PRELIMINARY ENVIRONMENTAL OVERVIEW

BROWNIE CREEK COAL LICENCES,

FORDING COAL LTD.

Project Report
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1.0 SUMMARY

This report describes existing environmental conditions of five coal licences held by Fording Coal Limited in the Brownie Creek area, to the east of the existing Fording Coal operation, on the west slope of the Continental Divide. These licences (No.'s 3899-3903) cover Lots 6691, 6694, 6703, 6706 and the east half of Lot 6713 and are being considered as a possible site for dumping of overburden material. This report summarizes previously existing information on the area and presents the results of field studies conducted during September, 1978, to June, 1979.

Short-term climatological data for the area were obtained from the Fording Coal station and compared to long-term data from the Fernie climatological station. There are no site-specific data on air quality for the Brownie Creek area. As the area is in a relatively natural and undisturbed state, the air quality is assumed to be good.

The main streams of the study area are Kilmarnock Creek and Henretta Creek and their major tributaries, respectively, Brownie Creek and McQuarrie Creek. These streams were surveyed and described from the eastern boundary of the study area to their respective confluences with the Fording River. Surface water hydrology measurements were made at six sites in the Kilmarnock Creek and Henretta Creek drainages in September, 1978.

Water quality data gathered during earlier B.C. Research studies and from two reports of the "Kootenay Air and Water Quality Study" were summarized. Earlier studies found that Kilmarnock Creek was an alkaline, low nutrient stream of high water quality and a source of intermittent high suspended solids. Henretta Creek had received no prior study.

Water quality samples were collected by B.C. Research on September 16, 1978, and May 11-12, 1979. These and previously collected water quality data indicate that Kilmarnock, Henretta, Brownie and McQuarrie Creeks were of high water quality, characteristic of undisturbed or relatively undisturbed watersheds. Analyses of samples from the Fording River downstream of Kilmarnock Creek indicated differences from other study streams, showing higher levels of turbidity, solids, phosphorus (in May, 1979), nitrate and manganese.

A previous B.C. Research study found that benthic invertebrate fauna in Kilmarnock Creek were indicative of small, clean, cold-water streams.

Fish populations were sampled in Henretta and Kilmarnock Creeks in September, 1978. Additional sampling took place in Kilmarnock Creek using an electroshocker and trap nets in May and June, 1979. Yellowstoné cutthroat trout was the only species captured. Stream survey and fish sampling results indicate that the lower reaches of Kilmarnock and Henretta Creeks are important as summer rearing areas for cutthroat trout. Kilmarnock Creek contained fish in spring which were in spawning condition and it is expected that some areas of the stream are spawned in late June and early July. Overwintering probably occurs in other streams. Both Brownie and McQuarrie Creeks appeared to be too small to provide fish habitat.

Surficial materials and soils of the Brownie Creek coal licence area were described from Resource Analysis Branch mapping. The dominant parent materials include blankets, veneers, or aprons of colluvium and/or till overlying bedrock. Soils in the area have mainly been derived from colluvium and morainal materials of variable depth. Soil development is represented by four soil orders: Podzolic, Luvisolic, Brunisolic and Regosolic. These soils and their distribution in the Brownie Creek coal licence area were described.

Vegetation studies conducted in the Fording Coal area by B.C. Research in 1969, 1970 and 1971 were summarized. Vegetation of the Brownie Creek coal licence area was sampled in September, 1978. The study area falls within the Dry Interior Region, represented by two forest zones: Subalpine Engelmann Spruce-Alpine Fir and Alpine Tundra. The study area was mapped into nine map units, each composed of one or more vegetation types. A listing of 145 species of vascular plants, bryophytes and lichens was made from the study area and floristic data for the 20 vegetation plots sampled were presented. Each of the nine map units and its vegetation types were described.

Wildlife sighting data obtained during B.C. Research wildlife studies conducted in 1969, 1970 and 1971 were summarized. A pellet transect survey of the Brownie Creek coal licence area was conducted in September, 1978, to provide an estimate of habitat use. An aerial winter survey of the Fording Coal area, including the Brownie Creek study area, was flown in March, 1979.

Elk were the most abundant ungulate in the Brownie Creek coal licence area. All habitats appeared to be used as summer range. No elk or elk tracks were observed in these coal licences during the March, 1979 survey. The lack of elk in the area in winter, and ungulates in general, can be attributed primarily to excess snow cover during most of the winter. Elk were observed wintering on the steep, south-facing meadow slopes of Eagle Mountain, Mount Turnbull and several ridges north of Henretta Creek.

Mule deer and white-tailed deer occur in small numbers in the Fording Coal area. Deer use most of the habitat types available during summer but do not appear to winter in the Brownie Creek area. Moose appear to make only limited use of the Brownie Creek coal licence area during the summer to fall period. Moose appear to be confined to the Fording River and Henretta Creek valley bottoms during winter. Nine moose were observed along Henretta Creek during the March, 1979, aerial survey.

Within the licence area, sign of bighorn sheep was abundant in meadow habitats to the east of Brownie Creek. Other habitats were used to a lesser extent. Sheep do not appear to winter in the Brownie Creek coal licence area. Mountain goats occur in moderate numbers in the higher regions east of the Fording valley. Goats appear to make little use of the study area during summer. During the March, 1979, survey, goats were observed in the rugged terrain at the headwaters of Henretta Creek and to the east of the Brownie Creek coal licence area. The steep meadow habitats at the eastern edge of the licence area appear to be used by goats during spring.

The occurrence and distribution of black bears, grizzly bears, smaller furbearers and birds in the Brownie Creek coal licence area were briefly described.

The present and potential resource use of the Brownie Creek coal licence area was described from Canada Land Inventory and Resource Analysis Branch information. The area generally has a low capability for agriculture and forestry. Logging has removed much of the mature coniferous forest cover of the Kilmarnock Creek valley bottom. The coal licence area has the general recreation features for vegetation and viewing, mostly of a low to moderate significance. Kilmarnock and Henretta Creeks provide opportunities for angling. Elk appeared to be the most sought after game animal in the area, followed by deer, moose and bighorn sheep. The potential for archaeaological sites in the Brownie Creek coal licence area is considered low.

A brief environmental sensitivity analysis was prepared, based on the limited amount of data collected for the Brownie Creek coal licence area. The general sensitivities of the major aquatic and terrestrial parameters were evaluated with regard to disturbance, specifically the possible use of the Brownie Creek drainage as a site for a waste dump. Dumping of overburden would result in an increased level of dustfall in the immediate area and in minor changes in the hydrologic regime of Brownie Creek. Streams in the area are highly sensitive to disturbance which may cause increased sedimentation, thereby having a direct effect on aquatic habitat. Aquatic resources in Kilmarnock Creek could undergo substantial alteration if siltation occurs.

The major problems which may be encountered by dumping of overburden above upper Brownie Creek would be the effects on slope stability of the surrounding areas. Steep slopes with fine textured soil developed on morainal material are highly sensitive to disturbance. Erosion and slope failure could result in disturbance of surrounding vegetation communities and consequent loss of wildlife habitat.

No major impacts on wildlife are expected to occur from possible dumping of overburden into the west side of the Brownie Creek drainage. Winter survey information indicated that this particular area is not a winter range. The location of a waste dump in the Brownie Creek coal licence area may result in interference with traditional ungulate migration routes.

The agricultural and forestry capability of the Brownie Creek coal licences would not be significantly affected by dumping of overburden material. Some effects on the recreation capability and use of the area are likely to occur. Reclamation of an overburden dump area will be conducted by Fording Coal Ltd. following established land-use objectives.

Several recommendations have been made to ensure that the aquatic resources of streams in the area will not be significantly affected. The monitoring of big game populations should be continued in the areas under the influence of Fording Coal Ltd.

2.0 INTRODUCTION

2.1 BACKGROUND

Fording Coal Limited has been involved in exploration and development of coal reserves in the upper Fording River Valley since 1967 and has operated a coal mine in the area since 1971. Open-pit coal mining is being conducted on the east side of the Fording River Valley along the northwest slopes of Eagle Mountain and on the west side of the Fording River along the lower slopes of the Greenhills Range. A coal preparation plant, loading facilities and associated office and maintenance facilities are located in the valley floor. Access is via paved highway from Elkford, B.C., 31 km to the south (Map 1). A rail spur runs north from Sparwood, B.C. and provides coal transport to the Robert's Bank bulk loading facility near Vancouver, B.C.

Fording Coal Ltd. has maintained annual payments on 5 coal licences lying in the Brownie Creek area to the east of the existing operations and is considering the possibility of their use for mine waste disposal. Overburden material could be dumped over the ridge lying between Mount Turnbull and Eagle Mountain (Figure 1) into the upper Brownie Creek drainage. These licences (Nos.3899-3903) cover Lots 6691, 6694, 6703, 6706, respectively, and the east half of Lot 6713 (Map 2).

As these licences are attached to an existing mining operation, the Ministry of Mines and Petroleum Resources, Reclamation Division, ruled at a meeting in Victoria on August 23, 1978, that review of a required environmental assessment would lie within the responsibility of the Ministry, and would not be subject to the "Coal Development Guidelines" of the Environment and Land Use Secretariat (E.L.U.C.).

Accordingly, the study was planned and conducted with emphasis on data collection and presentation based on those resource aspects most likely to come into conflict with any industrial land use of the 5 coal licences. The study is generally equivalent to a Stage I environmental assessment as outlined in the E.L.U.C. "Coal Development Guidelines" with the omission of socio-economic aspects. The study is based upon on-site data collected during field periods, a synthesis of available government information, and relevant data gathered during earlier B.C. Research investigations in the Fording area.

B.C. Research had previously been retained by Cominco Ltd. to study baseline environmental conditions of the Fording Coal area prior to development of the coal deposits. These studies were conducted from October, 1969 to October, 1971, and results were presented in a series of six progress reports (B.C. Research, 1970; __, 1970a; __, 1970b; __, 1971; __, 1972; __, 1973).

2.2 OBJECTIVES

The objectives of this study were:

- to assemble all available data and information relevant to the lands on and around Lots 6691, 6694, 6703, 6706 and 6713.
- to conduct field studies to obtain on-site data of important environmental parameters.
- to describe and report existing environmental conditions of the lands covered by the 5 coal licences and immediate vicinity.
- to evaluate the sensitivity of these lands to potential industry-related disturbance, with emphasis on important aquatic and terrestrial aspects.

2.3 STUDY AREA

The intensive study area for the purposes of this study consisted of the lands within and immediately surrounding Lots 6691, 6694, 6703, 6706 and the east half of Lot 6713. For aquatic aspects the study area included Kilmarnock Creek and its major tributary, Brownie Creek; as well as Henretta Creek from its confluence with the Fording River up to and including its major tributary, McQuarrie Creek. To provide a regional perspective for discussion of wildlife resources and resource use aspects, the upper Fording River watershed formed a larger study area.

For many of the environmental parameters described in this report, the general area of the present Fording Coal operations has also been covered.

2.4 PERSONNEL

This study was conducted within the Division of Applied Biology at B.C. Research, headed by Dr. C.C. Walden. The study was directed by Mr. I.V.F. Allen, Group Leader, Ecological Studies. Aquatic resources were studied by Dr. J. Malick with field assistance by Mr. J. Coustalin and Mr. C. Schmidt. Analytical services were provided by the Water Quality Group under the supervision of Dr. J. Leach and Mr. H. Lanz. Terrestrial studies were conducted by Mr. S. Parmar (terrain, soils, vegetation) and Mr. C. Schmidt (wildlife) with field assistance by Mr. M. Gordon. Resource use aspects were described by Mr. C. Schmidt. Drafting services were provided by Mr. F. Phillips and Mrs. E. Revoczi of the Supporting Services Division. Final report editing and production were done by Mr. G. Longworth and Mr. C. Schmidt.

2.5 ACKNOWLEDGEMENTS

Mr. R. Berdusco, Administrator of Environmental Services, and Mr. Dermot Lane, Reclamation Officer, at Fording Coal Ltd. provided logistic support and cooperated throughout the study. Staff of the Resources Analysis Branch (R.A.B.), Ministry of the Environment, Victoria, provided RAB data and mapping for the area, particularly Mr. Rod Chilton (climate), Mr. D. Demarchi (wildlife), Ms. B. Collins (recreation), and Mr. P. Shera (aquatics). Mr. T. Lee and Mr. L. Lacelle of the RAB, Kelowna, provided information on soils, surficial materials and vegetation. Mr. Ray Kenny, archaeologist, of the Heritage Conservation Branch, Victoria, provided information on heritage resources of the area. Special thanks are extended to Mr. Bill Warkinten, B.C. Fish and Wildlife Branch, Cranbrook, who provided winter survey data for the upper Elk Valley survey unit and provided valuable background information on ungulate ranges and winter distribution in the area. Mr. J. Drozduck, pilot for Crowsnest Helicopters, Fernie, provided helicopter support throughout the field studies.

3.0 METHODS

3.1 CLIMATE

Climate data for the Fording Coal area were obtained from Fording Coal Ltd. for the weather station operated by the company at the plant site. A summary of long-term climate data for Fernie, B.C. was obtained from the Atmospheric Environment Service's 25-year normals. Data for several Resources Analysis Branch (Ministry of the Environment, Victoria) stations to the south of Fording Coal were obtained, but data have not been included in this report.

3.2 AQUATIC STUDIES

3.2.1 Hydrology

Hydrological measurements included measurement of stream discharge, drainage basin and stream length. Stream discharge was obtained in September, 1978, using a Marsh McBirney Model 201 portable water meter attached to a wading rod. Current measurements were taken in a transect across each site at 25 cm intervals. The meter was located above the stream bottom at four-tenths of the water depth. Sites were located as shown on Map 2. Drainage basin area, stream length and gradient were derived from topographic maps of the area.

3.2.2 Water Quality

Seven water quality sites were selected in the study area and are shown on Map 2. Samples were collected on September 16, 1978, and May 11 and 12, 1979, in Henretta Creek, McQuarrie Creek, Kilmarnock Creek, Brownie Creek and the Fording River. Water temperature and pH were measured at each site and water samples were collected for analysis of dissolved oxygen, total alkalinity, EDTA hardness, specific conductance, turbidity, suspended solids, volatile solids, total solids, total phosphorus, nitrite, nitrate, sulphate, phenol, total organic carbon, oil and grease, and dissolved copper, iron and manganese.

Water was collected in prerinsed (deionized water) plastic bottles from sub-surface at mid-stream. Samples for oil and grease were collected in prerinsed 1-litre glass bottles. Samples for phenols were collected in 1-litre glass bottles containing a preservative solution of 1 ml 10% H_3PO_4 and 10 ml saturated $CuSO_4$ solution.

Samples for heavy metal analyses were filtered in the field through acid-washed 0.45 μm Millipore filters, into 250 ml acid-washed plastic bottles and preserved by the addition of 2 ml of 50% AR nitric acid. Samples for dissolved oxygen were collected in 300 ml glass bottles and preserved using the Winkler method for subsequent analysis.

Water temperature and pH were measured on-site, the latter using an IL Model 175 portable pH meter. Dissolved oxygen samples were analyzed using the Winkler method. Other samples were kept in coolers for subsequent return to the laboratory where they were stored at 2^{o}C until analyses were completed. Analytical procedures were based on methods outlined by the American Public Health Association (1975) and B.C. Water Resources Service (1976).

In the laboratory, pH was measured with a Radiometer Model 26 meter; turbidity and sulphate were determined using a Hach Model 2100 A turbidimeter. Flameless AAS using a Perkin-Elmer HGA-2100 graphite furnace and Perkin-Elmer 306 AAS unit were used to analyze samples for copper and iron. Flame AAS was used for manganese. Reference water samples from the U.S. Environmental Protection Agency and "round-robin" interlaboratory comparison samples from the Canada Center for Inland Waters have been analyzed routinely as a check on procedures.

3.2.3 Fisheries

Fish sampling was carried out by angling in Kilmarnock Creek, Henretta Creek and the Fording River during September 13-15, 1978. Fish were again collected during May 11-14 and June 18-19, 1979, but only in Kilmarnock Creek. Electrofishing and fyke trap nets were used for these collections. All fish were released after taking length and weight measurements. Collection sites are shown on Map 2.

Field observations and measurements included sex, sexual maturity, fork length and weight. Scales were taken for age determination. The relative condition of fish was calculated using the condition factor ("K") formula of Carlander (1969). The condition factor "K" is given by:

$$K = \frac{W \times 10^5}{L^3}$$

where: W = weight in grams

L = length in mm

10^5 = factor to bring the value near unity

3.3 TERRESTRIAL STUDIES

3.3.1 Surficial Materials and Soils

Surficial materials of the study area was described and mapped (1:25,000) from the surficial materials map (1:50,000) prepared by the Resources Analysis Branch, Kelowna (Map Sheet 82/J2, 1977).

Soils of the study area were described from the soils map prepared by the Soils Section of the R.A.B., Kelowna, and from Valentine, *et al*. (1978), and Canada Department of Agriculture (1978). Field observations were made during September 12-15, 1978.

3.3.2 Vegetation

Field studies of vegetation were conducted in conjunction with the wildlife study during September 12-15, 1978. Vegetation data from previous B.C. Research studies were reviewed. Preliminary vegetation map units were identified on air photos (1:20,000). Prior to sampling, these map units (habitat types) were checked by helicopter and/or ground reconnaissance. Within these units, representative vegetation plots were selected and analyzed to describe vegetation types. Twenty vegetation plots were assessed.

Vegetation plot data were collected to conform to the "Vegetation Data Sheets" of the Resources Analysis Branch, Kelowna, B.C. Plot boundaries were not measured but their dimensions correspond approximately to 100 sq. metre plots (10 m x 10 m) in forested areas and 16 sq. metre plots (4 m x 4 m) in non-forested areas. A visual estimate of canopy cover (Daubenmire, 1959) was made for each of the following five vegetation layers: tree (>10 m in height), tall shrub B_1 (2-10 m in height), low shrub B_2 (<2 m in height), herb, and the moss and lichen layer. Cover was estimated as a percentage for each plant species occurring in each layer, and as a total for each vegetation layer.

Plant species which could not be identified in the field were returned to the laboratory. Complete identification was not possible for some species as identifying features were often absent; in these cases plants were identified where possible to genus level. Many ephemeral spring and summer species were probably indistinguishable in the plots. Identification manuals of Hitchcock and Chase (1950) and Hitchcock and Cronquist (1973) were used for identifying vascular plants. In addition, Taylor and MacBryde (1977) was consulted as a general reference for vascular plants. Mosses and lichens were identified using Lawton (1971) and a checklist by Schofield (1968).

The diameter at breast height (dbh) and height were recorded for a selected representative of the dominant tree species on treed plots. The age of the selected tree was determined by core-sampling.

3.3.3 Wildlife

Field studies were conducted in the Brownie Creek study area during September 12-15, 1978 in conjunction with the vegetation survey. At each vegetation plot (except plot 20), a pellet transect was run to determine relative habitat use by ungulates and their distribution in the study area. A series of ten circular pellet plots, each 20 m^2 with plot centers 10 m apart, were located along a compass line running parallel to the contour. Sites were selected so that the transect would stay generally in the same habitat type. Pellets were classified as to species, relative age (<year or >year) and type (winter type or soft summer type). A minimum of 12 pellets constituted a pellet group and of these at least one half had to be within the 20 m^2 plot to be included.

Along each transects, the major species of forage were noted and checked for evidence of forage use. All observations of animals, tracks, droppings, beds, etc. were recorded. Additional wildlife observations were made during May 11-14, 1979 aquatic field work.

A helicopter winter survey was flown on the morning of March 19, 1979 to document the distribution and abundance of ungulates on their winter ranges during the late-winter period. The survey covered the 5 coal licences as well as most of the region between Kilmarnock and Henretta Creeks as well as the immediate areas to the north and south. A second reconnaisance survey was flown on May 12, 1979 over smaller portions of the study area, primarily to check on snow cover conditions and ungulate distribution in the alpine region.

Data for B.C. Fish and Wildlife Branch winter surveys of the upper Elk Valley survey unit flown during 1979 and previous years were obtained from the Branch's sub-regional office in Cranbrook. Information and mapping of ungulate ranges in the area were derived from B.C. Fish and Wildlife Branch reports (Demarchi, 1968) and from Canada Land Inventory and Resources Analysis Branch ungulate capability maps. Results of previous investigations of wildlife in the Fording Area by B.C. Research were used as background information.

3.4 RESOURCE USE

Information on land tenure was derived from NTS maps and from Fording Coal Ltd. Information on land capability was derived from the Canada Land Inventory maps for map sheets 82J/2 E & W and 82J/7W for: present land use, agriculture capability, forestry capability and recreation capability (Appendix 1). Forest cover mapping for map sheet 82J/2 E & W was obtained from the Resources Analysis Branch (RAB), Ministry of Environment, Victoria. Biophysical recreation capability mapping was obtained from the RAB. Information on hunting, guiding, angling and trapping was obtained from the B.C. Fish and Wildlife Branch (Cranbrook offices) and from published regulations (B.C. Fish and Wildlife Branch, 1978). Information on heritage resources in the area was obtained from the Provincial Archaeologist's office, Heritage Conservation Branch, Victoria.

4.0 ENVIRONMENTAL DATA

4.1 PHYSICAL OVERVIEW

4.1.1 Physiography

The study area is situated in the Rocky Mountains to the east of the upper Fording River Valley at approximately 114° 47' West by 50° 12' North. This region lies on the west slope of the High Rock Range which forms the most easterly range of the Front Ranges of the upper Elk Valley. The study area occupies the highlands between Henretta Creek on the north and Kilmarnock Creek on the south. Both these creeks arise on the western slopes of the Continental Divide and flow to the west through narrow valleys to their confluence with the Fording River.

Elevations in the area range from 1615 m (5300 ft) in the Fording Valley to 2895 m (9500 ft) on Mount Farquhar along the Continental Divide. The study area covered by the 5 coal licences ranges from 1800 m (5900 ft) to a maximum of 2470 m (8100 ft). The highest elevations within the larger study area, apart from those along the Continental Divide, are 2500 m (8200 ft) on Mount Turnbull and 2438 m (8000 ft) on Eagle Mountain.

4.1.2 Geology

The Fording Coal property is underlain by rock of the Mesozoic Era. The Triassic Spray Formation of shaley quartzite and sandy shales is disconformably overlain by the Jurassic Fernie Formation, which in this area is comprised of blue-black modular shales with thin calcareous sandstone bands. The Fernie Formation is conformably overlain by coal-bearing Upper Jurassic - Lower Cretaceous Kootenay Formation; approximately 1,220 m of sandstone and siltstone with interbedded mudstone and coal seams in the lower 550 m. The Brownie Creek coal licences are located on the east limb of the north plunging Eagle Mountain Syncline. The bedding strikes north by northwest and dips 25° to 45° westerly.

No coal deposits are located on the Brownie Creek coal licences, which are underlain by Fernie and Spray River Formations.

4.2 CLIMATE

Short term climatological data for the Brownie Creek study area was obtained from the Fording Coal station (Table 1). More extensive data was obtained from the Fernie climatological station (Table 2), located approximately 70 km (45 mi) south of the study area.

4.2.1 Temperature

The mean daily temperature at Fernie was 4.5°C (40.1°F) with maximum and minimum daily temperatures of 36.1 °C (97°F) and -41.7°C (-43°F), respectively (Table 2).

The Fording Coal climatological station has recorded a mean daily temperature of 1.0°C (33.8°F) over a seven year period. The extreme maximum and minimum daily temperature recorded was 32.2°C (90°F) and -40.0°C(-40°F), respectively (Table 1). The Fernie climatological station is located at an elevation of 1000 m (3300 ft), while the Fording Coal station is at an elevation of 1700 m (5600 ft), which accounts for the lower mean daily temperature of the latter.

4.2.2 Precipitation

The total annual precipitation at Fernie was 108.15 cm (42.58 in) (Table 2) while the Fording Coal station recorded 75.46 cm (29.70 in) (Table 1) for a seven year period.

Precipitation at both stations is fairly evenly distributed throughout the year, with maximums occurring in December and January. Minimum precipitation occurs in July at Fernie (3.68 cm, 1.45 in), but at Fording Coal, October exhibits the lowest mean monthly level (3.80 cm, 1.50 in).

Average annual snowfall at Fernie was 368.8 cm (145.2 in) (Table 2), while at the Fording Coal station it was somewhat higher (436.6 cm, 171.8 in) due to the increased elevation.

4.3 AIR QUALITY

There are no background air quality data for the immediate study area covering the Brownie Creek coal licences. As the area is in a relatively natural and undisturbed state, the air quality is assumed to be good. The only exceptions would be fugitive dust from logging roads in the Kilmarnock Creek Valley and, possibly, wind blown air emissions from the Fording Coal plant to the west. A description of these emissions, their sources and monitoring data are discussed in two reports of the "Kootenay Air and Water Quality Study" (B.C. Water Resources Service, 1976; B.C. Water Investigations Branch, 1978).

The ambient air quality station at Elkford, 19 km air distance to the south, indicated a low average dustfall value of 2.0 g per m^2 per month (Water Investigations Branch, 1978). No data are available for the Brownie Creek area. The lack of site specific data on temperature inversions in the Fording Coal area precludes an assessment of possible effects on air quality. During periods of inversions and low wind conditions, high levels of suspended particulates are possible in the Fording River Valley around the Fording Coal Ltd. plant and into the Henretta and Kilmarnock Creek Valleys.

4.4 AQUATIC RESOURCES

4.4.1 Identification and Description of Drainages

The main streams in the Brownie Creek coal licence area are Kilmarnock and Henretta Creeks which originate on the west slope of the High Rock Range and flow westward into the Fording River. These creeks are respectively 43.5 km and 53 km upstream from the confluence of the Fording River with the Elk River. Resources Analysis Branch point and reach description cards were filled out for these streams and are presented in Appendix 2.

The Henretta Creek drainage is relatively undisturbed with a single dirt road up the valley floor. The stream is on the north side of Mount Turnbull and flows into the Fording River upstream of Fording Coal operations. The creek is 10.2 km in length and drains an area of 45.8 km^2. The upper 6.7 km of Henretta Creek has a vertical drop of 640 m and an average gradient of 9.5%. This section of the stream is more precipitous than lower Henretta Creek but was outside the present survey area and will not be described further.

Lower Henretta Creek is 5.8 km in length, has a vertical drop of 98 m and an average gradient of 1.7%. This section of the stream flows through a flat-bottomed valley where the stream is only occasionally confined by the valley wall. The stream bed is mostly a single channel that is relatively straight, in some parts with a few pools. Other sections are more sinuous with good pool-riffle development. Stream-side (riparian) vegetation is characteristically low growing willows (Salix sp.) which overhang the stream and provide good cover for fish (Figure 2).

The stream bottom is composed primarily of cobble and gravel except in the lower reaches where outcroppings of bedrock are apparent. There were no debris blockages, falls or chutes in lower Henretta Creek.

McQuarrie Creek flows into Henretta Creek 3.3 km upstream of the Fording River. This stream originates from the north slope of Mount Farquhar and enters Henretta Creek from the south. McQuarrie Creek is a small stream 5.5 km in length and drains an area of 11.6 km^2. The creek undergoes a vertical drop of 411 m and has an average gradient of 7.5%. The stream is confined except where it has formed an alluvial fan from flowing over the valley wall into Henretta Creek. Old channel scars are evident on the alluvial fan. The lower reach of McQuarrie Creek is bordered by willows and coniferous trees which form a closed canopy over parts of the stream. The stream is characteristic of small second order streams where numerous pools are separated by debris or rock dams. Substrate composition in the pools was fine organic and inorganic materials whereas some small gravel and cobble were evident at the tail of the pools. McQuarrie Creek is too small to provide acceptable fish habitat.

Kilmarnock Creek flows into the Fording River downstream of Fording Coal Ltd. Part of the drainage area includes the south and east slopes of Eagle Mountain. Kilmarnock Creek has experienced substantial disruption. The lower section of the river is crossed by the main access road to Fording Coal Ltd. and the Canadian Pacific Railway. In addition, all but 1 km of the lower 5.6 km of Kilmarnock Creek has been logged without leaving any stream-side vegetation (Figure 3). Logging occurred after 1970 and a few small willow shrubs now border the stream.

Kilmarnock Creek is 10.2 km in length and drains an area of 45.8 km^2 on the west slope of the High Rock Range. The upper 4.2 km of Kilmarnock Creek is a high gradient mountain stream with a vertical drop of 396 meters and an average gradient of 9.4%. This section of the stream is confined in its valley and the north and south forks have falls or chutes that are barriers to fish.

Lower Kilmarnock Creek is 6 km in length, undergoes a vertical drop of 161 m and has an average gradient of 2.7%. This section of the creek flows through a flat bottomed valley where the stream is generally unconfined by the valley wall. The streambed is mostly a single sinuous channel. Pool development in the 1 km unlogged part of the stream is good, whereas the logged areas have fewer and smaller pools (Figure 3). Stream-side vegetation is sparse in the logged part of the stream, comprised of a few willow shrubs. In the forested section, riparian vegetation of coniferous trees and willow shrubs provided good stream cover (Figure 4). In addition, this section has significant amounts of in-stream fish cover in the form of tree stems and root balls.

The stream bottom throughout is composed primarily of cobble and gravel(Figures 3 and 4). Limited data on substrate composition were gathered by B.C. Research (1970a) in 1969 and these data are presented in Table 3. The sites were located near the mouth of Kilmarnock Creek (2K) and downstream of Brownie Creek (1K) (Map 2). The data are from single grab samples which do not adequately represent the larger size categories. Inherent variability in substrate sampling negates detailed analysis and comparison of single samples, however, moderate sediment levels are apparent. These samples were collected prior to logging and may not be indicative of present conditions.

A single fish barrier exists in lower Kilmarnock Creek where the lip of the culvert for the railroad crossing was 0.5 m above the downstream pool level. Fording Coal Ltd. has in the past raised the level of the pool each fall. Spring freshet eroded the pool lip away so that the blockage persisted each year from June to July until September or October when the pool level was again raised. The pool level was raised permanently in the fall of 1978 to facilitate movement of fish.

Brownie Creek flows into Kilmarnock Creek 4.8 km upstream from the Fording River. Brownie Creek is 5 km in length and drains an area of 14.5 km^2 which includes the east slope of Eagle Mountain. This small stream has a vertical drop of 731 m with an average gradient of 14.6%. It is confined in its upper reaches by a narrow valley but widens along its lower reach near Kilmarnock Creek. The lower 1 km length of Brownie Creek has been logged and has limited riparian vegetation, comprised of a few willows (Figure 5). In this part of the stream the substrate is composed mostly of cobble and gravel with few pools being evident. Brownie Creek is too small to provide suitable fish habitat.

4.4.2 Hydrology

Surface water hydrology measurements were made at six sites in the Kilmarnock Creek and Henretta Creek drainages (Map 2). Two sites were established in Kilmarnock Creek; near the mouth and upstream of Brownie Creek. One site was located in Brownie Creek near its confluence with Kilmarnock Creek. Similarly, two sites were located along lower and upper Henretta Creek with another site established in McQuarrie Creek.

Discharge measurements made at these sites during September 13-15, 1978 are shown in Table 4. Discharges were similar during May 11-14, 1979 but appeared to increase until early June. Both streams have considerably reduced discharge during the summer and winter period.

4.4.3 Water Quality

4.4.3.1 Review of existing data

Sampling of Kilmarnock Creek was begun by B.C. Research (1970a) with a single collection at two sites (1K and 2K) in 1969 (Map 2). Since that time, two Provincial agencies have also established collection sites on the stream (Map 2). Henretta Creek has apparently received no prior study. The B.C. Water Investigations Branch established a site near the mouth of Kilmarnock Creek[1] (1190042) and collected samples in 1975 and 1976. The B.C. Pollution Control Branch established site 0200252 where the road to Elkford crosses Kilmarnock Creek. This site has been sampled since 1977 (B.C. Pollution Control Branch, 1978; Crozier, 1978; pers. comm.). Full data sets of water quality or biological information for Kilmarnock Creek or other provincial sampling sites may be requested from the EQUIS data storage and retrieval system through the Pollution Control Branch or Water Investigations Branch, Victoria.

The earlier studies found that Kilmarnock Creek was an alkaline, low nutrient stream of high water quality (Table 5) and a source of intermittent high suspended solids. Further monitoring was suggested to provide background information for the assessment of future development in this drainage, as well as to determine its prsent suspended solids contribution to the Fording River (B.C. Water Investigations Branch, 1978). The B.C. Pollution Control Branch monitored Kilmarnock Creek in 1977 and 1978 and found that the suspended solids load was low at all times of the year, showing the usual slight increase during freshet (Crozier, 1978; pers. comm.).

Considerable data on the water quality and biology of the Fording River have been accumulated. This information will not be summarized here but the sources and types of information and provincial sampling site numbers are indicated. The earliest work in this area was performed by B.C. Research (1970a). This report contains data concerning water quality, stream bedload, aquatic invertebrates and the potential acid production of materials from various sources on the Fording Coal Ltd. property. B.C. Research

[1]This site was described as N-42 by B.C. Water Resources Service (1976b) and as 1190042 by B.C. Water Investigations Branch (1978a). Data are from the B.C. Water Investigations Branch (1978a) report.

(1973) carried out further work on invertebrates with a comparison of B.C. Fish and Wildlife Branch invertebrate sampling.

An excellent summary of work performed on the Fording River has been presented by the B.C. Water Investigations Branch (formerly Water Resources Service) in their "Kootenay Air and Water Quality Study" Phase I and Phase II (1976b, 1978a). The Phase I report assembles and assesses all available water quality and biological data available to the end of 1974. This report also presents information regarding mining operations in the Fording drainage and recommendations for monitoring. The Phase II report presents additional information on mining operations in the Fording drainage and results of water quality, sediment, invertebrate and periphyton studies performed subsequent to the Phase I report. The Phase II report also lists water rights for the Fording River and Pollution Control Permit summaries.

The Pollution Control Branch has since carried out suspended solids monitoring; 1977 data are reported by Crozier (1978) and further sediment studies are continuing. Provincial and Federal sampling site numbers for the Fording River are listed in Table 10 and shown in Figure 4 of the B.C. Water Investigations Branch (1978a) Phase II report. Additional sites for the Fording drainage basin include:

Site No.	Location and type of information documented
0200251	Fording River 1 mile upstream of Clode Creek haul road; water quality.
0200252	Kilmarnock Creek at culverts on road to Elkford; suspended solids only.
0200271	Fording River upstream of Kilmarnock Creek and 100 yds downstream of bridge to Greenhills area; water quality.

