

ELK RIVER COAL PROJECT

Mining and Environmental Planning Concept

CONFIDENTIAL
OPEN

TEXT

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GEOLOGICAL BRANCH
ASSESSMENT REPORT
ELCO MINING LTD.

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ELK RIVER COAL PROJECT

**MINING AND ENVIRONMENTAL
PLANNING CONCEPTS**

IN SUPPORT OF AN APPLICATION UNDER THE

COAL MINES REGULATION ACT

**TO THE
DEPUTY MINISTER, DEPARTMENT OF MINES AND
PETROLEUM RESOURCES
PROVINCE OF BRITISH COLUMBIA**

**FOR AUTHORIZATION OF EXPLORATION AND DEVELOPMENT
BY THE APPROVAL OF
A RECLAMATION PERMIT
AND A MINING LEASE**

SUBMITTED BY

ELCO MINING LIMITED

**VANCOUVER B.C.
MAY 1975**

ELK RIVER COAL PROJECT

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INTRODUCTION

Elco Mining Ltd., a Canadian company which has been registered in the Province of British Columbia, represents a consortium of European steel producers. This company, on behalf of the European consortium and Scurry-Rainbow Oil Limited, is examining the feasibility of mining and processing the Elk River coal deposit for the production of coking coal.

If the project is brought into operation a substantial part of its coal production will be consumed by the European steel mills, thus opening an additional market for Western Canadian coking coals overseas.

It is an objective of the consortium and Elco Mining Ltd., respectively, to develop the coal property in close cooperation with a group of Canadian partners at present represented by Scurry-Rainbow Oil Limited/Home Oil Ltd., and to serve also the growing demands of the Canadian market for indigenous coal.

In the course of the acquisition of a 50% equity in the project by Elco Mining Ltd. from Morrison-Knudson Company Inc. of the United States, certain geological and quality testwork becomes necessary in addition to previous investigations in order to be assured of coal reserves and coking qualities, to satisfy the quality requirements of the Canadian and European consumers and to enable Elco Mining Ltd. to do the mine planning and design work for the development of an open pit mine.

Before granting of exploration and reclamation permits the Minister for Mines and Petroleum Resources of British Columbia

requested the elaboration of an environmental planning concept for the period during and after operating a mine in the upper Elk Valley.

Since the impact of such a mining operation on the environment is specifically dependent on the applied mining method, the development of a basic mining concept also proved to be necessary, at this stage of consideration.

The present extent of our knowledge enables us to develop only preliminary conclusions with respect to this basic mining concept. However, this knowledge is sufficient to show that operations can be satisfactorily carried out on the Elk River deposit even under the relatively complicated geological and quality conditions encountered here.

This report has been prepared for submission to the Minister of Mines and Petroleum Resources of British Columbia in order to stress the considerable concern of Elco Mining Ltd. with respect to environmental and reclamation considerations in conjunction with their project, and to seek the close cooperation of governmental authorities, agencies and the public.

This report develops a mining concept believed suitable for the purpose of obtaining a medium quality coking coal blend, while carefully considering the effects of this mining development on the environment. The concept provides measures to protect the environment and the environment will be enhanced in the future in certain aspects by new features added to the landscape.

An openpit mine will provide 112 million short tons (102

million tonnes) of coal at a rate of four million short tons (3,628,000 tonnes) of clean coal per year for a period of at least 28 years. It will employ about 1,100 people, and require an expansion of the town of Elkford to accommodate in the order of an additional 6,000 people. Highway and railway connections to the minesite will be constructed.

The highway will provide improved access to the northern portion of the Elk River Valley, and the reclaimed mining area will provide fishing, boating and other features not previously available in the area. These features include six lakes and ponds having an area of 660 acres (267 ha.)

In addition to the open pit concept discussed in this report, there exists the possibility to also develop certain areas by underground methods. Studies in this regard will be undertaken in the future because underground mining, where feasible, provides a means for extracting much additional coal not accessible by open pit methods.

While underground mining may offer great potential for the future, it does not provide a viable basis initially for developing this project for the purposes desired. Opening up the European market for Western Canadian coal requires large tonnage from the very outset of operations. The reason for this is the great transportation distance to Europe requiring shipment by large scale bulk carriers travelling on a regular schedule.

Large scale initial operations are not possible by underground methods due to the nature of the mining development principles involved. Also, a specially trained, skilled, labour force is required for underground work. Since these skilled men

are not available, many years of operating a pilot training mine are required to gradually build the necessary skills and output.

Studies to date suggest that the variability in type of coals requires a preparation plant containing more than one processing circuit, with coal from very many different seam sources, all combined beyond the various circuits to produce a quality coking product. The multiple circuit concept requires large scale production to provide an economically viable preparation plant; also therefore, open pit coal production is the only method which will produce the blend required by the market and large volume to warrant the complex plant construction.

Another reason to commence mining by open pit methods is the high rate of coal recovery from open pit mining, which is in the order of 85 to 95% as compared to possibly 30% recovered from the reduced number and portion of seams which can be mined by underground methods.

When one considers the benefit to the economy of this large scale early activity, and the recovery of much more of this valuable resource from an area which is most favourable to providing an improved landscape and environment from that existing, it can be concluded that the open pit is the way to provide the economic base for the orderly development of the underground operation, thus providing maximum resource recovery and the benefit of many decades of future productivity from the underground mine is an enhanced environment.

It is the definite intention of Elco Mining Ltd. within their long-term planning to develop an underground test mine operating with hydraulic methods as soon as the open pit is

producing at its scheduled production level.

The report on "Mining and Environmental Planning Concepts" is submitted in two volumes; the first contains the text of the report whereas the second contains Appendices to both the Mining and Environmental Planning Concepts segments of the report. Large scale drawings are presented at a scale of 1"=400', while the Environmental Planning Concepts drawings are presented at a scale of 1"=800". All large scale drawings are also included as reductions in the bound volumes.

We should like to express our sincere appreciation to Techman Ltd., especially to Mr. C.J. Abbott and Mr. E.J. Blazenko, for their close cooperation and efficient work in preparing this report.

ELCO MINING LTD.

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This report, based upon office studies and limited field observations, was compiled and prepared during 1974 and 1975. During this period, cooperation and advice was received from many individuals and agencies, some of whom are listed below:

British Columbia Department of Mines & Petroleum
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Environment Canada
Water Survey of Canada
Canadian Wildlife Service
Department of Regional Economic Expansion

SUMMARY

This report outlines mining and environmental planning concepts for the development of an open pit coal mine situated in the upper Elk River Valley of eastern British Columbia.

The report has been prepared to provide the Government of the Province of British Columbia with the necessary information for evaluation and approval in principle of this open pit mine development.

The essential physical features of the development are:

1. The diversion of the Elk River during the lifetime of the open pit mine for a distance of 1.46 miles (2.35 km) through a tunnel and for 2.74 miles (4.41 km) in an open artificial river bed, also the diversion of small watercourses and Weary Creek.
2. The addition to the area of 6 lakes and ponds totalling 660 acres (267 ha).
3. Mining an area 3.9 miles (6.28 km) long within the valley floor and the east valley slope, to a depth of 400 feet (122 m) below the Elk River, and back-filling and landscaping of 2.85 miles (4.59 km) of the pit, leaving a lake 1.05 miles (1.69 km) long and 0.66 miles (1.06 km) wide at the south end.
4. Construction of a 490 acre (198 ha) tailings pond.
5. Construction of 43.8 miles (70.5 km) of railway to the

mine and 33.4 miles (53.7 km) of highway to and around the mine site.

The mine will produce 112,000,000 short tons (102,000,000 tonnes) of clean coal over a period of 28 years at a rate of 4,000,000 short tons (3,628,000 tonnes) per year and will employ 1100 people. The overburden ratio is 6.42 cu. yds. (5.41 m³/tonne) of overburden per short ton of raw coal recovered as an average over the lifetime of the mine.

The coal seams are composed principally of 18 groups or more with 40 to 60 individual members to be mined. Quality of the seams is quite variable and cokability ranges from quite deficient to excessive, thus requiring careful blending to produce a quality coking coal. This complex seam structure with its associated partings of widely varying thickness poses the main problem to economical mining, and is the principal factor dictating the mining development plan and methods to be employed.

The many seams and partings increase the rock dilution, and the varying physical characteristics of the coal require a large blending area, and a preparation plant design of two circuits appears to offer important advantages in maximizing clean coal recovery.

To recover a representative blend of all seams a multiple bench mining face is advanced southward with mining concurrently across 8 benches, each removed in two 25 foot (7.6 m) lifts, while ahead of the advancing box cut in the valley floor the mining of the eastern slope is completed at a rate which keeps ahead of the box cut and blends the low volatile coals from that area with the low and high volatile coals from the

valley box cut. Recovery of approximately 500,000 short tons (453,500 tonnes) of raw coal results in a cycle through all seams.

The chief mining problems are:

1. The extreme variability in the coal seam and parting thicknesses, with the resulting requirement for scheduling different types of equipment for different operations at each face in a high production operation, within the relatively small amount of working space which it is practical to make available.
2. The need to recover the thinner seams with minimum dilution and to be able to do this effectively without unnecessary degradation of the recovered product.

Analysis of the mining problems showed that large electric shovels cannot be efficiently or economically employed as the loading unit on this project. Maximum mobility is absolutely essential.

Large 24 cu. yd. (18.4 m³) front end loaders, and 11.5 cu. yd. (8.8 m³) hydraulic shovels having long reach, teamed with rubber tire mounted 10 5/8" rotary drills, all diesel powered, working 25 foot (7.6 m) benches, provide the tools to remove all coal without dozing, and the most precise control of partings separation of the 40° inclines which is available.

This mobile fleet of equipment tailored to job conditions will recover more coal and will produce a plant feed reduced in dilution to the extent that plant recovery should be at least 10% higher than that achieved by employing the conventional

shovel, dozer, front-end loader mining method.

During the initial 6 years of operation the overburden ratio is 8.37:1 cu.yd s.t. ($7.06 \text{ m}^3/\text{tonne}$) vs. 6.42:1 cu.yd. s.t. ($5.41 \text{ m}^3/\text{tonne}$) as a mine average. The mobile fleet will be employed in a more complex initial pit development than is possible with shovels. This scheme has not yet been developed in detail and is therefore not shown on the plans accompanying this report, but by this means we expect to improve the initial coal output and to delay some overburden removal.

When this proposed open pit operation has reached full production an underground mining operation will be developed, which has the potential to maintain operations on this property for a great many years after the open pit is completed.

The "Environmental Planning Concepts" segment of the report presents environmental description and impact considerations relative to the proposed mining concepts for the Elk River Coal Project. It also contains mitigation, reclamation and environmental enhancement concepts specifically related to the proposed mining scheme. These concepts should be considered as primary alternatives evolving from careful consideration by environmental scientists and engineers, but which will be modified and refined through additional study and government and public input.

Climate and air quality considerations (Section 2.0) are especially significant in pollution control; therefore, plant cover developed through a systematic revegetation program is recognized as a key element in the pollution control program. Dust from mining activity must also be controlled in disturbance areas and in coal processing and transport in the

active mining period before final reclamation is accomplished.

Because of the highly significant health and aesthetic impact considerations of air quality and the importance of climate in revegetation, future planning emphasis will be placed on development of site-specific revegetation guidelines and methods of minimizing cleared surface acreage.

The watercourses (Section 3.0) within the area possess high velocity and peaking characteristics which are due to the steep gradients of the Elk River and especially its tributaries. These gradients also tend to wash solids (suspended and bedload) into the watercourses.

Increasing the total length of the tributaries by channelling around critical mining areas and development of settling ponds will likely decrease the peak fluctuations, suspended solids and bedload. Suspended solids from Gardner Creek will be minimized by passing through a shallow lake. All diversion channels will have some means of trapping the sediment. Furthermore, the Elk River channel constructed of riprap will, initially, collect a considerable quantity of sediment.

An active revegetation program, keeping pace with mining, will also help to minimize erosion of the sloped areas, consequently the sediment load of the watercourses.

The only potential effect the tunnel may have on the water quality is temperature change; it may cause a decrease in the summer and an increase in the winter.

Geomorphology and geotechnical considerations (Section 4.0) are reflected in the mining concepts, with special attention to slope stability for safety and facilitation of final

reclamation. Aesthetics, hydrology and related environmental considerations will be altered as a result of the project. However, the landform aspect of the overall landscape concept presented here is especially favourable to reclamation in that relief is low to moderate (maximum dump slopes 25°), thereby minimizing erosion and revegetation problems and providing opportunities for development of special environmental enhancement features associated with fish, wildlife and recreation resources.

Soils (Section 5.0) will be stripped in stages from selected portions of the 5,075 acres (2,054 ha.) cleared at the mine-site. This element (or group elements) in the ecological system, is critical in reclamation both from the standpoint of revegetation and control of air and water pollution. Steps will be taken to stockpile materials which may be used in developing a replacement soil for reclamation which will be superior in some respects (especially higher nutrient levels) to the existing soil.

The existing vegetation (Section 6.0) in the project area is strongly influenced by a fire which destroyed most of the vegetation in 1936. Some good wildlife habitat exists, but much of the minesite is covered with dense conifer forest which has timber production value but low carrying capacity for wildlife.

Good wildlife habitat, a more limited resource in the East Kootenay region than timber, is steadily declining due to forest encroachment in the Elk River Valley and elsewhere. For this reason and for erosion control and watershed advantages, quality wildlife range is emphasized in reclamation planning for this project.

The present potential for aquatic life (Section 7.0) in the Elk River at the proposed mining site is rather limited. The steep gradient of each of the watercourses causes a swift current and migration is blocked on most of the tributaries. Also, there appears to be a reduction of macroinvertebrate productivity immediately downstream from the proposed mining site.

The existing fisheries of the area will be protected by a number of mitigative measures and enhancement techniques. Migration of fish through the tunnel and culverts will be aided by baffles and/or depressions and pools. Initial construction of a shallow lake will provide potential rearing and overwintering habitat, thus offsetting the reduction of habitat during the mining phase. Also, the lower ends of the creeks, draining into the lake, may be developed into spawning channels. Furthermore, the new Elk River channel will be built with pools and riffles, which maximizes fisheries habitat. Therefore, at mining completion, and perhaps within a few years of initial mining the total productivity will be greater than the temporary loss at the outset.

The present wildlife habitats (Section 8.0) within the project area are judged to have significant limitations for wildlife productivity. Present use of the project area by most ungulates is at best seasonal since snowfall in the area restricts winter residence. Present waterfowl use is apparently limited. Reclamation concepts as outlined in this submittal aim for restoration and enhancement of wildlife and recreation values so that coal extraction can be seen as part of an eventual tradeoff for more extensive forage production, creation of lakes and marshes, and removal of wind and fire deadfall barriers.

In particular, the overall increase in the water-land interface will promote shoreline habitats for mammals, waterfowl, amphibians, and insects. This reflects an orientation of reclamation and mitigation concepts toward optimization of wildlife diversity.

Based upon preliminary investigations, heritage resources (Section 9.0) do not appear to be significant. Further inquiries, consultations with government agencies, and development of heritage resource protection guidelines will be undertaken during future phases of project feasibility study.

A coal extraction environment will interrupt the continuity of the landscape, thereby detracting from a recreation experience for many people (Section 10.0). This adverse impact and increasing recreation activity in the upper Elk River Valley (which will develop with or without mining) will be on those people who have or would in the future use the area as a recreational retreat from more heavily populated areas.

Reclamation concepts set forth in this submittal deal with ultimate landscape modifications which include enhanced recreation potential through development of improved wildlife habitat, streams, lakes and ancillary facilities. The on-going coal mining and reclamation programs will be interpreted by many as an educational experience, i.e. as direct exposure to modern energy resource development technology, environmental impact and environmental conservation planning and methods.

Socio-economic considerations (Section 11.0) are related primarily to the substantial contribution this mining project

will make to the economy of the East Kootenay region. Social impacts will be considerable. As a result of about 1,100 new jobs being produced directly by the project, the population of Elkford will be increased by approximately 6,000.

Many people will benefit directly and indirectly from the project, and tradeoffs will have to be carefully evaluated in the decision-making process. Regional planning efforts are largely a government responsibility requiring input and cooperation from industry. Should the basic mining and environmental planning concepts presented by Elco Mining Ltd. receive approval in principal at this time, a coordinated approach will be developed for future planning efforts by the company and local and provincial government agencies.

1.0 LOCATION AND ACCESS

The Elk River coal property, located in the Elk River Valley in southeastern British Columbia, consists of 19,200 acres of coal licenses on Crown Forest land. The geographic location is $50^{\circ}24'$ north and $114^{\circ}56'$ west.

The proposed mining area will be approximately 49 miles (79 km) north of Sparwood by the proposed railway branch line, and approximately 28 miles (45 km) north of the new town of Elkford by the proposed highway connection.

Present access is available north from B.C. Highway No. 3 by paved road to Elkford and by the gravel surfaced forest service road north from Elkford.

Summer access to the north is possible over 20 miles (32 km) of unimproved power line maintenance road connecting to the Kananaskis Highway, which joins the Trans Canada Highway 25 miles (40 km) further north.

2.0 HISTORY OF THE DEPOSIT

2.1 Early Exploration

Elk River Valley coal deposits were first examined by Dr. G.M. Dawson of the CANADIAN GEOLOGICAL SURVEY in 1883. Between 1905 and 1920, 22 seams were uncovered on Big Weary Ridge and in 1920 the Aldridge tunnel was driven 650 feet (198 m) into the Big Weary Ridge.

2.2 Recent Activity

In 1952 some sampling was done by WEST CANADIAN COLLIERIES LTD. The most significant activity began in 1967 and 1968 when SCURRY-RAINBOW OIL LIMITED began acquiring leases and NORTH AMERICAN COAL CORPORATION under option agreement with Scurry-Rainbow Oil Limited began an exploration program. Activity was primarily confined to Big Weary Ridge. North American did not exercise their option and in 1969 Scurry-Rainbow Oil Limited independently extended exploration and evaluation of the deposit north to include Little Weary Ridge.

In December 1970 EMKAY CANADA NATURAL RESOURCES LTD. acquired a one-half interest in the Scurry-Rainbow licenses and exploration and coal analysis continued through 1970 and 1971, and a preliminary feasibility study report was prepared by Emkay.

Initial contacts between EXPLORATION UND BERGBAU GMBH and Scurry-Rainbow Oil Limited were established in early 1973 and with MORRISON-KNUDSON CO. INC. later that year.

2.3 European Consortium

After a presentation of the Elk River coal project and its development prospects to several interested European steel mills, a consortium was formed through Exploration und Bergbau GmbH, Dusseldorf, between:

AG der Drillinger Huettenwerke,
West Germany

August Thyssen Huette Ag,
West Germany

Estel N.V. Hoesch - Hoogovens,
Netherlands/West Germany

Italsider SpA,
Italy

Mannesmann AG,
West Germany

Ruhrkohle AG,
West Germany

Stahlwerke Peine-Salzgitter AG,
West Germany

On behalf of this consortium, a Canadian Company has been registered in the Province of British Columbia under the name of ELCO MINING LTD.

Acting for and on behalf of these steel mills, E&B entered into negotiations with Morrison-Knudson Co. Inc. in 1974 with the objective to take over their interest in the Elk River project. After having concluded the

final agreement , Elco Mining Ltd. will develop and operate the mining project on a scheduled basis of four million clean short tons (3,639,000 Tonnes) per annum, beginning in 1981.

3.0 DESCRIPTION OF COAL LICENSES

The coal licenses in which E & B are negotiating to acquire one-half interest are forty-two individual licenses, comprising 19,200 acres.

No's. 421 through 434 inclusive
 481 through 489 inclusive
 515
 771 through 779 inclusive
 951 through 957 inclusive

4.0 PHYSIOGRAPHY AND CLIMATE

4.1 General Area

The Elk River Valley is a broad U-shaped north-south trending glaciated valley flanked by rugged mountains ranging up to slightly more than 10,000 feet above sea level. The proposed project is located at an elevation of 5,100 to 6,300 feet.

4.2 Drainage

Elk River headwaters are located in the Upper and Lower Elk Lakes area approximately nine miles north of the northern property limits. Principal tributaries within the proposed mine area from north to south are Cadorna Creek, Gardner Creek, Weary Creek, and Bleasdell Creek, with only the Weary Creek being disturbed by the proposed open pit.

The Elk River and its tributaries drain an area of approximately 100 square miles north of the northern property limit, with the drainage basin nearly equally divided between the Elk River and Cadorna Creek. The mean annual flow of the Elk River is about 1,500 cubic feet (42.5 cubic metres) per second and the 100 year flood about 3,000 cubic feet (85 cubic metres) per second.

4.3 Open Pit Location

The proposed open pit mine is confined primarily to Little Weary Ridge and to the adjacent valley floor for a length of approximately 3.9 miles (6.25 km) along the valley, commencing 1/4 mile (400 m) south of the junction of the Elk River and Cadorna Creek.

4.4 Vegetation

The slopes of the valley contain spotty evergreen timber and brush cover, of very small diameter and height, with somewhat heavier and larger growth, comprised mainly of lodgepole pine under 30 feet (9 m) in height on the valley floor. The valley floor also contains a number of swamp meadows having numerous small ponds within them. A heavy layer of large diameter deadfall covering the ground results from the severe forest fire of 1936.

4.5 Weather Records

Weather records for the area are unavailable. Fernie reports average yearly precipitation of 41.48 inches (105.36 cm), with snowfall of 145 inches (368.3 cm). Temperature extremes at Fernie are +36°C. and -40°C. At the mine site snow on the ground measured approximately 18 inches (45.7 cm) at the end of November, 1974 and approximately 36 inches (91.4 cm) at the end of April, 1975. A 60 inch (152.4 cm) snowpack was measured at January 31, 1971. Frost penetration in

roads is expected to reach 36 inches (91.4 cm),
with zero penetration under undisturbed snow.

5.0 GEOLOGY

5.1 Structural Geology

In the Elk River Valley coal fields, beds of the Kootenay Formation have been folded into a northwest trending syncline. This syncline is probably the northern extension of the Alexander syncline which can be traced into the Fording River coal mining area and beyond for a distance of 30 miles to the south. As shown on Exhibit 1, the syncline is assymmetric with beds on the westside folded to near the vertical at the surface while beds along the eastern side of the valley dip westward at 35-45°.

The Lewis Thrust may be in the order of 8,000 to 10,000 feet (2,400 to 3,000 m) below the Elk River. (Dahlstrom et al 1962). The synclinal structure in the Elk Valley appears to be overridden and truncated along the west flank of the Elk River Valley by a fault which has been designated as the Elk River Thrust by some authorities.

Coal bearing strata of the Kootenay Formation are exposed on both the eastern and western synclinal limbs on either side of the valley.

Surface and subsurface information indicates a normal syncline fold without major fault offset as the most probable condition below the Elk Valley. However, some authorities believe that the Kootenay Formation beds exposed on the westside of the valley were displaced along a major thrust fault from a distance of

approximately five miles to the west. If such activity occurred it is considered to be west of the proposed open pit mine.

5.2 Stratigraphy

Coal bearing strata of the Kootenay Formation in the Elk River area exceed 2,000 feet (600m) in thickness and are mineable for a thickness of approximately 1,600 feet (490m). The mineable portion contains 18 groups of seams with the number of members over two feet thick varying from over 40 to over 60. The predominant rock type interval between coal seams is dark, grey siltstone. Siltstones grade laterally and vertically into sandstone layers and dark carbonaceous shale. Prominent coal seams are persistent, laterally, although the detailed lithology of intervals between seams is irregular, and the seams sometimes split and recombine into varying numbers of members.

Coal bearing strata are underlain by a massive basal sandstone bed about 300 feet (90 m) thick which probably correlates with what is known as the Moose Mountain Member of the Kootenay Formation in other parts of British Columbia and Alberta.

The total thickness of the Kootenay Formation is estimated to be 3,500 feet (1,050m). A marine shale sequence of 1,000 feet thick known as the Fernie Formation, underlies the basal sandstone member of the Kootenay Formation in the project area.

The Kootenay Formation is overlain by the Blairmore

Formation, which, where observed in the project area consists of a hard pebble conglomerate of about 200 feet (60m) in thickness.

5.3 Glaciation

Recent glaciation has deposited some glacial till on the valley slopes and up to 140 feet (43m) thick in the valley bottom. The till is an impervious assortment of angular rock fragments, in a dense clay matrix, interbedded and underlain by pervious water bearing glacial outwash gravel.

5.4 Geology of the Proposed Open Pit Area

The southern limit of the proposed open pit is set at sta. 180 at the pit bottom, approximately 400 feet (122m) below the present river level, with the southern pit slope extending southward to near an area which has been extensively disturbed by glaciation, landsliding and possibly minor faulting. The northern pit limit has been set 1/4 mile (400m) south of the Elk-Cadorna Creek junction to avoid disturbing Cadorna Creek. The base of the pit at the north limit is at sta. 370.

Sufficient reserves are contained within these limits to justify the construction of a 4,000,000 s.t. (3,600,000 Tonnes) per year preparation plant.

The average thickness of all mineable seams in the initial pit is 296 feet (90m) through seams 2-19 with another 37 feet (11m) of mineable thickness in

portions of seams 20-24 intersected in the pit slope.

The beds strike generally north 20°W, but with the strike increasing westerly from the south end of the pit to the north end. The dip ranges between 35 to 45°, but is more often 38 to 40°. Strike and dip vary somewhat locally.

A brief description of the coal seam formation is contained in Figure 1. The total coal thicknesses shown for seams over 2 feet thick are the average of all thicknesses obtained from drill holes and test pits along the proposed mining section from sta. 180-370.

Further information on the geology and description of the coal seam characteristics may be obtained from the Emkay Canada Natural Resources Ltd. report, Volume 1, dated March, 1971, with Exhibits, and from the Techman report on Preparation and Preliminary Flow Sheet, dated March, 1975, Appendix No. 1 of this report.

GEOLOGIC AGE	FORMATION	THICKNESS IN FEET	LITHOLOGY AT SCALE 1" = 200'	AVERAGE THICKNESS (COAL) PER SEAM IN FEET	AVERAGE INTERVAL BETWEEN SEAMS IN FEET	REMARKS		
JURASSIC - CRETACEOUS	BLAIRMORE	1000'				Pebble conglomerate where observed in the field.		
		1470'				Kootenay Formation above Seam 20 not explored--may contain additional coal.		
		KOOTENAY FORMATION	1730' (REPRESENTS EXPLORATION TO JANUARY 1, 1971)		(TOTAL COAL IN SEAMS OVER 2" THICK 305 FEET)			20 COAL SEAM Possibly 6 seams from 1-6 feet thick over a stratigraphic interval of 65 feet.
				●20 (9)	65	40	19 COAL SEAM From 2-5 seams ranging from 1-6 feet thick over a stratigraphic interval estimated to average 25 feet thick.	
				●19 (10)	73	80	18 COAL SEAM About four (4) seams 1-11 feet thick over a stratigraphic interval estimated to average 30 feet thick.	
				●18 (15)	30	90	17 COAL SEAM One (1) to seven (7) seams ranging from 1-9 feet thick over a stratigraphic interval estimated to be 50 feet thick.	
				●17 (18)	50	35	16 COAL SEAM About 5 seams from 1-5 feet thick over a stratigraphic interval estimated to be 75 feet thick.	
				●16 (16)	75	60	15 COAL SEAM About 5 coal seams 1-5 feet thick over a stratigraphic interval of about 50 feet.	
				●15 (20)	30	65	14 COAL SEAM Six coal seams ranging from about 1-7 feet thick over a stratigraphic interval up to 65 feet thick.	
				●14 (20)	39	55	13 COAL SEAM In south part of field four or more seams from 1-12 feet thick with shale splits over a stratigraphic interval of approximately 65 feet, merges into thick single seam to north.	
				●13 (22)	60	75	12 COAL SEAM Appears to range from about 12-28 feet thick with shale splits ranging from 5-15 feet thick.	
				●12 (20)	48	130	11 COAL SEAM Seam appears to merge with seam 12 near Station 255 + 00.	
				●11 (16)		60	10-10A COAL SEAM Varies from about 14 feet thick in south part of field to 35 feet thick north of Weary Creek.	
				●10 (28)		80	9 COAL SEAM Lateral continuity and thickness of seam persistent. Thickness varies from about 14-19 feet. May split into two (2) seams between Stations 240 + 00 and 270 + 00.	
				●9 (17)		30	8-8A COAL SEAM Varies from 17-26 feet thick, contains shale split which varies from 4-25 feet.	
				●8 (22)	30	75	7 COAL SEAM Varies from 4-9 feet thick, splits into two seams north of Station 295 + 00.	
				●7 (6)		50	6 COAL SEAM Average thickness 4 feet ranges up to 12 feet and splits into 2-3 seams in the area of Weary Creek.	
				●6 (7)		110	5 COAL SEAM Usually only a trace but does reach 3 feet thickness in several places.	
				●5 (4)		50	4-4A COAL SEAM Varies in thickness from about 20-37 feet; average thickness 27 feet.	
				●4 (30)	40	50	3 COAL SEAM Varies in thickness from about 4-15 feet; average about 7 feet.	
●3 (7)		60	2 COAL SEAM Varies in thickness from about 8-29 feet; average thickness 15 feet.					
●2 (15)		30	1 COAL SEAM A 1-2 foot shaly coal seam within basal sandstone member.					
●1 (2)			Basal sandstone member, estimated 500 feet thick.					
JURASSIC	FERNIE SHALE	1000'				Marine shale, estimated 500-1000 feet thick		

† Thickness estimated from published information and geologic relationships in Elk River Valley.

