Each mining operation involves exploration and coal removal, and some include a coal cleaning process. In this chapter, the active mining areas are described to give an understanding of the effluents generated from all phases of the operation. The proposed coal developments are outlined where information is available.

Other industrial wastes from the region are minimal. They include five refuse disposal sites which are discussed separately.

2.1 Fording Coal Limited

2.1.1 Description of the Exploration and Mining Activities

Fording Coal Limited has a 50 square mile coal licence area which straddles the Fording River (Figure 2-2). Within this area, (Figure 2-3) the Company is doing exploratory work and is operating two strip mines. One of the mines, Clode Pit, is on the east side of the Fording River; the second, Greenhills Pit, lies to the west of the Fording River. Operation of the pits involves the removal and dumping of approximately 50 million tons of overburden per year [27], which disturbs about 100 acres of land surface. In 1973, coal production was 2.3 millions tons of coal, represinting 70% of the design capacity[28].

The runoff from the Clode Pit flows into the Clode Creek settling basin which discharges into the Fording River. This discharge is not under application or permit from the Pollution Control Branch. The settling basin was authorized by the Water Rights Branch. The drainage from northeast of the Clode Pit accumulates in a marshy area adjacent to the Fording River north of the settling pond.

There are runoff channels from the north, central, and south parts of the Greenhills Pit. In the north, runoff from the pit and the surface flows into two settling ponds from which there is little or no discharge to the Fording River. The central and south runoffs from the pit flow directly into the Fording River. A third ditch carries the surface runoff from the exploration areas above the pit to the Fording River. These discharges are under application with the Pollution Control Branch (AE-2659 and AE-3059, Table 2-3).

Fording Coal Limited has two reclamation Permits (numbers 3 and 102) under the Mines Regulation Act and the Coal Mine Regulation Act. Permit No. 3 requires reclamation of the two strip mines and Permit No. 102 requires reclamation of the exploration areas on upper Clode Creek, the southern sections of Eagle and Henretta Mountains, and Turnbull Mountain (Points F, G, H, and I; Figure 2-2)[29]. Both reclamation programs are an attempt to minimize the effects of soil erosion on the water quality of the Fording River basin.

2.1.2 Description of the Plant Processes and the Refuse Disposal Sites

(a) The Coal Processing Plant and Maintenance Area

The coal processing plant and the maintenance area are the two sources of effluent and solid waste from the plant operations.

The coal processing plant is on the east side of the Fording River between Henretta and Kilmarnock Creeks (Figure 2-3). A simplified flow diagram of the process is given in Figure 2-4.

The raw coal from the mines is trucked to the processing plant where it is crushed and screened into three size fractions. Rejects are dumped on the refuse pile.

The large size coal is cleaned by heavy media separation. The medium, magnetite, is recycled. The clean coal overflows from the heavy medium open baths and the waste material in the underflow is trucked to the refuse pile. More details are shown in Figure 2-4.

The middle size coal is treated in heavy medium cyclones. As before, the medium is recycled. The overflow from the cyclones, or clean coal, is screened, centrifuged, and dried. The underflow contains the waste material which is trucked to the refuse pile.

The small size coal is thickened and treated in flotation cells. The overflow, or clean coal, from flotation is filtered and dried. The underflow from the cells contains waste material and is pumped to the tailing pond.

The tailing pond is situated on the west side of the Fording River, opposite the processing plant (Figure 2-3). At one time the pond received runoff from the Greenhills strip mine in addition to plant effluent, and more water was collected than the plant was able to reclaim. Therefore water levels increased, and on two occasions, June, 1972, and June, 1973, the water level in the pond threatened to cause dam failure. The Pollution Control Branch granted the company special permission to discharge a total of 61.7 million gallons to the Fording River.

The tailing pond now receives primarily the wastes from the flotation cells. Fording Coal Limited has a Pollution Control Permit (PE-424) to discharge 8.64 million gallons per day (GPD) of typical coal processing plant tailings to the pond. Further details are given in Table 2-3. Decant water from the pond is recycled back to the plant. There is no overflow from the pond to the river. However some effluent may exfiltrate from the pond and reach the river via groundwater flow.

The maintenance area at Fording Coal Limited is situated on the east side of the Fording River, close to the processing plant. The discharge flows with surface drainage from the plant area via a ditch to two settling ponds (Figure 2-3). There is no apparent discharge from the larger pond as the water exfiltrates or evaporates. There is, however, a noticeable discharge from the smaller settling pond, at least during part of the year. Fording Coal Ltd. has applied for Pollution Control Permits (AE-2659 and AE-2660) for the discharges. Application details are given in Table 2-3.

(b) Refuse Disposal Sites

Until 1974, coal refuse from the processing plant was deposited in a refuse disposal site on the east side of the Fording River, approximately ¼ mile north of the plant (Pollution Control Permit No. PR-1476, Figure 2-2). Pertinent information regarding the site is given in Table 2-4. The present disposal site (Pollution Control Permit No. PR-3959) is on the west side of the Fording River, northwest of the tailing pond.

The refuse, which is ½ to 5 inches in diameter, is trucked to the refuse site where it is spread and compacted by bulldozers. The refuse consists of coal particles, shale, sandstone, carbonaceous material, glacial till, and a minor amount of magnetite. The sulphur content of the coal is approximately 0.3%[30]. The refuse is relatively inert.

The Pollution Control Permit No. PR-3959 authorizes disposal of 2260 cu. yd./day (2400 tons/day) of refuse. The refuse site has an area of nine acres, a capacity of 0.9 million tons, and an estimated life of two years (until 1976).

Surface runoff and groundwater seepage from the new refuse site drain into the tailing pond. Runoff and groundwater from the old refuse site are collected by seepage drains and drainage ditches and discharged to the Clode Creek settling basin which overflows to the Fording River. The Clode Creek settling basin also receives runoff from the Clode Pit.

(c) Domestic Sewage Disposal

Domestic sewage from the plant and offices is treated by means of an oxidation ditch, a clarifier and a chlorinator before being discharged to a settling basin which is separated from the Fording River by a railway embankment (Figure 2-3). Effluent exfiltrates and evaporates from the basin. Originally the sewage effluent was discharged directly to the Fording River under Pollution Control Permit No. PE-309, which allowed a discharge of 25,000 GPD. The actual discharge rate is about 7,000 GPD. Further details are given in Table 2-3.

2.1.3 Effluent Sampling Data: Discussion and Recommendations

(a) Exploration and Mining

Exploration and mining causes land erosion which in turn can increase the sediment load and turbidity in rivers and creeks. Factors which increase erosion include channelling of the runoff water, steep slopes, unprotected ground, and dumping of unconsolidated material in or along water courses. The effects of erosion and possible acid drainage on the water quality of the major streams are documented in chapter 4.

B.C. Research[31] tested soil samples in the Fording Coal Limited coal licence area before the start of mining. The results showed that a potential acid drainage problem exists in the Clode Pit overburden and in an area not proposed for mining. In general, however, the sulphur content of the coal (0.3%) suggests that acid drainage should not be a problem. Visual indications of acid drainage are usually apparent and no such indications have yet been observed.

The only data available on the runoff from mining activities is the permit application data for the runoff from the Greenhills Pit (Table 2-3). The flow from this strip mine totals 3.2 million GPD from May to October and is reduced to 0.4 million GPD for the rest of the year.

The flow consists of mine drainage and runoff, and the weighted average suspended solids content is 120 mg/l. The suspended solids loading to the river from May to October would average nearly 2 tons/day. During the remainder of the year, the loadings of suspended solids would average approximately ½ ton/day, assuming a concentration of 280 mg/l. As these loadings may be of concern, we recommend that a site inspection of the area be carried out to verify these flow and concentration values. A first hand inspection of runoff quantity would be useful in determining whether more detailed monitoring is warranted.

(b) Tailing Pond

The supernatant from the tailing pond was sampled by the Pollution Control Branch during 1973 and 1974. Fording Coal Limited analysed the pond influent. The results, given in Table 2-5, show that the influent to the pond consists mainly of suspended solids (10,600 mg/l) with relatively little dissolved solids (300 mg/l). The heavy metal content of the pond supernatant is low, hence heavy metals are not expected to have any effect on the river. Increases in parameters such as suspended solids and nutrients along this section of the Fording River (documented in Chapter 4) are believed to be due to surface drainage rather than to exfiltration from the ponds. In any future monitoring of the pond liquid it would be useful to check the phosphorus and nitrate nitrogen content. Further analysis for heavy metals is not warranted.

(c) Drier Plant and Maintenance Area Discharge (settling ponds)

According to Permit Applications AE-2659 and AE-2660, the effluent flow from these sources totals 360,000 GPD (Table 2-3).

In 1973, Fording Coal Limited sampled the drainage from the drier plant and the maintenance complex, before and after treatment in the settling ponds (Figure 2-3). The results, summarized in Table 2-6, show that suspended solids in the discharges were reduced by the settling ponds to median values of 89 to 40 mg/1 although some high values, in the order of 2000 mg/1, were recorded. We understand that a significant amount of the total flow exfiltrates to the ground and does not overflow to the river. Assuming the total flow overflows to the river, that the mean low flow in the river is 9,200,000 GPD, and that the effluent averages 100 mg/1 suspended solids, the increase in suspended solids in the river would be of the order of 4 mg/1. Such a possible increase warrants further investigation. We recommend that a site inspection be carried out to determine more accurately the volume overflowing and the period of maximum overflow. Further effluent sampling may be needed, in which case we should consider adding oil and grease and nutrients to the list of parameters.

(d) Refuse Disposal Sites

The Pollution Control Branch and Fording Coal Limited sampled the stations associated with the old refuse disposal site (PR-1476). The results of analyses on the supernatant from the settling basin below the refuse site and at the stations on the Fording River upstream (station no. 110) and downstream (station no. 40) from the coal preparation plant are given in Table 2-7.

A comparison of the results for the supernatant from the Clode Creek settling basin and for the Fording River upstream indicates that the supernatant has higher concentrations of total solids, suspended solids, turbidity, total alkalinity and sulphate. The concentrations of dissolved metals are similar at the two stations. The quantity of supernatant discharged to the Fording River has not been measured. A comparison of the analytical results for Fording River upstream (station 110) and downstream (station 40) from the settling basin indicates that the water quality at the two stations is virtually identical except for increases in total solids, suspended solids, specific conductivity and turbidity. The increases in solids and turbidity are due to high values recorded at station 40 during May 1972 and May 1974. Unfortunately, station 110 and the settling basin discharge were not sampled at these times and it is thus not known whether the high values are entirely attributable to the settling basin discharge.

We consider the impact of the discharge from the settling basin to be negligible, except for the relatively high increase in solids and turbidity noted during periods of spring runoff. Further monitoring of the discharge is recommended in order to evaluate its impact on the Fording River during this time. As the monitoring program recommended in Chapter 4 for Clode Creek (which enters the Fording River via the settling basin) covers the parameters of concern, an additional monitoring program is not specified. However, the volume of supernatant discharged to the Fording River should be measured. Measurements of both concentrations and volume would enable the calculation of the quantity of contaminants being discharged.

(e) Domestic Sewage Disposal

The Pollution Control Branch has sampled the effluent discharged from the oxidation ditch and clarifier which are used to treat domestic sewage. The results are given in Table 2-8.

The effluent sampling data indicate that plant operation has been erratic. Suspended solids concentrations have often exceeded the permit limit of 65 mg/l with high concentrations of 1059 and 593 mg/l being recorded. BOD_5 concentrations however, have generally been low, and have met the permit limit of an average of 50 mg/l. Chlorine residual has been measured on three occasions and there has been either no residual chlorine (0.0 mg/l) or too much (1.2 and 3.0 mg/l). Fecal coliform numbers have generally met the permit limit of 10,000/100 ml. This discharge is not expected to have any adverse effects on the water quality of the Fording River since it is relatively small (7,000 GPD) and since it must percolate through the soil to reach the river. Accordingly, a specific monitoring program is not recommended.

2.2 Byron Creek Collieries Limited

2.2.1 Description of Exploration and Mining Area

In 1974 Byron Creek Collieries began development of a coal mine on Coal Mountain near Corbin (Figure 2-5) originally mined between 1908 and 1935[32]. Current plans are to bring production up to 1.5 million tons of power-plant coal per year[29]. The Company also plans to complete the mining of the North Ridge Pit by 1979, and then to use the pit as a dump for the overburden from other areas. Some exploration in the immediate vicinity of the pits is also projected.

2.2.2 Description of the Plant Process

As the coal at Byron Creek Collieries Limited is processed dry there is no water effluent from the plant[29]. The surface drainage is collected at one location and discharged to Michel Creek. The Company has applied for a Pollution Control Permit (AE-3957) to discharge 50,000 GPD. Details of the Application are summarized in Table 2-9. Proposed treatment is clarification in a settling pond. The overflow from the pond will have a BOD_5 of 3 mg/l and a suspended solids content of 450 mg/l.

2.2.3 Effluent Sampling Data

There are no data available for the runoff from the Byron Creek Collieries Limited mining area. The impact of the mining operation on the water quality of Michel Creek is discussed in Chapter 4.

2.3 Kaiser Resources Limited

2.3.1 Description of Exploration and Mining Areas

Kaiser Resources Limited owns lands containing the major coal reserves of the Fernie Basin. These properties are located between latitudes $49^{\circ}30'$ and $50^{\circ}08'$ N and longitudes $114^{\circ}41'$ and $114^{\circ}55'$ W[33]. Mining was started in the Crowsnest Pass area in 1898[34]. In February, 1968, the company now known as Kaiser Resources Limited purchased a large portion of the Crows Nest Industries' holdings, including the operating mines. The purchase agreement allowed Kaiser Resources Limited five years to explore the holdings. After this time the Company was to designate the 60% portion of the land it wished to control. The other 40% of the land was to be returned to Crows Nest Industries. Kaiser Resources Limited therefore carried out extensive and intensive exploration in the period 1969 to 1973. Two hundred and eighteen miles of roads were built, 375 miles were bulldozed in seam tracing and cross-cutting, 1.2 acres of land were disturbed by test pits and stripping, and 60 to 70 adits were excavated[33].

Kaiser Resources Limited is currently working the Balmer North underground mine, a hydraulic mine, and three strip mines named Harmer 1 and 2, Adit 29, and Camp 8 (Figure 2-6). The hydraulic mine uses water recycle and has no effluent discharge. Drainage and runoff from the area of the underground mine appear to flow to the coke plant settling lagoons (Figure 2-6). The mine drainage from the strip mines is sent to a settling pond in the open pit. Overflow from this pond is across the ground into Harmer Creek which then flows through a series of two smaller ponds and a larger settling pond. The last pond was created to remove solids accumulated from erosion of unvegetated land and from the open pit operation. Some of the drainage and runoff from Harmer Ridge also flows into a settling pond on Erickson Creek (Figure 2-6).

Other strip mines such as Erickson, Baldy Pits, C Strip, 7A and B Pits, "3" Strip, Balmer 10-4, Balmer 10-7, and McGillivary are not currently being worked. Some of them may become operational after 1976[35].

The impact on water quality from land erosion in exploration areas was estimated to be greater than the impact from actual mining or coal processing operations [36]. The Reclamation Section of the B.C. Department of Mines and Petroleum Resources, responsible for the enforcement of the Mines Regulation Act and the Coal Mines Regulation Act, has issued reclamation guidelines for exploration [37]. Companies must obtain a reclamation permit for mines and exploration areas. Kaiser Resources Limited holds two such Permits (Numbers 2 and 80). The Company has a program of resloping, terracing, seeding and planting reclaimed areas so that the areas are able to withstand the erosive action of water. Their schedule (Table 2-10) indicates that all unused areas will be seeded and planted by the end of 1975 [35]. If the Company's reclamation program is successful and if new exploration follows the guidelines, then effects on water quality due to land disturbances from exploration and mining should be minimized.

2.3.2 Description of the Coal Treatment Process and the Solid Waste Disposal Site

Kaiser Resources Limited washes coal at the Elkview coal preparation plant and manufactures coke at the Michel coke plant. The processes involved and the sources and disposal sites of the wastes are described below.

(a) Elkview Coal Preparation Plant

The coal preparation plant is located on the east side of the Elk River, just north of Sparwood (Figure 2-6). A simplified flow diagram is given in Figure 2-7.

Coal is obtained from the strip mines Harmer 1 and 2, Adit 29, and Camp 8 and trucked to a crusher plant. After crushing to less than four inches, the coal is conveyed to storage silos and then to the preparation plant where it is crushed, screened, and separated from the waste rock. The operations are similar to those described for Fording Coal Limited and include heavy media separation, heavy media cyclones, and flotation. The clean coal is dried in a fluidized bed drier before being shipped by rail to the Roberts Bank Superport.

The wastes from the flotation cells go to the tailing ponds where the settleable solids are removed. The supernatant water is recycled. The Company has received Pollution Control Permit PE-425[38] for the discharge of 900,000 GPD to 176 acres of tailing ponds. The permit states that effluent to the ponds must be equal to or better than typical coal preparation plant tailing and that the decant water is to be reused. There is to be no overflow of effluent from the ponds. More details of the permit are given in Table 2-11.

The solid wastes from screening and separation are trucked to the refuse disposal site which is described below.

Domestic sewage from the plant is treated by means of a septic tank and tile field.

The waste water which could reach the river is from minor effluent sources such as seepage from the tailing ponds, leachate and runoff from the refuse disposal areas, land drainage around the plant and plant spills.

The Company has a Department of Mines and Petroleum Resources Reclamation Permit for the plant area. Areas disturbed by construction and old tailing ponds have been revegetated[29].

(b) Present Refuse Disposal Sites

The coarse coal refuse from the Elkview coal preparation plant is deposited in a refuse disposal site about two miles north of Sparwood, on the east side of the Elk River. The site is shown on Figure 2-5 as point 512, which also refers to the Pollution Control Branch Permit file. The coarse coal refuse ranges in size from four inches to 28 mesh, and is hauled by truck from the coal preparation plant to the site, where it is spread and compacted by scrapers. The coarse coal refuse consists of rock, shale, sand, bony coal, coal fines, magnetite (Fe_3O_4), clay, calcite and traces of iron[39]. The sulphur content is about 0.2%[40]. The refuse is relatively inert.

The Pollution Control Permit PR-512 authorizes the disposal of 5500 cu. yd./day (6000 tons/day) of coal refuse in two sites referred to as the "old" and the "new" sites[38]. The old site has an area of 44 acres, and the new site has an area of 29 acres[41]. The combined capacity of the two sites is estimated to be about 3 million cu. yds.[39]. The old site is located on a fairly steep hillside about 1000 feet from the Elk River. The new site is on a relatively flat bench adjacent to the Elk River and extends to within 100 feet of the river. The new site is estimated to be about eight feet above the high water level of the Elk River and a partial earthen dyke has been constructed between the refuse pile and the river. A summary of pertinent information regarding these sites is contained in Table 2-4.

Groundwater seepage and surface runoff from the refuse sites are collected by vertical pressure relief wells, horizontal trench drains, and surface drainage ditches and are discharged to two low-lying areas adjacent to the Elk River[39]. These low lying areas act as settling basins to clarify the runoff. The marshy area to the south of the new refuse site also receives surface runoff from the yard area around the coal preparation plant, as well as spills from the coal preparation plant[42, 43]. Aerial photographs of the refuse sites show areas blackened by coal fines that mark the places where surface runoff from the refuse sites and the plant yard enters the two low lying areas. The water standing in the marshy area to the south is black with coal fines near the refuse site and plant yard and progressively lighter moving towards the Elk River[42].

We believe that the new refuse site is now full and that the old site will be full by the spring of 1982. After 1982, Kaiser Resources Limited plans to truck or convey (by conveyor) the coarse coal refuse to the west side of the Elk River. Here the material will initially be used for dyke construction of Lagoon E and later it will be deposited in the general area. Once the refuse sites are full, they will be revegetated as part of Kaiser's reclamation plan for the area[41].

(c) Old Refuse Disposal Sites

The Michel coal preparation plant was phased out in 1973. There were three refuse disposal sites associated with the Michel preparation plant. These sites are no longer in use and are not covered by pollution control applications or permits.

Two of the sites, referred to as the Michel refuse dumps, are located near the Michel plant and have a combined area of 22 acres. One site (point R1, Figure 2-5) which has an area of about two acres is located one mile south of the Michel plant, and about 350 feet west of Michel Creek. The other site (point R2, Figure 2-5) has an area of 20 acres and is located along the east bank of Michel Creek near the Michel plant[41]. Aerial photographs taken in September, 1971, show that the large refuse site was still in use at the time, and that coal refuse was being eroded and washed into Michel Creek along a 2000 foot front[44].

The reclamation plan (1969-1975) prepared by Kaiser Resources Limited in March, 1973, indicated that 17 acres of the 22 acres of refuse sites had been seeded and planted. Erosion control netting had been purchased to stabilize the steep creek side area of the large refuse site during revegetation[41].

The third refuse site, (point R3, Figure 2-5) referred to as the Michel-South refuse dump, is located two miles south of the Michel plant, and about 175 feet south of Michel Creek. The site has an area of 10 acres, of which nine have been seeded and planted as part of Kaiser's reclamation program[41].

No specific monitoring program is recommended for these three sites but the sites should be visited to determine if erosion has been effectively controlled.

(d) Michel Coke Plant

The coke plant is situated on the north bank of Michel Creek, in Michel (Figure 2-6). Ninety-nine acres are occupied by buildings, roads, and disposal areas. A simplified flow diagram of the process is given in Figure 2-8.

Coke is produced by heating coal, in the absence of air, in batch ovens. Coke oven gas is produced as a by-product together with tar and an aqueous condensate. The gas is separated from the tar and the aqueous phase in coolers and scrubbers and is used to heat the coke ovens. The tar is recovered in settling tanks and marketed. The aqueous condensate is recycled to cool and scrub the coke oven gas, and excess condensate is mixed with coke quench water. Coke is discharged from the ovens at the end of a batch and quenched with water sprays. Coke fines, called breeze, are separated from the quench water, and dried and stored for marketing. The quenched coke is stockpiled for marketing. The quench water is continuously reused to quench coke but is discharged once a week to prevent buildup of contaminants.

The plant has been in operation for many years and the major equipment is obsolete. Due to the age of the plant, control of the process is fairly crude, resulting in air and water emissions which would not occur in a modern plant. The major effluents are yard drainage and the weekly discharge from the breeze settling basin. The yard drainage is composed of settling pond overflows, spills, runoff, etc. The effluents are channelled through three settling ponds in series and then piped to two settling ponds near Michel Creek. Overflow from the last two ponds discharges through two coarse coke filters to Michel Creek. The Company has applied for a pollution control permit for the discharges. Details of the Application (AE-1329) are given in Table 2-11.

(e) Michel Creek Hydraulic Mine

The hydraulic mine uses water under high pressure to remove coal from underground tunnels bored into the mountainside. High pressure water jets disintegrate the coal from the seam and the coal and water slurry flow by gravity to a dewatering plant located near Michel Creek. The coal is separated from the water in a thickener and sent to the Elkview preparation plant for washing. The water is pumped back to the mine for reuse. There is usually no discharge of effluent to the creek from the operation. There are emergency holding ponds adjacent to the clarifier which are apparently used when the operation is being shut down.

There is one site (point R4, Figure 2-5) at the hydraulic mine which was used for the disposal of coal refuse from the dewatering plant. It is no longer used and is not covered by pollution control application or permit.

The site has an area of six acres and is located along the east side of Michel Creek, adjacent to the dewatering plant[41]. Aerial photographs taken in July, 1972 show that 25% of the site was in use at that time. Seventy-five percent of the site had been partially revegetated, and no erosion of the coal refuse was occurring except in a small unvegetated area adjacent to the dewatering plant[44]. The Kaiser Resources Limited reclamation plan (1969-1975) prepared in March, 1973, reported that the entire site had been revegetated[41].

Although no specific monitoring program is recommended for the site, it should be visited to determine if erosion is now being effectively controlled.

(f) Harmer Ridge Maintenance Area

A truck maintenance and washing operation is located near the strip mines (Figure 2-6) and the discharge is under application for a

Pollution Control Permit (AE-2062). Details of the Application are given in Table 2-11. In this operation oil and grease are discharged to a sump pit from which the oil is skimmed and trucked away. The washing operation also produces a waste water which contains oil and surfactants. The sump wastewater is treated by a peat moss filter which absorbs the oil. The flow of treated effluent is combined with the land drainage from the truck washing operation and from the mines. This drainage goes to a settling basin in the pit and then to the three settling basins on Harmer Creek which were previously described in section 2.3.1.

The maintenance shop washroom wastes are treated in an oxidation ditch, settled, chlorinated, and discharged to Baldy Creek which flows into Michel Creek. The discharge is under application for a Pollution Control Permit (No. AE-1195, Table 2-11).

2.3.3 Effluent Sampling Data: Discussion and Recommendations

(a) Exploration and Mining

There are few data available on the runoff water quality from exploration areas. Kaiser Resources Limited retained B.C. Research in 1973 to prepare a report on the effects of exploration on the environment[33]. The report set up a sensitivity scale for exploration areas, classifying them according to soil type, vegetation, and altitude. The erodibility of soils was a major factor considered. The erosion resulting from exploration and mining increases sediment loads and turbidity in creeks and rivers. Factors which increase erosion include channelling of the runoff water, steep slopes, unprotected ground, and dumping of unconsolidated material in or along water courses. The water quality will vary with the degree and extent of disturbance, the amount and duration of rainfall, and the catchment area.

The Reclamation Service, Mines Branch, has tested the pH of soils in the Sparwood area. All of the pH values were in the range of 6.5 to 7.8, except for the organic topsoil which was 5.1 to 6.5. (till overburden 7.1 - 7.8; organic topsoil 5.6 - 6.5; oxidized coal 6.5 - 6.8; tailing pond (dry) 6.6 - 6.9). The coal mined, mainly medium-volatile bituminous with excellent coking qualities, has a low sulphur content (0.25% to 0.7%) relative to eastern U.S.A. coals (4% to 7% sulphur). The low sulphur content and the basic pH of the soils suggest that acid-mine drainage problems, experienced in the eastern U.S.A. coal mines, will not be a problem in the Sparwood area. This suggestion is supported by the results of one sample taken from the Balmer North Mine drainage in February, 1972. The pH of 8.3 indicated a non-acid drainage. Other analyses of the sample (performed by the B.C. Water Resources Environmental Laboratory) showed low values: sulphate 5.0 mg/l; total phosphate 0.045 mg/l; dissolved copper 0.003 mg/l; suspended solids 56 mg/l; chemical oxygen demand 16 mg/l; and total sulphur 1.6 mg/l. Considering these values, we estimate that the drainage does not have a significant effect on Michel Creek. Therefore, no specific sampling program is recommended.

Drainage from the surface mines which flows to a large settling pond and overflows into Harmer Creek, may be affecting water quality in Harmer Creek, according to available biological data (see section 5.2). If further biological monitoring is carried out we recommend that water quality be measured at the settling pond outlet. Samples should be collected preferably on a monthly basis at first. Since it is not known which parameters are causing a problem, the first samples would be analysed for a wide range of variables including total solids, suspended solids, nitrate, orthophosphate, total organic carbon, ammonia, cyanide, phenol, copper, lead and zinc. Field analyses such as pH, dissolved oxygen and turbidity should also be performed. Once a few samples have been collected under different flow conditions it should be possible to reduce the number of analyses per sample to only the most important parameters.

(b) Elkview Preparation Plant

Data are available for the six groundwater monitoring wells below the tailing ponds (Lagoons C and D) and for the groundwater and surface runoff from the refuse disposal sites.

The Pollution Control Branch monitors the groundwater wells. The results from 1973-1974 are summarized in Table 2-12. For comparative purposes, the monitoring results for the supernatant from the lagoons and for an upstream and downstream station on the Elk River are included. Kaiser Resources Limited data for the lagoon supernatant and two stations on the Elk River are also presented (Table 2-12).

The data from the groundwater wells below the tailing ponds (EP-7, EP-8, EP-9, EP-16, EP-17, and EP-18), indicate that alkalinity, specific conductance, dissolved iron, dissolved manganese, and dissolved zinc were much higher below the ponds than upstream at the Elk River stations, EP-1 and 27. However, only the values for iron and manganese exceeded the level A Mining Objectives[46] and the Canadian Drinking Water Standards. The high values for dissolved iron and manganese in the groundwater may be due to the reduction of insoluble ferric and manganese compounds to soluble ferrous and manganous forms under anaerobic conditions in or beneath the tailing ponds.

The rate of groundwater flow into the Elk River from the tailing ponds area is not known, but is considered to be small compared to the flow in the Elk River. A comparison of the data for the Elk River stations upstream from Kaiser Resources (EP-1 and 27) with that for the station downstream from Kaiser Resources (EP-2) indicates that the water quality is essentially identical with the exception of small increases in specific conductivity and total alkalinity from upstream to downstream. It is thus concluded that the seepage from the tailing ponds is not having a detrimental effect on the water quality of the Elk River. A special monitoring program is not considered to be necessary for the tailing ponds.

The groundwater and surface runoff from the refuse disposal sites are monitored by the Pollution Control Branch and by Kaiser Resources

Limited. The results available for 1973-1974 are summarized in Table 2-13. The Kaiser Resources Limited data[45] are annual means for 1973 (mean of 4 samples), whereas, the Pollution Control Branch data represent one sample. Stations on the Elk River, upstream and downstream of Kaiser Resources Limited (EP-1 and EP-2), are included in Table 2-13 for comparative purposes.