4.4.3.2 1978/79 water quality studies

Water samples were collected at six sites in the Kilmarnock and Henretta Creek drainages with an additional site on the Fording River downstream of Kilmarnock Creek (Map 2). Sampling dates were September 16, 1978 and May 11 and 12, 1979. Results of analyses are shown in Tables 6 and 7. These data show that Kilmarnock Creek corresponds closely, with few exceptions, to earlier data collected by Water Investigations Branch, Pollution Control Branch and B.C. Research as shown in Table 5. Water Investigations Branch reports much higher iron values (up to 200 μg/l) than found in the present study (up to 7 μg/l) and B.C. Research reported considerably lower pH and alkalinity values but higher total solids than found in the present study.

Present and former water quality data indicate that Kilmarnock, Henretta, Brownie and McQuarrie Creeks were of high water quality, characteristic of undisturbed or relatively undisturbed watersheds. These streams exhibited high dissolved oxygen, pH usually above 8 and alkalinity of 99 to 147 mg $CaCO_3$/l (Tables 6 and 7). Turbidity and solids were low as were nutrient levels, phenol, oil and grease, and metals. The Fording River analyses indicated differences from other study streams, showing higher levels of turbidity, solids, phosphorus (in May), nitrate and manganese. Other water quality characteristics of the Fording River were similar to those found in Kilmarnock and Henretta Creeks.

4.4.4 Aquatic Invertebrates

Sampling for benthic invertebrates was not conducted during this study, however, limited collections were made in Kilmarnock Creek in October, 1969 by B.C. Research (1970a) and included three "kick" samples" collected at two sites. The sites were located near the mouth of Kilmarnock Creek (2K) and downstream of Brownie Creek (1K) (Map 2) and results are shown in Table 8.

The limited number of samples and the nature of the sampling make it difficult to comment on the productivity of the stream or to compare the sites. However, the presence of the two Heptageniidae indicate a clean,rocky substrate was present at the time of sampling. The fauna collected in the samples is indicative of small, clean, cold-water streams. The invertebrate fauna may have undergone some change since the collection of these samples as a result of logging in the Kilmarnock valley. Logging may have altered the hydrological regime, sediment load and algal community of the creek. Further sampling should be performed to document the present condition of these streams.

4.4.5 Fisheries

Fish populations were sampled by angling in Henretta and Kilmarnock Creeks in September,1978. Additional sampling took place in Kilmarnock Creek using an electroshocker and fyke trap nets in May and June, 1979. Throughout these sampling periods the only fish species captured was the Yellowstone cutthroat trout (Salmo clarki lewisi) (Figure 6). Dolly Varden and rainbow trout, which occur in the Elk River and the lower Fording River, may not be present in the upper Fording above the falls near Elkford.

Scott and Crossman (1973) indicate that spawning of Yellowstone cutthroat trout is expected 3 to 5 weeks after ice break up in small gravelly streams when water temperatures reach about 10^{o}C. Their redds are about 30 cm in diameter and 102 to 127 mm in depth. The eggs normally hatch in 6 or 7 weeks after which the alevins remain in the gravel for 1 or 2 weeks prior to emergence in August, assuming spawning occurs in mid to late June. Fry may move into a large stream or continue to reside in the natal stream for rearing. Food of these fish is mainly insects of aquatic and terrestrial origin although the larger fish may be piscivorous.

Sampling indicated that adult and juvenile fish use Kilmarnock and Henretta Creeks as summer rearing areas (Tables 9 and 10). Smaller fish than indicated in Table 10 were observed but not captured in the September, 1978 sampling.

Fish captured in the fall had fed entirely on aquatic and terrestrial insects with the aquatic insects of the order Trichoptera being the major source (Table 11). These fish ranged from 200 to 306 mm in length, 80 to 400 g in weight and 2+ to 4+ years of age. Condition factors varied from 1.0 to 1.4 (Table 10). It was also evident that the gonads and ovaries of these fish were maturing in preparation for spring spawning. The length and age relationship of fish from the study area is compared to Yellowstone cutthroat from Montana and Utah streams in Table 12. This comparison indicates that the 2+ age class may have been longer than fish from the other areas but that the 3+ and 4+ ages were similar to fish from Montana and Utah streams.

Juvenile and a few adult fish were collected in Kilmarnock Creek in mid-may (Table 13), one to two weeks after ice break up when maximum water temperatures were about 4^{o}C and discharge was similar to the previous September. These fish were captured primarily in the lower reach of Kilmarnock Creek, below the railroad crossing. They were probably moving into Kilmarnock Creek from the Fording River as it is doubtful that fish could overwinter in the stream; with the possible exception of the large pools at the downstream ends of the culverts at the railroad and highway crossings. Two of the fish captured in May were adult males in spawning condition. Other fish included one adult fish of undetermined sex and several juveniles

(Table 13). Condition factors of these fish ranged from 0.9 to 1.7 and were similar to those of fish captured in the previous fall. The juvenile fish were likely seeking a summer rearing area and the adults preparing to spawn in the creek.

Kilmarnock Creek was again sampled on June 18 and 19, 1979. More fish were captured at this time than during the mid-May sampling but no clear evidence of spawning could yet be seen. Again, more juveniles and adults were captured downstream of the highway than upstream (Table 14),but water temperatures were still in the 3 to 5°C range and probably retarded upstream movement. The adult fish were all males with the possible exception of two adult sized fish that yielded no sex products when the abdomen were pressed. Condition factors of these fish ranged from 0.9 to 1.7 and were similar to the May, 1979 and September, 1978 sampling. Freshet had occurred between the May and June, 1979 sampling and stream discharge in June was slightly greater than during the May sampling, but water was again clear.

Based on observations of fish and habitat it is expected that fish occur in Henretta Creek from its mouth to a point near the upper end of Reach 2 (on May 3) but would not enter McQuarrie Creek. Likewise cutthroat trout in Kilmarnock Creek would be expected to utilize the stream to near the upper end of Reach 3, but would not enter Brownie Creek.

Careful inspection of Kilmarnock Creek disclosed that the greatest areas of suitable spawning substrate per area of stream occurred in the lower sections of each of the three reaches. The upper sections of Reaches 1 and 2 contained isolated areas of suitable spawning habitat. The upper section of Reach 3 was not specifically assessed for spawning habitat, however, this section of the stream is steep and has a rocky substrate and does not appear to represent suitable spawning habitat.

Subsequent discussion with Mr. B. Lister, engaged in fisheries investigations of the Fording River, revealed that cutthroat were observed spawning in the Fording River in mid-June, 1979 when water temperatures had reached 5 to 6.5°C. He indicated that he had also surveyed the lower 3 km of Henretta Creek and found no spawning cutthroat, commenting that this section of Henretta Creek did not appear to contain particularly suitable spawning habitat. Based on this information, it is expected that spawning would occur in Kilmarnock Creek by late June or early July when water temperatures reach 5 to 6.5°C. However, he also mentioned that cutthroat sampled seemed to prefer spawning areas with standing trees along the bank; such areas are lacking along most of Kilmarnock Creek.

In summary, stream survey and fish sampling results indicate that the lower reaches of Kilmarnock and Henretta Creeks are important as summer rearing areas for cutthroat trout. Kilmarnock Creek contained fish in the spring which were in spawning condition and it is expected that some areas of the stream are spawned in late June and early July. Fish seem to move into the stream in spring for spawning and rearing but probably move out and overwinter in other streams. Some overwintering may occur in the pools located along Kilmarnock Creek below the railway and highway culverts.

4.5 TERRESTRIAL RESOURCES

4.5.1 Surficial Materials and Soils

4.5.1.1 Surficial Materials

The distribution of surficial materials in the Brownie Creek coal licence area is shown on Map 4. The dominant parent materials include blankets, veneers, or aprons of colluvium and/or till overlying bedrock. Gravelly silt and silty clay morainal blanket materials modified by gullying are found in the eastern part of Lot 6694, and in Lots 6706 and 6713, respectively. Gravelly fluvial fans along with colluvial aprons are found along Brownie and Kilmarnock Creeks near their junction. Steep rock outcrops and escarpments (cirques) are found at higher elevations. Modifying processes such as avalanching and gullying are quite common on steep slopes.

The dominant textural class is rubly colluvium, while morainal materials generally consist of compact, non-sorted and non-stratified material that contains a wide range of particle sizes and matrix of silt and clay.

4.5.1.2 Soils

Soils in the Brownie Creek licence area have mainly been derived from colluvium and morainal materials of variable depth, except at lower elevations near the junction of Brownie and Kilmarnock Creeks, where they have been derived from deep gravelly fluvial deposits. Soil development in the study area is represented by four soil orders: Podzolic, Luvisolic, Brunisolic and Regosolic. A brief description of each order along with its occurence in the study area is given below.

4.5.1.2.1 Podzolic soils

Podzolic soils occupy the major portion of the study area and occur extensively in the mature Engelmann spruce-alpine fir, logged, seral pine-Engelmann spruce-alpine fir, young Engelmann spruce-alpine fir and, to a limited extent, in the alpine larch-alpine fir, pioneer shrub, meadow and alpine fir krummholz map units. Soils belong to the Humo-Ferric Podzol Great Group and three Subgroups are found in the area: Orthic Humo-Ferric Podzol, Luvisolic Humo-Ferric Podzol and Sombric Humo-Ferric Podzol.

These soils have developed under less humid or cool conditions with accumulation of iron plus aluminum and little organic matter to give a Bf horizon. The iron and aluminum accumulation in the Bf horizon has come from the volcanic ash weathering which makes up a significant portion of the top soil.

Soils are of variable depth and range in texture from silty clay loam to gravelly sand. These occur on steep to very steep slopes. Orthic Humo-Ferric Podzols occur extensively at lower elevations, while Luvisolic Humo-Ferric Podzols are found on strongly rolling to hilly slopes in Lot 6713 and the western part of Lot 6706. Soils are quite deep at lower elevations but lithic phases are found at higher elevations (generally Sombric Humo-Ferric Podzol).

4.5.1.2.2 Luvisolic soils

Luvisolic soils occur in the northern portion of the study area in Lots 6713 and 6706 and also on the lower, southern slopes of Eagle Mountain and Mount Turnbull along the west side of Brownie Creek. These occur on strongly rolling to hilly areas in the mature Engelmann spruce-alpine fir and seral pine-Engelmann spruce-alpine fir map units. These soils have developed on morainal materials in well to imperfectly drained sites, in sandy loam to clay base - saturated materials under the forest vegetation, and in the forest grassland transition zone under humid to sub-humid soil moisture regimes. The dominant process in Luvisolic soils is the translocation of clay sized mineral particles in suspension from the A to the B horizon forming a Bt horizon. The clay accumulation is sometimes so great that root and water penetration are restricted and soils can become very wet in the spring.

Soils of this order in the study area belong to the Gray Luvisol Great Group and represent two Subgroups: Podzolic Gray Luvisol and Brunisolic Gray Luvisol. Soils are deep at lower elevations but occur only as a lithic phase at higher elevations.

4.5.1.2.3 Brunisolic soils

Brunisolic soils are found on hilly to very hilly areas in the seral pine-Engelmann spruce-alpine fir map unit with southern exposures, in alpine meadows, pioneer shrub and in the alpine fir-krummholz map units. These soils have developed generally on coarse textured, shallow colluvium and morainal materials which have a low water holding capacity. These soils are generally shallow and occur as lithic phases at higher elevations.

4.5.1.2.4 Regosolic soils

Regosolic soils are found at high elevations under dry, cold conditions or at lower elevations with extremely steep slopes or constantly eroding slopes. These soils occur above alpine meadows or grasslands in the non-vegetated and alpine fir-krummholz map units. Little vegetation grows here and frost action continually disrupts the surface materials.

These soils are generally rapidly to imperfectly drained. Both Regosol and Humic Regosol Great Groups are found in the area and are represented by the Orthic Regosol and Cumulic Humic Regosol Sub-groups.

4.5.2 Vegetation

4.5.2.1 Review of existing data

Vegetation sutdies were conducted by B.C. Research in the Fording Coal area in 1969, 1970 and 1971. Results of these studies were presented in three reports (B.C. Research, 1970; _____, 1971; _____, 1972). These studies concentrated on the high elevation ungulate ranges on Mount Turnbull and Eagle Mountain and the east slope of the Fording River valley. Studies were not conducted within the Brownie Creek coal licences at that time.

The first vegetation survey was conducted during October 15-31, 1969 (B.C. Research, 1970). Six vegetation plots were assessed, and from these data,in conjunction with air photo interpretation, a total of seven major vegetation types were defined and two additional types were mapped:

1. Communities of north faces (typified by presence of larch).
2. Open forest and grassland.
3. Open alpine grasslands.
4. Valley bottom meadows.
5. Burned areas carrying various ages of lodgepole pine.
6. Englemann spruce/subalpine fir forest.
7. Valley bottom grassland and willow communities.

A preliminary vegetation map of the upper Fording River valley and adjacent highlands was prepared.

Subsequently, a second vegetation survey was conducted between September 29 and October 4, 1970 covering the grassland ranges on Mount Turnbull and Eagle Mountain (B.C. Research, 1971). Six vegetation plots and several sites were assessed. Four major communities were defined:

1. Alpine tundra.
2. Alpine grasslands: rough fescue community
Idaho fescue community
3. Subalpine communities: subalpine grassland
subalpine open forest.
4. Creek ravine community

Descriptions of the plant communities were given, including characteristic species.

In addition, six forage assessment plots were established on the grassland ranges (four on Mount Turnbull and two on Eagle Mountain). Fall forage carry-over was estimated by hand clipping from sample quadrats within the plots. Values ranged from a low of 76.2 g/m^2 in an alpine tundra grassland to 228.8 g/m^2 in a fescue community on a low elevation, south-facing slope on Eagle Mountain.

Forage quality was evaluated by total nitrogen assay on composite samples of clipped herbage and browse. The results were summarized as follows: percent nitrogen ranged from 0.72% to 1.26%, crude protein ranged from 4.9 to 7.9 and nitrogen yield ranged from 0.69 g/m^2N to 1.75 g/m^2N. "On Mount Turnbull an inverse relationship was observed between forage carry-over, curing properties, total nitrogen content and the elevation of the plant community. Moreover, at a given elevation, the forage carry-over and its total nitrogen content was higher on Eagle Mountain than on Mount Turnbull due to inherent differences in the environs of each mountain. The crude protein content of the fall clipped forage was above the minimum requirement for winter feed. The communities comprising the grassland in the area were in good condition. This conclusion was based upon the observed floristic composition, carry-over yields and plant vigor." (B.C. Research, 1971).

In the following spring and summer (May 26-31 and July 26-29, 1971), the six grassland plots on Mount Turnbull and Eagle Mountain were re-assessed and the descriptions of grassland communities revised (B.C. Research, 1972). Vegetation data tables for plant communities were up-dated from the previous fall's survey. Five of the six forage assessment plots were sampled for over-winter forage losses and total nitrogen. The results of both the October, 1970 and May, 1971 sampling are presented as Appendices 3 and 4 of this report, and are summarized as follows: "Differences observed between total forage yields in the fall and spring were analyzed for statistical significance. The statistical analysis results presented are for total forage losses between the first week in October, 1970, and the last week in May, 1971. Spring carry-over forage yields ranged from 36.7 g/m^2 to 127.1 g/m^2 as compared to 76.2 g/m^2 to 228.8 g/m^2 in the fall. In all communities studied, the observed reduction in forage carry-over was significant at either 1% or 5% level. Mean forage losses ranged from 44.4% to 52.6% at five sites observed in the spring. The largest losses were observed at the higher elevation plots where the effect of weather is greatest and where the majority of elk range-use occurred during the winter of 1970-71. Determination of spring carry-over forage quality was masked by the presence of new growth in the clipped samples." (B.C. Research, 1972).

4.5.2.2 1978/79 vegetation studies

The Brownie Creek coal licences fall within the Dry Interior Region, represented by two forest zones: Subalpine Engelmann Spruce - Alpine Fir and Alpine Tundra (R.A.B., unpublished data). These two forest zones conform to the Engelmann Spruce-Subalpine Fir and Alpine Tundra biogeoclimatic zones described by Krajina (1969). The Subalpine Engelmann Spruce - Alpine Fir zone occurs at lower elevations to a maximum elevation of 2286 m (7,500 ft). This includes the valley bottoms of Brownie, Kilmarnock, McQuarrie and Henretta Creeks and extends to the upper slopes of Eagle Mountain and Mount Turnbull, covering the largest portion of the licence area. Above 2286 m (7,500 ft) lies the Alpine Tundra which occupies the mountain tops and covers only a small portion of the licence area. These elevation limits are only an approximation of the zonal boundaries which are modified by topography, aspect and micro-climatic factors.

The study area contains a diversity of plant communities. Elevational gradients largely account for the zonal transitions. Substrate ranges from fluvial materials in the valley bottoms to in situ weathered material at higher elevations along with blankets, veneers and aprons of colluvium and glacial till. The effect of aspect is extremely important, with steep south-facing slopes covered by meadows, as opposed to equivalent northerly aspects characterised by larch communities. Also, past fire activity has influenced the pattern of plant communities, especially through the formation of seral lodgepole pine (Pinus contorta) communities and subalpine meadows.

The climax forest in the Subalpine Engelmann Spruce - Subalpine Fir zone is composed of alpine fir (Abies lasiocarpa) and Engelmann spruce (Picea engelmanii). The zone is subdivided into the forested subzone generally below 2225 m (7,300 ft) and the Krummholz subzone at higher elevations. The forests in the Krummholz subzone, due to severe climatic conditions, attain only a shrub form (less than 10 m in height). Lodgepole pine is the major seral species in the forested subzone but rarely occurs in the Krummholz subzone.

At elevations greater than 2400 m (7,875 ft) climatic conditions are so severe that tree growth is impossible, however, small shrub growth (less than 2 m in height) does occur on some sites. This area is described as the Alpine Tundra zone. Alpine plant communities occur in the study area at lower elevations because of specific site conditions such as wind, exposure and aspect (edaphic tundra).

The Brownie Creek licence area was mapped into nine map units. (corresponding to habitat types) based on air photographs, forest cover maps, R.A.B. vegetation map and descriptions (unpublished), and field descriptions of vegetation types (Map 5). Complexes of map units were mapped where separation into distinct units was not feasible. Map units were composed of one or more vegetation types. These vegetation types were derived from an assessment of individual plot data whereby plots whose species composition were similar, were subjectively grouped into a vegetation type. These types were named by dominant species based upon their position in the canopy, total cover and constancy of cover.

A listing of 145 vascular plants, bryophytes and lichens was made from the study area (Appendix 5). Tree mensuration data are presented in Appendix 6. Floristic data for map units sampled are presented in Tables 14-19. The numerical coding of general plot data are explained in Appendix 7.

Descriptions of each map unit and its vegetation types are given below.

4.5.2.2.1 Mature Engelmann spruce-alpine fir map unit

This map unit represents areas of climax and late successional coniferous forests and covers large portions of the low to mid-elevation slopes of the licence area (Map 5). The upper limits of this map unit are at approximately 2200 m (7218 ft) elevation, depending upon slope and aspect.

The soils in this map unit are generally well drained but may be moderately well drained on gentle slopes. This unit is found on shallow to deep colluvial, deep morainal and deep fluvial soil materials on moderately to steeply sloping areas. This map unit is not restricted to any particular aspect.

Three plots were described in this map and all represent the spruce-fir-moss vegetation type (Table 14).

4.5.2.2.1.1 Spruce-fir-moss

The vegetation cover in this type was quite uniform and extensive (80-90%) (Figure 7). The semi-open tree canopy (27-40%) was mainly composed of Engelmann spruce (20-35% cover) with some alpine fir (5%) and occasional western larch (<u>Larix occidentalis</u>). All three species in the tree layer consisted of large (dbh 40 cm), overmature (>225 yr in age) and tall trees (height 20-24 m).

The shrub layer contained moderate to dense cover (45-70%) composed of numerous species. Alpine fir and Engelmann spruce composed the B_1 layer (2-10 m in height) with cover values ranging from 2 to 15 percent. The most dominant or frequently occurring shrubs in the B_2 layer (<2 m in height) included: fool's huckleberry (*Menziesia ferruginea*) (1-30%), Rocky Mountain rhododendron (*Rhododendron albiflorum*) (2-35%), grouseberry (*Vaccinium scoparium*) (2-30%), dwarf bilberry (*Vaccinium myrtillus*) (8-15%), alpine fir (2-5%) and Engelmann spruce (2-5%). The occurrence of Engelmann spruce and alpine fir, the two climax species in the shrub layer, indicates that these areas will remain under climax forests in the future unless some disturbance occurs.

The herb layer had a low total cover (6-10%) composed of numerous species but none represented higher than 3 percent cover. Typical species which occurred regularly with low cover values included: heart-leaved arnica (*Arnica cordifolia*), sedge (*Carex* sp.), bunchberry (*Cornus canadensis*), strawberry (*Fragaria virginiana*), one-sided wintergreen (*Pyrola secunda*) and veiny meadowrue (*Thalictrum venulosum*). The moss and lichen layer was well represented (24-42% cover) under the dense canopy of trees and shrubs, with the major species being *Lophozia* sp. (5-20%), *Pleurozium* sp. (15-30%) and *Aulacomnium* sp. (15%). Other species which occurred frequently with low cover values included: *Cladonia* sp. (<1 to 2%), *Atrichyum* sp. (2%) and *Peltigera* sp. (2%)

4.5.2.2.2 Logged map unit

This map unit occurs along Kilmarnock Creek and near the confluence of Brownie Creek and Kilmarnock Creek. It represents areas of early successional vegetation regenerating after logging which was started in the early 1970's in the study area. Before logging, this area was covered by climax forests of Engelmann spruce and alpine fir.

Three plots were described in this map and all represent the elderberry-currant-fireweed vegetation type (Table 15).

4.5.2.2.2.1 Elderberry-currant-fireweed

The total vegetation cover in this type was moderate (50-70%) and was mainly composed of herbs (Figure 8). Total shrub cover, all of which occurred as the B_2 layer, was low (10-15%), mainly composed of early pioneer species such as elderberry (Sambucus racemosa) (2-6%), bristly black currant (Ribes lacustre) (1-2%) and willow (Salix sp.) (1-2%). The presence of alpine fir and Engelmann spruce in some areas is a good indication that this map unit will revert to climax forest.

The moderate cover (40-60%) in the herb layer was quite variable in its species composition, depending upon available moisture, logging history and other site conditions. Fireweed (Epilobium angustifolium), an early colonizer on disturbed sites, was generally quite common and abundant in most areas (5-30%). Other herbs which were typical of this type or contributed significantly to their ground cover values included: smooth aster (Aster laevis) (<1 to 15%), strawberry (3-5%), fowl bluegrass (Poa palustris)(<1-15%), field horsetail (Equisetum arvense) (10%) and ryegrass (Elymus innovatus) (25%).

4.5.2.2.3 Seral pine-Engelmann spruce-alpine fir map unit

This map unit covers large portions of the licence area at lower elevations with moderate to steep, well-drained slopes. The vegetation consists of open coniferous seral forests with lodgepole pine as the major seral species, except at higher elevations where it is replaced by white bark pine (Pinus albicaulis). Lodgepole pine occurs in the tree or shrub layer along with alpine fir and Engelmann spruce which are the climax species and eventually replace lodgepole pine. Lodgepole pine stands develop primarily after fire and it appears that a series of fires had extended through the area giving rise to uneven aged stands. Both young seral and maturing seral communities occur in the licence area though the plots sampled were all in the young seral communities.

This unit is described by six vegetation plots all of which represent the pine-spruce-fir vegetation type (Table 16).

4.5.2.2.3.1 Pine-spruce-fir

This vegetation type occurs on well drained moderate to steep slopes generally with sandy loam textured (rarely silty clay loam) colluvial or morainal soil materials. This type represents young seral forests in various successional stages and includes both treed and shrubby areas (Figure 9).

On treed plots, the open tree canopy (4-25% cover) was formed by lodgepole pine (2-7%), alpine fir (2-5%) and Engelmann spruce (15%). The tree layer consisted of uneven aged trees (31-50 yr in age) with canopy height ranging from 12.5 m to 17.9 m (Appendix 6).

The shrub cover was quite variable (30-70%) depending upon available moisture and other site conditions. Evapotranspiration may generally be high where this type is found on southerly exposures, thereby affecting the shrub cover. The tall shrub layer (2-10 m in height) was entirely composed of lodgepole pine (3-5%), alpine fir (1-10%) and Engelmann spruce (3-10%), except one high elevation site (plot 3) where white bark pine also formed 4 percent cover. The low shrub layer (<2 m in height) was composed of numerous species and the most typical included: soapberry (Shepherdia canadensis) (2-35%), grouseberry (1-30%), alpine fir (2-5%), Engelmann spruce (2-5%), lodgepole pine (2%), willow (Salix sp.) (2%), common mountain juniper (Juniperus communis) (1-2%), bristly black currant (1-2%) and elderberry (1-2%). In one of the plots, fool's huckleberry formed 15 percent cover. The occurrence of climax species (Engelmann spruce and alpine fir) in the tree and/or shrub layer indicates that these areas, if not disturbed, will succeed to spruce-fir-moss type in the near future.

The herb cover was quite variable (10-70%) due to the shading effect of trees or shrubs and other site conditions. The herb layer was composed of numerous species but none of them formed higher than 5 percent cover except ryegrass (Elymus innovatus). The most typical herbs which occurred consistently included: common yarrow (Achillea millefolium) (<1-1%), pearly everlasting (Anaphalis margaritacea) (<1-2%), fireweed (1-2%) and strawberry (2-4%). Ryegrass with 50 percent cover, added significantly to the herb layer at one site (plot 17) on a steep slope with southerly aspect. The moss and lichen cover was low (<1 to 7%), represented by few species with none higher than 3 percent cover.

4.5.2.2.4 Young Engelmann spruce-alpine fir map unit

This map unit consists of immature open stands (generally less than 60 yrs old) or of non-productive brushland of Engelmann spruce and alpine fir. This map unit generally occurs between 2000 m (6560 ft) and 2200 m (7218 ft) elevation and covers a large portion of the higher elevations in the study area (Map 5). It occurs on shallow to deep colluvial and morainal soil materials on moderately to steeply sloping areas and is not restricted to any particular aspect.

This map unit is described by three vegetation plots representing two vegetation types. (Table 17).

4.5.2.2.4.1 Spruce-fir-grouseberry

This vegetation type consists of an open coniferous forest dominated by alpine fir and Engelmann spruce. Whitebark pine and alpine larch were sometimes found (Figure 10). This vegetation type occurs on level to steep slopes and covers most of the map unit. Generally, the soils are well drained but may be moderately well drained on gentle slopes.

The shrub cover was moderate to dense (40-70%) and was composed of numerous species. The tall shrub layer (2-10 m in height) was entirely formed by alpine fir (2%) and Engelmann spruce (6-8%) while the low shrub layer (<2 m in height) was dominated by grouseberry (15-50%). Other shrubs which occurred frequently with low cover values included: alpine fir (1-4%), Engelmann spruce (2-4%), alpine larch (Larix lyallii) (2%) and white bark pine (3%).

The very low cover (5-6%) of the herb layer was represented by few species with none having higher than 3 percent cover. Pussy-toes (Antennaria anaphaloides) and spike tristeum (Trisetum spicatum) occurred frequently with low cover values. Moss and lichen cover (3-12%) was poorly represented by Cladonia sp. (<1-3%), Stereocaulon sp. (1%) and Bryum sp. (10%).

This open coniferous forest, if remaining undisturbed, will eventually form mature climax stands. Changes will include the closing of the tree canopy and development of an understory with a well represented moss layer characteristic of humid conditions.

4.5.2.2.4.2 Fir-currant-grouseberry

This vegetation type is an early successional stage to the spruce-fir-grouseberry type and eventually will succeed to the same if undisturbed. This type was described by one vegetation plot (19) located in a creek bed (Map 5) and therefore, may not be representative of the whole area.

The shrub layer was similar in composition to the type described above except that the tall shrub layer (2-10 m in height) had lower cover values (6%) and the low shrub layer (<2 m in height) was dominated by northern gooseberry (Ribes oxycanthoides) (30%). Grouseberry, although reduced in its cover value, still contributed significantly to the shrub layer with 15 percent cover. Other low shrubs with cover values higher than 1 percent included: willow (Salix sp.) (2%) and elderberry (4%).

The herb layer had much higher cover (25%) and species diversity in this type than the spruce-fir-grouseberry vegetation type. Typical herbs with higher than 2 percent cover included: yellow penstemon (Penstemon confertus) (5%), pearly everlasting (3%), wheatgrass (Agropyron sp.) (3%), fireweed (3%) and strawberry (3%). (The moss and lichen layer could not be assessed due to a snow fall at the time this plot was assessed.)

4.5.2.2.5 Alpine larch-alpine fir map unit

This map unit occurs at higher elevations (generally above 2200 m) of the study area on steep slopes with north to north-west aspects. These areas are characterized by lower temperatures, longer snow periods and shorter growing seasons. This map unit generally occurs on well drained glacial till and colluvial materials of variable depth. Alpine larch and alpine fir compose the tree or shrub layer with Engelmann spruce occurring occasionally. These species may be the climax vegetation of high elevation north slopes.

Two vegetation plots were described in this map unit and both represent the larch-fir-grouseberry vegetation type (Table 18).

4.5.2.2.5.1 Larch-fir-grouseberry

This vegetation type represents mature (Figure 11) forests as well as immature shrubby areas. Alpine larch on treed areas has an open canopy (8% cover) with rounded crowns showing maturity (91 yrs old). The shrub and understory composition was generally similar in both shrubby and treed areas.

The shrub layer had dense cover (70%) composed of numerous species. The tall shrub layer (2-10 m in height) was formed by alpine larch (5-25%) with some alpine fir (2%). Grouseberry (30%) and crowberry (Empertrum nigrum) (4-30%) dominate the low shrub layer (<2 m in height). Other shrubs with lower cover values included: alpine larch (4-5%), alpine fir (1-2%), Rocky Mountain rhododendron (4%), Engelmann spruce (2%) and dwarf bilberry (2%).

The herb layer contained 25 percent cover composed of numerous species, the most typical included: aster (Aster alpigenus), curly sedge (Carex rupestris), hawkweed (Hieracium gracile), alpine bluegrass (Poa alpina) and spike trisetum, all with 1 percent or less cover. Woodrush (Luzula parviflora) (1-4%) and alpine timothy (Phleum alpinum) (1-5%) were common. Herbs which occurred occasionally but formed higher than 2 percent cover included: western pasqueflower (Anemone occidentalis) (7%), pussy-toes (Antennaria anaphaloides) (4%), aster (Aster sp.) (3%) and valerian (Valeriana sitchensis) (4%).

The moss and lichen layer had low cover (4-18%) with Aulacomnium sp. (18%) and Aulacomnium palustre the major mosses.

4.5.2.2.6 Meadow map unit

This is a broad map unit which includes: treeless meadows in the Alpine Tundra zone (above 2300 m); subalpine meadows with dry southern aspect in the Subalpine Engelmann Spruce-Alpine Fir zone at lower elevations; sedge meadows in wet pockets; and slide areas where continued snow movement prevents establishment of trees. The harsh alpine environment prohibits trees in the alpine areas, although occasionally straggling prostrate shrubs are found in sheltered areas. In subalpine meadows on south to south-easterly aspects with steep slopes, intense solar radiation creates intense moisture deficiency preventing establishment of trees. These meadows represent edaphic climax areas and probably will remain unchanged for long periods if undisturbed.

The soils have developed from till or colluvium materials of variable depth. Demarchi (1968) states that "soil studies carried out by Canada Land Inventory personnel reveal that grassland soils have developed over forest soils through repeated forest fires, which destroyed the forest cover more than 500 years ago --- and can be considered unique to the area". The invasion of trees into the meadows is suppressed by lush herb growth and grass-formed sods. Slight differences in slope, aspect or soil texture appear to modify the species composition.

Two vegetation types were described from this map unit (Table 19).

4.5.2.2.6.1 Fescue-wheatgrass

This vegetation type was described by two plots, one in the Alpine Tundra zone and another in subalpine Engelmann Spruce-Subalpine Fir zone (Figure 12). Species composition in both plots were similar.

This vegetation type occurs on steep slopes with a south or southeast aspect. The shrub layer was absent except in one plot where common mountain juniper occurred as a low shrub (<2 m in height) with 1 percent cover.

The herb layer contained a high cover (85-90%) composed of numerous species. Rough fescue (Festuca scabrella) (25-50%), bluebunch wheatgrass (Agropyron spicatum) (6%) and an unnamed hybrid of wheatgrass and squirrel tail (Agropyron caninum x Sitanion hystrix) (30%) dominated the herb layer. Other herbs which occurred commonly or formed higher than 2 percent cover included: strawberry (3-10%), yellow hedysarum (Hedysarum sulphurescens), yellow penstemon (3-4%), smooth aster (1-5%), varileaf phaclia (Phacelia heteropylla) and fowl bluegrass (4%). The moss and lichen layer (2-4%) was poorly represented by Torula princeps and Peltigera sp. due to dry conditions.

4.5.2.2.6.2 Aster-timothy-wheatgrass

This vegetation type occurs on steep slopes with an eastern aspect under favourable moisture regimes.

The very low shrub cover (3%) of the B_2 layer (<2 m in height) was composed of bristly black currant (2%) and grouseberry (1%)

The dense herb layer (80%) was dominated by showy aster (Aster conspicuus) (20%), alpine timothy (15%) and bluebunch wheatgrass (10%). Other herbs with higher than 2 percent cover included: rough fescue (8%), strawberry (8%), leafy bromegrass (Bromus pumpellianus) (5%), scarlet paintbrush (Castillaja miniata) (5%) and yellow penstemon (3%). The moss cover was poorly represented by Polytrichum sp. (2%).

4.5.2.2.7 Pioneer shrub map unit

This map unit is dominated by pioneer shrubs such as willows (*Salix* sp.), alders (*Alnus* sp.) and others prior to establishment of seral tree species. This pioneer unit may represent an early stage in succession to forest communities or it may represent shrub communities on recent surficial deposits including those subject to periodic disturbance such as avalanches and floodplains. This map unit occurs on a variety of sites mixed with other units.

4.5.2.2.8 Alpine fir-krummholz map unit

This map unit forms the upper portion of the Subalpine Engelmann Spruce - Alpine Fir zone. This unit has moderate to low cover of alpine fir and Engelmann spruce which, due to harsh climatic conditions at high elevations and exposure to wind, attain only a shrub growth form (<10 in height). Aspect and slope position determine moisture conditions which influence species composition.

4.5.2.2.9 Non-vegetated map unit

This map unit occurs at higher elevations of the licence area as the upper edge of the Alpine Tundra on steep talus slopes or disturbed areas at lower elevations. These slopes are composed of large boulders and afford little soil. Growth is severely restricted except to lichens and mosses, although there are pockets where enough moisture exists to support alpine fir, Engelmann spruce and other shrubs.