GENERALIZED COMPOSITE STRATIGRAPHIC SECTION
INITIAL STUDY AREA
ELK RIVER COAL FIELD

6.0 EXPLORATION

From 1968 to 1971 three exploration programs were completed on the previously described coal licenses, by NORTH AMERICAN COAL CO., 1968; Scurry Rainbow Oil, 1969; and by Emkay Canadian Natural Resources Ltd. 1970-71. The following is a summary of the results of these exploration programs.

<u>Program</u>	<u>Drill Core</u>	<u>Holes Rotary</u>	<u>Drill Footage</u>	<u>Bulk Samples</u>	<u>Trenching Footage</u>
1968	6	13	10,800	8	6,900
1969	16		9,621	4	5,125
1970	27	15	22,284	10	8,900
1971	<u>21</u>	<u>—</u>	<u>12,414</u>	<u>—</u>	<u>1,600</u>
	70	28	55,119	22	22,525

Full details of the exploration program may be found in the Emkay Canada Natural Resources Ltd. - Scurry Rainbow Oil Limited report of March, 1971, Volume 1 and exhibits.

Much additional exploration work is required prior to committing to a mining program. During 1975 a drilling and sampling program amounting to about 9,000 feet (2,700m) of core drilling, one adit and the re-opening of two trenches and seven tunnels is planned.

During 1976 and 1977 the program will be expanded to include about 200,000 feet (60,000m) of core and rotary drilling, and the extraction of sufficient bulk samples from all seams to supply a pilot washing plant on site to produce enough coal for semi-industrial washing and coking scale tests.

7.0 COAL RESERVES AND COAL RECOVERY

7.1 Total Licence Area Reserves

The total coal reserves of all classes, contained within the licence areas, proven, partly proven, inferred and uncertain, for possible open pit mining are 519,442,000 short tons (471,230,000 tonnes) in place at an overburden ratio of 6.66 cy./s.t. (5.62 m³/tonne). After waste, oxidation, pit and plant losses the net clean coal product is 331,893,000 s.t. (301,088,000 tonnes). Underground mining reserves for inferred and uncertain areas are 1,865,000,000 s.t. (1,691,900,000 tonnes) in place, yielding a clean coal recovery of 374,700,000 s.t. (339,922,000 tonnes). The above coal reserve calculations were obtained from the Emkay Canada Natural Resources report of March, 1971.

7.2 Proven Open Pit Reserves and Volume of Materials Handled

In this report we will deal only with the proven reserves within the limits of the proposed open pit mine between sta. 180 and 370 (plus pit end slopes) to a level approximately 400 feet below the Elk River.

Within these proposed pit limits seam groups 2-18 are generally mined down to the level of 400 feet (122 m) below the Elk River, and seam groups 19-24 are mined to a progressively lesser extent westward in the pit slope. The mining limit has been cut off as indicated due to seams westward deteriorating into generally thin unmineable members with very high and uneconomical

stripping ratios. Seam members within the groups have been considered mineable above two feet (0.6 m) in thickness. Mining losses have been calculated on the basis of one foot (0.3 m) lost for each mineable member of the groups. Dilution rock included in the coal is on the basis of one-half foot (0.15 m) of rock for each member mined, plus all partings three feet (0.9 m) thick and under.

Calculations were based on cross-sections generally at 1,000 foot (304.8 m) intervals with seams interpolated where not intersected by drill holes. Since some of the higher numbered seams were only intersected at 8,000 foot (2438 m) intervals additional drilling will result in a variation, particularly in seams 14-24.

The average thickness of coal recovered from seams 2-18 is 253 feet (77.1 m), with 37 feet (11.3 m) recovered from seams 19 - 24 through lesser depths in the pit slope.

Materials mined may be summarized as follows:

Glacial till overburden	70,170,000 cy. (53,680,050 m ³)
Rock overburden, including dilution rock with coal	969,500,000 cy. (741,667,500 m ³)
Oxidized coal	3,515,000 cy. (2,668,975 m ³)
Recovered raw coal	162,581,000 st. (147,491,000 tonnes)

Within the rock overburden quantity of 969,500,000 cy. (741,667,500 m³) is 24,511,000 cy. (18,750,915 m³) of partings 3.1 ft. to 12.0 ft. thick in addition to dilution partings under 3.0 feet thick which go to plant

feed.

The weight of coal is based on 1.22 s.t. per cu. yd. (1.45 tonnes/m³). The coal is distributed to generally lower volatile seams 2-10, 60.3% and higher volatile seams 11-24, 39.7%. The overburden ratio (oxidized coal included in O.B.) is 6.42 c.y./s.t. (5.41 m³/tonne) overburden per recovered short ton of raw coal.

The oxidized coal quantity is based on oxidation occurring to 15 to 25 feet (4.6 m to 7.6 m) below the coal surface, the greater depth being on slopes above the valley floor.

7.3 Dilution Rock, Thin Coal Seams and Partings

Adding the recovered raw coal and dilution rock, the plant feed is 202,896,000 s.t. (184,064,000 tonnes). Recovery on this diluted product, based on our preliminary flowsheet calculations is 55.6% for a clean recovered coal weight of 112,810,000 s.t. (102,340,000 tonnes).

The dilution rock adversely affects the plant recoveries. It is necessary to mine the thinner high volatile seams where the highest dilution occurs in order to obtain a quality coking coal.

This dilution represents 25% by weight of the high and medium volatile R.O.M. coal recovered (coal and dilution rock) but only 14% of the low volatile R.O.M. coal.

Table 1 provides a distribution of the coal and dilution

TABLE 1

PROPOSED OPEN PIT MINE STA. 180 TO 370

TABLE OF RAW COAL RECOVERIES BY SEAM

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Seam No.	Average Seam Thickness of Recoverable Members	Coal in Place Within Recoverable Members	Average Mining Loss	Net Recovered Seam Thickness	Weighted Average Mining Loss	RECOVERED RAW COAL		Seam % of Recovered Coal	Mining Loss	Dilution Rock Recovered	Total Recovered Mine Run Product	Dilution As % of Raw Coal Recovered	R.O.M.
	Ft.	Thousand Cu. Yd.	Ft.	Ft.	%	Thousand Cu. Yd.	Thousand S. T.		Thousand Cu. Yd.	Thousand Cu. Yd.	Thousand Cu. Yd.		
2	15.26	12,605	1.26	14.00	8.40	11,730	14,310	8.81	1,076	875	12,605	7.46	6.94
3	7.30	5,085	1.21	6.09	17.88	4,433	5,409	3.33	965	652	5,086	14.71	12.83
4	30.38	23,053	2.32	28.06	8.25	21,219	25,887	15.93	1,909	1,834	23,054	8.65	7.96
5	4.22	1,573	1.03	3.19	33.51	1,138	1,388	0.85	573	435	1,573	38.20	27.64
6	6.75	4,401	1.25	5.50	19.99	3,467	4,230	2.60	866	934	4,401	26.94	21.22
7	6.39	3,251	1.03	5.36	17.90	2,925	3,569	2.19	638	326	3,251	11.14	10.02
8	22.12	13,450	2.05	20.07	10.30	12,095	14,756	9.08	1,388	1,355	13,451	11.20	10.08
9	16.84	9,955	1.23	15.61	8.01	9,394	11,461	7.05	818	561	9,955	5.97	5.64
10	27.72	14,758	1.80	25.92	5.98	13,994	17,072	10.51	889	764	14,757	5.46	5.17
11	16.42	3,641	1.94	14.48	8.75	3,217	3,925	2.41	309	424	3,642	13.18	11.65
12	19.50	9,274	2.00	17.50	10.39	8,181	9,981	6.14	948	1,093	9,274	13.36	11.78
13	22.41	10,331	3.25	19.16	18.34	8,572	10,458	6.43	1,926	1,759	10,331	20.52	17.03
14	20.58	8,957	2.84	17.74	15.73	7,428	9,062	5.57	1,387	1,529	8,957	20.59	17.07
15	20.41	8,065	2.99	17.42	15.19	6,759	8,246	5.07	1,210	1,306	8,064	19.32	16.19
16	16.41	6,466	3.14	13.27	21.94	4,664	5,690	3.50	1,310	1,802	6,466	38.64	27.87
17	17.82	7,020	2.36	15.46	14.18	5,769	7,038	4.33	953	1,251	7,019	21.68	17.82
18	14.03	6,670	1.06	3.97	7.13	4,882	5,957	3.66	375	1,788	6,671	36.63	26.81
19	10.47	1,926	2.53	7.94	31.47	1,505	1,837	1.13	691	421	1,926	27.97	21.86
20	9.16	1,487	1.97	7.19	25.86	1,136	1,386	0.85	396	351	1,488	30.92	23.61
21	8.30	783	2.09	6.21	28.97	473	577	0.35	193	310	783	65.53	39.59
22	15.59	404	2.99	12.60	24.21	242	295	0.18	77	162	403	66.85	40.07
24	4.10	48	1.00	3.10	32.26	40	48	0.03	19	9	48	23.81	19.23
TOTAL:		153,203			12.43	133,263	162,582	100.00	18,916- 23,000+	19,941 40,316+	153,205 202,897+	14.96* 24.80x	13.02* 19.87x

* By Volume

+ S. T.

x By Weight

TABLE 2

ANNUAL OVERBURDEN AND COAL VOLUMES

<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
Year	Rock Overburden To Waste Dump	Glacial Till Overburden	Recovered Rock Dilution to Plant	Annual Total Overburden Including Dilution	Recovered Raw Coal	Annual Overburden Ratio
	Thousands Cu. Yd.	Thousands Cu. Yd.	Thousands Cu. Yd.	Thousands Cu. Yd.	Thousands S. T.	
* P. P.	6,920	2,570	80	9,570	340	28.15
1	41,780	12,280	720	54,780	4,411	12.41
2	38,650	7,950	850	47,450	5,882	8.07
3	39,110	6,900	890	46,900	5,882	7.97
4	33,690	6,950	810	41,450	5,882	7.05
5	40,250	4,800	950	46,000	5,883	7.82
6	35,850	2,330	950	39,130	5,882	6.65
7	31,350	1,000	650	33,000	5,882	5.61
8	30,860	1,000	640	32,500	5,883	5.52
9	31,160	1,000	640	32,800	5,882	5.58
10	30,770	960	630	32,360	5,882	5.50
11	30,960	960	640	32,560	5,883	5.54
12	30,860	1,350	640	32,850	5,882	5.58
13	30,870	2,000	530	33,400	5,882	5.68
14	30,920	2,000	580	33,500	5,883	5.69
15	30,940	2,000	560	33,500	5,882	5.69
16 - 20	157,370	6,752	2,830	166,952	29,412	5.68
21 - 25	172,700	3,798	3,600	180,098	29,412	6.12
26 - 28	108,064	3,570	2,751	114,385	16,655	6.87
	953,074	70,170	19,941	1,043,185	162,582 S.T. (133,263 Cu. Yd.)	

* Pre-Production

rock by seam group.

Table 2 provides an annual distribution of all material handled, assuming a coal preparation plant recovery of three million clean short tons in coal Year 1 and four million clean tons annually thereafter. Drawing No. 1619 shows this distribution graphically and the resulting cumulative mining ratio.

Upon examining the undersirable dilution resulting from mining of the 2-3 foot (0.6-0.9 m) seams with their associated partings and other dilution rock recovery, we performed a second calculation which eliminated all 2-3 foot (0.6-0.9 m) coal seams and their associated partings and other dilution rock. The recovery of raw coal on this basis would be reduced to 150,860,000 S.T. (136,858,000 tonnes) and the percentage of higher volatile coals would drop to 36.7% of the total. However, because the dilution would drop to 16.65% by weight of the recovered raw coal vs. 24.8% the plant recovery would increase to about 65%. Therefore, from the reduced tonnage of R.O.M. coal recovered (raw coal recovered + dilution rock recovered) of 175,976,000 S.T. (159,642,000 tonnes), a clean coal recovery of 114,384,000 S.T. could be achieved.

The results of this analysis would indicate that there is considerable disadvantage in mining the 2-3 foot (0.6 - 0.9 m) seams at all. However, see the following solution for improving the probability of these seams being economically mineable.

The dilution expected was based on a standard electric shovel, dozer, front-end loader mining bench plan and height layout, which has some considerable disadvantages

on this project . We believe a different mining method is preferable for this project. This alternative method is expected to reduce the dilution and mining losses to about half of those shown in our coal recovery calculations, and consequently to improve the possibility of making the thinner seams economically mineable, and to considerably increase the clean coal output, possibly by 10%.

This alternative method will be discussed in the section of this report dealing with development of a mining plan.

At this point we would like to mention that examination of some of the thinner coal seam cores which were not tested shows some poor quality coal. The number of thinner untested seams which may prove unsuitable is unknown. Also, the extent to which thinner seams pinch and swell or disappear and reappear is unknown. More data is needed on the type of dilution material to be handled by the plant, and of the color differences necessary to separate thin partings from thin coal seams at the mine. These latter two points were examined by some core study and it appears that approximately 2/3 of the dilution rock will pass through the breaker stations and into the plant. Also most partings are grey vs. coal black, which will help in separating during the mining. However, until substantial additional drilling is done we recommend that the plant recovery figure of 112,810,000 s.t. (102,340,000 tonnes) be used as a conservative estimate of yield.

8.0 COAL QUALITY, BLENDING AND PREPARATION PLANT REQUIREMENTS

8.1 Number of Seams and Coal Characteristics

Coal will be recovered from 22 or 23 seam groups with 40 - 60 or more individual members being mined across the width of the mine. These coals exhibit a wide range of properties as can be seen from Table 2 of the Appended "Report on Preparation and Preliminary Flow Sheet" of March 1975. Appendix No. 1.

The report referred to provides a summary of physical characteristics of the coals as necessary for a discussion of preparation plant design. Therefore only data not contained in Appendix No. 1 will be summarized here.

Table No. 3 contains additional characteristics to those covered in Appendix No. 1.

8.2 Ash Fusibility Factors

Coking studies indicate extremely high flow temperatures caused by the low percentage of alkalis and very high SiO_2 contents in the ash. They indicate that it would appear advisable that if the coal should be used as steam coals in power stations, they be limited to those stations using a dry ash removal system.

8.3 Cokability

On the basis of the maceral composition and volatile

TABLE 3

WASHED COAL SUMMARY BY SEAM OF
SULPHUR, PHOSPHORUS, INHERENT
MOISTURE & B.T.U.

<u>Seam No.</u>	<u>Sulphur</u>	<u>Inherent Moisture</u>	<u>B.T.U.</u>
2	.51	.62	13,990
3	.58	.61	14,159
4	.44	.68	14,474
6	.79	.42	14,325
7	.69	.60	14,160
8	.56	.48	14,302
9	.54	.46	14,266
10	.46	.50	13,504
11	.69	.40	14,283
12	.74	.49	14,406
13	.84	.52	14,557
14	.83	.53	14,327
15	.68	.41	14,586
16	.78	.41	14,543
17	.83	.31	14,714
18	.58	.53	14,700
19	.70	.43	14,805
20	.82	.55	14,650

Phosphorus content ranges from 0.04% to 0.10%
except for seams 2 (.014), 9 (.038) and 10 (.022)

constituents as well as of the dilatometer test results and the G-value readings, it is possible to classify the Elk River coals into three seam groups. (see Montan Consulting Report, dated October, 1973)

Group 1: The seams 3,4,6,7,8,9,10, which are low volatile and possess slight to deficient coking properties. However, a possible important exception should be noted. Seam 10 makes up about 10.5% of the total deposit, and there appears to be evidence that the seam 10 tests were based on partly oxidized coal, and therefore overall cokability might prove better than presently indicated.

Group 2: The seams 2,12,13,14,15 which are low to medium volatile, and have good coking properties.

Group 3: The seams 16,17,18,19,20 which are high volatile and have an excess of coking properties.

A blend consisting of the seams of Group 2 and 3 will, depending on the proportions of the individual seams, yield a coking coal with adequate to good coking properties. The proportions of the coal coming from the seam of Group 1 that can be blended together with coals from the seams of Group 2 and 3 depend on the following premises that should still be checked in detail:

- (a) If the macerals described as inert in the existing analyses react inert during coking, as can be reasoned from the dilatometer curves and the G-value readings, a portion of up to 30% will be possible in the composite blend. If greater

amounts are added, a definite deterioration in the coking properties would have to be reckoned with.

- (b) In view of the carbonization rank and the results of the coking tests, it can be concluded that these seam coals also have certain coking properties. Since a part of the macerals classed as inert possibly do not react fully as inert substances during coking, it might be possible that even in the case of adding up to 50% to the blend a fully cokable coking coal would result.

Elk River coal is probably blendable and cokable with Ruhr coking coal. The optimum proportion for blending with Ruhr Coal and coals of other origin can only be determined, however, once the premises a) and b) have been clarified in further quality investigations.

8.4 Coal Blending and Preparation Plant Treatment

Due to the large number of seams exhibiting a wide variation in such properties as % of volatile matter, raw ash content, grindability, and % of near gravity material, etc., together with a wide range in dilution rock content, a complex method of mining, blending and plant preparation techniques is required to produce a medium quality coking coal.

A mining method described later in this report produces a cross-section of all seams successively upon each

recovery cycle of approximately 500,000 s.t. (453,600 tonnes) of raw coal.

This coal is hauled from the mine by truck and dumped directly in six stockpiles as Shown in Table 4.

Coal in piles 1 and 2 are from the hard coarse seams of low and high volatile coals; those in piles 5 and 6 are from the soft, fine seams of the low and high volatile coals. These two groups of seams go respectively to the "hard" and "soft" coal circuits of the preparation plant, as described in appendix 1. Piles 3 and 4 are low and high volatile coals which in properties are intermediate, and may go together to either the "hard" or "soft" coal circuits.

The coal is loaded from at least 4 of the 6 stockpiles simultaneously by small front-end loaders, into movable loading hoppers, to be conveyed to the breaker stations prior to entering the 2 separate plant circuits. Further blending takes place as the coal leaves the plant as a combined flow from both circuits. Loading and unloading trains and rehandling to and from ships will further mix the product.

Considerations are being made not to apply the customary bucket wheel stacker-reclaimer because it is not considered that this method will provide satisfactory blending, considering the scheduling of coal flow from the mine.

We also consider that stockpiling the unbroken coal and feeding coal directly from breaker to plant provides superior washability characteristics.

TABLE 4PROPOSED BLENDING STOCKPILE DISTRIBUTION FOR RAW COAL BY SEAM

<u>STOCKPILE NO.</u>	<u>SEAM NO'S.</u>	<u>% OF RESERVES</u>	<u>APPROX. RAW COAL ASH</u>	<u>% DILUTION</u>	<u>% VOLATILES</u>
1	4, 4A, 6, 9	25.6	27	16	19.5
2	10, 17, 18, 19	19.6	32.6	26.5	25.9
3	5, 8	10.0	35.9	22.4	20.0
4	11, 12, 16	12.0	37.3	33.9	26.9
5	2, 3, 7	14.3	21.6	15.9	19.7
6	13, 15, 20 to 24	18.5	44.4	32.8	25.2

All conclusions relating to blending and coal handling are preliminary. The final methods employed can only be determined when proposed future studies are completed.

Clean coal storage has not been provided for except for the 3 - 12,500 ton silos (11,340 tonnes), due to the fact that a railway or terminal strike will result in delays which can only be partly made up by the railway, and therefore this additional surge capacity beyond 27,500 tons (24,950 tonnes) is probably not worth the expense. This matter will require further study of rail, transportation and shipping factors before the final clean coal storage capacity is decided.

The preparation plant output from the proposed open pit, as mentioned previously under Coal Recovery, is estimated at 4 million clean short tons per year over approximately 28 years for a total recovery of 112,810,000 clean short tons (102,340,000 tonnes). This output is based on a plant recovery from the rock diluted R.O.M. coal of 55.6%. (This is equivalent to 69.4 % recovery of the undiluted raw coal recovered from the mine).

Until quality analysis is completed no provision has been made for oxidized or thermal coal storage. It seems most probable that a coking blend will use all but the oxidized coal, and experience has shown that a small quantity of oxidized coal such as this 150,000 tons (136,050 tonnes) per year seems to be readily absorbed in the plant feed. If storage area should be required, the area by the spur provided for fuel storage and general unloading and storage can be suitably enlarged.

Oversize waste material is deposited in a 200 ton (181 tonnes) bin for truck transport to the tailings dike or to mine backfill.

The major portion of information relating to coal quality and preparation plant requirements is contained in Appendix 1. The Report on Preparation and Preliminary Flow Sheet.

Much additional information relating to coal analysis is available in the Emkay-Scurry report dated March 1971, the Coal Science and Minerals Testing Report of Birtley Engineering dated October, 1971, and the Montan Consulting report dated October, 1973.

8.5 Quality Control

The complex seams structure will require detailed exploratory drilling immediately ahead of the mining and this drilling will provide samples for analysis. Advanced planning from known product distribution can then be made, and sampling into the specific stockpiles will note the locations of variations within each pile and dilution content and type. A computer program will control the loading locations along the raw coal stockpiles to provide the best blending choice available at all times.

Sampling into the clean coal silos will note any variation in the clean coal so as to further blend to the three silos to the maximum extent possible.

9.0 DESCRIPTION OF PHYSICAL FEATURES OF THE MINING OPERATION

9.1 Elk River Diversion

An essential feature of the mining plan, if the best product and the maximum and most efficient recovery of the reserves is to be realized, is the diversion of the Elk River to the westward around the proposed open pit.

Fortunately, the previous study requirement for a 10.3 mile (16.6 km) diversion channel can be reduced to 4.2 miles (6.7 km), and the raising of the river high up the valley slopes and later dropping it back some hundreds of feet is also eliminated.

We propose a 20 foot (6.1 m) diameter tunnel for 1.46 miles (2.35 km), starting immediately north of the proposed pit about 1,000 feet (305 m) south of the Elk-Cadoran junction and an open channel of 2.74 miles (4.41 km). The tunnel grade is uniform, at 0.645% and slightly flatter than the existing river channel. The tunnel changes to open cut which decreases to a section 10 feet (3 m) deep in cut or cut and containing dike, and widens into a small lake 1825 feet (556 m) long of 16.3 acres (6.6 ha), within the original river bed beginning 2.6 miles (4.18 km) from the north end of the diversion. The grade of this section varies from 0.68 to 1.00%, except for a short pool and riffle created by some broken rock placed so as to regulate the level of the artificial lake.

Below the small lake in the existing channel bed the river enters a cut of generally 15' to 25' (4.6 to 7.6 m) deep on a 0.5% grade. The final 2600 feet (792 m) of the relocated channel is on a 2.5% grade, re-entering the original channel near the south end of the open pit. The side slopes of the excavated channel are 4:1, except near the outlet portal where there is a gradual transition to 2:1. Where the diversion channel is not in solid rock the channel will be lined with large riprap rock to a minimum thickness of 3 feet (0.9 m) below the stream grade, and extend up the side slopes to a height of 8 feet (2.4 m) above the channel grade level so that the water level at peak flow will not overtop the riprap.

The proposed tunnel has a capacity of about 4,200 cfs. (119 m³s). This capacity could be increased by increasing the head with a higher dam at the intake. However, the 100 year flow is projected at about 3,000 cfs. (85 m³s) so that the proposed 30 foot (9 m) dam appears quite adequate. Observations made along the river do not indicate flows over 3,000 cfs. (85 m³s)

Whether the tunnel would be bored, or blasted depends upon the availability of used boring equipment at the time of construction. Boring would probably be preferable due to the expected rock structure. Until detailed drilling to locate the most competent rock strata is undertaken comments about the tunnel must be conjectural. However, we would expect the tunnel to require concrete lining, and pre-cast baffles would have to be placed in the invert to reduce velocity along the invert to permit fish passage during high flows.

The channel diversion shown is moderately winding. When the detailed channel design to follow this conceptual layout is undertaken, the channel may be modified to include pools and riffles, etc., as may be deemed most aesthetic and suitable for fish habitat.

Haul road crossings of the proposed channel relocation require drainage structures. We have shown over-designed structures in relation to end area opening required for maximum water flow, with their base five feet (1.5 m) below the stream grade. A natural rock and gravel bed will therefore result, and the span is almost equal to the 50 ft. (15 m) channel width, so velocity increases will be moderate, and the riprap bed will provide reduced bed velocities for fish passage. The 25 ft. (7.6) rise by 38 ft. (11.6 m) span structures will resemble in appearance arch bridges more than culverts.

The southermost 2.1 miles (3.4 km) of the relocation channel can become the permanent channel, as it is still in the valley bottom, and can be constructed and landscaped in a natural manner, so that future relocating into the mined out area would be an unnecessary future disturbance.

The northernmost portion of the diversion, which includes the tunnel may be re-diverted back into the mined out area after about 22 years. Again, this section may be final designed in a more detailed manner. Due to the 550 foot (168 m) section of the backfilled area being constructed to 10% slopes, the river may be meandered laterally within 450 feet (137 m) without final slopes at the outside of the bends exceeding 2:1 or 26°.

9.2 Construction of Artificial Lakes

The excavation of the Elk River tunnel and diversion channel provide a substantial quantity of excavated rock and glacial till, and the first stages of mining prior to coal preparation provide much more material which must be disposed of. Within the first six years of mining a substantial portion of the existing swamp and pond environment is removed from the valley bottom. The diverted portion of the Elk River is also temporarily reduced in biological productive capacity.

For these reasons, and the desire to improve the environment and make maximum beneficial use of excavated waste materials we are proposing to dike a 98.5 acre (39.9 ha) section of flat land north of the proposed preparation plant site to provide a small lake capable of supporting fish and waterfowl. A small island of two acres (0.8 ha) is created for aesthetic reasons and for waterfowl nesting by building a depressed causeway to the location. This causeway is later submerged by the lake.

The initial mine dump on the west side of the valley will contain approximately 185 million cu. yds. (141.5 million m³) of waste rock and glacial till. The glacial till will be about 50 feet (15 m) deep on top of the dump. Considerable runoff water is diverted around this area during mining. We propose to build a depression of 31.5 acres (12.7 ha) into the dump, lined with compacted glacial till, to create a pond with slopes of about 10%, reaching 20 feet (6 m) deep, which may be filled with water by routing the final area drainage through it. This pond will be lined with the organic muskeg removed from the valley to provide a similar boggy environment around the shallow edges. Three hills 80 feet (24 m) high are proposed around

this pond to provide a natural setting for the pond and shelter for animals. Various types of forage and other vegetation will be planted on the slopes of the hills or within their shelter.

The southernmost portion of the mined out pit will fill with water, or can be filled at an accelerated rate by diverting part of the Elk River flow into it, thus creating a lake 4470 feet (1698 m) long and 3500 feet (1067 m) wide containing 448.6 acres (181.5 ha). The north end of the lake will have a substantial area only a few feet deep containing two islands and will warm sufficiently for swimming in midsummer. The lake steps down successively southward to a maximum depth of 395 feet (120 m). A connection is made between the Elk River and the lake where their levels are equal, to maintain the lake level.

9.3 Drainage Relocation

One of the earliest construction operations will be the relocation of waters draining into the initial west waste dump area. This is accomplished by collecting all streams into a drainage channel constructed along the route of the forestry road relocation west of all mining and dumping areas. The road rises to above elevation 5700 feet (1737 m). The waters diverted are clean, except for some temporary washing of channel slopes. Riprapping and ditch checks will be constructed along with slope seeding. This water is considered suitable for routing into Gardner Creek channel and thence into the artificial lake. The water will flow into or out of the lake through an equalization culvert connecting the north east corner of the lake with the relocated Elk River channel. The culvert

will have a 20 foot (6 m) span, because it will be partly submerged and therefore only the portion above the Elk River surface will serve to carry the flow from the lake and the area draining into the lake.

Of immediate requirement also is the northern portion of the Weary Creek diversion, which is diverted along the mountain slope in a canal partly in cut and partly diked. A maintenance road is constructed on top of the dike. During placement of the waste rock in the north fork of the original Weary Creek channel there will be some sediment from the dump run off entering the portion of Weary Creek crossing the valley floor to the original Elk River channel. Three small dams across the original Elk River channel will create three settling ponds to clarify the water before it enters the Elk River near the south end of the ultimate open pit.

After 20 years the Weary Creek diversion must be extended southward around the south limit of the open pit to enter the Elk River 0.4 miles (.64 km) downstream from the open pit. The north fork dump will have stabilized long before this so sediment will be confined to a small initial diversion channel slope washing which will be minimized by riprap, energy dissipating riprap structures on steep grades and slope seeding.

From the top of Little Weary Ridge northward to the north pit limit drainage is collected in a ditch constructed partly in cut and partly diked with a maintenance road along the dike. The drainage area is fairly limited. The seasonal runoff will be controlled with respect to scour by riprap, energy dissipating ditch checks on steep grades and slope seeding, and the water discharged into

the Elk River without a settling pond. The road along the top of the dike will serve as a low grade access to the Weary Creek Valley after completion of mining.

A string of swamps and ponds lie on the valley floor within the mining area from sta. 230 to sta. 320. These swamps appear to be at least 20 feet (6 m) deep in places. The valley floor can also be expected to contain aquifers under or within the glacial till. The slope of the rock below the swamps is favourable and a drain 30-45 feet deep to rock level will be of considerable benefit in making possible the excavation of the swamps, and also should be of benefit in dewatering the glacial till.