The results from the one groundwater station (EP-15) and the three surface water stations (EP-11, EP-12, EP-14) associated with the refuse sites were similar to those from the upstream Elk River station (EP-1), except as indicated below. The groundwater and surface runoff samples were generally higher in total solids and turbidity, and slightly higher in total iron and total aluminum. The groundwater station EP-15, showed higher concentrations of sulphate and zinc, (3½ and 10 times higher respectively) while one surface water station (EP-14) had greater levels of manganese and copper (eight and 10 times respectively). Only copper (0.37 mg/l at EP-14) was in sufficient concentration to be potentially harmful to aquatic organisms[47]. However, the high alkalinity (155 mg/l) suggests that this would not be a problem. The higher copper values may be due to spills or drainage from the plant area, as the copper levels at stations associated solely with the refuse sites were low. The most recent Pollution Control Branch sample from station EP-15 indicated a very low concentration of zinc in the groundwater.

The quantity of groundwater and surface runoff reaching the Elk River from the refuse sites and plant area is not known, but is considered to be very small compared to the flow in the Elk River. A comparison of Kaiser Resources Limited data for the Elk River upstream (EP-1) and downstream (EP-2) from the Kaiser operations indicates that the water quality is virtually identical at the two stations.

It is concluded that the refuse disposal sites have very little impact on the water quality of the Elk River. Consequently, we recommend that no special monitoring of the refuse site be undertaken during the study. The Company and the Pollution Control Branch should continue routine monitoring at the sampling stations associated with the refuse sites in order to detect any future water quality deterioration.

(c) Michel Coke Plant

Data on effluent discharged from the Michel coke plant are summarized in Table 2-14. Effluents from the coal drier basin and the holding ponds were sampled by the Pollution Control Branch. The major contaminant in the pond liquid was phenol which was present in concentrations of three to 735 mg/l. Other effluents discharged at the coke plant are sanitary wastes, compressor water, and boiler blowdown. Data on the effluent characteristics submitted by the Company in an application for a pollution control permit are also summarized in Table 2-14.

Most of the process effluent from the coke plant is treated in a series of ponds prior to discharge through a coke filter to Michel Creek. The effluent flow has been estimated to be 30,000 GPD although no actual measurements have been made. Effluent monitoring data, though scant, indicate that phenol and ammonia could cause an environmental problem in Michel Creek. The Company and the Pollution Control Branch are currently preparing a program to upgrade the discharges from the plant.

Measurements of phenol in the effluent ranged from three mg/l to 56 mg/l, (Table 2-14). One sample of the pond liquid showed a phenol concentration of 735 mg/l. Water Quality Criteria[48] suggests a lethal concentration of 7.5 mg/l of phenol for 50% survival of trout over 48 hours. The effluent may therefore not meet the Pollution Control Branch level A Mining Objective of 50% survival of test fish in 100% effluent over 96 hours[46]. More data on phenol concentration in the effluent and in the receiving waters are required to establish existing phenol levels.

The ammonia-nitrogen value of 65.5 mg/l (Table 2-14) also exceeds levels A, B and C of the Mining Objectives. The minimum flow of Michel Creek was 37 CFS (or 20 million GPD) and the effluent flow was approximately 30,000 GPD. The 65.5 mg/l of ammonia nitrogen in the effluent would therefore result in an increase of approximately 0.1 mg/l in Michel Creek. Water Quality Criteria,[48] notes that to avoid toxic effects, un-ionized ammonia nitrogen should not exceed 0.02 mg/l. It is not known whether the ammonia is in the un-ionized form, although it is not expected to be so, given the temperature and pH of Michel Creek[60]. More data on ammonia nitrogen in the effluent are required to confirm the one value given.

Coke plant effluent can have a high chemical oxygen demand (COD), and may contain cyanide and thiocyanates[49]. A single analysis of the pond water gave a COD of 7200 mg/l, a BOD_5 of 2100 mg/l and a cyanide level of 0.05 mg/l. The COD and BOD_5 values are high and should be verified. The cyanide level is acceptable but the value should be checked. Thiocyanates should also be measured if a suitable method can be developed by the Environmental Laboratory.

Other effluents from the coke plant do not appear to be a problem. The effluent from the coal drier scrubber contains suspended solids which settle out in the exfiltration basin. Sanitary wastes will be receiving secondary treatment and the addition of 100 GPD of boiler blowdown to the treatment facilities should not impair effluent quality. The only effect of compressor cooling water is on receiving water temperature. At a flow of 320,000 GPD and a temperature of $80^{o}F$ the cooling water would raise the temperature of Michel Creek by $1^{o}F$ at most, assuming a minimum creek flow of 26,000,000 GPD. Such an effect is considered negligible.

We recommend that a monitoring program be carried out on the process effluent discharged from the ponds. In the first instance the effluent should, if possible, be sampled twice a month during total recycle of quench water and when quench water is being bled from the circuit. A 24 hour composite is preferred. Parameters to be measured should include:

Phenol

Ammonia nitrogen

Cyanide

BOD_5

COD

Total organic carbon

Suspended Solids

Field measurements of pH and temperature should also be carried out, and the effluent flow should be measured.

Samples of the receiving water immediately above and below the dilution zone should be collected each time the effluent is sampled. The samples should be analysed for:

Phenol

Ammonia nitrogen

Cyanide

Field measurements of pH, temperature and dissolved oxygen are also required.

Frequency of sampling during the year will depend on evaluation of monitoring results.

(d) Michel Creek Hydraulic Mine

Problems have been experienced in the past with discharges from the coal thickener. These have now been corrected by pumping water back to the mine. There are no significant discharges from the mine or the coal thickener.

(e) Harmer Ridge Maintenance Area

The domestic effluent was sampled by the Pollution Control Branch six times between 1972 and 1974. The results (Table 2-15) show fairly large variations in BOD_5 and suspended solids. Half the samples met the

Pollution Control Permit limits (as given in Table 2-11). Results suggest that the plant operation is erratic.

The discharge is to Baldy Creek, about 3 miles upstream from its confluence with Michel Creek. Based on flow records for adjacent and similar streams, the Company estimates that the effluent is diluted by a factor of 40:1 in the upper reaches of the Creek and by a factor of 241:1 in the lower reaches. If this is the case, it is unlikely that the discharge will affect water quality. We recommend that the treatment works be inspected to ascertain requirements for maintaining efficient operation at all times. An on site inspection is required to confirm stream flows and our present estimate of water quality.

2.4 Proposed Mining Developments

Four new coal mining developments are proposed for the Elk River Basin. These are: on Coal Mountain south of Corbin (Crows Nest Industries); in the Hosmer Creek and Wheeler Creek area east of Hosmer (Kaiser Resources Limited); along Line Creek (Crows Nest Industries); and on Weary Ridge along the east side of the upper Elk River (Elco Mining Company, formerly Emkay Canada National Resources). Some details are available for the latter two.

The proposed Line Creek mine would be on a ridge about seven miles from the confluence with the Fording River[50]. Approximately one million tons of coal would be removed each year. The operation would involve open pit mining of the ridge, disposal of the overburden into a valley and diversion of the creek in the valley (a tributary of Line Creek) around the refuse pile. Once the pit is dug, some of the overburden may be returned and the pit would be converted into a lake. The drainage water would be removed via a ditch along Line Creek, but separated from the Creek by the hauling road. Settling basins would be built where required at the mine site and along the drainage ditch. The proposed site for the preparation plant is at the confluence of Line Creek and the Fording River. B.C. Research has been retained by

Crows Nest Industries to do a detailed background study in the region.

Elco Mining Company has not started mining its extensive deposits in the Upper Elk Valley (Figure 2-2), although relatively extensive exploratory work has commenced. Consultants for the Company state that relocation of a part of the Elk River would be required for the operation of a viable mine[51]. The coal under the river is of medium to high volatility and must be mixed with the coal of lower volatility from higher elevations to obtain a good quality coking coal.

The Elk River diversion would be on the west side of the river, between Cadorna and Weary Creeks. The proposed mine pit would be approximately five miles long, ½ to 3/4 miles wide, and about 600 feet deep. The Company plans to backfill the pit with waste rock and soil whenever possible. The erosion from the strip mines, construction sites and new river channel would probably have the greatest effect on water quality[52].

2.5 Other Sources of Industrial Wastes

Pollution Control Branch files show that there are five relatively small industrial refuse disposal sites in the region. The sites are shown on Figure 2-5 as points 3703, 3821, 1961, 2422 and on Figure 2-2 as point 3835. The numbers also refer to Pollution Control Branch Permit or Application files. Four of these sites are in operation and one has been closed. A summary of the pertinent information regarding each of these sites is contained in Table 2-4.

An evaluation of potential adverse effects indicates that the sites are unlikely to contribute to the deterioration of groundwater or surface water quality. Accordingly, no special monitoring of these sites is recommended.

2.6 Summary of Recommendations

Our recommendations for effluent sampling in Region 2 have been detailed in the preceding discussion. The recommendations involve both work required in addition to routine sampling, and changes to present sampling programs. The recommendations are summarized below for easy reference.

2.6.1 Fording Coal Limited

(a) Grenhills Mine Dewatering

Site inspection to confirm flows and possible suspended solids loading.

(b) Coal Plant Tailing Pond

In future routine monitoring, include nitrogen and phosphorus and exclude heavy metals.

(c) Drier Plant and Maintenance Complex

Site inspection to estimate volume overflowing and period of maximum overflow.

In future routine monitoring, include oil and grease and phosphorus and nitrogen.

2.6.2 Kaiser Resources Limited

(a) Surface Mine Drainage into Harmer Creek

Monitor monthly, or at the same time as recommended biological monitoring. Initial parameters:

Total solids	Total Organic Carbon
Suspended solids	Cyanide
NO_3-N	Phenol
NH_3-N	Cu, Pb, Zn.
PO_4 Dissolved	

Following evaluation of initial results, the number of parameters will be significantly reduced.

(b) Michel Coke Plant (AE-1329)

Initially monitor twice a month, during quench water recycle and quench water bleed from circuit.

Effluent parameters:

Suspended solids	Phenol
Chemical oxygen demand	Cyanide (total)
Total organic carbon	pH
BOD_5	Temperature
NH_3-N	Flow

Receiving water parameters (above and below dilution zone)

NH_3-N	Cyanide (total
Total organic carbon	pH
Suspended solids	Temperature
Phenol	Dissolved oxygen

(c) Maintenance Camp Domestic Waste (PE-1195)

Inspect treatment plant to evaluate operating efficiency. Site inspection of receiving waters.

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

3.1 Fernie

3.1.1 Description of the Sewage Treatment Facilities

The city of Fernie is an important commercial centre for the coal fields of the Elk and Fording Valleys. The 1971 census reported a population of 4422 and a municipal area of 1980 acres[53].

Until 1973, the municipal sewage disposal facilities consisted of two septic tanks and a one-acre oxidation lagoon which discharged into the Elk River. The lagoon discharge was under Pollution Control Permit PE-72 which is summarized in Table 2-9. In 1973, a new treatment plant was built. The new facilities include extended aeration, settling, and chlorination and are designed to treat storm water and sanitary sewage for a population of 6500. The discharge is to the Elk River and is under Pollution Control Permit PE-390 (formerly PE-306). Permit details are given in Table 2-9 and plant design details in Table 2-16.

3.1.2 Effluent Sampling Data: Discussions and Recommendations

The Pollution Control Branch sampled the effluent from the Fernie sewage treatment plant six times in 1974. The results, given in Table 2-17, indicate that the levels of suspended solids (mean 14 mg/l) and BOD_5 (23 mg/l) were within the permit levels shown in Table 2-9. According to the permit, the mean effluent discharge is 0.93 CFS giving a loading of suspended solids of approximately 70 lb/day. A comparison of effluent flow with the 1973 minimum daily discharge of the Elk River at Fernie of 310 CFS[11] suggests that the treated municipal discharge will have no effect on the water quality of the Elk River.

In January 1974, heavy rains and an unseasonable thaw occurred in Fernie. As a result, flows of more than 3 million GPD (5.6 CFS) passed through the plant and an unknown quantity of effluent bypassed the plant. Also, the city's sewers backed up flooding basements and streets, and creating a possible health hazard[38]. In June 1974, excessive flows to the treatment plant reoccurred, and untreated sewage was discharged to a field near the plant. We recommend that the system be modified to prevent the backup of sewage, and we understand that the city has agreed to such measures. If the treatment plant must be bypassed during floods, the flow quantity and quality should be monitored in order to evaluate effects on the river water quality.

3.2 Sparwood

3.2.1 Description of the Sewage Treatment Facilities

Sparwood, situated near the confluence of Michel Creek and the Elk River, had a population of 2990 in 1971[14].

Municipal effluent from the District of Sparwood is treated by an oxidation ditch with a capacity of 0.5 million gallons and a retention time of 23 hours. A 20 foot diameter clarifier with a 2.5 hour retention time is used for final sludge settling. Before discharge to the Elk River, the effluent is chlorinated to a chlorine residual of 0.2 mg/1. Sludge can be returned to the ditch or to storage and drying beds. The discharge to the Elk River is under Pollution Control Permit PE-253 which is summarized in Table 2-9.

3.2.2 Effluent Sampling Data: Discussion and Recommendations

The Pollution Control Branch sampled the Sparwood sewage treatment plant eight times from 1972 to 1974. The results, summarized in Table 2-18,show that the effluent meets the Pollution Control Permit limits given in Table 2-9. The mean loadings of BOD_5 and suspended solids are 33 lb/day and 39 lb/day respectively. As the minimum daily discharge of the Elk River in 1973 was 161 CFS[11], these loadings will have no effect on the water quality of the Elk River. The chlorine residual in the effluent is often below the usual acceptable limit of o.1 mg/1. We recommend that steps be taken to ensure that effective chlorination of the effluent is taking place.

3.3 Elkford

3.3.1 Description of Sewage Treatment Facilities

Elkford is situated on the Elk River, upstream from the confluence with the Fording River. The 1971 census gives a population of 605[14]. There was an estimated population of 2500 in December, 1974.

Elkford has a five cell lagoon system which has a total area of 9.9 acres. As of October 15, 1973, the lagoons were not aerated but there are plans to install diffused aeration. Chlorination facilities were not installed because there has been no effluent overflow to date. Effluent now exfiltrates to the ground from the third cell. The system is under Pollution Control Permit PE-454 which is summarized in Table 2-9.

3.3.2 Effluent Sampling Date: Discussion and Recommendations

The Pollution Control Branch sampled the Elkford sewage treatment plant twice during 1974. The results, given in Table 2-19, indicate a good quality effluent. One of the samples showed a high suspended solids content, but this value may be in error since BOD_5 and total organic carbon were low in the sample. The pH of the effluent is considered high for domestic effluent. Since the effluent percolates through the ground before entering the river, we do not expect the effluent to have any effect on the water quality of the Elk River.

3.4 Municipal Sources of Solid Wastes

The Pollution Control Branch files showed that there are seven municipal refuse disposal sites under permit or application within the region. Six of these sites are in operation and one has been closed. A summary of pertinent information regarding each of these sites is contained in Table 2-20. The location of the sites is shown as points 504, 505, 1480, and 1876 in Figure 2-2, and points 520, 1486, and 1671 in Figure 2-5. The numbers also refer to the Pollution Control permit or application files.

An evaluation of the potential at each site for adverse effects on groundwater or surface water (Table 2-20) indicated that it is unlikely that any of the municipal sites will contribute to the deterioration of groundwater or surface water quality.

Accordingly, no special monitoring of these sites is recommended.

3.5 The Influence of Agriculture

In the Elk River Basin, there is a limited amount of agricultural activity. The agricultural operations are located in the following areas[55]:

- Between Sparwood and the Fording River confluence
- Between Fernie and Olson
- At Morrisey

The sources which were considered to contribute nutrients to the receiving waters were fertilized irrigated cropland and animal confinement operations.

3.5.1 Fertilizer Contributions

Nutrient contribution from cropland was estimated only for the irrigated acreages. Fertilizer applied on non-irrigated acreage was assumed to contribute a negligible amount in comparison to that from irrigated cropland. The irrigated acreages and locations were determined from issued water licences. Fertilizer application rates of 50 lbs nitrogen per acre per year and 10 lbs phosphorus per acre per year were assumed in calculating the potential source loadings.

The method used to estimate the fraction of applied nutrient ultimately reaching the receiving water was based on results from the Okanagan Basin Study[56]. In this study lysimeter tests were used to derive the fraction of nutrients reaching the groundwater. These fractions were 0.168 of the nitrogen applied as fertilizer and 0.021 of the phosphorus applied as fertilizer.

We then assumed that 80% 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 waters:

Nitrogen:	50 x 0.168 x 0.8 = 6.7 lb/year
Phosphorus:	10 x 0.021 x 0.8 = 0.17 lb/year

Table 2-21 gives nutrient loadings to the receiving waters from irrigated fertilized lands, based on the above assumptions. The area of irrigated fertilized land in the Elk valley was estimated from the 1971 agricultural census[57]. The total nitrogen and phosphorus loadings to the Elk River from cropland was thus estimated to be 8600 lb/year and 220 lb/year respectively.

3.5.2 Livestock Contributions

Nutrient contributions from livestock operations are mainly due to poor management practices. Beef cattle are often wintered near streams because of the natural shelter and water supply provided. A significant amount of animal wastes can thus accumulate near the streams. When the spring thaw occurs, the runoff can flush this waste into the stream.

The method used to derive nutrient loadings to the river from livestock confinement operations was again based on results from the Okanagan Basin Study[56]. 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 leaked into 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[57]. Results are presented in Table 2-21 and show that total loadings to the Elk River from livestock sources were 11,000 lb/year of nitrogen and 230 lb/year of phosphorus.

3.5.3 Discussion of Results

The total nutrient contribution from agricultural activity to the Elk River was estimated to be 19,000 lb/year of nitrogen and 440 lb/year of phosphorus. These loadings are considered to be insignificant on an annual basis. However, if all the wintering areas were located on sloped land along the watercourses, a short term problem might occur during spring runoff. A visual assessment is required to evaluate the animal waste management practices in the Elk River Basin. If the majority of the cow-calf operations are well managed, no problem would result from fertilized cropland during spring runoff. Fertilizer is usually applied on the land prior to spring runoff, therefore a fast thaw could carry a significant amount of the fertilizer into the stream over a short period of time.

3.6 The Influence of Forestry

As a result of widespread wildfires in the last 50 years, about 50 to 60% of the lands in this region are occupied by immature forests, mainly of lodgepole pine. These stands are increasing in importance as a source of pulpwood. Old growth forests of mature and over-mature Engelmann spruce and alpine fir occupy perhaps 10 to 15% of the area, usually on steep slopes and over 4500 feet elevation.

Logging practices (especially road construction and log skidding) are likely to cause soil erosion and stream sedimentation. These problems are likely to be most severe in the steeply sloping areas of the mature spruce-fir forests. Regeneration problems are also likely to be encountered on steep exposed slopes, which could prolong the period of logging impact on water quality.

Existing and proposed logging operations in Region 2 are relatively limited in extent. The areas involved are shown in Figures 2-2 and 2-5. The major center of activity is in the south of the Basin, along the Wigwam River and its tributaries (Lodgepole, Bighorn, and Rabbit

Creeks). Other smaller areas of active logging are found in the upper reaches of Fording and Line Creeks, further north in the Region. The unstable and highly erodible surficial materials in the Line Creek valley, derived from underlying shales and sandstones, require special consideration and management if erosion is to be controlled.

3.7 The Influence of Dams

The only major dam in the region is the Elko dam on the Elk River, 1/2 mile downstream from the village of Elko. The dam and its associated power plant are now owned by B.C. Hydro, but the original development of the Elko site was undertaken by the East Kootenay Power Co. Ltd. in 1906. Further expansions of the operation, completed in 1924 and 1950, brought the operation to its present state of development.

The Elko dam development is relatively small by today's standards. The dam is a concrete gravity type, 32 feet high and 216 feet long. The power house has an installed capacity of 9.6 MW. The reservoir behind the dam is small, with a storage capacity of only 610 acre-feet, and consequently the Elko plant may be classed as a run-of-the-river plant.

The reservoir is contained mostly within the channel of the Elk River with only 25 acres being flooded by the creation of the reservoir. The fluctuations in the reservoir water level due to the operation of the power plant are small, with the reservoir normally operated between elevations 3020.5 and 3014 feet. The backwater effects from the reservoir are estimated to extend no more than two to three miles upstream from the dam.

No studies have been conducted on the impact of the Elko dam on the Elk River. However, we believe that the Elko dam probably has relatively little effect on the Elk River. Since it is a run-of-the-river plant, it has little effect on the natural flow pattern in the Elk River, and thus the effects on aquatic life and water quality due to altered flow patterns are minimized. Also, the reservoir is confined to a relatively short reach of the natural river channel, so that the ill-effects associated with reservoirs which inundate large areas of valley bottom are neglible. The last addition to the dam was 25 years ago and in that time the Elk River will have established new equilibrium conditions in the vicinity of the dam.

4. WATER SAMPLING DATA

4.1 Introduction

The waters of the Elk River basin have been sampled by Provincial and Federal agencies and by consultants retained by Industry.

Since 1970 the Pollution Control Branch has collected approximately 750 samples involving a total of 15,000 analyses. The results of these analyses are discussed in this chapter, together with data from other sources. To facilitate the presentation and discussion of data we have divided the Region as follows:

- The Elk River from its headwaters to the confluence with the Fording River.
- The Fording River.
- The Elk River from Fording River to Michel Creek.
- Michel Creek.
- The Elk River from Michel Creek to Lake Koocanusa.

4.2 The Elk River From its Headwaters to its Confluence With the Fording River

4.2.1 Presentation of Data

The Elk River originates in glacier-fed Upper and Lower Elk Lakes. It meanders across a bush-covered valley floor about one mile wide for about ten miles to below Cadorna Creek. In the next five miles, to Aldridge Creek, the river gradient is steeper and the riverbed relatively straight. From Aldridge Creek to Round Prairie the valley is wider, the river meanders and is occasionally interrupted by log jams or boggy stretches. From Round Prairie to the confluence with the Fording River the stream velocity is higher and streamside vegetation is mainly trees with lighter underbrush.

The only effluent source in this area is the Elkford sewage treatment plant which exfiltrates through the ground. However, the proposed Elco Mining Ltd. operations, including the diversion of the Elk River from

Cadorna to Weary Creeks, lies in this section of the Elk River.

Figure 2-9 shows the locations of the water sampling sites. The Pollution Control Branch sites are described in more detail below, beginning with the upstream site:

Site 41: On the Elk River, upstream from Cadorna Creek.

Site 43: On the Elk River, at the bridge at Round Prairie, approximately five miles north of Elkford.

Site 39: On the Elk River, approximately ½ mile south of the Boivin Creek confluence (downstream of the Elkford sewage treatment plant).

The data collected by the Pollution Control Branch, from 1972 to 1974, are summarized in Table 2-22. More details on some parameters are given in Table 2-23. The turbidity data for site 43, upstream of Elkford, and site 39, downstream from Elkford, are plotted in Figure 2-10. Data were also obtained from the B.C. Fish and Wildlife Branch[20], B.C. Research[51], and the Federal Government[74]. They are not included due to space limitations, but are in many cases, discussed.

4.2.2 Discussion and Recommendations

The discussion is subdivided into some general comments, the Elco Mining Ltd. exploration area, and the data from the vicinity of the town of Elkford.

(a) General

The headwaters of the Elk River and Cadorna Creek are made up of glacial meltwaters. Surface runoff is added as these waters flow down the Elk valley. Samples were analyzed from site 41, B.C. Research site WS 1 and Fish and Wildlife Branch site FW 1 above Cadorna Creek and at B.C. Research site WS 13 on Cadorna Creek (Figure 2-9). Results showed lower values for pH, specific conductance and total carbon than for sites downstream or for any other tributaries sampled on the Elk River.

Downstream of these sites surface runoff is added by Aldridge, Bleasdell, Weary, Forsyth/Quarrie, Bingay, Boivin, Weigert, Brule, and a number of unnamed Creeks. The soils of the drainage areas of these tributaries (and of the direct drainage areas to the Elk River) are derived from glaciated limestone materials. Surface runoff water has higher pH, specific conductance, dissolved solids, hardness, alkalinity and total carbon than glacier and snow melt water in the Upper Elk River and Cadorna Creek.

(b) Elco Mining Exploration Area

The Elco Mining Ltd. exploration area is situated between Cadorna and Weary Creeks (Figure 2-9). Some water quality data from a site upstream (41) and downstream (43) of the exploration area are presented in Table 2-23. During low flow, there was a slight increase in the alkalinity, and dissolved and total solids from the upstream to downstream station. No data were available from the upstream site during high flow. However, at the downstream site, the suspended solids and turbidity were higher at high flow than at low flow (124 mg/l and 20 JTU in May compared to 4 mg/l and 0.7 JTU in August). The high values during spring runoff and the small increases across the exploration area could be attributed to the effects of tributaries as well as to possible soil disturbances caused by exploration.

Results of samples from the B.C. Research sites just downstream of the exploration area, showed that alkalinity, hardness, pH, specific conductance and dissolved solids were lower in August than in July or September. Kunkle and Meiman[58] noted a similar phenomenon for a mountain watershed. The spring runoff may scour or clean the watershed resulting in little contact between water and the soil which contributes ions to the water.

In July the runoff contained more dissolved solids than in August when the streamflow was only slightly less. In September the water was flowing at a lower rate and had made significant soil contact. As a result there were higher values for parameters such as alkalinity, hardness, pH, specific conductance and dissolved solids. These results demonstrate the sensitivity of water quality to flow and to stream disturbances.

The alkalinity at upper Elk River sites was in the range of 70-90 mg/l, indicating limited buffering capacity for acid mine drainage, should it occur. No studies of the potential acid production of soils in the Elco Mining region are available but some preliminary work was carried out by B.C. Research for Fording Coal[31]. Results showed that there was no naturally occurring acid drainage, although some areas could produce acid mine drainage if conditions became favourable for bacterial action. No sampling has been undertaken to determine whether acid drainage occurs in the now active mining area.

The E.P.A. Water Quality criteria[48] suggests that a change in alkalinity by an unnatural disturbance should be less than 25% of the natural level to protect aquatic life. This criterion demonstrates the importance of alkalinity as a parameter in assessing water quality. Alkalinity should therefore be monitored in areas, such as mining areas, when it may be affected.

If the Elco Mining Ltd. operation is to proceed, we recommend that the location of potential acid mine drainage areas be determined. Monitoring and appropriate corrective action can then be taken to check potential problems.

If mining development proceeds, we also recommend that the water quality upstream and downstream from the future mining sites be characterized. Analyses should include:

pH
total solids
dissolved solids
suspended solids
specific conductance
temperature
turbidity
total alkalinity
organic carbon
hardness
sulphate
acidity
total iron

River sediments should be analyzed for particle size distribution and total organic carbon, and heavy metal content on occasion.

The preferred sampling frequency for both water and sediment samples is:

Mid-January
Mid-April
First week in June
First week in July
First week in August
Mid-October

The water and sediment sampling we have proposed should be carried out at least one year before site preparation. The program will be started in Phase II of this study if time and resources permit. We recommend that government agencies concerned with future mining development should ensure that a sampling program is undertaken in time.

(c) The Elk River in the Vicinity of Elkford

The village of Elkford is the townsite for the Fording Coal operation, and uses a lagoon system for the disposal of municipal sewage. There has been no positive discharge of effluent from the system due to exfiltration of effluent to the adjacent stream bed.

A comparison of water quality upstream (site 43) and downstream (site 39) from Elkford showed that pH, dissolved solids, specific conductance, chloride and organic carbon were slightly higher downstream. Data available from Environment Canada[74] on Weigert and Brule Creeks, which flow into the Elk River upstream of the Fording River, are comparable to values for other tributaries in the Elco Mining area further north.

In general, water quality in this segment of the Elk River is suitable for raw water supplies for serving the water licences issued (Table 2-2).

Turbidity downstream from Elkford (site 39) in the spring of 1972 was significantly higher than upstream from Elkford (site 43) as shown in Figure 2-10. Site disturbances in the area of Elkford townsite might have caused the addition of silt-laden runoff and hence the higher turbidity. These disturbances could have taken place during the construction of the Elkford townsite[6].

We recommend that the Pollution Control Branch continue its routine monitoring. The monitoring should include sampling for the following parameters:

- pH
- Total solids
- Suspended solids
- Specific conductance
- Temperature
- Turbidity
- Organic carbon
- Chloride
- Organic nitrogen
- Total phosphorus
- Fecal coliform

If possible, the upstream site 43 should be moved closer to Elkford.

4.3 Fording River and its Tributaries

4.3.1 Presentation of Data

The headwaters of the Fording River and its tributaries are in the high valleys of the High Rock Range (altitude 7,000 to 7,500 feet). A small proportion of the total flow is derived from the east slopes of the Greenhills Range, separating the Elk and the Fording rivers. For the first eight miles, to Henretta Creek, the river drops steeply by 1500 feet. For the next 20 miles the gradient is more moderate, the river dropping only 800 feet, and taking a more meandering course. The river drops 400 feet in about 3 miles then 400 feet in about 10 miles to join the Elk River.

The Fording Coal plant is located between Henretta Creek and Kilmarnock Creek just as the river begins the 20 mile section of moderate gradient (Figure 2-9).

Line Creek joins the Fording River about 12 miles from the mouth of the Fording River. The pits of Crows Nest Industries Ltd., not presently in operation, are about six miles up Line Creek (Figure 2-9).

The location of sampling sites is shown on Figure 2-9. The Pollution Control Branch sites are described in more detail below, starting with the upstream site.

Site 110: On the Fording River, south of the confluence with Henretta Creek.

Site 40: On the Fording River at the Fording Coal plant site.

Site 93: On the Fording River due east of Elkford.

Site 28: On the Fording River just before its confluence with the Elk River.

Site 44: On Line Creek downstream from Crows Nest Industries Ltd.

Summaries of the data obtained at these sites are presented in Tables 2-24 and 2-22. More details on some parameters are given in Table 2-25. Data collected by B.C. Research and the Fish and Wildlife Branch on the Fording River upstream from Clode Creek and on Aldridge Creek, an adjacent watershed, are compared with the Pollution Control Branch data (Table 2-26). A plot of organic carbon concentrations at Pollution Control Branch sites sampled in 1973 is presented in Figure 2-11.