4.5.3 Wildlife

The Fording River valley and adjacent highlands support a variety of wildlife species including ungulates, large carnivores, small furbearers and birds. A list of mammal species which may occur in the Fording River drainage area is presented as Appendix 8. This list was compiled from range maps shown in Banfield (1974) and Cowan and Guiguet (1973). Many of the fifty-three species listed may actually not be present in the Brownie Creek coal licences or the larger, general study area (Kilmarnock and Henretta Creek valleys and area between).

A wide variety of bird species favouring upland habitat types may occur in the upper Fording River watershed area. A list of 150 species whose breeding ranges coincide with the area is presented as Appendix 9. This list includes species which may not be present in the area due to lack of suitable habitat. Conversely, several additional species may occur as migrants only. Due to the short time spent in the study area many bird species which may breed in the area may have been missed. The observations recorded were, therefore, biased toward the larger and more observable species.

Ungulates are the major wildlife resource in the upper Fording River and consequently received greater attention than other wildlife. Ungulates inhabiting the Fording River drainge area are mule deer (*Odocoileus hemionus hemionus*), white-tailed deer (*Odocoileus virginianus ochrourus*), moose (*Alces alces andersoni*), elk (*Cervus elaphus nelsoni*), mountain goats (*Oreamnos americanus*) and bighorn sheep (*Ovis canadensis canadensis*). All of these are important big game animals and, with the exception of mountain goats, are open to hunting in the Fording River drainage area.

4.5.3.1 Review of previous B.C. Research wildlife studies

Wildlife aspects studied during the previous B.C. Research investigations of the Fording Coal area were concerned only with ungulates and results were detailed in three reports (B.C. Research, 1970b; ____, 1971; ____, 1972).

Wildlife observations were first done in conjunction with the vegetation survey in October, 1969. Observations were summarized in a subsequent report (B.C. Research, 1970b) and, together with results of an aerial big game survey conducted on April 26, 1970, are presented as Appendix 11. The aerial survey covered the Fording River valley and Mount Turnbull and Eagle Mountain area. Seventeen elk and one moose were counted during the survey. As well, elk and moose winter ranges were delineated on a map, as based on previous B.C. Fish and Wildlife Branch surveys. In addition to observation data, the report presented information from autopsy of a hunter-killed moose (October 27, 1969).

Observations of big game and sign were collected during vegetation studies conducted from September 29 - October 4, 1970 and were summarized in B.C. Research (1971). Food habit data for a buck mule deer collected on Eagle Mountain on October 3, 1970 were given (see Appendix 12). In addition, food habits data were given for two hunter-killed moose from the Green Hills area of the Fording River valley (see Appendix 13).

Observations of big game and sign were again collected during May 26-31 and July 26-29, 1971 vegetation studies (B.C. Research, 1972). Results were tabulated and are presented as Appendix 14. Information from a B.C. Fish and Wildlife Branch survey conducted on February 20, 1971 and observations by Fording Coal Ltd. field personnel were also discussed.

4.5.3.2 1978/79 wildlife studies

The pellet transect survey conducted in September, 1978 served to provide an estimate of level of use of habitat types available; data are presented in Table 20 and the location of plots (transects) are indicated on Map 5. The aerial survey served to delineate winter and spring ranges in the larger study area; survey results are presented in Table 21 and sightings indicated on Map 6. Details of the flight are summarized in Appendix 9.

The importance of the Brownie Creek coal licence area and the habitats available have been briefly evaluated for each of the major wildlife species or groups of species. The preliminary nature of field surveys precluded a detailed assessment of habitat relationships.

4.5.3.2.1 Elk

Elk are the most abundant and widespread ungulate in the upper Fording River drainage area. Much of this region represents elk summer range, rated as Class 3 (moderate capability), Class 4 (moderate low) or Class 5 (low capability) by the R.A.B. The exceptions are the rocky ridges, bluffs and talus slides on the higher peaks of the Continental Divide. The Brownie Creek coal licences lie mostly in Class 4 and Class 5 lands.

Elk sign was generally abundant in the area surveyed during September, 1978. Fresh droppings and several beds were found on the open ridge in Lot 6694, east of Brownie Creek near plots 1 and 2. A fresh bed and a single elk were also observed at the top edge of the burn along McQuarrie Creek, near plot 10 in the seral pine-spruce-fir habitat. Fresh tracks and beds were also observed in the creek bottom near the confluence of Henretta and McQuarrie creeks and in the seral pine-spruce-fir habitat along Brownie Creek near plot 20 (Map 5). During studies conducted in 1969-70 and 1971 elk and sign were observed on Mount Turnbull and Eagle Mountain (Appendices 10 and 13).

Further evidence of the abundance and widespread occurrence of elk in the area was provided by the abundance of well established game trails in the area and a game lick on the west slope of Mount Farquhar near plot 7. These would be used mostly by elk but also by other ungulates in the area.

The pellet transect survey provided an insight into the relative habitat preferences of elk in the study area on a seasonal basis as pellets were described as summer or winter - type. The highest overall use appeared to be in the logged habitat sampled at plots 11, 13 and 16 with 1.0 to 1.6 pellet groups per plot (Table 20). Summer-type droppings ranged from 50-80 percent of the total elk pellets in the areas sampled. Next highest were the seral pine-spruce-fir habitat (0.2 to 0.4 pellet groups per plot) which had 50-100 percent summer-type pellets and the meadow habitat (0 to 0.4 pellet groups per plot) with 75-100 percent summer-type pellets (Table 20).

All habitat types in the area appear to be used as summer range. The logged, meadow and seral pine-spruce-fir habitat types have a high capability as elk summer range. The mature and young Engelmann spruce-alpine fir and alpine larch-alpine fir habitats have a moderate capability. Suitable elk forage is available in these habitat types, including both grasses and forbs in the herb layer and browse in the B2 shrub layer.

Results of the survey indicate that the logged habitat in the Kilmarnock Creek valley received heavy use by elk, especially along the interface with the remaining stands of mature Engelmann spruce-alpine fir. This was supported by the observation of numerous, well-used elk trails heading down from the mature forest into the logging slash. The presence of piled-up slash in much of the logged area, however, detracts from the suitability of this habitat as elk tend to avoid areas of excessive accumulation of slash. The mature Engelmann spruce-alpine fir habitat on the south side of the upper Kilmarnock Valley provides important cover for elk in the summer and fall.

Elk winter ranges in the upper Fording area were mapped by Demarchi (1968) and included the southern exposure slopes on Eagle Mountain, Mount Turnbull and the slopes on the north side above Henretta Creek. The preliminary R.A.B. biophysical mapping identifies these same areas as elk winter range, as well as the valley bottoms of Henretta and Kilmarnock creeks and the Fording River, mostly as Class 3 (moderate capability) winter range. The steep, south-facing grassland slopes of Mount Turnbull are rated as Class 1 (high capability) winter range while the grassland slopes north of Henretta Creek are rated as Class 2 (moderate-high capability) winter range.

The results of the March 19, 1979 aerial survey by B.C. Research confirmed that the southern-exposure, grassland slopes in the previously described areas are the main winter ranges for elk in the upper Fording drainage area. Fifty elk (in five bands) were counted on the steep, south-facing grassland slopes of Eagle Mountain (Map 6; Table 21). A large band of elk were observed on the west ridge of Mount Turnbull, again in a grassland type habitat just above treeline (Map 6). An abundance of tracks on the south facing alpine slopes of Mount Turnbull suggests that this band had been active over a fairly large area. A band of three elk were observed on an open hill top and a band of fifteen on an open, grassy ridge top north of Henretta Creek (Figure 14; Map 6).

During annual surveys conducted by the Fish and Wildlife Branch, elk have regularly been counted on the south-facing slopes of Eagle Mountain above lower Kilmarnock Creek. During a spring survey conducted by B.C. Research on April 22, 1970, a band of sixteen elk were seen on a south-west slope on Eagle Mountain (Appendix 11).

No elk or elk tracks were observed in the Brownie Creek coal licence area during the March 19, 1979 B.C. Research survey. The lack of elk use in this area can be attributed primarily to excess snow cover during most of the winter. Only a few, small patches of meadow habitat were snow-free in the area during the survey. This factor and the relative remoteness of this area from the winter ranges on Eagle Mountain and Mount Turnbull impose major limitations on the capability of the area as elk winter range. The Kilmarnock Creek valley bottom, though rated as a Class 3 winter range, presently has no capability as winter range due to the removal of the mature forest cover. The logged areas, however, appear to be used heavily during the spring "green-up" period.

Of the habitat types described in this study, the meadow habitat has a high capability and the seral pine-spruce-fir habitat has a moderate capability as elk winter range. It must be emphasized that these are only potential capabilities with respect to the Brownie Creek coal licences. The capabilities of these habitats is due to their generally open nature which allows rapid snow-melt, their location in generally steep, southern exposure terrain and the presence of forage species which are consumed by elk during the winter to spring period.

The meadow habitats sampled in 1978 had several species of grasses, including rough fescue (Festuca scabrella), bluebunch wheatgrass (Agropyron spicatum) and bluegrass (Poa sp.), as well as aster (Aster sp.), all of which are consumed by elk. The range survey conducted by B.C. Research in 1971 found that several species of sedges (Carex sp.), aster (Aster sp.) and lupine (Lupinus sp.) were also present in the meadow habitat, and along with the grasses previously mentioned, are generally considered to be valuable elk forage (Kufeld, 1973).

Browse is also a necessary source of forage during winter. Several species of browse considered to be valuable elk winter forage (Kufeld, 1973) occur in the seral pine-spruce-fir habitat including: soapberry (Shepherdia canadensis), aspen (Populus tremuloides), willows (Salix sp.), rose (Rosa sp.), serviceberry (Amelanchier alnifolia) and bearberry honeysuckle (Lonicera involucrata). Aspen, willows, rose and serviceberry were found to be the major browse species consumed by elk on the Grave Lake winter range to the south of the Fording valley during an earlier study by B.C. Research (1977).

Areas where the meadow habitat, with its abundance of herbage, and the seral pine-spruce-fir habitat, with an abundance of palatable shrubs, occur together are particularly valuable winter range. Such areas are predominant along the mid-to-lower elevation, south-facing slopes on Mount Turnbull and Eagle Mountain. The availability of forage in the meadow and seral pine-spruce-fir habitats and the availability of shelter and cover in the latter habitat, further enhances the capability of the south-facing slopes of Mount Turnbull and Eagle Mountain as elk winter range, and also as valuable summer range. These habitats also occur in the Brownie Creek coal licence area, however, the capability is greatly reduced by extended snow cover.

4.5.3.2.2 Deer

Mule deer and white-tailed deer occur in small numbers in the Fording River drainage area. Most of the Brownie Creek study area and adjacent highlands represent summer range for mule deer, rated as Class 4 (moderate to low capability). The valley bottoms of Henretta and Kilmarnock Creeks and the Fording River have the same rating as well as being rated as Class 5 (low capability) summer range for white-tailed deer.

Deer sign was observed infrequently during ground work in September, 1978. No deer were observed although the remains of a hunter killed mule deer were found on the slope near Plot 17 west of Brownie Creek. During previous field work by B.C. Research (in fall 1970 and summer 1971), several mule deer were observed on Eagle Mountain. The results of the pellet transect survey indicate that deer occur in most of the habitat types available in the study area, but at low densities.

Some information on food habits of deer in the area is available from an earlier study (B.C. Research, 1971). Analysis of rumen samples from the yearling buck collected on Eagle Mountain in October, 1970 revealed that browse and herbage were almost equally consumed (50.3% and 49.7%, respectively) (Appendix 12). Important browse species were box wood (Pachistima myrsinites), rose (Rosa sp.) and black cottonwood (Populus trichocarpa). Herbage was comprised mostly of avens (Geum triflorum). The high proportion of herbage in the sample is expected during the summer and fall when forage is abundant in the grassland and seral pine-spruce-fir habitats.

Preferred deer habitats include open coniferous forests, sub-climax brush, aspen parklands, the edges of deciduous forests, alpine and subalpine meadows and riparian habitats. Most of the habitat types in the area have some capability as summer range for deer, with the logged, seral pine-spruce-fir and young Engelmann spruce-alpine fir habitats favoured as summer range.

No specific deer winter ranges are identified by the biophysical mapping of the R.A.B. Deer or deer sign were not observed during the March 19, 1979 aerial survey of the study area nor during B.C. Fish and Wildlife Branch winter surveys conducted from 1976 to 1979.

Deep winter snow (during most years) and cold temperatures make the upper Fording area unsuitable as deer winter range. During the late winter and early spring period when south facing hillsides become snow-free, such slopes have some capability, though limited, as deer winter range. Once the snow has left the large logged areas, these would likely receive considerable use by deer during the spring and early summer.

4.5.3.2.3 Moose

Moose are moderately abundant in the upper Fording River drainage area, occurring primarily in valley and creek bottoms. Most of the upland region of the Brownie Creek coal licences and adjacent area, with the exception of the exposed ridge tops and rock bluffs, are classified as Class 4 and Class 5 (moderate - low and low capability, respectively) moose summer range. As well, the valley bottom of the Fording River and Kilmarnock and Henretta Creeks have at least a moderate capability.

During September, 1978 field work very little moose sign was observed in the Brownie Creek licence area and little evidence of moose sign was noted during the pellet transect survey (Table 21). Some sign was observed at the lower elevations along creek drainages. Two adult bull moose were observed in a bog approximately 2 km northwest of Plot 10 within the large burn area (seral pine-spruce fir habitat) along McQuarrie Creek.

As moose are primarily browsers, the species favours valley bottoms and sub-climax forests at low elevations where browse is plentiful. Examination of a hunter killed moose (October 27, 1969) revealed that the rumen sample was comprised mostly of willow (*Salix* sp.) and red-osier dogwood (*Cornus stolonifera*) twigs; these shrub species also showed evidence of browsing along water courses in the area (B.C. Research, 1970b).

Analysis of rumen samples from two hunter killed moose from the Greenhills area determined that mainly browse was used by one animal (96.7%) whereas the other used almost exclusively herbage (grasses and forbs, 98.7%) (Appendix 13) (B.C. Research, 1971). In the latter sample, pinegrass (*Calamagrostis* sp.) was the most important food while in the sample dominated by browse, willow (*Salix* sp.) and soapberry (*Shepherdia canadensis*) were the most abundant food source, followed by alder (Alnus sp.) and black cottonwood (Populus trichocarpa).

In the Brownie Creek coal licence area, willows, alder, soopolallie and serviceberry are all available, particularly along the creek bottoms and the latter two species in the seral pine-spruce-fir habitat. Moose generally inhabit sub-climax forests where abundant deciduous vegetation is available, such as burn areas, river bottoms and lake shores. The seral pine-spruce-fir, logged and mature and young Engelmann spruce-alpine fir habitats all have a moderate capability as summer moose range. Moose appear to make only limited use of the Brownie Creek licence area during the summer to fall period.

In the upper Fording River area, moose appear to be confined to the Fording River and Henretta Creek valley bottom during the winter period, moving down to their ranges from the upper valleys and adjacent uplands with the onset of heavy snowfalls. Moose winter ranges generally occur in valley bottoms and in the early successional stages of burns at lower elevations. Moose are heavily dependent on browse as a food source during the critical winter period.

The R.A.B. biophysical mapping identifies Class 3 moose winter ranges in the upper Fording River drainage area as being along the valley bottoms of the Fording River and the lower portions of Kilmarnock and Henretta Creeks. Only the upper portion of the Kilmarnock Creek winter range extends into the Brownie Creek coal licence area.

During the March 19, 1979 aerial survey, nine moose were observed along Henretta Creek (Map 6; Table 22). All were close to the creek in open habitat where willows and other shrubs were abundant. Sightings varied from 1735 m (5700 ft) to 1830 m (6000 ft) along the creek, generally a high elevation for wintering moose. However, snow conditions in the area at the time of the survey were conducive to moose as maximum depth along the creek did not exceed 30-60 cm (1-2 ft) and browse was readily available through the snow.

Moose were not observed along Kilmarnock Creek although several sets of old tracks were noted. In the Fording River Valley moose tracks were relatively abundant south of Kilmarnock Creek.

Few moose have been observed in the upper Fording River area during recent Fish and Wildlife Branch surveys. These surveys, however, were not conducted specifically for moose and a large portion of the wintering population may have been missed. Demarchi (1968) reported that "scattered moose winter singly, in pairs and small groups in the riparian habitat and open burns along the Elk and Fording Rivers".

Of the habitat types available in the study area, the mature Engelmann spruce-alpine fir and logged habitats have a low capability as moose winter range. The pioneer shrub habitat, comprised primarily of willow growing along a creek, has a moderate capability as moose winter range and is predominant along Henretta Creek. The Kilmarnock Creek bottom will not provide suitable moose winter range until the logged areas have regenerated a tall shrub cover (from five to ten years).

4.5.3.2.4 Bighorn sheep

Rocky Mountain bighorn sheep are relatively abundant in the upper Fording River drainage area and are a common summer resident in the higher regions of the Brownie Creek coal licence area and vicinity. To the east of the Fording River, all of the upland regions are classified as summer range for sheep, either Class 4 (moderate-low capability) or Class 5 (low capability).

During September, 1978 field work, sheep sign was fairly abundant in the open, south-facing subalpine zone on the ridges east of Brownie Creek (Lots 6694 and 6706). Sheep droppings were particularly abundant in the meadow habitats along the open, steep ridges at Plots 2 and 5 (Map 5; Table 21) and in the alpine larch-alpine fir habitat at Plot 6, lying just below the meadow habitat on the ridge in Lot 6706. The pellet survey indicated lesser use of the other habitat types (Table 21).

On the basis of the field data it appears that the meadow habitat has a high capability as sheep summer range. This can be attributed to the nature of the terrain where this habitat occurs (steep, southern exposure slopes), the early snow melt in the spring and an abundance of high quality sheep forage, including bluebunch wheatgrass (*Agropyron spicatum*) and bluegrass (*Poa* sp.).

The capability of the meadow habitats on these ridges is further enhanced by the proximity of escape terrain along the adjoining rock bluffs at Mount Farquhar and Mount Pierce. This rugged terrain may also be used during the lambing period (late May-early June).

The higher portions of the seral pine-spruce-fir, young Engelmann spruce-alpine fir and alpine larch-alpine fir habitats where these occur in the proximity of steep, open terrain, also represent summer sheep range. Several species of herbs, in addition to the aforementioned grasses, are available in these open habitats. The alpine basin to the east of the Brownie Creek licence area represents a large expanse of suitable summer range. Sheep summer range also occurs on the steep, south-facing grasslands (meadow habitat) on Mount Turnbull and Eagle Mountain.

The preliminary R.A.B. biophysical mapping does not identify any specific sheep winter ranges in the study area. No evidence of sheep activity was observed in the Brownie Creek coal licence area and vicinity during the March 19, 1979 aerial survey by B.C. Research. Prime sheep winter ranges are on windblown ridges with a southern exposure where the reduced snow cover allows sheep to forage for exposed vegetation. As sheep are primarily grazers, the availability of exposed forage is extremely important to the species. The major limitation of the open ranges within the Brownie Creek coal licence area appears to be predominant snow cover during most of the winter period. Large expanses of steep, open meadow with a southern exposure are critical for sheep during winter and these are not available. Such ranges are, however, present on the south slopes of Mount Turnbull and Eagle Mountain and, on the basis of habitat availability, these areas have a capability as sheep winter range.

Bighorn sheep in the study area may utilize winter ranges on the east slopes of the Continental Divide (Mr. W. Warkinten, pers. comm.) or may move to winter ranges lower in the Fording drainage. Important sheep winter ranges are located in the Todhunter and Ewin Creek areas to the south (Demarchi, 1968).

4.5.3.2.5 Mountain goat

Mountain goats occur in moderate numbers in the higher regions of the upper Fording River drainage area, primarily the steep, rugged terrain along the Continental Divide. The higher elevations in the Brownie Creek coal licence area, the high elevation, south-facing slopes of Mount Turnbull and Eagle Mountain and the steep, rocky bluffs and ridges along the Continental Divide to the east are classified as Class 4 (moderate-low capability) or Class 5 (low capability) goat summer ranges by the R.A.B. biophysical mapping. The species prefers such rugged terrain and inhabits cliffs, rocky bluffs and talus slopes at the base of cliffs. Mountain goat summer and winter ranges are often contiguous, with goats moving to wind blown ridge tops and bluffs during the winter period.

Neither mountain goats nor their sign were observed during September, 1978 field work in the Brownie Creek coal licence area. The only areas within the immediate study area which have a capability as goat summer range, are the steep grassland ridges trending westward from Mount Farquhar and Mount Pierce. These are dominated by alpine tundra, characterized by steep, rocky bluffs with only sparse vegetation cover.

Of the habitat types described in this study, the meadow, non-vegetated (alpine tundra) and the higher elevation of the young Egelmann spruce-alpine fir map units have a moderate capability as goat summer range.

Demarchi (1968) described the steep grassland on the south-facing slopes north of Henretta Creek as "moderately important" goat winter range and that two or more bands of goats winter on these ranges. Part of this range has been delineated as a Class 3 (moderate capability) winter range under the preliminary R.A.B. biophysical mapping. This is the only winter range specifically delineated as goat winter range in the upper Fording River drainage area by the R.A.B.

Several small groups of mountain goats were observed during the March 19, 1978 aerial survey by B.C. Research. This included four goats in an area of steep, rocky bluffs on the south-facing ridge of Mount Farquhar (Map 6). Groups of three and four goats were observed in similar habitat on the rugged, south-facing slopes of Courcelette Peak at the headwaters of Henretta Creek (Map 6; Table 22). All of these locations were in extremely rugged, steep terrain where snow cover was considerably less than in the lower alpine basins. The snow shedding characteristics of this rugged terain are critical to the survival of goats during the winter.

During a reconnaissance flown on May 12, 1979, a band of five goats were observed on the steep, south-facing grassland slope (meadow habitat) lying on the ridge west of Mount Farquhar (in Lot 6706). During the March, 1979 survey of the area by the B.C. Fish and Wildlife Branch several goats were observed in similar terrain at the headwaters of McQuarrie Creek (Mr. W. Warkinten, pers. comm.). These sightings suggest that actual extent of goat winter ranges in the area may be larger than that delineated by the R.A.B. and could well include part of the Brownie Creek coal licence area.

On the basis of habitat type, the meadow and non-vegetated (alpine tundra) habitats have a moderate to high capability as goat winter range. As well, the upper edges of the young Engelmann spruce-alpine fir and alpine fir-krummholz habitats have a moderate capability and may be important for providing cover and forage during severe winter storms. These habitats provide grasses and forbs which become available under windswept conditions as well as several shrubs, including alpine fir (*Abies lasiocarpa*) and willow (*Salix* sp.).

4.5.3.2.6 Black bear

Black bear (Ursus americanus cinnamomum) sign was observed along a game trail near Plot 12 in the mature Engelmann spruce-alpine fir map unit. The mature forests in the Kilmarnock Creek valley provide suitable habitat for black bears, as do the more open forests along the slopes above the valley and the riparian habitats along larger tributary streams. Open habitats of the higher elevations and exposed ridge tops are not suitable for black bears. The recently logged areas in the Kilmarnock Creek valley are also not favoured black bear habitats as the species generally avoids large, open habitats. Black bears are probably subject to heavy hunting pressure in the area at present. The population appears to be low over most of the study area although food is abundant in most habitats.

4.5.3.2.7 Grizzly bear

The open forested habitats along the higher slopes (seral pine-spruce-fir and young Engelmann spruce-alpine fir map units) and meadows along ridge tops throughout the study area provide suitable habitat for grizzly bears (Ursus arctos). No sign of grizzly was observed during field work although a family of grizzly has been reported as residents in the upper regions of the Brownie Creek drainage for several years (Mr. Ken Clark[9], pers. comm.). The area covered by the Kilmarnock and Henretta Creek valleys and highlands between is large enough to support several bears. Food supply for grizzlies is generally abundant in the region, with grasses and forbs on high elevation meadows and snow slide areas (meadow and seral pine-spruce fir map units) and berry producing shrubs and forbs at lower elevations.

4.5.3.2.8 Other large carnivores

Other large canivores which may occur in the study area include coyote (Canis latrans lestis), wolf (Canis lupus columbianus), mountain lion (Felis concolor missoulensis) and lynx (Lynx lynx canadensis). Of these, only coyote were observed during field work: a lone animal along Henretta Creek during the March 19, 1979 aerial survey. Coyote tracks were observed along lower Kilmarnock Creek in May, 1979. Coyotes and wolves are expected to occur in low numbers throughout the upper Fording drainage area. Lynx occur throughout the coniferous forest zone and may inhabit the creek valleys and the coniferous forests such as in the Engelmann spruce-alpine fir map unit.

4.5.3.2.9 Mustelids

The study area provides habitat for marten (Martes americana abietinoides) in the remaining portions of the mature Engelmann spruce-alpine fir map unit in the Kilmarnock Creek valley and along the lower slopes above Henretta Creek. Mink (Mustela vison energumeros) and river otter (Lutra canadensis evexa) are aquatic furbearers and suitable habitat is restricted to the larger streams in the region such as the Fording River. Mink likely occur along most of Kilmarnock and Henretta Creeks and along the larger tributary streams such as Brownie and McQuarrie Creeks. Wolverines (Gulo gulo luscus) inhabit the alpine regions of the Fording drainage area and can occur throughout the study area. All of the map units may be utilized by this species at some time. Two smaller mustelids, ermine (Mustela erminea invicta) and long-tailed weasel (Mustela frenata oribasus), inhabit mixed forests and riparian habitats and may occur along Kilmarnock and Henretta Creeks and the Fording River.

4.5.3.2.10 Waterfowl

The study area is generally unsuitable for waterfowl, being rated as Class 7 lands (no capability for waterfowl production). The Fording River has a potential for use by river ducks such as Harlequin Ducks and Common Mergansers. One pair of Harlequin Ducks were observed on lower Kilmarnock Creek and a lone male on the Fording River at WS7 in May, 1979. The species probably breeds along these streams at relatively low densities.

4.5.3.2.11 Upland game birds

The study area provides suitable habitat for Blue Grouse, Spruce Grouse, Ruffed Grouse and White-tailed Ptarmigan.

Blue Grouse prefer open habitats during the summer period and frequent burns, logging slash and open coniferous hillsides. These are relatively abundant in the study area. A hen with a brood of three young were observed in September, 1978 in the seral pine-spruce-fir map unit at Plot 17 and a male Blue Grouse along the steep slope within the same map unit between Plots 17 and 18. Several birds were shot by hunters during the September, 1978 field period in the Brownie Creek area. The study area provides excellent habitat for Blue Grouse, particularly throughout the seral pine-spruce-fir map unit. The open coniferous forest along the hillsides and the denser coniferous forest in the valley bottom provide suitable habitat during the non-breeding period.

Spruce Grouse also appeared to be abundant in the area, though confined to the lower elevations within the spruce forest. This species is usually associated with coniferous forests and the seral pine-spruce-fir and Engelmann spruce-alpine fir map units provide ideal habitat. In September, 1978 Spruce Grouse were observed in the seral pine-spruce-fir map unit at Plot 4 (1 male) and in an open stand of immature mixed spruce and pine in the same map unit below Plot 17 (a hen and two young). The remaining stands of Engelmann spruce-alpine fir in the Kilmarnock Creek valley and the open stands in the seral pine-spruce-fir map unit along the Brownie Creek drainage afford suitable habitat for Spruce Grouse.

Ruffed Grouse were not observed and are expected to be less abundant. Ruffed Grouse inhabit sub-climax deciduous and mixed forests at lower elevations, preferring riparian habitats along streams and other moist situations. Such habitat is available along the lower reaches of Henretta Creek, and formerly along much of lower Kilmarnock Creek. Regeneration of the logging slash in the Kilmarnock Valley will provide good habitat for Ruffed Grouse in the future.

White-tailed Ptarmigan inhabit the alpine tundra region, preferring rocky alpine meadows and rock slides. Such habitat occurs only at the higher elevations in the Brownie Creek coal licence area, but is abundant in the alpine region to the east along the Continental Divide, mostly in the non-vegetated map unit. White-tailed Ptarmigan move down to the valley bottom during winter and likely utilize the Kilmarnock and Henretta Creek valleys during this period.

4.5.3.2.12 Raptorial birds

A variety of raptorial birds (hawks, falcons, owls) may occur in the upper Fording area, though only those preferring open, mountainous terrain would frequent the study area in and around the Brownie Creek coal licence area. Species observed during September, 1978 included Merlin, American Kestrel, Golden Eagle, Red-tailed Hawk and a medium size raptor tentatively identified as a Prairie Falcon. These are all species which inhabit open terrain. American Kestrels were abundant in the lower Kilmarnock Valley in May, 1979 and displayed reproductive behaviour.

4.5.3.2.13 Other birds

Several other groups of birds occur in the Fording River drainage area and may occur within the present study area. Songbirds (Order Passeriformes) were the most common and varied group of birds. During September, 1978 the following species were observed: Nuthatches, Dark-eyed Junco, Yellow-rumped Warbler, American Robin, Gray Jay, Mountain Bluebird, Common Raven, Clark's Nutcracker and American Goldfinch. Several flocks of passerines were observed and appeared to be migrating through the area. In May, 1979 the following species were observed in the lower Kilmarnock Creek area: American Robin, Mountain Bluebird, Dark-eyed Junco, Gray Jay, Clark's Nutcracker, Stellar's Jay and Common Raven.

All of the above-mentioned species may breed in the area, as well as several species of chickadees, sparrows, thrushes, vireos and warblers. Those species preferring open habitats would utilize the logged, seral pine-spruce-fir and meadow map units while those preferring older forests would utilize the Engelmann spruce-alpine fir map units and the alpine larch-alpine fir map unit.

Information on other groups of birds (water birds, shorebirds, swifts, hummingbirds, woodpeckers, etc.) is lacking. The short field periods during the late summer and early spring period resulted in a few sightings of birds of these groups. Two killdeer were observed along lower Kilmarnock Creek and a spotted sandpiper in the Fording Valley in May, 1979.

4.6 RESOURCE USE

4.6.1 Land Tenure

Lands in the Fording River drainage area north of Kilmarnock Creek are Crown land, much of which is held under coal leases or licences.

The Brownie Creek study area centres around Lots 6691, 6694, 6203, 6706 and the east half of Lot 6713 which are held as coal licences by Fording Coal Ltd. The immediate area of the Fording Coal preparation plant in the Fording valley is included within the municipal boundaries of Elkford. No private dwellings, homesteads, water rights licences or other mineral claims or licences occur in the area covered by the Brownie Creek coal licences.

4.6.2 Present and Potential Resource Use

4.6.2.1 Present land use

The Canada Land Inventory (CLI) present land use mapping for the study area covering the Brownie Creek coal licences is as follows. The lower elevations in the Kilmarnock Creek Valley are designated as T_1 (mature productive woodland) (at least one tree per acre greater than 11.1 in d.b.h.). The lower, south-facing slopes of the Kilmarnock Creek Valley as well as several areas of the Brownie Creek and upper McQuarrie Creek drainage areas are designated as T_2 (immature productive woodland). Most of the area above the creek valleys is designated as U_2 (non-productive woodland on a non-productive site). The highest slopes, devoid of any continuous tree or shrub cover, are designated as L (rock and other unvegetated surfaces).

The same general distribution of these land use designations applies to the larger study area. The Fording River Valley bottom and adjacent, lower slopes are generally designated as T_1 or T_2, while most of the highlands in the region are designated as U_2, with L on the highest, exposed alpine slopes.

4.6.2.2 Agriculture

Generally, the Brownie Creek coal licences and the larger study area have a very low capability (Class 6 or 7) for agriculture.

Limitations are imposed by near surface bedrock, unsuitable topography, stoniness and adverse climate (in various combinations). The valley bottom of the Fording River has a slightly better capability with combinations of Class 5 (permanent pasture or forage), Class 6 (natural grazing) and Class 7 lands. Agriculture is presently not practiced in the upper Fording River valley.

4.6.2.3 Forestry

The forestry capability of the Brownie Creek coal licences and most of the higher elevations of the larger study is very low, rated as Class 6 (11-30 ft^3 per acre per year) or Class 7 (0-11 ft^3 per acre per year). Limitations are imposed by adverse climate and restricted rooting depth. The valley bottoms along lower Kilmarnock and Henretta Creeks are rated as Class 4 (51-70 ft^3 per acre per year) with the major tree species being Engelmann spruce. Limitations are imposed by soil moisture deficiency and short growing season. The Fording River Valley bottom and adjacent, lower slopes are similarly classified as Class 4 lands for Engelmann spruce with some areas of Class 3 (71-90 ft^3 per acre per year) and Class 5 (31-50 ft^3 per acre per year) for Engelmann spruce. Short growing season and soil moisture deficiency are also the limiting factors in the Fording River Valley.

Portions of the Kilmarnock Creek Valley bottom have been logged in recent years by Crows Nest Industries. This logging extends to the western edge of Lot 6694. Most of the mercantile timber in the Kilmarnock Creek valley has been removed, though stands are still present within Lot 6694. Additional logging in the valley does not appear imminent in the immediate future. Clearing of forest cover has been undertaken by Fording Coal Ltd. along the lower, south-facing slopes at the entrance of the Kilmarnock Creek valley, but has not involved substantial amounts of mercantile timber.

4.6.2.4 Recreation

The Brownie Creek coal licences and the larger study area in general, provide opportunities for extensive outdoor activities such as angling, hunting, camping, hiking, photography and nature interpretation. Recently constructed access along logging and exploration roads has opened up both the Kilmarnock and Henretta Creek valleys.

The recreation capability of the upper Fording River area has been revised by the R.A.B.; this mapping replaces the previous C.L.I. mapping and is described below.

The area covered by the Brownie Creek coal licences has the general recreation features for vegetation (krummholz-subalpine, coniferous or non-forested) and viewing. In addition, other features identified include landform (avalanche tracks and talus), rock formations, local topographic features, small surface waters and waterfalls. The significance of most of these features is rated as moderate or low. The surrounding area has generally the same features. The Eagle Mountain and Mount Turnbull areas also have the feature of wildlife (large mammals). The ridges and peaks along the Continental Divide have the highly significant feature of rock formations.

4.6.2.4.1 Angling

Angling is a common recreational use of the upper Fording River valley. A fishing closure is in effect along the Fording River and its tributaries from December 1 through to June 15 of the following year (B.C. Fish and Wildlife Branch, 1978a). Both Kilmarnock and Henretta Creeks provide cutthroat trout throughout the summer and fall. Angling conducted as part of the fisheries study proved to be fairly successful. However, both these creeks, especially Henretta Creek, are likely subject to less fishing effort than the Fording River. Site-specific data on angler use of the area is lacking.

4.6.2.4.2 Hunting

The upper Fording River watershed lies in Fish and Wildlife Branch Management Unit 4-23. Game animals open to hunting in this area during the 1978/79 hunting season included: mule and white-tailed deer (bucks only), moose (bulls only), elk (bulls only plus limited entry season on antlerless), bighorn sheep (full curl rams only), black bear, mountain lion, raccoon, coyote, skunk, bobcat, lynx, wolverine, grouse (blue, spruce and ruffed), ptarmigan, mourning doves and waterfowl (B.C. Fish and Wildlife Branch, 1978). There is no open season on mountain goats in the Fording River watershed.