9.4 Settling Ponds and Mine Drainage

In conjunction with diking for the artificial lake north of the plant site will be dike construction for a settling pond to collect sediment from the large west initial waste dump. Water pumped from the northern end of the mine will also be collected here. The water will be discharged after clarifying, into the artificial lake over a spillway at the west end of the settling pond.

The dike for settling pond No. 1 becomes the north shore of the artificial lake, and has been shown as having a 10% slope so that a 300 foot band of trees may be planted here to provide a natural appearing shoreline. The dike will ultimately serve as a portion of the future final highway location through the mined out area.

From a suitable point east of this northernmost settling pond No. 1 a canal is constructed adjacent to the coal haul

road, in cut or primarily within a channel carried on an embankment, and extending southward to just south of the south limit of the open pit where a 50.5 acre (20.4 ha) settling pond No. 2 is constructed. The canal will be used to carry the balance of the water pumped from the mine. This canal is on a rather flat grade and will occasionally need some cleaning out of sediment deposits, to maintain its capacity.

The amount of water to be removed from the open pit is unknown, and future studies must examine this matter in some detail. It is sufficient to say that after initial discharge of trapped water, the recharging rate should be fairly low and the primary source of water to be removed from the mine will be from precipitation. Pumps will be sized appropriately and the number added to as the area of the open pit enlarges southward, because all water percolating through the mine backfill will find its way to the working area.

9.5 Tailings Ponds and Preparation Plant Fresh Water Return Pond

The first stage of tailings pond construction immediately south of the preparation plant has an area of 152.7 acres (61.8 ha) and a capacity for fine tailings and trapped winter ice of approximately 8 years to elevation 5200 (1585 m). The first stage dike will be constructed from mine waste, compacted impervious glacial till and mine waste rock.

Clean water will be pumped back from the south end of the tailings pond to a clean water storage pond located within the railway loop. From there it will be pumped as required to the preparation plant. A small amount of clean makeup

water will be drawn from the artificial lake located at the north end of the plant site.

The second stage of the tailings pond covers 336.8 acres (136.3 ha). The dike will be constructed with an impervious till section and waste rock from the oversize bin at the plant will be deposited in the dike while the first stage pond is being filled with tailings. There is sufficient coarse waste along with adding some slope protection rock, plus glacial till, to complete the second stage dike by the time the first stage pond is full. Since the haul distance back to the mine is greatest in the initial years, and the amount of coarse plant waste to dike is greater than the till portion, it is most economical to build the south tailings pond dike as quickly as plant waste supply allows, thereby delaying the coarse plant waste haul back to the mined out area as long as possible. Glacial till in smaller amounts than the coarse waste would then have to be hauled from the south end of the mining area to the pond dike.

Actually, the most economical rate of 2nd stage tailings pond construction is a matter for some study, as back-haul of waste to the mine while hauling till to the dike is a factor to be considered vs. much shorter plant reject haul to the pond dike and empty return to the till pit. Also, we hope that a revised mining concept (See section 10.0, Mine Planning and Operation) will reduce the amount of fine and coarse tailings, thus requiring smaller ponds and dikes and less backhaul to the mine. This is therefore a study to follow test mining analysis of the success in attempting relatively dilution free thin seam mining, and partings removal. Considering that there is

more than three times as much coarse waste as there is need for in the tailings pond dike, and considering the long haul for the dilution rock in one direction from the mine, and for the coarse plant reject in the other direction, back to the mine, there is a considerable economy to be realized here by selective clean mining.

Based on present dilution volumes the two tailings ponds shown have a capacity of 32 years at 4 million clean tons (3,629,000 tonnes) per year of plant output.

9.6 Preparation Plant Site Layout

The proposed plant site is situated on a small rise of glacial till to the west of the Elk River relocation channel, between sta. 206 and sta. 252, with the railway loop track immediately south of the plant site and north of the tailings pond. The railway embankment is actually a dike separating the tailings pond from the clean water return pond.

The actual plant facilities, thickener, driers, waste rock bin, shop, warehouse, change house and office are all located at \pm elevation 5205 (1586 m) on the west side of the site, with the blending bed area and ramp roads occupying a space of 3300 (1006 m) by 1000 feet (305 m) at elevation 5180 feet (1579 m) between the plant and the relocated Elk River. The coal storage silos are at elevation 5190 (1582 m) within the railway loop with the train loading facilities on the south segment of the railway loop at the edge of the tailings pond.

With the construction camp and parking area to the west

and the shop parking area to the east, the small 700' x 400' (213 m x 122 m) lake has been preserved. The office has been situated about 500 feet (152 m) south of the small lake with a view beyond it of the 98.5 acre (39.9 ha) lake further northeast, and looking over a treed area to the clean water return pond about 500 feet (152 m) south.

The area for unloading and storage of fuel and other materials is located on a spur truck to the southwest of the plant facilities at the base of the mountain slope.

The relocation highway from Elkford has a connecting road which enters the plant site at the office location with a branch which loops around the construction camp and back to the highway.

Drainage from the upper level of the plant site will be taken into the tailings pond. Drainage from the lower level and blending bed will be collected in a toe drain between the river and the blending bed and carried by a pipe across the river relocation and into the mine drainage ditch which empties into the south settling pond No. 2. Sewage and waste effluent from the shop will be handled with suitable treatment facilities.

9.7 Mine Haul Roads

One of the initially constructed facilities is the main coal haul road from the north end of the mine to the south tailings pond No. 2. This road is also connected to two branch roads which lead to the blending piles by 30 foot (9 m) high ramps to permit dumping coal in a level pile

from elevation 5210 (1588 m). This main road and most others are 100 feet (30.5 m) wide. Another major road needed from the outset is the road to the top of Weary Ridge. A good deal of this road is on a -10% grade loaded. Roads in general vary between a maximum of 8% and 10% grades depending upon what can be achieved. Hauling from the box cut benches to the mine backfill is via three 80 foot (24.4 m) wide bench roads in the west pit wall. The back slopes of these roads will be pre-sheared or line drilled with small diameter drills to minimize subsequent rock spalling.

Hauling waste from the reaches is via ramp and 100 foot wide road cut into the east pitslope which is the No. 2 seam footwall. Coal haul branch roads will connect with the reach levels and to main roads to the plant. Some of these can be seen on the plans illustrating some of the stages of the mining operation.

9.8 Highway and Railway Connections

The topographical information available for planning a highway location was a series of 1" = 1000 ft. scale plans. These were adequate for projecting a route and for plotting an approximate profile. Because the terrain is generally not steeply mountainous it was possible, even with the limited contour data, to project a route which will be very close to an acceptable final route such as can be determined with say 5 foot contours on 1" - 200 ft. (1:2400) scale plans. The route selected from Elkford to the mine site has maximum curvature of 3° with most curves of lesser degree. There are only a few short sections of 4% to 6% grade, otherwise grades are generally

considerably less.

Crest vertical curves have minimum sight distance of 600 ft. (183 m). We have used certain sections of the existing forestry road route where possible, but deviated a good deal to eliminate the steep grade and sharp curve sections of the forestry road.

The route shown can be constructed to safe modern highway standards, and considering the long term industrial use as well as the increasing public traffic to be expected, we recommend that this type of modern highway route from Elkford to the minesite be adopted. The distance from Elkford to the preparation plant site is 28 miles (45 km).

With reference to the highway profile grade and excavation quantities, we have performed a computer quantity takeoff and computer plotting of the resulting mass diagram. The quantities as balanced show a 2,316 foot (706 m) average haul. Had the contour data been accurate enough to warrant the work we could have modified the grade lines slightly, as they are generally below the ruling desirable 6% maximum, and reduced the average haul. When better contours are available, such modifications should reduce the average haul distances.

The combined railway and highway corridor intentionally intersects the gravel hillside 1.7 miles (2.74 km) north of Elkford, in order to obtain suitable fill for large stretches of embankments of both facilities to the north and south. The final alignment and grade of both facilities should be set here so as to balance the fill requirements to the north and south.

North from the preparation plant we have diverted the forestry road to the west of the initial waste dump. The road rises to elevation 5714 (1742 m) before dropping down to the Cadorna Creek crossing approximately 1.36 miles (2.19 km) upstream from its junction with the Elk River. The route then traverses a modest rise before crossing the Elk River 1.8 miles upstream from the north end of the open pit. At 0.7 miles north from the Elk River crossing it joins the existing Kan Elk power transmission line maintenance road.

Grades through this section reach 8% with maximum degree of curvature 8° . The length of the section from the preparation plant to the junction with the transmission line road is 5.60 miles.

At the time the Elk River is placed back into open channel, through the mined out area, the highway north of the preparation plant can also be placed back in the valley if desired. Drawing No. 1605 shows this route, using the section from the plant site past the artificial lake and across the dike separating settling pond No. 1 from the lake, which is built at the commencement of mining; and thence over the tunnel outlet portal. It crosses the mine backfill at elevation 5334 (1626 m) and the Cadorna Creek at a point 450 feet (137 m) downstream from the waterfall, joining the west road diversion just before crossing the Elk River. The route has the advantage of much better curvature and grades. Whether the road is placed back near the valley bottom will depend on what the route is used for, or planned for 22 years after the mine commences operation, or upon the desires of governing bodies to have an equal route to the one existing prior to mining.

South of Elkford we have not dealt with the highway, except for a length of about 1.1 miles (1.0 km) which must be revised to make room for the railway.

The proposed rail link from Sparwood was studied by INTERNATIONAL ENGINEERING COMPANY, a subsidiary of Morrison-Knudson Inc. Our terms of reference were to examine this route briefly and comment upon its acceptability. We have done this to a limited extent, and find that the route seems basically satisfactory. However, one of the conditions noted which can be altered, is the numerous crossings of the highway, or forestry road, both north and south of Elkford. The route we have shown combines the highway and railway routes in an acceptable corridor at several locations, and eliminates all highway-railway crossings between the junction with the Fording River railway and mine site. Even the crossing into the plant site has been eliminated as a result of moving the railway loop to the south of the plant.

One major relocation is recommended from mile 3.42 (km 5.5) to mile 17.42 (km 28.03) measured from the junction to the Fording River Railway (which we have added). The south portion of this relocation eliminates some highway crossings and places the railway lower in the valley. The length is reduced here by 1,000 feet (304 m), Grades are no worse, and adverse summit rises are less. Excavation and embankment quantities are also reduced.

The northern portion of this relocation results from the town of Elkford being built across the originally proposed route (Boivin Cr. by Elkford crossed at mile 15.56 (km 25.04). Here we recommended that the railway and highway be placed in a common corridor on the river flat,

passing around the eastern edge of Elkford, except for leaving a trailer camp and service station on the east side of the tracks. The route past the sewage treatment facilities must be about 50 feet (15 m) west of where we have shown it on our plan, which was drawn without benefit of the exact sewage treatment plant location.

The total length of the I.E. Co. route which has been revised is 20.96 miles (33.72 km). Our location reduces the length of the railway by 0.47 miles (0.77 km). The length to be constructed which is the distance from the junction with the Fording River Railway and the point where the loading loop re-joins the main line is 43.77 miles (70.43 km).

The final location and design of both the highway and railway require field study, including soils investigation, and the preparation of 1" - 200' (1:2400) scale contour mapping of the projected routes, where this is not presently available.

9.9 Hydrological

The absence of precipitation and runoff records in the upper Elk River area is a minor problem in hydrological analysis. However, the region does not appear to differ greatly from many other areas where records are available. Furthermore, observation of the streams on the site gives a good indication of flow to the experienced observer. Therefore, final sizing of drains, culverts and settling ponds, etc. is not a difficult matter.

For this conceptual study we have used accepted practice

in performing approximate calculations for sizing of drainage facilities, so that features shown are realistic. The final mining plan will provide more detailed data set out on the basis of accepted practice augmented by careful field study of existing conditions, and by obtaining some records of precipitation and runoff during the pre-mining period.

TABLE 5

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TABLE OF QUANTITIES RELATING TO EARTHWORKS OUTSIDE THE MINE

	<u>Cubic Yards</u>	<u>Cubic Metres</u>
1) Elk River Diversion Tunnel 22' excavation diameter Rock Excavation		
7,680' length	108,127	82,717
Concrete lining, portals and outfall	19,700	15,070
2) Elk River Diversion open channel Elk River Diversion rock riprap	940,000 225,000	719,100 172,125
3) Weary Creek relocation and main- tenance road	600,000	459,000
4) East Slope drainage relocation and maintenance road	405,000	309,825
5) West Slope Forestry Road and drainage relocation	700,000	535,500
6) Valley bottom initial drainage ditches	740,000	566,100
7) Plant site excavation	975,000	745,875
8) Plant site and blending bed embankment	1,550,000	1,185,750
9) Initial tailings pond dike	3,200,000	2,448,000
10) Initial tailings pond capacity	11,720,000	8,965,800
11) Second tailings pond dike	8,940,000	6,839,100
12) Second tailings pond capacity	30,650,000	23,447,250
13) Dikes around artificial lake and along Elk River relocation and island	2,040,000	1,560,600
14) Highway, Elkford to plant site	3,220,000	2,463,300
15) Railway, Fording Junction to mine site	*6,450,000	4,934,250

*This is the original I.E. Co. estimate. The final will be somewhat less, but is not altered pending more detailed work.

10.0 MINE PLANNING AND OPERATION

10.1 Development of the Mining Concept and Related Equipment Selection

The Elk River Coal deposit with its 22 mineable seam groups divided into 40 to 60 or more mineable members presents possibly a unique mining problem, at least in comparison to presently operating coal mines.

Upon analysis it becomes clear that the key element governing the selection of a mining method is quality control, due to the great variability in coal characteristics from seam to seam. The mining method must therefore be the one best able to provide for the blending of all seams from all concurrently active work areas, through a cycle time and volume consistent with reasonable blending bed size and requiring as short a time as possible in stockpile.

A relatively flat valley such as this is favorable for a dragline operation, until one examines the quality and coal recovery aspects. A previous study proposed draglines working 2,000 foot (610 m) sections at a time. This plan requires approximately 3.3 years and nearly 20 million tons (18,144,000 tonnes) of coal to complete one cycle through the seams, and therefore quality control is totally absent and the plant output would range gradually between the extremes of excess cokability and extremely deficient cokability. It also presented problems in mining small coal seams. Further, it proposed a very major relocation of the Elk River in terms of both length and elevation changes. For these reasons it

was ruled out.

The second element of importance is the fact that higher volatile coals in large part lie beneath the Elk River, but are essential to produce a quality coking coal.

Third, is the large number of seams, many thin members with associated partings, and the problems involved in separating this coal from the rock.

Fourth, is the very adverse effect of dilution on the clean coal recovery through the preparation plant.

Fifth, the high rate of production proposed requires a large working area.

Sixth, the frequent change from rock to coal across a bench requires a great deal of moving of equipment for blasting and switching from rock to coal excavation.

Seventh, the 40° incline of the coal seams places much rock and coal out of reach of conventional mining equipment working at the bench level.

Eighth, the thin seams of coal lying at 40° cannot be dozed down the face of a conventional shovel bench height, and they cannot be excavated from above by dragline or backhoe because scheduling requires that the drilling must proceed and these machines and trucks cannot work on top of a drilled area.

Ninth, the mining method must permit uncomplicated coal hauling and drilling access ramp systems to all benches at all times.

Tenth, the method should permit backfilling the valley excavation with a minimum of lifting of waste rock.

Eleventh, the valley slope material must be removed in advance of the valley floor excavation.

It was readily apparent that each seam must be intersected frequently and as concurrently as possible to provide blending within desirable time limits. Accordingly the 8 bench pattern with 500 feet (152.4 m) of width to each bench, and each bench projecting across the entire group of seams, and with a continuous access ramp intersecting all benches at each end of the benches, was chosen. Mining will proceed successively across each bench with each face advancing eastward about 400 feet (122 m) in advance of the next lower bench face. As excavation of rock following a blast is completed along the 500 feet (152.4 m) of width parallel to the strike of the seams, the rock excavation equipment interchanges with coal excavation equipment from an adjacent bench. Blasting again follows the coal excavation and the rock loading cycle is repeated. A complication of this procedure is that some rock seams are too thin for large excavating equipment, or for large rotary drilling equipment, and smaller drilling and excavating units must be interjected into the cycle with obvious complications for the large excavating equipment scheduling.

Analysis of the distribution of coal in the terrain indicates that it necessary to commence mining at the north end of the proposed pit, which is $\frac{1}{4}$ mile (400 m) south of the confluence of the Elk River and Cadorna Creek. At the same time the volume of low volatile coal, and the need to remove this high level material in

front of the advancing 8 bench valley box cut, requires early commencement of excavation at the top of the Little Weary Ridge.

Analysis of the distribution of low and high volatile coals shows that by mining Little Weary Ridge down to a level of 800 feet (244 m) above the pit bottom, plus one 2500 foot (762 m) "reach" immediately in advance of the box cut, while the box cut advances south until no more material must be placed outside the box cut, results in a ratio of low and high volatile coals which is exactly the same as the mine average of 60% low to 40% higher volatile coals, during the approximately 6 years required to reach this stage.

From this point 2500 foot (762 m) "reaches" are mined concurrently with a 2500 foot (762 m) advance of the box cut so that the reaches are always completed just ahead of the advancing box cut face. The excavated waste rock from the box cut is all placed back into the mine after 6 years, (34 million cu. yds. (26,010,000 cm) is also placed back in the mine within the latter part of the first 6 years) and the reach waste is placed on top of the box cut waste. Of this, material from +500 (152.4 m) above the pit bottom to +800 (244 m) is placed at the east side of the valley by utilizing ramps from each reach to a continuous hauling bench 100 feet (30.5 m) wide excavated into the footwall of No. 2 seam. The slope of this bench is excavated parallel to the bedding planes of the footwall sandstone, and in the process the troublesome No. 1 seam located within the footwall sandstone is removed, creating a more stable highwall.

Material from the +400 (122 m) to +500 (152.4 m) foot level is hauled west around the south end of the box cut and placed on top of the west side of the filled in box cut dump. In the north portion of the pit this is done in such a manner that a valley and river channel are created to permit the river to be placed back into open channel. Glacial till and topsoil are always excavated from the valley floor just in front of the advancing box cut, and placed on top of the advancing final pit backfill.

The first 6 years see completion of spoiling from Weary Ridge into the north fork of the Weary Creek Valley, After approximately 20 years the Weary Creek must be diverted from its present bed crossing the Elk Valley. southward around the south end of the mine, ahead of the box cut advance. After this, the mining of the north end of the Big Weary Ridge above +800 (244 m) is deposited in the valley of the south fork of Weary Creek, and "reach" and valley box cut mining continue in sequence to the southern limit of the mine.

When our mining concept was first established we commenced development details based on employing 25 cu. yd. (19.1 cm) electric shovels operating on 50 foot (15.2 m) high benches. The large shovels were required to obtain the required output within the work area of 8 - 500 foot (152.4 m) wide benches plus Weary Ridge work area, while also considering the number of working locations available, and the amount of moving required.

The amount of moving and scheduling problems resulting in only 55% of normal output from these shovels, and many other factors which we will describe, made us look for an alternate method of mining which would be more mobile

and flexible, and would also solve a number of other problems relating to the shovel approach.

We now conclude that the shovel should be set aside in favor of a 24 cu. yd. (18.4 m^3) front-end loader and 11.5 cu. yd. (8.8 m^3) hydraulic shovel method, with the electric drills on crawlers also replaced by 70,000 lb. (31,746 kg) pressure 10 5/8" (270 mm) rotary drills on rubber tires. Hauling would still be done by 170 ton (154.2 tonnes) electric rear dump trucks. Some small drills would still be employed in the 3" to 5" (76-127 mm) crawler air trac percussion type for drilling partings and pit slopes but mostly the smaller drills would also be rubber mounted.

The reasons for recommending the change of equipment are as follows:

1. Mobility. The electric shovels would have to walk nearly 200 miles (320 km) per year, trailing electric cables, moving each time a new coal face is exposed, and moving off three benches adjacent to each blast. There are approximately 1172 loading positions per year. Some loading positions require only a few hours of work, others at most a few days. You may find yourself scheduling coal loading in a 30 foot (9m) seam which must be removed while a shovel does 5 hours on the next bench before requiring the position occupied by the coal loading equipment on the 30 foot (9m) face which normally would require 10 times the time to remove. Next you might have 5 alternating coal and parting members to remove before

a shovel could return to that particular working face, yet only a few hours might be required for the shovel to complete its task elsewhere.

Scheduling relatively unmobile equipment to meet the infinitely varying time requirements therefore is not going to work out in practice, and the project manager will begin eliminating thin coal seam mining and also begin mining partings with coal in order to simplify his scheduling till it is workable. This results in lost coal in the mine, and reduced output in the preparation plant, with considerable financial implications.

On the other hand, mobile large front-end loaders which have recently become available, and which will continue to be improved and enlarged prior to this project commencing, can move quickly between sites, and can be doubled and quadrupled at any available working bench, by tandem loading, so that 2.5 times the production of a 25 cu. yd. (19.1 m) shovel may be obtained at a single available working face if necessary.

If rock is in short supply, the loaders move to glacial till within minutes, until the rock scheduling is corrected. The loaders are preferable in till material in any case due to frequent load bearing problems for heavy shovels.

2. Truck Utilization, Much idle truck time with consequent high unproductive wage costs are largely eliminated by having loaders which can move as quickly as the trucks.

3. The same loaders will load coal as will load rock in the thicker coal seams, eliminating some moving.
4. Cleanup dozing at the face is mostly eliminated by using loaders, with some considerable costs eliminated.
5. It is not practical to go to 25 foot (7.6 m) benches with large shovels, as even 50 foot (15.2 m) benches requires too much moving. Therefore in working 50 foot (15.2 m) benches a lot of rock is out of reach of the shovels due to the 40° slope of the coal seams. It would require 10 - D9 dozers with rippers to feed the inaccessible rock to the shovels.
6. When thin partings of rock are encountered, the dozers cannot sit on the narrow width and must "yo-yo" the rock down to the loading bench. 40° "yo-yo" causes lubricating problems.
7. The feeding of rock from the coal seams by dozer results in additional mining losses and dilution of the coal with rock.
8. Dozing coal results in degradation which reduces preparation plant yield.
9. By being able to mine 25 foot (7.6 m) benches with front end loaders nearly all the rock can be reached by the 24 cu. yd. (18.4 cm) unit. A thin layer will be left on the coal for removal by hydraulic shovels with long reach

which have very precise bucket control and can reach every yard of material from the bench level, thus completely eliminating all rock and coal dozing. Furthermore these machines with precise control and the ability to excavate up a plane surface at any angle, can carefully and accurately remove successively rock, coal and thin partings with little mining loss and little dilution.

We believe that even conservatively speaking, this mining method will increase the clean coal output by 10% per year over the shovel concept.

10. Eliminating of difficult coal dozing cuts the cost of coal loading to about half of that necessary with the shovel concept.
11. The amount of dilution rock hauled to the plant and the amount of plant reject hauled back to the mine, or to the tailings dike is substantially reduced.
12. The size of the tailings ponds and dikes can be reduced if dilution is reduced.
13. The size of the blending bed is cut in half as the full cycle through all seams for 25 foot (7.6 m) benches is half that for 50 foot (15.2 m) benches. Therefore one cycle is approximately 500,000 s.t. (453,600 tonnes) instead of 1,000,000 s.t. (907,200 tonnes).

14. Electric power distribution costs are eliminated. On the other hand, figured by itself, diesel power is more expensive.
15. Capital cost of equipment is much less, using the loader concept.
16. Finally, analysis of the initial 6 operating years shows a stripping ratio of 8.37:1 ($7.06 \text{ m}^3/\text{tonne}$) compared to a mine average of 6.42:1 ($5.51 \text{ m}^3/\text{tonne}$) and the cumulative ratio in the first years is even much higher. The ability to be flexible and work in a complex development scheme is beyond the shovel capability because of lack of mobility and less ability to "double-up" in available working sites. However, the loaders can handle a more complicated mining plan. Accordingly, we have proposed to study the initial pit operation with a view to improving the financial position in the first few years by delaying some overburden removal and by at the same time obtaining sufficient coal to satisfy plant needs. A great many costs are fixed, and it is therefore most important to generate maximum revenue from the outset.

10.2 Operating Factors

This project requires a considerable number of 170 ton (154.2 tonnes) trucks partly because the working area required for mining the complex structure effectively is quite extensive. Consequently, the amount of material lifted out of the mine to outside dumps initially is large, being 253,000,000 cu. yd. (193,545,000 m³). In order to backfill the mine with minimum lift the average slope of the waste backfill must be fairly flat. The result of these two factors is a fairly long haul from the mining area to the backfill area, especially for the material from the reaches.

The average haul for waste rock during the initial 6 years while we are mining the top of Little Weary Ridge and opening up the initial box cut in the valley floor is 1.77 miles (2.85 km) with a lift of 360 feet (110 m). The average for the whole project is 1.95 miles (3.14 km) with a lesser lift of 200 feet (61 m). Converting the haul and lift to equivalent level haul we find that truck requirements for rock removal, based on haul only are about 95% of the initial requirement as a mine average. Therefore it is the higher stripping ratio of 8.37 cu.yd./st. (7.06 m³/tonne) during the initial 6 years vs. 6.42 cu.yd./s.t.(5.41 m³/tonne) for the project average which makes a requirement for more rock trucks during the first 6 years.

For coal hauling to the preparation plant, including dilution rock, the initial 6 year average haul is 2.23 miles (3.59 km) with a lift of 285 feet (87 m). These numbers do not consider the downhill hauls which are treated as zero lift. The project average haul for coal

is 2.17 miles (3.49 km) with a 228 foot (69.5 m) lift. It is planned to analyse the initial pit to maximize coal output and minimize initial excavation using a modified plan with mobile equipment. This analysis will result in more detailed haulage cycle calculations than have been done to date, and numbers arising from that work will supercede those listed above.

Based on the above initial hauling requirements the number of 170 ton (154.2 tonnes) trucks for both rock and coal hauling is 46 at 100% mechanical availability and normal operating efficiency, working 5796 hours per year. The requirement is therefore on the average 55 trucks at 80% mechanical availability, with normal operating efficiency. However, the probability, at a 95% level, of having 46 trucks on the line with 80% mechanical availability, requires a fleet of 64 trucks, since the average mechanical availability of 80% is not constant, but varies up or down considerably on a day to day basis. If the average hauls could be varied from day to day, and the number of loaders raised and lowered with the varying truck fleet the 55 trucks might be nearly adequate.

However, this project with its exacting quality requirements and complicated scheduling does not need the added factor of truck number fluctuations requiring undesired haulage pattern modifications. Therefore the 64 trucks are needed, 55 for rock and 9 for coal on the average.

After 6 years the truck requirements are reduced from 64 to 50. The truck productivity ranges from 109 to 153 bank cu. yds. (83 - 117 m³) per hour, on average conditions for the major hauls, and types of loading units employed. No special coal trucks are provided. 86% of the trucks

are needed for rock hauling. Also the 170 ton (154.2 tonne) rock box size is sufficient in height for the loaders. A 170 ton (154.2 tonne) coal box could not be entirely loaded. Loading equipment will frequently change between rock and coal at the same face. For these reasons two types of trucks would be difficult to schedule. Lower loaded tire pressure on the coal stockpiles is an advantage arising from under-loaded coal trucks.

Loading of the trucks is by 24 cu. yd. (18.4 m^3) front end loader. These units have put out 2,500 tons (2268 tonne) per hour in rock excavation. We are rating them at 1,574 tons (1428 tonnes) per hour, or 700 bank cu. yds. (535 b m^3) per hour, with net operating hours per year, based on 70% mechanical availability of 5071 hours. Annual rating is therefore 3,550,000 b.c.y. ($2,715,750 \text{ b m}^3$) per loader. The number of 24 cu. yd. (18.4 m^3) loaders required during the first 6 years is 12, and after that 10.

A very important machine in this operation is the 11.5 cu. yd. (8.8 m^3) hydraulic shovel. This machine is expected to load 59% of the coal or 2,836,000 cu. yds. ($2,169,540 \text{ m}^3$) per year, being the portion in thinner seams. It will also load 722,000 cu yds. ($552,330 \text{ m}^3$) of dilution rock to the plant, based on our reserve calculations. We actually expect this quantity can be substantially reduced as going to the plant, but the material will then be loaded to the dump. 2,925,000 cu.yds. ($2,237,625 \text{ m}^3$) is also scheduled for hydraulic shovels as rock excavation to the dump. Total excavation per year by these units is therefore 6,483,000 cu. yds. ($4,959,495 \text{ m}^3$).

We expect the hydraulic shovels at 80% mechanical availability and considering lost time during moving, to work 5646 hours per year. Productivity is estimated at 394 b.c.y. (301 b m^3) per hour, or 887 tons (805 tonnes) per hour loading rock and 481 s.t. (436 tonnes) per hour loading coal. Annual productivity is 2,225,000 cu. yds. ($1,702,125 \text{ m}^3$). 3 - 11.5 cu. yds. (8.8 m^3) hydraulic shovels are required.

Some coal may be obtained from the pit bottom by large hydraulic backhoe, probably yielding 6 million washed tons (4,590,000 tonnes) of coal over the mine life. We have deliberately excluded this coal from our reserve calculations, as a contingency against possible unforeseen variations in the seam quality, especially as related to thinner coal seams.