4.3.2 Discussion and Recommendations

(a) Fording River

The water quality of the Fording River above the Fording Coal operations was similar to Aldridge Creek, a tributary of the Elk River. The data showed the usual seasonal changes due to high and low runoff periods (Table 2-26).

In 1970, before the Fording Coal operations, B.C. Research sampled tributaries of the Fording River in the vicinity of the present coal plant[31]. The results, from Clode, Eagle, and Kilmarnock Creeks indicated that the water quality met the British Columbia drinking water standards[59].

Data collected following startup of Fording Coal Ltd. operations are discussed below, by parameter. The data are in Tables 2-24, 2-22, and 2-25.

Specific Conductance and Alkalinity

From 1972 to early 1974 these parameters showed little change other than an increase downstream due to the addition of runoff water (Table 2-24). Annual minimums occurred during spring runoff.

Suspended Solids

Concentrations were relatively high during spring runoff in 1972 and 1974 (80 to 240 mg/l) but remained low in 1973 due to below average runoff flow in that year (less than 8 mg/l). Values tabulated in Table 2-25 also show a significant increase past the Fording Coal plant site, of from 4 to over 100 mg/l.

A nonstandard analysis was carried out by Environment Canada at site 8NK21, near site 40[75]. The test used was called "suspended residues" and consisted of 30 day settling of the sample, decantation, filtration and drying. The data showed that the 1972 maximum "suspended residue" occurred in early June rather than mid-May which is the time Pollution Control Branch samples were taken with results as shown in Table 2-25. It is therefore probable that higher concentrations of suspended solids occurred in spring 1972 than we have indicated. The result demonstrates the importance of sampling at the correct time to obtain the maximum concentrations which last for relatively short periods.

High levels of suspended solids can affect aquatic life. The possible effects are documented in Chapter 5 on biological data. Such effects include possible mortality of fish due to decreased intra-gravel oxygen and abrasive action on gills, and a decrease in invertebrate populations due to sedimentation.

Turbidity

This parameter follows the same trend as suspended solids with the most rapid increase over background values occurring near the Fording Coal plant site (Table 2-24 and 25). Turbidity can affect aquatic life by reducing light penetration and hence periphyton growth and fish visibility. These effects are discussed in more detail in Chapter 5.

Nitrogen and Phosphorus

Total nitrogen and total phosphorus concentrations were at a maximum during the spring runoff of 1973 and 1974. The highest values occurred at the Fording Coal plant site (Table 2-25). The values were particularly high in May 1974, being 0.47 mg/l total N and 0.187 mg/l total P. These values are equivalent to the discharge of secondary treated sewage from 2,000 persons. The concentrations should not have a significant effect on aquatic life,but are a measurable source of nutrient entering Lake Koocanusa.

Organic Carbon

Organic carbon concentrations were higher downstream than upstream of the Fording Coal plant, reaching a maximum at the plant site (Figure 2-11). The concentrations were not high enough to be of significance but do indicate that addition to the river of organic material, such as coal fines, petroleum products or domestic sewage, is taking place.

Review of the data indicates that the Fording Coal operation has a significant effect on the Fording River, especially during the spring runoff period. These effects are associated mainly with suspended solids, turbidity and nutrients. To confirm these conclusions and to quantify the sources of pollution more accurately, we recommend a season of sampling at the following locations:

Site 110: The Fording River downstream from Henretta Creek, upstream of Fording Coal Ltd.

Site 40: The Fording River downstream from Clode Creek.

New sites: On the Fording River downstream from the Fording Coal plant site, but upstream from Kilmarnock Creek.

: On the Fording River downstream from Kilmarnock Creek.

Henretta Creek, Clode Creek, Kilmarnock Creek and the Fording River between these Creeks, should also be sampled if resources permit. The samples should be analysed for the following:

pH
total solids
dissolved solids
suspended solids
specific conductance
turbidity
total alkalinity
organic carbon
total nitrogen
total phosphorus

In June or August the samples should also be tested for the presence of dissolved arsenic, copper, lead, manganese, nickel and zinc and total iron.

The preferred sampling times are as follows:

Mid-January
Mid-April
Mid-May
The first week of June
The first week of July
The first week of August
Mid-October.

In addition to the operation of the Fording Coal plant, extensive exploration has been carried out in the area. In 1973 exploration took place on Turnbull Mountain, (between Clode Creek and Henretta Creek) and on Eagle Mountain (between Clode Creek and Kilmarnock Creek). Drilling programs were also conducted on Henretta Mountain. Due to the possible effects of exploration on water quality we recommend that future exploration in the area incorporate a water quality monitoring program to measure the before and after effects. Information from such a program can be used to plan exploration in a way that will minimize effects on water quality.

(b) Line Creek

Water quality data were collected at site 44, on Line Creek (Figure 2-9), until December 1972. Results listed in Table 2-22 were similar to those of the upper Fording River (Table 2-24), except for turbidity which was higher on Line Creek.

In 1972 Crows Nest Industries removed 19,000 tons of coal from a test pit along Line Creek. The pit was then reclaimed as was a previously worked pit. Settling ponds were built to prevent mine runoff water from entering Line Creek. In 1973, drill holes were made and seeding of the two test pits was carried out[32].

The proposed mining developments along Line Creek were described briefly in Chapter 2. The Company will retain Consultants to carry out an environmental impact study before site development. The study should provide further information on present water quality and describe the environmental effects of the proposed development.

To complete our present study, we recommend sampling Line Creek and, if possible, the discharges entering and leaving the existing settling ponds. Samples should be analyzed for the same parameters recommended for the Fording River in Section 4.3.2-a.

4.4 The Elk River From the Fording River to Michel Creek

4.4.1 Presentation of Data

This section of the river is approximately 11 miles long, of moderate gradient and with rapidly flowing water. Streamside vegetation consists of trees with light underbrush. The river valley is about three miles wide narrowing to one mile at Sparwood. The open pit mines and the Elkview Preparation Plant of Kaiser Resources Ltd. are on the east side of the valley. The tailing ponds are situated adjacent to the river (Figure 2-12).

Figures 2-9 and 2-12 show the location of sampling sites. The Pollution Control Branch sites are described in more detail below:

Site 27: On the Elk River mid-way between the Fording River and Grave Creek.

Site 111: On the Elk River upstream from the confluence of Michel Creek.

Site 26: On Grave Creek near its confluence with the Elk River.

Site 117: On Otto Creek, 50 ft. from its confluence with the Elk River.

Summaries of the data collected at the Pollution Control Branch sites are given in Table 2-27.

4.4.2 Discussion and Recommendations

The data collected are discussed by parameter.

Specific Conductance and Alkalinity

The Elk River, upstream from Michel Creek (sites 27 and 111) showed low values during the spring runoff period (Table 2-27). Grave Creek (site 26), which drains the Harmer Ridge mining sites, showed consistently high values but this was not detectable in the downstream Elk River site 111 (Table 2-27).

Suspended Solids

In 1972, measurements were made only in Grave Creek. The results showed a heavy silt loading from the Harmer Ridge mines to the creek. A value of 1796 mg/l was recorded on May 15, 1972.

In 1973 and 1974 annual peaks occurred during spring runoff at all sites. In 1973 the suspended solids in Grave Creek remained low but in 1974 the concentration was higher in early May than at any other site. Concentrations were consistently higher downstream from the coal preparation plant than upstream from the plant. However, concentrations were generally less than the maximum permitted for drinking water standards[59]. Although the suspended solids load is not considered a problem as such, the changes in particle size and organic content of the stream sediment may be important. These changes may in turn have significant effects on aquatic life, as referred to in Section 4.3.2-a. We recommend that sediment samples be taken at all the water sampling sites for analysis of particle size distribution and organic carbon content.

Turbidity

The turbidity was high in the spring of 1972 on Grave Creek (165 JTU) and upstream from Grave Creek and the Elkview Preparation Plant (119 JTU). No spring data are available for the downstream site 111. During 1973 and 1974, turbidity remained low at all sites. Since streamflow in 1972 was higher than usual the turbidities may be partly due to natural erosion. High runoff also affects erosion from soil disturbances.

Other Parameters

Other parameters measured at the sites (Table 2-27) showed seasonal variations but the values remained low.

The tributaries of the Elk River between the Fording River and Michel Creek do not appear to alter the water quality of the Elk River. There is no station on the Elk River just above the confluence with the Fording and thus it is not known whether the high turbidity results at station 27 were influenced by the Fording River.

We recommend that sampling be continued for another year to confirm our conclusions and to relate water quality with sediment analyses. The sites should be located upstream (a new site) and downstream (site 111) from the Elkview Preparation Plant. Grave Creek and upstream site 27 should also be sampled. Parameters and sampling frequency should follow those previously suggested in Section 4.3.2-a.

4.5 Michel Creek

4.5.1 Presentation of Data

Michel Creek, a tributary of the Elk River, is about 24 miles long and drains an area of 250 square miles (Figure 2-12). The area has been one of the centres of exploration of Kaiser Resources Ltd. which operates a coking plant and hydraulic mine near the creek (Chapter 2). Kaiser Resources Ltd. also operates several mines on Harmer Ridge, which is partly drained by Erickson Creek, a tributary of Michel Creek (Figure 2-12). Other tributaries of importance are Baldy Creek, which receives the discharge from a secondary sewage treatment plant, and Open Cut Creek, which drains the open pit mine of Byron Creek Collieries. Michel Creek also receives runoff from Coleman Collieries Ltd., an open pit mine located in Alberta at the Provincial boundary.

The locations of the Pollution Control Branch sampling sites are shown in Figure 2-12. The sites for which data are available are as follows:

- Site 98: On Michel Creek, downstream from the confluence with Erickson Creek.
- Site 46: On Michel Creek, upstream from the coking plant.
- Site 25: On Michel Creek, downstream from Baldy Creek and the coking plant.
- Site 97: On Erickson Creek near the confluence with Michel Creek.
- Site 112: On Baldy Creek, near the confluence with Michel Creek.

The data obtained from these sites are summarized in Tables 2-28 and 2-29.

4.5.2 Discussion and Recommendations

The data collected are discussed by parameter.

Suspended Solids and Turbidity

Peak concentrations of suspended solids were obtained at all stations during spring runoff. For example, in Spring 1972 a concentration of 432 mg/l was recorded upstream from Michel (site 46), and 556 mg/l downstream from Natal (site 25). As mentioned in Section 4.3.2-a, such high suspended solids can effect aquatic life. Turbidity at Site 25 was also high reaching 120 JTU in 1972 and 68 JTU in 1974. We believe such high values can only occur as a result of soil disturbances due to industrial activity in the drainage area. High turbidity can also be detrimental to aquatic life as mentioned in Section 4.3.2-a. High values were also recorded in the tributaries of Erickson Creek and Baldy Creek.

Oil and Grease

A high concentration of 16.2 mg/l was measured at site 25, downstream from Natal, on April 11, 1972. This was possibly caused by an oil spill into Michel Creek or on to the ground during the previous winter.

Phenols

Concentrations downstream from the coking plant (site 25) were 0.100 mg/l in February 1974, 0.038 mg/l in March 1974 and 0.021 mg/l in April 1974. Upstream from the plant (site 46) concentrations were 0.002 mg/l or less. These values suggest that the source of phenols is the coke plant discharge and confirm the results of effluent analysis discussed in Chapter 2.

Public water supplies should, preferably, contain less than 0.001 mg/l phenol to avoid taste and odour problems[48]. The recommended maximum for drinking water is less than 0.002 mg/l[59]. Phenols may affect the taste of fish at levels that do not appear to affect fish physiology adversely[48]. According to these standards the concentration of phenol in Michel Creek could limit the use of the water and affect fish taste.

Ammonia

As discussed in Chapter 2, ammonia is one of the contaminants from the coke plant. The average concentration in Michel Creek varied from 0.017 mg/l upstream (site 46) to 0.054 mg/l downstream (site 25). On February 12 and March 26, 1974 the ammonia concentrations were 0.20 mg/l and 0.11 mg/l at the downstream site. At a pH of 8.5 and a temperature of 10°C, the un-ionised ammonia content of the water would be approximately 5% of the ammonia concentration[60]. Aquatic life is sensitive to un-ionised ammonia which should not exceed a concentration of 0.02 mg/l to provide adequate protection[48]. The un-ionised ammonia concentration in Michel Creek, although at times significant, has not exceeded the recommended maximum value.

More data are required on turbidity and suspended solids on upper Michel Creek to determine the effects of the mining operations in these areas. We recommend that sampling for one year be carried out at the following stations on Michel Creek:

Site 184:	On Michel Creek, upstream from Open Cut Creek.
New Site:	On Open Cut Creek
:	On Michel Creek, downstream from Open Cut Creek.
Site 185:	On Michel Creek, upstream from the discharge from Coleman Collieries.
Site 186:	On Michel Creek, downstream from the discharge from Coleman Collieries.
New Site:	The discharge from Coleman Collieries.
Site 46:	On Michel Creek, upstream from the coke plant.
Site 25:	On Michel Creek, downstream from the coke plant.

The samples should be analyzed for the following parameters:

Suspended solids
Dissolved solids
Specific conductance
Turbidity
Total phosphorus
pH

Total nitrogen
Total organic carbon
Total alkalinity

Samples should be checked at least once for heavy metal content. At sites 46 and 25 samples should also be analysed for phenol, ammonia and cyanide.

In addition to the water samples we recommend that sediment samples be taken at sites 184, 185, 186, in Open Cut Creek, in Michel Creek downstream from Open Cut Creek, and from the Coleman Collieries discharge. The samples should be analysed for particle size distribution and organic carbon content. The data will be useful in evaluating the impact of sediments on aquatic life.

Preferred sampling times are:

Mid-January
Mid-April
First week of June
First week of July
First week of August
Mid-October

4.6 The Elk River From Michel Creek to Lake Koocanusa

4.6.1 Presentation of Data

From the confluence with Michel Creek, north of Sparwood, the Elk River flows south 58 miles to Lake Koocanusa. The activity in this section of the river basin is mainly agriculture and forestry. The river receives discharges of treated sewage at Fernie and Sparwood. The Coal Creek tributary drains an area of old logging and mining activity. The Wigwam River drains an active logging area.

The location of Pollution Control Branch sampling sites is shown on Figure 2-12. The sites are described as follows:

Site 103: On the Elk River at Sparwood, 100 feet upstream from the sewage treatment plant outfall.

Site 102: On the Elk River approximately five miles downstream from Sparwood.

Site 24: On the Elk River at Hosmer.

Site 113: On the Elk River two miles downstream from Fernie.

Site 16: On the Elk River between Elko and the confluence with the Kootenay River.

Sites 115 and 116: On Coal Creek upstream and downstream from the Fernie garbage dump.

Site 114: On a tributary to Coal Creek near the Fernie garbage dump.

The data from these sites are summarized in Tables 2-30, 2-31.

4.6.2 Discussion and Recommendations

As in other sections of the Elk River, the most pronounced changes in water quality occurred during spring runoff. Parameters related to soil-water contact, such as hardness, alkalinity, dissolved solids and specific conductance, decreased in the spring. Parameters related to soil movement such as suspended solids, turbidity, phosphorus and iron, increased in the spring.

Generally, the water quality of this stretch of the Elk River and its tributaries was good. Parameters indicating water quality deterioration at certain points are discussed below:

Suspended Solids and Turbidity

Suspended solids and turbidity were high at Hosmer (site 24) in the spring of 1972 (600 mg/1 and 84 JTU respectively). Organic nitrogen, dissolved iron and total phosphorus also tended to be higher at Hosmer than at other sites in this lower stretch of the Elk River. Reasons for the higher values at this point are not known and will require further investigation.

Phenols

Phenol concentrations in the Elk River at Sparwood have increased at certain times from a background level of less than 0.002 mg/l to 0.02 mg/l, when the corresponding concentration in Michel Creek was 0.100 mg/l. The coking plant on Michel Creek is believed to be the source of phenols, as discussed in Section 4.5.2. The data suggest that the coking plant is at times having a significant effect on the Elk River at Sparwood, which could limit the use of the water and affect aquatic life.

Ammonia

High concentrations of ammonia in Michel Creek also affected the Elk River at Sparwood. In February 1974 recorded ammonia concentrations were 0.200 mg/l in Michel Creek and 0.100 mg/l in the Elk River at Sparwood. These concentrations, although significant, should not affect aquatic life or water use, as discussed in Section 4.5.2.

Fecal Coliform

At site 103, 13 samples were taken between November 1973 and June 1974. The median coliform count was 17 MPN/100 ml indicating pollution presumably from domestic waste. Since the Elk River upstream from site 103 showed low fecal coliform counts, and site 103 is upstream from the Sparwood treated sewage discharge, we assume the coliforms originated from Michel Creek. There were no data directly from Michel Creek to confirm the source of coliform.

Fecal coliform data at site 102, downstream from the Sparwood sewage treatment plant, showed higher values than the upstream site in 1973. Values ranged from 2 to 920 with an average of 300 from 5 samples during the year. In 1974 values were less than 10 MPN/100 ml indicating perhaps that more effective chlorination of the effluent was taking place.

To confirm our findings, and to complement the monitoring program proposed for other stretches of the Elk River, we recommend that one year's sampling be carried out at the following sites:

Sites 103, 102, 24, 116, 16 and at a new site on the Elk River upstream from Fernie.

The samples should be analysed for the following:

Alkalinity
Organic carbon
Fecal coliform
Total nitrogen
pH
Total phosphorus
Suspended solids
Dissolved solids
Specific conductance
Turbidity

In addition, samples at sites 102 and 103 around the Sparwood sewage treatment plant, should be analysed for COD, BOD and residual chlorine.

4.7 Summary of Recommendations

The location of recommended sampling sites for Phase II of the study is shown in Figures 2-13 and 2-14. A summary of parameters to be measured at these sites is given in Table 2-32. Not all parameters will necessarily be measured each time the site is sampled. For example, if heavy metal concentrations are not significant at certain sites after one or two results, analyses for heavy metals will be discontinued. Certain parameters may be added depending on results and visual appraisal of the sites. Similarly, certain sites may be dropped or added as results of the field study are evaluated. Preferred sampling frequency for both water and sediment samples is:

Mid-January
Mid-April
First week in June

First week in July
First week in August
Mid-October

In any area which is to be explored or mined, a monitoring program should be carried out to characterise water quality before intensive development takes place. Results from such a program will be useful in planning development in a way that will minimize effects on water quality.

5. AQUATIC BIOLOGY

5.1 Presentation of the Data

The anticipated increase in mining activities and the proposed diversion of the Elk River between Cadorna and Bleasdell Creeks (Chapter 2) have resulted in several biological studies of the region. There are therefore some benthic invertebrate, fisheries and periphyton data available for the Elk River system.

Benthic invertebrates have been sampled as part of five studies carried out by Crozier[61], Hooton[20], Bull et al[62], B.C. Research[63], and the Pollution Control Branch in a post impoundment study of the Libby Dam[64]. All of the samples for which data are presented were collected in Chris Bull rock baskets[65]. Other samplers were used but these were either for comparative purposes or preliminary work and the results are not included.

The five studies included 15 sampling stations which extended from the upper Elk River (area of the proposed diversion) to just upstream of the confluence with the Kootenay River. Several stations were also located on tributaries close to Fording Coal Ltd. and Kaiser Resources Ltd. (Figures 2-15 and 2-16). Unfortunately, these stations do not correspond to water quality stations. Representatives of the invertebrate orders Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies) and Diptera (true flies) were found in all of the studies but not at each station (Table 2-33).

Fisheries data were obtained from creel censuses carried out by the Fish and Wildlife Branch in the winter of 1966[66], and the summer of 1971[20]. In 1966 only the area south of Morrissey was surveyed, but in 1971 the census included the areas from Aldridge Creek to Tobermory Creek (upper Elk) and from Fernie to Michel Creek (lower Elk). Mountain white fish (*Prosopium williamsoni*) predominated in the winter catches with an angler catch effort of 1.5 fish/hour/angler. In the summer it was primarily a cutthroat trout

(*Salmo clarki*) fishery with some Dolly Varden (*Salvelinus malma*), brook trout (*Salvelinus fontinalis*) and mountain whitefish being caught. The estimated catch effort for July was 2.26 and 0.85 fish/hour/angler and for August 1.29 and 0.64 fish/hour/angler for the upper and lower Elk respectively. The stomach contents of over 100 fish in 1971 and 1972 were examined[20,62]. Representatives of the orders Ephemeroptera, Plecoptera, some Coleoptera (water beetles) and Hymenoptera (aquatic wasps) and a few Diptera were found.

Visual stream habitat inventories for ten tributaries of the Elk and Fording Rivers were also carried out[20]. These were Boivin, Bingay, Forsyth, Quarris, Aldridge, Bleasdell, Cadorna, Tobermory, Line and Todhunter Creeks. Except for Boivin and Aldridge Creeks, abundant spawning and rearing areas were recorded.

As part of the Libby post impoundment study[64], the Pollution Control Branch collected periphyton on glass slides attached to Chris Bull samplers at station 16 (Figure 2-16). The relative amounts of the species present are summarized in Table 2-34.

5.2 Discussion of the Data

Benthic invertebrates have become a popular group to monitor in aquatic studies because they are relatively sessile and different taxonomic groups are sensitive to water and substrate quality change in varying degrees. Also they depend to a large extent on periphyton and algae for food and they are a major fish food.

Quantitative comparisons amongst the five invertebrate studies (Table 2-33) are not possible due to differences in the mesh sizes of the nets used (only two of the sizes are known, Table 2-33), the sorting methods and the sample dates. The sample dates are important because emergence, and thus the relative numbers of mature and immature stages, varies amongst different groups at different times. This fact was apparent, particularly at station 16, where there was a significant increase in the numbers of plecopterons and chironomids between May and November (Table 2-33).

Quantitative comparisons within the studies are also of limited value because only one or two samples were collected at many of the stations. Benthic invertebrates are not evenly distributed in the substrate and at least three samples should be taken to overcome the variability. However, significant quantitative differences were apparent at station D (in Harmer Creek) and station 2 (on the Elk River near Aldridge Creek) relative to the other stations of the respective studies.

Station 2 on the north part of the Elk River had fewer individuals than the other sites of the same study but the authors attributed this result to the natural substrate-type present. It was primarily bedrock which is not good invertebrate habitat.

At station D on Harmer Creek there was a decreased number of Ephemeroptera, Plecoptera, and Trichoptera and a large increase in the number of chironomids relative to the other stations of the same study (Table 2-33). Ephemeroptera, Plecoptera and Trichoptera are generally associated with clean-water areas, whereas chironomids are tolerant or semi-tolerant to organic pollutants or sedimentation. The Family Chiromidae are however a diverse group and different genera are found in a wide range of habitats. The large number of chironomids at station D corresponding to the decreased number of individuals in the other groups suggest the presence of high nutrient levels, low oxygen levels or increased sedimentation. Unfortunately there are no water or substrate chemistry data available to substantiate these suggestions. Station D was located approximately 300 feet from the large settling pond of Kaiser Resources Ltd. (section 2.2). It is therefore possible that drainage from the ponds contained nutrients, sediment or some other characteristic which contributed to the observed invertebrate population. Further work is required to ascertain whether the one sample station was a true indication of the invertebrate population in this area.

Qualitative comments concerning the orders of invertebrates found in the five studies can be made. The four orders of invertebrates represent from twelve[20] to fourteen[63] families. They are found in sufficient numbers at the sample stations (with the exception of D) to suggest that the mining activities on the Elk River were not adversely effecting the invertebrate populations. The Fording River data suggest a moderately productive invertebrate community[63], however, little can be said about the individual stations due to the limited number of samples. Coal mining had only been initiated one year before the study and as the mining has been continuing further work is required in the Fording River area.

Invertebrate biomass gives some indication of the productivity of an area and of potential fish food. It was not determined in any of the studies. However, the same orders of invertebrates were found in the stomachs of over 100 fish as were found in the substrate[20,62], and the 1966 and 1971 creel censuses showed an angling catch effort of 0.64 to 2.26 fish/hour/angler. These facts suggest that a successful resident fishery exists in the Elk River. Since these fish depend largely on the invertebrate populations for food we can deduce that, at least until 1971, the invertebrate biomass was sufficient to support the successful fishery.

The periphyton samples were taken only at station 16 (Figure 2-16) and thus no comparisons are possible. Two of the species found in most of the samples (Diatoma vulgare and Achnanthes minutissima) are known to be relatively tolerant to organic pollution but also occur in low to moderately productive undisturbed areas. This result and the relative abundance of species present appear to indicate that the periphyton community has not been drastically disturbed in the given area of the Elk River. These conclusions agree with the results of the invertebrate and fisheries data.

5.3 General Biological Effects of Suspended Solids and Turbidity

High levels of suspended solids can have a detrimental effect on aquatic life. Harmful concentrations and exposure times are, however, dependent on species and life-stage.

Peters[67] found 5, 39, 90 and 100 percent mortality of rainbow trout eggs in a stream with corresponding levels of suspended solids of 16 (8-67), 128 (59-363), 197 (69-486) and 318 (55-884) mg/l. He attributed the mortality to sedimentation and decreased intra-gravel oxygen. Alderdice and Wickett[68] noted that such mortalities were also due to the build up of metabolites (eg., CO_2) as a result of sedimentation and decreased flow through the settled matter. These effects are enhanced by small particle size of the suspended material.

Cutthroat trout are one of the major summer sports fishes in the Elk River Region and are also spring spawners. The increased levels of suspended solids below the mining operations during spring suggest that the cutthroat trout populations may be affected.

The suspended solids may also affect the fry and adult fishes. Herbert and Merkins[69] found that suspensions of kaolin and diatomaceous earth were harmful to rainbow trout at levels of 270 ppm. (Death occurred in as little as 10 days).

In some cases the gills of the respiratory epithelium were thickened and the lamella fused, possibly due to the abrasive action of the suspended materials. Gills damaged in this way would be less viable and more susceptible to disease. Carbon is a larger and coarser material than kaolin[70] and thus if coal dust is present in the river, the abrasive action may be more severe.

The influence of suspended solids on invertebrate populations is reviewed by Cordone and Kelley[71]. In general the harm is a result of settling of the suspended material and ruining of invertebrate habitats. Ephemeroptera, Plecoptera, and Trichoptera depend largely on rock surfaces and would be most severely effected. However, Hoak[72] found that inert deposits of 2 cm resulted in 50% mortality of more tolerant tubifex worms. Knowledge of the amount of sedimentation due to the high suspended solids levels is important.

The suspended solids decrease light penetration (increase turbidity) and thus decrease photosynthesis. This can effect periphyton growth and thus reduce the available fish and invertebtate food. The decreased light may also reduce visibility for fish and their ability to find food.

Duchrow and Everhart[70] found that the settleable solids and colour contributed greatest to turbidity. If coal dust is present and continues to be present in the mining areas, turbidity may increase. Some observations should be made to determine whether the turbidity is reducing periphyton growth.

5.4 Recommendations

The data available suggest that, at least until 1971, the Elk River supported a successful fishery, that the benthic invertebrates consituted a large part of the fish diet, and that the industries in the Elk River Valley were not having a detrimental effect on the invertebrate populations except possibly at station D (near Kaiser Resources Ltd. large settling pond). However, the last creel census was done in 1971 and the last major invertebrate sampling was undertaken in 1972. The data from the Fording River were insufficient to allow any definite conclusions to be made about the individual stations. Also the data were collected only one year after Fording Coal Ltd. commenced mining. No biological data are available from the vicinity of the municipal sewage treatment discharges. With these points in mind the following recommendations are made.

(a) The present condition of the aquatic populations in the Fording River should be assessed by a detailed study. The study should include benthic invertebrate and/or periphyton sampling, sediment particle-size distribution determinations and water chemistry analyses. Sample stations should be chosen to include areas upstream of Fording Coal Ltd. and downstream to the confluence with the Elk River. The invertebrates and/or periphyton and the sediment samples should be collected from the same areas and at least once during the summer. The water chemistry samples should be collected at the same time and place as well as the times and stations indicated in chapter 4. Relevant water chemistry parameters are suggested in chapter 4. The possibility of carrying out a creel census should be considered.

(b) A detailed aquatic study should be carried out on Michel Creek, Harmer Creek, and the Elk River in the vicinity of Kaiser Resources Ltd. The study should be similar to that described above for the Fording River.

(c) Some background data should be obtained from the vicinity of the proposed Elco Mining Ltd. operations.

(d) Pending initial water chemistry results, the possibility of collecting some benthic invertebrate and/or periphyton samples from the vicinity of the municipal waste discharges should be considered.

(e) A detailed stream habitat survey of the upper Elk River with emphasis on the coal licence area between Cadorna and Bleasdell Creeks, should be undertaken as a second priority. This survey should include mapping of fish spawning and rearing areas and documentation of the use of riparian habitat by wildlife.

BIBLIOGRAPHY

1. Canada Department of Transport, Meteorological Branch, Temperature and Precipitation Tables for British Columbia, Toronto, 1967.

2. Canada Land Inventory, ARDA, Agroclimatological Atlas of British Columbia, Map no. 18, Mean Annual Snowfall.

3. Canada Land Inventory, ARDA, Agroclimatological Atlas of British Columbia, Map no. 2 (mean January temperature), Map no. 4 (mean July temperature).

4. Canada Land Inventory, ARDA, Agroclimatological Atlas of British Columbia, Map no. 13, Average Frost-free Period.

5. Holland, S.S., Landforms of British Columbia, B.C. Dept. of Mines and Petroleum Resources, Bulletin no. 48, 1964.

6. B.C. Dept. of Mines and Petroleum Resources, Geology,Exploration and Mining in B.C., 1970, 1971, 1972, 1973.

7. Nichols, R.W., East Kootenay Study Area, Preliminary Appraisal of Water Resources, Water Investigations Branch, Water Resources Service March 1973.