The Fording Coal area is protected by a "no shooting area" comprising those lands covered by Lots 6710, 6709, 6639, 6699, 6700, 6981, 6638, 6698, 6697, 6982, 6637, 6688, 6635, 6687 and an unspecified lot lying between Lots 6635 and 6687 (B.C. Fish and Wildlife Branch, 1978).

Recently improved access into the Kilmarnock and Henretta Creek valleys has facilitated use of the area by hunters. The field work conducted in September, 1978, coincided with the beginning of the hunting season. Several hunting parties were active in the Kilmarnock Creek valley, including several camper-type vehicles and two small trailers which had established camps in the valley. One hunter interviewed had taken a six point elk bull on the west side of Brownie Creek and reported another six point elk bull having been taken on the south side of Kilmarnock Creek. One deer kill was found on the hillside west of Brownie Creek (near Plot 17).

Elk appeared to be the most sought after game animal in the area. Deer, moose and bighorn sheep are of secondary importance with the latter species most actively hunted in the higher elevations on the west slope of the Continental Divide. Grouse species are also secondary game species and are fairly abundant in the area. One party of hunters, however, spent a day hunting within the Brownie Creek coal licence area specifically for blue grouse and had taken several birds.

Most hunters appeared to be local residents, going into the area for a day or several days at a time. One hunter was spending a week in the area and reported that he had been hunting in the upper Fording River watershed for "many years".

Site specific data on hunter days, kill locations and success rates are not generally available for the area. The hunter samples for 1970, 1971, 1973 and 1974 resulted in elk kill locations in the following areas during these four years (number of elk kills in brackets): Clode Creek (1), Henretta Creek (1) and the Fording River valley (23). The hunter sample cards were not specific to a location, other than indicating drainage, so it was not possible to determine the portion of the 23 elk taken in the Fording River valley which were taken near or within the present study area.

4.6.3 Heritage Resources

Detailed studies of heritage resources have to-date not been conducted in the upper Fording River drainage. A reconnaissance level archaeological survey of the middle Elk River drainage was conducted by Choquette (1973), but only partially sampled the present study area. Archaeological site EbPr1, a transitory campsite, was found near the mouth of Kilmarnock Creek.

The potential for finding other sites in the upper Fording River valley and Henretta and Kilmarnock Creeks has not been evaluated. Within the Brownie Creek coal licence area the potential for archaeological sites is low due to the topography of the area.

The potential for finding historic sites is low as the area was not used during the settlement period. In the middle Elk River drainage most historic sites date to the post-1900 period.

5.0 ENVIRONMENTAL SENSITIVITY ANALYSIS

A brief environmental sensitivity analysis has been prepared, based on the limited amount of data collected for the Brownie Creek coal licence area. The general sensitivities of the major aquatic and terrestrial parameters are evaluated with regard to disturbance, specifically the dumping of overburden material into the upper Brownie Creek drainage, which appears to be the most logical site for a waste dump. The projected impacts of the dumping of overburden into this area on the major environmental parameters will be identified but must be considered preliminary only as the nature of the overburden material and the extent of the dump area are not known at this time.

5.1 AIR QUALITY

The Brownie Creek coal licence area is presently in a natural, relatively undisturbed state. The Kilmarnock and Henretta Creek valleys may presently be affected by particulate emissions from the Fording Coal Ltd. preparation plant, however, site specific data are lacking. Location of an overburden dumping site into the upper Brownie Creek drainage area would result in an increased level of dustfall which would affect the air quality of the immediate area. This, however, should not significantly affect the overall air quality of the Kilmarnock Creek valley or the rest of the Brownie Creek coal licence area.

5.2 AQUATIC RESOURCES

5.2.1 Hydrology

Dumping of overburden above Brownie Creek would result in minor changes in the hydrologic regime of the watershed. Brownie Creek would be the only stream directly affected.

5.2.1 Water Quality

Water quality data indicate that Henretta and Kilmarnock Creeks are of high water quality, with generally low solids. Consequently, these streams are highly sensitive to disturbance which may cause increased sedimentation, thereby having a direct affect on aquatic habitat. Depending on the amount of material, the stream may need to be diverted or a number of settling ponds established to reduce siltation during periods of heavy run-off.

Kilmarnock Creek would be sensitive to leaching of possible contaminants from the overburden material, especially during the snowmelt period in the spring. A study of potential acid drainage of coal and overburden material was conducted during the earlier B.C. Research investigations of the Fording Project (B.C. Research, 1970a). Overall, this study found that there was little potential for an acid mine drainage problem. However, considering the importance of Kilmarnock Creek as fish habitat, it may be necessary to test the overburden material which is proposed for dumping in the upper Brownie Creek drainage for possible contaminants. Also, the water quality of Brownie and Kilmarnock Creeks should be monitored during the first year of the dumping operation.

5.2.3 Fisheries

Aquatic resources in Kilmarnock Creek could undergo substantial alteration if siltation occurs. Siltation resulting from inadequately designed development above Brownie Creek would not be flushed readily, except during freshet, and could seriously affect the capacity of the stream to provide adequate food resources for rearing fish and suitable spawning areas for adult cutthroat trout. Siltation and other changes in water quality characteristics could alter the present status of aquatic flora and invertebrate fauna of

Kilmarnock Creek. Installation of settling ponds along Brownie Creek would help to reduce the potential for a siltation problem.

The lower two reaches of Henretta Creek and the lower three reaches of Kilmarnock Creek must be regarded as being highly sensitive to disturbance. Reaches 1 and 3 of Kilmarnock Creek have already been drastically affected by the removal of forest and shrub cover, thereby affecting the quality of the aquatic habitats available. This may already have had an effect on the cutthroat trout population using Kilmarnock Creek for spawning and summer rearing habitat.

5.3 TERRESTRIAL RESOURCES

5.3.1 Surficial Materials and Soils

In general, the major problems which may be encountered by dumping of overburden above upper Brownie Creek would be the effects on slope stability of the surrounding areas. Areas of colluvial and morainal material on steep slopes could be covered by the proposed dump. Such steep slopes with fine textured Luvisolic and Luvisolic Humo-Ferric Podzols developed on morainal materials, where drainage is hindered by clay accumulation in the B horizon (Bt horizon), are highly sensitive to disturbance. These areas remain soaked with water in spring and are likely to have slope failures if disturbed.

In general it can be expected that failures in colluvial materials and morainal (till) veneers will take the form of shallow surface slides and flows; the thick till units can be expected to undergo both deep seated and shallow surface failures. Morainal materials are generally more sensitive to disturbance than colluvium or fluvo-glacial materials, but are better suited for reclammation purposes.

The general sensitivity mentioned above attempts to reflect not so much the natural stability of the materials but rather their stability when disturbed and applies to surficial materials and not the bedrock.

5.3.2 Vegetation

Sensitive vegetation units reflect areas which represent uniqueness of any plant ecosystems, high forestry values, valuable wildlife habitats and/or are difficult to reclaim after surface disturbance. Forestry values in the study area are generally low and no unique or rare plant communities were found in the area.

Vegetation occurring on fine textured, gravelly silt to silty clay Luvisols or Luvisolic Humo-Ferric Podzols on the lower south to southeastern slopes of Eagle Mountain and Mount Turnbull (along Brownie Creek) are sensitive to disturbance during the snow melt period in the spring. During this period erosion and slope failure in the area surrounding the dump site could result in disturbance of surrounding vegetation communities and consequent loss of wildlife habitat.

Moist vegetation communities are more sensitive to disturbance than dry or mesic communities as they are easily damaged due to poor drainage and instability of underlying materials. The short-term effects of disturbance in moist communities will generally be higher with respect to greater erosion and more stream sedimentation. These problems are severe on sites with steep slopes. The long-term effects of disturbance in moist communities probably will be lower than in dry communities, provided slope instability and erosion are controlled.

5.3.3 Wildlife

Sensitivities to wildlife from proposed industrial disturbance are primarily related to loss of habitat and disturbance of animals on their home ranges. Of greatest significance are ungulate winter ranges which are often critical to the survival of populations. As well, traditional migration routes, earth licks and calving/lambing areas are of considerable importance.

The limited baseline data collected during the study indicate that no major impacts are expected to occur on wildlife from possible dumping of overburden material into the west side of the upper Brownie Creek drainage area. Habitat loss may affect the meadow and seral pine-Engelmann spruce-alpine fir habitat types, both of which have a high capability as summer range for elk. However, winter survey information indicated that this particular area is not a winter range. Excessive prolonged snow cover throughout the winter appears to render most of the Brownie Creek coal licence area unsuitable as ungulate winter range.

Dumping of overburden into the upper Brownie Creek drainage area may have some effect on migrations between the ranges in the Mount Turnbull-Eagle Mountain area and the area to the east of Brownie Creek up to the Continental Divide. Elk and bighorn sheep are expected to move between these regions. On the basis of the number of game trails observed in the area some interference with traditional migration routes is possible.

The effects of habitat loss and possible disturbance caused by dumping of overburden are not expected to have any significant impacts on carnivorous and furbearing mammals. Some habitat for grizzly bears and upland furbearers will be removed. The effects on birds are expected to be minor.

5.4 RESOURCE USE

5.4.1 Land Tenure

Dumping of overburden material into the upper Brownie Creek drainage area would not affect any privately owned lands, buildings or other private holdings.

5.4.2 Present and Potential Land Use

5.4.2.1 Agriculture

Agricultural capability would not be significantly affected by dumping of overburden into the upper Brownie Creek drainage.

5.4.2.2 Forestry

The forestry capability of the area selected for a waste dump would be reduced but this would not affect the overall, low forestry capability of the Brownie Creek valley.

5.4.2.3 Recreation

Recreation capability and use would likely be affected by the increased industrial activity in the area. This would reduce the aesthetic quality of the immediate area and remove much of the Brownie Creek drainage area from outdoor recreation such as hunting, hiking and nature interpretation. An expanded no-shooting zone will be required and this will affect the opportunities for hunting in the area.

5.4.3 Heritage Resources

As no site-specific studies for heritage resources have been conducted in the immediate area, the effects of an overburden dump cannot be properly evaluated. However, the area is not expected to have a high potential for archaeological sites.

5.5 RECLAMATION CONSIDERATIONS

Reclamation of an overburden dump area will be conducted by Fording Coal Ltd. following clearly established land-use objectives. These land-use objectives are based on land capability analysis (Canada Land Inventory and Resources Analysis Branch biophysical analysis). The primary long-range land-use objective in the Fording mining area is to re-establish pre-existing land-use capabilities.

The aim of Fording Coal Ltd. is to eventually establish native species on reclaimed lands. The actual species used and practices for establishing these species are being developed through Fording Coal Ltd.'s reclamation research program. Current practices at Fording Coal to reclaim mined areas include:

- resloping to 26°
- pre-logging and salvage of organic top soils from all areas which will be mined or used for waste dumps
- drainage control to prevent clean water from entering mine areas and to prevent contaminated water from being discharged into natural water courses.

6.0 RECOMMENDATIONS

The following recommendations are made to avoid or minimize negative impacts of the proposed dumping of overburden material into the upper Brownie Creek area:

- The waste dump configuration should be designed to incorporate a series of settling ponds along Brownie Creek (below the dump site) to reduce the effects of increased siltation on the Kilmarnock Creek drainage. Drainage ditches should be designed to trap run-off from the area in order to control erosion and avoid stream sedimentation.
- Settling ponds should be sized to ensure an adequate residence time and a discharge that meet Pollution Control Board standards.
- Monitoring of water quality of Brownie Creek and Kilmarnock Creek should be conducted regularly during the first year of operation of the waste dump and as required thereafter to detect possible changes in water quality.
- Evaluation of fish habitat along Kilmarnock Creek suggests that the complete removal of forest cover along the lower and middle portions of the Creek (Reaches 1 and 3) has decreased the suitability of the stream as fish habitat. No further removal of live timber should be permitted along Kilmarnock Creek. It is recognized that this is not the specific responsibility of Fording Coal Ltd., however, it is suggested that the company communicate with the Provincial resource management agencies to ensure that Kilmarnock Creek is protected from further poor logging practices.
- Consideration should be given to the feasibility of removing and storing the upper soil horizons (A and B layers) of the proposed waste dump area for use as future reclamation material.

- The nature of the overburden and other potential waste material should be assessed for possible leaching of contaminants into the drainage system and as a growth medium for reclamation use.

- Where possible, vegetation screens should be left in the area of the proposed dump to minimize the impact on the aesthetic amenities of the area and to minimize surface erosion and siltation of drainages.

- Construction of access roads into the Brownie Creek drainage should be kept to a minimum, or if possible, avoided. Roads which are constructed should be restricted to company use only.

- Reclamation of the waste dump should be initiated soon after it is completed in order to minimize erosion and possible siltation of drainages. The current philosophy of the reclamation objective of Fording Coal Ltd. to enhance the capability of reclaimed lands for wildlife use should be continued. Emphasis should be placed on reclaiming the dump area to provide suitable summer range for deer and elk, primarily through the planting of grasses and forbs recognized as being preferred summer range.

- The monitoring of resident big game populations should be continued in the areas under the influence of Fording Coal Ltd. This can be accomplished by an annual winter helicopter survey and regular ground surveys during the winter period (December-May). This will serve to provide an estimate of wintering populations, to delineate the actual extent of winter ranges and to identify migration routes in the Fording Coal area.

- The present no-shooting zone will have to be extended to include the proposed waste dump area and surroundings. This should be done in consultation with the B.C. Fish and Wildlife Branch.

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TABLES

' TABLE 1

CLIMATE DATA FROM FORDING COAL LIMITED*, 1970-1977

1970	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temperature (°C)													
Mean Daily	-7.2	-3.3	-3.9	-1.1	5.0	12.8	13.9	16.7	0.6	-5.6	-10.6	-10.0	0.6
Maximum	6.7	11.1	13.3	13.3	23.3	29.4	28.9	30.0	21.1	20.6	13.3	5.0	30.0
Minimum	-31.7	-20.0	-27.2	-17.2	-15.6	-1.1	0.0	-1.1	-11.7	-16.7	-30.0	-27.2	-31.7
Precipitation (mm)													
Total	92.7	26.1	32.3	47.2	37.6	107.4	45.7	10.4	53.1	14.7	52.8	124.0	644.1
Annual Snowfall (cm)													N/A
1971													
Temperature (°C)													
Mean Daily	-10.6	-8.3	-8.3	0.0	7.2	10.0	13.3	16.7	6.7	0.0	-4.4	-10.6	1.1
Maximum	7.2	8.9	8.9	13.3	22.2	26.7	30.0	32.2	22.2	18.9	6.7	0.6	32.2
Minimum	-32.8	-25.6	-27.2	-19.4	-6.1	-1.1	-1.1	1.1	-5.6	-25.6	-24.4	-31.7	-32.8
Precipitation (mm)													
Total	120.9	41.1	37.6	93.7	73.9	43.9	39.9	19.0	59.9	76.7	35.4	196.1	837.4
Annual Snowfall (cm)													421.6
1972													
Temperature (°C)													
Mean Daily	-15.0	-8.3	-2.8	-1.7	6.1	8.9	10.6	12.8	3.9	0.0	-4.4	-12.8	0.0
Maximum	0.6	6.7	10.6	15.6	26.7	24.4	28.9	28.3	21.1	15.6	5.0	4.4	28.9
Minimum	-40.0	-32.2	-28.9	-19.4	-8.3	0.0	-1.7	-2.8	-12.2	-19.4	-20.0	-36.1	-40.0
Precipitation (mm)													
Total	221.4	131.0	122.7	66.3	15.7	73.6	74.4	72.9	56.9	49.3	13.2	93.7	1011.7
Annual Snowfall (cm)													832.1
1973													
Temperature (°C)													
Mean Daily	-7.2	-7.8	-3.3	0.0	6.1	9.4	13.3	12.8	8.3	2.2	-7.8	-7.8	1.7
Maximum	5.6	8.9	8.3	12.3	25.6	28.3	28.9	29.4	26.1	14.4	5.6	3.3	29.4
Minimum	-34.4	-28.9	-15.6	-16.7	-9.4	-2.2	-2.2	-1.7	-6.1	-9.4	-25.0	-27.8	-34.4
Precipitation (mm)													
Total	55.4	28.4	50.0	21.6	45.7	77.7	29.0	85.3	18.0	36.3	95.8	82.8	626.1
Annual Snowfall(cm)													387.1

TABLE I (concluded)

1974	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
<u>Temperature (°C)</u>													
Mean Daily	-11.7	-6.7	-5.0	1.7	3.3	11.7	12.8	11.1	8.3	4.4	-4.4	-7.2	1.7
Maximum	4.4	2.2	7.2	16.7	16.1	27.8	28.9	28.3	23.3	22.2	9.4	2.2	28.9
Minimum	-36.7	-19.4	-24.4	-10.6	-5.6	-2.2	-0.6	-2.2	-11.1	-13.3	-18.9	-24.4	-36.7
<u>Precipitation (mm)</u>													
Total	142.7	59.4	67.8	77.7	142.0	39.6	15.2	57.4	37.6	48.8	80.8	78.5	847.6
Annual Snowfall (cm)													504.4
<u>1975</u>													
<u>Temperature (°C)</u>													
Mean Daily	-10.6	-11.7	-7.2	-1.1	5.0	8.9	15.6	10.0	8.9	0.6	-5.6	-8.3	0.6
Maximum	10.6	2.2	3.9	12.2	20.0	22.8	31.1	24.4	23.9	20.0	12.8	3.3	31.1
Minimum	-33.9	-30.0	-12.2	-26.1	-5.6	-1.7	2.8	0.6	-2.2	-10.6	-21.7	-21.1	-33.9
<u>Precipitation (mm)</u>													
Total	48.0	94.7	56.1	53.6	38.9	69.8	90.2	81.5	20.3	57.1	23.6	67.1	701.0
Annual Snowfall (cm)													359.2
<u>1976</u>													
<u>Temperature (°C)</u>													
Mean Daily	-7.9	-7.5	-6.7	2.3	7.3	+N/A	15.8	14.0	10.0	2.2	-3.9	-5.2	N/A
Maximum	8.3	4.4	7.2	16.7	21.1	N/A	26.0	23.0	21.7	19.4	7.8	7.8	26.0
Minimum	-23.9	-22.8	-31.6	-10.0	-5.0	N/A	7.0	3.5	2.2	-13.9	-21.1	-13.3	-31.6
<u>Precipitation (mm)</u>													
Total	108.2	69.1	20.6	16.5	32.0	N/A	80.8	303.8	100.7	21.1	21.3	24.1	N/A
Annual Snowfall (cm)													266.4
<u>1977</u>													
<u>Temperature (°C)</u>													
Mean Daily	-11.6	-4.1	-5.3	3.7	5.1	11.2	13.3	11.2	6.1	2.2	-6.7	-12.9	1.0
Maximum	1.1	5.0	6.1	24.4	18.3	27.2	26.6	25.0	18.9	15.0	3.3	1.1	27.2
Minimum	-25.0	-18.9	-17.8	-11.1	-3.3	-2.8	0.0	0.0	-2.2	-13.9	-22.8	-30.0	-30.0
<u>Precipitation (mm)</u>													
Total	50.8	11.9	85.9	4.6	123.7	50.1	55.1	82.1	43.9	0.4	60.5	46.8	614.3
Annual Snowfall (cm)													285.3

*Department of Transport-Canada, Meteorological Branch, Monthly Climatological Station Report for Cominco-Fording River.

+ Data incomplete.

TABLE 2

SUMMARY OF CLIMATE DATA FROM FERNIE, 1941-1970

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Fernie, Normals 1941-70	Temperature (°C)													
	Mean Daily	-8.3	-4.6	-1.8	4.6	9.6	13.2	16.5	15.5	10.8	5.6	-1.0	-5.4	4.5
	Maximum	10.6	12.2	17.2	26.7	32.8	36.1	35.6	35.0	31.7	25.6	15.6	12.2	36.1
	Minimum	-39.4	-40.0	-31.7	-20.0	-7.8	-2.2	0.0	-1.1	-18.3	-24.4	-32.2	-41.7	-41.7
	Precipitation (mm)													
	Mean Total	143.8	107.9	80.3	69.3	66.3	86.6	36.8	48.0	66.0	106.7	117.6	152.1	1081.5
	Annual Snowfall (cm)													368.8

*January values are based on a four year period.

TABLE 3

SIZE CLASSIFICATION OF GRAVEL IN KILMARNOCK CREEK, OCTOBER 1969*

Location	Percent of Total Weight									
	+38.1 mm	+25.4	+19.0	+12.7	+9.5	+4.7	+2.8	+1.6	+0.2	-0.2
Kilmarnock Creek										
lower (2K)	2.3	16.9	12.8	15.2	11.9	16.8	7.7	5.4	10.5	0.5
upper (1K)	11.4	18.6	12.3	12.2	4.6	9.4	8.9	9.2	13.3	0.1

* Source: B.C. Research. 1970a. Ecological Study - Fording River. Phase 1, Progress Report No. 2. Report to Cominco Ltd., Trail, B.C.

TABLE 4

DISCHARGE MEASUREMENTS IN THE KILMARNOCK AND HENRETTA CREEK DRAINAGES, SEPTEMBER 13-15, 1978

Site		Discharge (m^3/s and cfs)
Lower Kilmarnock Creek	(WS1)	0.54 (19.1)
Upper Kilmarnock Creek	(WS2)	0.50 (17.6)
Brownie Creek	(WS3)	0.03 (1.1)
Lower Henretta Creek	(WS4)	0.68 (24.0)
Upper Henretta Creek	(WS5)	0.63 (22.2)*
McQuarrie Creek	(WS6)	0.04 (1.4)

* Estimated

TABLE 5

WATER QUALITY CHARACTERISTICS OF KILMARNOCK CREEK COLLECTED 1969-1978

	Water Investigations Branch[1] Site 119042 (1975-1976)				Pollution Control Branch[2] Site 0200252 (April, 1977-June, 1978)				B.C. Research[3]	
	max	min	mean	No. of values	max	min	mean	No. of values	Site 1K (October, 1969)	Site 2K (October, 1969)
Alkalinity, Total mg/ℓ	125	102	113	4					23.0	33.5
Carbon, Total mg/ℓ									1.0	0.5
Total Organic mg/ℓ	2	<1	1.3	3						
Total Inorganic mg/ℓ									22.0	33.5
Hardness, Total mg/ℓ	142	104	124	4					150	150
Nitrogen, Ammonia mg/ℓ	0.01	0.006	0.009	3						
Nitrate mg/ℓ	0.22	0.02	0.10	3						
Organic mg/ℓ	0.09	0.03	0.06	3						
Total mg/ℓ	0.32	0.09	0.17	3						
pH	8.6	8.3	8.4	4					7.2	7.2
Oxygen, Dissolved mg/ℓ									11.3	13.2
Dissolved Intragravel mg/ℓ									6.9	9.2
Phosphorus, Total mg/ℓ	0.011	0.008	0.01	4						
Total Dissolved mg/ℓ	0.008	0.003	0.006	4						
Solids, Dissolved mg/ℓ	158	116	140	4					85	140
Suspended mg/ℓ	4	2	4	4	20	1	4	13		
Total mg/ℓ	162	118	137	4					303	259
Specific Conductance μmhos/cm									168	170
Temperature °C									4	1
Turbidity APHA Units									3.5	7.0
Turbidity J.T.U.	2.5	0.5	1.1	4						
Arsenic, Total μg/ℓ	<5	<5	<5	4						
Copper, Total μg/ℓ	<1	<1	<1	4						
Iron, Total μg/ℓ	200	<100	100	4						
Lead, Dissolved μg/ℓ	<1	<1	<1	4						
Manganese, Dissolved μg/ℓ	<20	<20	<20	3						
Nickel, Dissolved μg/ℓ	<10	<10	<10	4						
Zinc, Total μg/ℓ	20	<5	9	4						

[1] B.C. Water Investigations Branch, 1978

[2] B.C. Pollution Control Branch, 1978

[3] B.C. Research, 1970a

TABLE 6

WATER QUALITY CHARACTERISTICS OF THE FORDING RIVER AND KILMARNOCK AND HENRETTA CREEK DRAINAGES, SEPTEMBER 16, 1978

	Kilmarnock Creek		Brownie Creek	Henretta Creek		McQuarrie Creek	Fording River
	WS1	WS2	WS3	WS4	WS5	WS6	WS7
Temperature (°C)	5	3.5	6	4.5	4	4	8
pH	8.0	8.2	8.4	8.0	7.6	8.2	8.4
Dissolved Oxygen (mg/l)	10.3	11.3	10.3	10.3	10.6	10.4	9.8
Alkalinity (mg $CaCO_3$/l)	121	106	147	110	99	144	133
Hardness (mg $CaCO_3$/l)	139	126	165	136	124	161	169
Specific Conductance (µmhos/cm)	250	222	290	242	225	282	310
Turbidity (NTU)	0.8	0.4	0.4	0.5	0.7	0.6	13
Suspended Solids (mg/l)	2	<1	1	1	<1	1	10
Volatile Solids (mg/l)	2	<1	<1	1	<1	1	6
Total Solids (mg/l)	168	157	180	154	142	173	192
Total Phosphorus (µg/l)	<10	-	<10	<10	-	-	<10
Nitrite (µg N/l)	<2	-	<2	<2	-	-	5
Nitrate (µg N/l)	79	-	5	44	-	-	1455
Sulphate (mg/l)	21	19	19	25	26	17	30
Phenol (µg/l)	5	-	5	5	-	-	4
TOC	ND	ND	ND	ND	ND	ND	ND
Oil and Grease (mg/l)	<5	-	<5	<5	-	-	<5
Dissolved Copper (µg/l)	0.6	0.4	0.4	0.5	0.4	0.4	0.4
Dissolved Iron (µg/l)	3.9	3.8	4.1	6.0	6.0	3.0	7.0
Dissolved Manganese (µg/l)	0.6	0.2	0.9	0.5	0.2	0.2	7.5

ND: Not Detectable

TABLE 7

WATER QUALITY CHARACTERISTICS OF THE FORDING RIVER AND KILMARNOCK AND HENRETTA CREEK DRAINAGES, MAY 11 AND 12, 1979

	Kilmarnock Creek		Brownie Creek	Henretta Creek		McQuarrie Creek	Fording River
	WS1	WS2	WS3	WS4	WS5	WS6	WS7
Temperature ($^{\circ}C$)	3	3	1	3	3	5	7
pH	8.3	8.3	8.4	8.1	8.3	8.2	8.3
Dissolved oxygen (mg/l)	15.8	14.8	15.8	15.3	14.5	14.3	13.6
Alkalinity (mg $CaCO_3$/l)	140	128	138	120	112	111	133
Hardness (mg $CaCO_3$/l)	160	169	147	163	164	114	175
Specific conductance (μ mhos/cm)	260	245	245	265	280	195	280
Turbidity (NTU)	0.7	0.2	0.3	0.2	0.2	0.4	9.6
Suspended solids (mg/l)	<1	<1	<1	<1	<1	<1	12
Volatile solids (mg/l)	<1	<1	<1	<1	<1	<1	3.2
Total solids (mg/l)	201	191	172	206	221	145	274
Total Phosphorus (μg/l)	<5	-	<5	<5	-	-	30
Nitrite (μg N/l)	<2	-	<2	<2	-	-	2
Nitrate (μg N/l)	101	-	9	51	-	-	1080
Sulphate (mg/l)	21	31	16	42	53	20	45
Phenol (μg/l)	1	-	<1	<1	-	-	<1
TOC (mg/l)	ND	ND	ND	ND	ND	6	ND
Oil and Grease (mg/l)	<5	-	<5	<5	-	-	<5
Dissolved copper (μg/l)	0.4	0.4	0.6	0.4	0.5	0.5	0.5
Dissolved Iron (μg/l)	1.2	1.0	1.0	1.0	1.1	5.0	3.5
Dissolved Manganese (μg/l)	0.4	0.4	0.4	0.3	0.3	2.4	6.9

ND = Not Detectable

TABLE 8

INVERTEBRATES COLLECTED IN KILMARNOCK CREEK, OCTOBER 1969

	Site		
	Lower Kilmarnock (2K)	Upper Kilmarnock (1K)*	
Plecoptera (Stoneflies)			
Chloroperlidae			
Alloperla spp	5	46	26
Perlodidae			
Isoperla spp	-	5	-
Ephemeroptera (Mayflies)			
Heptageniidae			
Rhithrogena spp	10	20	23
Ironodes spp	-	2	-
Trichoptera (Caddisflies)	-	-	-
Diptera (True Flies)			
Empididae (Dance Flies)			
Hemerodromie sp	-	35	12
Chironomidae (Midges)	124	-	750

* Two samples

TABLE 9

FISH SAMPLE SITES AND FISHING EFFORT
IN THE FORDING RIVER AND KILMARNOCK AND HENRETTA CREEKS - SEPTEMBER, 1978

Site	Date	Drainage	Location	Type of Effort	Length of Time	Comments
F1	13 and 15 Sept	Kilmarnock Creek	Mouth of Kilmarnock Creek to 2 km upstream	Angling	7 man-hours	CT5 captured; returned 2 undersize and observed several other fish.
F2	13 and 15 Sept	Kilmarnock Creek	1.25 km of stream 2.75 km from mouth	Angling	4 man-hours	CT1,2,6,7,8, and 9 captured; no other fish caught.
F3	13 Sept	Kilmarnock Creek	1.5 km of stream upstream from Brownie Creek	Angling	4 man-hours	No fish caught or observed.
F4	14 Sept	Henretta Creek	1.0 km of stream 1.25 km from mouth	Angling	6 man-hours	CT3 and 4; other fish observed.
F5	14 Sept	Henretta Creek	1.0 km of stream 3.5 km from mouth	Angling	2 man-hours	No fish caught or observed.
F6	14 Sept	Henretta Creek	1.0 km of stream 4.5 km from mouth	Angling	2 man-hours	No fish caught or observed.
F7	15 Sept	Fording River	1.0 km of stream upstream from Kilmarnock Creek	Angling	1 man-hour	CT10, 11 and 12

TABLE 10

FISH CAPTURED IN THE FORDING RIVER AND KILMARNOCK AND HENRETTA CREEKS - SEPTEMBER, 1978

Date	Time	Species	Site	Type of Effort	Fork Length (cm)	Weight (g)	Sex	Maturity	K Factor
13 Sept	1500	cutthroat (CT1)	F2	Angling	30.6	400	M	IV	1.4
13 Sept	1500	cutthroat (CT2)	F2	Angling	20.5	120	M	IV	1.4
14 Sept	1200	cutthroat (CT3)	F4	Angling	22.0	110	F	IV	1.0
14 Sept	1200	cutthroat (CT4)	F4	Angling	20.0	80	M	IV	1.0
15 Sept	1630	cutthroat (CT5)	F1	Angling	21.0	95	M	IV	1.0
15 Sept	1200	cutthroat (CT6)	F2	Angling	20.1	90	M	IV	1.1
15 Sept	1200	cutthroat (CT7)	F2	Angling	23.5	140	F	IV	1.1
15 Sept	1200	cutthroat (CT8)	F2	Angling	23.2	135	F	IV	1.1
15 Sept	1200	cutthroat (CT9)	F2	Angling	22.7	145	F	IV	1.2
15 Sept	1400	cutthroat (CT10)	F7	Angling	26.0	215	M	IV	1.2
15 Sept	1400	cutthroat (CT11)	F7	Angling	23.5	150	M	IV	1.1
15 Sept	1400	cutthroat (CT12)	F7	Angling	31.0	330	M	IV	1.1

F1 - Lower Kilmarnock Creek

F2 - Middle Kilmarnock Creek

F4 - Middle Henretta Creek

F7 - Fording River upstream of Kilmarnock Creek

TABLE 11

AGE AND STOMACH CONTENTS OF FISH CAUGHT IN THE FORDING RIVER, KILMARNOCK AND HENRETTA CREEKS, SEPTEMBER, 1978

Date	Species	Site	Fork Length (cm)	Weight (g)	Age	Stomach
13 Sept.	cutthroat (CT1)	F2	30.6	400	4+	Stomach full 50% adult Plecoptera, 35% adult Trichoptera
13 Sept.	cutthroat (CT2)	F2	20.5	120	3+	Stomach full 70% adult Trichoptera, 25% immature Trichoptera
14 Sept.	cutthroat (CT3)	F4	22.0	110	2+	Stomach half full 50% immature Trichoptera, 20% adult Trichoptera
14 Sept.	cutthroat (CT4)	F4	20.0	80	2+	Stomach full 90% larval and pupal aquatic insects
15 Sept.	cutthroat (CT5)	F1	21.0	95	3+	Stomach empty
15 Sept.	cutthroat (CT6)	F2	20.1	90	2+	Stomach half full 50% immature Trichoptera, 45% adult Trichoptera
15 Sept.	cutthroat (CT7)	F2	23.5	140	3+	Stomach quarter full 50% immature Trichoptera
15 Sept.	cutthroat (CT8)	F2	23.2	135	3+	Stomach full 50% immature Trichoptera, 20% adult Trichoptera
15 Sept.	cutthroat (CT9)	F2	22.7	145	3+	Stomach full 80% immature Trichoptera, 10% immature aquatic insects
15 Sept.	cutthroat (CT10)	F7	26.0	215	3+	Stomach full 50% ants, 50% unidentifiable
15 Sept.	cutthroat (CT11)	F7	23.5	150	3+	Stomach quarter full 50% immature aquatic insects, 50% unidentifiable
15 Sept.	cutthroat (CT12)	F7	31.0	330	4+	Stomach full 80% unidentifiable

TABLE 12

COMPARISON OF LENGTH AND AGE OF FISH FROM THE STUDY AREA AND THOSE FROM MONTANA AND UTAH STREAMS

		Age						
		1+	2+	3+	4+	5+	6+	7+
Kilmarnock Creek	Fork Length (mm)		201	222	306			
Henretta Creek	Fork Length (mm)		210					
Yellowstone Lake, Wyo. (Scott and Crossman, 1973)	Total Length (mm)	46	129	225	312	393	444	485
Flint Creek, Mt. (Corlander, 1969)	Total Length (mm)	66	119	175				
Logan River, Ut. (Corlander, 1969)	Total Length (mm)	99	170	231				
Montana Streams (Corlander, 1969)	Total Length (mm)	74	132	198	279	330	302	
Thompson River, Mt. (Corlander, 1969)	Total Length (mm)	130	198	262	318			
W. Gallatin River, Mt.	Total Length (mm)							
6000' elev.		104	175	257	274			
5000' elev.		119	185	274				
4000' elev.		104	185	310				
(Corlander, 1969)								