In all coal mines the large rotary drill maintains low drilling costs and is capable of high output in cubic yards drilled per year. However, in this mine with many sloping coal seams close together, the partial bench depth holes necessary due to sloping coal below requires that these holes be drilled to the coal and then stemmed short of the coal, thus losing the normal benefit of sub-grade drill hole explosive capacity, with resulting burden reduction to maintain proper burden depth ratio, and consequent reduction in drilling yield in cu. yd. per foot of drilling. The sloping seams require an angle hole following each coal seam removal. To reach and excavate the coal effectively it is necessary to drill 25 foot (7.6 m) benches. The results of these factors is a yield per lin. foot of 10-5/8" (270 mm) inch hole of only 8.9 b.c.y. ($22.34 \text{ b m}^3/\text{lin. metre}$). Drilling production in these relatively soft rocks is estimated

at 50 lin. ft. (15.24 m) per hour, for 2,579,000 b.c.y. (1,972,935 b m³) drilled per year, per drill.

Mobility is important as mentioned previously so we are proposing that a 70,000 lb. (31,746 kg) down pressure rubber tired truck mounted drill be used. Fifteen of these units are required during the first 6 years and 12 thereafter.

A number of partings are too thin for large rotary drills. These will be handled by 3-3 inch (76 mm) drills and two 4-5 inch size (102 - 127 mm) drills, one 3 inch (76 mm) and 1-5 inch (127 mm) being crawler mounted, the balance on rubber tires. Drilling of 1,390,000 cu. yds. (1,063,340 m³) per year of partings is required plus line drilling of road slopes in the pitwall. Drilling of partings is parallel to the dip. As a result of the thin sections frequently being drilled and the line drilling, the net drilling output is an amazingly low 1.16 cu. yds. per lin. ft. (2.91 m³/lin. m).

The amount of drilling equipment and the low yields indicate extremely expensive drilling and blasting on this project, as compared to the usual conditions encountered.

Road maintenance is of great importance to the success of this operation. We have not shown a crusher at the Bradford Breaker site, believing that selected sandstone at the pit should be crushed with mobile equipment to obtain superior quality surfacing material. Gravel beds from the river areas of the site should be saved, crushed, and blended with the crushed rock to obtain optimum dense graded mixes for surfacing. Winter sanding material on the

other hand should be crushed and the fines removed for most effective "sanding", which actually will use a 1½ inch to 3/8 inch (38 mm - 9.5 mm) grading for truck roads, with CaCl₂ as compared to the much finer material for highway use.

The major factor in good trucking roads and consequent reduced truck maintenance is the use of adequate crushed gravel, especially where the rock is soft and breaks down rapidly. This assumes intelligent construction of the road subgrades, free of deleterious materials, and properly compacted. Four Caterpillar No. 16 graders will be required on the roads. An 8,000 gallon (36,331 litre) Caterpillar water wagon is also essential for dust control, along with use of CaCl₂ on permanent roads. A silo for CaCl₂ will be provided at the unloading site.

10.3 Slope and Foundation Stability and Waste Dump Construction

A geotechnical report by Golder and Brawner, dated September, 1971 indicates that the footwall of the No. 2 seam should be stable to the mining heights planned. Our mining plan removes a 100 foot (30.5 m) wide bench in this footwall for 900 feet (274 m) down from the top of Little Weary Ridge, thus making the overall condition more stable than the condition which was used as the basis for calculations in the Golder - Brawner report. This is especially true as it removes the weak plane resulting from the No. 1 coal seam down to this level, a condition which was causing Golder - Brawner some concern.

Horizontal drains in the slope below the +700 (213 m) level hauling bench should relieve hydrostatic pressure

adequately, since the slope of the No. 2 footwall is being exposed gradually in 25 foot (7.6 m) lifts. The drains would be drilled and installed from the working benches. The amount of water in the lower reaches of the slope, especially related to No. 1 coal seam, should be checked during the future drilling program, and the vertical interval at which the drains are required to drain the slope above before the undrained height becomes unsafe, should be determined from this testing.

Water from the horizontal drains can be collected in an attached pipe and discharged at openings well north of the current working benches, where during the winter it will run under the snow and into the waste pile. It will reappear in the pumping sumps at the toe of the advancing dumps along with other seepage water and be pumped out of the mine.

Vertical pipes must be drilled into the slope at about 100 foot (30 m) vertical intervals and 15 foot (4.6 m) high steel mesh snow fence installed to prevent avalanche buildup down the ultimate slope height of 1600 feet (488 m). One would have hoped that a slope exposed to the prevailing winds such as this would have some tendency to blow clear but based on field observations it does not appear that this will be the case.

The pit wall above the +700 (213 m) road level will be created by fairly wide spaced holes drilled deeper than the average. The 11.5 cu. yd. (8.8 m³) hydraulic shovels will excavate these craters and backfill them with soil

hauled to the site up the coal haul roads, or obtained from the current outside face slopes where available. Intermediate holes will be drilled a few feet deeper than necessary and the bottoms filled with drill cuttings. These unshot holes will provide water traps to provide water for trees or shrubs planted in them. Large trees can be expected to grow in the large craters and smaller trees or shrubs in the small craters. Initial grass planting in the soil filled craters will spread over the rock crevices as the trees develop and protect the face. The snow fences will minimize snow sliding damage to the developing trees. Should the snow fence method still not be effective, (l. ref.) a snow retention method used in an area in Rogers Pass would be completely effective here, but would probably be somewhat more expensive than the snow fences.

Cratering of the No. 2 footwall, which is the east pit slope below the +700 level (213 m) road will be accomplished in a different manner than above the +700 (213 m) level road. Here vertical holes will be drilled with a 5 inch (127 mm) percussion drill after removal of the coal from every third 25 foot (7.6 m) bench and small craters will be produced and backfill with soil. We do not want to put many holes in the footwall slab above the No. 1 coal seam for stability reasons, so vegetation placed on this portion of the slope will be less dense.

The Golder-Brawner report was received after our pit end and west slopes were set. The report indicates that the north and south end slope design is stable as presented. The overall west slope is also stable. However, the

Golder-Brawner calculations indicate that the 120 foot (36.6 m) high slopes between the 80 foot (24.4 m) wide haul road benches would be better if 2 or 3° flatter than we have designed. We realized that the design slope between benches was steep and accordingly included small diameter line drilling of this slope to minimize spalling. Considering the 2° - 3° variance from the recommended it may be that the slope between benches will require slight modification during final mine design analysis.

With respect to the till overburden slope over 100 feet (30.5 m) high at the north end of the pit, we should find out what the water conditions are across the width of the valley at sta. 370 prior to finalizing this slope design. The incline is presently set at 2:1 which should be stable. The toe of the slope for an unknown height will likely have to be excavated and backfilled with shot rock within hours progressively across the lower face, to prevent sloughing below the water table. This method is very effective and inexpensive and has been used on till slopes of similar and greater heights with 100% success for similar conditions in the Rocky and Selkirk Mountain areas. This method has consistently been more effective than horizontal drains in till.

Waste dumps outside the pit limit on the east slope and the southern end in particular of the west dump are on a glacial till foundation and these foundations must be checked to determine the load bearing capability. The dumps will be constructed in lifts from the bottom up, and monitoring of the pressure buildup can prevent failures until consolidation allows the addition of further load. We have the latitude to reduce the amount of material on the east slope and increase the height of the northern

and central portions of the west dump, and the southern end of the west dump can be stepped back if necessary. Therefore waste disposal outside the pit is not considered to be a problem, provided that advance foundation study is done, so that the final dumps can be planned accordingly prior to dump construction.

Reclamation is covered primarily in the environmental section of this report. Only a few more comments will therefore be made in this section as being closely related to engineering and mining aspects.

Some mines present very severe problems in the disposal of waste rock to stable and reclamable slopes. Those particularly difficult in this respect are the ones where mining is from the top of high peaks which are gradually levelled and the waste dumped from many hundreds of feet above the base of the waste dump.

While this mine has many difficult features which increase the cost of mining, it is reasonably favourable with respect to satisfactory disposal of waste in an environmentally desirable manner. This is because most of the waste dumps, due to the relative location of where rock must be excavated and where it must be dumped, are automatically in this dumping process built in lifts from the bottom up. This very factor, however, produces high haulage costs due to abnormally high average lift of waste materials, compared to other western coal mines, although not so high in relation to the average open pit copper mine, for example.

A further favourable condition is the large amount of

glacial till and organic swamp material available. This material is stripped ahead of the mining and placed on top of the advancing waste dumps, or used in special features, such as the relocated swamp and pond on the initial western waste dump. Consequently, the rock dumps are covered by till, and being built from the bottom up in most cases, can be built to a desirable slope angle favourable to revegetation.

Most of the glacial till will be loaded with 24 cy. (18.4 m³) front end loaders and hauled with 170 ton (154.2 tonne) trucks, but a few scrapers would likely be an asset, and also a large grader such as a Ray Go Giant, for levelling the surface of the large spoil areas. Details of the requirements for and amount of this type of equipment must still be calculated.

10.4 Manpower Requirements

During the initial 6 years of operation the mine and preparation plant, including all classes of supervisory, maintenance and operating personnel, are expected to employ on site approximately 1100 people.

Planning to date has not included the study of personnel requirements for accommodation and amenities. The present townsite space at Elkford is very nearly used up, and expansion for at least another 600 people must take place on a bench 1 - 2.5 miles (1.6 - 4 km) to the south. This bench is probably not adequate in space, but the addition of another moderately sloping area in the mouth of the Boivin Creek valley at Elev. 4500 - 4600 (1372 - 1402 m) should make up the deficiency. The alternative area

would be two large benches on a fan 2.5 miles (4 km) to the north. That area appears to offer similar or greater space on terrain a little less irregular, although further away.

TABLE 6LIST OF MAJOR EQUIPMENT ITEMS

170 Ton electric drive trucks	64
Rubber tire mounted 70,000 lb. - 10 5/8 rotary drills	15
Crawler mounted air trac drill 3"	1
Rubber Tire mounted air trac type mobile drills 3" - 5"	4
Front End Loaders 24 cu. yd.	12
Hydraulic Shovels 11.5 cu. yd.	3
Front End Loaders 6 cu. yd.	6
Rubber Tired Dozers Cat 834	2
Dozers Cat D9	12
Graders Cat 16	4
Grader Ray Go Giant	1
Scrapers Cat 657	3
Compactors 835 F	2
8000 Gallon Water Tanker	1
Maintenance, service supply, transport equipment and facilities.	

11.0 DEVELOPMENT SCHEDULE

The following time-schedule for the project is anticipated:

Middle 1975 to Middle 1976	Prefeasibility-Studies including additional exploration and test work,
Middle 1976 to Early 1978	Feasibility - Study and Mine Planning,
Early 1978	Arrangements for project financing, Decision to put the mine into production,
Early 1978 to Early 1979	Completion of mine planning, calling and evaluation of tenders, issuing purchase orders,
1979 to 1981	Construction and mine development,
Middle 1981	Commence coal production
1982	Minimum coal production 2 million s.t. clean coal
1983 - 1984	Coal production 3 million s.t. clean coal per year
1985	Coal production 4 million s.t. clean coal

1.0 INTRODUCTION

The East Kootenay Region (Map 1), located in the extreme southeastern part of British Columbia, has been historically an area for coal mining activity. Much of the early mining was underground and quantities were small. Adverse effects to environmental and recreation values that typify coal extraction by open-pit methods were relatively few. Both underground and open-pit mining have been viewed as conflicting with concerns for big game production, forestry and recreation. However, the open-pit mining and environmental planning concepts presented here are believed to represent the best possible conservation approach to energy resource development and ecosystem protection and enhancement at the Elk River site.

The Elk River originating in Upper and Lower Elk Lakes, flows south between two mountain ranges and through the property to Elkford and Sparwood. It then continues southwest to join the Kootenay River near the Canada-United States border.

The project site lies within the glaciated valley at an elevation range of approximately 5,000 ft. (1,524 m.) to 7,000 ft. (2,134 m.), with adjacent mountains extending to 9,000 ft. (2,743 m.) (Photograph P-1). The topography of the area is expected to produce significant variability of climate, soils and related vegetation over small geographical distances.

An evaluation of the resources in the study area is given in the synoptic Land Capability Analysis Map (East Kootenay region) conducted by the CANADA LAND INVENTORY. This inventory indicates the uniqueness and importance of the big game and recreational capability in the area. "Moderate big

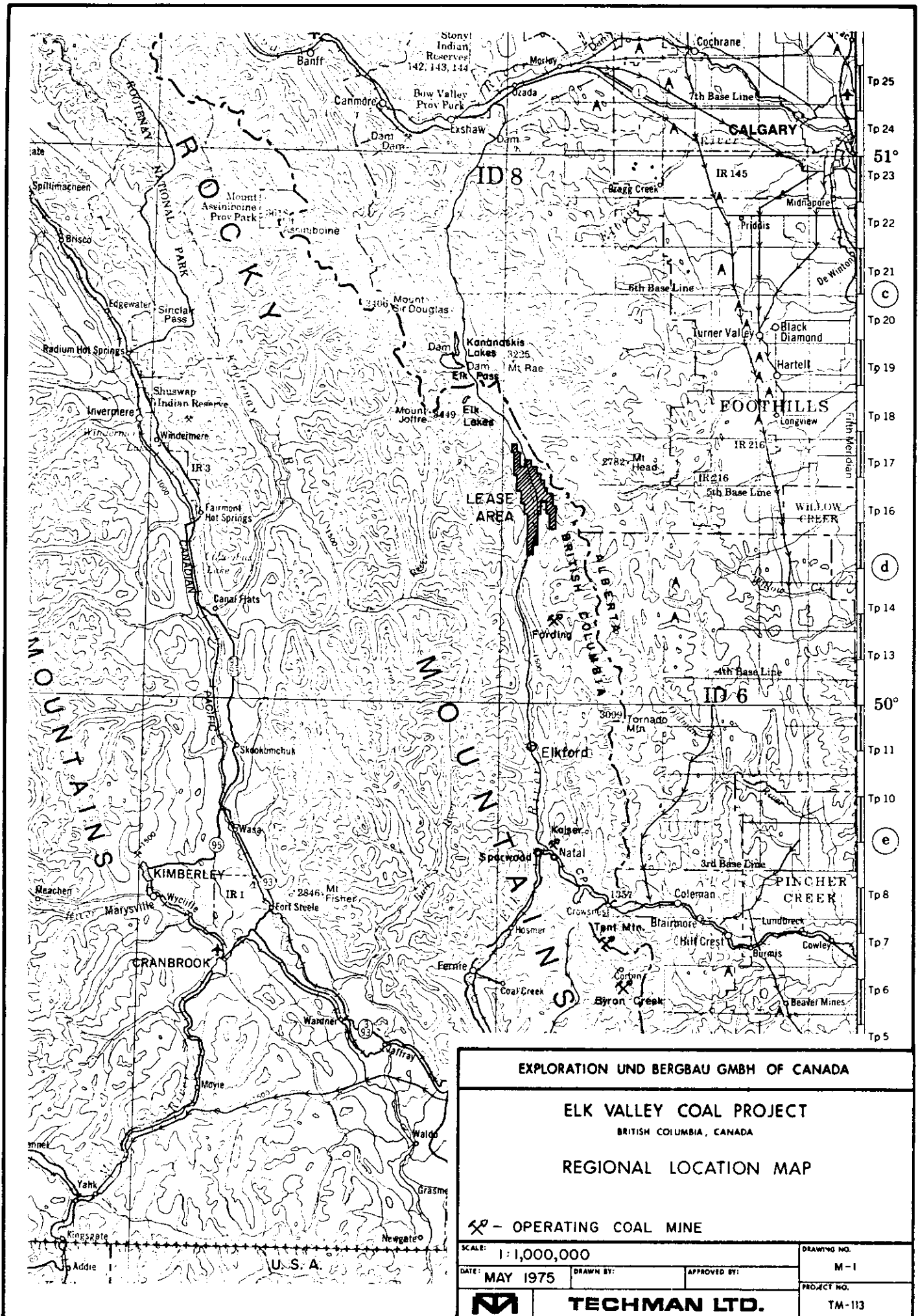
game range" occupies 19% of the project area; other big game ranges are classified as "high" or "moderate yield forest" land. Recreational values in this area are associated with scenic river valleys, uplands and mountains; thus, "moderate recreation" (10%) and "extensive recreation" (5%) are important use potentials of the project area. Forestry rates high in local importance, but is of relatively low value when compared to production at the provincial level. Forestry forms the largest single resource block - 58% of the project site - in the following groups: high yield forest, 23%; moderate yield forest, 21%; and limited yield forest, 14%. The remaining 8% of the project area has been classified as "highland" which has capabilities for big game range, primarily summer range, and extensive recreational activities (Map M3).

A viable mine operation will require diversion of the Elk River channel at the proposed minesite, and clearing and recontouring of the landscape. These environmental changes will result from pit operations, construction of the plant site and transportation systems, and accumulation of overburden and plant waste material. The mining concept presented here is an alternative to the original project advanced for mining of coal in the project area. The new alternative entails a mining approach and environmental planning concepts which decrease the diversion of the Elk River to 4.2 miles (6.8 km.) Moreover, the valley conditions of the study area and the mitigating concepts proposed will avoid the problems encountered in other pit-mining locations in less favourable topography.

Impact considerations, mitigation features, and reclamation techniques presented here as preliminary environmental planning concepts are related to the existing minesite environment,

mining concepts and to a limited degree, the regional ecology and social fabric of the East Kootenay Region. Considerably more work remains to be done in actual feasibility studies to validate these concepts in terms of both technical and economic feasibility and social acceptance. Community interaction, especially with local and provincial planners and resource managers, will be emphasized in these feasibility studies.

The conceptual planning presented in this report is based largely on several government reports and especially a series of baseline surveys conducted in the study area by B.C. RESEARCH for Emkay-Scurry in 1972 (Selected References).



EXPLORATION UND BERGBAU GMBH OF CANADA

ELK VALLEY COAL PROJECT
BRITISH COLUMBIA, CANADA

REGIONAL LOCATION MAP

⚡ - OPERATING COAL MINE

SCALE: 1:1,000,000		DRAWING NO. M-1	
DATE: MAY 1975	DRAWN BY:	APPROVED BY:	PROJECT NO. TM-113
TECHMAN LTD.			

PROPOSED
PIT AREA

PROPOSED
NORTHEAST
DUMP AREA

LITTLE
WEARY RIDGE

PROPOSED
NORTHWEST
DUMP AREA

PROPOSED
WEARY
DUMP AREA

BLEASDELL
CREEK


WEARY
CREEK

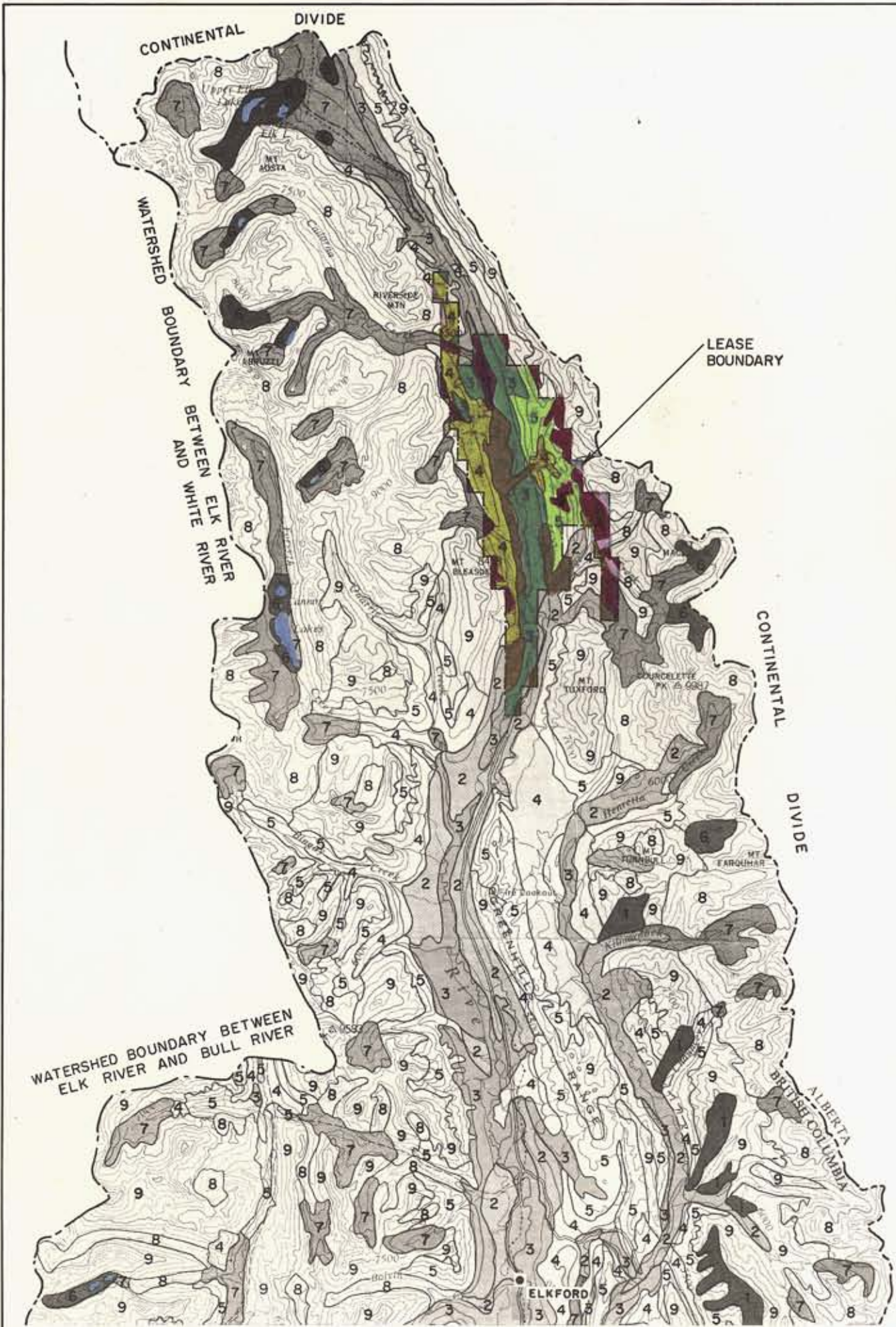


EXISTING
FORESTRY
ROAD

PROPOSED
PREP. PLANT
SITE

ELK
RIVER

ELCO MINING LTD.			
ELK RIVER COAL PROJECT BRITISH COLUMBIA, CANADA			
ELK RIVER STUDY AREA			
SCALE:			Drawing No.
DATE:	DRAWN BY:	APPROVED BY:	PROJECT NO.
MAY 1975			TM - 113
 TECHMAN LTD.			



LEGEND

BIG GAME

1 PRIME BIG GAME RANGE
These lands are important winter concentration ranges for ungulates (deer, moose, sheep and goat) that summer over a widespread area. These wintering areas also have capabilities for summer production.

2 MODERATE BIG GAME RANGE
These lands have slight limitations to the production of ungulates but are important year-round or seasonal use areas.

FORESTRY

3 HIGH YIELD FOREST
Productivity ranges from 71 to 130 cubic feet per acre per year for main commercial species.

4 MODERATE YIELD FOREST
Productivity ranges from 51 to 70 cubic feet per acre per year for main commercial species.

5 LIMITED YIELD FOREST
Productivity ranges from 31 to 50 cubic feet per acre per year for main commercial species. Large units of this class would be required to sustain a viable industry.

RECREATION

6 QUALITY RECREATION
Sites and units with capability for intensive recreation use. Includes historic and view sites, natural phenomena, ski areas and man-made attractions of National or Provincial significance as well as shoreline features of regional significance for bathing, camping, boating and cottaging.

7 MODERATE RECREATION
Important upland areas containing streamside camping sites or units offering a full range of extensive recreation activities of high quality. These areas may be used casually or intermittently for important single activities.

8 EXTENSIVE RECREATION
Generally large units with capability for a limited range of extensive recreation pursuits and small site specific attractions with limitations of climate or topography.

SPECIAL CATEGORY

9 HIGHLAND
This is high elevation land with capabilities for both Big Game and Recreation. For Big Game it contains excellent summering areas for many species as well as escape terrain and wintering ranges for mountain goat and sheep. Capabilities for Recreation are of the *Extensive Recreation* type such as hiking and riding, mountain climbing, wildlife viewing and hunting.

L- ELK RIVER 75(2)A.

ELCO MINING LTD.	
ELK RIVER COAL PROJECT BRITISH COLUMBIA, CANADA	
CANADA LAND INVENTORY SYNOPTIC LAND CAPABILITY	
SCALE: 0 5 MILES	DRAWING NO. M-3
DATE: MAY 1975	DRAWN BY: APPROVED BY:
TECHMAN LTD.	PROJECT NO. TM-113

2.0 CLIMATE AND AIR QUALITY

2.1 Existing Conditions

Climatic data of the upper Elk River Valley can only be generalized due to the absence of a permanent weather recording station in the area. The property is in the mountainous subsection of the southeast climatic region of British Columbia, and experiences a mean daily temperature of less than 55°F. (13°C.) in July, and less than 20°F. (-7°C.) in January. Frost-free days in the upper portion of the valley range from less than 50 to a maximum of 100 days. Precipitation is high during the winter, with a secondary peak occurring in the spring; summer precipitation is relatively low and is characterized by frequent thunderstorms.

Winter snowfall data on a monthly average are available from five snow courses in the East Kootenay drainage basin (Table 1). The snow course closest to and approximating lease conditions is located on the upper Fording River tributary of the Elk River (Elev. 4,400 ft., 1,341 m.). Here the average value of accumulated snow depths in March, the month of maximum snow depth, is 27 inches (68.6 cm.), this being a water equivalent of 7.6 inches (19.3 cm.). In March, 1975 the snowpack was rated above average, with a reading of 31.6 inches (80.3 cm.). Snowfall data from Mt. Joffre, Fernie, New Fernie and Morrissey Ridge are also presented in Table 1. They provide additional snow depth information at elevations within the range of those in the project area.

2.2 Impact Considerations

Production of atmospheric dust from

- a) actual mining operations,
- b) exposure of overburden materials and coal ore depots to wind, and
- c) traffic, and transport of coal

could present serious annoyance problems and health hazards. Furthermore, excessive dust will impair photosynthesis and plant growth in the area and adversely affect landscape aesthetics.

The cumulative effects of such problems depend on the direction and velocities of wind and the possibility of atmospheric inversions in the valley. These conditions influence atmospheric pollution levels at specific locations.

Snowfall necessitates the creation of artificial snow banks (road clearing) and snow dumps (clearing of work sites) with their repercussions on drainage, erosion, and water quality. This, again, is dependent upon the accumulation and frequency of snowfall. Provision for snow storage must anticipate differential snowfall according to elevation and normal year-to-year variation (Table 1).

2.3 Mitigation & Reclamation Concepts

A thorough examination of the meteorological varia-

bles that will affect the dispersal and deposition of coal dust must be undertaken. A comprehensive coal dust control program will necessitate:

- a) Baseline data of prevailing winds and flow patterns of air-borne particles;
- b) Tracking and prediction of dust-flow and -fall from the center of mining activity;
- c) Adjustment in the timing or location of dust producing activities where possible;
- d) Establishment of a water spraying program to reduce dust problems at minesite;
- e) Ongoing re-seeding and reclamation as mining proceeds (see Sections 5.0 and 6.0);
- f) Maintenance of tree zones as wind belts, particularly to combat high winds;
- g) Dust control on roadways (considerations of water spraying, surfacing and speed controls);
- h) A monitoring system to identify potential health hazards or to maintain environmental standards.

Incorporation of dust control programs is recognized as a primary factor in good mine operation in that dust control is essential to safe mining operations.

Drainage and erosion problems resulting from precipi-

tation must be anticipated in erosion mitigation design. Spring runoff and summer storms imply peak water flows in the river system. Channel width and tunnel design must demonstrate peak flow capability. Similarly, erosion mitigation and slope-and-bank stabilization (Sections 3.0 and 4.0) will be consistent with the prevention of washouts. Settling ponds, in particular, must be designed to accommodate peak flow levels.

Revegetation is regarded as an air quality mitigation approach for the stabilization of soil in disturbed and landscaped areas.

The revegetation program must anticipate the regime of precipitation and snow-melt conditions. Fertilization and seeding will be influenced by the timing of favourable and unfavourable precipitation periods to minimize erosive loss of fertilizer, seed and seedlings. Selection of plant species for revegetation purposes will take account of their tolerance limits and adaptability to local climatic conditions.

The importance of such variables as minimum temperature, wind velocities, and snowfall relate to considerations of worker comfort. Planning for the insulation of buildings and for heating provisions is dependent on climate.