8. Well cards, Groundwater Division, Water Investigations Branch, Water Resources Service, Victoria, B.C.

9. Dam Inspection Information, Power and Major Licences Division, Water Resources Service, Victoria, B.C.

10. Water Register, Fernie Water District, Michel, Fernie, Rock Creek and Tobacco Plains Precints, Water Rights Branch, Water Resources Service, Victoria, B.C.

11. Water Survey of Canada, Inland Waters Directorate, Dept. of the Environment, Ottawa, Surface Water Data, B.C., 1970, 1971, 1972, 1973.

12. Water Survey of Canada, Inland Waters Directorate, Dept. of the Environment, Ottawa, Historical Streamflow Summary to 1970, B.C.

13. Water Survey of Canada, Canada Inland Waters Directorate, Dept. of the Environment, Ottawa, Surface Water Data, Reference Index, 1972.

14. B.C. Dept. of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in B.C., June 1973.

15. Hawkins, W., B.C. Dept. of Economic Development, Personal Communications, November 7, 1974.

16. Coal Licences, East Kootenay Area, B.C. Dept. of Mines and Petroleum Resources, Victoria, B.C.

17. Canada Land Inventory, Land Capability Analysis, East Kootenay Area, 1970.

18. Canada Land Inventory, Land Capability for Recreation, Fernie 82 G, 1968.

19. Canada Land Inventory, Land Capability for Recreation, Kananaskis Lakes, 82 J, 1968.

20. Hooton, R., Andrusak, H., Bull, C.J., Elk River Report, Fish and Wildlife Branch, Dept. of Recreation and Conservation, Victoria, 1971.

21. Sinclair, D.C., Kootenay and Elk River Creel Census, Fish and Wildlife Branch, Dept. of Recreation and Conservation, Victoria, 1966.

22. Demarchi, R.A., A Survey of the Big Game Resources in the Coal Licence Area in the Upper Elk and Fording River Watersheds, Fish and Wildlife Branch, Dept. of Recreation and Conservation, Victoria, 1968.

23. Bull, C.J., Summertime Recreation in the Elk Valley, Fish and Wildlife Branch, Dept. of Recreation and Conservation, Victoria, 1972.

24. Demarchi, R.A., A General Wildlife Capability Inventory of Crows Nest Industries Ltd. Lands in the East Kootenay Region of B.C., Fish and Wildlife Branch, Dept. of Recreation and Conservation, Victoria, 1967.

25. Canada Land Inventory, Land Capability for Wildlife, Waterfowl, Fernie 82 G, 1970.

26. Canada Land Inventory, Land Capability for Wildlife, Waterfowl, Kananaskis Lakes, 82 J, 1971.

27. Application for Permit Respecting Reclamation Under Section 8 of the Coal Mines Regulation Act, Fording Coal Ltd., September 1969.

28. Fielder, T.M., Editor, Canadian Mines Handbook 1974-1975, The Northern Miner, Northern Miner Press Ltd., 1974.

29. Permit and Application files, Reclamation Branch, Department of Mines and Petroleum Resources, Victoria, B.C.

30. Pollution Control Branch File PR 1476, Victoria, B.C.

31. Allen, J.V.T., Duncan, D.W., Walden, C.C., Phase I Progress Report No. 2, Ecological Study, Fording River, Prepared for Cominco Ltd., B.C. Research Project Report No. 1325, 1970.

32. Geology, Exploration and Mining in B.C., 1970-73, B.C. Department of Mines and Petroleum Resources, 1974.

33. Allen, J.V., Errington, J.C., Shirgood, J.V., Galbraith, D.M., Coal Exploration Programs, Environmental Protection Reclamation, B.C. Research, August, 1973.

34. The Story of Our Coal Resources, Queen's Printer, Victoria, B.C.

35. Dick, J., Kaiser Resources Ltd., Crowsnest Mining Operation Reclamation Report 1973-1975, January 10, 1973.

36. The Impact on the Environment of Surface Mining in Alberta, 3 Volumes, Environmental Conservation Authority of Alberta, 1972.

37. McDonald, J.D., Dick, J., Reclamation Guidelines for Exploration, B.C. Department of Mines and Petroleum Resources, 1973.

38. Permit, Application and Area Files, Pollution Control Branch, Victoria and Nelson.

39. Phillips, Barratt, Hillier, Jones and Partners, Report on the Elkview Preparation Plant Waste Disposal Area, Prepared for Kaiser Resources Ltd., Natal, B.C., December, 1970.

40. Pollution Control Branch File PR 512, Correspondence dated March 19, 1973.

41. Dick, J., Reclamation Plan 1969-1975, Kaiser Resources Ltd., Crowsnest Mining Operation, March 19, 1973.

42. Aerial Photographs, Kaiser Resources Ltd., Elkview Coal Preparation Plant, Sparwood, Project no. 67/72 (P/17), Photograph no. 5 BC(c) 79:68-140, Photographed July 30, 1972. Field Operations Division, Surveys and Mapping Branch, Lands Service, Victoria, B.C.

43. Pollution Control Branch File PR-512, District Office Report, June 26, 1973.

44. Aerial Photographs, Project no. 29/71, Map Sheet 82 G/10W, 82G/15W, Photographs nos. 1-32, Photographed September 17, 1971. Field Operations Division, Surveys and Mapping Branch, Lands Service, Victoria, B.C.

45. Kaiser Resources Ltd., Annual Report of Sampling and Monitoring Program in conjunction with the Elkview Preparation Plant, Permits PE-425-P and PR-512-P, July 1973.

46. Pollution Control Objectives for the Mining, Mine-Milling and Smelting Industries of B.C., Water Resources Service, Victoria, December, 1973.

47. Clarke, R., McV., A Summary of Toxicity Information for Major Effluent Components from Inorganic Chemical Industries, Resource Management Branch, Central Region, Environment Canada, Technical Report no. CEN/T-74-9, 1974.

48. Water Quality Criteria 1972, A Report of the Committee on Water Quality Criteria, Environmental Protection Agency, Washington D.C., 1972.

49. Barker, J.E., Thompson, R.J., Biological Oxidation of Coke Plant Wastes, American Iron and Steel Institute, 1971.

50. Letter from J.J. Crabb, Vice-President Exploration Crowsnest Industries Ltd., to J.D. McDonald, Dept. of Mines and Petroleum Resources, April 17, 1975.

51. Allen, J.V.F., Morrison, D.G., Report no. 2, Baseline Description of Elk River and its Tributaries, prepared for Emkay Canada Natural Resources Ltd., B.C. Research, March 1974.

52. Future Strip Mining in the Elk Valley with Special Reference to the Emkay Scurry Proposal, Inter-Sector Committee, B.C. Environment and Land Use Committee, 1974.

53. B.C. Dept. of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in B.C., June 1973.

54. Cote, D.J., Pollution Control Study for the City of Fernie, B.C., Underwood McLellan and Associates Ltd., 1969.

55. Canada Land Inventory, Land Capability for Agriculture, Fernie 82 G, Department of the Environment.

56. Okanagan Basin Study Agreement, Technical Supplement No. IV, 1974.

57. Statistics Canada, Agriculture, B.C. Catalogue, Vol. IV, Part 3, p. 96-711, 1971 Census of Canada.

58. Kunkle, S.H., Meiman, J.R., Water Quality of Mountain Watersheds, Hydrology Paper No. 21, Colorado State University, June 1967.

59. Recommended Water Quality Standards, Health Branch, B.C. Department of Health, 1969.

60. Trussell, R.P., The Percent Un-Ionised Ammonia in Aqueous Ammonia Solutions at Different pH Levels and Temperatures, J. Fisheries Research Board of Canada, Vol. 29, No. 10, 1972.

61. Crozier, R.J., Leinweber, L.R., Libby Dam Pre-Impoundment Study, Pollution Control Branch, Water Resources Service, Victoria, December, 1974.

62. Bull, C.J., Clark, T., Arber, J., Unpublished Data from a 1972 Survey of the Elk River Valley, Conducted by Fish and Wildlife Branch, Dept. of Recreation and Conservation, Victoria, B.C.

63. B.C. Research, Ecological Survey, Fording River Invertebrate Populations, Prepared for Cominco Ltd., 1973.

64. Libby Dam Post-Impoundment Study, Water Resources Service, Victoria, B.C.

65. Bull, C.J., A Bottom Fauna Sampler for Use in Stony Streams, Progressive Fish Culture, Vol. 30, p. 119-120, 1968.

66. Andrusak, H., Williams, J.D., Ellis, C.G., Elk River Winter Fishery, B.C. Fish and Wildlife Branch, Dept. of Recreation and Conservation, 1970.

67. Peters, J.C., The Effects of Stream Sedimentation on Trout Embryo Survival, Biological Problems in Water Pollution, U.S. Dept. of Health, Education and Welfare, Cincinnati, Ohio, 1965.

68. Alderdice, D.F., Wickett, W.P., A Note on the Response of Developing Chum Salmon Eggs to Free Carbon Dioxide in Solution, Journal of the Fisheries Research Board of Canada, Vol. 15, No. 5, p. 797-799, 1958.

69. Herbert, D.W.M., Merkins, J.C., The Effect of Suspended Mineral Solids on the Survival of Trout, Int. Journ. of Air and Water Pollution, Vol. 5, No. 1, p. 46-55, 1961.

70. Duchrow, R.M., Everhart, W.H., Turbidity Measurement, Trans. Amer. Fish Soc., Vol. 100, No. 4, p. 682-690. 1971.

71. Cordone, A.J., Kelley, D.W., The Influences of Inorganic Sediment on the Aquatic Life of Streams, Calif. Fish and Game, Vol. 47, No. 2, p. 189-228, 1961.

72. Hoak, R.D., Physical and Chemical Behaviour of Suspended Solids, Sewage and Industrial Wastes, Vol. 31, p. 1401-1408, 1959.

73. Water Resources Service Data Bank, Victoria, B.C.

74. National Water Quality Data Bank (NAQUADAT), Water Quality Branch, Inland Waters Directorate, Dept. of the Environment, Ottawa, Ontario.

75. Summary of Suspended Sediment Analysis for Year 1972, Fording River below Clode Creek (Station No. 8NK-21). Unpublished Data. Water Survey of Canada,Inland Waters Branch, Dept. of the Environment.

FIGURE 2-1
REGION 2

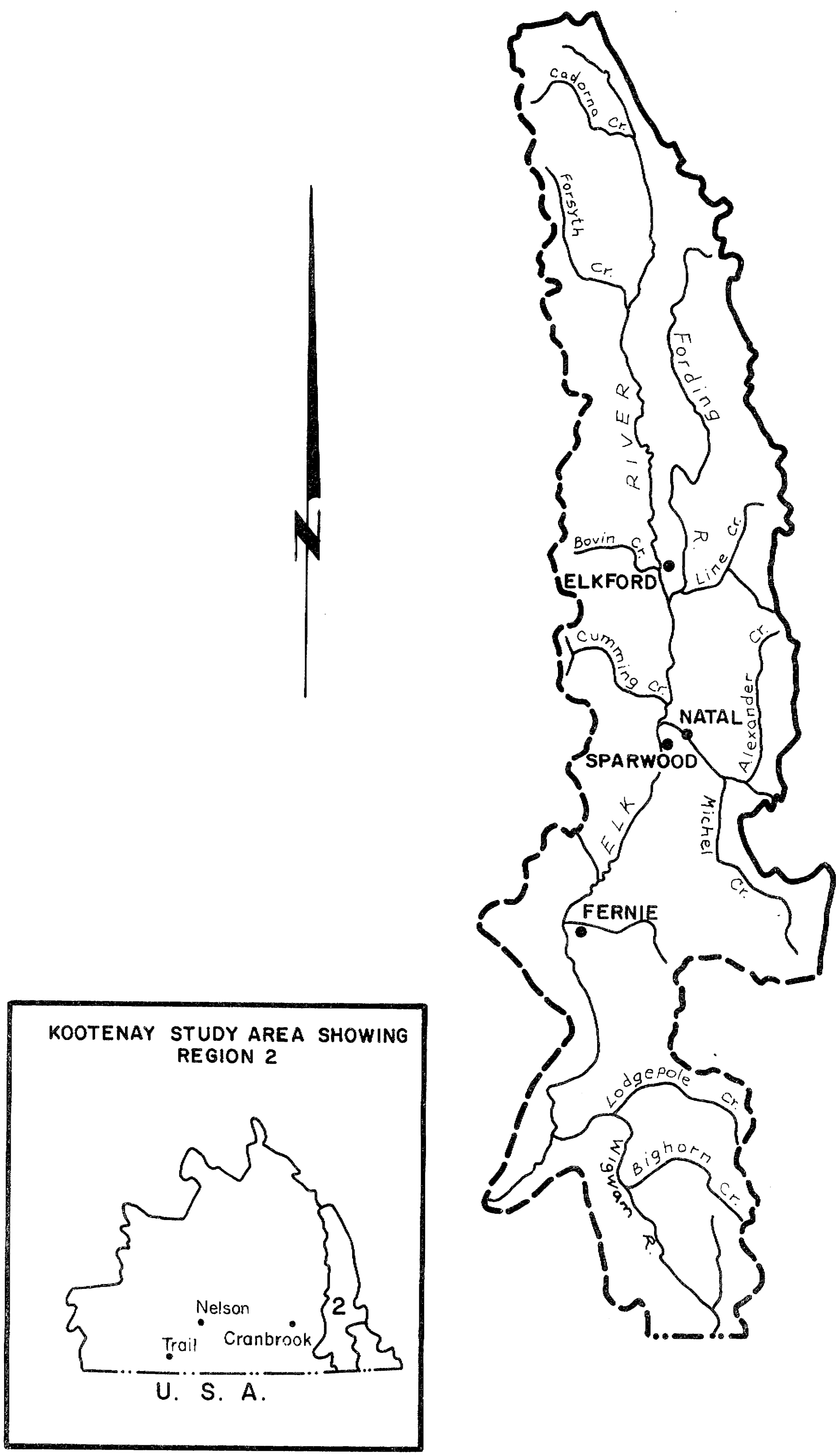


FIGURE 2-2
ELK RIVER BASIN
(NORTH SECTION)

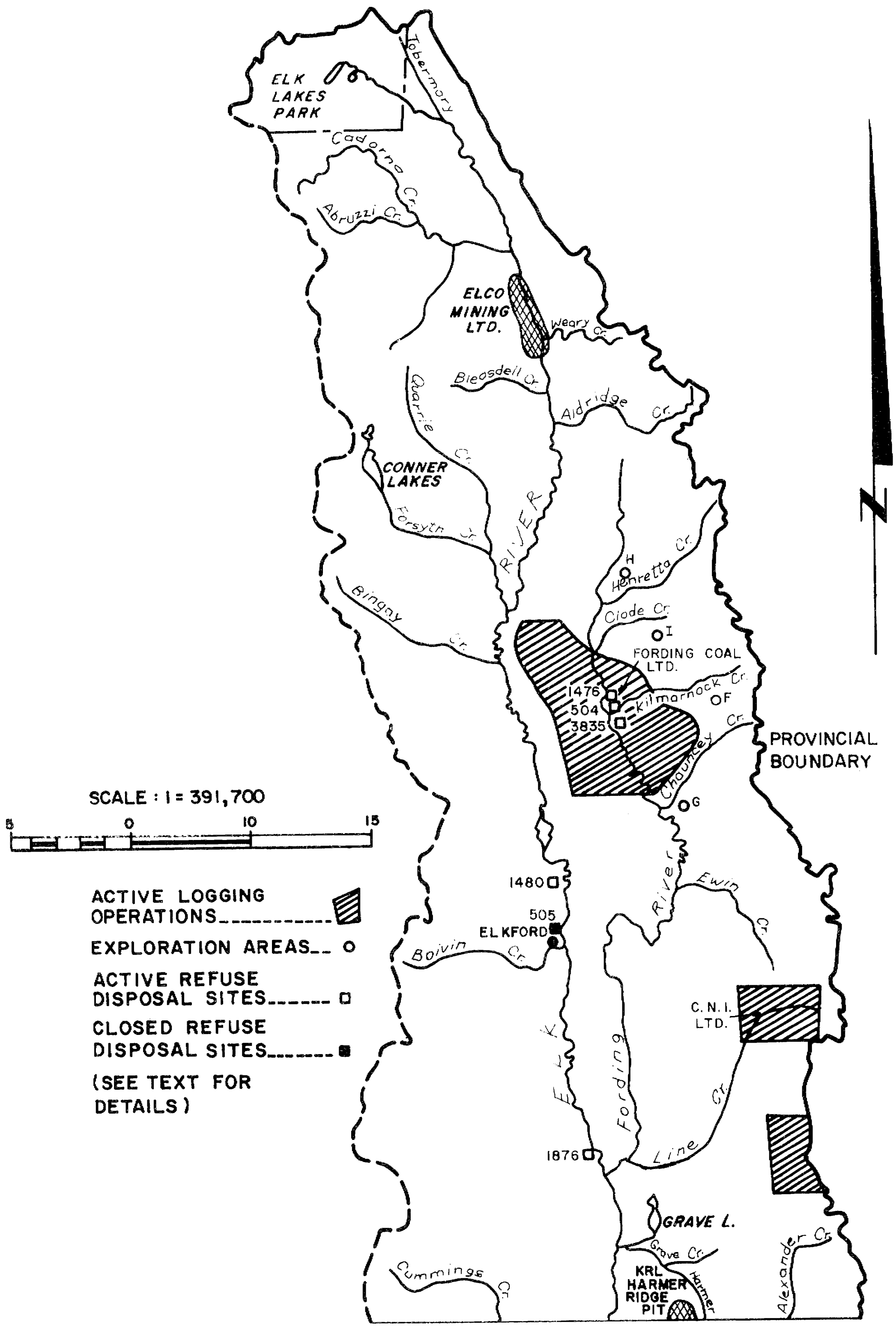


FIGURE 2-3
FORDING COAL LTD.
DIAGRAMMATIC VIEW OF MINING OPERATIONS AND DISCHARGE POINTS

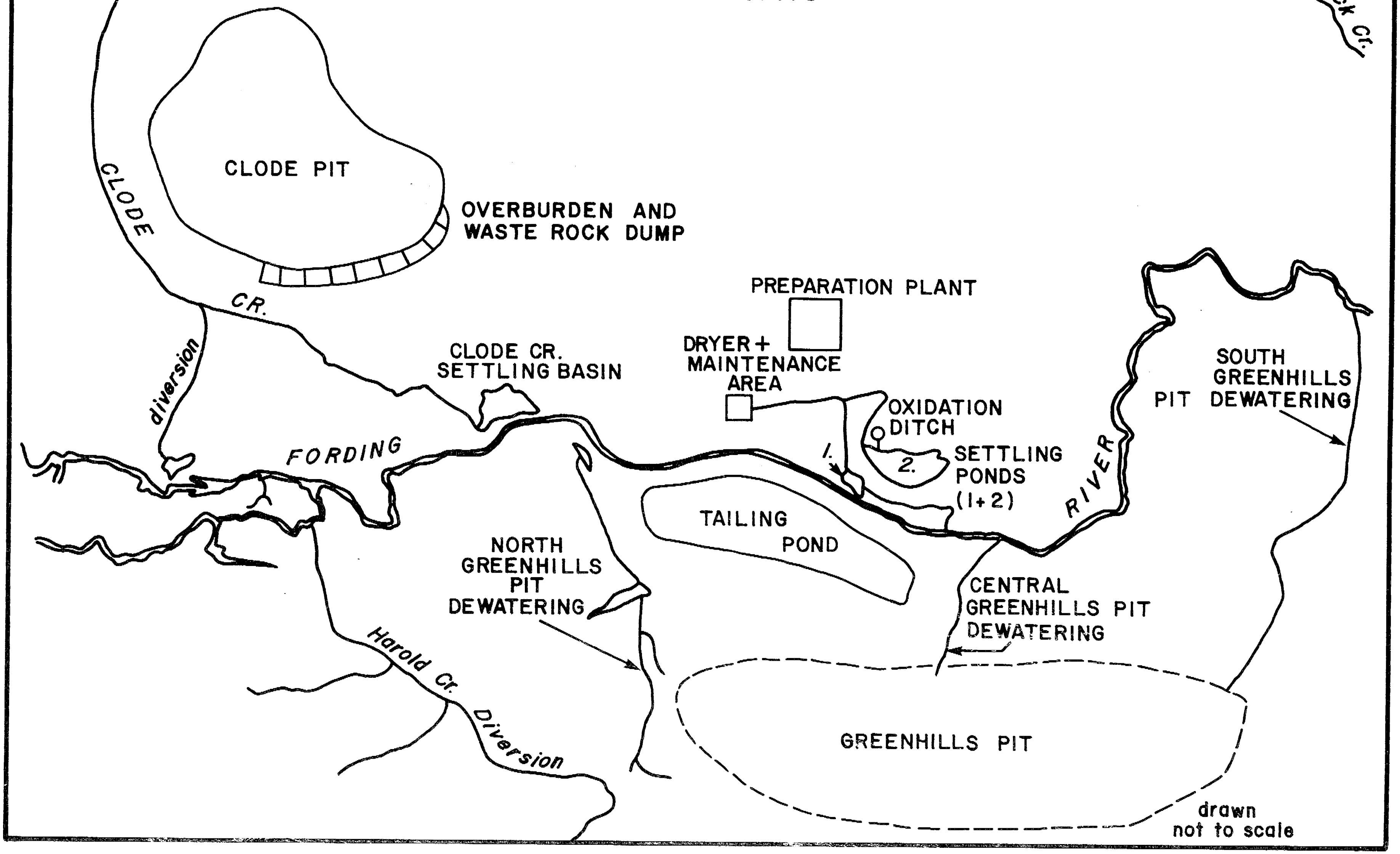


FIGURE 2-4
FORDING COAL LTD.
SIMPLIFIED FLOW DIAGRAM OF THE COAL PROCESSING PLANT

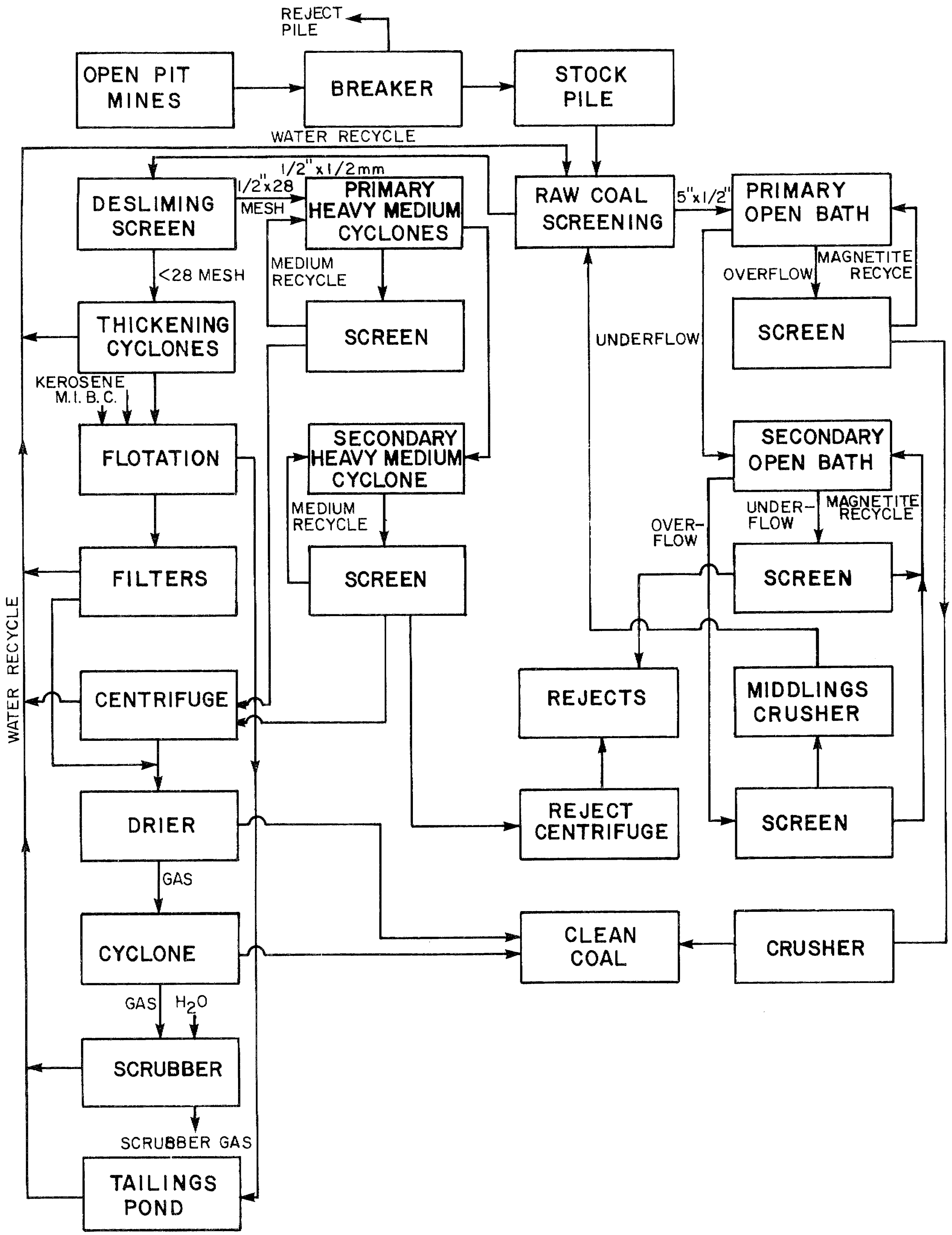
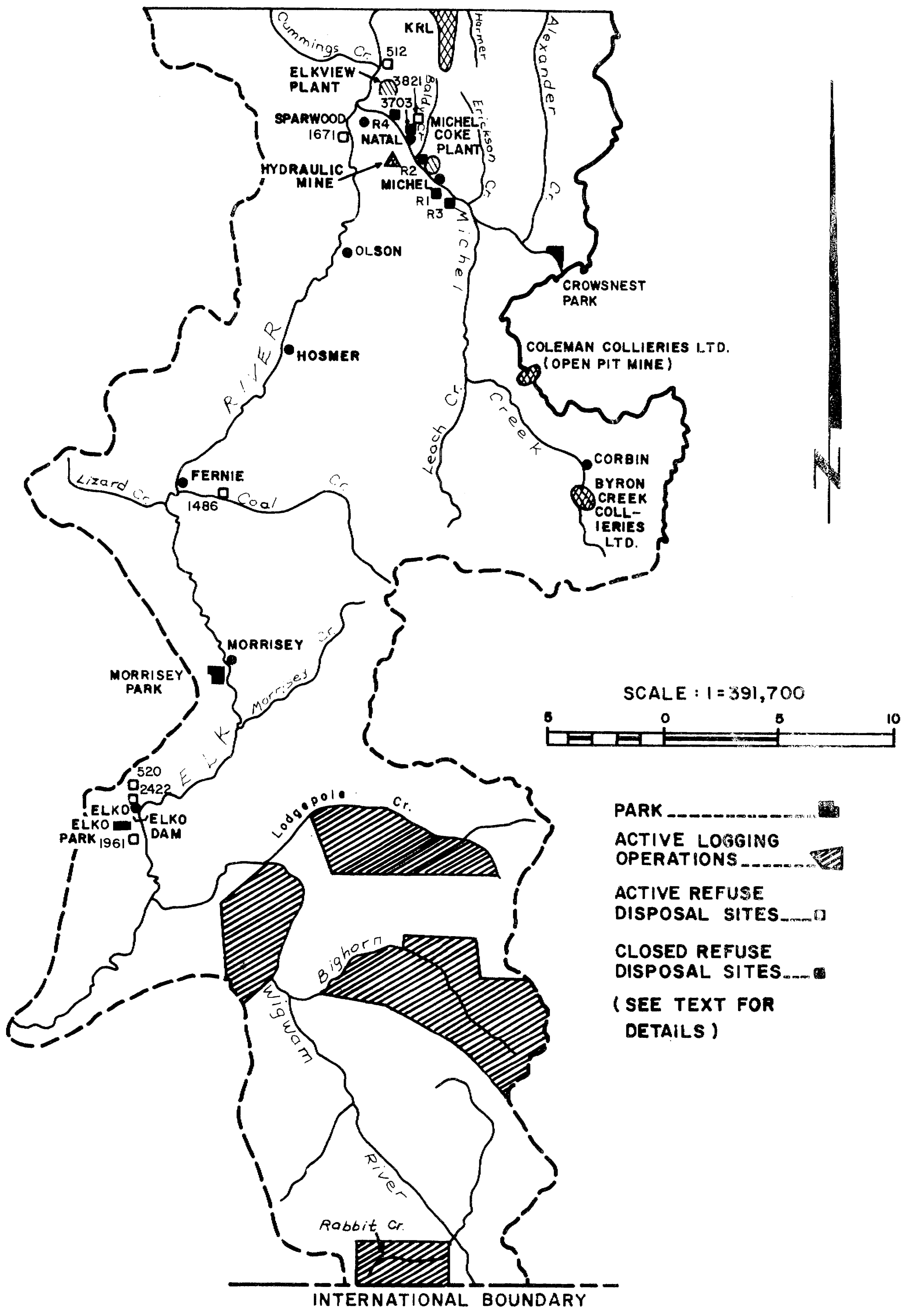


FIGURE 2-5

ELK RIVER BASIN

(SOUTH SECTION)