TABLE 13

FISH CAPTURED IN KILMARNOCK CREEK MAY 11, 12 and 14 AND JUNE 18 and 19, 1979

Date	Time	Species	Site	Type and Duration of Effort	Fork Length (cm)	Weight (g)	Sex	Maturity	K Factor
11 May	1030	cutthroat (CT13)	F1	Electroshocker - 2 h	13.7	25	-	-	0.9
11 May	1030	cutthroat (CT14)	F1	Electroshocker - 2 h	14.8	35	-	-	1.0
11 May	1030	cutthroat (CT15)	F1	Electroshocker - 2 h	10.4	20	-	-	1.7
11 May	1030	cutthroat (CT15)	F1	Electroshocker - 2 h	12.7	30	-	-	1.4
11 May	1030	cutthroat (CT16)	F1	Electroshocker - 2 h	14.2	45	-	-	1.5
11 May	1030	cutthroat (CT17)	F1	Electroshocker - 2 h	12.7	25	-	-	1.2
11 May	1030	cutthroat (CT18)	F1	Electroshocker - 2 h	11.8	20	-	-	1.2
11 May	1030	cutthroat (CT19)	F1	Electroshocker - 2 h	9.0	-	-	-	-
11 May	1130	cutthroat (CT20)	F2	Electroshocker - 1 h	9.4	-	-	-	-
11 May	1430	cutthroat (CT21)	F2	Electroshocker - 1.5 h	15.4	50	M	V	1.3
12 May	0910	cutthroat (CT22)	T1	Trap Net - 24 h	22.9	155	-	-	1.2
14 May	1240	cutthroat (CT23)	T1	Trap Net - 48 h	14.0	35	-	-	1.2
14 May	1240	cutthroat (CT24)	T1	Trap Net - 48 h	14.6	35	-	-	1.1
14 May	1240	cutthroat (CT25)	T1	Trap Net - 48 h	19.5	85	M	V	1.1
18 June	0815	cutthroat (CT26)	T1	Trap Net - 17 h	14.3	35	-	-	1.2
18 June	0815	cutthroat (CT27)	T1	Trap Net - 17 h	14.3	35	-	-	1.2
18 June	0815	cutthroat (CT28)	T1	Trap Net - 17 h	13.8	30	-	-	1.1
18 June	0815	cutthroat (CT29)	T1	Trap Net - 17 h	15.7	40	M	V	1.0
18 June	0815	cutthroat (CT30)	T1	Trap Net - 17 h	16.9	55	M	V	1.1
18 June	0815	cutthroat (CT31)	T1	Trap Net - 17 h	15.7	40	M	V	1.0
18 June	0815	cutthroat (CT32)	T1	Trap Net - 17 h	17.5	60	M	V	1.1
18 June	0815	cutthroat (CT33)	T1	Trap Net - 17 h	18.6	70	-	-	1.0
18 June	0815	cutthroat (CT34)	T1	Trap Net - 17 h	20.1	95	M	V	1.1
18 June	1115	cutthroat (CT35)	F1	Electroshocker - 2.5 h	9.0	10	-	-	1.3
18 June	1115	cutthroat (CT36)	F1	Electroshocker - 2.5 h	10.6	12	-	-	1.0
18 June	1115	cutthroat (CT37)	F1	Electroshocker - 2.5 h	10.2	15	-	-	1.4
18 June	1115	cutthroat (CT38)	F1	Electroshocker - 2.5 h	15.6	45	M	V	1.1
18 June	1330	cutthroat (CT39)	F1	Electroshocker - 1 h	8.5	-	-	-	-
18 June	1330	cutthroat (CT40)	F1	Electroshocker - 1 h	9.2	-	-	-	-
18 June	1330	cutthroat (CT41)	F1	Electroshocker - 1 h	18.2	80	M	V	1.3
18 June	1430	cutthroat (CT42)	F2	Electroshocker - 1 h	14.4	40	M	V	1.3
19 June	0800	cutthroat (CT43)	T2	Trap Net - 48 h	14.0	35	-	-	1.2
19 June	0815	cutthroat (CT44)	T1	Trap Net - 24 h	9.5	-	-	-	-
19 June	0815	cutthroat (CT45)	T1	Trap Net - 24 h	10.5	20	-	-	1.7
19 June	0815	cutthroat (CT46)	T1	Trap Net - 24 h	11.7	22	-	-	1.3
19 June	0815	cutthroat (CT47)	T1	Trap Net - 24 h	11.4	22	-	-	1.4
19 June	0815	cutthroat (CT48)	T1	Trap Net - 24 h	12.3	25	-	-	1.3
19 June	0815	cutthroat (CT49)	T1	Trap Net - 24 h	12.5	28	-	-	1.4
19 June	0815	cutthroat (CT50)	T1	Trap Net - 24 h	11.7	25	-	-	1.5
19 June	0815	cutthroat (CT51)	T1	Trap Net - 24 h	12.8	28	-	-	1.3
19 June	0815	cutthroat (CT52)	T1	Trap Net - 24 h	14.0	35	-	-	1.2
19 June	0815	cutthroat (CT53)	T1	Trap Net - 24 h	14.6	30	-	-	0.9
19 June	0815	cutthroat (CT54)	T1	Trap Net - 24 h	15.7	42	-	-	1.0
19 June	0815	cutthroat (CT55)	T1	Trap Net - 24 h	14.2	34	-	-	1.1
19 June	0815	cutthroat (CT56)	T1	Trap Net - 24 h	14.5	38	M	V	1.2
19 June	0815	cutthroat (CT57)	T1	Trap Net - 24 h	15.4	45	M	V	1.2
19 June	0815	cutthroat (CT58)	T1	Trap Net - 24 h	16.2	50	-	-	1.1

TABLE 14

VEGETATION DATA FOR MATURE ENGELMANN SPRUCE - ALPINE FIR MAP UNIT, BROWNIE CREEK COAL LICENCES AREA, 1978

Vegetation Type	Spruce - Fir - Moss			Frequency %
Plot Number	9	12	14	
Elevation (metres)	2105	1890	1810	
Slope (degrees)	13	13	6	
Aspect (degrees)	310	310	210	
Date : Day	13	14	14	
Month	9	9	9	
Year	78	78	78	
Plot Size (metres)	10 X 10	10 X 10	10 X 10	
Moisture Regime*	4	4	5	
Slope Pos Macro	4	5	5	
Surface Shape	4	4	4	
Slope Pos Moist	3	3	2	
Exposure Type	6	6	6	
Total Vegetation Cover (percent)	90	90	80	
Bare Ground	2	1	5	
Dead Wood	6	7	10	
Humus	2	2	5	
Rock	0	0	0	
TREE COVER (%)	27	40	35	100
Picea engelmannii	20	35	35	100
Abies lasiocarpa	5	5		66
Larix occidentalis	2			33
SHRUB COVER (%)	70	45	50	100
B_1 Layer				
Abies lasiocarpa	2	2	15	100
Picea engelmannii	2	2	2	100

(continued...)

TABLE 14 (continued)

Vegetation Type	Spruce - Fir - Moss			Frequency %
Plot Number	9	12	14	
B_2 Layer				
Abies lasiocarpa	2	5	5	100
Menziesia ferruginea	1	15	30	100
Picea engelmannii	2	5	2	100
Amelanchier alnifolia		2	1	66
Rhododendron albiflorum	35	-	2	66
Vaccinium myrtillus		15	8	66
Vaccinium scoparium	30	2		66
Empetrum nigrum	1			33
Linnaea borealis	1			33
Lonicera involucrata			1	33
Ribes lacustre	1			33
HERB COVER (%)	6	10	8	100
Arnica cordifolia	1	3	2	100
Carex sp.	+	1	+	100
Cornus canadensis	1	1	2	100
Fragaria virginiana	1	2	1	100
Pyrola secunda	1	1	•	100
Thalictrum venulosum	2	2		66
Anemone multifida		+		33
Equisetum scirpoides			+	33
Osmorhiza chilensis		+		33
Petasites palmatus			1	33
Pyrola sp.			+	33
Pyrola uniflora			+	33
MOSS AND LICHEN COVER (%)	42	34	24	100
Cladonia sp.	2	•	•	100
Atrichyum sp.		2	2	66
Lophozia sp.	20		5	66
Peltigera sp.		2	2	66
Pleurozium sp.		30	15	66
Aulacomnium sp.	15			33
Hylocomium sp.	5			33

• See legend in Appendix 7

+ Less than 1%

TABLE 15

VEGETATION DATA FOR LOGGED MAP UNIT, BROWNIE CREEK COAL LICENCES AREA, 1978

Vegetation Type	Elderberry - Currant - Fireweed			Frequency %
Plot Number	11	13	16	
Elevation (metres)	1775	1750	1755	
Slope (degrees)	12		2	
Aspect (degrees)	250		190	
Date : Day	14	14	14	
Month	9	9	9	
Year	78	78	78	
Plot Size (metres)	10 X 10	10 X 10	10 X 10	
Moisture Regime*	6	5	6	
Slope Pos Macro	6	6	6	
Surface Shape	2	8	4	
Slope Pos Moist	1	2	2	
Exposure Type	6	6		
Total Vegetation Cover (percent)	50	70	70	
Bare Ground	15	5	5	
Dead Wood	25	15	15	
Humus	10	10	10	
Rock	0	0	0	
SHRUB COVER (%)	10	15	10	100
B_2 Layer				
Ribes lacustre	1	2	2	100
Sambucus racemosa	6	6	2	100
Amelanchier alnifolia	1	1		66
Salix sp.		1	2	66
Abies lasiocarpa		2		33
Linnaea borealis	1			33
Lonicera involucrata			2	33
Picea engelmannii		2		33
Rosa acicularis			1	33
Rubus idaeus	1			33
Rubus parviflorus		1		33
Shepherdia canadensis			1	33

(continued ...)

TABLE 15 (concluded)

Vegetation Type	Elderberry - Currant - Fireweed			Frequency %
Plot Number	11	13	16	
HERB COVER (%)	40	55	60	100
Aster laevis	+	1	15	100
Epilobium angustifolium	30	5	10	100
Fragaria virginiana	3	5	5	100
Poa palustris	+	15	1	100
Thalictrum venulosum	1	+	1	100
Achillia millefolium	+	●		66
Astragalus americanus		+	+	66
Calamagrostis canadensis	●	4		66
Carex nigricans		2	1	66
Equisetum scirpoides	+		+	66
Senecio pseudaureus	+	+		66
Trisetum spicatum		2	+	66
Agoseris elata		1		33
Agropyron repens	+			33
Agropyron spicatum		2		33
Agrostis scabra			1	33
Aira caryophyllea		1		33
Anaphalis margaritacea	1			33
Carex atrata		1		33
Carex sp.	1			33
Cinna latifolia		+		33
Cirsium vulgare		2		33
Cornus canadensis	1			33
Deschampsia elongata	1			33
Elymus glaucus	1			33
Elymus innovatus			25	33
Equisetum arvense		10		33
Geum macrophyllum		+		33
Luzula parviflora			1	33
Petasites sagittatus		1		33
Pyrola sp.	●			33
Urtica dioica	1			33
MOSS AND LICHEN COVER (%)	+		1	66
Aulacomnium palustre			●	33
Dicranum sp.			+	33
Peltigera sp.			●	33
Polytrichum sp.	+			33

* See legend in Appendix 7

+ Less than 1%

TABLE 16

VEGETATION DATA FOR SERAL PINE-ENGELMANN SPRUCE-ALPINE FIR MAP UNIT
BROWNIE CREEK COAL LICENCES AREA, 1978

Vegetation Type	Pine - Spruce - Fir						Frequency %
Plot Number	3	4	10	15	17	20	
Elevation (metres)	2040	1795	2025	1830	2000	1980	
Slope (degrees)	19	7	9	15	17	3	
Aspect (degrees)	290	210	320	210	90	120	
Date : Day	12	12	13	14	15	15	
Month	9	9	9	9	9	9	
Year	78	78	78	78	78	78	
Plot Size (metres)	10 X 10	10 X 10	10 X 10	10 X 10	10 X 10	10 X 10	
Moisture Regime*	6	5	5	6	5	5	
Slope Pos Macro	4	5	5	4	4	5	
Surface Shape	2	2	2	4	2	4	
Slope Pos Moist	1	1	1	1	1	1	
Exposure Type	1	6	6	6	2	6	
Total Vegetation Cover (percent)	65	80	75	70	85	85	
Bare Ground	20	8	7	16	10	8	
Dead Wood	4	10	15	2	3	5	
Humus	1	2	1	2	2	2	
Rock	15	0	2	10	0	0	
TREE COVER (%)		4		25		20	50
Abies lasiocarpa		2		3		5	50
Picea engelmannii				15		15	33
Pinus contorta		2		7			33
SHRUB COVER (%)	30	70	60	60	40	55	100
B_1 Layer							
Picea engelmannii	3	10	10	10	3	3	100
Abies lasiocarpa	2	10	1	2		2	83
Pinus contorta			5	3	5	3	67
Pinus albicaulis	4						17

(continued ...)

TABLE 16 (continued)

Vegetation Type	Pine - Spruce - Fir						Frequency %
Plot Number	3	4	10	15	17	20	
B_2 Layer							
Abies lasiocarpa	2	5	2	2	2	2	100
Picea engelmannii	2	5	5	2	2	3	100
Shepherdia canadensis	10	5	2	30	20	35	100
Vaccinium scoparium	1	20	30	8	1	5	100
Juniperus communis	1			2	2	1	67
Ribes lacustre	1		2		1	2	67
Sambucus racemosa	2			1	1	2	67
Pinus contorta				2	2	2	50
Populus tremuloides		1	+		2		50
Salix sp.			2		2	2	50
Rosa acicularis				+	1		33
Alnus sinuata		1					17
Amelanchier alnifolia						1	17
Arctostaphylos uva-ursi				1			17
Empetrum nigrum			2				17
Ledum groenlandicum		2					17
Linnaea borealis		2					17
Lonicera involucrata					2		17
Lonicera utahensis		1					17
Menziesia ferruginea		15					17
Pinus albicaulis	3						17
Rhododendron albiflorum			6				17
Ribes oxycanthoides		1					17
Rosa woodsii	1						17
Rubus idaeus					1		17
Spiraea betulifolia		1					17
HERB COVER (%)	35	15	20	10	70	25	100
Achillea millefolium	1	+		+	1	+	83
Anaphalis margaritacea	1		+	1	1	2	83
Epilobium angustifolium	2	1	1		1	2	83
Fragaria virginiana	4	2		2	3	3	83
Aster laevis	2		1		+	+	67
Aster sp.	2	+	+		1		67
Astragalus americanus	1	1	2			5	67
Antennaria anaphaloides	1		+	+			50
Aster conspicuus				1	5	2	50
Castilleja miniata	4		+	+			50
Gentiana amarella	+			+	+		50
Thalictrum venulosum		3			+	1	50
Arnica cordifolia		1		+			33
Aster alpinus		+		+			33
Calamagrostis canadensis			2			3	33
Campanula rotundifolia	+					+	33
Carex sp.	+			+			33
Cornus canadensis		1		1			33
Eriogonum umbellatum	1				1		33
Hedysarum sulphurescens	1	1					33
Polemonium pulcherrimum	2		4				33
Senecio pseudaureus				+		+	33
Trisetum spicatum	1		+				33
Agoseris aurantiaca	1						17
Agoseris sp.				+			17
Agropyron sp.						4	17
Agropyron spicatum			2				17
Agrostis scabra	1						17
Aira caryophyllea					+		17

(continued ...)

TABLE 16 (concluded)

Vegetation Type	Pine - Spruce - Fir						Frequency %
Plot Number	3	4	10	15	17	20	
HERBS (cont'd)							
Antennaria racemosa			+				17
Antennaria sp.					1		17
Astragalus miser			2				17
Carex rupestris			2				17
Cirsium vulgare	1						17
Elymus glaucus				+			17
Elymus innovatus					50		17
Epilobium sp.				+			17
Fritillaria pudica			+				17
Geranium viscosissimum					+		17
Heuchera cylindrica	+						17
Hieracium albiflorum			+				17
Mitella nuda						+	17
Penstemon confertus					+		17
Petasites palmatus		1					17
Phacelia heterophylla					+		17
Phleum alpinum	3						17
Poa palustris					2		17
Poa sp.	+						17
Pyrola secunda				+			17
Pyrola sp.		+					17
Sedum stenopetalum					+		17
Senecio sp.	+						17
Senecio triangularis			2				17
Sitanion hystrix	1						17
Valeriana sitchensis			2				17
Vicia americana				+			17
MOSS AND LICHEN COVER (%)	2	7	7	1	●	4	100
Cladonia sp.		2		+		1	50
Peltigera sp.	+	2	1				50
Pleurozium sp.	1		2	+			50
Dicranum sp.			1			1	33
Aulacomnium palustre		1					17
Aulacomnium sp.						2	17
Bryum sp.	+						17
Hylocomium sp.		2					17
Pogonatum alpinum			3				17
Polytrichum sp.					+		17
Tortula princeps				+			17

* See legend in Appendix 7

\+ Less than 1%

TABLE 17

VEGETATION DATA FOR YOUNG ENGELMANN SPRUCE-ALPINE FIR MAP UNIT, BROWNIE CREEK COAL LICENCES AREA, 1978

Vegetation Type	Spruce - Fir - Grouseberry		Fir - Currant -Grouseberry	Frequency %
Plot Number	1	7	19	
Elevation (metres)	2220	2205	2040	
Slope (degrees)	14		2	
Aspect (degrees)	260		90	
Date: Day	12	13	15	
Month	9	9	9	
Year	78	78	78	
Plot Size (metres)	10 X 10	10 X 10	10 X 10	
Moisture Regime*	6	6	5	
Slope Pos Macro	3	4	5	
Surface Shape	2	8	4	
Slope Pos Moist	1	2	3	
Exposure Type	1	1	6	
Total Vegetation Cover (percent)	70	50	80	
Bare Ground	18	20	8	
Dead Wood	8	15	5	
Humus	2	0	2	
Rock	2	15	5	
SHRUB COVER (%)	70	40	55	100
B_1 Layer				
Abies lasiocarpa	2	2	4	100
Picea engelmannii	8	6	2	100
B_2 Layer				
Abies lasiocarpa	4	1	1	100
Picea engelmannii	4	2	1	100
Vaccinium scoparium	50	30	15	100
Larix lyallii	2	2		66
Salix sp.	1		2	66
Empetrum nigrum	1			33
Pinus albicaulis	3			33
Ribes oxyacanthoides			30	33
Sambucus racemosa			4	33

(cont....)

TABLE 17 (concluded)

Vegetation Type	Spruce - Fir - Grouseberry		Fir - Currant -Grouseberry	Frequency %
Plot Number	1	7	19	
HERB COVER (%)	5	6	25	100
Trisetum spicatum	+	+	•	100
Antennaria anaphaloides	1	+		66
Carex sp.	+		2	66
Epilobium angustifolium	1		3	66
Agoseris aurantiaca	1			33
Agropyron sp.			3	33
Anaphaloides margaritacea			3	33
Aster alpigenus	1			33
Aster alpinus			+	33
Aster laevis		•		33
Astragalus americanus			1	33
Calamagrostis canadensis			1	33
Epilobium sp.		1		33
Equisetum arvense			•	33
Equisetum scirpoides			2	33
Eriogonum umbellatum		+		33
Fragaria virginiana			3	33
Fritillaria pudica		+		33
Heracleum lanatum			2	33
Penstemon confertus			5	33
Penstemon sp.		+		33
Poa alpina	+			33
Senecio triangularis		3		33
Valeriana sitchensis		1		33
MOSS AND LICHEN LAYER (%)	3	12		66
Cladonia sp.	3	+		66
Stereocaulon sp.	1	1		66
Brachythecium sp.		+		33
Bryum sp.		10		33
Peltigera sp.	1			33
Polytrichum sp.		1		33

• See legend in Appendix 7

\+ Less than 1%

TABLE 18

VEGETATION DATA FOR ALPINE LARCH - ALPINE FIR MAP UNIT, BROWNIE CREEK COAL LICENCES AREA, 1978

Vegetation Type	Larch - Fir - Grouseberry		Frequency %
Plot Number	6	8	
Elevation (metres)	2350	2260	
Slope (degrees)	17	22	
Aspect (degrees)	290	20	
Date : Day Month Year	13 9 78	13 9 78	
Plot Size (metres)	10 X 10	10 X 10	
Moisture Regime*	5	4	
Slope Pos Macro	3	3	
Surface Shape	2	4	
Slope Pos Moist	1	1	
Exposure Type	1	3	
Total Vegetation Cover (percent)	95	95	
Bare Ground	4	2	
Dead Wood	0	0	
Humus	1	3	
Rock	0	0	
TREE COVER (%)	8		50
Larix lyallii	8		50
SHRUB COVER (%)	70	70	100
B_1 Layer			
Abies lasiocarpa	2	2	100
Larix lyallii	5	25	100

(continued ...)

TABLE 18 (concluded)

Vegetation Type	Fescue --- Wheatgrass		Aster - Timothy - Wheatgrass	Frequency %
Plot Number	5	2	18	
HERBS (cont'd)				
Antennaria anaphaloides	1	+		66
Aster laevis	1	5		66
Campanula rotundifolia	1	1		66
Cerastium arvense	1	2		66
Cirsium vulgare	+	1		66
Eriogonum umbellatum	1	2		66
Heuchera cylindrica	2	1		66
Phacelia heterophylla	1	4		66
Poa compressa	2	2		66
Poa palustris		4	2	66
Polemonium pulcherrimum	1	1		66
Potentilla sp.	1	2		66
Sedum stenopetalum	+	+		66
Trisetum spicatum	1		2	66
Agoseris aurantiaca	1			33
Agropyron caninum x *Sitanion hystrix*		30		33
Agrostis extrata	1			33
Anemone multifida			+	33
Antennaria parvifolia	+			33
Antennaria sp.			+	33
Arabis sp.	+			33
Aster alpinus			1	33
Aster conspicuus			20	33
Aster foliaceous	●			33
Bromus pumpellianus			5	33
Carex atrata	1			33
Castilleja miniata			5	33
Danthonia intermedia			2	33
Draba sp.	1			33
Epilobium angustifolium	1			33
Gentiana amarella			1	33
Habenaria sp.	+			33
Phleum alpinum			15	33
Poa alpina			2	33
Poa gracillima	1			33
Potentilla nivea			+	33
Senecio pseudaureus			1	33
Thalictrum sp.	+			33
Thalictrum venulosum			2	33
Tragopogon dubius		1		33
MOSS AND LICHEN COVER (%)	2	4	2	100
Tortula princeps	2	4		66
Peltigera sp.	+			33
Polytrichum sp.			2	33

● See legend in Appendix 7

\+ Less than 1%

TABLE 19

VEGETATION DATA FOR MEADOW MAP UNIT, BROWNIE CREEK COAL LICENCES AREA, 1978

Vegetation Type	Fescue --- Wheatgrass		Aster - Timothy - Wheatgrass	Frequency %
Plot Number	5	2	18	
Elevation(metres)	2365	2160	2225	
Slope (degrees)	29	27	24	
Aspect (degrees)	180	145	90	
Date: Day	13	12	15	
Month	9	9	9	
Year	78	78	78	
Plot Size (metres)	4 X 4	4 X 4	4 X 4	
Moisture Regime*	7	6	6	
Slope Pos Macro	2	3	3	
Surface Shape	4	2	3	
Slope Pos Moist	1	1	1	
Exposure Type	1	1	1	
Total Vegetation Cover (percent)	85	90	85	
Bare Ground	5	5	9	
Dead Wood	0	0		
Humus	1	0	1	
Rock	9	5	5	
SHRUB COVER (%)		1	3	66
B_2 Layer				
Juniperus communis		1		33
Ribes lacustre			2	33
Vaccinium scoparium			1	33
HERB COVER (%)	85	90	80	100
Achillea millefolium	1	2	1	100
Festuca scabrella	50	25	8	100
Fragaria virginiana	3	10	8	100
Hedysarum sulphurescens	2	6	2	100
Penstemon confertus	3	4	3	100
Agropyron spicatum	6		10	66
Allium cernuum		1	•	66

(cont....)

TABLE 19 (concluded)

Vegetation Type	Larch - Fir - Grouseberry		Frequency %
Plot Number	6	8	
B_2 Layer			
Abies lasiocarpa	1	2	100
Empetrum nigrum	30	4	100
Larix lyallii	4	5	100
Vaccinium scoparium	30	30	100
Picea engelmannii		2	50
Rhododendron albiflorum		4	50
Vaccinium myrtillus		2	50
HERB COVER (%)	25	25	100
Aster alpigenus	1	+	100
Carex rupestris	1	+	100
Hieracium gracile	1	●	100
Luzula parviflora	4	1	100
Phleum alpinum	5	1	100
Poa alpina	1	+	100
Trisetum spicatum	+	1	100
Achillea millefolium		+	50
Anemone occidentalis		7	50
Antennaria anaphaloides	4		50
Antennaria microphylla		+	50
Arnica diversifolia	+		50
Arnica mollis		1	50
Aster sp.	3		50
Cinna latifolia		+	50
Fragaria virginiana		2	50
Fritillaria pudica		1	50
Pedicularis bracteosa		1	50
Poa juncifolia	1		50
Potentilla sp.		1	50
Pyrola sp.		+	50
Scutellaria galericulata		+	50
Senecio triangularis		2	50
Valeriana sitchensis		4	50
Veronica wormskjoldii	+		50
MOSS AND LICHEN COVER (%)	4	18	100
Aulacomnium palustre	2		50
Aulacomnium sp.		18	50
Cladonia sp.	1		50
Peltigera sp.		+	50
Polytrichum sp.	1		50

* See legend in Appendix 7

\+ Less than 1%

TABLE 20

RESULTS OF PRELIMINARY PELLET TRANSECT SURVEY OF THE
BROWNIE CREEK COAL LICENCE AREA, SEPTEMBER 12-15, 1978

Habitat Type (Map Unit)	Mature Engelmann Spruce-Alpine Fir									Logged								
Vegetation Plot No.	9			12			14			11			13			16		
Category / Species	Total Pellet Groups (T)	Mean Pellet Groups Per Plot (M)	Range (R)	T	M	R	T	M	R	T	M	R	T	M	R	T	M	R
Deer	0	-	-	2	0.2	0-1	1	0.1	0-1	2	0.2	0-1	2	0.2	0-2	1	0.1	0-1
Moose	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Elk	0	-	-	0	-	-	2	0.2	0-1	10	1.0	0-3	16	1.6	0-5	10	1.1	0.2
Bighorn Sheep	0	-	-	1	0.1	0-1	0	-	-	3	0.3	0-1	0	-	-	0	-	-
Total	0	-	-	3	0.3	0-1	3	0.3	0-1	15	1.5	0-3	18	1.8	0-5	11	1.1	0.3

TABLE 20 (continued)

Habitat Type (Map Unit)	Seral Pine-Spruce-Fir																	
Vegetation Plot No.	3			4			10			15			17			20		
Category / Species	T	M	R	T	M	R	T	M	R	T	M	R	T	M	R	T	M	R
Deer	0	-	-	0	-	-	0	-	-	1	0.1	0-1	3	0.3	0-2		NOT DONE	
Moose	0	-	-	0	-	-	0	-	-	0	-	-	1	0.1	0-1			
Elk	2	0.2	0-1	4	0.4	0-1	2	0.2	0-1	4	0.4	0-2	3	0.3	0-2			
Bighorn Sheep	1	0.1	0-1	0	-	-	0	-	-	0	-	-	0	-	-			
Total	3	0.3	0-1	4	0.4	0-1	2	0.2	0-1	5	0.5	0-2	7	0.7	0-2			

TABLE 20 (concluded)

Habitat Type (Map Unit)	Young Engelmann Spruce-Alpine Fir									Alpine Larch-Alpine Fir						Meadow								
Vegetation Plot No.	1			7			19			6			8			2			5			18		
Category / Species	T	M	R	T	M	R	T	M	R	T	M	R	T	M	R	T	M	R	T	M	R	T	M	R
Deer	0	-	-	1	0.1	0-1	0	-	-	0	-	-	1	0.1	0-1	0	-	-	0	-	-	0	-	-
Moose	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Elk	0	-	-	0	-	-	1	0.1	0-1	0	-	-	1	0.1	0-1	4	0.4	0-2	4	0.4	0-2	0	-	-
Bighorn Sheep	3	0.3	0-2	0	-	-	0	-	-	11	1.1	0-4	1	0.1	0-1	14	1.4	0-3	5	0.5	0-2	0	-	-
Total	3	0.3	0-2	1	0.1	0-1	1	0.1	0-1	11	1.1	0-4	3	0.3	0-2	18	1.8	0-4	9	0.9	0-3	0	-	

TABLE 21

SIGHTINGS OF UNGULATES DURING AERIAL SURVEY OF THE

FORDING COAL AREA, MARCH 19, 1979

Species	Number, Age and sex	Location	Comments
Moose	3 (2 bulls and 1 u/c*)	Henretta Creek bottom 1735 m (5700 ft), near Moore Creek (Lot 6644)	Along creek; willows abundant and many tracks in area; pioneer shrub habitat
	4	Henretta Creek bottom just upstream of McQuarrie Creek at 1800 m (5900 ft) (Lot 6718)	Near creek; many tracks evident in creek bottom; willows abundant along creek; edge between pioneer shrub and seral pine-spruce-fir habitats
	2 (cow and calf)	Upper Henretta Creek bottom at about 1830 m (6000 ft)	Along creek near top of drainage basin; edge of subalpine zone in pioneer shrub habitat
Elk	3 (2 adult bulls and 1 u/c)	Ridge north of lower Henretta Creek (opposite Mount Turnbull) at 2255 m (7400 ft) (Lot 6721)	On top of ridge, partly snow-free; smaller elk may have been a spike bull; meadow habitat surrounded by seral pine-spruce-fir habitat
	15	Ridge north of middle Henretta Creek, north by northeast of Mount Turnbull at 2255 m (7400 ft) (Lot 6722)	On open, southwest trending ridge, mostly snow-free; meadow habitat
	30	West ridge of Mount Turnbull at 2375 m (7800 ft) (Lots 6709/6711)	On wind swept, west facing slope, mostly snow-free; edge of meadow habitat above seral pine-spruce-fir habitat; many tracks in area
	10	South slope of Eagle Mtn. at about 2135 m (7000 ft), west of first tributary north of Kilmarnock Cr. (Lot 6696)	On steep, open slope in meadow habitat partly snow-free; many feeding craters through snow
	3	Southwest slope of Eagle Mtn. at about 2040 m (6700 ft) west of first tributary north of Kilmarnock Cr. (Lot 6697)	On steep, rocky slope in meadow habitat; mostly snow-free, also feeding craters through snow
	14	South slope of Eagle Mtn. at about 1980 m (6500 ft), just west of first tributary north of Kilmarnock Cr. (Lot 6696)	On meadow in seral pine-spruce-fir habitat
	12	Southwest slope of Eagle Mtn. at about 1735 m (5700 ft), at edge of cleared area above lower Kilmarnock Cr. (Lot 6697)	In open stand of trembling aspen in mixed aspen-alpine fir habitat, partly cleared area
	11	South slope of Eagle Mtn. at about 1980 m (6500 ft), between first and second tributaries north of Kilmarnock Creek	In opening in seral pine-spruce-fir habitat
Mountain goat	3	Upper Henretta Creek basin to south of Courcelette peak at about 2285 m (7500 ft) (Lot 6722)	On steep, rocky bluffs north of upper Henretta Creek; non-vegetated map unit
	4	Upper Henretta Creek basin to southeast of Courcelette peak at about 2590 m (8500 ft)	On steep, rocky bluffs at top end of Henretta Creek basin; non-vegetated map unit
	4	Steep slopes west of Mount Farquhar at about 2440 m (8000 ft) (Lot 6705)	On steep, rocky bluffs near divide; non-vegetated map unit

u/c = unclassified

FIGURES

FIGURE 1

View of ridge between Mount Turnbull (on the right) and Eagle Mountain (on the left), lying above and to the west of Brownie Creek. This east-facing slope is a possible site for dumping of overburden material. The west-facing slope above Brownie Creek (foreground) shows the meadow and the alpine larch-alpine fir map units (23645-22A).

FIGURE 2

Henretta Creek at water sample site WS5. Note the dense cover of willows (Salix sp.) along the banks which provides cover for fish. Many of these shrubs were heavily browsed by moose (Alces alces andersoni). (23649-22A)

FIGURE 3

Electro-shocking along lower Kilmarnock Creek, May 11, 1979. This stretch of the creek lies between the Fording River (in the trees in the background) and the Fording Highway. Note the clarity of the water during the early freshet period (23791-6)

FIGURE 4

Fish trap site T2 along middle Kilmarnock Creek. This is the only section of the creek, downstream of Brownie Creek, with forest cover along its banks (23791-18).

FIGURE 5

Brownie Creek crossing the logging road in the Kilmarnock Creek valley at water sample site WS3. This stream has very little discharge and has no value as fish habitat due to its small size (23649-7A).

FIGURE 6

Yellowstone cutthroat trout (Salmo clarki lewisi)captured by angling during the September 13-15, 1978 sampling period (23648-16).

FIGURE 7

Spruce-fir moss vegetation type at plot 14 in the mature Englemann spruce-alpine fir map unit. The abundance of climax species in the shrub layer indicates that the climax forest will perpetuate. Numerous well-used game trails were found in this habitat type on the north-facing slope of the Kilmarnock Creek valley (23646-30).

FIGURE 8

Elderberry-currant-fireweed vegetation type at plot 11 in the logged map unit. The logged areas sampled indicated a high level of use by elk. An abundance of forage is available from the pioneer species of this habitat type which now occupies much of the Kilmarnock Creek valley bottom (23646-23).

FIGURE 9

Pine-spruce-fir vegetation type at plot 3 in the seral pine-Englemann spruce-alpine fir map unit. This habitat type occupies the low to mid-elevations of the study area. Forage is relatively abundant and the areas sampled indicated a moderate level of use by elk (23645-12A).

FIGURE 10

Spruce-fir-grouseberry vegetation type at plot 1 in the young Englemann spruce-alpine fir map unit. This habitat type covers the higher elevations of the study area (23645-8A).

FIGURE 11

Larch-fir-grouseberry vegetation type at plot 6 in the alpine larch-alpine fir map unit. This habitat type occupies the higher, northern aspect elevations of the study area. Little evidence of ungulate use was found in the areas sampled (23645-18A).

FIGURE 12

Fescue-wheatgrass vegetation type at plot 2 in the meadow map unit. The meadow habitat type occurs on steep slopes with a southern aspect. The areas sampled generally indicated a high level of use by elk (Cervus elaphus nelsoni) and bighorn sheep (Ovis canadensis canadensis). Note the abundance of grasses and forbs (23645-11A).