TABLE 1

WINTER SNOWFALL DATA: ACCUMULATED SNOW DEPTHS AND
WATER EQUIVALENT IN INCHES

(Summarized from Snow Survey Bulletins: Department of Lands, Forests and Water Resources; British Columbia)

SNOW COURSE	UPPER ELK RIVER		MORRISSEY RIDGE		MOUNT JOFFRE		FERNIE #10		NEW FERNIE #10A	
	Snow	W.E.	Snow	W.E.	Snow	W.E.	Snow	W.E.	Snow	W.E.
	4,400 ft.		5,750 ft.		6,100 ft.		3,500 ft.		4,100'	
	50° 01 min.		50° 32 min.		49° 27 min.		49° 30 min.		49° 30 min.	
Snow Survey Bulletin	114° 56 min.		115° 07 min.		114° 58 min.		114° 56 min.		115° 02 min.	
Jan. 1	Mean(N)*	26(1) 4.7	50(1) 14.3	--	--	30(5) 5.9	38(1) 9.1			
	Max.	26 4.7	50 14.3	--	--	40 7.9	38 9.1			
	Min.	26 4.7	50 14.3	--	--	23 4.1	38 9.1			
Feb. 1	Mean(N)	27(3) 5.8	73(12) 22.1	51(4) 12.5	28(34) 6.9	45(22) 11.5				
	Max.	35 8.1	98 29.9	69 17.3	48 12.0	66 18.4				
	Min.	22 4.4	50 12.7	36 7.6	6 1.7	26 6.3				
	1975	20 5.0	-- --	-- --	31 21.0	-- --				
Mar. 1	Mean(N)	27(26) 7.6	81(11) 27.8	51(5) 14.5	30(35) 8.3	50(24) 14.6				
	Max.	50 13.0	115 39.6	73 21.7	54 15.2	71 23.0				
	Min.	6 2.7	60 17.6	38 9.7	4 2.0	24 8.1				
	1975	31.6 7.2	51.6 13.7	-- --	39.9 9.2	-- --				
Apr. 1	Mean(N)	24(26) 7.4	83(12) 31.3	56(6) 17.6	24(36) 8.1	45(23) 15.9				
	Max.	44 13.6	107 44.1	76 28.0	48 16.4	69 23.8				
	Min.	5 1.0	57 19.9	38 10.5	0 0.0	20 7.9				
	1975	31.6 8.5	-- --	-- --	35.6 11.1	-- --				
May 1	Mean(N)	4(18) 1.4	74(11) 30.9	51(6) 18.7	7(28) 2.7	20(23) 7.8				
	Max.	17 5.5	105 49.0	69 30.4	39 13.9	55 21.3				
	Min.	0 0.0	54 22.1	33 10.9	-- --	-- --				
May 15	Mean(N)	0(1) 0.0	60(8) 26.4	-- --	1(17) .3	7(14) 3.2				
	Max.	-- --	90 41.6	-- --	11 4.7	26 11.4				
	Min.	-- --	27 15.0	-- --	0 0.0	0 0.0				
June 1	Mean(N)	-- --	28(8) 14.5	-- --	0(1) 0.0	2(3) .7				
	Max.	-- --	58 26.7	-- --	0 0.0	6 2.0				
	Min.	-- --	0 0.0	-- --	0 0.0	0 0.0				

*N refers to the number of years that measurements have been taken .

3.0 HYDROLOGY AND WATER QUALITY

3.1 Existing Conditions

The Elk River originates in the upper and lower Elk Lakes (115°06' West, 50°33' North), and flows southeast and south for approximately nine miles (14.5 km.) to the northern boundary of the project area. It continues south through the area for a distance of approximately 13 miles (20.9 km.) After flowing south to Natal, it turns and flows southwest to join the Kootenay River about 10 miles (16.0 km.) from the Canada-United States border. Cadorna Creek (Drainage Basin B, Map 5), the major tributary above the area, originates near Cadorna mountain and flows southeasterly joining the Elk River just north of the proposed diversion.

Within the project area, downstream from the Cadorna Creek confluence, the Elk River has four main tributaries - Gardner, Weary, Bleasdel and Aldridge. Also, there are a number of small drainages, most of which are intermittent. These originate from drainage off the ridges which flank the valley, or the small swamp-meadows which dot the valley floor.

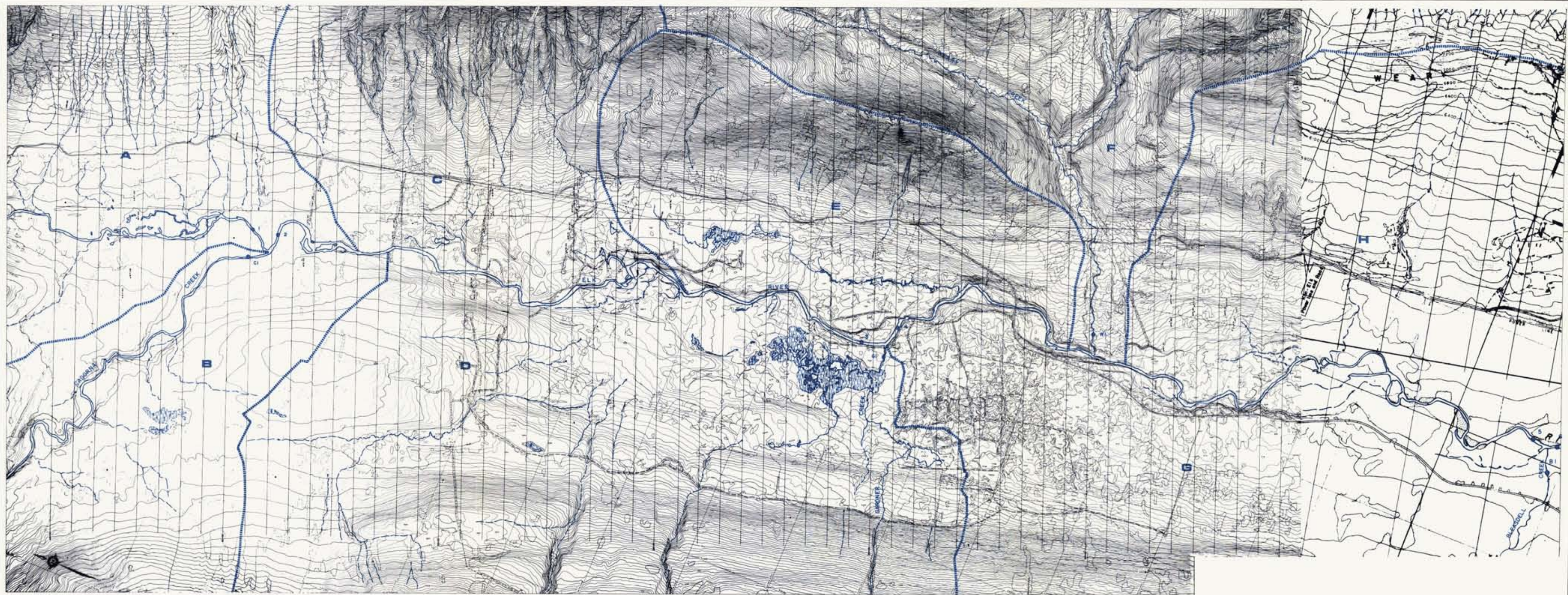
Two stream habitat types occur on the Elk River within the project area, a pool and riffle and a meandering-braided habitat. The pool and riffle habitat occurs between the Elk-Cadorna confluence and the Elk-Weary confluence. This type of habitat is characterized by a straight and narrow streambed and is subject to high current velocities. The meandering and braided habitat type occurs upstream of the project area and

again from the confluence of Weary Creek to the southern end of the area. The wider and meandering nature of this section of the stream helps to reduce the velocity of the current.

The discharge rates recorded by B.C. Research (Progress Report #2, Table 2) indicates that the Elk River upstream from the Cadorna Creek is much more subject to flash peaks (HWF:LWF = 5.4:1) than Cadorna Creek (HWF:LWF = 2.7:1) and Aldridge Creek (HWF:LWF = 4.4:1). The other three main tributaries all seem to exhibit flash peak characteristics, Gardner Creek HWF:LWF = 5.6:1; Bleasdell Creek, HWF:LWF = 5.1:1; and Weary Creek, HWF:LWF = 4.8:1 (see Table below). The difference in the discharge rate recorded at the Forestry Bridge and the sum of the upstream tributaries indicates a significant contribution from other sources, most of which is from the intermittent streams located in drainage basins C, D and E (Map 5).

Discharge rates recorded by B.C. Research, 1972:

	<u>July</u> HWF (cfs.)	<u>August</u> (cfs.)	<u>September</u> LWF (cfs.)
Elk River (upper Bridge)	309	293	57
Cadorna Creek	419	370	152
Gardner Creek	<u>28</u>	<u>10</u>	<u>5</u>
Sum discharge	756	673	214
Elk River at the Forestry Bridge	1085	600	300
Sum discharge of above	<u>756</u>	<u>673</u>	<u>214</u>
Difference	329 cfs.	-73 cfs.	86 cfs.
	(9.3 m ³ s)	(-2.07 m ³ s)	(2.43 m ³ s)



LEGEND

- E** DRAINAGE BASIN DESIGNATION
- DRAINAGE BASIN BOUNDARIES

- O-1 MINING AT COMPLETION
- O-2 ROAD AND UTILITY MODIFICATIONS
- O-3 EXISTING SURFACE DRAINAGE AND MONITORING STATIONS
- O-4 MODIFIED SURFACE DRAINAGE
- O-5 EXISTING VEGETATION
- O-6 REVEGETATION PLAN

K-ELK RIVER 75(2)A

ELCO MINING LTD.	
ELK RIVER COAL PROJECT	
WESTERN COLUMBIA, CANADA	
EXISTING SURFACE DRAINAGE AND MONITORING STATIONS	
SCALE	DATE
1:50,000	MAY 1975
TECHMAN LTD.	

3.2 Environmental Considerations

While previous mining proposals required the diversion of the Elk River about 10 miles (16 km.), including an extreme gradient of the watercourse at the end of the diversion, the concept presented in this submission has reduced the impact by diverting the river only 4.2 miles (6.8 km.) and maintaining a grade of 0.5% to 1.0%, except for a short section of 2.5%.

Diverting the Elk River through 1.46 miles (2.35 km.) of 20 feet (6.1 m.) wide tunnel may minimally affect the water quality in several ways. The perpetual darkness would cause a drop in photosynthesis, thus causing a drop in dissolved oxygen. Also, tunnels tend to maintain a fairly constant air temperature as compared to the outside; inside the tunnel it would be cooler in the summer, but warmer in the winter. Therefore, it may cause a temperature change of the water as it passes through the tunnel. However, with an estimated tunnel throughput time of about 30 minutes, these effects will be minimal. Alteration of the tributaries and diversion of the Elk River into 2.7 miles (4.4 km.) of new channel from the tunnel exit to a point downstream from the Forestry Bridge may affect the water by exposing it to more radiation, thus causing a rise in temperature.

If water draining through the backfilled material or dump sites leaches out soluble elements, it may contaminate other groundwater and/or surface water. This condition, along with a definitive understanding of groundwater regimes will be assessed.

Straight and smooth-bottomed channels are usually

designed to quickly move water from an area. This, however, produces flash peaks downstream.

Beaver ponds and marsh areas tend to retain runoff waters, thus reducing fluctuations in discharge rates. Also, the calm conditions created allow the sediment to settle out. However, the channel water is usually warmer than the receiving waters and they often contain considerable quantity of natural produced carbon, nutrients and toxic compounds (note the dark color of Gardner Creek, Appendix B-P7).

Water draining from coal mining areas and/or coal piles tends to contain chlorides, sulphates, iron and occasionally barium which when released in a watercourse causes a drop in the dissolved oxygen and the pH. The flourishing growth of iron bacteria tends to deposit the iron on the river bed as ferric hydroxide (KLEIN, 1962, p.120). Therefore, these parameters will be monitored on a regular basis.

The mining operation may be a source of coal, coal dust, phenols (from solid waste disposal) and oil which could gain access to the watercourses. Precautions will be taken to ensure that this does not happen.

Also, with the establishment of a campsite in the area there exists the potential for nutrient or organic enrichment of the streams. Furthermore, some of the inorganic fertilizers used during the revegetating program will be worked into the stream but this will be kept to a minimum (Section 6.0 for details on application methods).

3.3 Mitigation & Reclamation Concepts

B.C. Research (Report #2) observed the compacted glacial till which is to be used for construction of drainage ditches resists erosion (BCR Report #2).

The drainage diversions around the edges of the hills, rather than straight down the hillside, will create a greater holding capacity because of their lower gradients. Rock and debris working into these channels will create a large number of small pools. These pools will dampen the flash peaks and create calmer conditions, allowing the suspended solids to settle out (Map M6).

After the coal has been removed from the pit, the ditch could be re-routed over a mining bench and into the final lake, thus creating a drainage gradient suitable for spawning (Appendix A-R2 and R3).

The ditch which is designed to pick up those streams feeding the drainage gullies off Gardner Ridge is to be directed into Gardner Creek, which in turn, is to be directed into the shallow lake (Appendix A-R1). This shallow lake may be colonized by salmonids which could use the lower reaches of the Gardner drainage system as a spawning area.

The drainage ditch which utilizes the drainage from the northwest dump may be colonized by fish, but it is unlikely that it would be suitable for salmonids.

After the valley floor is mined out and backfilled, water will tend to fill the void. Therefore, it should be determined if there is a danger of toxic or undes-

The banks of the Elk River throughout the lease area are quite stable. Those banks which are exposed are composed of glacial till-predominantly gravel compacted in a strong silt-clay matrix, which resists erosion (BCR Report #2). Therefore the sediment load of the Elk River is mainly due to the solids being worked into the watercourses (Appendix B-P9).

The sediment discharge of the Elk River at Upper Bridge - upstream from the Cadorna Creek confluence, ranged from 15.6 gms./second in July to less than 2.3 gms./second in September. The largest proportion of this sediment was in the form of suspended solids. In contrast, the Cadorna Creek sediment discharge for August was greater than the Elk River but most of this was in the form of bedload. However, the September suspended sediment was almost double that of the Elk. The suspended sediment of the Elk River at the Forestry Bridge - downstream from the Gardner Creek confluence - was greater than the sum of the suspended sediment in the Elk River and Cadorna Creek (BCR Report #2, Table 3), indicating there may be a significant concentration of suspended solids contributed from the C and D drainage basins (Map 5).

The concentration of total solids tends to increase as the water flows down the Elk River. All the tributaries between Cadorna Creek and Aldridge Creek confluences, contained a greater concentration than the Elk, with Creek D (WS17) > Gardner Creek (WS14 and WS18) > Bleasdell Creek (WS9) > Weary Creek (WS10) > Creek A (WS15) > Creek B(WS16).

Although there appears to be a general correlation

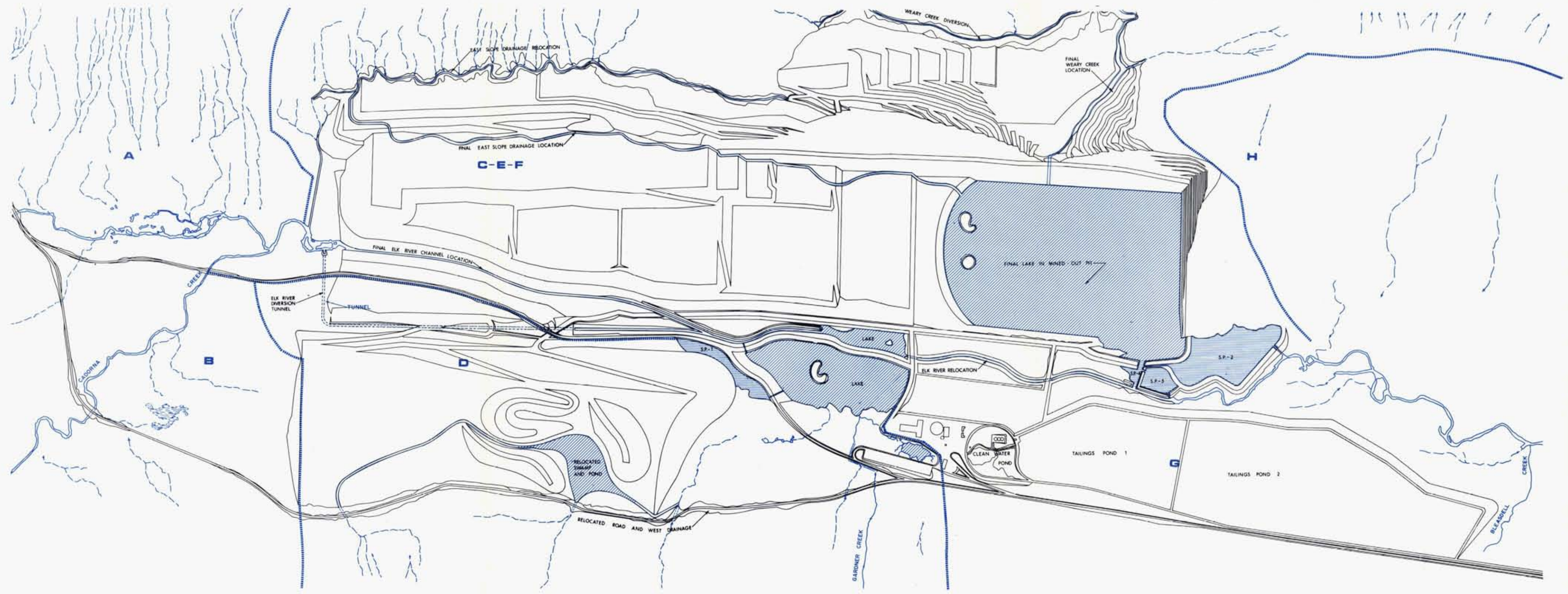
between the gradient of the creek and solids load, this does not hold true for Creeks A and B (both have an extremely steep gradient, 35.3% and 30.6%, respectively [BCR Report #2, Table 1], but a relatively low concentration of dissolved solids). This may indicate that the intermittent creeks upstream from the project area carry more solids in the Elk River than those intermittent creeks located downstream from the project area, even though they have a lesser gradient (Table 2).

There seems also to be a trend in all streams, except at Cadorna Creek, towards an increase in solids later in the year (i.e. September > August > July [BCR, Report #3, Table 5]).

The B.C. Research results indicate some general trends which appear to be consistent; for example, there is a steady increase in solids, conductivity, carbon, dissolved oxygen, pH and alkalinity as the water progresses downstream.

Some of the creeks, particularly Creek D (WS17), both branches of Gardner Creek (WS14 and WS18), and Bleasdell Creek, all have a high conductivity with an accompanying high alkalinity and hardness (BCR Report #3, Tables 4, 6 and 7). These results, combined with the above results, indicate background levels of heavy metals to be in detectable concentration.

HOOTON (1971, Table 11), after taking nine readings, (which provides a better mean), also found the pH and dissolved solids are higher at downstream locations.



LEGEND

- E ORIGINAL DRAINAGE BASIN DESIGNATION
- MODIFIED DRAINAGE BASIN BOUNDARIES
- ▒ SETTLING POND
- ▒ LAKE

K-ELK RIVER 75(2)A

ELCO MINING LTD.	
ELK RIVER COAL PROJECT	
WEST COAST, CANADA	
MODIFIED SURFACE DRAINAGE	
	M - 6

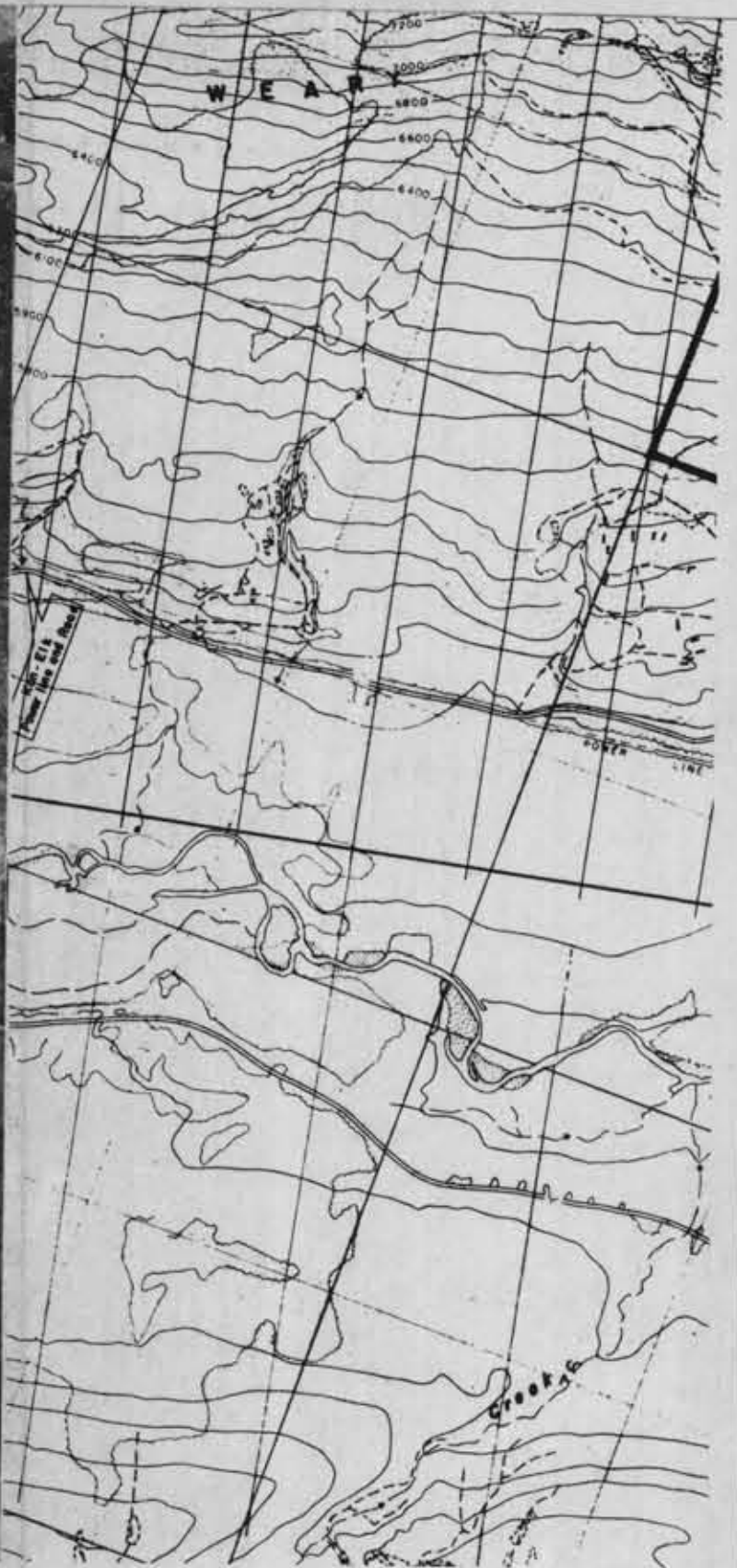
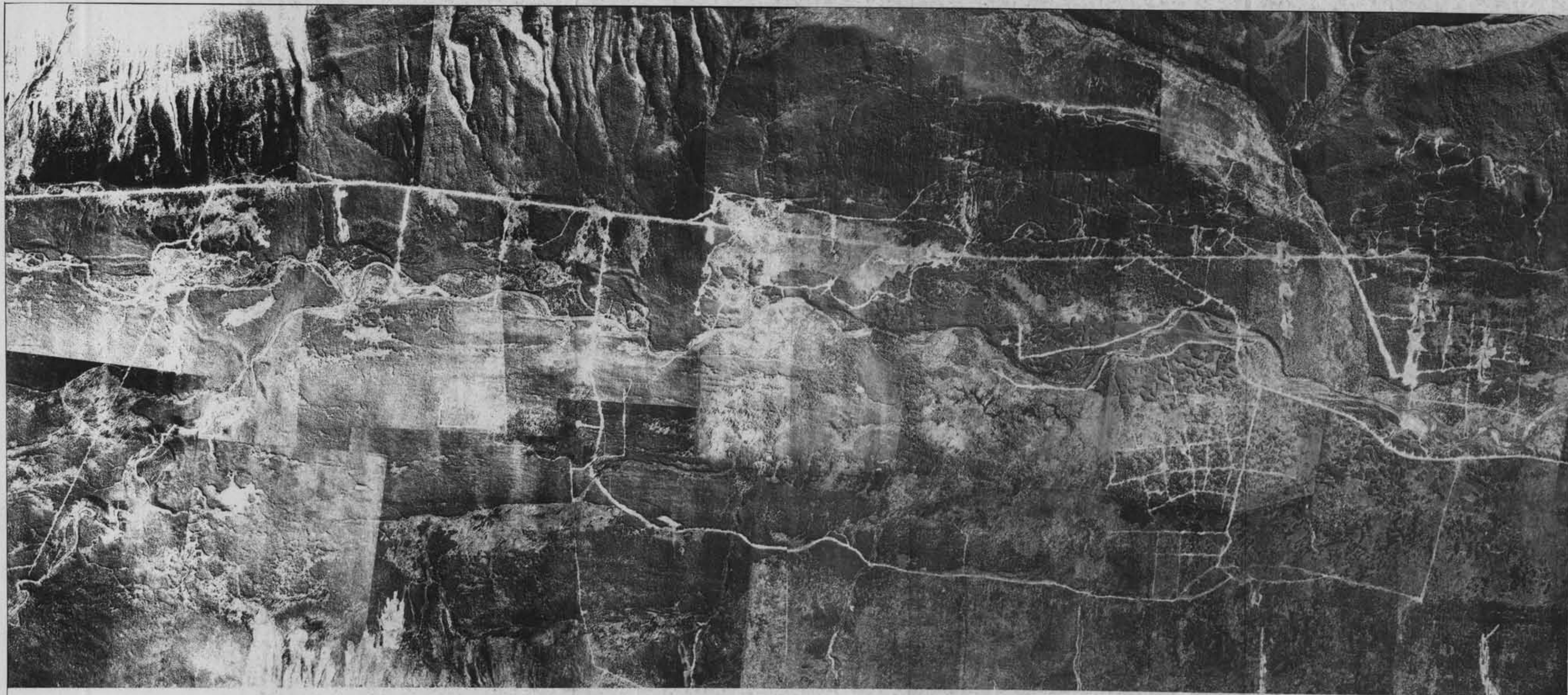
irable ions leaching out of the backfill material and contaminating ground or surface water.

The organic load and nutrient enrichment of the water-courses will be controlled by treating (probably in the form of activated sludge) all domestic sewage. The effluent from this sewage treatment plant will be directed into at least one settling pond, or it could be used in the revegetation program as a fertilizer (since it is nutrient rich). The sludge from this treatment system may be used as organic base for the revegetation program.

Beaver ponds constructed on top of the northwest dump at completion of mining will help to remove sediment and reduce the flash peak of the water draining off the ridge.

The large stones (shot rock) used to line the channel would create a large number of microhabitats, behind, between and below the rocks, where the current would be reduced. These microhabitats would tend to trap much of the organic material and, initially, they would trap a considerable quantity of sediment.

The construction of the channel will include alternating pools and riffles. These pools will help to minimize fluctuations of the water temperature and to enhance fisheries (Section 7.3). It may also initially help remove sediment until the sediment load reaches equilibrium. If the pools cause an increase in the gradient at the riffles, this can be compensated for by building the channel in a meandering manner, thus increasing the total length of the channel and



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ELK RIVER COAL PROJECT
WESTERN CANADA, CANADA
PHOTO MOSAIC

DATE	1977	SCALE	1:50,000
MAY 1977		NO. 2	
TECHMAN LTD.		TM-12	

reducing the gradient. Meandering will also tend to reduce the chance of flash peaks downstream.

Programs to revegetate the channel banks will be initiated immediately after construction. Vegetation will be planted which will offer the greatest amount of shade for the watercourse and yet not impede fishing access. Sections of the channel banks which are subject to erosion will also be vegetated.

TABLE 2

II-23

Hydrological Data: Elk
River and Tributaries*

S I T E

*Raw data obtained
from B.C.
Research, 1972.

	DATE	GRADIENT	DEPTH (ft.)	WIDTH (ft.)	VELOCITY (ft./sec.)	DISCHARGE (cfs.)	DEGREE OF FLASHNESS	% BANK STABILITY	BEDLOAD DISCHARGE (gms./sec.)	SUSPENDED SEDIMENT DISCHARGE (gms./sec.)	TOTAL SEDIMENT DISCHARGE (gms./sec.)
<u>Elk River</u>											
Upper Bridge	July 5		2.5	37	3	309			1.7	11.6	15.6
	Aug. 10		2.3	33	2.8	293			2.1	11.6	13.7
	Sept. 24	.8	1.2	24	1.6	57	5.4	63	0.1	2.2	2.3
Forestry Br.	July 6		3.3	37	6.4	1085					
	Aug. 11		2.7	35	5.2	600					
	Sept. 25	.8	2.0	31	3.5	300	3.6	65	0.1	10.1	10.2
<u>Tributaries</u>											
Cadorna Cr.	July 6		2*	49	5.1	419					
	Aug. 11		1.5	63	3.7	370			17.5	9.4	26.9
	Sept. 24	1.7	0.8	45	3.7	152	2.7	93	0.1	4.3	4.4
Gardner Cr.	July 12		1.7	10	1.3	28					
	Aug. 13		1.5	7	1.0	10					
	Sept. 25	11.4	0.5	10	1.0	5	5.6				
Bleasdell Cr.	July 11		0.8	20	2.5	46					
	Aug. 14		0.7	18	2.0	23					
	Sept. 30	10.7	0.6	9	1.8	9	5.1	100			
Weary Cr.	July 11		1.1	12	1.4	19					
	Aug. 13		0.6	10	2.4**	14					
	Sept. 29	10.9	0.5	10	0.8	4	4.8	100			
Aldridge Cr.	July 13		0.9	23	2.7	57					
	Aug. 13		1.8	12	1.2	28					
	Sept. 29	7.1	1.3	8	1.2	13	4.4	75			
Creek A	July	35.3			0.6	0.2					
	August Sept.										
WS-15	July				0.8						
	August Sept.				0.5	1.0 1.0					
Creek B	July				3.8	2.0					
	August				2.6	0.3					
	Sept.	30.6			dry	dry	6.6				
Creek C	July				1.1	0.1					
	August				dry	dry					
	Sept.	17.8			dry	dry					
Creek D	July				2.4	0.7					
	August				2.7	0.6					
	Sept.	20.4			1.5	0.6	1.1				

4.0 GEOMORPHOLOGY AND GEOTECHNICAL CONSIDERATIONS

4.1 Existing Conditions

The project area is located in the Front Range province of the Rocky Mountains. The morphology of the area has been determined for the most part by thrust faulting, minor normal faulting and by subsequent erosion.