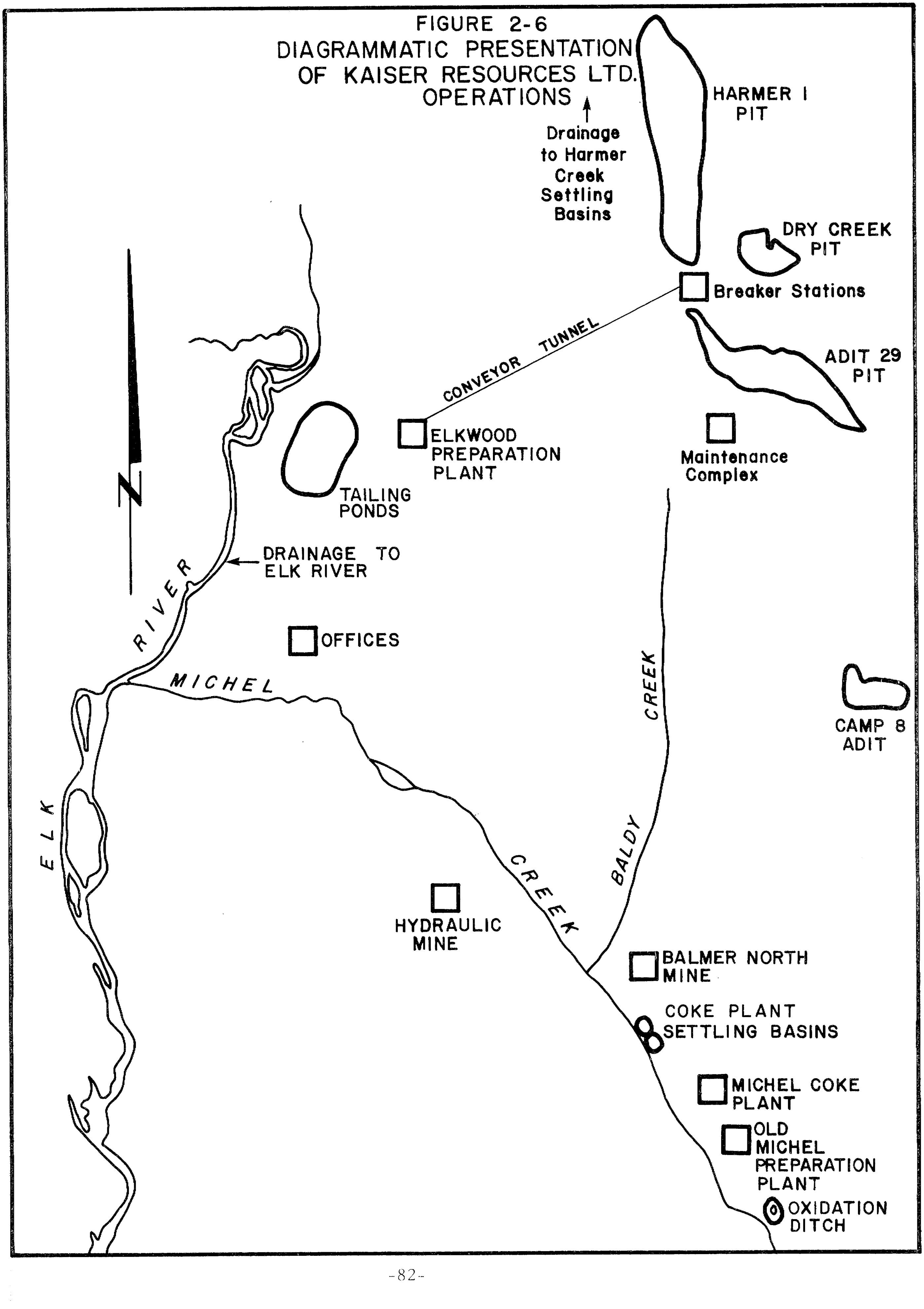


FIGURE 2-6
DIAGRAMMATIC PRESENTATION
OF KAISER RESOURCES LTD.
OPERATIONS
HARMER I
PIT
Drainage
to Harmer
Creek
Settling
Basins
DRY CREEK
PIT
Breaker Stations
CONVEYOR TUNNEL
ADIT 29
PIT
ELKWOOD
PREPARATION
PLANT
Maintenance
Complex
TAILING
PONDS
DRAINAGE TO
ELK RIVER
RIVER
OFFICES
MICHEL
CREEK
CAMP 8
ADIT
ELK
BALDY
CREEK
HYDRAULIC
MINE
BALMER NORTH
MINE
COKE PLANT
SETTLING BASINS
MICHEL COKE
PLANT
OLD
MICHEL
PREPARATION
PLANT
OXIDATION
DITCH

FIGURE 2-7

KAISER RESOURCES LTD.
SIMPLIFIED FLOW DIAGRAM OF THE ELKVIEW COAL PROCESSING PLANT

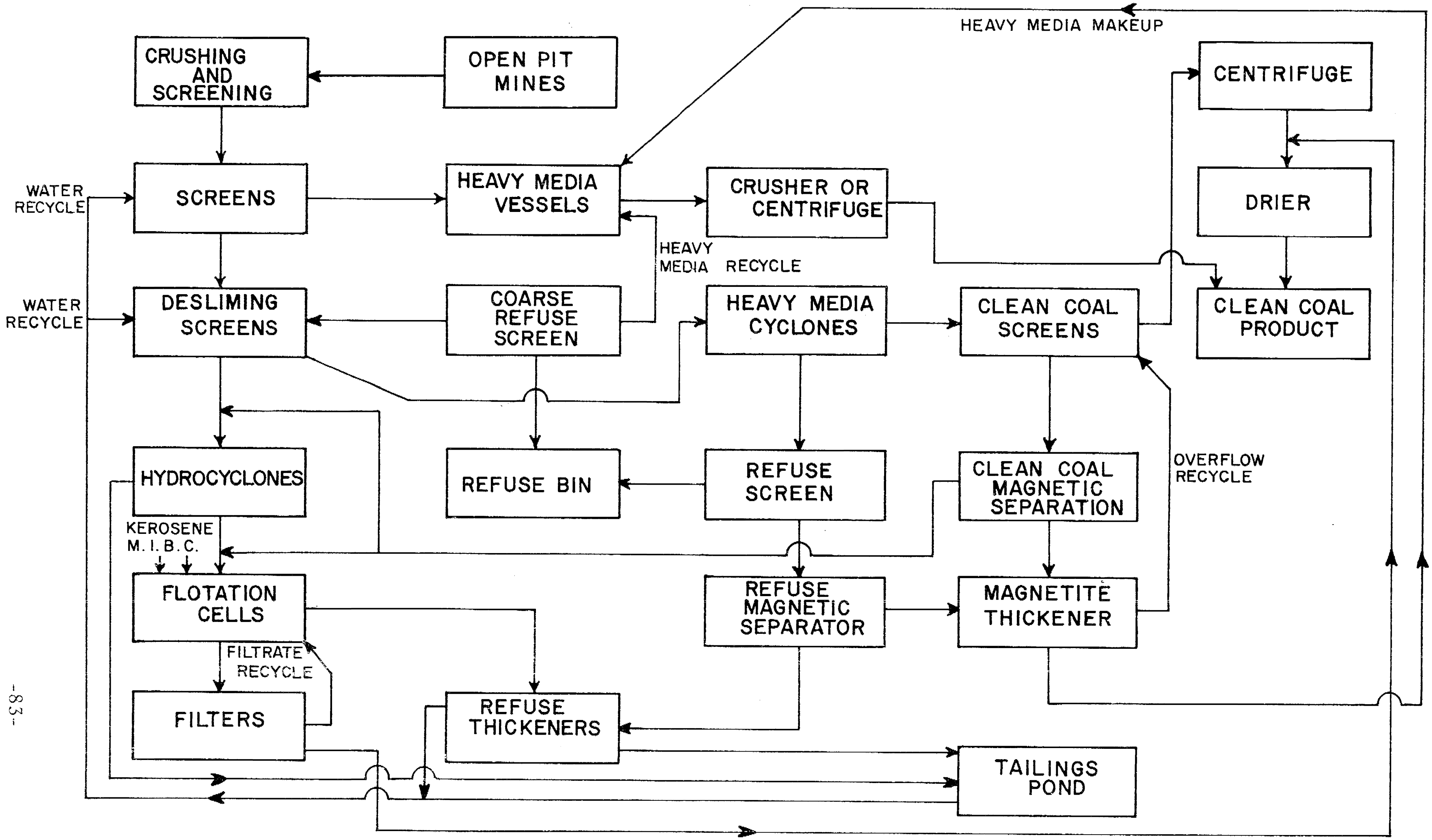


FIGURE 2-8
KAISER RESOURCES LTD.
SIMPLIFIED FLOW DIAGRAM OF THE MICHEL COKE PLANT

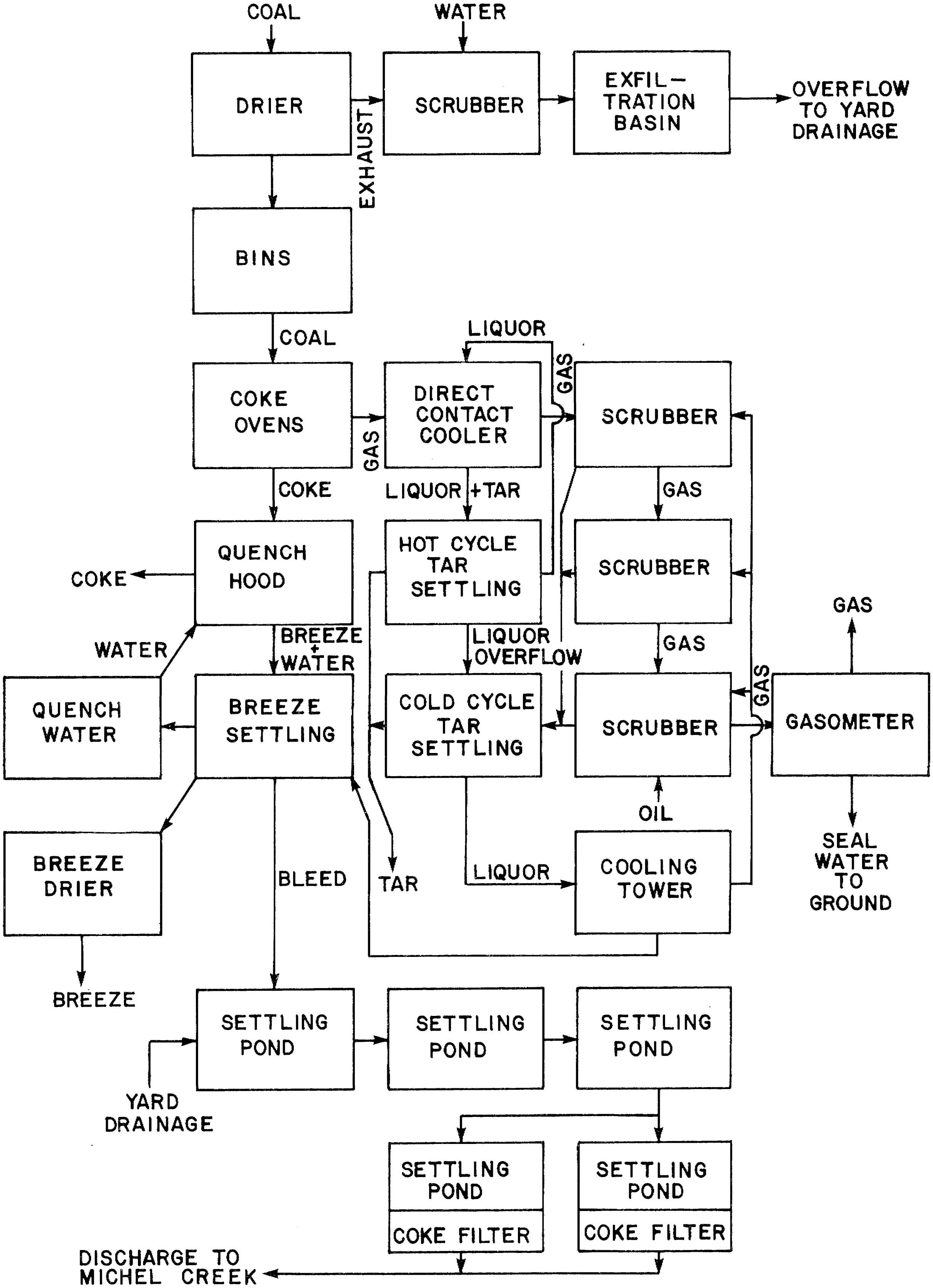


FIGURE 2-9

ELK RIVER BASIN

(NORTH SECTION)

LOCATION OF WATER SAMPLING SITES

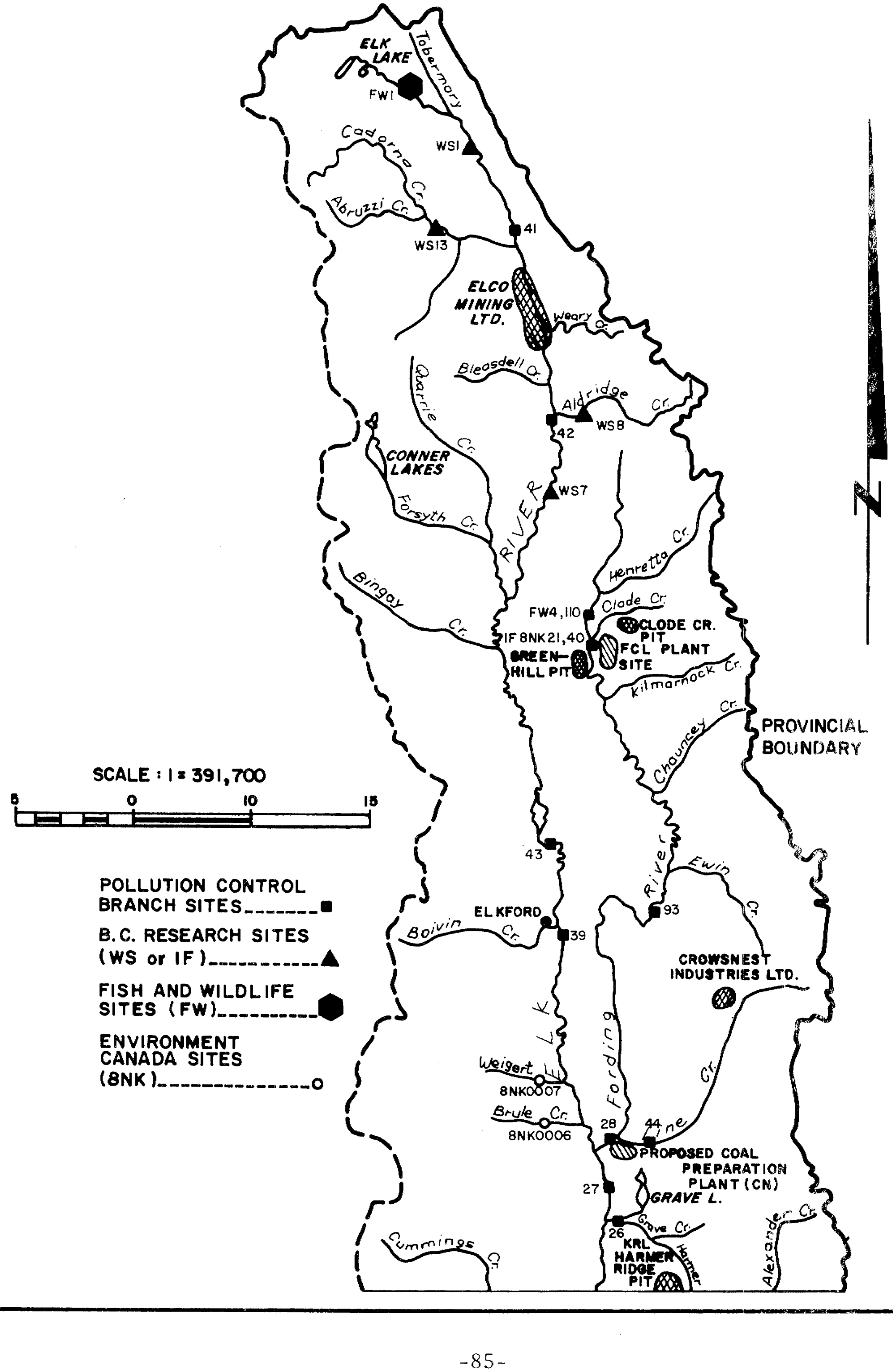


FIGURE 2-10

TURBIDITY ON THE ELK RIVER AROUND ELKFORD

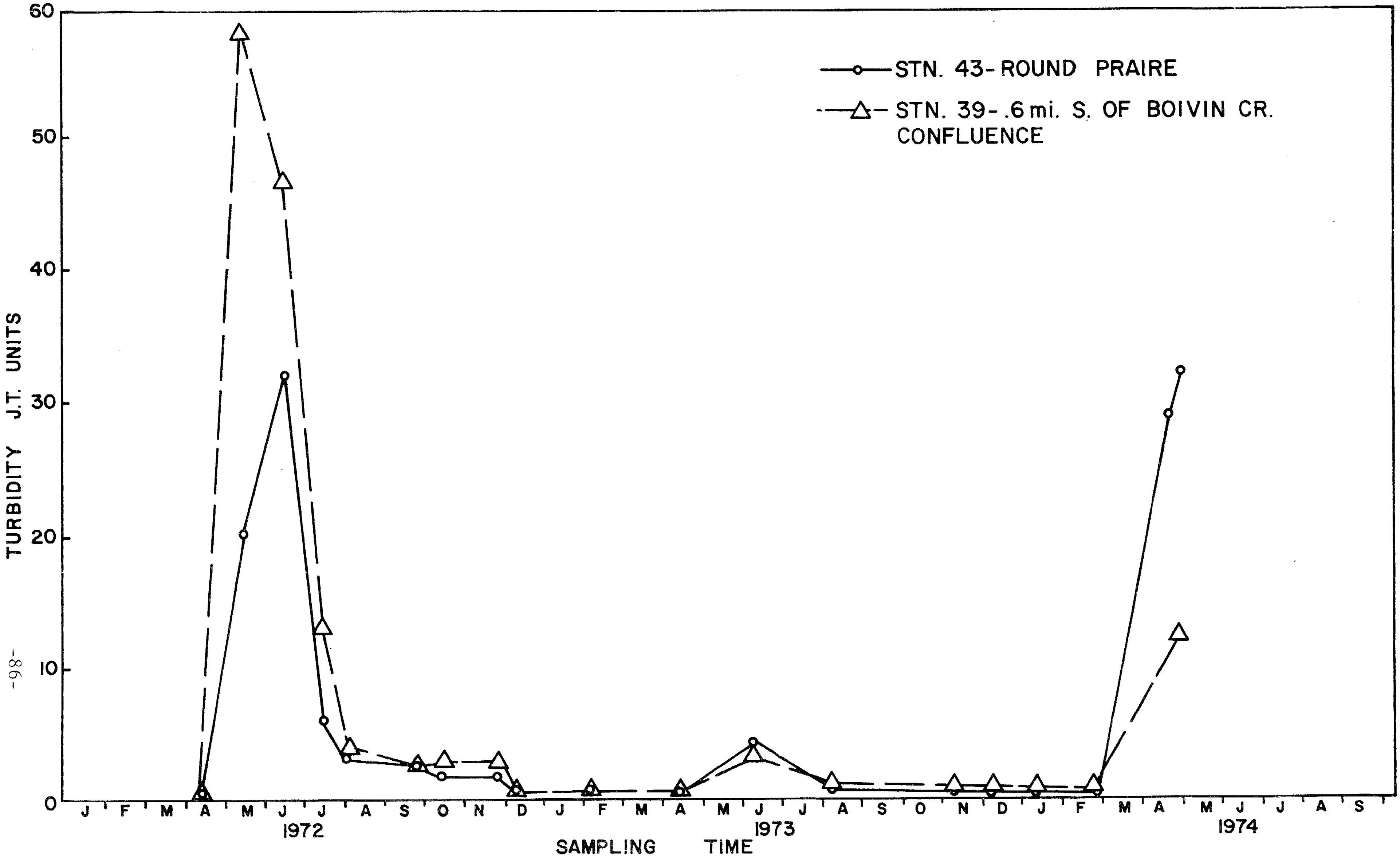


FIGURE 2-11

VARIATION OF TOTAL ORGANIC CARBON AROUND THE FORDING COAL PLANT SITE IN 1973

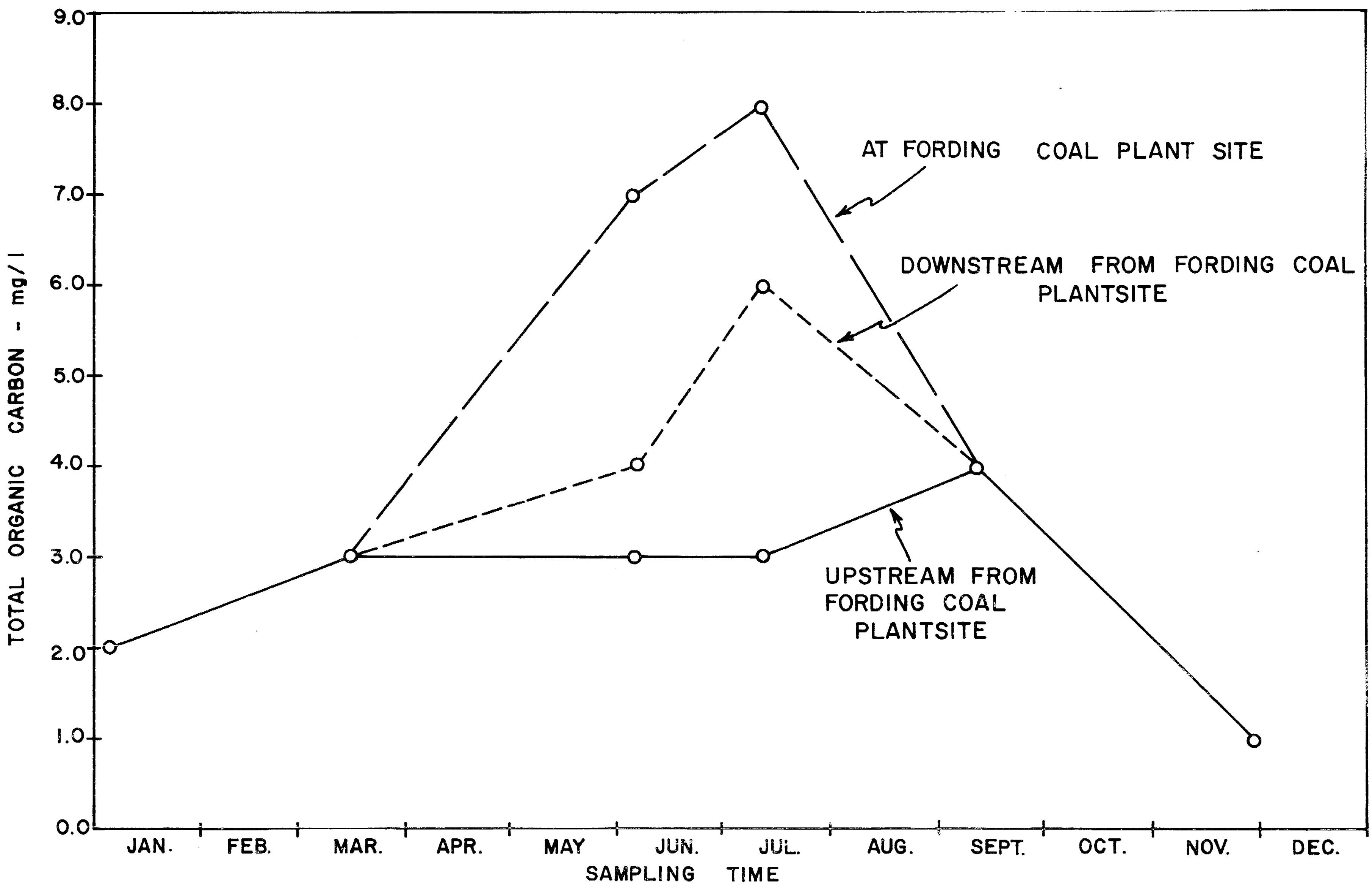


FIGURE 2-12

ELK RIVER BASIN
(SOUTH SECTION)
LOCATION OF WATER SAMPLING SITES

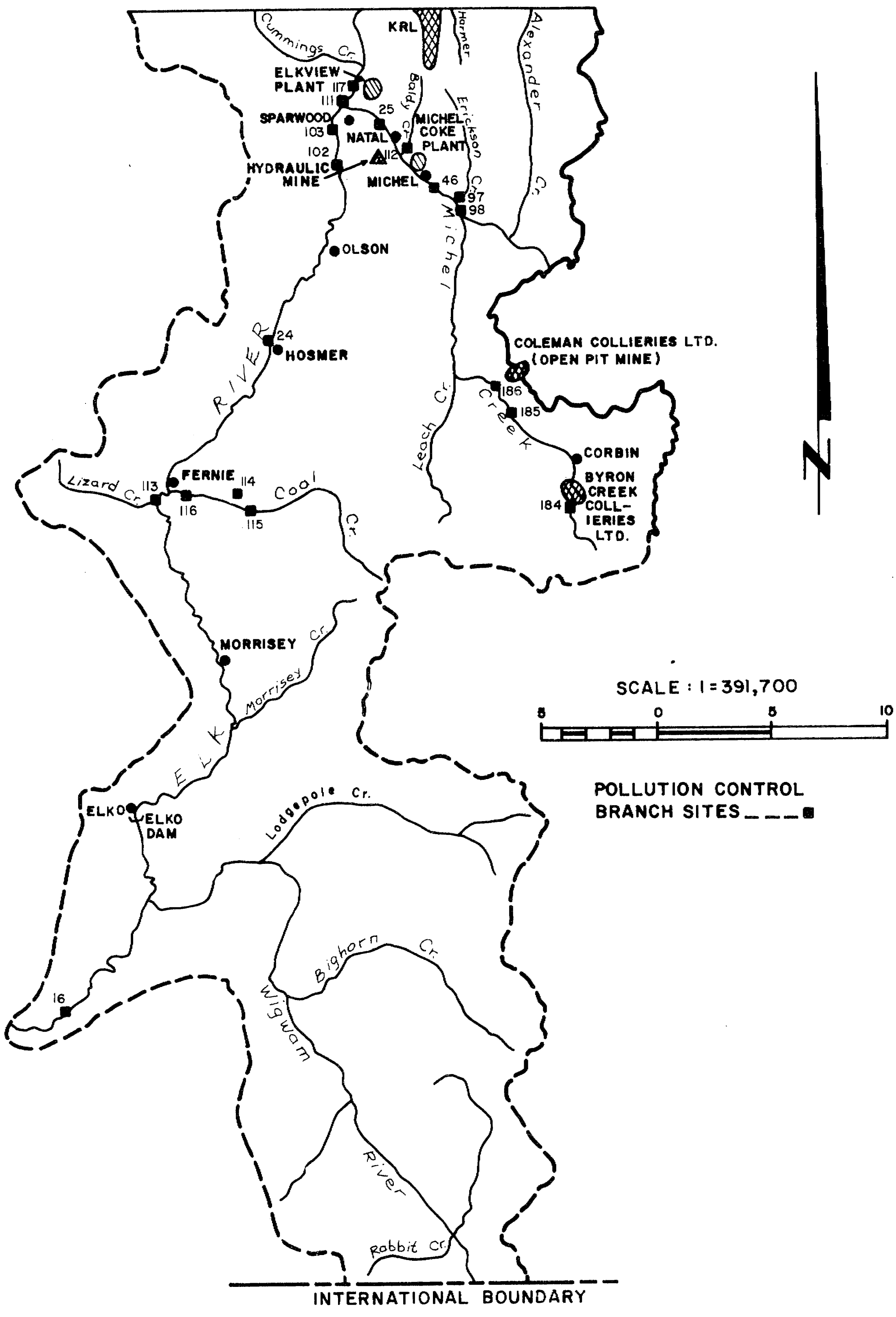


FIGURE 2—13
ELK RIVER BASIN
(NORTH SECTION)
RECOMMENDED WATER SAMPLING SITES

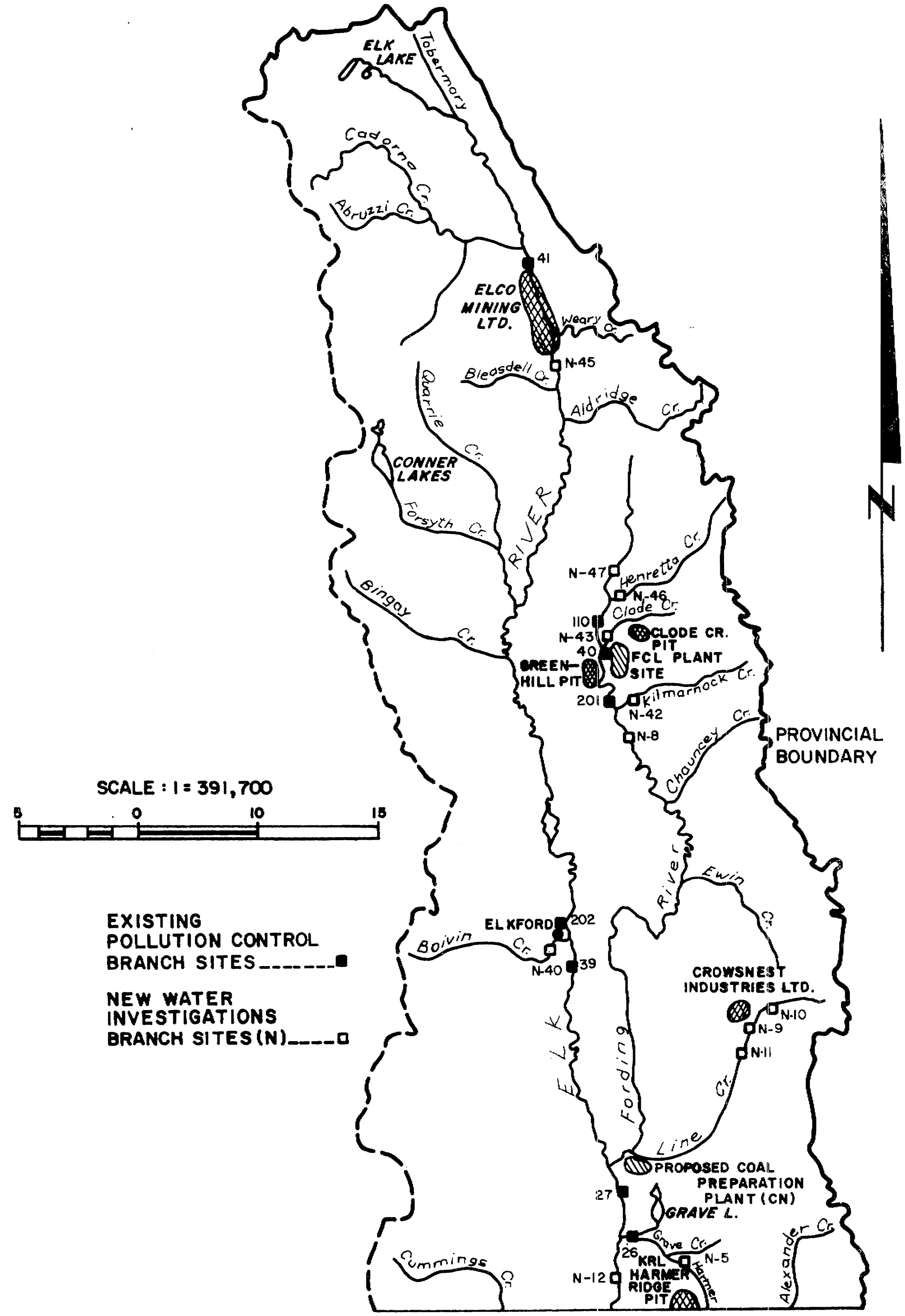


FIGURE 2-14

ELK RIVER BASIN

(SOUTH SECTION)