FIGURE 13

Earth lick in a ravine, located near plot 7 in Lot 6706 on the west ridge of Mount Farquhar. The lick had numerous tracks of ungulates and would be used during the spring-summer period (23649-2A).

FIGURE 14

Band of 15 elk observed on exposed grassland ridge north of Henretta Creek on March 19, 1979. Other bands of elk, ranging from 3 to 30 animals, were observed on similar open, southern exposure grasslands on Mount Turnbull and Eagle Mountain (23769-14).

APPENDICES

APPENDIX 1

DATA AND INFORMATION SOURCES USED IN THE FORDING COAL STUDY

MAPS

National Topographic Series Maps

1:50,000 Scale 82J/2 E & W
82J/7W

1:125,000 Scale 82J/SW (and part of 82J/SE)
82G/NW (and part of 82G/NE)

AIR PHOTOS

a) Federal - Energy, Mines and Resources Canada
NAPL Production Center, Ottawa

RSA 30590-67
RSA 30590-68

(high level colour)

b) Provincial - Ministry of the Environment
Surveys and Mapping Branch
Map Production Division, Victoria

BC7428:135-139
BC7428:190-203
BC7428:233-244

(1:20,000 black and white)

c) McElhanney Surveying and Engineering Ltd., Vancouver

06519-0 L1-2 to 8
06519-0 L2-14 to 18

(1:30,000 colour)

AIR PHOTO MOSAICS

McElhanney Surveying and Engineering Ltd., Vancouver

Black and white air photo mosaics prepared for Fording Coal Ltd. and B.C. Research at scales of 1:10,000 and 1:30,000 (based on 1978 aerial photography).

APPENDIX 1 (Concluded)

LAND CAPABILITY MAPS

Resources Analysis Branch, Ministry of the Environment, Victoria

a) Canada Land Inventory maps for NTS map sheets 82J/2 E & W and 82J/7W for:

   - present land use
   - recreation
   - agriculture
   - forestry
   - waterfowl
   - ungulate (NTS map sheet 82J/SW)

b) Forest cover map for 82J/2 E & W at 1:50,000

c) RAB Biophysical maps for 82J/2 at 1:50,000 for:

   - surficial materials
   - soils
   - vegetation
   - recreation
   - ungulates

WATER QUALITY AND ASSOCIATED AQUATIC BIOLOGY DATA

B.C. Water Resources Service. 1976b. Kootenay Air and Water Quality Study Phase I, Water Quality in Region 2, The Elk River Basin. Ministry of the Environment, Victoria.

B.C. Water Investigations Branch. 1978a. Kootenay Air and Water Quality Study Phase II, Water Quality in The Elk and Flathead River Basins. Ministry of the Environment, Victoria.

Crozier, R.J. 1978. Report on sediment production in the vicinity of East Kootenay coal mining operations, August, 1978. P.C.B., Ministry of the Environment, Nelson.

AIR QUALITY

B.C. Water Resources Service. 1976a. Kootenay Air and Water Quality Study Phase I, Air Quality in Region A, The Fording - Sparwood - Fernie Area. Ministry of the Environment, Victoria.

B.C. Water Investigations Branch. 1978. Kootenay Air and Water Quality Study Phase II, Air Quality in the Elkford - Sparwood - Fernie Region. Ministry of the Environment, Victoria.

APPENDIX 2

RESOURCES ANALYSIS BRANCH -

AQUATIC BIOPHYSICAL DATA CARDS, SEPTEMBER, 1978

W. S. 1.

POINT SAMPLE

Point No. __ of __

SYSTEM NAME (or Alias) KILMARNOCK CREEK
SYSTEM NO. 35 07 00 300 070
Location of site (specific) LOWER KILMARNOCK CK. 100 m UPSTREAM OF C.P. RAIL
Reach No. 1
Crew J.G.M. Agency ___ Date 76 09 13 Time 1300
NTS Map 83J/2 Access V2
Photographer MALICK Roll 1 Frames 2(4,5)
Weather PARTLY CLOUDY Fish Sample Card (No) Yes
Air Temp °C ___ Water Sample No. ___

BANK	L	R
Form	S	S
Genetic Mat.	F	F
Organic	1	1
Clay / Silt / Sand	3	3
S. Grav.	2	2
L. Grav.	2	2
Gravel total	4	4
Cobble	89	89
Boulder	3	3
Cobble + Boulder	92	92
Bedrock	0	0
VEG. Cont.	1	1
VEG. Decid.	C1 6 1	1 6
VEG. Under	1	1
VEG. Ground	9 –	– 9
CHANNEL COVER Crown	1 0	0 1
CHANNEL COVER Overhang	1 0	0 1
BIOTA Aquatic Veg		
Invertebrates		
Algae		

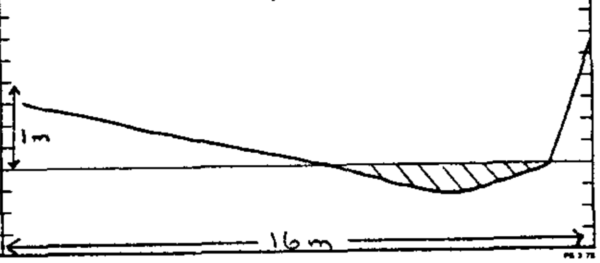
BED MATERIAL	
Ice Scouring	?
Imbric	L
Compac	M
Log	M
D_{90} (cm)	25
Texture %: Organic	1
Clay	1
Silt	1
Sand	1
Clay/Silt/Sand total	3
S. Grav	2
L. Grav	2
Gravel total	4
Cobble	89
Boulder	3
Cobble + Boulder	92
Bedrock	0 0

HYDRAULICS	Meth
Valley Flat W(m)	200 E
Chan Width (m)	16 M
Wet Width (m)	5 M
Slope (%)	5.0 M
Max Depth (cm)	37 M
Avg. Depth (cm)	22 M
Wet X-sec area	1.0 m² M
Velocity (m/sec)	1.2 M
Flow (m³/sec)	0.54 M
Bank Height (m)	1.4 M
Flood Signs: Ht	1.4, Type D
Bank Ice Scour	N
Stage	L
Flow Char	E
Valley-Chan	>10
Side Chan	L
DEBRIS Channel	L
DEBRIS Stable %	0
DEBRIS Floodplain	L

WATER QUALITY: Water temp. °C ___ Turbidity ___ TDS ___ D.O. ___ pH ___

FISH SPECIES PRESENT:

STREAM CROSS-SECTION (looking downstream)



Comments:

C1 - Vegetation Deciduous - Salix sp.

W. S. 2

POINT SAMPLE

Point No. __ of __

SYSTEM NAME (or Alias) KILMARNOCK CREEK
SYSTEM NO. 35 07 00 300 070
Location of site (specific) 1 Km ABOVE BROWNIE CK. ON KILMARNOCK CK.
Reach No. 3
Crew J.G.M. Agency ___ Date 78 09 13 Time 1715
NTS Map 83J/2 Access V2
Photographer MALICK Roll 1 Frames 6,7
Weather PARTLY CLOUDY Fish Sample Card (No) Yes
Air Temp °C ___ Water Sample No. ___

BANK	L	R
Form	S	S
Genetic Mat.	F	F
Organic	1	1
Clay	0	0
Silt	0	0
Sand	3	0
Clay/Silt/Sand total	3	0
S. Grav.	5	0
L. Grav.	5	0
Gravel total	10	0
Cobble	84	2
Boulder	2	97
Cobble + Boulder	86	99
Bedrock	0	0
VEG. Cont.	C1 2 1	1
VEG. Decid.	C2 2 1	1
VEG. Under	1	1
VEG. Ground	9 –	– 9
CHANNEL COVER Crown	1 0	0 1
CHANNEL COVER Overhang	1 0	0 1
BIOTA Aquatic Veg		
Invertebrates		
Algae		

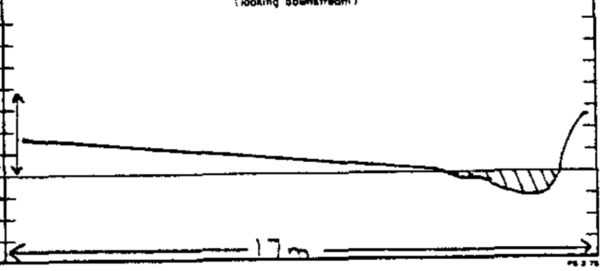
BED MATERIAL	
Ice Scouring	?
Imbric	L
Compac	M
Log	M
D_{90} (cm)	15
Texture %: Organic	1
Clay	0
Silt	1
Sand	2
Clay/Silt/Sand total	3
S. Grav	2
L. Grav	2
Gravel total	4
Cobble	25
Boulder	67
Cobble + Boulder	92
Bedrock	0 0

HYDRAULICS	Meth
Valley Flat W(m)	100 E
Chan Width (m)	17 M
Wet Width (m)	3.8 M
Slope (%)	11.5 M
Max Depth (cm)	40 M
Avg. Depth (cm)	19 M
Wet X-sec area	0.7 m² M
Velocity (m/sec)	1.52 M
Flow (m³/sec)	0.50 M
Bank Height (m)	0.8 M
Flood Signs: Ht	3, Type D
Bank Ice Scour	N
Stage	L
Flow Char	E
Valley-Chan	>10
Side Chan	Nil
DEBRIS Channel	M
DEBRIS Stable %	0
DEBRIS Floodplain	L

WATER QUALITY: Water temp. °C ___ Turbidity ___ TDS ___ D.O. ___ pH ___

FISH SPECIES PRESENT:

STREAM CROSS-SECTION (looking downstream)



Comments:

C1 - Vegetation Coniferous - Picea sp.
C2 - Vegetation Deciduous - Salix sp.

W.S. 3

POINT SAMPLE

Point No ___ of ___

SYSTEM NAME (or Alias) BROWNIE CREEK

SYSTEM NO 35 0700 300 070 010

Location of site (specific) BROWNIE CK - 100 m UPSTREAM FROM KILMARNOCK Ck. Reach No 1

Crew J.G.M. Agency ___ Date 78 09 15 (yr mo day) Time 1045

NTS Map 82 J/2 Access V2

Photographer MALICK Roll 1 Frames 2 (17,18)

Weather RAIN Fish Sample Card: (No) Yes ___

Air Temp °C ___ Water Sample No. ___

L		BANK		R
S	S	Form	S	S
F		Genetic Mat.		F
		Texture %		
5	5	Organic	5	5
11	3	Clay	3	11
	3	Silt	3	
	5	Sand	5	
10	5	S. Grav.	5	10
	5	L. Grav.	5	
74	69	Cobble	69	74
	5	Boulder	5	
	0	Bedrock	0	

Distr.	Sp	VEG.	Sp	Distr.
1		Conif.		1
C1 1	1	Decid.	1	1
1		Under		1
9	-	Ground	-	9

CHANNEL COVER				
Distr.	% Area	Level	% Area	Distr.
1	0	Crown	0	1
1	0	Overhang	0	1

BIOTA	Sp	Abun
Aquatic veg.		
Invertebrates		
Algae		

BED MATERIAL		
Ice Scouring	Y (?) N	
Imbric	Nil (L) M H	
Compac	Nil L (M) H	
Log	Nil L (M) H	
D_{90} (cm)	20	

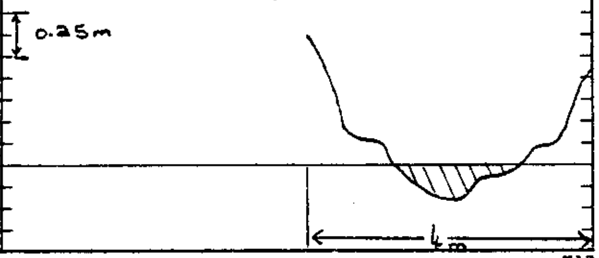
Texture %		
Organic	2	2
Clay	1	10
Silt	4	
Sand	5	
S. Grav	5	10
L. Grav.	5	
Cobble	63	78
Boulder	15	
Bedrock	0	0

HYDRAULICS		Meth
Valley Flat W(m)	400	E
Chan Width (m)	6.7	M
Wet Width (m)	2.2	M
Slope (%)	6	E
Max Depth (cm)	22	M
Avg. Depth (cm)	10	M
Wet X-sec area	0.22 m²	M
Velocity (m/sec)	0.2	M
Flow (m³/sec)	0.03	M
Bank Height (m)	1	M
Flood Signs Ht	1	Type D
Bank Ice Scour	Y ? (N)	
Stage	Dry (L) M H Fld	
Flow Char.	P S R (B) T	
Valley Chan	0-2 2-5 5-10 (10+) N/A	
Side Chan	(Nil) L M H	
DEBRIS Channel	Nil L (M) H	
DEBRIS Stable %	3	
DEBRIS Floodplain	Nil L (M) H	

WATER QUALITY	Water temp °C	Turbidity m cm	TDS	D O	pH

FISH SPECIES PRESENT:

STREAM CROSS-SECTION (looking downstream)



Comments:

C1 - Vegetation Deciduous - Salix sp.

W.S. 4

POINT SAMPLE

Point No ___ of ___

SYSTEM NAME (or Alias) HENRETTA CREEK

SYSTEM NO 35 0700 300 090

Location of site (specific) LOWER HENRETTA CK. 3 Km. FROM FORDING RIVER Reach No. 1

Crew J.G.M. Agency ___ Date 78 09 14 (yr mo day) Time 1200

NTS Map 82 J/2 Access V4

Photographer MALICK Roll 1 Frames 10, 11

Weather CLOUDY Fish Sample Card: (No) Yes ___

Air Temp °C ___ Water Sample No ___

L		BANK		R
F	S	Form	U	S
F		Genetic Mat.		F
		Texture %		
1	1	Organic	24	24
14	1	Clay	20	60
	3	Silt	20	
	10	Sand	20	
45	10	S. Grav.	10	15
	35	L. Grav.	5	
40	35	Cobble	1	1
	5	Boulder	0	
	0	Bedrock	0	

Distr.	Sp	VEG.	Sp	Distr.
C1 6	1	Conif.	2	6
C2 8	1	Decid.	1	8
1		Under		1
8	-	Ground	-	8

CHANNEL COVER				
Distr.	% Area	Level	% Area	Distr.
2	2	Crown	1	2
7	5	Overhang	5	7

BIOTA	Sp	Abun
Aquatic veg		
Invertebrates		
Algae		

BED MATERIAL		
Ice Scouring	Y (?) N	
Imbric	Nil (L) M H	
Compac	Nil L (M) H	
Log	Nil L (M) H	
D_{90} (cm)	10	

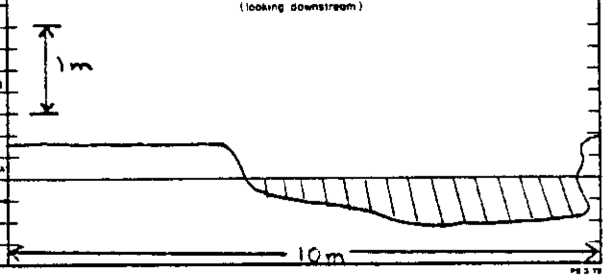
Texture %		
Organic	2	2
Clay	1	5
Silt	1	
Sand	3	
S. Grav	5	20
L. Grav.	15	
Cobble	70	73
Boulder	3	
Bedrock	0	0

HYDRAULICS		Meth
Valley Flat W(m)	200	E
Chan Width (m)	10	M
C3 Wet Width (m)	5.5	M
Slope (%)	4.5	M
Max Depth (cm)	68	M
Avg. Depth (cm)	42	M
Wet X-sec area	2.29 m²	M
Velocity (m/sec)	0.5	M
Flow (m³/sec)	0.68	M
Bank Height (m)	0.55	M
Flood Signs Ht	2	Type D
Bank Ice Scour	Y ? (N)	
Stage	Dry (L) M H Fld	
Flow Char.	P S R (B) T	
Valley Chan	0-2 2-5 5-10 (10+) N/A	
Side Chan	(Nil) L M H	
DEBRIS Channel	Nil (L) M H	
DEBRIS Stable %	1	
DEBRIS Floodplain	Nil (L) M H	

WATER QUALITY	Water temp. °C	Turbidity m cm	TDS	D O	pH

FISH SPECIES PRESENT:

STREAM CROSS-SECTION (looking downstream)



Comments :

C1 - Vegetation Coniferous - Picea sp., Pinus sp.
C2 - Vegetation Deciduous - Salix sp.
C3 - Undercut Bank Stabilized by Willow Roots

W.S. 5

POINT SAMPLE

Point No ___ of ___

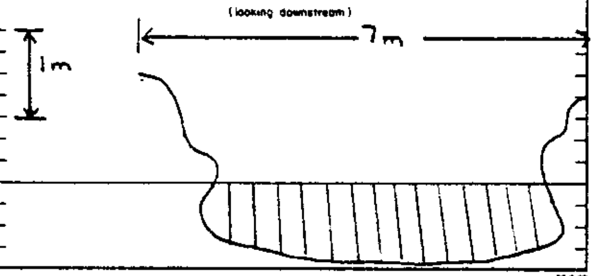
SYSTEM NAME (or Alias) HENRETTA CREEK
SYSTEM NO 35 07 00 200 090
Location of site (specific) UPPER HENRETTA CK-0.5km ABOVE Mc QUARRIE CK. Reach No. 2
Crew J. G. M. Agency ___ Date 78 09 14 (yr mo day) Time 1500
NTS Map 83 J/2 Access V4
Photographer MALICK Roll 1 Frames 12, 13
Weather MOSTLY CLOUDY Fish Sample Card (No) Yes
Air Temp °C ___ Water Sample No ___

L	BANK	R
U S	Form	U S
F	Genetic Mat.	F
	Texture %	
24 24	Organic	24 24
20	Clay .004	20
60 20	Silt .062	20 60
20	Sand 2	20
15 10	S. Grav. 16	10 15
5	L. Grav. 64	5
1 1	Cobble 256	1 1
0	Boulder	0
0	Bedrock	0
Distr. Sp.	VEG.	Sp. Distr.
C1 1	Conif.	2 1
C2 9 2	Decid.	1 9
1	Under	1
8 –	Ground	– 8
	CHANNEL COVER	
Distr. % Area	Level	% Area Distr.
1 0	Crown	0 1
8 30	Overhang	20 8
	BIOTA	Sp. Abun.
	Aquatic Veg	
	Invertebrates	
	Algae	

BED MATERIAL			Texture %	
Ice Scouring	Y (?) N		Organic	1 1
Imbric	(Nil) L M H		Clay	1
Compac	Nil L (M) H		Silt	1 3
Log	Nil L (M) H		Sand	1
D_{90} (cm)	20			
HYDRAULICS		Meth	S. Grav	3
Valley Flat W(m)	75	E	L. Grav	3 6
Chan Width (m)	7	M	Cobble	60
Wet Width (m)	5.5	M	Boulder	30 90
Slope (%)	5	M	Bedrock	0 0
Max Depth (cm)	55	M		
Avg. Depth (cm)	42	M		
Wet X-sec area	2.18m²	M		
Velocity (m/sec)	0.58	M		
Flow (m³/sec)	0.63	E		
Bank Height (m)	1.2	M		
Flood Signs	Ht 3	Type (D)		
Bank Ice Scour	Y ? (N)			
Stage	Dry (L) M H Fld			
Flow Char.	P S R (B) T			
Valley/Chan	0-2 2-5 (5-10) 10+			
Side Chan	(Nil) L M H			
DEBRIS Channel	Nil (L) M H			
DEBRIS Stable %	2			
DEBRIS Floodplain	Nil (L) M H			

WATER QUALITY	Water temp.	Turbidity	TDS	D.O.	pH
	°C	m cm			

FISH SPECIES PRESENT:



Comments:

- C1 - Vegetation Coniferous - Pinus sp., Picea sp.
- C2 - Vegetation Deciduous - Salix sp., 1 Tree Populus Tremuloides
- C3 - Undercut Banks Stabilized by Roots

W.S. 6

POINT SAMPLE

Point No ___ of ___

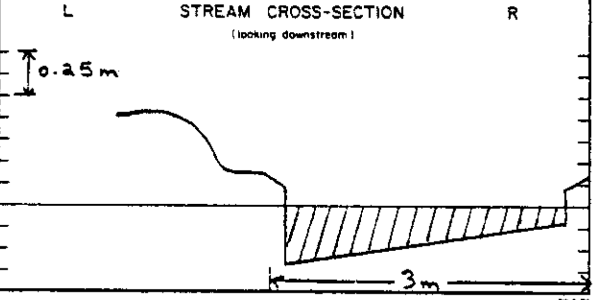
SYSTEM NAME (or Alias) Mc QUARRIE CREEK
SYSTEM NO 35 07 00 200 090 030
Location of site (specific) Mc QUARRIE CK - 400m ABOVE HENRETTA CK. Reach No 1
Crew J. G. M. Agency ___ Date 78 09 14 (yr mo day) Time 1630
NTS Map 83 J/2 Access V4
Photographer MALICK Roll 1 Frames 14, 15, 16
Weather MOSTLY CLOUDY Fish Sample Card (No) Yes
Air Temp °C ___ Water Sample No ___

L	BANK	R
S S	Form	S S
F	Genetic Mat.	F
	Texture %	
50 50	Organic	50 50
50 25	Clay .004	25 50
25	Silt .062	25
0	Sand 2	0
0	S. Grav. 16	0
0	L. Grav. 64	0
0	Cobble 256	0
0	Boulder	0
0	Bedrock	0
Distr. Sp.	VEG.	Sp. Distr.
C1 7 1	Conif.	1 7
C2 6 1	Decid.	1 6
1	Under	1
5 –	Ground	– 5
	CHANNEL COVER	
Distr. % Area	Level	% Area Distr.
7 45	Crown	45 7
1 0	Overhang	3 2
	BIOTA	Sp. Abun.
	Aquatic Veg.	
	Invertebrates	
	Algae	

BED MATERIAL			Texture %	
Ice Scouring	Y (?) N		Organic	3 3
Imbric	(Nil) L M H		Clay	2
Compac	Nil L (M) H		Silt	2 14
Log	Nil L (M) H		Sand	10
D_{90} (cm)	15			
HYDRAULICS		Meth	S. Grav	10
Valley Flat W(m)	200	E	L. Grav	5 15
Chan Width (m)	0.49	M	Cobble	68 68
Wet Width (m)	2.4	M	Boulder	0
Slope (%)	5	M	Bedrock	0 0
Max Depth (cm)	35	M		
Avg. Depth (cm)	25	M		
Wet X-sec area	0.61m²	M		
Velocity (m/sec)	0.26	M		
Flow (m³/sec)	0.04	M		
Bank Height (m)	0.7	M		
Flood Signs	Ht 1	Type (D)		
Bank Ice Scour	Y ? (N)			
Stage	Dry (L) M H Fld			
Flow Char.	P S R (B) T			
Valley/Chan	0-2 2-5 5-10 (10+)			
Side Chan	Nil (L) M H			
DEBRIS Channel	Nil L (M) H			
DEBRIS Stable %	5			
DEBRIS Floodplain	Nil (L) M H			

WATER QUALITY	Water temp.	Turbidity	TDS	D.O.	pH
	°C	m cm			

FISH SPECIES PRESENT:



Comments:

- C1 - Vegetation Coniferous - Picea sp.
- C2 - Vegetation Deciduous - Salix sp.

REACH

Reach No. 1

SYSTEM NAME (or Alias) KILMARNOCK CREEK
SYSTEM NO. 35 0700 300 070
Compiling Agency ______ Access V2 NTS Map(s) 82J/2
Field Obs J.C.M Date 78 09 13 (yr mo day) Weather CLOUDY
Field Photo (Y) N Photog MALICK Roll 1 Frames 4,5
Air Photos Init 06519-0 Photo # 12-15+16 Yr 1978 Photo Scale(s) 1:30,000

ACTIVE VALLEY WALL PROCESS	
Rock / Soil falls	Nil (L) M H
Mud / Snow flows	(Nil) L M H
Slumps / Glides	(Nil) L M H
Slides	(Nil) L M H
Gullies	(Nil) L M H
BAR PRESENCE	
Side / Point	Nil L (M) H
Mid Channel	Nil (L) M H
Transverse	(Nil) L M H
Junction	(Nil) L M H
Diamond / Braiding	(Nil) L M H
Lee	(Nil) L M H
Dunes	(Nil) L M H
Islands	(Nil) L M H
LATERAL CHANNEL MOVEMENT	
Apparently Stable	(Yes) No
Bar Veg. Progressions	(Nil) L M H
Cut-Offs / Ox Bows	(Nil) L M H
Meander Scars	Nil (L) M H
Avulsions	Yes (No) #
Terraces	(Yes) No # 1
Constrictions	Yes (No) #
Unstable Banks (%)	0

CHANNEL WIDTH (m)	16	
BED MATERIAL (%)		
Fines (clay silt sand)	10	
Gravel (2-64 mm)	80	
Large (64 mm+)	10	
Bedrock	0	
CHANNEL COVER	% Area	Distr
Crown	0	1
Overhang	2	5
RIPARIAN VEG.	Sp	Distr
Coniferous		1
Deciduous		5
Understorey		5
Ground		9
TOTAL POOLS (%)	10	
Bedrock control (%)	0	
Stage	Dry (L) M H Fld	
Flow Char	P S (R) B T	
Valley Chan	0-2 2-5 5-10 (10+) N/A	
Confinement	Ent Conf Fr (Oc) Un N/A	
Pattern	St Sin (Ir) Im Rm Tm	
Vert Stab	(Deg) ? Agr N/A	
Side Chan	(Nil) L M H	

FISH SUMMARY					STREAM FEATURE		
	Species	Use	Ref	Map	Type	Ht (m)	Length (m)
1	CUTTHROAT S.R			✓			

Channel Debris: Nil (L) M H — % Stable Debris: 5
Floodplain Debris: Nil (L) M H

(Fish)

YCt
r 3 b/u | 18
(Width) (Vall-Chan) (Slope) (Bed Material)

REACH

Reach No. 2

SYSTEM NAME (or Alias) KILMARNOCK CREEK
SYSTEM NO. 35 0700 300 070
Compiling Agency ______ Access V2 NTS Map(s) 82J/2
Field Obs J.C.M Date 78 09 13 (yr mo day) Weather CLOUDY
Field Photo Y (N) Photog ______ Roll ______ Frames ______
Air Photos Init 06519-0 Photo # 12-15+16 Yr. 1978 Photo Scale(s) 1:30,000

ACTIVE VALLEY WALL PROCESS	
Rock / Soil falls	Nil (L) M H
Mud / Snow flows	(Nil) L M H
Slumps / Glides	(Nil) L M H
Slides	(Nil) L M H
Gullies	(Nil) L M H
BAR PRESENCE	
Side / Point	Nil L (M) H
Mid Channel	Nil (L) M H
Transverse	(Nil) L M H
Junction	(Nil) L M H
Diamond / Braiding	(Nil) L M H
Lee	(Nil) L M H
Dunes	(Nil) L M H
Islands	(Nil) L M H
LATERAL CHANNEL MOVEMENT	
Apparently Stable	(Yes) No
Bar Veg Progressions	(Nil) L M H
Cut-Offs / Ox Bows	(Nil) L M H
Meander Scars	Nil (L) M H
Avulsions	Yes (No) #
Terraces	(Yes) No # 1
Constrictions	Yes (No) #
Unstable Banks (%)	0

CHANNEL WIDTH (m)	15	
BED MATERIAL (%)		
Fines (clay silt sand)	10	
Gravel (2-64 mm)	80	
Large (64 mm+)	10	
Bedrock	0	
CHANNEL COVER	% Area	Distr
Crown	80	8
Overhang	20	7
RIPARIAN VEG.	Sp	Distr
Coniferous		8
Deciduous		3
Understorey		7
Ground		1
TOTAL POOLS (%)	60	
Bedrock control (%)	1	
Stage	Dry (L) M H Fld	
Flow Char	P S (R) B T	
Valley Chan	0-2 2-5 (5-10) 10+ N/A	
Confinement	Ent Conf Fr (Oc) Un N/A	
Pattern	St Sin (Ir) Im Rm Tm	
Vert Stab	(Deg) ? Agr N/A	
Side Chan	(Nil) L M H	

FISH SUMMARY					STREAM FEATURE		
	Species	Use	Ref	Map	Type	Ht (m)	Length (m)
6	CUTTHROAT S.R			✓			

Channel Debris: Nil L (M) H — % Stable Debris: 15
Floodplain Debris: Nil (L) M H

(Fish)

YCt
r 3 b/u | 18
(Width) (Vall-Chan) (Slope) (Bed Material)

REACH

Reach No. 3

SYSTEM NAME (or Alias) KILMARNOCK CREEK
SYSTEM NO. 35 0700 300 072
Compiling Agency ______ Access V2 NTS Map(s) 82J/2
Field Obs. I.G.M. Date 78 09 13 (yr mo day) Weather CLOUDY
Field Photo **Y** N Photog. MALICK Roll 1 Frames 6,7
Air Photos Init ____ 065 19-0 Photo # 62-15,16 Yr. 1978 Photo Scale(s) 1:30,000

ACTIVE VALLEY WALL PROCESS	
Rock / Soil falls	**Nil** L M H
Mud / Snow flows	**Nil** L M H
Slumps / Glides	**Nil** L M H
Slides	**Nil** L M H
Gullies	Nil **L** M H
BAR PRESENCE	
Side / Point	Nil L **M** H
Mid Channel	**Nil** L M H
Transverse	**Nil** L M H
Junction	**Nil** L M H
Diamond / Braiding	Nil **L** M H
Lee	Nil **L** M H
Dunes	**Nil** L M H
Islands	Nil **L** M H
LATERAL CHANNEL MOVEMENT	
Apparently Stable	**Yes** No
Bar Veg. Progressions	Nil **L** M H
Cut-Offs / Ox Bows	**Nil** L M H
Meander Scars	Nil **L** M H
Avulsions	Yes **No** #
Terraces	**Yes** No # 1
Constrictions	Yes **No** #
Unstable Banks (%)	0

CHANNEL WIDTH (m)	15	
BED MATERIAL (%)		
Fines (clay silt sand)	10	
Gravel (2-64 mm)	30	
Large (64 mm+)	60	
Bedrock	0	
CHANNEL COVER		
Level	% Area	Distr.
Crown	0	1
Overhang	2	5
RIPARIAN VEG.		
Storey	Sp.	Distr.
Coniferous		1
Deciduous		5
Understorey		5
Ground		9
TOTAL POOLS (%)	10	
Bedrock control (%)	0	
Stage	Dry **L** M H Fld	
Flow Char.	P S R **B** T	
Valley Chan	0-2 2-5 5-10 **10+** N/A	
Confinement	Ent Conf Fr **Oc** Un N/A	
Pattern	St Sin **Ir** Im Rm Tm	
Vert. Stab.	**Deg** ? Agr N/A	
Side Chan	Nil **L** M H	

FISH SUMMARY				STREAM FEATURE		
Species	Use	Ref	Map	Type	Ht (m)	Length (m)

Channel Debris: Nil L **M** H — % Stable Debris 10
Floodplain Debris: Nil **L** M H

(Fish) (YCt)

r 9 b/u 13
(Width) (Vall. Chan) (Slope) (Bed Material)

REACH

Reach No. 4

SYSTEM NAME (or Alias) KILMARNOCK CREEK
SYSTEM NO. 35 0700 300 070
Compiling Agency ______ Access V2 NTS Map(s) 82J/2
Field Obs. I.G.M. Date 78 09 13 (yr mo day) Weather CLOUDY
Field Photo Y **N** Photog ______ Roll ______ Frames ______
Air Photos Init ____ 065 19-0 Photo # 62-15+16 Yr 1978 Photo Scale(s) 1:30,000

ACTIVE VALLEY WALL PROCESS	
Rock / Soil falls	Nil **L** M H
Mud / Snow flows	**Nil** L M H
Slumps / Glides	**Nil** L M H
Slides	**Nil** L M H
Gullies	Nil L **M** H
BAR PRESENCE	
Side / Point	Nil L **M** H
Mid Channel	**Nil** L M H
Transverse	**Nil** L M H
Junction	**Nil** L M H
Diamond / Braiding	**Nil** L M H
Lee	**Nil** L M H
Dunes	**Nil** L M H
Islands	**Nil** L M H
LATERAL CHANNEL MOVEMENT	
Apparently Stable	**Yes** No
Bar Veg. Progressions	**Nil** L M H
Cut-Offs / Ox Bows	**Nil** L M H
Meander Scars	Nil **L** M H
Avulsions	Yes **No** #
Terraces	Yes **No** #
Constrictions	**Yes** No # 2
Unstable Banks (%)	0

CHANNEL WIDTH (m)	10	
BED MATERIAL (%)		
Fines (clay silt sand)	10	
Gravel (2-64 mm)	20	
Large (64 mm+)	60	
Bedrock	10	
CHANNEL COVER		
Level	% Area	Distr
Crown	30	8
Overhang	30	7
RIPARIAN VEG.		
Storey	Sp.	Distr.
Coniferous		8
Deciduous		3
Understorey		7
Ground		1
TOTAL POOLS (%)	10	
Bedrock control (%)	1	
Stage	Dry **L** M H Fld	
Flow Char.	P S R **S** T	
Valley Chan	0-2 **2-5** 5-10 10+ N/A	
Confinement	**Ent** Conf Fr Oc Un N/A	
Pattern	St Sin **Ir** Im Rm Tm	
Vert. Stab.	**Deg** ? Agr N/A	
Side Chan	**Nil** L M H	

FISH SUMMARY				STREAM FEATURE		
Species	Use	Ref	Map	Type	Ht (m)	Length (m)

Channel Debris: Nil L **M** H — % Stable Debris 10
Floodplain Debris: Nil **L** M H

(Fish) (Ø)

5 9 b/c 12
(Width) (Vall. Chan) (Slope) (Bed Material)