As detailed in the Mining Section of this submittal, the proposed mine area consists of the upper Kootenay Formation which dips to southwest at angles ranging from 35° to 50°. The steeper dips are generally found in the northern segment of the project area.

Glaciation and subsequent erosion in the valley floor and along the lower reaches of the valley flanks has played an active role in creating the existing benches and outwash fans which are characteristic of the project area. Prominent geomorphic features in the area include alluvial fan development on several tributary creeks and the alluvial benches on the valley bottom south of Aldridge Creek. A rock slide, possibly related to faulting, is located on the west face of Big Weary Ridge approximately one mile south of Weary Creek (GOLDER, BRAUNER AND ASSOCIATES LTD., 1971).

The narrowness or width of the valley floor, between the valley slope, can also be measured from Map M2. At key reference points, then, the calculated widths are as follows:

	<u>(miles)</u>	<u>(km.)</u>
a) Cadorna Creek - Elk River confluence		
Width	0.5	(.8)
b) Weary Creek - Elk River confluence (widest point in project area)		
Width	1.2	(1.9)
c) Elk River - Gardner Creek confluence		
Width	1.0	(1.6)
d) Elk River - Aldridge Creek confluence		
Width	0.9	(1.4)
e) Mosquito Flats area		
Width	1.2	(1.9)

These measurements are only approximations, but they ultimately determine the feasibility of intra-valley movement corridors and the placement of mining development.

4.2 Altered Landform & Stability Considerations

Successful coal extraction, as outlined in this submittal, will necessitate landform alterations, and eventually the creation of a replacement landscape. The most striking landform changes as detailed in the Mining Report involve, sequentially, the relocation of the Elk River channel and some of its tributaries, establishment of the mining pit, the accumulation of waste and overburden on spoil piles, and the creation of tailing ponds and settling and silt retention ponds (Map M6). Several seasonal streams (Map M5) will be diverted into the relocated river, while the main tributaries would be redirected outside the immediate mining area (Map M6) or left unaltered.

Any potential environmental impacts have been considered under various subject headings in this report. However, in broader geomorphic terms, the Mining Report proposes the replacement of a so-called natural landscape with a man-formed landscape. The former developed in response to various glacial and climatic processes that shaped it. Having such a history, the present landscape "anticipates" such inputs as flowing water and adjusts to a predictable "balanced" state. In the reclaimed environment, soil erosion and river flooding will establish a new equilibrium over decades of time, and the performance of the new landscape (in terms of bioproductivity, water quality, recreational value) will be comparable to the existing.

4.3 Mitigation & Reclamation Concepts

Land reclamation and landform alteration as delineated in the Mining Report aims for an unobtrusive landscape that compares with existing conditions, in terms of productivity, erosion and aesthetics.

As slope angles determine the frequency of landslides and degree of erosion, there is a recognized need for bank and slope stabilization procedures for such new landscape features as overburden and waste piles. Dump rehabilitation would include recontouring of slope surfaces to a maximum of 25°, terracing of slopes, and staged revegetation.

Such landform design will be extended into a revegetation program (Section 6.0), with selective revegetation to proceed according to local conditions (Table 4,

Acreage Classification for Revegetation).

The orientation of landscape planning and revegetation is the simulation of a "natural" landscape after mining operations are concluded. Such a landscape would conform to the requirements for the recolonization of wildlife (Section 8.0) and the consideration of aesthetic criteria (Section 10.0). In certain areas, reclamation concepts will undoubtedly enhance productivity for fish and wildlife, such as the creation of new lakes and beaver ponds and improved gradients in tributary streams for fish (Appendix A-R6, R11).

Reductions in the present gradients of existing streams will necessarily decrease the amount of suspended solids in water.

Future planning programs will include the integration of geotechnically oriented data with that of other disciplines. Information obtained from field investigations and exploration drilling programs will be used to evaluate inter-related criteria such as various stability conditions, groundwater parameters, drainage conditions, foundation criteria and soils characteristics as related to salvage of topsoil and nutrient requirements for revegetation programs.

5.0 SOILS

5.1 Existing Conditions

The Canada Land Inventory (Soil Capability for Agriculture Map) classifies the soils of the Elk Valley as mainly Gray Wooded (Luvisol), although the alluvial soils range from Eutric Brunisols to Regosols and Gleysols. North of Sparwood, the best ratings obtained were Classes 4 and 5: both indicating severe limitations that restrict the range of crops, but hinting that "improvement practices are feasible".

In the lease area, the distribution of vegetation communities may be correlated with the soil groups present. B.C. Research conducted a limited soil survey at selected vegetation macroplot sites.

Extrapolating from B.C. Research data, and assuming that soil types are indeed correlated with existing vegetation, the vegetation map (M7) included in the presentation can serve as a map of associated soil types. Relating vegetation to soil types, and percentage of total area, the following generalizations would apply to the major portions of the lease: coniferous forest (pine and spruce) with the Degraded Eutric Brunisol, about 47.1%; open forest with the Melanic Brunisol subgroup, about 26.5%; forest and shrub, and meadow with the Melanic Brunisol subgroup, about 16.8%; and alluvial benches and fans in various locations on the valley bottom with the Orthic Regosol subgroup.

With the exception of the shrub and sedge communities

on the valley bottom benches, the soil and subsoil material is judged to be well drained and permeable to seepage water (BCR Report #1). However, in the shrub and sedge areas, poor soil permeability and water impoundment by beavers has promoted the accumulation of organic material.

5.2 Soil Removal & Stockpiling

Soil storage and the development of so-called "manufactured soil" (from surface humus and herbaceous vegetation, logging slash and peat) must be regarded as a prerequisite of successful revegetation. Consideration must also be given to development of an optimum base for soil to promote stability and appropriate drainage, nutrient enrichment of the soil medium, and the choice of plant species. Failure to plan for surface runoff or wind erosion in reclaimed areas for example would render the initial stockpiling as wasted effort.

The initial revegetation program will include provisions for preservation of available soils and suitable soil materials - whether it be base material peat, or timber waste. It is fortunate that the mine-site contains deep peat bogs which will provide an ample supply of this valuable material for soil development. Allocation for storage of such materials will follow guidelines to minimize erosive loss and subsequent organic pollution of water.

5.3 Soil Development in Reclamation Programs

Section 6.0 presents land classification criteria for

revegetation, with selective programs according to slope conditions.

Soil development is regarded as essential to the reclamation program because of the limited amounts of actual soil material that can be retained. The top layer of soil and surface material of humus and herbaceous vegetation will be mixed with logging slash and peat in optimal proportions to be determined through testing. This mixture will form the basis of the developed, or manufactured soil. Moisture holding deficiencies inherent in the coarse textured coal mine spoils present problems, but the combination of materials described above can overcome this difficulty. As the revegetation program (Section 6.0), indicates, the nutrient status of existing "natural" soils and reclaimed soils is intended to be replenished by fertilizer treatments.

6.0 VEGETATION

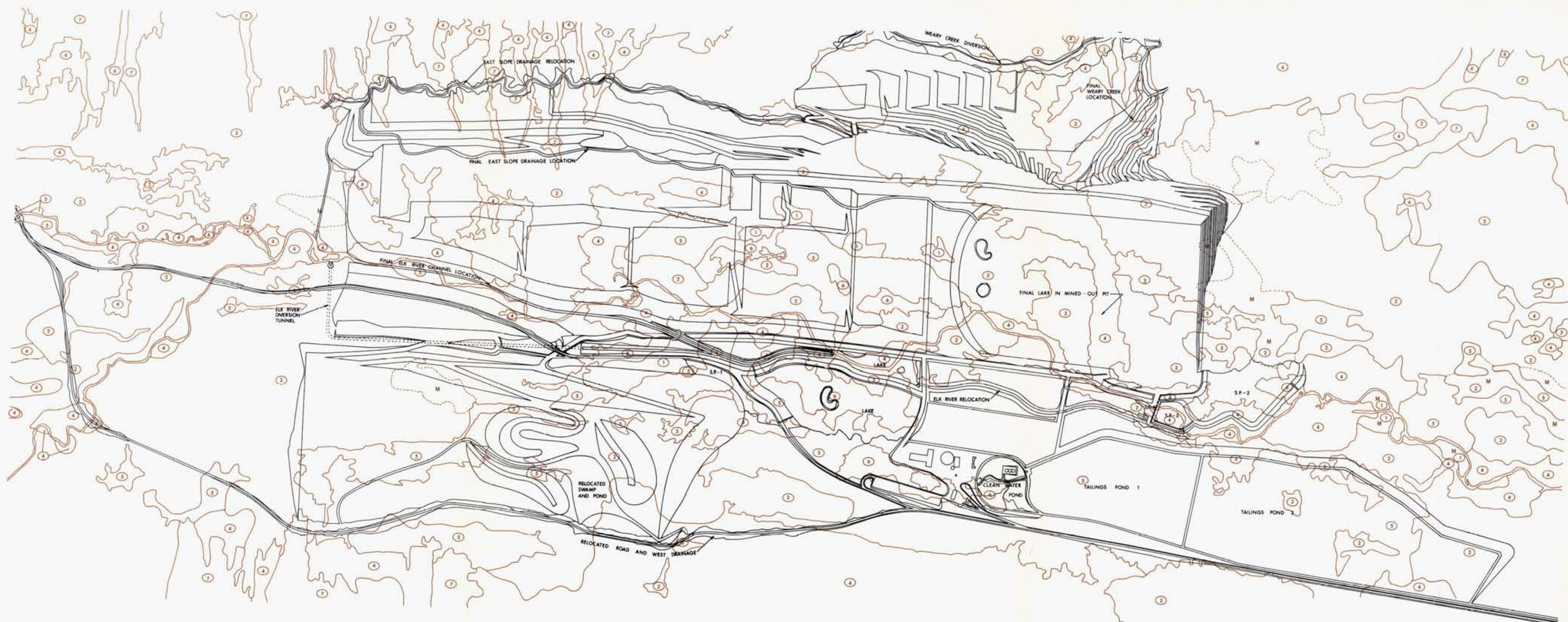
6.1 Existing Vegetation & Plant Ecology Considerations

B.C. Research (Report #1) described plant communities and habitat types* in the Elk River Valley and the project area on the basis of aerial photograph interpretation, and on-site observations. Vegetation community mapping units are delineated on the basis of dominant species composition and maturity. An existing vegetation map for the immediate mining site is presented here, based on this work (Map M7). Plant community and habitat description was prefaced in the B.C. Research report with the comment: "The plant communities and habitat types in the ... permit area are not unique to the Elk River Valley ... (They) are to be found to some extent elsewhere in the valley".

According to habitat type, vegetation in the Elk River Valley, including the project area, is composed of coniferous forest, mixed deciduous and coniferous forest, shrub, meadow and alpine communities.

The coniferous forest habitat type is dominant in the Elk River Valley; it occupies 47.1% of the entire project area. The most prevalent community is immature lodgepole pine with small pockets of mature pine and mature spruce representing survivors of the 1936 forest fire.

*"Plant community" was defined as a vegetation unit characterized by the dominant plant species (p.11); forest communities and related understory were grouped into larger and more inclusive ecological units termed "habitat types", denoting an ecosystem having "characteristic interactions of climate, vegetation, and soil ..." (p.11).



- LEGEND
- M MATURE TIMBER
 - ① SPRUCE
 - ② PINE
 - ③ PINE-ASPEN
 - ④ OPEN FOREST
 - ⑤ FOREST AND SHRUB
 - ⑥ FEN OR MEADOW
 - ⑦ ALPINE

K-ELK RIVER 75(2)A

ELCO MINING LTD.	
ELK RIVER COAL PROJECT	
BRITISH COLUMBIA, CANADA	
EXISTING VEGETATION	
DATE	SCALE
MAY 1982	1" = 100'
PROJECT	14-93
TECHMAN LTD.	

The deciduous and coniferous forest habitat type is composed primarily of a pine-aspen community above the valley bottom on the western exposure of Weary Ridge and further south down the east side of the valley; an aspen-pine community on the Weary Creek alluvial fan; and veteran stands of spruce-cottonwood on the alluvial benches south of Aldridge Creek. This habitat type occupies 2.4% of the project area.

The open forest habitat type occupies the more steeply sloping portions of the permit area. This habitat type is composed primarily of open stands of immature pine, immature pine and spruce, with an abundance of shrubs, and shrub and grass communities. It occupies 26.5% of the project area.

The forest and shrub habitat type, occupying 14.1% of the project area occurs on flat to gently sloping benches of the valley bottom. These are characterized by an abundance of moisture due to restricted soil drainage and beaver activity locally restricting surface drainage. Representative communities are pine, pine-spruce, willow-sedge and birch-sedge.

The meadow habitat type occurs on poorly drained flat or nearly flat areas of the valley bottoms or around beaver ponds. This community occupies only 2.7% of the project area. Representative species include sedges, willows and scrub birch.

The alpine habitat type comprises 6.2% of the area, the majority of which is designated "snow patch" or "slide" type. Representative communities are fireweed-wild rye and shrub dominated alder-willow.

Drill and trench disturbances (Appendix B-P12) resulting from exploration were seeded with a mixture of grasses and clover in the fall of 1971 (Appendix B-P14). These disturbed sites were surveyed by B.C. Research during 1972 for success of vegetation establishment and the occurrence of any naturally colonizing plant species.

Three vegetation classes, good, moderate and poor, were designated based on the number of plants per unit area. B.C. Research calculated that "an average disturbed site" would have the following coverage within the three revegetation classes: 25% in the "good" class; 31% in the "moderate" class; and 44% in the "poor" class. Revegetation by native plant species was considered negligible over most of the disturbed areas.

Two biogeoclimatic zones are described for the region: an Engelmann spruce-subalpine fir zone extending from the valley floor to approximately 7,500 feet (2,286 m.) and an alpine zone occurring at elevations above 7,500 feet (2,286 m.). It should be emphasized that this designation refers to the eventual climax community, i.e. the theoretical community toward which all successional development in a given region is tending. At present as a result of a forest fire in 1936, early seral (subclimax) communities predominate in the area. Similarly, the "beaver habitats" in the valley are considered successional, or disturbance habitats, having typically a short ecologic history, reverting back to "normal" forest succession when abandoned by the beavers (Appendix B-P13). The abundance of beaver habitat, open forest and deciduous growth has been maintained by a variety of disturbance conditions. If

present conditions are to serve as a model for future reclamation, they must be seen as early seral rather than as late seral or climax stages.

6.2 Vegetation to be Cleared

Table 3 itemizes the habitat types, in terms of actual acres of vegetation on the project area, that will be removed or disturbed. These acreages have been converted to percentages of the total acreages of the respective habitat types on the project area.

The loss of vegetative cover implicit in the establishment of a mining development and ancillary supply corridors as outlined in the mining report entails the following impact considerations:

- a) The loss of timber production time through removal of predominantly immature stands (\pm 40 years); mature stands to be harvested.
- b) erosion control and watershed deterioration;
- c) loss of food base and cover for resident and migratory wildlife, as discussed in Section 8.0;
- d) the loss of significant recreation or aesthetic potential, as recognized in Section 10.0.

6.3 Revegetation Concepts

A plan for revegetation, whether it be reseeding with

grasses and legumes or planting with shrubs and trees, must appreciate local conditions of the mining development area. Precedents in revegetation elsewhere only establish guidelines, not prescriptions for reclamation. Plant species and ecotypes (varieties) must be regarded as organisms with definite limits of tolerance and dependence on the suitability of local conditions for any successful adaptation. Hence, successful revegetation depends on a program of experimental revegetation before and during the actual mining period. Prior experimentation with seed mixes, shrubs or trees on anticipated post-mining substrates will have long-term economic advantages.

To evaluate any revegetation program it is necessary to establish criteria for success in terms of species desirability, cover per unit area, soil holding capability, forage potential, and aesthetics. The initial community established by the program must be related to long-term plant species and community succession. The initial and secondary communities should be consistent with environmental guidelines provided by the resource management agencies, which in turn reflect public values. What is necessary, then is an overall, integrated mitigation and reclamation program in which revegetation is given some direction.

Traditional problem areas in coal mine revegetation are: creation of unstable steep slopes, inadequate moisture retention, and loss of organic and inorganic material (problems of soil development and stabilization). Reclamation procedures that will alleviate soil loss and enhance revegetation have been identified. They include those measures desirable for soil develop-

ment (see Section 5.0) and the erosion control techniques discussed under the heading of "Hydrology and Water Quality" (Section 3.0). Similarly, an ongoing program of reseeded and planting will be subject to the constraints discussed in the section entitled "Climate and Air Quality" (Section 2.0).

Broad objectives will include a commitment to limit the amount of cleared surface exposed at any one time; this will require a continual reclamation program, synchronized with the rate of coal removal. To insure optimum utilization of existing soil for reclamation, stockpile areas (Appendix B-P10) for storage of topsoil and soil matrix materials (logging slash, peat, till) will be given planning priority. A final reclamation plan is necessary to detail the procedures of landscape contouring, soil base preparations, control of fine grained materials, and the enhancement of soil capability through fertilization before the actual revegetation.

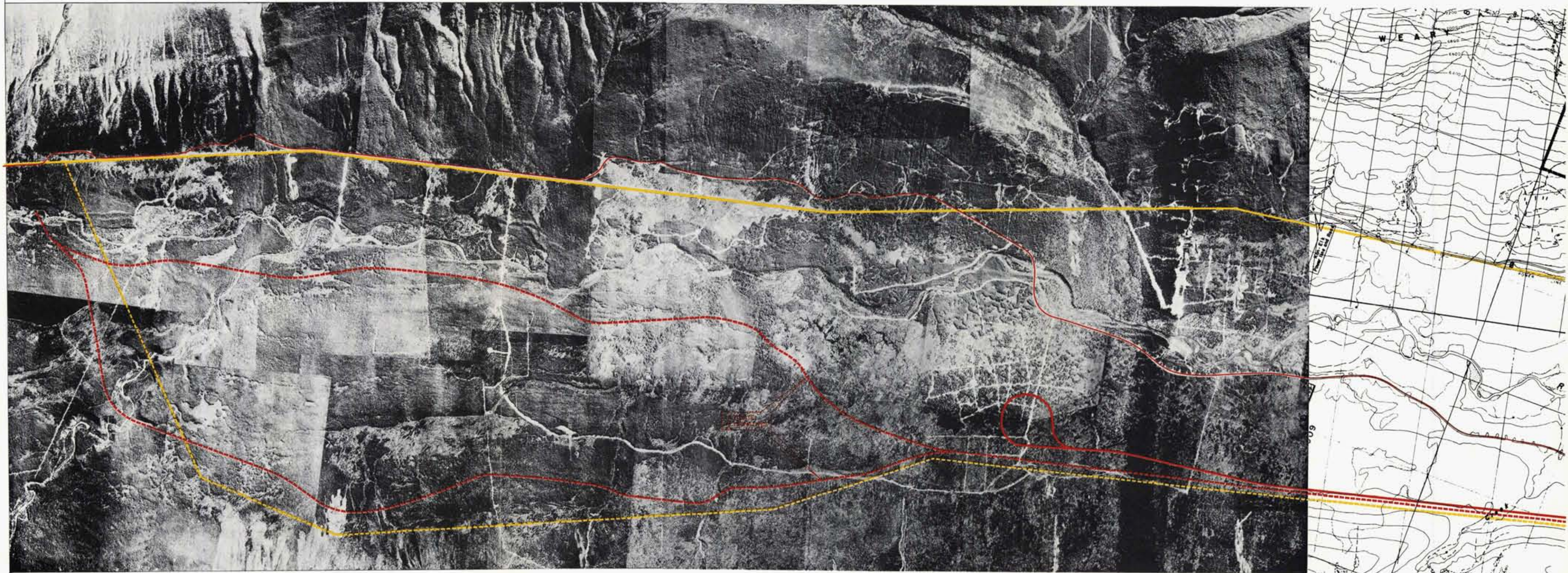
Roadways and exploration trails within the project area merit particular attention (Appendix A-R7 and R8) because of their potential for excessive erosion, particularly where stream crossings are involved. Recontouring and removal of structural debris will precede the final landscape improvement scheme with the choice of revegetation techniques to anticipate local disturbances.

Right-of-way clearing (Appendix A-R9) will create aesthetic impact and linear wildlife habitats. It is essential that these areas be planned and managed to develop plant community stability and aesthetic attrac-

tiveness. Linear habitats often provide corridors for animal movements between other habitats and valuable "edge" characteristics. Efforts will be directed to the design of these clearings to maximize their biological potential and enhance any functions for animal shelter, food, and nesting areas. However, in the case of road right-of-way clearings, considerations of traffic and animal safety requirements may nullify the benefits that the clearings of segregated powerline clearings may realize. Revegetation of road clearings can, however, add some continuity between tall stands of forest and the abrupt barrenness of a road (Map M8).

In addition to the general concepts discussed above, site specific renderings are presented in Appendix A which indicate the anticipated visual effects of the reclamation program, including revegetation in eight of the eleven drawings. It should be noted that, in general, forage for wildlife is emphasized on relatively flat slopes (Appendix A-R2) conifers dominate the steeper slopes for aesthetic reasons, and shrubs and deciduous trees are prominent along water courses and lake-shores to enhance wildlife and fish habitat. Recreational use features such as fishing access will be taken into account. Primary consideration in initial seeding will always be given to erosion control in all areas and special plantings will be employed in potential problem areas.

Table 4 and the following Revegetation Plan (Map M9) present the overview concept for the minesite. Slope angle is indicated as the key variable with other parameters to be refined through the field study program. It is especially significant that dump slopes



EXISTING POWER LINE LOCATION ————
 POWER LINE RELOCATION - - - - -
 EXISTING FORESTRY ROAD ————
 HIGHWAY LOCATION (FORESTRY) - - - - -
 RAILWAY LOCATION ————

0-1 MINING AT COMPLETION
 0-2 ROAD AND UTILITY MODIFICATIONS
 0-3 EXISTING SURFACE DRAINAGE AND MONITORING STATIONS
 0-4 MODIFIED SURFACE DRAINAGE
 0-5 EXISTING VEGETATION
 0-6 REVEGETATION PLAN

ELK RIVER 75(2)A

ELCO MINING LTD.	
ELK RIVER COAL PROJECT	
ROAD AND UTILITY MODIFICATIONS	
DATE: 1975	SCALE: 1:50,000
BY: M.B.	DATE: 10-11
TECHMAN LTD.	

are benched and do not exceed 25° as is often the case in Rocky Mountain coal mining, thereby insuring that a good vegetative cover can be readily established as mining progresses. Table 5 provides revegetation data for the minesite.

TABLE 3

DISTRIBUTION OF HABITAT TYPES WITHIN THE
MINE SITE OF THE ELK RIVER COAL PROJECT

<u>HABITAT TYPES</u>	<u>ACRES</u>	<u>(HECTARES)</u>	(%) <u>Total Habitat Type on Project Area</u>
1. Forest			
Pine*	2,625.7	(1,062.6)	30.4
Spruce	79.0	(32.0)	54.3
Pine-Aspen	114.6	(46.4)	25.5
2. Open Forest	897.5	(363.2)	18.2
3. Forest and Shrub	1,180.1	(477.6)	44.9
4. Fen or Meadow	138.1	(55.9)	26.9
5. Alpine	<u>39.8</u>	<u>(16.1)</u>	2.9
TOTAL	5,074.8**	(2,053.8)	

Notes:

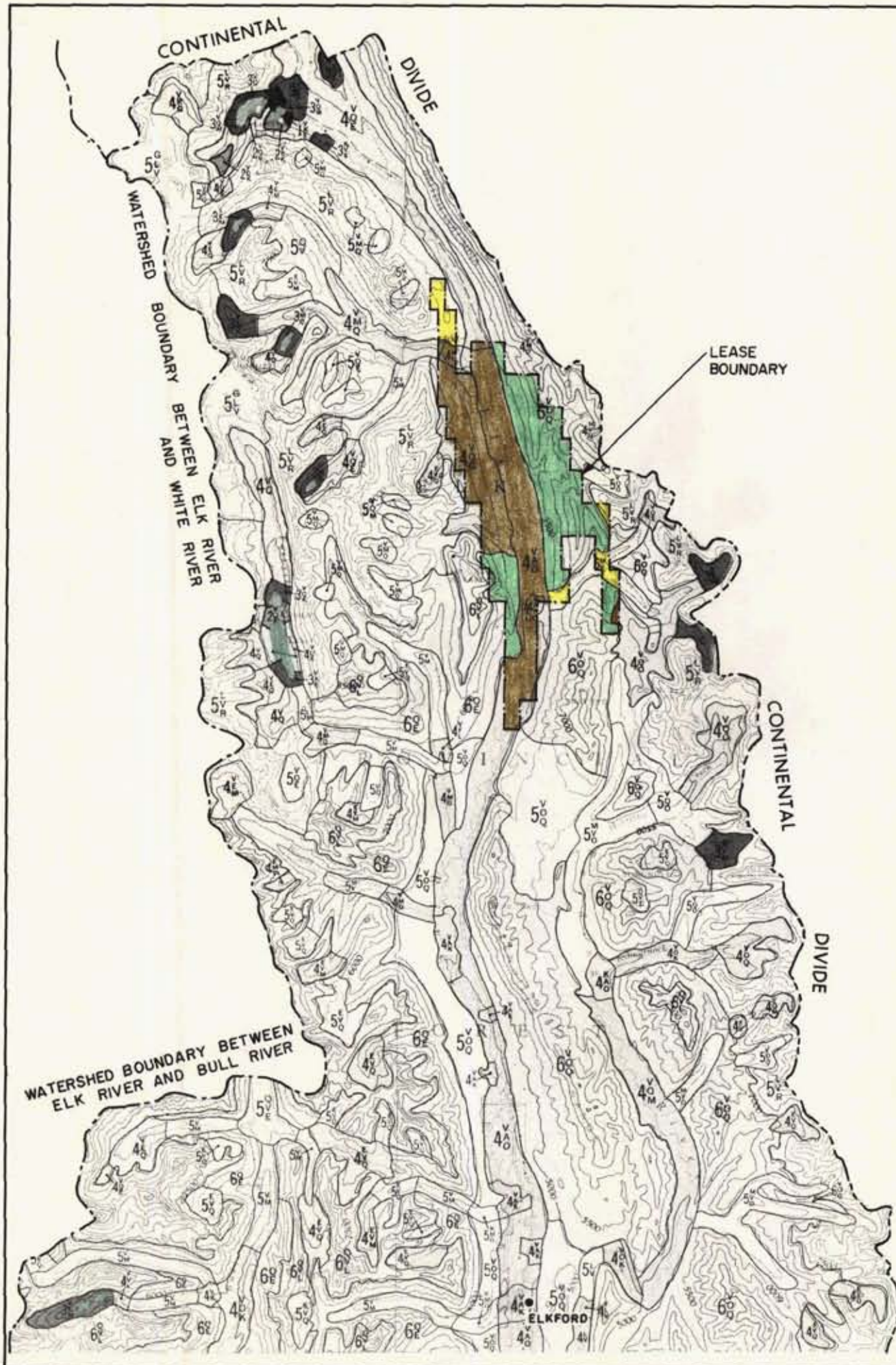
* Pine (2,625.7 acres) includes 38.2 acres of mature pine.

** This represents 26.4% of the total lease area of 19,200 acres.

TABLE 4
ACREAGE CLASSIFICATION FOR REVEGETATION AND
MITIGATIVE ENHANCEMENT OF OFFSITE UNGULATE RANGES

TYPE	CHARACTERISTICS	TREATMENT
A. HIGH CAPABILITY Natural Soil Reclaimed Soil	Low relief (0° to 15°) Offsite* wildlife habitat improvement areas. Bench slopes on dumps & other level disturbance areas	Fertilized & seeded where appropriate with preferred forage species. Fertilized & seeded with preferred forage species.
B. MODERATE CAPABILITY Natural Soil Reclaimed Soil	Moderate relief (15° to 25°) Offsite* wildlife habitat improvement areas. Dump slopes; some exploration trenches, road cuts & fills	Fertilized & seeded where appropriate with preferred forage species. Fertilized & seeded with initial cover crop and/or conifers. Planted where appropriate with conifers.
C. LOW CAPABILITY Reclaimed Soil	High Relief (25° to 35°) Some exploration trenches & most roadway cut & fill slopes	Fertilized, mulched & seeded with initial cover crop and/or conifers. Planted where appropriate with conifers.
D. PARTIALLY RECLAIMABLE Reclaimed Soil	35°+ slopes Pockets on excavated rock faces	Utilize mining or specially developed benches for aesthetic landscape plantings.

*Offsite: Key wildlife areas, outside the mining site depicted on the revegetation map, with potential for forage improvement to offset temporary losses resulting from mining.