RECOMMENDED WATER SAMPLING SITES

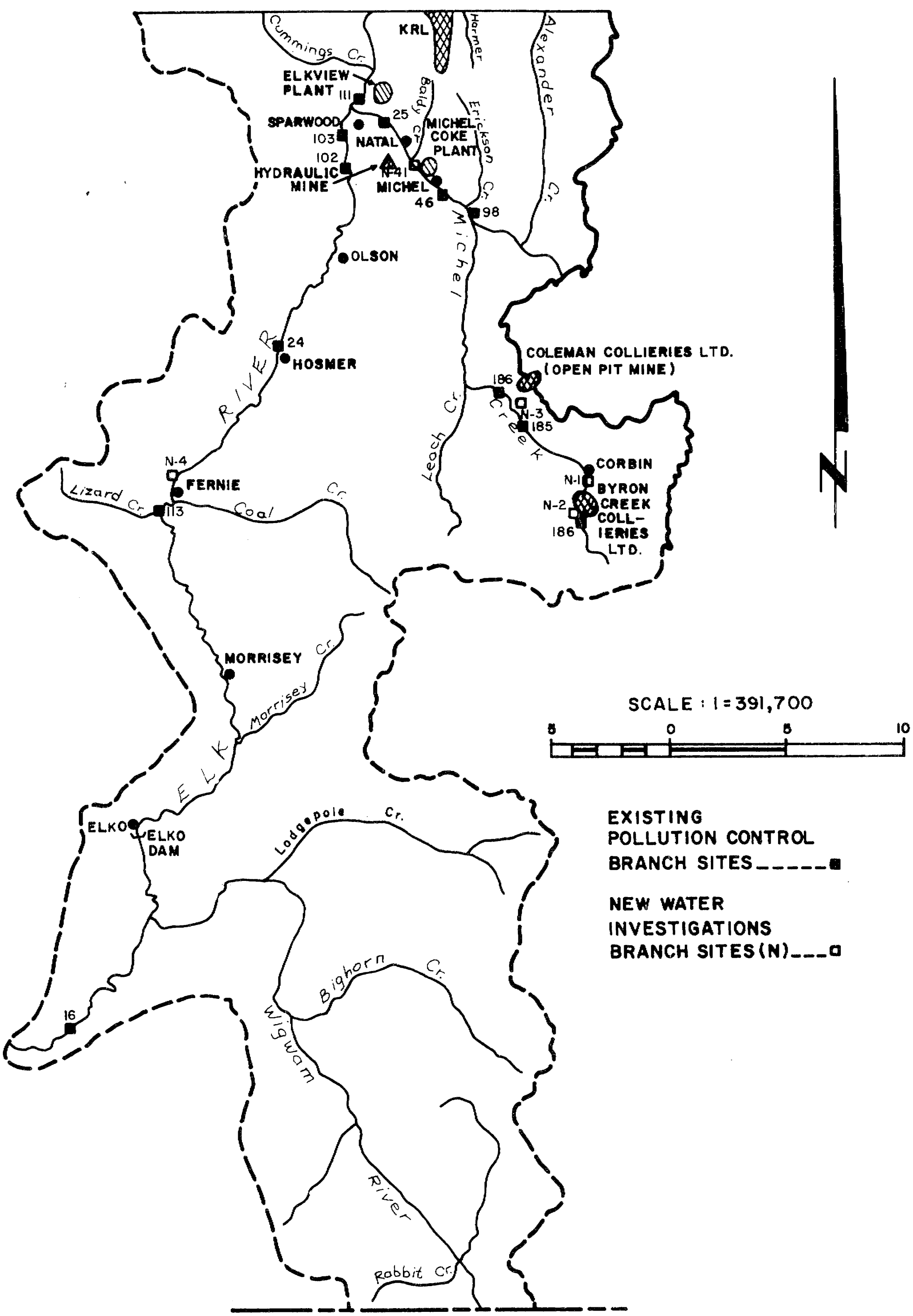


FIGURE 2–15

ELK RIVER BASIN

(NORTH SECTION)

LOCATION OF AQUATIC BIOLOGY SAMPLING SITES

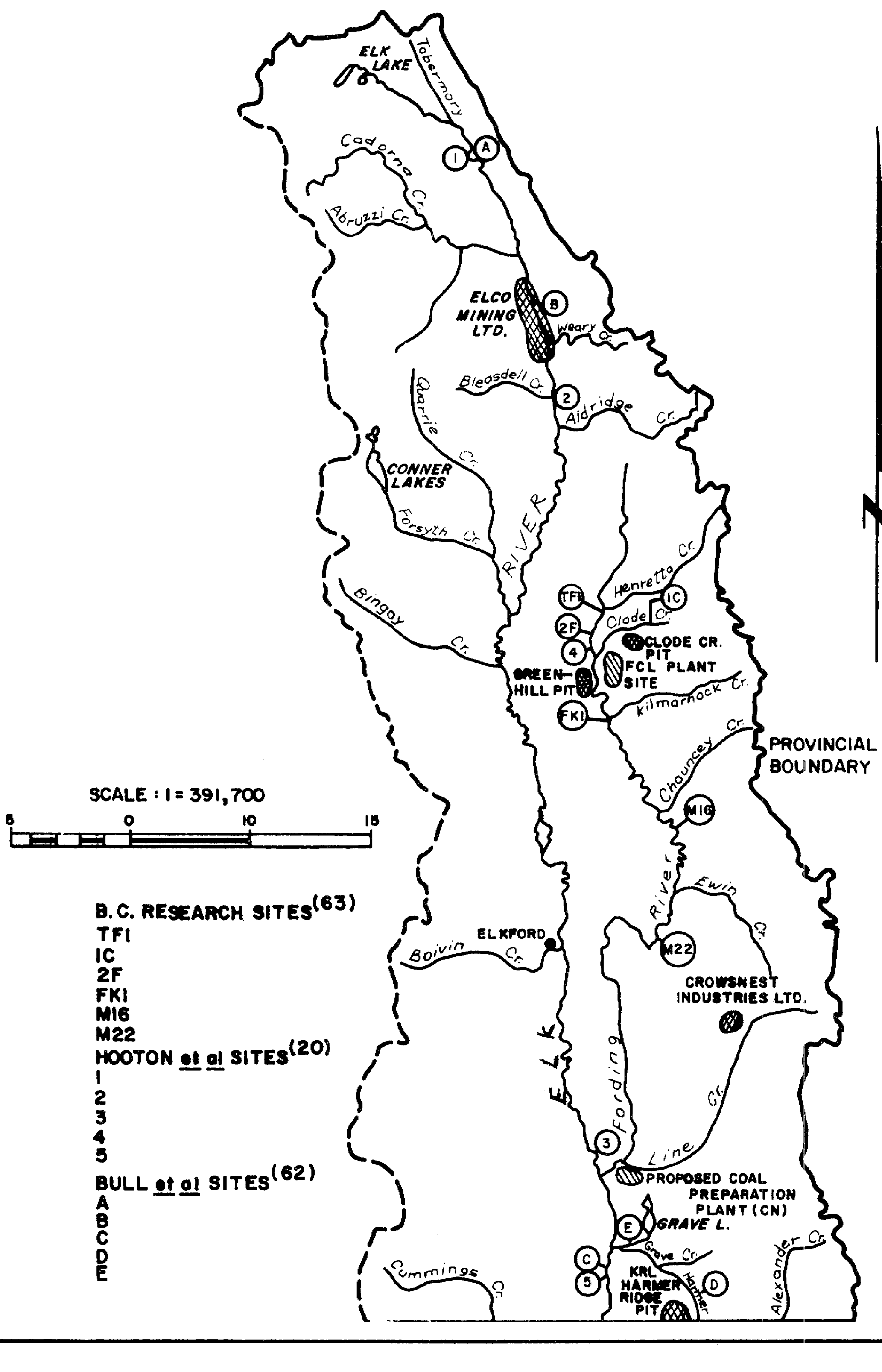


FIGURE 2-16
ELK RIVER BASIN
(SOUTH SECTION)
LOCATION OF AQUATIC BIOLOGY SAMPLING SITES

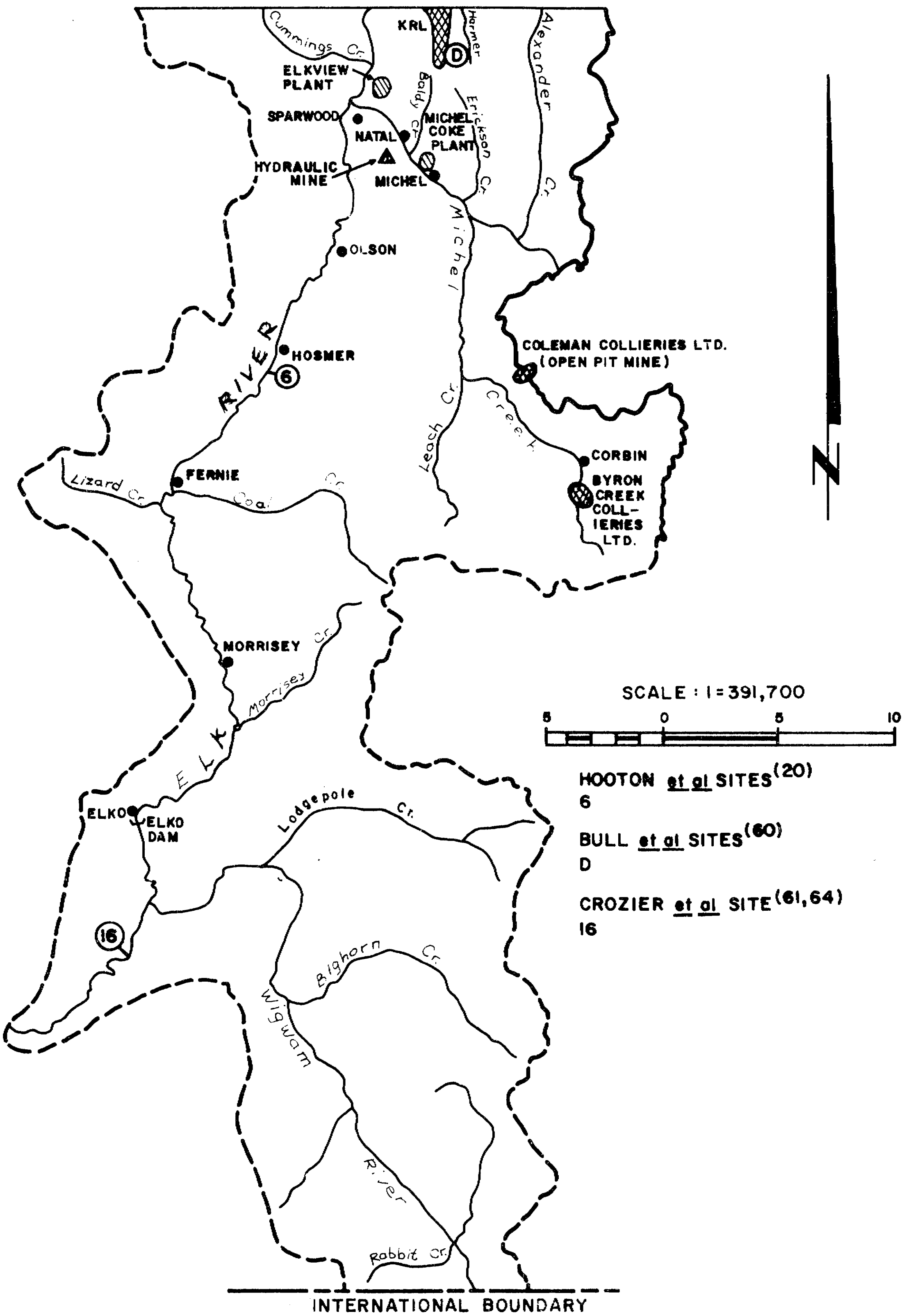


TABLE 2-1

SUMMARY OF FLOW RATES OF THE ELK RIVER AND ITS MAJOR TRIBUTARIES

Stream	Drainage Area* (mi^2)	Mean Annual* Discharge (CFS)	Maximum Daily Discharge Recorded (CFS)	Minimum Daily Discharge Recorded (CFS)
Elk R. near Natal	760	984	9900	88
Elk R. at Elko	1370	2100**	22600	66
Elk R. near the mouth	1720	2710	33500	206
Wigwam R. at the mouth	350	600**	--	--
Fording R. at the mouth	239	317	3630	35
Michel Cr. at the mouth	246	426	5210	37

* References 11, 12 & 13

** Estimated

TABLE 2-2

SUMMARY OF WATER LICENCES IN REGION 2

(FOR FOOTNOTES SEE LAST PAGE)

Source	No. of Licences	Quantity	Purpose	Owner	Location *	Comments
Aqueduct Cr.	1	40,000 GPD[+]	industrial waterworks	Kaiser Resources Ltd.	Pcl.35,D.D. 851631 of L.4588 & Pcl. 76 D.D. 11288 of L.4589	5 A.F. of storage capacity
Baldrey Cr.	5	30 AF ≠ 16,500 GPD	irrigation domestic	K.M. Kimecik G. Tymchuck	L. 2 of L's 3048 & 6394, D.L. 12751, L. 11707	12 acres irrigated
Baldy Cr.	1	90,000 GPD	waterworks	Kaiser Resources Ltd.	L. 4588, Pcl. A, Pl. 6342	assumed to be domestic and industrial
Bean Cr.	1	60 AF 500 GPD	irrigation domestic	W. Dicken	L. 5, R.P. 1141 of D.L. 11707	38.3 acres irrigated
Boardman Cr.	1	5000 GPD	domestic waterworks	Fernie Snow Valley Ski Ltd.	S. 1/2 of L. 4126	
Boivin Cr.	1	250,000 GPD	waterworks domestic	Village of Elkford	Village of Elkford	
Brooks Cr.	1	210 AF	irrigation	D.A. Beese	L. 1 of L. 363, pl. 4042	140 acres irrigated (assumed)
Callagham Cr.	1	10,000 GPD	domestic waterworks	Palmhill Ventures Ltd.	Blk. A of L. 7340, Pl. 1656 (Elko)	
Cossarini Cr.	1	27.75 AF 500 GPD	irrigation domestic	Kaiser Resources Ltd.	D.L. 4588 Pcl. no. 12, R.P. 1358	14 acre irrigated
Cummings Cr.	1	18,000 GPD	industrial	Elk Valley Trailer Courts Ltd.	L. 1 of L's 9488, 7781 & 8525, pl. 7704	

TABLE 2-2 Continued

SUMMARY OF WATER LICENCES IN REGION 2

Source	No. of Licences	Quantity	Purpose	Owner	Location*	Comments
Dalzell Cr.	2	225 AF 7000 GPD	irrigation domestic		L. 4144, L. 3049	150 acres irrigated
Elk River	1	10,000 GPD 1.18X106 GPD	domestic industrial	Kaiser Resources Ltd.	L. 1 Pl. 1358 & Pcl. A., Pl.6342 of L.4588	coal washing
	1	180,000 GPD	industrial	McGauley Redi-Mix	Pcl. 35 of L. 4588	gravel washing
	1	187.5 AF	irrigation	L.K. & D.L. Bryant	L's 33-46 incl. of L 6678, Pl. 1360	75 acres irrigated
	1	726,550 GPD 1000 GPD	industrial domestic	Crows Nest Industries Ltd.		
	1	$484X10^6$ GPD	power	B.C. Hydro (Elko Dam)	Elko (Sl. 35)	
Fairy Cr.	1	$12X10^6$ GPD 100,000 GPD	waterworks waterworks	City of Fernie	Dist. Blks. 86 & 89 of L. 4588, Pl. 734A blk. 90 - 146	
Fir Cr.	1	$5.38X10^6$ GPD	industrial	Kaiser Resources Ltd.	L. 4589	fluming
Fording River	1	473,600 GPD 5000 GPD	industrial domestic	Fording Coal Ltd.	L's 6638,6698 & 6699	
	1	500 GPD	domestic	B.J. Volpatti	L. 6637	
Hartley Cr.	6	164 AF 1500 GPD	irrigation domestic	--	D.L. 3047, L.9, RP. 1410, L.12379, L.3048, L's 12755-12758 incl.	110 acres irrigated (assumed)
Hollow (Harmer) Cr.	3	63.5 AF 2000 GPD	irrigation domestic	--	L. 6679	25 acres irrigated
Labelle Cr.	2	1500 GPD 70.75 AF	domestic irrigation	--	D.L.6678, L.54, L's 17-21,23-25.	27.8 acres irrigated

TABLE 2-2 Continued

SUMMARY OF WATER LICENCES IN REGION 2

Source	No. of Licences	Quantity	Purpose	Owner	Location	Comments
Littlemoor Cr.	7	164 AF 4000 GPD	irrigation domestic	--	L. 8450	160 acres irrigated (estimated)
MacKenzie Spring	1	100,000 GPD	domestic waterworks	District of Sparwood	District of Sparwood	
Mahon Cr.	11	6500 GPD 2000 GPD	domestic industrial	--	D.L. 6393 L's 9, 5, 6, 10, 19, 2, 4, 8, 9, 1& 3	
Mansfield Cr.	4	2500 GPD 50 AF	domestic irrigation	--	L. 9491, L. 3049	20 acres irrigated
Matheson & Coal Creeks	1	338,000 GPD 20,000 GPD	industrial waterworks	Kaiser Resources Ltd.	L's 4588 & 4589	assumed to be domestic
Michel Cr.	1	432,000 GPD	industrial	Kaiser Resources Ltd.	Michel	Steam-160,000 GPD Cool Comp.-250,000 GPD Coke Ovens-22,000 GPD
	1	275,000 GPD	waterworks	Kaiser Resources Ltd.	within 3 mi. of Michel R.R. Stn.	assumed to be domestic and industrial
	1	300,000 GPD	industrial	Kaiser Resources Ltd.	L. 1 of L. 5, 4588 & 4589, & L's 2 & 3 of L. 4589 Pl. 7590	mining
Mott Cr.	2	60.25 AF 3000 GPD	irrigation domestic	--	D.L. 12743 L. 30, R.P. 1360 of D.L.'s 6678 & 7784	23.6 acres irrigated
Nordstrum Cr.	2	150 AF 3000 GPD	irrigation domestic	R.H. Ully G. Rasmussen	L. 2316 & L. 2242 L. 11710	100 acres irrigated
Otto Cr.	1	1.6×10^6 GPD	industrial	Kaiser Resources Ltd.	Pcl. 35 of L. 4588	mining

TABLE 2-2 Continued

SUMMARY OF WATER LICENCES IN REGION 2

Source	No. of Licences	Quantity	Purpose	Owner	Location	Comments
Qualtieri Cr. & Lapna Spring	6	2500 GPD 7.5 AF	domestic irrigation	--	D.L. 4588, L.'s 50, 14, 36, 37, 35A, 42	8.5 acres irrigated
Raymond Cr.	1	43 AF 1000 GPD	irrigation domestic	--	D.L. 14031, 5245	29 acres irrigated
Scrubby Cr.	1	10,000 GPD	domestic	Corbin Investment Co.	D.L. 6999 & Blk. A., R.P. 2268 of D.L.7001	
Silver Spring Lake	13	6500 GPD	domestic	--	S.L. 28 (near Elko)	
Simms Cr.	1	48.5 AF 500 GPD	irrigation domestic	G. Tymchuk	L. 10, R.P. 1411 of D.L.'s 6393 & 11707	19.4 acres irrigated
Spring	1	300 AF	irrigation domestic	--	L's 8530 & 3531	300 acres irrigated
Summit L.	1	4000 GPD 1000 GPD	industrial domestic	Alberta Natural Gas Co.	L.A. of L. 13832	
Thorne Cr.	1	100,000 GPD	domestic	E. Stephenson	Ptn. S.L. B of L.4589	
Whiting Cr.	3	2000 GPD 40 AF	domestic irrigation	--	L. 8529, L. 11701 L. 7782, L. 8532	30 acres irrigated

+ GPD: Imperial gallons per day
≠ AF : acre-feet (This unit is used for irrigation water licences, and is the volume of water which may be used during the irrigation season. An acre-foot is equal to 271,322 Imperial gallons).
* All lots are in the Kootenay Land District (KLD)

Minor sources of water supply for domestic and irrigation purposes which are smaller than those previously listed include: Bach Cr., Brown Brook, Cokato Cr., Corbin Cr., Couch Cr., Currie Cr., Dock Cr., Hosmer Cr., Lizard Cr., Llewellyn Cr., Magel Cr., Manning Cr., Murdock Cr., Mutz (Jane) Cr., Thomas Brook, and numerous springs.

TABLE 2-3

FORDING COAL LTD. EFFLUENT DISCHARGES

DATA TAKEN FROM POLLUTION CONTROL PERMITS AND APPLICATIONS FOR PERMIT

Description / Permit or Application No.	PE-424	AE-2659	AE-2660	AE-3059	PE-309
Date of Permit or Application	July 29, 1971	June 6, 1973	June 6, 1973	August 23, 1973	October 21, 1969
Operation and Waste Type	Coal Plant	Greenhills Pit dewatering, drier plant washdown, product storage area	Maintenance complex, wash plant storm sewers	Diverted natural stream from Greenhills strip mine	Domestic sewage from plant and offices
Effluent Flow	8,640,000 GPD	Total:2,972,800 GPD Greenhills Pit dewatering: 2,800,000 GPD May to Oct. only	187,200 GPD	400,000 GPD Maximum:2,000,000 GPD	25,000 GPD (average)
Effluent Quality	Typical Coal processing plant tailings	Total Flow: S.S. 150 mg/1; T.S.3650 mg/1; pH 6.5-9.5; Temp.32-60°F Greenhills Flow: 99 mg/1; 161 mg/1; 6.5-9.5; 32-60°F	S.S. 150 mg/1 T.S.3650 mg/1 pH 6.5-9.5 Temp. 32-60°F	S.S.113-460 mg/1 T.S. 210-560 mg/1 pH 7.0-7.2 Temp. 32-60°F	Equivalent or better than an average of: S.S. 65 mg/1 T.S. 540 mg/1 $BOD_5$50 mg/1 pH 6-8 Coliform MPN:$1X10^4$/100ml
Treatment	Tailings Pond water reclaim	Greenhills Pit dewatering none. Remainder: settling ponds	Settling ponds	None	Oxidation ditch, clarifier, chlorination. Sludge drying beds
Discharge	No discharge except seepage to ground and Fording R.	Pit dewatering to Fording River, remainder to ground	Fording River	Fording River	Exfiltration pond adjacent to Fording River (formerly discharged directly to Fording R.)

Note: Remarks concerning Permits, Applications and Abbreviations are given in Table 2-11.

TABLE 2-4

DESCRIPTION OF INDUSTRIAL REFUSE DISPOSAL SITES IN REGION 2

Pollution Control Branch Application or Permit Number	Operation, Location And Status	Type of Refuse	Quantity of Refuse	SITE SUITABILITY FACTORS				Potential For Adverse Effects on Groundwater or Surface Water	Comments
				Depth to Groundwater Table (ft.)	Underlying Soils	Surface Runoff or Flooding	Distance to Surface Water and Wells (ft.)		
PR-1476	Fording Coal Ltd. Fording River valley 30 miles N. of Sparwood Site closed, now use PR-3959	Coal preparation plant refuse (coal particles, shale, sandstone, carbonaceous material, siltstones, till and magnetite).	2260 cu. yd/day (2400 tons/day)	Groundwater collected in underdrains & ditches & conveyed to settling pond prior to discharge to Fording R.	Soft organic soil (0-3 ft. dense glacial till (3 ft.)	Clode Cr. & several unnamed Creeks diverted around site, surface runoff carried via ditches to settling pond prior to discharge to Fording River	800 No wells nearby	Groundwater: nil. Surface water:see Section 2.1.3	Site surrounded by impervious dykes (roads) MAP**=40 in/yr(refer to section 2.1.2)
AR-3835	Fording coal Ltd. Fording River valley Site in operation Level C*	Industrial-95% (paper, wood, metal, glass & inert material) municipal-5%	8 cu.yd/day(5 days/week)	0	glacial till	surface runoff flows through site	100(small creek) 600 (Fording River)6000 to well	Groundwater: nil Surface water: negligible	Present site unsatisfactory. New site chosen. Unresolved 23/9/74. Site used for about 3 years.

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

TABLE 2-4 continued

DESCRIPTION OF INDUSTRIAL REFUSE DISPOSAL SITES IN REGION 2

Pollution Control Branch Application or Permit Number	Operation, Location and Status	Type of Refuse	Quantity of Refuse	SITE SUITABILITY FACTORS				Potential for Adverse Effects on Groundwater or Surface Water	Comments
				Depth to Groundwater Table (ft.)	Underlying Soils	Surface Runoff or Flooding	Distance to Surface Water and Wells (ft.)		
AR-3073	Kaiser Resources Ltd. Michel Site closed	Ash, coal & coke fines from dryer, wet scrubber & yard wastes	15 cu.yd/ day	150	Sand gravel	no	600 to creek 4200 to well	Groundwater: nil Surface water: nil	Closed about 8/ 74. Now use AR-3821
PR-2422	Wolverine Valley Lumber Elko Site in operation Level C	Woodwaste (mainly log yard wastes)	10 cu.yd/ day (200 yd/month)	200	Gravel bedrock	no	10,000 to River 2000 to well	Groundwater: nil Surface water: nil	MAP=20 in/ year PE= 22 in/ yr.
PR-1961	Crows Nest Industries Elko Site in operation Level C	Woodwaste (log yard)	5 cu.yd/ day	Great	Clay loam with gravel pockets, glacial till	no	2600 1000 to well	Groundwater: nil Surface water: nil	

TABLE 2-4 continued

DESCRIPTION OF INDUSTRIAL REFUSE DISPOSAL SITES IN REGION 2

Pollution Control Branch Application or Permit Number	Operation, Location and Status	Type of Refuse	Quantity of Refuse	SITE SUITABILITY FACTORS				Potential For Adverse Effects on Groundwater or Surface Water	Comments
				Depth to Groundwater Table (ft.)	Underlying Soils	Surface Runoff or Flooding	Distance to Surface Water and Wells (ft.)		
PR-512	Kaiser Resources Ltd. Sparwood	Coal preparation plant refuse (rock shale, sand, bony coal fines, magnetite, clay calcite & traces of iron)	5500 cu.yd/ day (6000 tons/ day)	Groundwater collected in wells, trenches & ditches & conveyed to settling ponds prior to discharge	Glacial till under lain by bedrock & river deposits (gravel sand, silt).	Surface runoff diverted in drainage ditches to settling ponds prior to discharge to Elk River.	100 (Elk R.) No wells nearby	Groundwater: negligible Surfacewater: negligible Permittee has conducted monitoring program which indicates that the site is having no detectable effect on Elk R. water quality. Monitoring is continuing	Site expected full in 1982, at which time the refuse will be disposed of in lagoon E on the W.side of Elk R. MAP=40 in/yr. PE=18 in/yr.
AR-3821	Kaiser Resources Ltd., Michel site in operation	Ash, coal & coke fines from dryer wet scrubber & yard wastes	15 cu.yd/ day	50	Coal, rock sandy gravel, overburden (strip mine)	no	600 to Creek 400 to well	Groundwater: nil Surfacewater: nil	Site is in abandoned strip mining area

TABLE 2-5

FORDING COAL LTD.

RESULTS FROM MONITORING THE TAILING POND

Parameters \ Source	Pollution Control Branch Analysis Of Supernatant March 1973 to Nov.1974				Fording Coal Ltd. Measurement of Pond Effluent
	High Value	Low Value	Average Value	No. of Analyses	
Alkalinity(total) mg/l	186	105	124	10	
Aluminum (diss.) mg/l	<0.5	<0.01	<0.10	11	
Copper (diss.) mg/l	0.003	<0.001	<0.0014	11	
Flow GPD					8,640,000
Iron (diss.) mg/l	<0.1	<0.04	<0.08	11	
Lead (diss.) mg/l	<0.006	<0.001	<0.0015	11	
Manganese (diss.) mg/l	0.1	0.02	0.06	11	
Mercury (diss.) μg/l	0.07	<0.05	<0.053	11	
Oil & Grease mg/l	2.2	<1.0	<1.3	11	
pH	8.3	7.2	7.9	7	
Solids, suspended mg/l	208	14	55	11	10,600
Solids, total mg/l	1262	288	441	11	10,900
Sulphate mg/l	489	68	134	11	
Turbidity JTU	54	35	21	10	
Zinc (diss.) mg/l	<0.007	0.005	<0.005	11	

TABLE 2-6

FORDING COAL LTD.