REACH

Reach No. 1

SYSTEM NAME (or Alias) BROWNIE CREEK

SYSTEM NO. 35 070 300 070 010

Compiling Agency ______ Access V2 NTS Map(s) 82J/2

Field Obs. J.G.M. Date 78 09 15 (yr mo day) Weather CLOUDY

Field Photo (Y) N Photog MALICK Roll 1 Frames 17,18

Air Photos Init 065-19-0 Photo # L2-15+16 Yr. 1978 Photo Scale(s) 1:30,000

ACTIVE VALLEY WALL PROCESS		CHANNEL WIDTH (m)	5
Rock / Soil falls	(Nil) L M H	BED MATERIAL (%)	
Mud / Snow flows	(Nil) L M H	Fines (clay silt sand)	10
Slumps / Glides	(Nil) L M H	Gravel (2-64 mm)	70
Slides	(Nil) L M H	Large (64 mm+)	20
Gullies	(Nil) L M H	Bedrock	
BAR PRESENCE		**CHANNEL COVER**	% Area Distr.
Side / Point	Nil L (M) H	Crown	0 1
Mid Channel	(Nil) L M H	Overhang	2 5
Transverse	(Nil) L M H	**RIPARIAN VEG.**	
Junction	(Nil) L M H	Storey	Sp. Distr.
Diamond / Braiding	(Nil) L M H	Coniferous	1
Lee	Nil (L) M H	Deciduous	5
Dunes	(Nil) L M H	Understorey	5
Islands	(Nil) L M H	Ground	9
LATERAL CHANNEL MOVEMENT		TOTAL POOLS (%)	10
Apparently Stable	(Yes) No	Bedrock control (%)	0
Bar Veg. Progressions	(Nil) L M H	Stage	Dry (L) M H Fld
Cut-Offs / Ox Bows	(Nil) L M H	Flow Char.	P S R (B) T
Meander Scars	Nil (L) M H	Valley Chan.	0-2 2-5 5-10 (10+) N/A
Avulsions	Yes (No) *	Confinement	Ent Conf Fr (Oc) Un N/A
Terraces	(Yes) No * 1	Pattern	St Sin (Ir) Im Rm Tm
Constrictions	Yes (No) *	Vert. Stab.	(Deg) ? Agr N/A
Unstable Banks (%)	0	Side Chan.	(Nil) L M H

FISH SUMMARY				STREAM FEATURE		
Species	Use	Ref	Map	Type	Ht (m)	Length (m)

Channel Debris: Nil L M H | % Stable Debris

Floodplain Debris: Nil L M H

(Fish) ∅

5 14 u | 17

(Width) (Vall-Chan) (Slope) (Bed Material)

REACH

Reach No. 1

SYSTEM NAME (or Alias) HENRETTA CREEK

SYSTEM NO. 35 0200 380 090

Compiling Agency ______ Access V4 NTS Map(s) 82J/2

Field Obs. J.G.M. Date 78 09 14 (yr mo day) Weather CLOUDY

Field Photo (Y) N Photog MALICK Roll 1 Frames 10,11

Air Photos Init 065-19-0 Photo # L1-6+7 Yr. 1978 Photo Scale(s) 1:30,000

ACTIVE VALLEY WALL PROCESS		CHANNEL WIDTH (m)	10
Rock / Soil falls	(Nil) L M H	BED MATERIAL (%)	
Mud / Snow flows	(Nil) L M H	Fines (clay silt sand)	10
Slumps / Glides	(Nil) L M H	Gravel (2-64 mm)	60
Slides	(Nil) L M H	Large (64 mm+)	10
Gullies	Nil (L) M H	Bedrock	20
BAR PRESENCE		**CHANNEL COVER**	% Area Distr.
Side / Point	Nil L (M) H	Crown	5 2
Mid Channel	Nil (L) M H	Overhang	20 7
Transverse	(Nil) L M H	**RIPARIAN VEG.**	
Junction	(Nil) L M H	Storey	Sp. Distr.
Diamond / Braiding	(Nil) L M H	Coniferous	6
Lee	Nil (L) M H	Deciduous	8
Dunes	(Nil) L M H	Understorey	1
Islands	Nil (L) M H	Ground	6
LATERAL CHANNEL MOVEMENT		TOTAL POOLS (%)	15
Apparently Stable	(Yes) No	Bedrock control (%)	3
Bar Veg. Progressions	Nil (L) M H	Stage	Dry (L) M H Fld
Cut-Offs / Ox Bows	Nil (L) M H	Flow Char.	P S (R) B T
Meander Scars	Nil (L) M H	Valley Chan.	0-2 2-5 5-10 (10+) N/A
Avulsions	Yes (No) *	Confinement	Ent Conf Fr (Oc) Un N/A
Terraces	(Yes) No * 1	Pattern	St Sin (Ir) Im Rm Tm
Constrictions	(Yes) No * 1	Vert. Stab.	(Deg) ? Agr N/A
Unstable Banks (%)	0	Side Chan.	(Nil) L M H

FISH SUMMARY					STREAM FEATURE		
	Species	Use	Ref	Map	Type	Ht (m)	Length (m)
2	CUTTHROAT SM			✓			

Channel Debris: Nil L (M) H | % Stable Debris 3

Floodplain Debris: Nil (L) M H

(Fish) Y Ct

r 1.7 b/u | 16

(Width) (Vall-Chan) (Slope) (Bed Material)

REACH

Reach No. 2

SYSTEM NAME (or Alias) HENRETTA CREEK
SYSTEM NO 35 0700 300 090
Compiling Agency ______ Access V4 NTS Map(s) 82J/2
Field Obs. J.G.M. Date 78 09 14 (yr mo day) Weather CLOUDY
Field Photo Y (circled) N Photog. MALICK Roll 1 Frames 12, 13
Air Photos 06519-0 Photo # L1-667 Yr. 1978 Photo Scale(s) 1:30,000

ACTIVE VALLEY WALL PROCESS	
Rock / Soil falls	Nil (circled) L M H
Mud / Snow flows	Nil (circled) L M H
Slumps / Glides	Nil (circled) L M H
Slides	Nil (circled) L M H
Gullies	Nil L (circled) M H
BAR PRESENCE	
Side / Point	Nil L M (circled) H
Mid Channel	Nil L (circled) M H
Transverse	Nil (circled) L M H
Junction	Nil (circled) L M H
Diamond / Braiding	Nil (circled) L M H
Lee	Nil L (circled) M H
Dunes	Nil (circled) L M H
Islands	Nil L (circled) M H
LATERAL CHANNEL MOVEMENT	
Apparently Stable	Yes (circled) No
Bar Veg. Progressions	Nil L (circled) M H
Cut-Offs / Ox Bows	Nil L (circled) M H
Meander Scars	Nil L (circled) M H
Avulsions	Yes No (circled) *
Terraces	Yes (circled) No * 1
Constrictions	Yes No (circled) *
Unstable Banks (%)	0

CHANNEL WIDTH (m)	7	
BED MATERIAL (%)		
Fines (clay silt sand)	10	
Gravel (2-64 mm)	60	
Large (64 mm +)	30	
Bedrock	0	
CHANNEL COVER		
Level	% Area	Distr
Crown	3	6
Overhang	25	8
RIPARIAN VEG.		
Storey	Sp	Distr
Coniferous		5
Deciduous		8
Understorey		1
Ground		8
TOTAL POOLS (%)	15	
Bedrock control (%)	0	
Stage	Dry L (circled) M H Fld	
Flow Char	P S R (S circled) T	
Valley Chan	0-2 2-5 5-10 10+ (circled) N/A	
Confinement	En Cont Fr Oc (circled) Un N/A	
Pattern	St Sin Ir (circled) Im Rm Tm	
Vert. Stab	Deg (circled) ? Agr N/A	
Side Chan	Nil L (circled) M H	

FISH SUMMARY				STREAM FEATURE		
Species	Use	Ref	Map	Type	Ht (m)	Length (m)

Channel Debris Nil L M (circled) H | % Stable Debris 5
Floodplain Debris Nil L (circled) M H

(Fish) YCt

r 9 b/u 16
(Width) (Vall. Chan) (Slope) (Bed Material)

REACH

Reach No. 1

SYSTEM NAME (or Alias) McQUARRIE CREEK
SYSTEM NO 35 0700 300 090 020
Compiling Agency ______ Access V4 NTS Map(s) 82J/2
Field Obs J.G.M. Date 78 09 14 (yr mo day) Weather CLOUDY
Field Photo Y (circled) N Photog. MALICK Roll 1 Frames 14,15,16
Air Photos 06519-0 Photo # L1-667 Yr. 1978 Photo Scale(s) 1:30,000

ACTIVE VALLEY WALL PROCESS	
Rock / Soil falls	Nil (circled) L M H
Mud / Snow flows	Nil (circled) L M H
Slumps / Glides	Nil (circled) L M H
Slides	Nil (circled) L M H
Gullies	Nil (circled) L M H
BAR PRESENCE	
Side / Point	Nil L (circled) M H
Mid Channel	Nil (circled) L M H
Transverse	Nil (circled) L M H
Junction	Nil (circled) L M H
Diamond / Braiding	Nil (circled) L M H
Lee	Nil L (circled) M H
Dunes	Nil (circled) L M H
Islands	Nil (circled) L M H
LATERAL CHANNEL MOVEMENT	
Apparently Stable	Yes (circled) No
Bar Veg. Progressions	Nil (circled) L M H
Cut-Offs / Ox Bows	Nil (circled) L M H
Meander Scars	Nil L (circled) M H
Avulsions	Yes No (circled) *
Terraces	Yes (circled) No * 1
Constrictions	Yes (circled) No * 1
Unstable Banks (%)	0

CHANNEL WIDTH (m)	1	
BED MATERIAL (%)		
Fines (clay silt sand)	20	
Gravel (2-64 mm)	60	
Large (64 mm +)	10	
Bedrock	10	
CHANNEL COVER		
Level	% Area	Distr
Crown	45	7
Overhang	5	2
RIPARIAN VEG.		
Storey	Sp	Distr
Coniferous		7
Deciduous		6
Understorey		1
Ground		5
TOTAL POOLS (%)	10	
Bedrock control (%)	2	
Stage	Dry L (circled) M H Fld	
Flow Char	P S R (S circled) T	
Valley Chan	0-2 2-5 5-10 10+ (circled) N/A	
Confinement	En Cont Fr Oc (circled) Un N/A	
Pattern	St Sin Ir (circled) Im Rm Tm	
Vert. Stab.	Deg (circled) ? Agr N/A	
Side Chan	Nil (circled) L M H	

FISH SUMMARY				STREAM FEATURE		
Species	Use	Ref	Map	Type	Ht (m)	Length (m)

Channel Debris Nil L M (circled) H | % Stable Debris 20
Floodplain Debris Nil L (circled) M H

(Fish) Ø

5 7 b/u 26
(Width) (Vall. Chan) (Slope) (Bed Material)

APPENDIX 3

STATISTICAL ANALYSIS OF RANGE FORAGE LOSSES FROM FALL TO SPRING, AS DETERMINED BY FORAGE CLIPPING IN OCTOBER 1970 AND MAY 1971†

Location and Plant Community	Elevation (m)	Aspect	Slope (°)	AVER. YIELD gm/m²		Percent Loss	STATISTICAL SIGNIFICANCE	
				Fall	Spring		Calculated F. value	Significance level
Alpine tundra								
Plot 4, Turnbull	2,395	SSW	27	76.2	36.7	51.8%	114.654	**
Alpine grasslands								
a. Rough fescue								
Plot 1, Turnbull	2,310	S	27	88.9	42.1	52.6%	22.071	**
b. Plot 3, Eagle	2,310	S	35	140.9	--	--	--	--
c. Idaho fescue								
Plot 5, Eagle	2,040	S	30	228.8	127.1	44.4%	27.860	**
Subalpine grasslands								
Plot 2, Turnbull	2,085	S	30	186.3	91.8	50.7%	13.856	*
Plot 6, Turnbull	2,145	SSW	30	142.1	69.3	51.2%	24.692	**

† Source: B.C. Research, 1971. Report of Grassland Vegetation Studies in the Upper Fording River Valley Between September 29 and October 4, 1970. Progress Report No. 1, Phase 2. Report to Cominco Ltd.

* Difference in average yields statistically significant at the 5% level.

** Difference in average yields statistically significant at the 1% level.

APPENDIX 4

RESULTS OF TOTAL NITROGEN ASSAY CONDUCTED ON FORAGE FROM MOUNT TURNBULL AND EAGLE MOUNTAIN, OCTOBER 1970 COMPARED TO MAY 1971*

Plot No. and Location	Elevation (m)	Aspect	Slope (°)	TOTAL NITROGEN					
				OCTOBER, 1970			MAY, 1971		
				% N	Crude Protein	N(gm/M²)	% N	Crude Protein	N(gm/M²)
Alpine tundra									
Plot 4, Turnbull	2,395	SSW	27	1.267	7.9	0.96	1.551	9.7	0.57
Alpine grasslands									
a. Rough fescue									
Plot 1, Turnbull	2,310	S	27	0.777	4.9	0.69	1.217	7.6	0.51
Plot 3, Eagle	2,310	S	35	1.239	7.7	1.73	--	--	--
b. Idaho fescue									
Plot 5, Eagle	2,040	S	30	0.721	4.5	1.65	1.215	7.6	0.84
Subalpine grasslands									
Plot 2, Turnbull	2,085	S	30	0.945	5.9	1.75	1.192	7.5	1.09
Plot 6, Turnbull	2,145	SSW	30	0.833	5.2	1.18	1.144	7.2	0.79

* Source: B.C. Research. 1971. Report of Grassland Vegetation Studies in the Upper Fording River Valley Between September 29 and October 4, 1970. Progress Report No. 1, Phase 2. Report to Cominco Ltd.

APPENDIX 5

LIST OF PLANT SPECIES FOUND IN THE BROWNIE CREEK COAL LICENCES AREA, 1978

Scientific Name	Common Name
TREES	
Abies lasiocarpa (Hook.) Nutt.	Alpine Fir
Larix lyallii Parl.	Alpine larch
Picea Engelmanni Parry	Engelmann's spruce
Pinus contorta Dougl.	Lodgepole pine
SHRUBS	
Abies lasiocarpa (Hook.) Nutt.	Alpine Fir
Alnus sinuata (Regel) Rydb.	Sitka alder
Amelanchier alnifolia Nutt.	Serviceberry
Arctostaphylos uva-ursi (L.) Spreng.	Kinnikinnick
Empetrum nigrum L.	Crowberry
Juniperus communis L.	Common mountain juniper
Larix lyallii Parl.	Alpine larch
Larix occidentalis Nutt.	Mountain larch
Linnaea borealis L.	Twinflower
Lonicera involucrata (Rich.) Banks	Bearberry honeysuckle
Lonicera utahensis Wats.	Utah honeysuckle
Menziesia ferruginea Smith	Fool's huckleberry
Picea engelmannii Parry	Engelmann's spruce
Pinus albicaulis Engelm.	White bark pine
Pinus contorta Dougl.	Lodgepole pine
Populus tremuloides Michx.	Trembling aspen
Rhododendron albiflorum Hook.	Rocky mountain rhododendron
Ribes lacustre (Pers.) Poir.	Bristly black currant
Ribes oxycanthoides L.	Northern gooseberry
Rosa acicularis Lindl.	Prickly rose
Rosa woodsii Lindl.	Wood's rose
Rubus idaeus L.	Red raspberry
Rubus parviflorus Nutt.	Thimbleberry
Salix sp.	Willow
Sumbucus racemosa L.	Elderberry
Shepherdia canadensis (L.) Nutt.	Soapberry
Spiraea betulifolia Pall.	Shiny-leaf spiraea
Vaccinium myrtillus L.	Drwarf bilberry
Vaccinium scoparium Leiberg	Grouseberry

APPENDIX 5 (Cont'd)

Scientific Name	Common Name
HERBS	
Achillea millefolium L.	Common Yarrow
Agropyron caninum (L.) Beauv. X *Sitanion hystrix* (Nutt.) Sm.	Unnamed hybrid
Agropyron repens (L.) Beauv.	Quackgrass
Agropyron spicatum (Pursh) Scribn & Smith	Bluebunch wheatgrass
Agropyron sp.	Wheatgrass
Agoseris aurantiaca (Hook.) Greene	False-dandelion
Agoseris elata (Nutt.) Greene	Tall Agoseris
Agoseris sp.	False-dandelion
Agrostis exarata Trin.	Spike bent
Agrostis scabra Willd.	Bentgrass
Aira caryophyllea L.	Silver hairgrass
Allium cernuum Roth	Nodding onion
Anaphalis margaritacea (L.) Benth. & Hook.	Pearly everlasting
Anemone multifida Poir	Cut-leaved anemone
Anenome occidentalis Wats	Western pasqueflower
Antenneria anaphaloides Rydb.	Pussy-toes
Antennaria microphylla Rydb.	Rosy pussy-toes
Antennaria parvifolia Nutt.	Nuttel's pussy-toes
Antennaria racemosa Hook.	Raceme pussy-toes
Antennaria sp.	Pussy-toes
Arnica cordifolia Hook.	Heart-leaved Arnica
Arnica diversifolia Greene	Sticky arnica
Arnica mollis Hook.	Hairy arnica
Arabis sp. L.	Rockcress
Aster alpigenus (T. & G.) Gray	Aster
Aster alpinus L.	Aster
Aster conspicuus Lindl.	Showy aster
Aster foliaceus Lindl.	Leafy aster
Aster laevis L.	Smooth aster
Aster sp.	Aster
Astragalus americanus (Hook.) Jones	American milk-vetch
Astragalus miser Dougl.	Weedy milk-vetch
Bromus pumpellianus Scribn.	Bromegrass
Calamagrostis canadensis	Bluejoint reedgrass
Campanula rotundifolia L.	Harebell
Carex atrata L.	Blackened sedge
Carex nigricans Retz.	Black alpine sedge
Carex rupestris All.	Curly sedge
Carex sp.	Sedge
Castilleja miniata Dougl.	Scarlet paintbrush
Cerastium arvense L.	Field chickweed

APPENDIX 5 (Cont'd)

Scientific Name	Common Name
HERBS (Cont'd)	
Cinna latifolia (Trev.) Griseb.	Wood seedgrass
Cirsium vulgare (Savi) Tenore	Bull thistle
Cornus canadensis L.	Bunchberry
Danthonia intermedia Vasey	Timber danthonia
Deschampsia elongata (Hook.) Munro	Slender hairgrass
Draba sp.	Whitlow-grass
Elymus glaucus Buckl.	Wild ryegrass
Elymus innovatus Beal	Ryegrass
Epilobium angustifolium L.	Fireweed
Epilobium sp. L.	Fireweed
Equisetum arvense L.	Field Horsetail
Equisetum scirpoides Michx.	Sedgelike horsetail
Eriogonum umbellatum Torr.	Sulfur eriogonum
Festuca scabrella Torr.	Rough fescue
Fragaria virginiana Duchesne	Strawberry
Fritillaria pudica (Pursh) Spreng	Yellow bell
Gentiana amarella L.	Northern gentian
Geranium viscosissimum F. & M.	Sticky purple geranium
Geum macrophyllum Willd.	Large-leaved avens
Habenaria sp.	Bog-orchid
Hedysarum sulphurescens Rydb.	Yellow hedysarum
Heracleum lanatum Michx.	Cow parsnip
Heuchera cylindrica Dougl.	Roundleaf alumroot
Hieracium albiflorum Hook.	White-flowered hawkweed
Hieracium gracile Hook.	Hawkweed
Luzula parviflora (Ehrh.) Desv.	Wood rush
Mitella nuda L.	Bare-stemmed mitrewort
Osmorhiza chilensis Hook & Arn.	Mountain sweet cicely
Pedicularis bracteosa Benth.	Bracted lousewort
Penstemon confertus Dougl.	Yellow penstemon
Penstemon sp.	Penstemon
Petasites palmatus (Ait.) Gray	Sweet coltsfoot
Petasites sagittatus (Banks) Gray	Sweet coltsfoot
Phacelia heterophylla Pursh	Varileaf phacelia
Phleum alpinum L.	Alpine timothy
Poa alpina L.	Alpine bluegrass
Poa compressa L.	Canada bluegrass
Poa gracillima Vasey	Pacific bluegrass
Poa juncifolia Scribn.	Alkali bluegrass
Poa palustris L.	Fowl bluegrass
Poa sp. L.	Bluegrass
Polemonium pulcherrimum Hook.	Skunk-leaved Jacob's-ladder

APPENDIX 5 (Concluded)

Scientific Name	Common Name
HERBS (Cont'd)	
Potentilla nivea L.	Snow cinquefoil
Pyrola secunda L.	One-sided wintergreen
Pyrola sp.	Wintergreen
Pyrola uniflora L.	Single delight
Scutellaria galericulata L.	Marsh skullcap
Sedum stenopetalum Pursh	Wormleaf stonecrop
Senecio pseudaureus Rydb.	Streambank butterweed
Senecio sp.	Groundsel
Senecio triangularis Hook.	Groundsel
Sitanion hystrix (Nutt.) J.G.S.	Squirreltail
Thalictrum sp. L.	Meadow rue
Thalictrum venulosum Trel.	Veiny meadowrue
Tragopogon dubius scop.	Yellow salsify
Trisetum spicatum (L.) Richt.	Spike trisetum
Urtica dioica L.	Stinging nettle
Valeriana sitchensis Bong.	Valerian
Veronica wormskjoldii Roem. & Schultz	American alpine speedwell
Vicia americana Muhl.	American vetch
BRYOPHYTES AND LICHENS	
Aulacomnium palustre	
Aulacomnium sp.	
Atrichyum sp.	
Brachythecium sp.	
Bryum sp.	
Cladonia sp.	
Dicranum sp.	
Hylocomium sp.	
Lophozia sp.	
Peltigera sp.	
Pleurozium sp.	
Pogonatum alpinum	
Polytrichum sp.	
Stereocaulon sp.	
Torula princeps	

APPENDIX 6

TREE MENSURATION DATA FOR BROWNIE CREEK COAL LICENCES AREA, 1978

Map Unit	Plant Community	Plot Number	Plant Species	DBH (cm)	Age* (yr)	General Canopy Height (m)
Mature Engelmann Spruce - Alpine Fir	Spruce - Fir - Moss	9	*Abies lasiocarpa*	30	225	24.0
			Larix occidentalis	25	240	20.2
			Picea engelmannii	40	260	21.3
		12	*Picea engelmannii*	31	326	23.0
		14	*Picea engelmannii*	34	309	22.1
Seral Pine-Spruce-Fir	Pine - Spruce - Fir	4	*Abies lasiocarpa*	19	38	15.3
			Pinus contorta	20	42	15.0
		15	*Abies lasiocarpa*	15	31	14.2
			Picea engelamnnii	20	37	13.5
			Pinus contorta	25	37	12.5
		20	*Abies lasiocarpa*	17	40	11.8
			Picea engelmannii	35	50	17.9
Alpine Larch - Alpine Fir	Larch - Fir - Grouseberry	6	*Larix lyallii*	17	91	11.3

* Boring height at 5 feet

APPENDIX 7

LEGEND

NUMERICAL CODING OF GENERAL PLOT DATA

MOISTURE REGIME:

hydric	1
sybhydric	2
hygric	3
subhygric	4
mesic	5
submesic	6
subxeric	7
xeric	8
very xeric	9

SLOPE POSITION MOISTURE:

shedding	1
normal	2
receiving	3
collecting	4
seepage	5

SLOPE POSITION MACRO:

apex	1
face	2
upper slope	3
middle slope	4
lower slope	5
valley floor	6
plain	7

EXPOSURE TYPE:

wind	1
insolation	2
front pocket	3
cold air drainage	4
(other)	5
not applicable	6

SURFACE SHAPE:

smooth convex	1
irregular convex	2
smooth straight	3
irregular straight	4
smooth concave	5
irregular concave	6
smooth flat	7
irregular flat	8

APPENDIX 8

LIST OF MAMMALS POSSIBLY OCCURRING IN THE FORDING RIVER AREA*

Common Name	Latin Name
ORDER INSECTIVORA (Insectivores)	
Masked shrew	Sorex cinereus cinereus
Vagrant shrew	Sorex vagrans obscurus
American water shrew	Sorex palustris navigator
Pigmy shrew	Microsorex hoyi washingtoni
ORDER CHIROPTERA (Bats)	
Little brown bat	Myotis lucifugus alascensis
Long-eared bat	Myotis evotis evotis
Long-legged bat	Myotis volans longicrus
Silver-haired bat	Lasionycteris noctivagans
Big brown bat	Eptesicus fuscus pallidus
Hoary bat	Lasiurus cinereus
ORDER LAGOMORPHA (Pikas, Hares and Rabbits)	
American pika	Ochotona princeps princeps
Snowshoe hare	Lepus americanus columbiensis
ORDER RODENTIA (Rodents)	
Least chipmunk	Eutamias minimus oreocetes
Yellow pine chipmunk	Eutamias amoenus luteiventris
Hoary marmot	Marmota caligata okanagana
Columbian ground squirrel	Spermophilus columbianus columbianus
Golden-mantled ground squirrel	Spermophilus lateralis tescorum
American red squirrel	Tamiasciurus hudsonicus richardsoni
Northern flying squirrel	Glaucomys sabrinus latipes
American beaver	Castor canadensis leucodontus
Deer mouse	Peromyscus maniculatus artemisiae
Bushy-tailed wood rat	Neotoma cinerea cinerea
Gapper's red-backed vole	Clethrionomys gapperi galei
Northern bog lemming	Synaptomys borealis chapmani
Heather vole	Phenacomys intermedius levis
Muskrat	Ondatra zibethicus osoyoosensis
Richardson's water vole	Arvicola richardsoni richardsoni
Meadow vole	Microtus pennsylvanicus drummondii
Long-tailed vole	Microtus longicaudus vellerosus
Western jumping mouse	Zapus princeps idahoensis
American porcupine	Erethizon dorsatum nigrescens

Continued...

APPENDIX 8 (Concluded)

Common Name	Latin Name
ORDER CARNIVORA (Carnivores)	
Coyote	Canis latrans lestis
Wolf	Canis lupus columbianus
Red fox	Vulpes vulpes macroura
American black bear	Ursus americanus cinnamomum
Grizzly bear	Ursus arctos
American marten	Martes americana abietinoides
Ermine	Mustela erminea invicta
Long-tailed weasel	Mustela frenata oribasus
American mink	Mustela vison energumenos
Wolverine	Gulo gulo luscus
American badger	Taxidea taxus jeffersonii
Striped skunk	Mephitis mephitis hudsonica
River otter	Lutra canadensis evexa
Mountain lion	Felis concolor missoulensis
Lynx	Lynx lynx canadensis
Bobcat	Lynx rufus pallescens
ORDER ARTIODACTYLA (Cloven-hoofed Mammals)	
Mule deer	Odocoileus hemionus hemionus
White-tailed deer	Odocoileus virginianus ochrourus
Moose	Alces alces andersoni
American elk	Cervus elaphus nelsoni
Mountain goat	Oreamnos americanus
Bighorn sheep	Ovis canadensis canadensis

Total: 53 species

* Source: Banfield, A.W.F. 1974. The Mammals of Canada. University of Toronto Press, Toronto. 438 p.

APPENDIX 9

CHECK LIST OF BIRDS WHOSE BREEDING RANGES COINCIDE WITH THE FORDING RIVER AREA†*

ORDER GAVIIFORMES (Loons)

Common loon

ORDER PODICIPEDIFORMES (Grebes)

Horned grebe
Eared grebe

ORDER CICONIIFORMES (Herons)

American bittern

ORDER ANSERIFORMES (Geese, Ducks)

Canada goose
Mallard
Pintail
Green-winged teal
Blue-winged teal
American widgeon
Northern shoveler
Lesser scaup
Barrow's goldeneye
Bufflehead
Harlequin duck
Hooded merganser
Common merganser

ORDER FALCONIFORMES (Vultures, Hawks, Falcons)

Turkey vulture
Goshawk
Sharp-shinned hawk
Cooper's hawk
Red-tailed hawk
Golden eagle
Bald eagle
Marsh hawk

Continued...

ORDER FALCONIFORMES (Vultures, Hawks, Falcons) cont'd

Osprey
Prairie falcon
Peregrine falcon
Merlin
American kestrel

ORDER GALLIFORMES (Grouse)

Blue grouse
Spruce grouse
Ruffed grouse
White-tailed ptarmigan
Sharp-tailed grouse

ORDER GRUIFORMES (Rails)

Sora
American coot

ORDER CHARADRIIFORMES (Shorebirds)

Killdeer
Common snipe
Spotted sandpiper
Wilson's phalarope

ORDER COLUMBIFORMES (Doves)

Mourning dove

ORDER STRIGIFORMES (Owls)

Great horned owl
Pygmy owl
Great gray owl
Long-eared owl
Short-eared owl
Saw-whet owl

Continued...

ORDER CAPRIMULGIFORMES (Goatsuckers)

Common nighthawk

ORDER APODIFORMES (Swifts, Hummingbirds)

Black swift
Vaux's swift
Rufous hummingbird
Calliope hummingbird

ORDER CORACIIFORMES (Kingfishers)

Belted kingfisher

ORDER PICIFORMES (Woodpeckers)

Common flicker
Pileated woodpecker
Lewis's woodpecker
Yellow-bellied sapsucker
Williamson's sapsucker
Hairy woodpecker
Downy woodpecker
Black-backed three-toed woodpecker
Northern three-toed woodpecker

ORDER PASSERIFORMES (Perching Birds)

Eastern kingbird
Western kingbird
Say's phoebe
Willow flycatcher
Least flycatcher
Hammond's flycatcher
Ducky flycatcher
Western flycatcher
Western wood pewee
Olive-sided flycatcher
Horned lark

Continued...

APPENDIX 9 (concluded)

ORDER PASSERIFORMES (Perching Birds)

Violet-green swallow
Tree swallow
Bank swallow
Rough-winged swallow
Barn swallow
Cliff swallow
Gray jay
Steller's jay
Black-billed magpie
Common raven
Common crow
Clark's nutcracker
Black-capped chickadee
Mountain chickadee
Boreal chickadee
White-breasted nuthatch
Red-breasted nuthatch
Brown creeper
American dipper
House wren
Winter wren
Rock wren
Gray catbird
American robin
Varied thrush
Hermit thrush
Swainson's thrush
Veery
Western bluebird
Mountain bluebird
Townsend's solitaire
Golden-crowned kinglet
Ruby-crowned kinglet
Water pipit
Bohemian waxwing
Cedar waxwing
Common starling
Solitary vireo
Red-eyed vireo
Warbling vireo
Orange-crowned warbler
Yellow warbler
Yellow-rumped Warbler
Townsend's warbler
Northern waterthrush
MacGillivray's warbler
Common yellowthroat
Wilson's warbler
American redstart
House sparrow
Western meadowlark
Yellow-headed blackbird
Red-winged blackbird
Brewer's blackbird
Brown-headed cowbird
Western tanager
Luzuli bunting
Evening grosbeak
Purple finch
Cassin's finch
Pine grosbeak
Gray-crowned rosy finch
Pine siskin
American goldfinch
Red crossbill
White-winged crossbill
Rufous-sided towhee
Savannah sparrow
Vesper sparrow
Dark-eyed junco
Chipping sparrow
Brewer's sparrow
White-crowned sparrow
Fox sparrow
Lincoln's sparrow
Song sparrow

---

† Source: Godfrey, W.E. 1966. The Birds of Canada. National Museum of Canada. Bull. No. 203, Biol. Series No. 73. Queen's Printer. Ottawa, 428 p.

* This list does not include migrant species which may pass through the area but do not breed there.

APPENDIX 10

B.C. RESEARCH WINTER SURVEY REPORT, MARCH 19, 1979

Survey Area:	Fording Coal - Kilmarnock and Henretta Creeks
Date, Time:	March 19, 1979; 0818-0945 hrs.
Aircraft:	Hughes 500, CF-AHH Crowsnest Helicopters Ltd., Fernic, B.C. (Sparwood base)
Pilot:	Jim Drozduk
Observers:	C. Schmidt (BCR) - right front R. Berdusco (Fording Coal) - left rear K. Clark (Fording Coal) - right rear
Weather:	Cloud - 70% Temp. - -1°C to 3°C by noon Wind - calm to light breeze Precip. - nil over past 24 hrs.
Snow conditions:	Up to 100% at high elevations, 2-3 ft high or more (.6-.9 m); south facing slopes open at low and mid-elevations but generally not open at high elevations (except for highest ridge tops); upper creek valleys are generally 100% covered; logging slash along Kilmarnock Creek is also 100% cover.
Areas covered:	Henretta Creek valley plus side slopes to divide; Kilmarnock Creek valley plus slopes on north side to Mount Pierce; McQuarrie and Brownie Creeks and adjacent highlands; south facing slopes of Mount Turnbull.
Animal sightings:	Moose - 9 Elk - 98 Mountain goats - 11 Coyote - 1

APPENDIX 11

WILDLIFE OBSERVATIONS IN OCTOBER, 1969
AND APRIL, 1970 IN THE FORDING
COAL AREA*

Sighting No. (See Figure attached)	Species	Date	Comments
1	Moose	Oct. 27/69	Hunter-killed moose along Fording River
2,3	Elk	Oct. 15-31/69	Sign (tracks and droppings) on Eagle Mountain
4	Elk	Oct. 15-31/69	Sign on Mount Turnbull
5	Elk	April 27/70	Single cow elk on north slope of Eagle Mountain (on small snow-free patch)
6	Elk	April 27/70	16 elk (15 cows and calves and 1 adult bull) on SW slope of Mount Turnbull at 1950m; slope 22°.
7	Moose	April 27/70	Single moose on west slope of Castle Mountain at 1735 m.
8	Beaver	Oct. 15-31/69	Beaver dams on Fording River; on set tracks observed

* Source: B.C. Research. 1970b. Ecological Study - Fording River. Progress Report No. 3, Completing Phase 1. Report to Cominco Ltd.

APPENDIX 12

MULE DEER FOOD HABITS AS DETERMINED FROM ANALYSIS OF A FALL RUMEN SAMPLE*

Species	Common Name	Percent by Volume
Forbs		
Achillia millefolium	Yarrow	Tr
Geranium viscosissimum	Cranesbill	Tr
(Geum triflorum)	Avens	22.2
Heuchera sp	Alum root	Tr
Polemonium sp	Polemonium	4.4
Valeriana sp	Valerian	3.3
Forb 1 (unidentified)	--	7.3
Forb 2 (unidentified)	--	5.6
Forbs (unidentified)	--	4.4
Subtotal		47.2
Browse		
Pachistima myrsinites	Oregon box wood	22.6
Populus trichocarpa	Black cottonwood	3.4
Rosa gymnocarpa	Rose	16.6
Spiraea sp	Spiraea	Tr
Browse (unidentified)	--	7.7
Subtotal		50.3
Grass		
Grass sp (unidentified)		2.5
Subtotal		2.5
TOTAL		100

* Source: B.C. Research. 1971. Report of Grassland Vegetation Studies in the Upper Fording River Valley between September 29 and October 4, 1970. Progress Report No. 1, Phase 2. Report to Cominco Ltd.