DESCRIPTIVE LEGEND

Seven classes of land are differentiated on the basis of the intensity of outdoor recreational use, or the quantity of outdoor recreation, which may be generated and sustained per unit area of land per annum, under perfect market conditions.

"Quantity" may be measured by visitor days, a visitor day being any reasonable portion of a 24 hour period during which an individual person uses a unit of land for recreation.

"Perfect market conditions" implies uniform demand and accessibility for all areas, which means that location relative to population centres and to present access do not affect the classification.

Intensive and dispersed activities are recognized. Intensive activities are those in which relatively large numbers of people may be accommodated per unit area, while dispersed activities are those which normally require a relatively larger area per person.

Some important factors concerning the classification are:

- The purpose of the inventory is to provide a reliable assessment of the quality, quantity and distribution of the natural recreation resources within the settled parts of Canada.

- The inventory is of an essentially reconnaissance nature, based on interpretation of aerial photographs, field checks, and available records, and the maps should be interpreted accordingly.

- The inventory classification is designed in accordance with present popular preferences in non-urban outdoor recreation. Urban areas (generally over 1,000 population with permanent urban character), as well as some non-urban industrial areas, are not classified.

- Land is ranked according to its natural capability under existing conditions, whether in natural or modified state; but no assumptions are made concerning its capability given further major artificial modifications.

- Sound recreation land management and development practices are assumed for all areas in practical relation to the natural capability of each area.

- Water bodies are not directly classified. Their recreational values accrue to the adjoining shoreland or land unit.

- Opportunities for recreation afforded by the presence in an area of wildlife and sport fish are indicated in instances where reliable information was available, but the ranking does not reflect the biological productivity of the area. Wildlife capability is indicated in a companion series of maps.

CLASS 1 LANDS IN THIS CLASS HAVE VERY HIGH CAPABILITY FOR OUTDOOR RECREATION.

Class 1 lands have natural capability to engender and sustain very high total annual use based on one or more recreational activities of an intensive nature. Class 1 land units should be able to generate and sustain a level of use comparable to that evident at an outstanding and large bathing beach or a nationally known ski slope.

CLASS 2 LANDS IN THIS CLASS HAVE A HIGH CAPABILITY FOR OUTDOOR RECREATION.

Class 2 lands have natural capability to engender and sustain high total annual use based on one or more recreational activities of an intensive nature.

CLASS 3 LANDS IN THIS CLASS HAVE A MODERATELY HIGH CAPABILITY FOR OUTDOOR RECREATION.

Class 3 lands have natural capability to engender and sustain moderately high total annual use based usually on intensive or moderately intensive activities.

CLASS 4 LANDS IN THIS CLASS HAVE MODERATE CAPABILITY FOR OUTDOOR RECREATION.

Class 4 lands have natural capability to engender and sustain moderate total annual use based usually on dispersed activities.

CLASS 5 LANDS IN THIS CLASS HAVE MODERATELY LOW CAPABILITY FOR OUTDOOR RECREATION.

Class 5 lands have natural capability to engender and sustain moderately low total annual use based on dispersed activities.

CLASS 6 LANDS IN THIS CLASS HAVE LOW CAPABILITY FOR OUTDOOR RECREATION.

Class 6 lands lack the natural quality and significant features to rate higher, but have the natural capability to engender and sustain low total annual use based on dispersed activities.

SUBCLASSES

Subclasses indicate the kinds of features which provide opportunity for recreation. They are, therefore, positive aspects of land and do not indicate limitations to use. Features may be omitted from a unit, either because of the imposed three-feature limit, or because their presence was unknown or unconfirmed.

The degree to which these features are judged capable, collectively, of generating and sustaining use for recreation, determines the class. The sequence in which they are listed indicates the order of their significance. Subordinate features may be relatively insignificant and the class of a unit should not be interpreted to indicate the capability of a secondary or tertiary feature.

The subclasses are:

SUBCLASS A—Land providing access to water affording opportunity for angling or viewing of sport fish.

SUBCLASS B—Shoreland capable of supporting family beach activities. In high class units this will include family bathing. In Classes 4 and 5, the activities may be confined to dry land due to cold water or other limitations.

SUBCLASS C—Land fronting on and providing direct access to waterways with significant capability for canoe tripping.

SUBCLASS D—Shoreland with deeper inshore water suitable for swimming or boat mooring or launching.

SUBCLASS E—Land with vegetation possessing recreational value.

SUBCLASS F—Waterfall or rapids.

SUBCLASS G—Significant glacier view or experience.

SUBCLASS H—Historic or pre-historic site.

SUBCLASS J—Area offering particular opportunities for gathering and collecting items of popular interest.

SUBCLASS K—Shoreland or upland suited to organized camping, usually associated with other features.

SUBCLASS L—Interesting landform features other than rock formations.

SUBCLASS M—Frequent small water bodies or continuous streams occurring in upland areas.

SUBCLASS N—Land (usually shoreland) suited to family or other recreation lodging use.

SUBCLASS O—Land affording opportunity for viewing of upland wildlife.

SUBCLASS P—Areas exhibiting cultural landscape patterns of agricultural, industrial or social interest.

SUBCLASS Q—Areas exhibiting variety, in topography or land and water relationships, which enhances opportunities for general outdoor recreation such as hiking and nature study or for aesthetic appreciation of the area.

SUBCLASS R—Interesting rock formations.

SUBCLASS S—A combination of slopes, snow conditions and climate providing downhill skiing opportunities.

SUBCLASS T—Thermal springs.

SUBCLASS U—Shoreland fronting water accommodating yachting or deep water boat tripping.

SUBCLASS V—A vantage point or area which offers a superior view relative to the class of the unit(s) which contain it, or a corridor or other area which provides frequent viewing opportunities.

SUBCLASS W—Land affording opportunity for viewing of wetland wildlife.

SUBCLASS X—Miscellaneous features with recreational capability.

SUBCLASS Y—Shoreland providing access to water suitable for popular forms of family boating.

SUBCLASS Z—Areas exhibiting major, permanent, non-urban man-made structures of recreational interest.

K-ELK RIVER 75(2)A

ELCO MINING LTD.			
ELK RIVER COAL PROJECT BRITISH COLUMBIA, CANADA			
CANADA LAND INVENTORY RECREATION LAND CAPABILITY			
SCALE: 0 5 MILES	DRAWING NO. M-11		PROJECT NO. TM-113
DATE: MAY 1975	DRAWN BY:	APPROVED BY:	
TECHMAN LTD.			

TABLE 5

REVEGETATION IN TERMS OF RECLAIMED ACREAGES

SLOPE CHARACTER- ISTICS	RECLAIMED MINE AREA		RECLAIMED ROADS		TOTAL	
	Acres	Hectares	Acres	Hec.	Acres	Hectares
A. 0°-15°	2,775.1	(1,123.1)	5.8	(2.3)	2,780.9	(1,125.4)
B. 15°-25°	183.7	(74.3)	---	---	183.7	(74.3)
C. 25°-37°	941.2	(380.9)	74.5	(30.2)	1,015.7	(411.1)
D. 35°+	<u>270.2</u>	(<u>109.3</u>)	<u>---</u>	<u>---</u>	<u>270.2</u>	(<u>109.3</u>)
	4,170.2	(1,687.7)	80.3	(32.5)	4,250.5	(1,720.1)
<u>UNCLASSIFIED:</u>						
Minesite to Elkford:	Corridor Area				<u>475.2</u>	(<u>192.3</u>)
			TOTAL		<u>4,725.7</u>	(<u>1,912.5</u>)
					acres	hectares

7.0 AQUATIC LIFE

The fisheries of a watercourse can be limited by a number of physical and/or chemical variables. Common parameters which may limit fish productivity or which may further limit the fisheries if measures are not adopted to at least maintain existing conditions include the following.

Habitat - streams which have a variety of types of habitat are usually considered the most productive for salmonids. Riffle areas produce the greatest abundance of macroinvertebrates (the food of fish); however, generally fish feed in the riffles only at night and they spend the daylight hours in the cool deep pools. Therefore, a stream with alternating pools and riffles usually has good potential for high fish productivity. Furthermore, the riffles help oxygenate the water and may provide spawning habitat (if moderate sized gravel is available), while the pools provide rearing and overwintering habitat.

Current - heavy current sometimes limits the fishery potential as fish will not tolerate swift currents for long periods.

Temperature - fish are poikilotherms (cold-blooded), therefore their metabolic rate is determined by the temperature of their environment. While most fish can tolerate water temperature other than the preferred, sudden (even though small) changes can cause fish kills (THREINEN, 1958). Furthermore a temperature rise may have adverse effects on hatching of fish eggs. However, the salmonid productivity of some extremely cold watercourses can be increased by allowing warming, that is, by

removing some of the streambank vegetation.

Oxygen - the dissolved oxygen is frequently a limiting factor. Salmonids require a high concentration of dissolved oxygen. The lower limits of dissolved oxygen tolerance for salmonids is considered to be 5 p.p.m. This factor must also be considered necessary for spawning redds (fish eggs).

Sediment - sediment and silt can kill fish directly, but more frequently these materials affect the fisheries by settling out on spawning redds, thus reducing the oxygenation of the fish eggs, causing embryo mortality. HYNES (1973) feels, "tolerable level of turbidity is probably less than 80 mg./l. of inert silt and that any considerable amount of deposition is bound to have biological consequences".

Food - salmonid fish feed mainly on invertebrates - both terrestrial and aquatic - and other fish. Streambank vegetation serves to increase the availability of invertebrate from both environments. Enhancement techniques, such as adding organic material to a nutrient poor stream, or increasing the total habitat, micro or macro, will increase the productivity of aquatic invertebrates, thus increasing the fisheries potential (MUNDIE, 1974).

7.1 Existing Conditions and Populations

The Elk River upstream from the Cadorna Creek confluence is a braided, meandering stream with considerable potential for trout spawning (Clark, undated).

B.C. Research (Report #2, Table 4) reports that downstream from Cadorna Creek the streambed becomes narrow and straight, thus creating a swift current with a sub-

strate composed of mainly large boulders and rubble. It contains a large number of pools, most of which are quite large and deep and offer adequate fish shelter (Class 2)*. The stream bank vegetation consists mainly of pine forest and brush (primarily willow), which helps stabilize the stream bank.

Stream bank vegetation shades the waters (helping to maintain constant temperature); provides a habitat for terrestrial insects which are a source of food for fish; and the leaves, seeds, roots and twigs being dropped or washed into the watercourse provide a food source for a large number of aquatic invertebrates and a nutrient source for aquatic plants (primary producers).

Downstream from the Weary Creek confluence the Elk River becomes a meandering, braided stream again, with a more gradual gradient (Hooton, 1971, and BCR Report #2) and contains a substrate composed of finer material - rubble and gravel (BCR Report #2). Clark (undated) describes these side channels as being important spawning and rearing areas, and since they provide a greater river bottom surface, the total macroinvertebrate productivity would probably be much higher than the single channel.

Tributaries of the Elk River

Within the project area those tributaries lying between Cadorna and Bleasdell Creeks are the watercourses which will be directly affected by the mining activity. The

**Class 1 pools are largest, deepest and offer maximum fish shelter; classification is graded down to Class 5 pools, which are small, shallow, and offer no fish shelter (BCR Report #2, p.13).*

creeks within this area include Gardner Creek, Weary Creek and five intermittent streams.

Of the "on-site" creeks, Gardner is probably the most important for fish. The lower end, which is ponded by beaver dams, provides good rearing habitat. This pond is fed by three tributaries, all of which have an extremely steep gradient and would therefore be of limited fisheries value except in the lower portions which may be suitable for spawning redds. Furthermore, if fish managed to migrate past this first steep gradient, the pools in the upper reaches are relatively short and shallow (Class 4 and 5) offering little shelter for fish. The substrate is composed mainly of coarse material - boulders, rubble and gravel, providing limited habitat. Most of the stream bank vegetation along this creek is made up of forest with the balance being brush.

At its upper reaches, Weary Creek has a steep gradient (about 350 feet [106.7 m.] vertical drop per mile) and offers little potential for fish spawning or rearing. It also contains three barriers to fish migration - a log jam, a waterfall, and high velocity water. However, a good sized cutthroat was sighted upstream from these barriers (Clark, undated). There are a number of pools (26) of which half are large and deep (Class 1). The substrate fairly medium-sized material, therefore offering some potential for spawning. The stream bank vegetation does not contain any forest; it is made up of mainly brush (Appendix B-P8).

Most of the other five tributaries, being intermittent, would be of minimal value to any aquatic life. However,

their steep gradients probably contribute to a significant sediment load which is carried into the Elk River during runoff periods.

The other two tributaries within the project area, but outside the mining site, namely Bleasdell Creek and Aldridge Creek, are the most important fisheries tributaries within the lease area, with the Aldridge ranking first.

Bleasdell Creek has a steep gradient ranging from 200 ft./mile (100 m./km.) at the lower reaches to 500 ft./mile (250 m./km.) at the upper reaches. It contains a variety of substrate sizes. The habitat is mainly riffles with a few small shallow pools. Its streambanks are mainly forest with some brush. However, Clark (undated) implies fish migration up this creek may be blocked by an improperly installed road culvert.

Aldridge Creek gradient is more moderate, ranging from 130 ft./mile (65 m./km.) to 280 ft./mile (140 m./km.) Near the mouth, the stream breaks up into a braided stream and the stream banks contain thick growths of willows. There are numerous locations in this area which would be suitable for spawning. Upstream from this area the creek is made up of a pool-riffle habitat with a variety of substrate sizes, but only pockets of spawning-sized gravel (Clark, undated).

Macroinvertebrates

Comparing the results of Hooton et al (1971) macroinvertebrate collections (presented in Appendix C in graph form) indicate there is an inhibiting effect

exerted on the macroinvertebrates within the project area - at the lower end (Station 2 - upstream from Aldridge Creek, presented in Appendix C in graph form). This type of inhibition (which affects all groups of organisms) usually indicates the presence of a toxin. However, he points out that the conditions at Station 2 differed from the other stations in that the gradient was steeper (causing a swift current) and the substrate was bedrock, cobble and sand, rather than gravel, which may account for this difference in relative abundance. Hooton (1971) also found there was a shift in population as the summer progressed, with mayflies (Ephemeroptera) and stoneflies (Plecoptera) becoming more and more dominant.

The results of the B.C Research (Report #5) macro-invertebrate samples (presented in Appendix C in graph form) indicate a considerable reduction in macro-invertebrates downstream from the Cadorna Creek confluence, with the greatest reduction occurring at two stations - one downstream from the Gardner confluence (Station WS3) and the other immediately upstream from Aldridge Creek (WS5, close to Station 2, used by Hooton et al).

During August all of Elk River within the lease area appears to be as productive as the upstream locations with the exception of the area directly below the Weary confluence (Station WS-4a is Station WS-4 relocated to the west side of the river).

October sampling indicates a possible return to the springtime conditions in that the area downstream from Gardner Creek is less productive than the upstream

areas. And there is also (as during the spring) a reduction of organisms downstream from the Bleasdell Creek confluence.

Comparing the macroinvertebrate samples collected in the tributaries for each of the three sampling periods, Gardner Creek sample contained very few organisms. The results of the July sampling indicate Creeks A and D also have low productivity.

Weary Creek experienced the most interesting shift in community structure. During the spring there was a dense population of mayflies (91 individuals), with caddisflies (Trichoptera) ranking second (16 individuals), and trueflies (Diptera) ranking third (11 individuals). The stonefly population was very sparse with only three organisms were collected. During the summer, however, stoneflies (P) became dominant (67 individuals) with mayflies (E) ranking second (36 individuals), caddisflies (T) third (28 individuals) and flies (D) fourth (24 individuals). The results of the samples indicate there is a return to a community structure similar to the springtime except that flies now rank second (28 individuals) and stoneflies third (22 individuals).

The community structure in Aldridge Creek remained fairly constant throughout the period, although the productivity (total number of individuals) was lower than that of Bleasdell Creek and Cadorna Creek.

Bleasdell Creek and Cadorna Creek had similar productivity and community structure.

In the tributaries there is a definite shift in community structure as the summer progresses. The warmer weather appears to favour all the organisms but especially stoneflies, which becomes quite numerous by fall. This increase in productivity is probably a response of the organism to availability of food (deciduous leaves and other organic material being dropped or washed into the watercourse).

7.2 Impact Considerations

Mining activities in the East Kootenays has resulted in impacts which should be used as an example to develop sound mitigative measures. Strip coal mining and stream alteration can result in:

- reduced or eliminated spawning habitat;
- reduced rearing potential;
- reduced fish holding capacity (clearing of stream-bank vegetation, channelization removes the cutbank and pool habitat);
- reduction in diversity and abundance of aquatic macroinvertebrates.

Hooton et al (1971) feel that the most serious impact of strip mines on watercourses is the runoff and subsequent siltation of the streambed. Reference is made to the reduced fisheries productivity of Harmer Creek, Erickson Creek, Clode Creek and portions of Michel Creek as examples of the effects of strip mining on watercourses in the East Kootenays.

Diversions and the relocation of watercourse are also

considered to be potential sources of serious erosion, siltation and flooding problems. Proper planning well in advance of production is expected to minimize the effect of piled waste and overburden slumping and runoff problems.

7.3 Mitigation Measures & Enhancement Techniques

While the above mentioned concerns may present a problem, proper mitigative measures could minimize the effect. The Upper Elk River and the tributaries within the study area (especially Weary Creek and the five intermittent streams between Cadorna confluence and Gardner Creek) already possess flash peak characteristics (Table 2). The diversion of the headwaters of these intermittent streams, as indicated in the accompanying drawings (Appendix A-R1) will reduce this peaking. Precautions should also be taken to reduce the erosion-siltation problem. For example, using gabions and/or rock berms strategically placed in drainage ditches and settling ponds with sediment trap outflows will reduce a large percentage of the sediment gaining access to the Elk River (Appendix A-R4,5). But erosion controlled at the source, by vegetating the stream banks and all hillsides, is of even greater significance.

Furthermore, the large rocks used to construct the Elk River diversion channel will create microhabitats behind, between and below these large rocks. Here current is reduced thus allowing much of the sediment load of the stream to settle out. In addition, in areas where potential erosion problems exist, the rip-

rap will be graded with the coarse material near the bottom and with the finer material near the top, which should remove much of the sediment load being carried down the channel bank by runoff.

The exposed channel will be subject to temperature fluctuations. However, if the channel is built with pools and riffles, the water temperature will not experience extreme fluctuations and will offer a varied habitat.

The increased surface area due to coarse, oblique shaped shot rock will increase the primary productivity, and consequently fish productivity. These micro-habitats would probably also be suitable for fish shelter, where there is a reduced current, thus compensating for the reduction of cutbank habitat.

The 1.4 miles (2.3 km.) of tunnel may affect the temperature and/or the dissolved oxygen (Section 3.3). However, considering a velocity of 3.5 ft/sec. (.72 m./sec.), the velocity at Forestry Bridge during September (BCR Report #2, Table 2), the water would take 35 minutes or less to pass through the tunnel (or winter rate of approximately 2 ft./sec. [2.1 m./sec.] would require one hour). It is unlikely that the waters would experience a serious change in dissolved oxygen or temperature during this period. However, pools at both ends of the tunnel will help to equalize the temperature besides providing a resting place for migrating fish.

The tunnel may present a barrier to migrating salmonid fish, but baffles (Appendix A-R5) should aid fish in

passing through (fish cannot swim against velocities of greater than .5 cm./sec. for very long). In Germany tunnel workmen have observed fish migrating through long tunnels and large resident fish populations dwelling within these tunnels. Therefore, the tunnel concept for this project is unlikely to prevent fish migration.

Each end of the tunnel, especially if the current can be kept to a minimum, will probably be used by fish as a daytime refuge (shelter).

All culverts will be planned and placed in such a manner so as not to block fish passage (see Appendix A-R5 and R10). Therefore fish will be allowed to migrate upstream into the mining site and colonize the shallow lake, and probably the settling pond. The Gardner Creek feeding this lake may be used by the newly established population as a spawning area or it could be altered into a spawning channel.

Relocating the drainages off Little Weary Ridge and Weary Creek and directing them into the deep lake will reduce the magnitude of the flash peaks, thus improving the Elk River fish habitat.

In summary, the information available indicates that at present the Elk River within the project area has low to moderate fisheries potential due to the swift current and extreme discharge oscillations. Fisheries of the section may also be limited by the apparent low productivity of fish food organisms (macroinvertebrates) downstream from the Weary Creek (Stations WS4, WS4a and WS5). Judging from the macroinvertebrates and

the water chemistry results, it appears that the water from the vicinity of the proposed mining site contains an inhibiting substance. This hypothesis is further illustrated by the difference in color between the water of Gardner Creek and of the Elk River (Appendix B-P7).

Open-pit mining possesses the potential for exerting a serious impact on the watercourses of the area. However, if proper precautions are taken, the effect would be minimal, and the long-term effect (with the development of lakes) will be an increase in the fisheries potential.

TABLE 6

FISH OF THE UPPER ELK RIVER WATERSHED

S P E C I E S	RELATIVE ABUNDANCE	HABITAT	FOOD	SPAWNING SEASON	SPAWNING HABITAT
Yellowstone Cutthroat Trout (<u>Salmo clarki lewisi</u>)	Abundant	Lakes & rocky pools & back eddies of streams	Primary - aquatic and terrestrial invertebrates. Secondary - fish.	Spring and early summer	Migrate short distances > 2 miles. Spawn in redds dug on upstream end of riffles.
Dolly Varden (<u>Salvelinus malma</u>)	Common	Probably live in lakes & migrate into stream to spawn.	Primary - fish. Benthic organisms - molluscs, insect larvae and fish eggs.	Fall (mid-August to early November)	May migrate long distances; Spawn in streams.
Eastern Brook Trout (<u>Salvelinus fontinalis</u>)	Occasional	Thrives best in cold, clear streams.	Primary - insects; Secondary - fish.	Spawn in fall; hatch in spring	Constructs redds in gravel beds of streams (and possibly lake shoals.)
Mountain Whitefish (<u>Prosopium williamsoni</u>)	Abundant	Lakes & streams (often found in swift flowing streams)	Chiefly a bottom feeder, mainly on insect larvae.	Spawn in late October or early November. Eggs hatch in March	Release eggs on gravel in shallow water. Spawn in lakes.
Bridgelip Suckers (<u>Catostomus columbianus</u>)	Rare	Running water.	Probably eat algae off rocks.	Late spring.	Probably spawn in streams.

8.0 TERRESTRIAL WILDLIFE

8.1 Preliminary Findings on Wildlife Habitat Conditions and Utilization

Wildlife of the Elk River Valley can be categorized according to resource use:

- a) Big game: elk(wapiti), moose, mule deer, white-tailed deer, mountain goat, bighorn sheep, grizzly bear, black bear, cougar.
- b) Fur bearers: coyote, lynx, muskrat, wolverine, beaver.
- c) Upland game birds: blue grouse, spruce grouse, ruffed grouse.
- d) Waterfowl: mallard, green-winged teal, widgeon, common merganser.
- e) Miscellaneous: songbirds, shorebirds, raptors, amphibians, reptiles, small mammals, insects.

Species composition for the area is lacking for micro-tine rodents, carnivores, birds, reptiles and amphibians.

Land capability maps (Canada Land Inventory) indicate the importance of big game capability in the project area; alternatively, the capability for waterfowl here is estimated as "negligible" or "nonexistent".

"Moderate big game range", consisting of Class 3 range and Class 3 winter range, covers approximately 19% of

the project area. For waterfowl, the Canada Land Inventory characterizes the Elk River Valley as Class 7, being defined as an area with such severe limitations that almost no waterfowl are produced. A Class 6 habitat, with low capability for waterfowl production, is located halfway between Cadorna and Aldridge Creeks along the Elk River. Seasonal use of this region by waterfowl migrants has been observed but not evaluated.

Previous inventory projects in the valley have centered primarily on ungulate distributions. Almost the entire area is used as summer range by elk, moose, deer, black bear and grizzly. Moose, unlike deer and elk, reportedly remain on the flats and lower slopes of the valley throughout the summer. Relative numbers and wintering distributions within the project area are not presently known.

It is reported that the riparian habitat along the Elk River as well as the south and west facing slopes along Aldridge Creek serve as "moderate to extensively used" winter range for elk and moose.

According to British Columbia Fish and Wildlife aerial surveys, mountain goat winter ranges seem well removed from the project area. Significant elk winter ranges are placed along the Todhunter and Ewin tributaries of the Elk River; moose winter ranges along the base of the Greenhills Range; and bighorn sheep winter ranges along Ewin Creek.

These wintering ranges are situated outside the immediate project area, but the degree of movement to the Elk River property and its importance for summer

ranges or movement corridors (access to northerly ranges) for these ungulates remains undetermined.

Snowfall data for the lease are unavailable, and it is ultimately this variable that can limit the capability of this area as winter range. Generally, ungulates are severely restricted by snow which exceeds two-thirds of chest height, deer then being more confined than moose (KELSALL AND TELFER, 1971).

Beavers are significant residents of the valley bottom areas in that they have contributed to the marshy nature of the flat benches above the Elk River.

8.2 Habitat Removal Considerations

As Table 3 indicates, about 5,074 acres (or 2,053.8 ha, 26.4% of the entire 19,200 acres [7,770.2 ha.] of project area) will be removed or disturbed by mining development. The greatest single acreage loss involves pine forest (2,625.7 acres, 1,062.6 ha., or 30.4% of the existing stands on the project area). While this pine forest may provide cover for big game, it would have marginal value for forage. As grazing and browsing by ungulates is expected to occur mainly in the valley bottoms and on the lower slopes of adjacent mountains, the loss of 2,215.7 acres (896.7 ha.) of "open forest", "forest and shrub", and "fen or meadow" habitats (Table 3) will encroach on summer, and possibly winter, foraging for the ungulates.

The proposed coal mining development will necessitate habitat removal or alteration and, until reclamation

proceeds, renewable resource productivity will be disrupted. However, total habitat loss must be measured in the context of the entire Elk River Valley, not only in the immediate coal development area. Development of service lines and transportation corridors to the mining area will have adverse affects on wildlife especially since these facilities follow the valley bottom. Local east-west movements will be hindered and road kill problems should be expected.

Habitat removal must be examined in an ecological context, in terms of the interrelations and interactions among ecosystem elements. Loss of habitat ultimately results in localized mortality for sedentary wildlife, and increased competition and starvation elsewhere for the more mobile species. To illustrate that this is a real problem, approximately 50% of the bighorn sheep in the East Kootenay region died during the 1964-65 winter due to a combination of adverse environmental conditions resulting in malnutrition and disease (B.C. Fish and Wildlife Branch).

Ungulates traverse several habitat types and relatively long distances, certainly during seasonal movements. Localized interruption in the continuity of the landscape, such as intensive mining activity, could result in alteration of traditional movements.

Loss of beaver habitat entails similar biotic and physical effects. Beaver dams typically foster a wide array of animal and plant life, and exert significant effects on stream flow variables and water quality downstream. Amphibians in considerable numbers can be expected to use these ponds year round or

seasonally for spawning and early development. These animals are in turn an important food source for birds, mammals and possibly fish.

8.3 Possible Responses to Anticipated Disturbances

A general scenario of wildlife response to significant disturbance is as follows: As habitat destruction proceeds, local animal populations perish or withdraw to less favourable habitat; actual movements from preferred habitat to marginal or overpopulated habitat imposes risk factors on wildlife; both physiological stress due to disturbance, and the coalescence of normally well dispersed individuals contribute to substantial drains on the carrying capacity of the range; all these factors, beginning with the initial disturbance and ending with loss of food quality, individually and/or collectively affect wild animals through mortality from injury, disease, starvation and reproductive failure.

Taking the ungulates as indicator species, some examples of wildlife vulnerability and response to disturbance can be described:

- a) Ungulate species feed extensively on browse during the winter, and if they remain in the project area during winter, loss of habitat because of mining activity would engender increased inter-specific and intraspecific competition and mortality. In turn, further habitat reduction would result from the co-actions of different animals

intensively browsing and limiting the growth and extension of forage species.

- b) White-tailed deer and moose usually feed in isolation or small groups. Limited availability of suitable habitat results in clumping of individuals, thus increasing exposure to hunting.

- c) For elk and mule deer in particular, breeding and calving correspond to the timing of seasonal movements. Breeding success depends on the synchronization of sexually segregated herds. Restricted access to the rutting areas by either males or females can avert reproduction. Pregnant or lactating females are sensitive to interference; adverse conditions lead to embryo resorption, abortion, or calf abandonment.

Alternatively, land alteration necessarily creates new ecological conditions, or niches. As resident wildlife species are expelled or restricted, population levels of "disturbance" species or species adapted for human altered environments can be expected to rise. Many of the animals that have been designated "pests" (starlings, house sparrows, house mice) commonly possess the ability to adapt to changing conditions. Further, the assumption of pest-like behaviors by the native fauna is likely. Both black and grizzly bears are attracted to settlements with poor garbage or sewage disposal, becoming a nuisance, and a danger as man-bear interaction increases. Elk commonly shift ranges to foraging areas created by road and forest clearing; ultimately, those elk

isolated by development can become dependent on winter feeding programs. Disturbance and overgrazing of revegetated areas by elk may necessitate such feeding programs, or other control programs. Similarly, rodents are rapid colonizers of disturbance habitats and revegetated lands. Under these conditions, high rodent levels produce benefits for raptors and mammalian predators but may present problems for the revegetation program.