RESULTS FROM MONITORING EFFLUENT FROM THE DRIER PLANT AND MAINTENANCE COMPLEX

Sample Location	Drier Plant and Product Storage Area								Maintenance Complex							
	Pond Inlet				Pond Outlet				Pond Inlet				Pond Outlet			
	Max.	Min.	Median	No. of Values	Max.	Min.	Median	No. of Values	Max.	Min.	Median	No. of Values	Max.	Min.	Median	No. of Values
pH	7.4	7.2	7.2	10	7.5	7.2	7.2	10	7.4	7.0	7.2	9	7.5	6.9	7.3	8
Suspended Solids mg/1	17.5×10^4	708	10585	10	2110	20	89	10	570	50	100	9	70	13	41	8
Total Solids mg/1	17.5×10^4	941	11280	9	10970	149	480	9	1480	280	413	8	460	229	330	7

TABLE 2-7

MONITORING RESULTS FOR FORDING COAL LTD. REFUSE DISPOSAL SITE (PR-1476)

Source of Data	Fording Coal Ltd.'73			PCB (1973)			PCB (1973)			PCB (Jan.'73-Mar.'74)			PCB (May'72-May'74)		
PCB Station No.	--			110			40			110			40		
Sampling Location	Supernatant From Settling Basin Below Refuse Site			Fording River Upstream From Fording Coal Ltd.			Fording Downstream Settling Basin			Fording River, Upstream From Fording Coal Ltd.			Fording River, Downstream From Settling Basin		
Number of Samples	8			6			6			9			14		
Parameters	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Acidity mg/l	0	0	0								NO		DATA		
Alkalinity, tot.mg/l	206	144	174	125	111	119	136	89	118	127	100	118	139	89	122
Aluminum, tot.mg/l	0.2	<0.10													
diss.mg/l	0.1	<0.10	<0.01	<0.5	<0.01	<0.01	<0.5	<0.01							
Copper, total mg/l	0.01	<0.005	<0.005												
diss. mg/l	0.01	<0.005	<0.005	0.002	<0.001		0.003	<0.001		0.003	<0.001	0.0013	0.003	<0.001	0.0013
Iron, total mg/l	3.4	0.10	0.83												
diss. mg/l	0.10	<0.05		<0.1	<0.04		<0.1	<0.04		<0.10	<0.04	0.067	<0.10	<0.04	0.067
Lead, total mg/l	0.02	<0.01													
diss. mg/l	<0.01		<0.01	0.018	<0.001		0.01	<0.001		0.018	<0.001	0.003	0.010	<0.001	0.002
Manganese, tot. mg/l	<0.05	<0.05													
diss.mg/l	<0.05	<0.05		<0.01		<0.01	0.02	<0.01		<0.02	<0.01	0.012	0.03	<0.01	0.014
Mercury, total µg/l	<0.05		<0.05												
diss. µg/l	<0.05		<0.05	<0.85	<0.05		<0.05	<0.05	<0.05	0.06	<0.05	0.051	<0.05	<0.05	0.05
pH				8.4	7.8	8.1	8.5	7.7	8.1	8.4	7.4	8.1	8.5	7.3	8.1
Solids, susp. mg/l	110	3	26	8	2	4	8	2	5	8	2	4	218	2	30
Solids, total mg/l	367	277	317	196	122	163	210	110	171	200	122	171	352	110	207
Spec. cond. µmho/cm				330	238	292	370	200	299	342	238	303	370	200	318
Sulphate mg/l	49	18	37	37	12	28	46	<5	26	43	12	30	47.5	<5.0	29.3
Turbidity JTU	40	1		<1.0			4.5	<1.0	2	0.47	0.10	0.24	96	0.40	9.5
Zinc,total mg/l	0.03	<0.01	0.02												
diss. mg/l	0.02	<0.01		0.04			0.008	<0.005		0.04	<0.005	0.009	0.008	<0.005	0.0053

TABLE 2-8

FORDING COAL LIMITED SEWAGE TREATMENT PLANT EFFLUENT

POLLUTION CONTROL BRANCH MONITORING RESULTS

(APRIL 1972 - MAY 1974)

Parameter	Maximum	Minimum	Average	No. of Analyses
BOD_5 mg/1	103	15	47	9
Carbon, organic mg/1	99	20	50	9
Chlorine, residual mg/1	3.0	0.0	1.4	5
Coliforms, fecal MPN	17,000	170	7,714	5
Nitrogen: ammonia mg/1	7.1	1.0	3.4	5
nitrate mg/1	0.34	0.09	0.17	5
nitrite mg/1	1.1	0.026	0.30	5
Oxygen, dissolved mg/1	8.7	1.4	4.0	7
pH	9.2	7.9	8.4	16
Solids, suspended mg/1	1059	28	224	10
Solids, volatile suspended mg/1	228	20	76	5
Solids, total mg/1	1530	458	742	8
Specific conductance μmho/cm	1270	602	936	2

TABLE 2-9

MUNICIPAL AND INDUSTRIAL EFFLUENTS IN REGION 2

OTHER THAN KAISER RESOURCES AND FORDING COAL

DATA TAKEN FROM POLLUTION CONTROL PERMITS AND APPLICATIONS FOR PERMIT

Description / Permit or Application No.	PE-72	PE-390	PE-253	PE-454	AE-3383	AE-3957
Name	District of Fernie	City of Fernie	District of Sparwood	District of Elkford	McGauley Ready Mix Concrete Co. Ltd.	Byron Creek Collieries Ltd.
Date of Permit or Application	June 24, 1963	March 12, 1971	Sept. 25,1972	Nov. 19, 1973	Jan. 10, 1974	Sept. 9, 1974
Operation and Waste Type	domestic	domestic	domestic	domestic	gravel washing plant	surface mine runoff
Effluent Flow Rate	16,700 GPD	500,000 GPD	380,000 GPD	210,000 GPD	57,000 GPD	50,000 GPD
Effluent Quality	S.S.50 mg/1 T.S.140 mg/1 BOD_5 30 mg/1 ph 7 Temp. 35-50^oF Coliforms, 12,000/100 ml	S.S.57 mg/1 BOD_5 50 mg/1	S.S.45 mg/1 BOD 45 mg/1 Cl_2 0.1-1.0mg/1 residual	S.S.60 mg/1 BOD 45 mg/1	S.S.32 mg/1 Settleable Solids 5 mg/1	S.S.450 mg/1 T.S.1000 mg/1 BOD_5 3 mg/1 pH 6.5-9.5 NH_3 10 mg/1 Cu 0.3 mg/1 Pb 0.1 mg/1 Zn 5.0 mg/1
Treatment	oxidation pond	extended aeration, settling, chlorination	oxidation ditch, clarifier, chlorination	aerated lagoon, polishing lagoons, chlorination	settling pond, exfiltration pond	settling pond
Discharge Point	Elk River	Elk River	Elk River	Elk River	to ground	Corbin Creek

NOTE: Remarks concerning Permits, Applications and abbreviations are given in TABLE 2-11.

TABLE 2-10

ANTICIPATED SCHEDULE OF KAISER RESOURCES RECLAMATION ACTIVITIES 1973-75 [35]

	Nature & Date of Reclamation Operations				
	Site Preparation		Revegetation		
Disturbed Area	Resloping & Terracing	Ripping & Harrowing	Seeding	Planting	Supplementary Seeding & Planting
Erickson Pit	1973	1974-75	1973-75	1973-75	
Baldy Pits		1973	1973	1973	1974-75
C Strip	1974	1974	1975	1975	
7A & B Pits					1973-74
3 Strip	1975				
Balmer 10-7	1974	1974	1975	1975	
McGillivray			1973	1973	1974
Harmer Knob	1973		1974	1974-75	
Assembly Pad		1973	1973	1974	
Harmer 1 & 2	1974-75	1975	1975	1975	
Adit 29 #1	1974	1974	1975	1975	
#2	1975	1975			
#3	1975	1975			
#4	1975	1975			

TABLE 2-11

KAISER RESOURCES LTD. EFFLUENT DISCHARGES

DATA TAKEN FROM POLLUTION CONTROL PERMITS AND APPLICATIONS FOR PERMIT

Description / Permit or Application No.	PE-425	PE-1195	AE-1329	AE-2062	AE-2417	AE-2840	AE-2841
Location	Sparwood	3 miles N.E. of Natal	Michel	Harmer Ridge	Michel	Michel	Michel
Date of Permit or Application	July 14, 1972	Feb. 4, 1972	Sept. 24, 1970	May 4, 1973	April 10, 1973	July 18, 1973	July 18, 1973
Operation and Waste Type	coal preparation plant	maintenance camp domestic waste	coke plant	truck washing	washroom and showers	coal dryer water scrubbers	boiler blowdown compressor cooling
Effluent Flow Rate	900,000 GPD $5.8X10^6$ GPD in emergency	6,000 GPD	446,000 GPD	7,000 GPD	22,000 GPD	14,000 GPD	320,100 GPD
Effluent Quality	typical coal preparation plant tailings	S.S. 20mg/1 BOD_5 16mg/1	S.S.7400 mg/1 T.S.8000 mg/1 D.O. 4mg/1 NH_3 50mg/1 phenols 55mg/1 pH 8 temp.65-70^o	S.S. 9000mg/1 T.S. 1% oils 15mg/1 pH 7.6-9.8 surfactants 2mg/1 phenols 0.05 mg/1	S.S. 60mg/1 BOD 45 mg/1	S.S. 33000mg/1 T.S. 33350mg/1	compressor water:20^{o}F temp.rise boiler blowdown: S.S.2000mg/1 T.S.2500mg/1 SO_4 220mg/1 alk. 640mg/1 temp.210^{o}F

TABLE 2-11 Continued

KAISER RESOURCES LTD. EFFLUENT DISCHARGES

DATA TAKEN FROM POLLUTION CONTROL PERMITS AND APPLICATIONS FOR PERMIT

Description \ Permit of Application No.	PE-425	PE-1195	AE-1329	AE-2062	AE-2417	AE-2840	AE-2841
Treatment	tailings pond, water reclaim	oxidation ditch, clarifier, chlorination, polishing lagoon outfall	holding tanks water recycle	peat moss oil trap, settling ponds	oxidation ditch, chlorination	tailings pond, water recycle	none
Discharge	no discharge except seepage to ground	Baldy Creek	Michel Creek	Harmer Creek	Michel Creek	no discharge except seepage to ground	Michel Creek

Notes:

1. Permits are prefixed by letters PE, and applications by letters AE.
2. Conditions shown for applications are not necessarily those for which a permit will be issued.
3. Following abbreviations are used:

GPD	gallons per day
S.S.	suspended solids
T.S.	total solids
D.O.	dissolved oxygen
Alk.	alkalinity
Temp.	temperature

TABLE 2-12

MONITORING RESULTS FOR KAISER RESOURCES LTD.

TAILING PONDS (PE-425)

Source of Data	PCB (1973-74)			PCB (1973-74)			PCB (1973-74)		
PCB Station No.	119			120			121		
Sampling Location	EP-7, Groundwater Below Lagoon C			EP-8, Groundwater Below Lagoon C			EP-9, Groundwater Below Lagoon C		
No. of Samples	5*			4*			5*		
Parameters	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Acidity mg/l	17	6	10	16	7	10	24.5	16.6	20
Alkalinity, total mg/l	340	183	256	259	199	223	360	290	327
Aluminum, diss. mg/l		N	O		D	A	T	A	
Arsenic, diss.mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper, diss. mg/l	0.004	<0.001	0.0016	0.011	<0.001	0.0045	0.01	<0.001	0.004
Iron, diss. mg/l	<0.1	<0.04	0.052	0.1	<0.04	0.07	0.6	<0.04	0.18
Lead, diss. mg/l	0.004	<0.001	0.0016	0.003	<0.001	0.0015	0.002	<0.001	0.0012
Manganese, diss. mg/l	0.8	0.01	0.212	1.0	0.21	0.645	1.64	0.15	0.87
Mercury, diss. µg/l	0.09	<0.05	0.058	0.09	<0.05	0.06	0.18	<0.05	0.08
pH	7.9	7.4	7.7	8.05	7.4	7.7	8.3	7.5	7.7
Specific cond. µmho/cm	472	472	472	504	504	504	658	658	658
Turbidity JTU		N	O		D	A	T	A	
Zinc, diss. mg/l	0.03	<0.005	0.01	0.05	<0.005	0.0165	0.05	<0.005	0.016

* Minimum number of samples analyzed for each parameter except specific conductance for which only one sample was analyzed.

TABLE 2-12 Continued

MONITORING RESULTS FOR KAISER RESOURCES LTD.

TAILING PONDS (PE-425)

Source of Data	Kaiser Resources (1973)			Kaiser Resources (1973)			Kaiser Resources (1973)		
PCB Station No.	--			--			--		
Sampling Location	EP-4, Lagoon Supernatant			EP-1, Elk R. Upstream from Kaiser Resources			EP-2, Elk R. Downstream from Kaiser Resources		
No. of Samples	7*			7*			7*		
Parameters	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Acidity mg/l		N	O		D	A	T	A	
Alkalinity, total mg/l	160	130	146	155	105	141	160	145	151
Aluminum, total	3.3	<0.02	0.8	1.2	<0.1	0.4	1.4	0.04	0.4
diss. mg/l	0.2	<0.01	<0.1	0.2	0.02	0.1	0.2	0.02	0.1
Arsenic, diss. mg/l	<0.02	<0.02	<0.02	0.04	<0.02	0.02	0.04	0.02	0.02
Copper, total mg/l	0.96	0.02	0.19	1.01	0.01	0.17	0.73	0.02	0.13
diss. mg/l	0.73	0.01	0.14	0.93	<0.01	0.16	0.63	0.02	0.11
Iron, total mg/l	2.4	0.04	0.58	1.7	0.01	0.53	1.9	0.01	0.48
diss. mg/l	0.6	0.04	0.14	0.25	<0.01	0.08	0.25	<0.01	0.07
Lead, total mg/l	1.1	0.02	0.18	0.2	0.01	0.06	0.25	0.02	0.07
diss. mg/l	0.20	<0.01	0.05	0.18	<0.01	0.04	0.23	<0.01	0.06
Manganese, total mg/l	0.04	0.02	0.03	0.06	<0.01	<0.02	0.06	0.01	<0.02
diss. mg/l	0.02	0.01	<0.02	<0.01	<0.01	<0.01	0.01	0.01	0.01
Mercury, diss. µg/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
pH	8.1	7.9	8.0	8.1	7.9	8.0	8.1	7.9	8.0
Specific cond. µmho/cm		N	O		D	A	T	A	
Turbidity JTU	724	33	201	31	1	7.4	31	1	8
Zinc, total mg/l	0.07	<0.01	0.02	0.04	<0.01	0.02	0.06	<0.01	0.02
diss. mg/l	0.01	<0.01	0.01	0.02	<0.01	0.01	0.05	<0.01	0.02

* Minimum number of samples analyzed for each parameter except manganese (total and dissolved) for which only 5 samples were analyzed.

TABLE 2-12 Continued

MONITORING RESULTS FOR KAISER RESOURCES LTD.

TAILING PONDS (PE-425)

Source of Data	PCB (1973-74)			PCB (1969-1974)		
PCB Station No.	111			27		
Sampling Location	EP-2, Elk R. Downstream from Kaiser Resources			Elk R., 7 miles upstream from Kaiser Resources		
No. of Samples	16			18		
Parameters	Max.	Min.	Mean	Max.	Min.	Mean
Acidity, mg/l	N	O		D	A	T A
Alkalinity, total	160	135	149	159	122	140
Aluminum, diss. mg/l	NO	DATA		<0.5	<0.01	0.068
Arsenic, diss. mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper, diss. mg/l	0.003	<0.001	0.0012	0.006	<0.001	0.0016
Iron, diss. mg/l	<0.10	<0.04	0.063	<0.10	<0.04	0.063
Lead, diss. mg/l	0.003	<0.001	0.0013	<0.003	<0.001	0.0012
Manganese, diss. mg/l	<0.02	<0.01	0.012	<0.02	<0.01	0.012
Mercury, diss. µg/l	<0.85	<0.05	0.094	0.120	<0.05	0.061
pH	8.65	7.5	8.2	10.3	7.4	8.2
Specific cond. µmho/cm	400	258	345	400	210	325
Turbidity JTU	12	0.52	2.6	119	<0.1	9.9

TABLE 2-12 Continued

MONITORING RESULTS FOR KAISER RESOURCES LTD.

TAILING PONDS (PE-425)

Source of Data	PCB (1973-74)			PCB (1973-74)			PCB (1973-74)		
PCB Station No.	158			159			160		
Sampling Location	EP-16, Groundwater Below Lagoon D			EP-17, Groundwater Below Lagoon D			EP-18, Groundwater Below Lagoon D		
No. of Samples	5*			5*			4*		
Parameters	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Acidity mg/l	17.5	11	15	10.5	6.5	8.8	40.5	17.6	25.2
Alkalinity, total mg/l	262	235	246	200	185	191	349	233	304
Aluminum mg/l		N	O		D	A	T	A	
Arsenic, diss. mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper, diss. mg/l	0.004	<0.001	0.002	0.002	<0.001	0.0012	0.004	<0.001	0.002
Iron, diss. mg/l	1.8	0.26	1.1	<0.10	<0.04	0.064	2.5	0.04	0.96
Lead, diss. mg/l	0.001	<0.001	0.001	0.003	<0.001	0.0014	0.001	<0.001	0.001
Manganese, diss. mg/l	0.49	0.2	0.29	0.09	<0.01	0.03	0.48	0.17	0.30
Mercury, diss. μg/l	0.16	<0.05	0.076	<0.05	<0.05	0.05	<0.05	<0.05	0.05
pH	7.95	7.4	7.6	8.1	7.2	7.7	7.8	7.2	7.4
Specific cond. μmho/cm	600	600	600	462	462	462	700	700	700
Turbidity JTU		N	O		D	A	T	A	
Zinc, diss. mg/l	<0.005	<0.005	0.005	0.012	<0.005	0.007	<0.005	<0.005	0.005

* Minimum number of samples analyzed for each parameter except specific conductivity, for which only one sample was analyzed.

TABLE 2-13

MONITORING RESULTS FOR KAISER RESOURCES LTD.

REFUSE DISPOSAL SITES (PR-512) 1973-74

Source of Data	PCB (1974)	Kaiser Resources (1973)	Kaiser Resources (1973)	Kaiser Resources (1973)	Kaiser Resources (1973)	Kaiser Resources (1973)	Kaiser Resources (1973)
PCB Station No.	0200144	0910271	0910272	0910273	0910274	--	--
Sampling Location	EP-15, Ground-water, Old Ref-use Site	EP-11, Surface water, Old Ref-use Site	EP-12, Surface water, New Ref-use Site	EP-14, Surface water, Swamp South of New Ref-use Area	EP-15, Ground-water, Old Ref-use Site	EP-1, Elk R., Up-stream From Kaiser Resources Ltd.	EP-2, Elk R., Down-stream From Kaiser Resources Ltd.
No. of Samples	1	4	4	4	4	4	4
Parameters	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Acidity mg/l	1.0	nil	nil	nil	nil	nil	nil
Alkalinity, tot.mg/l	103	155	165	155	160	140	150
Aluminum,tot. mg/l	<0.010	1.4	0.4	0.56	0.7	0.4	0.4
diss.mg/l	<0.010	<0.1	0.1	0.1	0.1	0.1	0.1
Arsenic, total mg/l	<0.005	<0.02	<0.02	<0.02	<0.02	<0.02	0.04
diss. mg/l	<0.005	-	-	-	-	-	-
Chromium, total mg/l	<0.005	0.1	<0.1	<0.1	<0.1	-	-
diss. mg/l	<0.005	<0.1	<0.1	<0.02	<0.01	-	-
Copper, total mg/l	0.002	0.04	0.02	0.38	0.05	0.05	0.06
diss. mg/l	0.002	0.10	0.02	0.37	0.03	0.05	0.05
Iron, total mg/l	0.8	2.9	0.4	1.2	1.28	0.7	0.6
diss. mg/l	<0.10	0.13	0.04	0.31	0.21	0.2	0.2
Lead, total mg/l	0.001	0.05	0.02	0.04	0.04	0.04	0.07
diss. mg/l	<0.001	0.04	0.02	0.03	0.04	0.02	0.03
Manganese, tot.mg/l	<0.02	<0.03	0.01	0.18	0.02	<0.02	<0.02
diss.mg/l	<0.02	<0.01	<0.01	0.10	0.02	<0.01	<0.01
Mercury, total μg/l	0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
diss. μg/l	<0.05	-	-	-	-	-	-
Nickel, total mg/l	-	<0.06	<0.02	0.02	0.02	-	-
diss. mg/l	<0.01	<0.02	<0.02	<0.02	0.02	-	-
pH	8.1	8.0	8.2	7.9	8.0	8.0	8.0
Solids, susp. mg/l	112	22	26	25	14	24	23
Solids, total mg/l	286	415	336	314	539	289	289
Spec. cond. μmho/cm	262	-	-	-	-	-	-
Sulphate mg/l	38.3	22	26	26	70	19	20
Turbidity JTU	64	4	27	38	2	7	8
Zinc, total mg/l	0	0.03	<0.01	0.06	0.20	0.02	0.02
diss. mg/l	<0.005	<0.01	<0.01	0.03	0.19	0.01	0.02

TABLE 2-14

KAISER RESOURCES LTD. MICHEL COKE PLANT EFFLUENT MONITORING RESULTS

	Coal Dryer Scrubber	Final Settling Ponds Effluent		
		East Pond	East Pond	West Pond
Data Source	P.C.B. Sampling	P.C.B. Sampling	P.C.B. Sampling	P.C.B. Sampling
Date	Oct. 11/73	Nov. 28/74	Apr. 24/74	Apr. 24/74
Treatment	Exfiltration Basin	Settling, Coke Filter	Settling, Coke Filter	Settling, Coke Filter
Discharge Point	Ground	Michel Creek	Michel Creek	Michel Creek
Flow (GPD)				
Alkalinity mg/l	328	281		
Arsenic mg/l	<0.005		<0.005	<0.005
BOD_5 mg/l				
Carbon, organic mg/l	10,951			
Chromium, hexavalent mg/l				
COD mg/l				
Colour, APHA units		100		
Copper, dissolved mg/l	0.002			0.007
Cyanide mg/l			<0.01	<0.01
Iron, dissolved mg/l	0.05			<0.1
Lead, dissolved mg/l	<0.001			<0.001
Magnesium mg/l			21.8	22.3
Manganese, dissolved mg/l	0.01			0.02
Mercury μg/l	0.07			
Nickel, dissolved mg/l				
Nitrogen: ammonia mg/l	0.02	65.5		
nitrate mg/l	0.29			
nitrite mg/l	0.204			
Oil and Grease mg/l		10.9		
pH	7.9		8.1	8.1
Phenol mg/l		56		3.0
Phosphate mg/l				
Spec. Cond. μmho/cm	400	915	454	468
Solids, suspended mg/l	22,300	121	48	82
Solids, total mg/l	22,600	502	326	356
Sulphate mg/l	40.5	112	66.8	63.4
Sulphur, total mg/l				
Surfactants mg/l				
Temperature ^{o}C	20			
Zinc, dissolved mg/l	<0.005			0.005

TABLE 2-14 Continued

KAISER RESOURCES LTD. MICHEL COKE PLANT EFFLUENT MONITORING RESULTS

	Settling Pond Liquid	Sanitary Wastes		Compressor Water	Boiler Blowdown
		Showers	Toilets		
Data Source	P.C.B. Sampling	Permit Application	Permit Application	Permit Application	Permit Application
Date	Feb. 7/72	Apr. 10/73	Apr. 3/72	July 18/73	July 18/73
Treatment	Settling	nil	Septic Tank	nil	nil
Discharge Point	Michel Creek	Michel Creek	Michel Creek	Michel Creek	Michel Creek
Flow (GPD)		11,800	10,000	320,000	100
Alkalinity mg/l					360
Arsenic mg/l					
BOD_5 mg/l	2,107				
Carbon, organic mg/l					
Chromium, hexavalent mg/l	<0.005				
COD	7,200				
Colour, APHA units					
Copper, dissolved mg/l	0.003				
Cyanide mg/l	<0.01				
Iron, dissolved mg/l					
Lead, dissolved mg/l	<0.003				
Magnesium mg/l					
Manganese, dissolved mg/l					
Mercury µg/l					
Nickel, dissolved mg/l	<0.01				
Nitrogen: ammonia mg/l	180	1.1			
nitrate mg/l					
nitrite mg/l					
Oil and Grease mg/l			20		
pH	9.3				10.3-12.1
Phenol mg/l	735				
Phosphate mg/l		0.07			
Spec. Cond. µmho/cm					
Solids, suspended mg/l	16,000	3,300	50		592
Solids, total mg/l	18,684	3,700	300		1170
Sulphate mg/l	161	25			110
Sulphur, total mg/l	20				
Surfactants mg/l		0.04			
Temperature °C				10-26	65-100
Zinc, dissolved mg/l	<0.005				

TABLE 2-15

KAISER RESOURCES LTD. DOMESTIC WASTE DISCHARGE FROM THE MAINTENANCE CAMP NEAR NATAL (PERMIT NO. PE-1195) POLLUTION CONTROL BRANCH MONITORING RESULTS

Sampling Date	BOD_5 mg/1	Solids, Total mg/1	Solids, Suspended mg/1
April 5, 1972	12		469
Jan. 11, 1973	57	490	83
July 16, 1973	< 10	622	9
Feb. 12, 1974	66	462	117
April 30, 1974	16	430	45
Aug. 20, 1974	< 10	428	22

TABLE 2-16

SOME DESIGN FACTORS FOR THE SEWAGE TREATMENT PLANT

OF THE CITY OF FERNIE[38, 54]

Design Factors	Data
Population projection	1980 : 5300 1990 : 6500 2000 : 7500
Design population	6500
Area to be serviced	City of Fernie, West Fernie, Annex extension, Bench Land Subdivision, S.W. of Elkview Subdivision, N.to N.W. of City.
Infiltration rate	Two to three times dry weather flow.
Flow	Design: 100 gallons per person per day. Peak: 2.5 of dry weather flow.
Loading	0.17 lb. of BOD_5 per person per day.
Plant details	-Aerated lagoon of 520,000 gallon capacity, with an aeration section and a settling zone, and an overflow rate of 330 gallons/ft^2/day. -Oxygen supply at 1.3 lb. O_2/lb. BOD_5 applied. -Sludge holding lagoon of 6300 gallons for sludge storage up to 10 years. -Chlorine contact chamber with effluent retention of 60 minutes at design flow.

TABLE 2-17

CITY OF FERNIE SEWAGE TREATMENT PLANT EFFLUENT

POLLUTION CONTROL BRANCH MONITORING RESULTS (1974)

Parameters	Maximum Value	Minimum Value	Average Value	No. of Analyses
BOD_5 mg/l	44	12	23	6
Carbon, organic mg/l	32	19	23	4
Chlorine, residual mg/l	0.45	0	0.33	4
Coliform, fecal MPN/100 ml	160,000	1,400	42,200	4
Nitrate, dissolved mg/l	0.49	0.49	0.49	1
Oxygen, dissolved mg/l	9.8	5.6	8.1	5
pH	7.6	7.4	7.5	6
Solids, suspended mg/l	26	5	14	5
Solids, total mg/l	328	248	284	6
Spec. Cond. µmho/cm	483	439	460	5
Temperature °C	25	4	10.5	5

TABLE 2-18

DISTRICT OF SPARWOOD SEWAGE TREATMENT PLANT EFFLUENT

POLLUTION CONTROL BRANCH MONITORING RESULTS

FROM 1972 TO 1974

Parameters	Maximum Value	Minimum Value	Average Value	No. of Values
BOD_5 mg/l	102	<10	29	8
Carbon, organic mg/l	84	6	26	8
Chlorine, residual mg/l	<0.1	0	0	5
Oxygen, dissolved mg/l	8.0	2.4	3.9	6
pH	7.8	7.3	7.6	8
Solids, suspended mg/l	80	4	33	8
Solids, total mg/l	502	418	459	7

TABLE 2-19

VILLAGE OF ELKFORD SEWAGE TREATMENT PLANT EFFLUENT

POLLUTION CONTROL BRANCH MONITORING RESULTS

Parameter \ Date of Sample	April 25, 1974	June 18, 1974
BOD_5 mg/l	29	13
Carbon, organic mg/l	57	54
Coliform, fecal MPN/100 ml	1100	<2000
pH	9.3	10.2
Solids, suspended mg/l	19	119
Solids, total mg/l	352	372

TABLE 2-20

DESCRIPTION OF MUNICIPAL REFUSE DISPOSAL SITES IN REGION 2

Pollution Control Branch Application or Permit Number	Operator and Location	Status of Refuse Disposal Site and Level of Operation*	Type of Refuse	Quantity of Refuse	Site Suitability Factors					Potential For Adverse Effects on Groundwater or Surface Water	Comments
					Depth to Groundwater Table (feet)	Underlying Soils	Surface Runoff or Flooding	Distance to Surface Water (feet)	Distance to Wells (feet)		
PR-504	Fording Coal Ltd. Elkford area	Site in operation level A	municipal	12 cu. yd./ day	50+	sand,clay	no	200 (Kilmar-nock Creek)	none nearby	Groundwater: nil Surfacewater: nil	site is on a bench 40-70ft. vertically above Kilmarnock Creek
PR-1480	Village of Elkford	Site in operation level A	municipal sewage treatment plant sludge	84 cu.yd/week week (1500 people)	50+	gravelly till (rel-atively impervious)	no	200 (Crossing creek)	1000+	Groundwater: nil Surfacwwater: nil	Possible bear prob-lem, Cominco to be responsible for re-moval of bears. MAP**=40 in/yr. PE***=20 in/yr.
PR-505-P	Fording Coal Ltd. Elkford	Site closed level A	municipal	18 cu.yd/ day	100	sand	no			Groundwater: nil Surfacewater: nil	Site 180 ft. from Elkford, site had a potential bear problem. PR-1480 now used.
PR-1876	Regional District of East Kootenay, Upper Elk Valley	Site in operation level C	municipal	10 cu.yd/ day	not a problem	silty glacial till	no	100 and 600 (intermittent streams)	1000+	Groundwater: nil Surfacewater: nil	MAP=40 in./yr. PE= 18 in./yr.