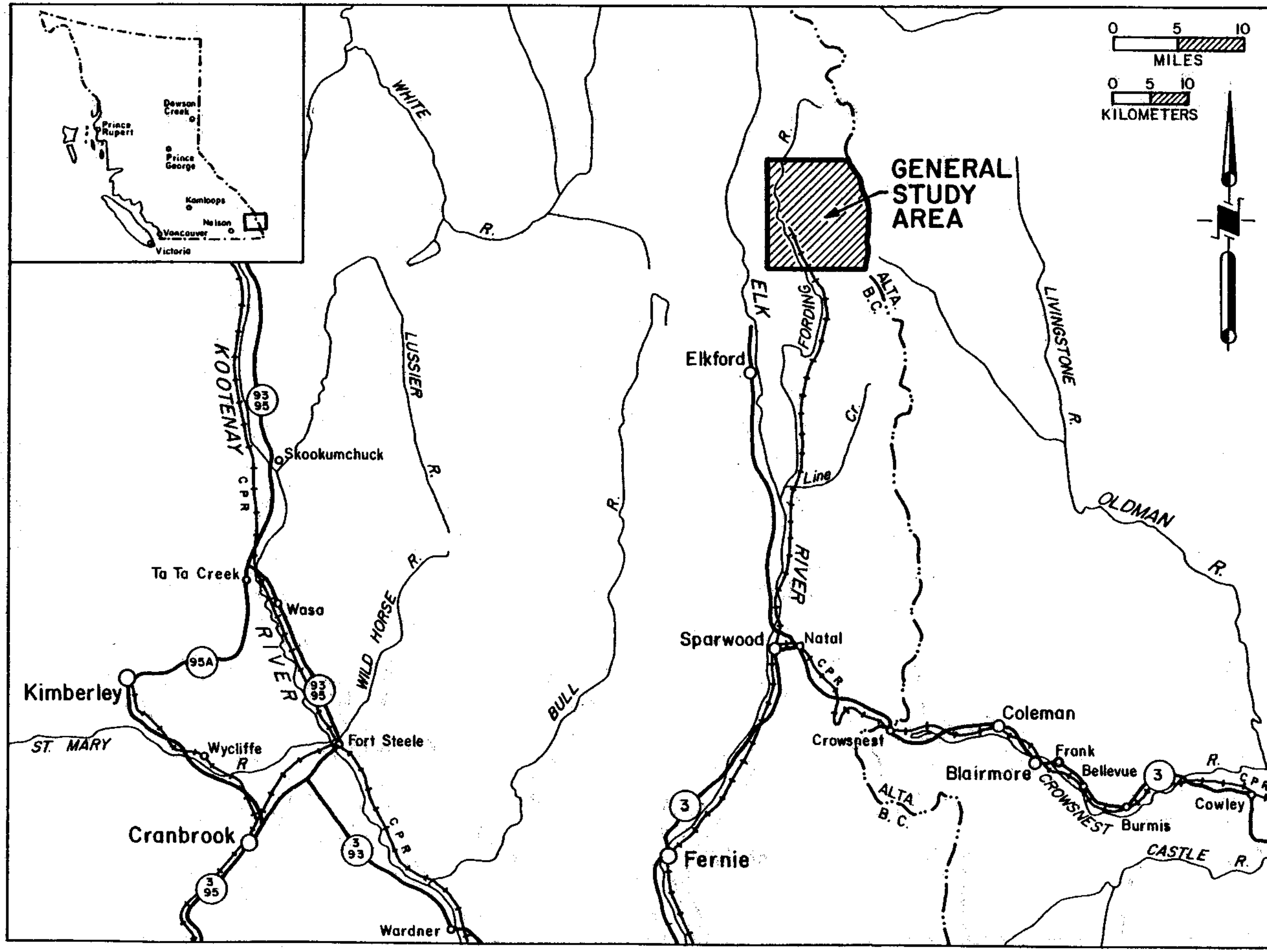
APPENDIX 14

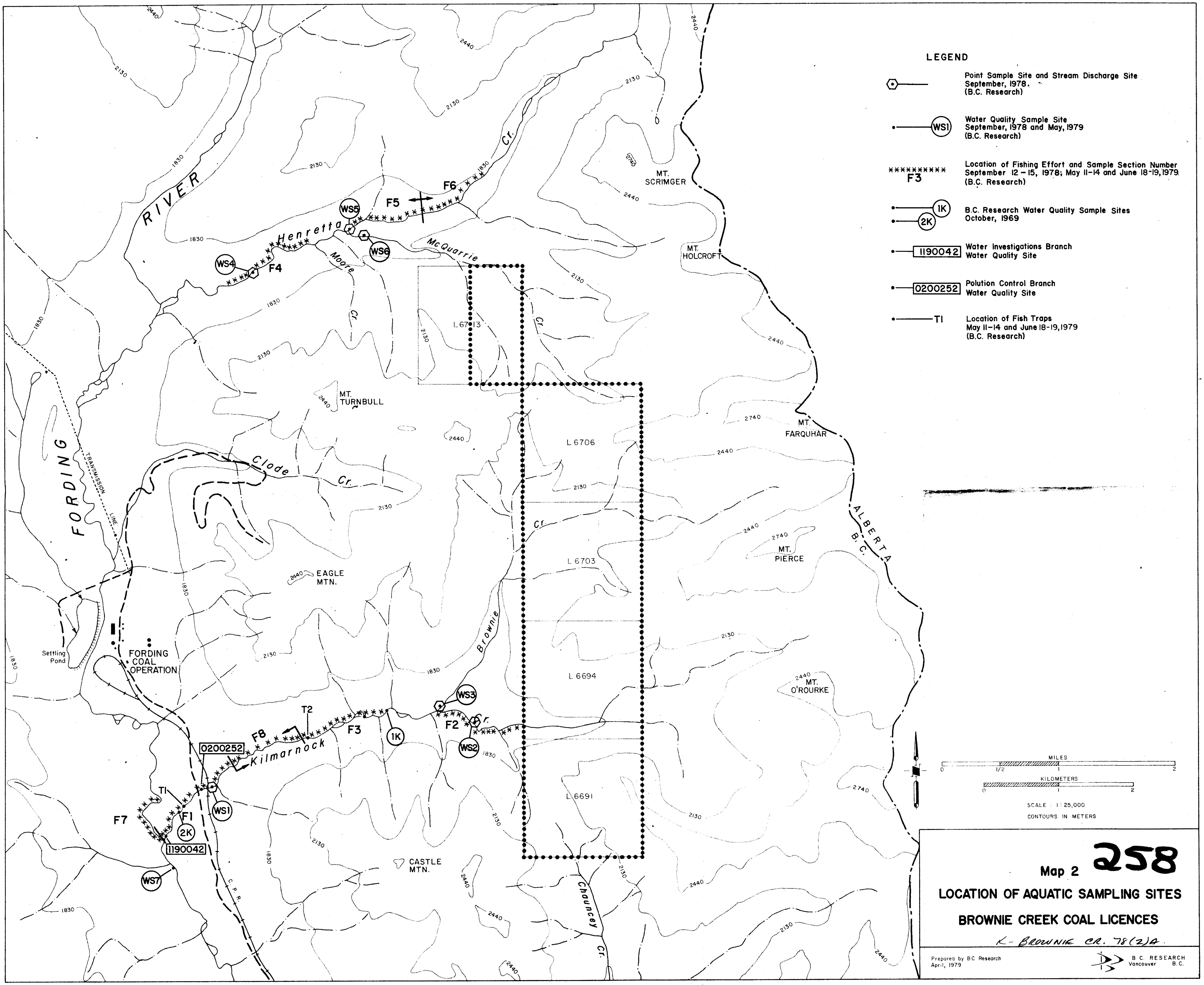
BIG GAME OBSERVATIONS IN THE UPPER FORDING RIVER VALLEY, EAGLE MOUNTAIN AND MOUNT TURNBULL REGION, MAY AND JULY, 1971*

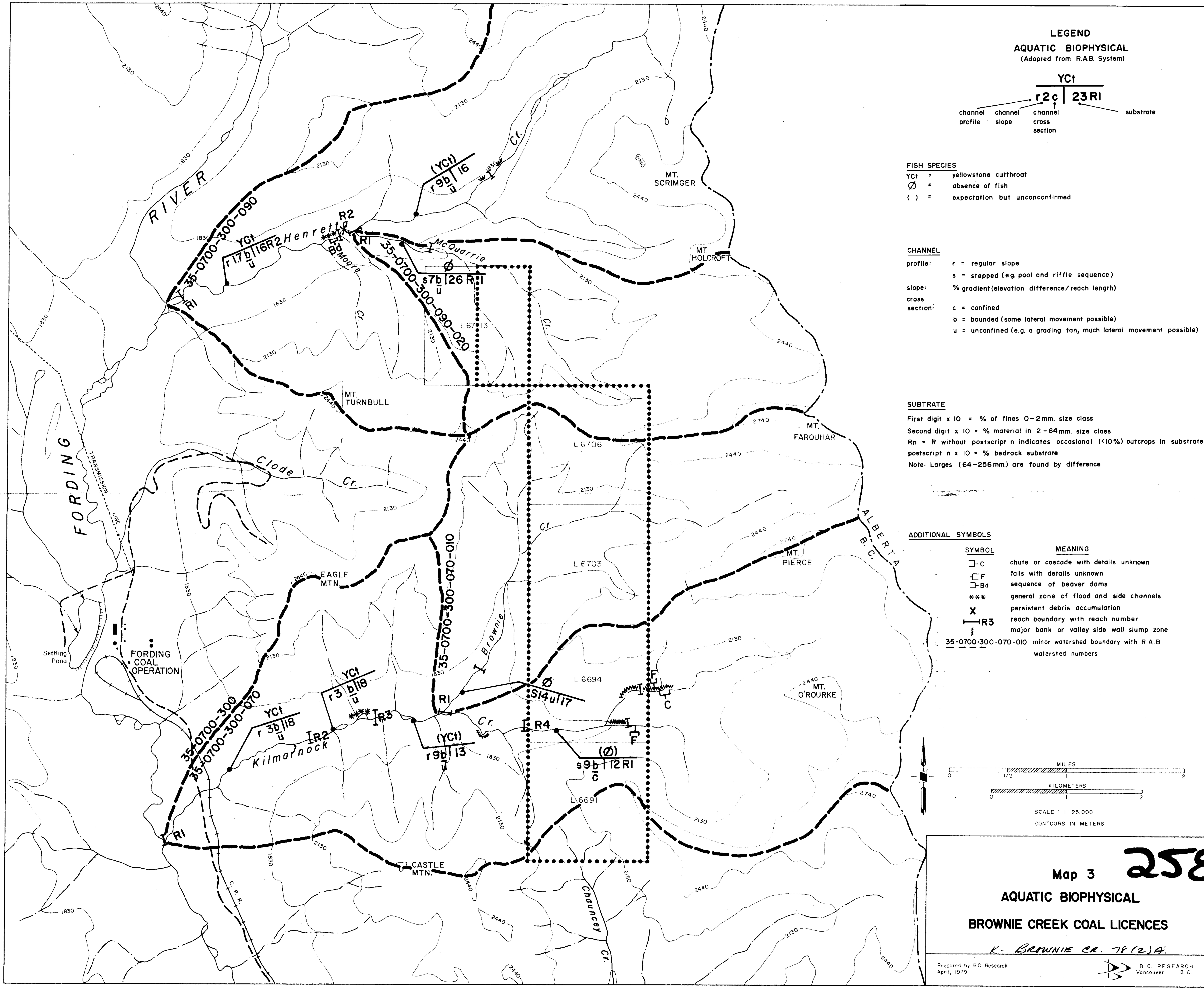
Location and Community Type	Date	Species	Observation
May 27-29, 1971	May 27-29, 1971		
EAGLE MOUNTAIN			
Plot 5 area, Idaho fescue	May 27	Elk	1 cow, 1 short yearling, 1 unclassified elk grazing the open grassland, 6,700 ft.
SE side of Eagle Mt. on open grassland	May 27	Elk	1 unclassified elk, 6,500 ft. Subtotal 4.
MOUNT TURNBULL			
Between plots 1 and 2, open subalpine forest	May 28	Elk	1 cow, 1 short yearling calf, 7,000 ft.
East of plot 1, rough Fescue alpine grassland	May 28	Elk	2 cows, 2 short yearling calves, 7,500 ft.
West of plot 2, open forest community	May 29	Elk	3 unclassified. 6,500 ft. Subtotal 9 Total 13
July 27-28, 1971	July 27-28, 1971		
EAGLE MOUNTAIN			
Southwest side, spruce fir forest	July 27	Mule deer	Adult buck, 6,000 ft.
MOUNT TURNBULL			
East end of Clode Creek valley bottom, spruce-fir forest	July 28	Elk	8 unclassified, 6,600 ft. Total 8 elk 1 mule deer

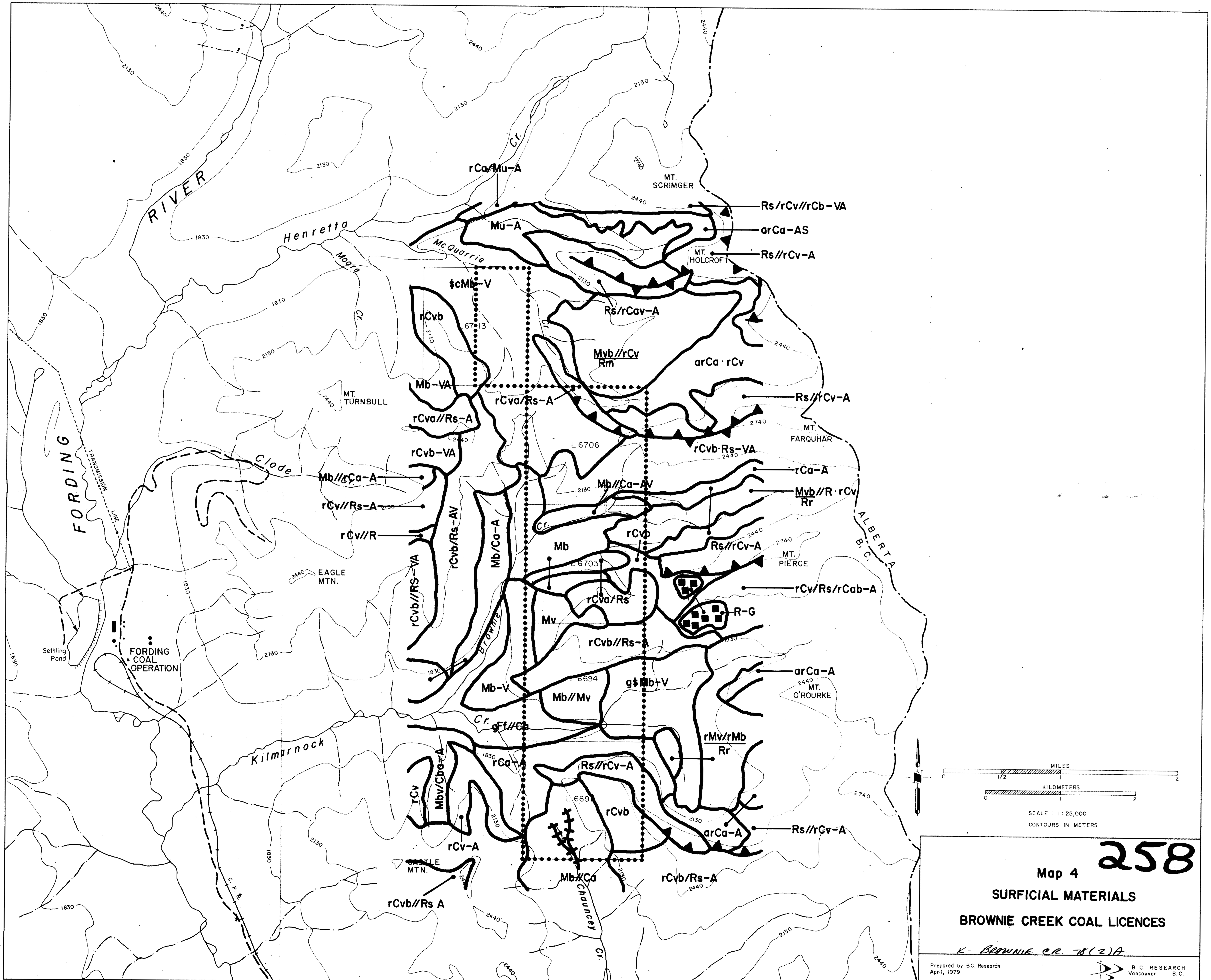
* Source: B.C. Research. 1972. Range Survey and Wildlife Observations in the Upper Fording River Valley, 1971. Report No. 2, Phase 2. Report to Cominco Ltd.

Map 1
LOCATION MAP




LEGEND
Point Sample Site and Stream Discharge Site September, 1978. (B.C. Research)
Water Quality Sample Site September, 1978 and May, 1979 (B.C. Research)
Location of Fishing Effort and Sample Section Number September 12 - 15, 1978; May 11-14 and June 18-19, 1979 (B.C. Research)
B.C. Research Water Quality Sample Sites October, 1969
Water Investigations Branch Water Quality Site
Polution Control Branch Water Quality Site
Location of Fish Traps May 11-14 and June 18-19, 1979 (B.C. Research)
WS1
F3
1K
2K
1190042
0200252
T1
MILES
KILOMETERS
SCALE 1:25,000
CONTOURS IN METERS
Map 2 258
LOCATION OF AQUATIC SAMPLING SITES
BROWNIE CREEK COAL LICENCES
K - BROWNIE CR. 78(2)A
Prepared by BC Research April, 1979
B.C. RESEARCH Vancouver B.C.
FORDING RIVER
Henretta Cr.
McQuarrie Cr.
Moore Cr.
Clode Cr.
Brownie Cr.
Kilmarnock Cr.
Chauncey Cr.
MT. SCRIMGER
MT. HOLCROFT
MT. TURNBULL
MT. FARQUHAR
MT. PIERCE
MT. O'ROURKE
EAGLE MTN.
CASTLE MTN.
ALBERTA
B.C.
TRANSMISSION LINE
Settling Pond
FORDING COAL OPERATION
C.P.R.
L 6713
L 6706
L 6703
L 6694
L 6691
WS2
WS3
WS4
WS5
WS6
WS7
F1
F2
F4
F5
F6
F7
F8
T2


LEGEND
AQUATIC BIOPHYSICAL
(Adapted from R.A.B. System)
YCt
r2c | 23RI
channel profile
channel slope
channel cross section
substrate
FISH SPECIES
YCt = yellowstone cutthroat
Ø = absence of fish
( ) = expectation but unconconfirmed
CHANNEL
profile: r = regular slope
s = stepped (e.g. pool and riffle sequence)
slope: % gradient (elevation difference/reach length)
cross section: c = confined
b = bounded (some lateral movement possible)
u = unconfined (e.g. a grading fan, much lateral movement possible)
SUBTRATE
First digit x 10 = % of fines 0-2mm. size class
Second digit x 10 = % material in 2-64mm. size class
Rn = R without postscript n indicates occasional (<10%) outcrops in substrate
postscript n x 10 = % bedrock substrate
Note: Larges (64-256mm.) are found by difference
ADDITIONAL SYMBOLS
SYMBOL
MEANING
chute or cascade with details unknown
falls with details unknown
sequence of beaver dams
general zone of flood and side channels
persistent debris accumulation
reach boundary with reach number
major bank or valley side wall slump zone
35-0700-300-070-010 minor watershed boundary with R.A.B. watershed numbers
MILES
KILOMETERS
SCALE 1:25,000
CONTOURS IN METERS
Map 3
258
AQUATIC BIOPHYSICAL
BROWNIE CREEK COAL LICENCES
K. BROWNIE CR. 78 (2) A.
Prepared by BC Research
April, 1979
B.C. RESEARCH
Vancouver B.C.
FORDING RIVER
TRANSMISSION LINE
Henretta
McQuarrie
Moore Cr.
Clode Cr.
Browne Cr.
Kilmarnock
Chauncey Cr.
MT. SCRIMGER
MT. HOLCROFT
MT. TURNBULL
MT. FARQUHAR
MT. PIERCE
MT. O'ROURKE
EAGLE MTN.
CASTLE MTN.
FORDING COAL OPERATION
Settling Pond
ALBERTA
B.C.
C.P.R.
L 6713
L 6706
L 6703
L 6694
L 6691
35-0700-300-090
35-0700-300-090-020
35-0700-300-070-010
35-0700-300
35-0700-300-070



258

Map 4

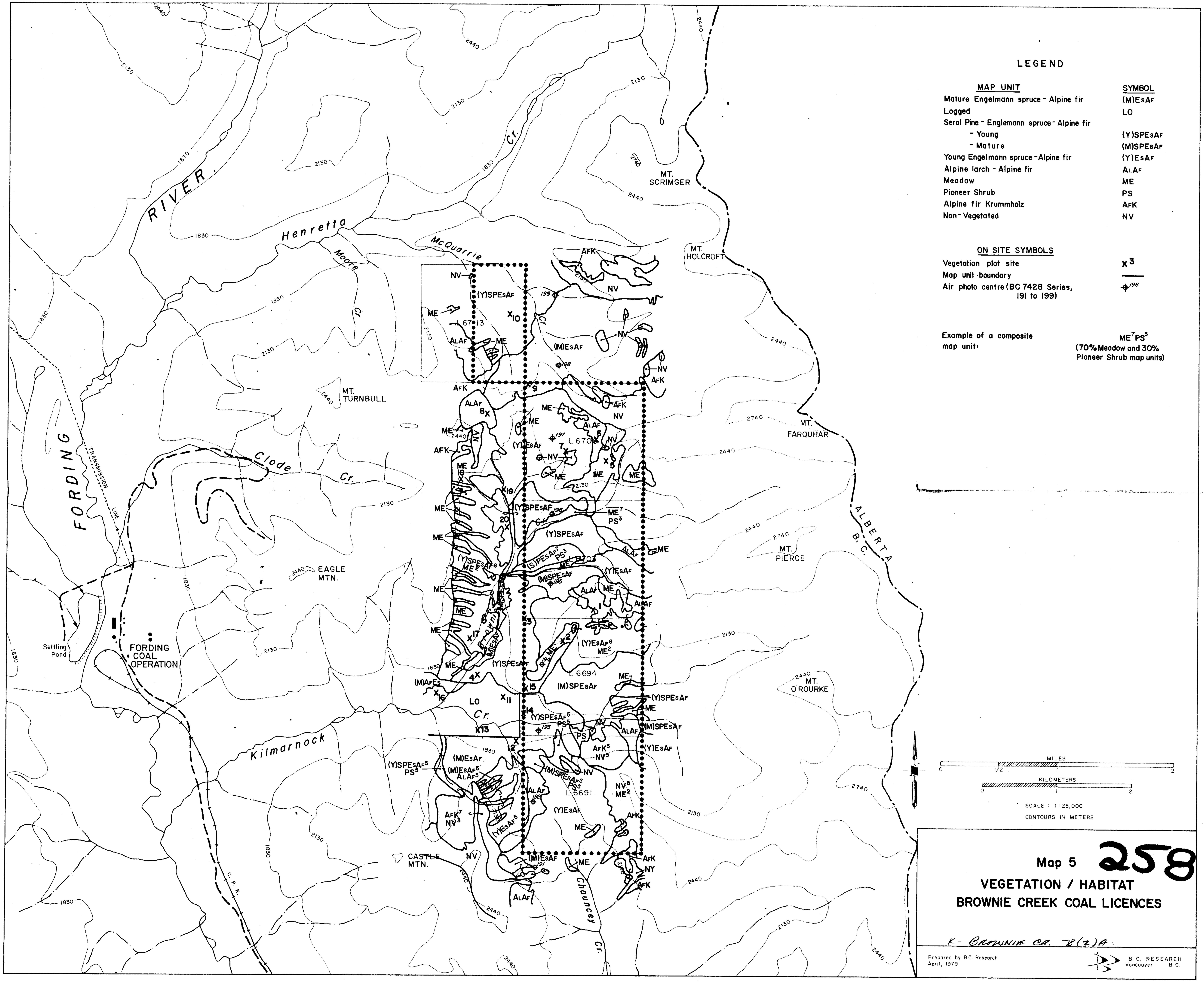
SURFICIAL MATERIALS

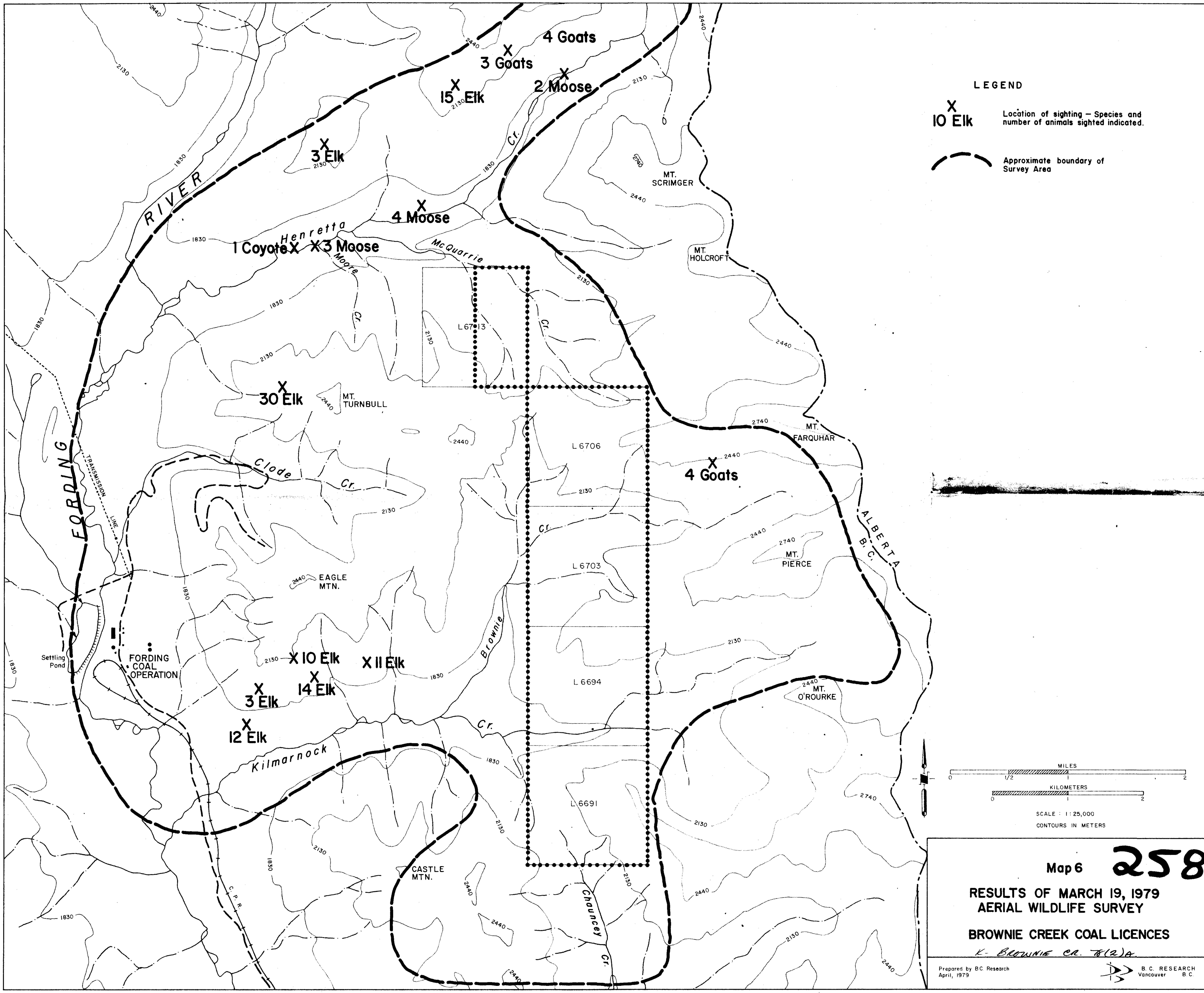
BROWNIE CREEK COAL LICENCES

K- BROWNIE CR. 78(2)A

Prepared by B.C. Research
April, 1979

B.C. RESEARCH
Vancouver B.C.


LEGEND
MAP UNIT
SYMBOL
Mature Engelmann spruce - Alpine fir
(M)EsAF
Logged
LO
Seral Pine - Engelmann spruce - Alpine fir
- Young
(Y)SPEsAF
- Mature
(M)SPEsAF
Young Engelmann spruce - Alpine fir
(Y)EsAF
Alpine larch - Alpine fir
ALAF
Meadow
ME
Pioneer Shrub
PS
Alpine fir Krummholz
AFK
Non- Vegetated
NV
ON SITE SYMBOLS
Vegetation plot site
x3
Map unit boundary
Air photo centre (BC 7428 Series, 191 to 199)
Example of a composite map unit:
ME7PS3
(70% Meadow and 30% Pioneer Shrub map units)
MILES
KILOMETERS
SCALE : 1:25,000
CONTOURS IN METERS
Map 5
258
VEGETATION / HABITAT
BROWNIE CREEK COAL LICENCES
K- BROWNIE CR. 8(2)A.
Prepared by B.C. Research
April, 1979
B.C. RESEARCH
Vancouver B.C.
FORDING
RIVER
Henretta
McQuarrie
Moore
Cr.
Clode
Kilmarnock
Chauncey
MT. SCRIMGER
MT. HOLCROFT
MT. TURNBULL
MT. FARQUHAR
MT. PIERCE
EAGLE MTN.
MT. O'ROURKE
CASTLE MTN.
FORDING COAL OPERATION
Settling Pond
TRANSMISSION LINE
C.P.R.
ALBERTA
B.C.
L 6713
L 6704
L 6694
L 6691



Map 6 258

RESULTS OF MARCH 19, 1979 AERIAL WILDLIFE SURVEY

BROWNIE CREEK COAL LICENCES

K- Brownie Cr. 78(2)A

Prepared by B.C. Research
April, 1979

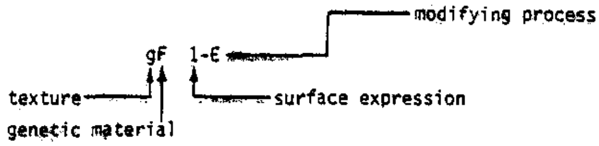
B.C. RESEARCH
Vancouver B.C.

LEGEND-SURFICIAL MATERIALS

(Adapted from R.A.B. Surficial Map)

Explanation of Letter Notation

A combination of letters is used to designate each map unit. The relative position of letters within the symbol indicates the characteristic that they represent.



Units consisting of two or more types of terrain are designated by two or more groups of letters separated by dots and slashes:-

e.g. gFt/dCf (See Composite Units below)

Material underlying the surface unit is shown by a symbol that is written beneath the surface unit symbol and separated from it by a horizontal line:-

e.g. $\frac{sEv}{gFt}$

Texture

letter symbol	name	particle size (mm.)	other characteristics
g	gravelly	>2-256	rounded & subrounded particles (includes interstitial sand)
s̸	silty	0.0039-0.0625	
c	clayey	<0.0039	
d	diamicton		heterogeneous mixture of particles of any size, roundness or angularity in silt and clay matrix
r	rubbly	2-256	angular and subangular particles with finer interstitial material
a	blocky	>256	angular and subangular particles

Notes:-

(1) The absence of a textural term from a unit symbol indicates that texture of the material was not observed in the field and cannot be reliably interpreted from air photos. The reader is referred to the general textural descriptions under the heading Genetic Materials (below).

(2) Where two textural terms are used together, they are written in order of increasing importance. eg. s̸s is silty sand, sg is sandy gravel.

(3) A diamicton texture is always implied in the case of morainal (M) materials. Any textural term written in the symbol merely modifies this basic texture. eg. s̸M indicates till consisting of silty diamicton, not silt alone.

Surface Expression

letter symbol	name	description
a	apron	a relatively gently sloping surface that is at the foot of a steeper slope and underlain by material derived from that steeper slope.
b	blanket	a mantle of unconsolidated material which has no constructional form of its own, but derives its general surface expression from the topography of the unit which it overlies; it masks minor topographic irregularities in the underlying unit and is more than 1 m thick. - if the underlying unit consists of unconsolidated materials, it is shown in the unit symbol; if no underlying unit is shown, it may be assumed to be bedrock.
f	fan	a surface that is the sector of a cone.
m	rolling	elongate or linear, parallel or subparallel hills or ridges with slopes generally less than 15° and local relief of more than 1 m.
r	ridged	elongate or linear, parallel or subparallel hills or ridges with slopes predominantly between 15 and 35° on unconsolidated materials and between 15 and 90° on bedrock.
s	steep	steeply inclined erosional slopes (scarps) with gradients commonly greater than 35° on unconsolidated materials and greater than 36° on bedrock
u	undulating	low hills and depressions with slopes generally less than 15° and rounded or irregular in plan; local relief greater than 1 m.
v	veneer	a mantle of unconsolidated materials which has no constructional form of its own, but derives its surface expression from the topography of the underlying unit; it reflects minor irregularities of the underlying surface, is generally between 10 cms and 1 m in thickness, and outcrops of the underlying unit are common. - if the underlying material is unconsolidated, it is included in the unit symbol; if no underlying unit is indicated, it is assumed to be bedrock.

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Genetic Materials

letter symbol	name (process status*)	
C	colluvial (A)	products of mass wastage; includes rubbly bedrock-derived material and material derived from unconsolidated Quaternary sediments; includes earthflow, mudflow and landslide deposits and talus material. - generally consists of massive to moderately well-stratified sediments with a great range of particle sizes.
F	fluvial (I)	material transported and deposited by streams and rivers; alluvial materials. - generally consists of moderately to well-bedded and moderately to well-sorted gravels and/or silt.
M	morainal (I)	material deposited directly by glaciers; till. - generally consists of compact, non-sorted and non-stratified material that contains a wide range of particle sizes and a matrix of silt or clay.
R	bedrock (I)	outcrops and rock covered by less than 10 cms. of unconsolidated material.

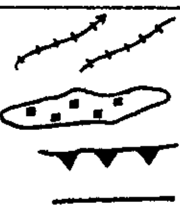
On-Site Symbols

glacier meltwater channel (minor) (direction of flow known, unknown)

blockfield

mountain escarpment

terrain unit boundary



*A process status descriptor is designated for each genetic material and for each modifying process on the basis of their most common state of activity at the present time. (See Processes above). <u>Process status descriptors are shown in unit symbols on the map only where the current state of activity is contrary to the designated state.</u>

Modifying Processes

letter symbol	name (process status*)	description
A	avalanched (A)	slopes modified by frequent snow avalanches and by the deposition of rock debris transported by snow avalanches.
G	frost shattered (A)	rock surfaces covered with angular fragments derived *in situ* by frost shattering.
S	soliflucted (A)	surface modified by the slow down-slope movement of saturated overburden across a frozen or otherwise impermeable substrate.
V	gullied (A)	surface crossed by deep, steep-sided ravines that are parallel or subparallel and result from fluvial erosion.

Composite Units

Composite units are employed where two or three types of terrain are intermixed or occupy such small areas that they cannot be designated as separate units at the scale of mapping. Symbols (defined below) are used to indicate the relative amounts of each terrain type, and the components are always written in decreasing order of importance.

.	the components on either side of this symbol are approximately equal.
/	the component in front of the symbol is more extensive than the one that follows.
//	the component in front of the symbol is considerably more extensive than the one that follows.

eg.	Mb/R	Mb is considerably more extensive than R
	Mb/R.Cv	Mb is considerably more extensive than R; R and Cv are of roughly equal extent
	Mb/R//Cv	R is less extensive than Mb; Cv is considerably less than R