TABLE 2-20 (Continued)

DESCRIPTION OF MUNICIPAL REFUSE DISPOSAL SITES IN REGION 2

Pollution Control Branch Application or Permit Number	Operator and Location	Status of Refuse Disposal Site and Level of Operation*	Type of Refuse	Quantity of Refuse	Site Suitability Factors					Potential For Adverse Effects on Groundwater or Surface Water	Comments
					Depth to Groundwater Table (feet)	Underlying Soils	Surface Runoff or Flooding	Distance to Surface Water (feet)	Distance to Wells (feet)		
PR-1671	District of Sparwood	Site in operation Level B	municipal septic tank sludge	16 cu. yd/ day, 800 IGPD for 20 days/ year	15+	gravelly glacial till	no	300(small creek) 1000 (Elk River)	10,000+	Groundwater: nil Surfacewater: nil	Sludge to be de-watered in drying bed prior to landfilling.
PR-1486	City of Fernie	Site in operation level A	municipal	50 cu.yd/ day(6000 people)	8	silty till, some gravel	small creek diverted	100 (small creek) 210 (Coal Creek)	1,000+	Groundwater: nil Surfacewater: nil	Possible bear prob-lem. This is a new site, old site is nearby.
PR-520	Regional District of East Kootenay, Elko	Site in operation level B	municipal	2 tons/ day	8+	gravel	intermit-tent stream on SW corner of site	100 (intermit-tent stream)	--	Groundwater: nil Surfacewater: nil	MAP=16 in./yr. PE=22 in./yr.

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

**MAP: mean annual precipitation

***PE: average annual potential evapotranspiration

TABLE 2-21

NUTRIENT CONTRIBUTION TO THE ELK RIVER FROM LIVESTOCK AND FERTILIZED IRRIGATED CROPLAND

	Raymond Creek	Fernie-Olson	Sparwood, Fording R. Confluence	Totals
Farms reporting cropland	1	14	9	24
Cropland area - acres	100	1022	895	2017
Irrigated cropland area-acres	29	470	785	1283
Nitrogen contribution to the River from irrigated cropland-calculated lb.N_2/year	195	3170	5200	8565
Phosphorus contribution to the River from irrigated cropland-calculated lb.P/yr.	5	79	130	215
Number of head of cattle	160	540	460	1160
Nitrogen contribution to the River from cattle: calculated lb. N_2/year	1500	5100	4400	11000
Phosphorus contributions to the River from cattle: calculated lb. P/year	32	105	90	230
Total nutrient contributions to the River from irrigated cropland and cattle				
Nitrogen lb/year	1695	8270	9600	19565
Phosphorus lb/year	37	184	220	440

TABLE 2-22

SUMMARY OF WATER QUALITY DATA COLLECTED AT
POLLUTION CONTROL BRANCH SITES 41, 43, 39 AND 44

Site No. and Sampling Period	Site 41 July '72- Aug.'72				Site 43 April '72-Oct. '74				Site 39 April '72-Oct.'74				Site 44 June '72-Dec. '72			
Parameter / Type of Value	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No of Values
Alkalinity, Total mg/1	100	94	97	2	190	120	138	18	195	115	140	20	143	112	125	7
Carbon, Organic mg/1					15	1	5.4	8	55	< 1	9.5	10				
Colour, True-Relative Units	5	5	5	2	10	5	5.3	18	15	< 5	6	20	5	< 5	5	7
Conductance, Specific µmho/cm	210	205	207	2	460	250	309	23	340	145	304	26	360	250	298	7
Nitrogen, Ammonia mg/1					0.02	0.005	0.012	7	0.02	< 0.005	0.01	9				
Nitrogen, Nitrate mg/1					0.10	< 0.02	0.06	8	0.09	0.02	0.06	10				
Nitrogen, Nitrite mg/1					< 0.005	< 0.005	0.005	8	< 0.005	< 0.005	0.005	10				
Nitrogen, Organic mg/1					0.21	< 0.01	0.05	8	0.18	< 0.01	0.04	9				
Nitrogen, Total (by add.)mg/1							0.127				0.115					
Oxygen, Dissolved mg/1					11.8	0.2	8.9	9	13	7.4	10.6	11	9.6	9.6	9.6	1
Phosphorus, Dissolved mg/1					0.005	< 0.003	0.003	8	0.013	< 0.003	0.004	10				
Phosphorus, Total mg/1					0.1	< 0.003	0.018	9	1.06	< 0.003	0.106	11				
pH	8.2	8.0	8.1	4	8.4	7.2	8.1	33	8.6	7.7	8.1	37	8.7	8.1	8.3	12
Solids, Dissolved mg/1	104	100	102	2	186	136	164	18	192	138	171	20	206	120	167	7
Solids, Suspended mg/1	8	6	7	2	144	2	20	18	976	2	77	20	70	2	19.7	7
Solids, Total mg/1	110	108	109	2	288	150	189	18	1130	156	249	20	208	142	187	7
Turbidity J.T.U.	4.2	3.5	3.8	2	32	0.16	7.13	19	155	0.2	14.7	21	12	0.45	4.32	7

Note: All Information Drawn From Data Bank (73)

TABLE 2-23

POLLUTION CONTROL BRANCH WATER QUALITY DATA FOR SITES ON THE ELK RIVER

AROUND THE ELCO MINING CO. EXPLORATION AREA

Site	Site 41 Upstream from Elco Mining Co. exploration area		Site 43 Downstream from Elco Mining Co. exploration area and upstream from Elkford							
Sampling date	July 1972	Aug. 1972	May 1972	June 1972	July 1972	Aug. 1972	April 1973	June 1973	Aug. 1973	April 1974
Alkalinity, total - mg/l	94	100				120				
Solids, dissolved - mg/l	100	104				138				
Solids, suspended - mg/l			124	144	30		12	10	4	82
Solids, total - mg/l	108	110				150				
Turbidity J.T.U.	4.2	3.5	20	32	5.9	3.0	0.2	29	0.7	32

TABLE 2-24

SUMMARY OF WATER QUALITY DATA COLLECTED AT POLLUTION CONTROL BRANCH SITES 110, 40, 93 AND 28

Site No. and Sampling Period	Site 110 - Jan. '73 - Nov. '74				Site 40 - May '72 - Nov. '74				Site 93 - May '72 - Nov. '74				Site 28 - May '72 - Dec. '72			
Parameter / Type of Value	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values
Alkalinity, Total mg/l	127	100	119	11	141	89	123	15	155	106	137	16	159	115	131	8
Carbon, Organic mg/l	4	< 1	2.2	11	8	< 1	3.3	11	6	< 1	2.6	11				
Colour, True-Relative Units	5	< 5	5	11	50	< 5	11	15	25	< 5	6.6	16	35	< 5	8.7	8
Conductance, Specific µmho/cm	342	238	297	16	370	200	316	21	360	230	315	22	370	255	304	8
Nitrogen, Ammonia mg/l	0.06	< 0.005	0.015	10	0.07	< 0.005	0.02	11	0.1	< 0.005	0.26	11				
Nitrogen, Nitrate mg/l	0.09	< 0.02	0.03	10	1.15	< 0.02	0.15	11	0.24	0.05	0.11	11				
Nitrogen, Nitrite mg/l	<0.005	<0.005	0.005	10	0.02	<0.005	0.006	11	<0.005	<0.005	0.005	11				
Nitrogen, Organic mg/l	0.08	<0.01	0.04	10	0.47	<0.01	0.09	11	0.15	<0.01	0.06	11				
Nitrogen, Total (by add.) mg/l			0.09				0.26				0.2					
Oxygen, Dissolved mg/l	12.1	8.4	10.5	9	12.3	8.6	10.7	9	13	10	11.4	9	9.4	9.4	9.4	1
Phosphorus, Dissolved mg/l	0.004	<0.003	0.003	11	0.018	<0.003	0.005	11	0.015	<0.003	0.004	11				
Phosphorus, Total mg/l	0.007	0.004	0.005	11	0.187	0.004	0.025	11	0.12	0.003	0.018	11				
pH	8.4	7.4	8.1	21	8.5	7.3	8.1	28	8.6	7.3	8.2	31	8.8	8	8.3	14
Solids, Dissolved mg/l	196	118	167	11	216	108	174	15	200	120	173	16	208	128	176	8
Solids, Suspended mg/l	8	2	3.4	11	148	2	23.3	14	206	2	21	16	240	4	46	8
Solids, Total mg/l	200	122	170	11	352	110	202	16	342	126	194	17	406	160	222	8
Turbidity J.T.U.	0.47	0.1	0.25	11	96	0.4	11.5	15	55	0.17	5.9	16	57	0.95	11.4	8

NOTE: All information drawn from data bank(73)

TABLE 2-25

THE CONCENTRATIONS OF CERTAIN PARAMETERS IN THE FORDING RIVER DURING SPRING FRESHET

Parameter \ Site		Site 110	Site 40	Site 93	Site 28
Nitrogen, total mg/1	Spring 1973	0.07	0.16	0.08	
	Spring 1974	0.05	0.47	0.15	
Phosphorus, total mg/1	Spring 1973	0.005	0.023	0.020	
	Spring 1974	0.007	0.187	0.119	
Suspended Solids mg/1	Spring 1972	not detectable	118	206	240
	Spring 1973	2	8	8	not detectable
	Spring 1974	4	148	80	not detectable
Turbidity J.T.U.	Spring 1972	not detectable	96	55	57
	Spring 1973	0.3	4.5	2.4	not detectable
	Spring 1974	0.4	57	21	not detectable

TABLE 2-26

WATER QUALITY DATA FOR THE UPPER FORDING RIVER

Site	IF	4	110	110	WS-8 on Aldridge Creek
Sampling Agency	B.C. Research	Fish & Wildlife	P.C.B.	P.C.B.	B.C. Research
Sampling Date	Oct. 1969	July-Aug. 1970	Sept.'73	May'74	
Alkalinity mg/1			121	123	129
Carbon-Inorganic mg/1	10.5				
Organic mg/1	16.0		4.0	2.0	<1
Total mg/1	26.5				30
Conductivity-μmho/cm	169		300	285	318
Hardness mg/1	140				155
pH	7.2	7.6 (average)	8.2	8.1	8.1
Solids, dissolved mg/1	161	229 (average)	162	166	182
Turbidity J.T.U.	1.0		0.2	0.4	0.2
Reference	31	20	73	73	51

TABLE 2-27

SUMMARY OF WATER QUALITY DATA COLLECTED AT POLLUTION CONTROL BRANCH SITES 27, 111, 26 AND 117

Site No. and Sampling Period	Site 27 - July '69 - Dec. '74				Site 111 - Jan. '73 -Jan.'75				Site 26 - May '72 - Dec. '74				Site 117 - Feb. '73 - Nov. '74			
Parameter / Type of Value	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values
Alkalinity, Total mg/1	159	122	142	37	160	130	148	23	178	120	154	28	233	199	217	9
Carbon, Organic mg/1	8	<1	2.8	21	8	<1	3	21								
Colour, True-Relative Units	15	<5	5.3	54	10	<5	5.2	22	50	<5	7	29				
Conductance, Specific μmho/cm	400	210	326	54	400	258	344	35	478	275	379	37	550	480	516	7
Nitrogen, Ammonia mg/1	0.08	0	0.01	22	0.03	<0.005	0.01	21								
Nitrogen, Nitrate mg/1	0.16	0.03	0.08	22	0.19	0.04	0.1	23								
Nitrogen, Nitrite mg/1	0.005	<0.005	0.005	22	<0.005	<0.005	0.005	22								
Nitrogen, Organic mg/1	0.11	<0.01	0.03	22	0.12	0.01	0.05	21								
Nitrogen, Total (by add) mg/1			0.125				0.165									
Oxygen, Dissolved mg/1	13.8	8.0	11.2	21	13.6	7.9	11.5	21	12	11.6	11.8	2				
Phosphorus, Dissolved mg/1	0.05	<0.003	0.005	22	0.004	<0.003	0.003	22								
Phosphorus, Total mg/1	0.07	<0.003	0.014	22	0.05	0.003	0.012	22								
pH	10.3	7.4	8.2	101	8.6	7.5	8.2	41	8.8	7.5	8.3	50	8.2	7.6	7.9	15
Solids, Dissolved mg/1	219	132	187	54	220	150	195	22	286	142	224	29				
Solids, Suspended mg/1	322	1	20	54	48	2	11	22	1796	2	75	29				
Solids, Total mg/1	476	158	207	55	238	166	206	22	1966	164	299	29				
Turbidity, J.T.U.	119	<0.1	92	53	17	0.5	3	21	165	0.3	10.2	28	19	2	6	7

NOTE: All information drawn from data bank[73]

TABLE 2-28

SUMMARY OF WATER QUALITY DATA COLLECTED AT POLLUTION CONTROL BRANCH SITES 98, 46, and 25

Site No. and Sampling Period	Site 98 - May'72 - Jan.'75				Site 46 - May'72 - Jan.'75				Site 25 - April'72 - Jan.'75			
Parameter / Type of Value	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values
Alkalinity, Total mg/l	156	3	119	19	159	82	129	30	176	80	137	34
Carbon, Organic mg/l					21	<1	4.6	21	19	<1	5.3	21
Colour, True-Relative Units	30	5	7.5	18	50	<5	7.5	30	40	<5	7	34
Conductance, Specific µmho/cm	360	128	270	23	350	144	282	46	410	166	311	48
Nitrogen, Ammonia mg/l					0.16	<0.005	0.017	29	0.26	<0.01	0.05	33
Nitrogen, Nitrate mg/l					0.38	<0.02	0.09	29	0.37	<0.02	0.18	33
Nitrogen, Nitrite mg/l					<0.005	<0.005	0.005	29	<0.005	<0.005	0.005	33
Nitrogen, Organic mg/l					0.6	<0.01	0.1	29	1.3	<0.01	0.18	33
Nitrogen, Total (by add.) mg/l							0.212				0.415	
Oxygen, Dissolved mg/l					14.7	8.8	11.8	24	15	8.8	10.9	24
Phosphorus, Dissolved mg/l					0.02	<0.003	0.007	24	0.02	<0.003	0.007	24
Phosphorus, Total mg/l					0.17	0.006	0.026	25	0.21	<0.007	0.032	25
pH	8.7	7.5	8.2	32	8.9	7.6	8.3	56	8.5	7.4	8.1	63
Solids, Dissolved mg/l	188	82	147	17	190	86	154	31	220	96	171	34
Solids, Suspended mg/l	452	2	44	17	432	2	28	31	556	96	171	34
Solids, Total mg/l	548	90	184	17	520	114	183	31	660	114	220	35
Turbidity J.T.U.	73	0.2	7.5	17	93	0.19	7.8	32	120	0.36	13.4	36

NOTE: All information drawn from data bank[73]

TABLE 2-29

SUMMARY OF WATER QUALITY DATA COLLECTED AT POLLUTION CONTROL BRANCH SITES 97 and 112

Site No. and Sampling Period	Site 97 May'72 - July'72				Site 112 Jan.'73 - Aug.'74			
Parameter / Type of Value	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values
Alkalinity, Total mg/1	99	73	84	3	174	66	111	9
Carbon, Organic mg/1					35	2	11.5	8
Colour, True-Relative Units	35	5	16.7	3				
Conductance, Specific µmho/cm	210	165	188	3	562	315	387	12
Nitrogen, Ammonia mg/1								
Nitrogen, Nitrate mg/1					0.13	0.13	0.13	1
Nitrogen, Nitrite mg/1					0.005	0.005	0.005	1
Nitrogen, Organic mg/1								
Nitrogen, Total (by add.) mg/1								
Oxygen,Dissolved mg/1								
Phosphorus, Dissolved mg/1								
Phosphorus, Total mg/1								
pH	8.2	7.7	8.0	6	8.7	6.9	8.0	17
Solids, Dissolved mg/1	110	90	98	3	350	202	262	8
Solids, Suspended mg/1	328	6	131	3	124	2	91.5	8
Solids, Total mg/1	418	116	229	3	610	226	341	8
Turbidity J.T.U.	81	3.6	34.5	3	78	4.1	32.3	9

NOTE: All information drawn from data bank (73)

TABLE 2-30

SUMMARY OF WATER QUALITY DATA COLLECTED AT

POLLUTION CONTROL BRANCH SITES 103, 102, 24 AND 16

Site No. and Sampling Period	Site 103 - Nov.'72 - Dec.'74				Site 102 - Nov. '72 - Nov.'74				Site 24 - April '72-Sept.'74				Site 16 - Aug. '68 - Jan. '74			
Parameter / Type of Value	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values
Alkalinity, Total mg/1	171	75	144	25	167	121	147	12	177	85	143	20	188	92	133	79
Carbon, Organic mg/1	22	<1	4.9	23	16	1	4.4	11	34	1	5.8	11	19	≤1	4.4	33
Colour, True-Relative Units	10	<5	5.4	25	5	<5	5	12	25	<5	7	20	10	<5	5.3	35
Conductance, Specific µmho/cm	420	6	327	41	370	122	304	19	430	198	316	26	390	180	298	74
Nitrogen, Ammonia mg/1	0.8	0.006	0.054	23	0.05	<0.005	0.013	11	0.1	<0.005	0.021	19	0.17	0	0.028	54
Nitrogen, Nitrate mg/1	0.19	0.04	0.1	23	0.18	0.02	0.08	11	1.63	<0.02	0.21	21	0.22	0	0.08	55
Nitrogen, Nitrite mg/1	<0.005	<0.005	0.005	23	<0.005	<0.005	0.005	11	<0.005	<0.005	0.005	21	0.024	0	0.005	54
Nitrogen, Organic mg/1	0.35	<0.01	0.08	23	0.16	<0.01	0.06	11	1.6	0.02	0.2	19	0.17	<0.01	0.06	45
Nitrogen, Total (by add.) mg/1			0.24				0.16				0.436				0.173	
Oxygen, Dissolved mg/1	14.6	5	11.1	23	15.4	7	10.8	9	15.6	7.4	11.7	19	15.3	2	11.8	57
Phosphorus, Dissolved mg/1	0.02	<0.003	0.005	23	0.008	<0.003	0.004	11	0.03	<0.003	0.009	20	0.68	0	0.02	54
Phosphorus, Total mg/1	0.13	0.003	0.02	24	0.035	0.006	0.014	12	0.43	0.006	0.04	20	0.85	0	0.04	54
pH	8.7	7.6	8.3	47	9	7.9	8.4	22	8.7	7.6	8.2	37	8.95	6.6	8.2	102
Solids, Dissolved mg/1	224	118	187	25	216	144	194	13	228	122	181	20	216	118	173	54
Solids, Suspended mg/1	104	2	40.5	25	22	2	5.3	12	660	2	49	20	222	1	24	54
Solids, Total mg/1	280	142	202	26	218	166	198	12	782	160	230	20	428	158	203	55
Turbidity J.T.U.	260	0.5	14.4	25	8	0.4	2.3	13	84	0.55	10.7	20	140	0.2	11.9	63

NOTE: All information drawn from data bank[73]

TABLE 2-31

SUMMARY OF WATER QUALITY DATA COLLECTED AT

POLLUTION CONTROL BRANCH SITES 116, 114, 115 AND 113

Site No. and Sampling Period	Site 116 - Jan.'73 - Oct.8'73				Site 114 - Jan.'73 - Jan.'75				Site 115 - Jan.'73 - Oct.'74				Site 113 - Jan.'73 - Sept.'74			
Parameter / Type of Value	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values	Max.	Min.	Average	No. of Values
Alkalinity, Total mg/l													190	120	149	11
Carbon, Organic mg/l	10	2	4.4	8	9	1	3	8	9	2	3.9	8	16	1	4	10
Colour, True-Relative Units													15	<5	6.4	11
Conductance, Specific µmho/cm	215	125	178	9	305	200	250	11	220	135	179	9	390	208	318	19
Nitrogen, Ammonia mg/l													0.04	<0.005	0.014	11
Nitrogen, Nitrate mg/l	0.05	<0.02	0.03	3	0.17	0.09	0.13	4	0.03	<0.02	0.02	3	0.16	<0.02	0.07	11
Nitrogen, Nitrite mg/l	<0.005	<0.005	0.005	3	<0.005	0.005	0.005	4	<0.005	<0.005	0.005	3	<0.005	<0.005	0.005	11
Nitrogen, Organic mg/l													0.38	0.01	0.1	11
Nitrogen, Total (by add) mg/l															0.19	
Oxygen, Dissolved mg/l													13.4	7.5	11	11
Phosphorus, Dissolved mg/l													0.017	<0.003	0.007	11
Phosphorus, Total mg/l	0.02	0.014	0.017	8	0.028	0.005	0.015	9	0.056	0.015	0.021	8	0.275	0.008	0.04	11
pH	8.2	7.4	7.9	16	8.6	7.1	8.1	18	8.3	7.4	7.8	16	8.7	7.5	8.2	21
Solids, Dissolved mg/l									76	76	76	1	218	148	185	11
Solids, Suspended mg/l									4	4	4	1	40	2	12.4	11
Solids, Total mg/l									80	80	80	1	396	160	216	11
Turbidity, J.T.U.													65	0.7	8.8	11

NOTE: All information drawn from data bank(73)

TABLE 2-32

SUMMARY OF RECOMMENDED RECEIVING WATER SAMPLING FOR PHASE II

Location	Elk River													Fording River				
Parameter / Site No.	204	N 45	202	39	27	N 12	111	103	102	24	N 4	113	16	N 47	110	40	201	N 8
Alkalinity	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X
Carbon, Organic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Coliform, Fecal			X	X				X	X	X	X	X	X					
Metals, Heavy					X	X	X							X	X	X	X	X
Nitrogen, Ammonia			X	X											X	X	X	X
Nitrogen, Nitrate and Nitrite	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Phenol								X	X									
Phosphorus, Total	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Specific Conductance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sediment Sample			X	X	X	X	X								X	X	X	
Solids, Dissolved	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Solids, Suspended	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Location	Henretta Creek	Clode Creek	Kilmarnock Creek	Crows Nest Pond Discharge	Line Creek		Harmer Creek	Grave Creek	Open Cut Creek	Michel Creek								Coleman Collieries Runoff	Boivin Creek
Parameter / Site No.	N 46	N 43	N 42	N 9	N 10	N 11	N 5	26	N 2	184	N 1	185	186	203	46	N 41	25	N 3	N 40
Alkalinity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Carbon, Organic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Coliform, Fecal																	X		X
Metals, Heavy	X	X	X	X	X	X	X	X	X	X	X	X	X					X	
Nitrogen, Ammonia							X								X	X	X		X
Nitrogen, Nitrate and Nitrite	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Phenol															X	X	X		X
Phosphorus, Total	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Specific Conductance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sediment Sample								X	X	X	X	X	X					X	
Solids, Dissolved	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Solids, Suspended	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

NOTE: Sites prefixed N are new W.I.B. sites -- all others are established P.C.B. sites.

TABLE 2-33

BENTHIC MACROINVERTEBRATES FROM THE ELK RIVER AREA

(all samples were collected using Chris Bull samplers)

	No. of Samples	Ephemeroptera (Mayfly) Nymphs	Plecoptera (Stonefly) Nymphs	Trichoptera (Caddisfly) Larvae	Chironomidae Larvae	Diptera (Midges) Pupae	Simulidae (Black fly) Larvae	Other	Miscellaneous
B.C. Research Station TF1									
Sept.29-Nov.10/70	1	41	47	3	2			1	
Nov.10/70-July 13/71	1		7	3					
July 13-Sept.28/71	1	22	14	8	21				
Sept.28-Oct.26/71	1	26	10	4	21				
Station 1C									
July 13-Sept.28/71	1	5	30	11	18			6	
Sept.26/71	1	28	70		12			6	5 Turbellaria
Station 2F									
Sept.29-Nov.10/70	1	129	127		64				
Sept.28-Oct.26/71	1	40	52						
Station FK1									
Sept.29-Nov.10/70	1	17	2	17	1			1	
Sept.28-Oct.26/71	1	75	34						
Station M16									
Sept.29-Nov.10/70	1	17	38					2	
July 13-Sept.28/71	1	56	31		12				
Sept.28-Oct.26/71	1	79	56	4	8			1	

TABLE 2-33 Continued

BENTHIC MACROINTERTEBRATES FROM THE ELK RIVER AREA

(all samples were collected using Chris Bull samplers)

	No of Samples	Ephemeroptera (Mayfly) nymphs	Plecoptera (stonefly) nymphs	Trichoptera (caddis fly) larvae	Chironomidae larvae	Diptera (midges) pupae	Simulidae (black fly) larvae	Other	Miscellaneous	Comments
Station M22 Sept.29-Nov. 10/70	1	89	75	3	23			2		
Jul. 13-Sept. 28/71	1	12	36	2	59			14		
Sept. 28-Oct. 26/71	1	7	14		23					
Hooton et al[20]										
Station 1 ?-Aug. 3/71	3	156	55	7	25			3		substrate in Stations 1, 3, 4, 5, and 6 was gravel of 2-5" diam.
?-Sept. 1	3	128	77	5	50					
?-Oct. 5	3	724	403	15	115			2		
Station 2 ?-Aug. 3	3	27	18	2	12			1		Station 2 substrate was bedrock, cobble and sand.
?-Sept. 1	3	89	26	9						
Station 3 ?-Aug. 3	3	165	28	10	40			4		
?-Sept. 1	2	163	66	18	60					
?-Oct. 5	3	595	263	4	35			22		
Station 4 ?-Aug. 3	2	129	159	23	25			11		
?-Sept. 1	3	243	249	36	200			4		
?-Oct. 5	3	425	284	12	50			81		
Station 5 ?-Aug. 3	3	119	40	2	20			7		
?-Sept. 1	3	260	79	18	180			13		
?-Oct. 5	3	142	49	3	85			41		
Station 6 ?-Aug. 3	3	129	79	9	65			19		
?-Sept. 2	3	353	165	26	95			13		
?-Oct. 5	3	441	237	4	80			30		

TABLE 2-33 Continued

BENTHIC MACROINVERTEBRATES FROM THE ELK RIVER AREA

(all samples were collected using Chris Bull samplers)

	No. of Samples	Ephemeroptera (mayfly) nymphs	Plecoptera (stonefly) nymphs	Trichoptera (caddis fly) larvae	Chironomidae larvae	Diptera (midges) pupae	Simulidae (black fly) larvae	Other	Miscellaneous	Comments
Crozier et al [61] station 16 Oct.22/71-	2									rocks 1"-2" on sand base mesh 505 microns
Dec.6/71	2	845	3	39						
Bull et al [62] station A Jul.-Aug./72	2	12	30	7	7			1		plant detritus + fine gravel
station B Jul.-Aug./72	2	112	130	42	154			4	2 Annelida	plant detritus + fine gravel
station C Jul.-Aug./72	3	95	84	67	64				2	plant detritus + sand
station D Jul.-Aug./72	2	7	5		1230					algae + fine gravel
station E Jul.-Aug./72	2	23	4	16	125			233	1 Annelida	weeds, algae
Crozier et al (1973) [64] station 16 Mar.28-May 3/73	1	178	41	8	546	60	22	3	1 misc. worm	sand substrate-some** silt
station 16 Mar.28-May 3/73	1	177	20	6	926	66	40	5	1 Hirudinea 1 Annelida	sand substrate-some** silt Net fell off when being removed.
station 16 Sep.19-Oct.29/73	1	100	150	1	1260	2		5	1 leopard dace? 2 Annelida	substrate mostly silt
station 16 Oct.3-Nov.28/73	1	207	721	5	2031	1	21	3	8 Nematodes	sand substrate-some silt
station 16 Oct.3-Nov.28/73		190	646	5	2167		14	2	2 leopard dace? 1 Nematode	sand substrate-some silt Mesh size 505 microns

**this is with the sample

Note: For sample site location see Figures 2-15 and 2-16

TABLE 2-34

PERIPHYTON COUNTS FROM POLLUTION CONTROL BRANCH SITE 16 ON THE ELK RIVER

August 23 - October 23, 1972	total = 1185 cells/mm^2
Achnanthes minutissima Kutz	36.8 %
Cocconeis pediculus Ehrb.	33.8 %
Diatoma vulgare Bory	11.5 %
March 28 - May 3, 1973	total = 1695 cells/mm^2
Achnanthes minutissima Kutz	48.2 %
Coccaneis pediculus Ehrb.	22.3 %
Diatoma vulgare Bory	8.1 %
September 19 - October 29, 1973	total = 345 cells/mm^2
Cocconeis pediculus (Ehrb.)	18.2 %
Achnanthes minutissima Kutz	16.2 %
Ulothrix sp.	16.2 %
Diatoma vulgare Bory	14.6 %
Gomphonema olivaceum (Lyngb) Kutz	9.7 %
September 19 - October 29, 1973	total = 111 cells/mm^2
Cocconeis pediculus Ehrb.	53.0 %
Gomphonema olivaceum (Lyngb.) Kutz	20.0 %
Diatoma vulgare Bory	11.3 %
Cymbella ventricosa	5.2 %
October 31 - November 28, 1973	total = 42.2 cells/mm^2
Diatoma vulgare Bory	82.2 %
Gomphonema sp.	7.0 %
Stigeoclonium tenue	4.5 %