8.4 Mitigation Measures and Management Techniques

A wildlife resource strategy must evolve to relate land use and reclamation to wildlife habitat change, and the requirements of associated wildlife species. Such an environmental program should be based on the premise that diversity of wildlife is a desirable goal for a healthy and aesthetically pleasing environment.

Suggested guidelines for the environmental planning programs, as they relate specifically to wildlife, would include:

- a) An inventory of key wildlife resources, with considerations for resident and occasional species, population estimates, temporal distribution, habitat distribution, migration routes, and timing of critical life processes. These provide data to assess the initial impact of mining activity, and establish a baseline for development of management criteria.
- b) Identification of limiting factors: food sources, breeding locations, nesting and denning sites,

protective cover. A re-establishment of viable wildlife populations necessitates planning for the environmental conditions that enhance their carrying capacity success and distribution.

- c) Areas of potential impact, as determined from a) and b) above, to be outlined in order to institute a program of mitigation procedures as mine planning proceeds.
- d) Establishment of broad goals for impact alleviation: retention and creation of biological corridors to maintain all undisturbed spaces within the project as wildlife habitats; seasonal operations organized to minimize disturbance to crucial wildlife activities; use of manual rather than mechanical techniques where possible; sanctuary zones designated as wildlife refuges for the remainder of the lease; and a program of people management (hunting and access restrictions).
- e) A feedback system to gauge wildlife populations as mining development occurs, to sense unanticipated wildlife trends; provisions for adjustment and alternative mitigation measures.
- f) Consultation with Provincial Fish and Wildlife to determine East Kootenay wildlife management goals; presently the highest priorities for wildlife habitat improvement in the region are reduced livestock grazing and forest encroachment in key winter range areas (DEPT. OF RECREATION & CONSERVATION).

Land reclamation is a stated goal of the proposed mining project. Specifically, an objective of the environmental program is the recreation of wildlife habitat. New landscape features (Appendix B-R1 and R4) such as lake and marsh development, seem ideally pre-adapted for beaver colonization, further enhancement of reclaimed habitat to proceed according to the biological requirements of beaver.

As explained in the vegetation section (6.0), forage for big game animals will be encouraged in reclamation. The post-mining environment should be more productive in this regard than the existing coniferous slopes (Table 5). Furthermore, access in much of the project area is presently restricted due to the abundance of snags at and above ground level (Appendix B-P6 and P7).

9.0 HERITAGE RESOURCES

9.1 Information to Date

An evaluation of recreation resources given in the Land Capability Map (Ferne Area) conducted by the Canada Land Inventory, indicates no evidence of historic or pre-historic sites in the Elk River Valley.

Reference to the Elk River dates to the Palliser Expedition of 1858 (SPRY, 1963). Significantly, Palliser completely circumvented the upper Elk River Valley. Palliser entered present British Columbia through the Kananaskis Pass and proceeded west along the (present) Palliser River to its confluence with the Kootenay River. The return to the prairies involved the crossing of the Elk River near its junction with the Kootenay, and subsequent eastward movement, south of the Elk River, through the North Kootenay Pass. Palliser's associate, Blakiston, is recorded as crossing the Elk River near Wigwam River.

There is some possibility that Line Creek (north of Grave Creek, about 10 miles [16.1 km.] north of Natal-Michel), was part of a North Fork Pass route to the prairies. Similarly, other passes in the area, such as Weary Creek Gap or Fording River Pass, may have served as commercial routes for local Indians trading at fur trading posts in Alberta.

At present, however, no archaeological or historical inventory of the area is available.

9.2 Planning Considerations

There is a need for preliminary study to investigate the possibility of archaeological sites, historical routes, and historical buildings or remains. Consultation with universities, local history societies, native peoples, and the appropriate governmental agencies is required.

Commitments will be made for the preservation of on-site archaeological and historical sites through the development of heritage resources protection planning guidelines.

10.0 RECREATION RESOURCES AND USE

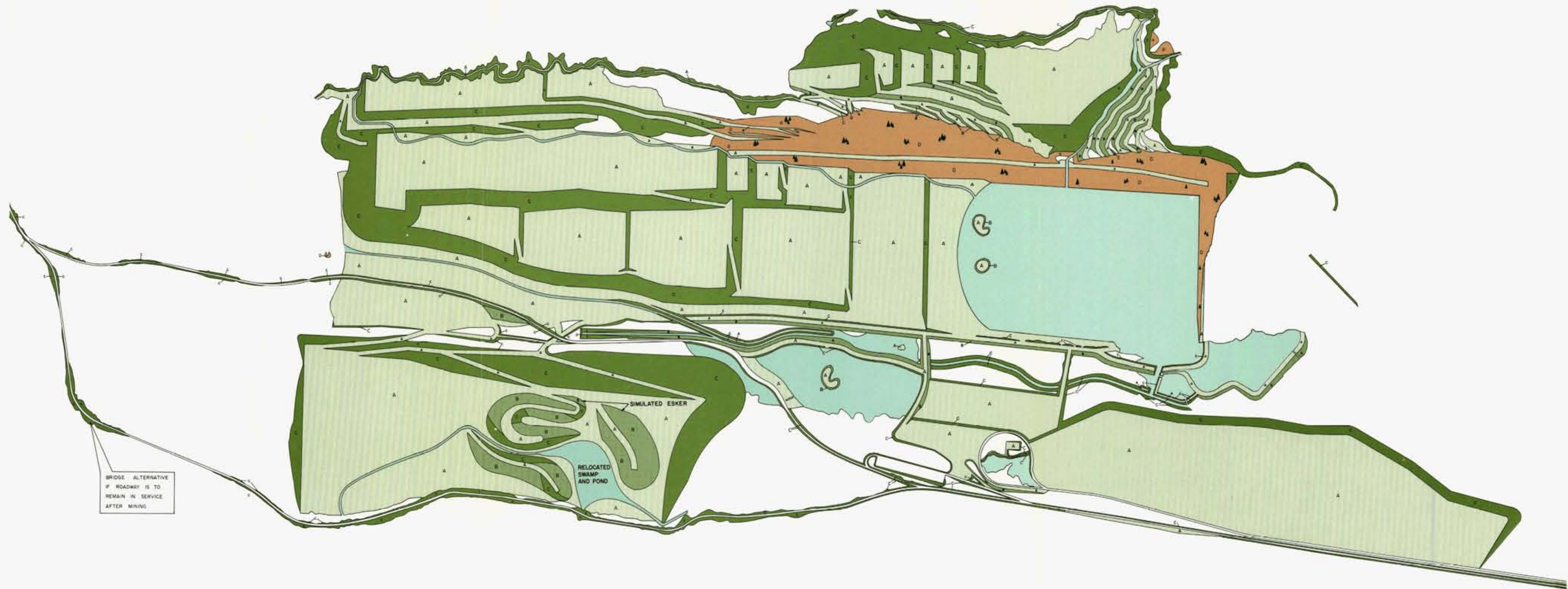
10.1 Resource Base Considerations

The Canada Land Inventory (Map M11) indicates the relative importance of recreation capability in the upper Elk River watershed. Recreation values, associated with scenic river valleys and mountains, are classified as "moderate". Reference is made to the possibilities for frequent viewing, sport fishing potential, and general outdoor recreation, such as hiking and nature study. Outside of the project area, the Canada Land Inventory judges the Elk Lakes (Appendix B-P4) and the upper Cadorna Creek watersheds as having "High Quality Recreational Values" (Appendix B-P5; Map M4).

Aside from hunting and fishing facilities near the Elk River-Cadorna Creek confluence (Appendix B-P15), there are no commercial recreational developments in the upper Elk River Valley, but there are sites naturally suited for camping, and all of the creeks and tributaries support game fish populations. The access and the fishing on almost all the creeks is impeded by fire-burned windfall, thick growths of brush along the banks and/or steep gradients (Appendix B-P6, 7 and 11). The valley provides a variety of big game, notably elk moose and deer.

The natural scenery has been modified considerably in the project area by roads and exploration scars (Map M2; Appendix B-P12).

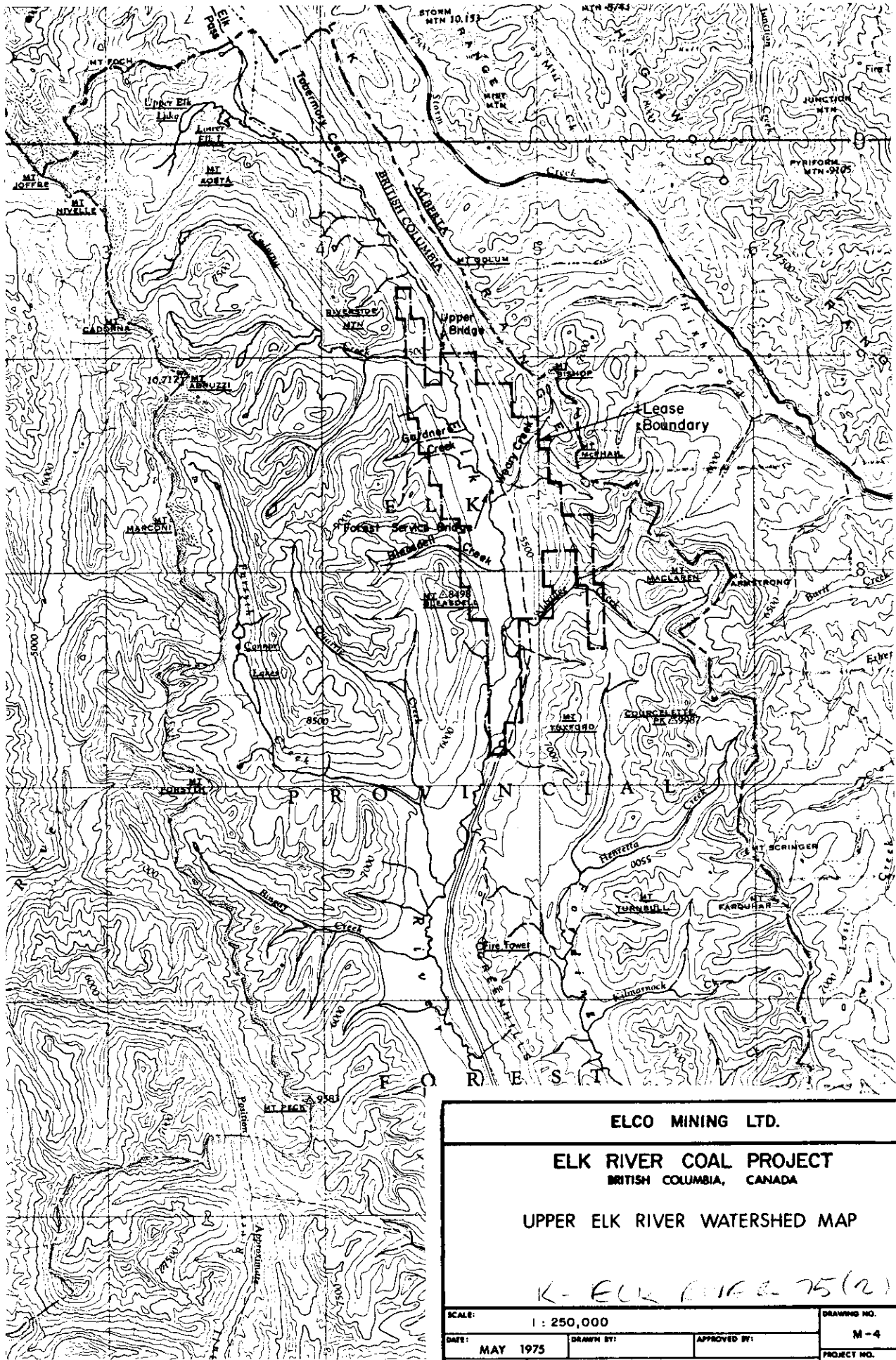
There are two points of visitor access to the upper Elk



- LEGEND**
- A SLOPE
 - B SLOPE
 - C SLOPE
 - D SLOPE
 - WATER SURFACE

K-ELK RIVER-75(2)A

ELCO MINING LTD.	
ELK RIVER COAL PROJECT	
WEST COLUMBIA, GEORGIA	
REVEGETATION PLAN	
DATE: 10/11/93	SCALE: 1" = 50'
TECHMAN LTD.	



ELCO MINING LTD.			
ELK RIVER COAL PROJECT BRITISH COLUMBIA, CANADA			
UPPER ELK RIVER WATERSHED MAP			
<i>K-ELK 0163 75(2)A</i>			
SCALE:	1 : 250,000		DRAWING NO.
DATE:	MAY 1975	DRAWN BY:	APPROVED BY:
TECHMAN LTD.			M-4
			PROJECT NO. TM - 113

River Valley: a northern entry via the Elk Pass road (Appendix B-P3) from the Kananaskis Lakes (Appendix B-P2) in Alberta, and a southern entry from Elkford, British Columbia (Appendix B-P16).

10.2 Existing and Potential Use Considerations

In a survey conducted by British Columbia Fish and Wildlife and B.C. Research during July and August of 1971, an estimated 181 anglers fished along the upper Elk River and caught approximately 344 cutthroat, 34 Dolly Varden, and 185 whitefish; the success ratio for cutthroat was 0.90 while success for all species was 1.48.

A further recreational survey (Bull, 1972) was conducted in the Elk Valley. The study was limited to the area between the headwaters of Elk River and its confluence with Fording River; that is, encompassing the project area. Essentially, the study measured summertime recreation; some of the findings relevant to the Elk River Coal Project include:

- a) During July and August, 1972, some 10,000 people spent a total of 24,000 days of recreation in the Elk Valley. The valley is apparently heavily utilized in winter by snowmobile enthusiasts.
- b) The valley was visited equally by Albertans and British Columbians, with most Albertans entering from the north and most British Columbians entering from the south.

- c) The reasons for seeking recreation in the Elk Valley were rated by the respondents in the following order of decreasing importance: fishing, relaxation, other, camping, hunting and hiking. The "other" category related to aesthetic values of the valley such as mountain scenery, clean air, quiet surroundings, and wildlife viewing.
- d) Hunting becomes the predominant recreational activity in the fall, with moose and elk as the principal target species.
- e) Recreationists desire few, if any, changes within the upper valley. Of the 12 categories in the survey for "changes which would increase enjoyment", the largest group, 17.2% (n=21) of 122 respondents, wanted less mining activity.

Information is not yet available on how many vehicles actually travelled the valley length through the project area, or the degree of recreation here.

The upper Elk River is situated close to a number of expanding population centers in B.C. and Alberta. The Kananaskis Lakes to the north of the Elk Lakes support heavy recreation use at present.

Winter use of the area will expand with the growing popularity of snowmobiles and cross-country skiing. Current estimates of 50 and 200 snowmobiles on a weekend day have been reported for the upper Elk River area. Thus, projections of increased land use and of further demand for recreational considerations in the valley are not unwarranted.

10.3 Impact Consideration

The impact possibilities contained in the preceding sections of this report also relate to the recreational potential of the valley and the aesthetic features that recreationists seek.

The existing recreation trends and values, as determined by British Columbia Fish and Wildlife (Bull, 1972) provide a preliminary basis for predictions of public concerns relative to mining development impact on recreation; these concerns include:

- a) local removal and alteration of mountain scenery;
- b) loss of fishing locations, and game fish productivity;
- c) noise pollution, including that of local mining development and along the length of the valley (daily traffic, train noise);
- d) air pollution: coal dust and traffic dust;
- e) water pollution: seepage of industrial waste; uncontrolled sedimentation;
- f) loss of big game capability;
- g) loss of winter recreation: snowshoeing, cross-country skiing, and snowmobiling;
- h) alteration or interruption of the proposed Continental Divide Trail; effects on hiking, camping, regional aesthetics;
- i) loss of resident wildlife: bird watching, nature study and wilderness atmosphere; and,
- j) crowding of alternative recreation areas.

10.4 Mitigation & Reclamation Concepts

Preceding discussions of mitigation and reclamation can be interpreted in a recreation context. Ultimate reclamation aims for revegetation and increased wildlife and fish productivity, coincidentally restore traditional recreation uses and offer potential recreational alternatives. The shallow lake below the northwest dump setting pond (Appendix A-R1) is a primary example. It could be available early in project development as a recreation resource for picnicking, fishing and observation of mining activity. An information station can be established here as an educational resource, providing interpretative material on energy resource development and local ecology.

A peripheral benefit from mining activity would be the upgrading of the present road in the valley; this will enhance access to Cadorna Creek and the Upper Elk River Valley.

A comprehensive recreation resource program will be useful in conjunction with mining development. This implies adjustment to minimize recreation resource damage and definition of environmental management goals. Present landscape and wildlife utilization by the public will guide the direction of reclamation. Examples might be creation of waterfalls (aesthetic criteria), increased acreage of forage lands for elk productivity (hunting criteria), or return to climax conifers (forestry criteria).

Specific provisions for a recreation-oriented program during mining development might include:

- a) Consultation with provincial planning departments regarding short term and long term land use.
- b) Improvements in road quality with a by-pass of the mining area;
- c) Small-scale experiments during development of a program to establish natural areas.
- d) General containment of mining activities, and mitigation procedures outlined previously.

11.0 SOCIO-ECONOMIC CONSIDERATIONS

11.1 Regional Context

Recreation is the outstanding land use activity in the Upper Elk River Valley, and along with mining, forestry and limited ranching, provides the economic base for the East Kootenay region. This is one of the fastest growing regions in British Columbia, with a 29.2% population increase in the five-year period between 1967 and 1972, twice the provincial average.

The Upper Elk River Valley is situated close to a number of population centers in both British Columbia and Alberta, allowing some half a million people to make daily trips to the Valley.

11.2 Impact Consideration

Socio-economic considerations relative to the proposed project focus on the new town of Elkford (Appendix B-P16). In addition to the recreation potentials noted it is recognized that the proposed mining project will directly affect development of this community. It is, from its inception, a mining town serving as a residence and trade center for existing mines in the Elk River Watershed (Map M1). Additional mining and steadily increasing recreational trade will require expansion of Elkford.

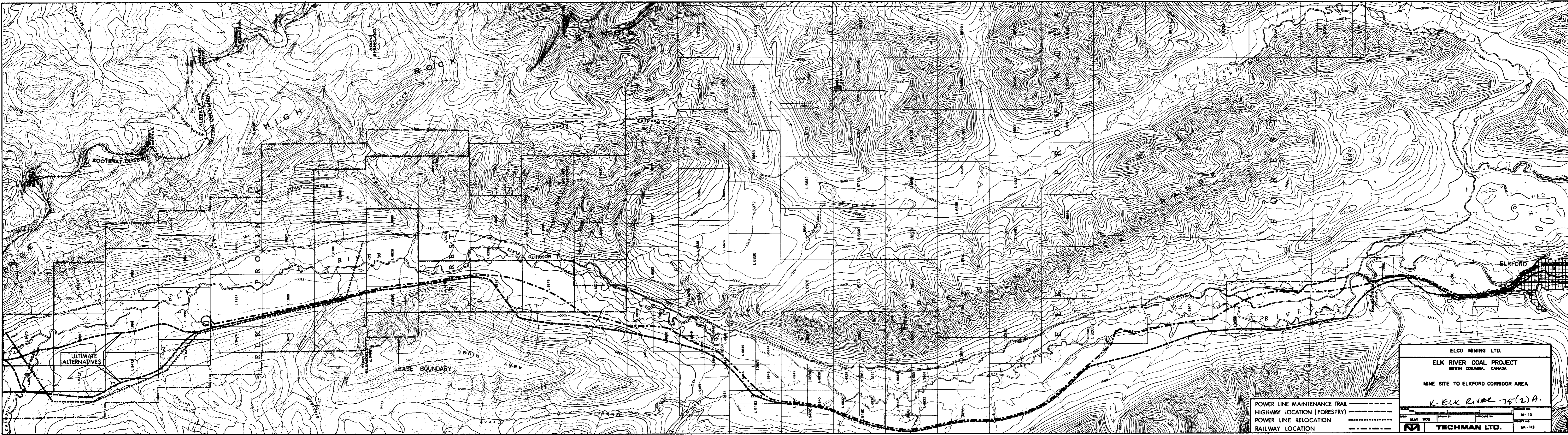
The proposed Elk River mine will employ an estimated

1100 people directly, with anticipated expansion of the town of Elkford in the order of an additional 6000 people. The full population growth impact remains to be analyzed for urban and regional planning purposes. Income benefits to residents can be anticipated.

A survey conducted in the East Kootenay Area under the Canada Land Inventory in 1966 determined that 32% of the non-farmers inventoried had been out of work at some time in the preceding three years. The average total family income reported by respondents from a small sample was \$4,994 in 1965. Total family incomes of less than \$3,000 were recorded by 18% of the non-farm and 32% of the farm respondents. This unemployment problem continues and is especially serious at present due to the depressed condition of the forest products industry.

Land use alternatives for the Upper Elk River area at this point appear to be concerned primarily with mining development and improved transportation and recreation facility development. Improvements to the Elk River roadway linking Sparwood and the Kootenay Valley to the Elk and Kananaskis Valleys would greatly increase traffic and recreational activity in the valley and expand the economic base for the new town of Elkford (Map M10).

It is evident that with or without mining, recreational use of this valley will most probably increase rapidly in the coming years, thus increasing the need for support and control facilities and programs. Revenue generated by energy resource development projects in the East Kootenays should prove very helpful in providing the necessary government services associated with increasing outdoor recreation activity.



ULTIMATE ALTERNATIVES

PROVINCIAL HIGHWAY

ELK RIVER

LEASE BOUNDARY

ABBY RIDGE

OLIVOSO

FLATS

CLACK ROCK

ELK RIVER

ELK RIVER

ELK RIVER

ELK RIVER

ELK RIVER

ELK RIVER

ELK RIVER

ELK RIVER

ELK RIVER

ELK RIVER

ELK RIVER

ELK RIVER

ELKFORD

- POWER LINE MAINTENANCE TRAIL
- HIGHWAY LOCATION (FORESTRY)
- POWER LINE RELOCATION
- RAILWAY LOCATION

ELCO MINING LTD.
 ELK RIVER COAL PROJECT
 BRITISH COLUMBIA, CANADA

MINE SITE TO ELKFORD CORRIDOR AREA

L-ELK RIVER 75(2)A

DATE: MAY 1975	DRAWN BY:	APPROVED BY:	SCALE: 1" = 1000'
TECHMAN LTD.			PROJECT NO. M-10
			PRODUCT NO. TM-113

Wildfire, especially, which can prove much more disruptive than mining, will require much greater control effort as recreation use increases.

The adverse impact associated with increased mining and recreation activity in the valley will be on those people who have been or would in the future use the area as a recreational retreat from more heavily populated areas. This will include three guide outfitter operations. The availability of other areas in the East Kootenay region which can provide this "wilderness" experience must be considered in future project and regional development planning. Furthermore, the tradeoffs represented by economic productivity from mining and potential recreation benefits through facility development must be weighed.

11.3 Cooperative Approach to Planning

Regional planning efforts are largely a government responsibility requiring input and cooperation from industry. Should the basic mining and environmental planning concepts presented by Elco Mining Ltd. receive approval in principal at this time, a coordinated approach can be developed for future planning efforts by the company and local and provincial government agencies.

GLOSSARY OF ENVIRONMENTAL TERMS

Adaptability - the ability of an organism or a population to respond to changes in its environment so as to continue living and reproducing.

Brunisols - brown forest soils, characteristically well-drained.

Carrying Capacity - the maximum level to which the resources of a habitat can be used by organisms without inducing instability.

Climax - the final or ultimate community in a succession.

Cover - vegetation that serves to protect or conceal animals.

Cutbank - a condition which exists where the river current has undermined a section of the bank creating a steep unvegetated slope.

Disturbance - any disruption of environmental conditions, usually unanticipated by wildlife and usually related to human activity, which threatens the ability of a particular animal to survive.

Ecology - the study of relationships between organisms and their environment.

Ecosystem - a complex of interrelated organisms and non-living environmental elements, which interact to form identifiable patterns.

Ecotype - a variant within a species that is genetically adapted to local ecological conditions; equivalent to an "ecological race". For example, a particular plant species may have a dwarf, winter-dormant variant adapted for alpine conditions and, alternatively, a dense, bushy type with year-round growth for coastal environments.

Flash Peaks - a condition typical of areas which are well drained; these tend to retain very little water thus causing the levels of discharge rates of watercourses to oscillate. Watercourses which receive runoff from such well drained areas reach peak discharge rates shortly after periods of precipitation; this is a flash peak.

Forb - any herb that is not a grass or grasslike; for example, legume plants.

Gleysols - grey and/or yellow-grey colored soils usually resulting from water-logging and lack of aeration.

Habitat - the place where an organism (or a community of organisms) lives or regularly appears; it is commonly defined with respect to the type of soil, topography, and vegetation which occupy the area.

HWF - high water flow in c.f.s.

Indicator Species - those organisms which are selected, on the basis of their association with a particular community or habitat type and/or on the basis of their known responses and sensitivities, to evaluate changes in the physical environment.

Indigenous - implying a plant or animal that is native to a particular region.

Leaching - the process by which soluble compounds or elements are dissolved by water percolating through soil.

Limiting factors - any condition which approaches or exceeds an organism's limits of physiological or behavioral tolerance.

Luvisols (Gray-Wooded) - soils which have developed from high base materials under forests and characterized by an impoverished gray layer near or at the surface of the mineral soil.

LWF - low water flow in c.f.s.

Macrophytes - vascular aquatic plants, such as bullrushes.

Macroinvertebrates - those aquatic invertebrates (mainly insect larvae) which are visible without the aid of a microscope.

Microhabitat - a small unit of space which can support a particular species or community.

Microtine rodents - generally, the smaller rodents, such as voles or meadow mice.

Migration - a periodic population movement involving a round trip that is usually of seasonal occurrence.

Niche - the position, role or status of an organism within

its community and ecosystem resulting from the organism's structural adaptations, physiological responses, and specific behaviors. The elk (wapiti), for example, occupies the niche of a social, herding, summer grazing/ winter browsing, seasonally migrating ungulate.

Peat - a highly organic soil of partially decomposed vegetable matter.

Poikilotherms - animals, such as fish or insects, which are cold-blooded, that is, their body temperature is dependent upon external temperatures and varies with them.

Pool - that stretch of a watercourse where the water is calm and deep.

Population - an interbreeding group within a species, isolated to some degree from other populations in the species.

Productivity - rate of energy storage, or rate of biomass formation in a community; commonly, the productivity of an ecosystem refer to its "richness". The productivity of each trophic level (that is, each group of organisms which feed on smaller organisms or plants) is limited by primary productivity (plant life), which in turn is limited by the photosynthetic process of the plants.

Regosols - soils usually developing from unconsolidated or soft rock deposition.

Riffle - the rocky area of a watercourse where the water is shallow and the current swift.

Salmonid - a member of the salmon family used in this presentation as a reference to trout and char.

- Sedge - any of the various rush - like or grass - like plants growing in wet places such as ponds.

Sere (seral) - a series of communities which develop in a given physical environment; the relatively transitory communities are called seral stages.

Substrate - the river bottom material.

Ungulate - any hoofed animal, such as elk (wapiti) deer, moose, and bighorn sheep.

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ELK RIVER COAL PROJECT

Mining and Environmental Planning Concept

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APPENDICES

May 1975

GEOLOGICAL BRANCH
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APPENDIX VOLUME

APPENDIX 1 - ELK RIVER COAL PROJECT, REPORT ON PREPARATION
AND PRELIMINARY FLOWSHEET

APPENDIX 2 - DRAWINGS SUBMITTED IN ASSOCIATION WITH MINING
CONCEPTS

(Appendix 2 has been prepared in large scale under separate cover and is included in the Appendix Volume at a reduced scale).

#1602	Plan at Completion of Initial Pit (6 years)
#1603	Plan of Project at 22.7 Years
#1604	Plan of Project at Completion, Excluding Mine Backfill (28 Years)
#1605	Plan of Project at Completion (28 Years)
#1606	Contour Map of the Completed Mining Area
#1607	Orthophoto Mosaic
#1608	Typical Cross-Sections, Sta. 180 and Sta. 205 ...
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#1610	Miscellaneous Typical Cross-Sections
#1611	Profile, Elk River Diversion
#1612	Profiles; Weary Creek Diversion
	; East Slope Drainage Relocation
	; Valley Bottom Drainage Ditch
#1613	Profiles; Forestry Road & West Drainage Relocation ; Final Forestry Road Location
#1614	Geological Exploration Plan
#1615	Geological Section of Projected Syncline Structure, Station 250 + 00
#1616	Geological Section, Sta. 180
#1617	Geological Section, Sta. 260
#1618	Geological Section, Sta. 340
#1619	Graph Showing Cumulative Mining Volumes and Mining Ratio
#1620	Preliminary Plan of Proposed Railway and Highway Locations to Elk River Coal Project (Railway Mileage 0.0 - 12.9)
#1621	Preliminary Plan of Proposed Railway and Highway Locations to Elk River Coal Project (Railway Mileage, 12.9 - 27.2) (Highway Mileage, 0.0 - 11.8)
#1622	Preliminary Plan of Proposed Railway and Highway Locations to Elk River Coal Project (Railway Mileage, 27.2 - 34.4) (Highway Mileage, 11.8 - 19.1)

- #1623 Preliminary Plan of Proposed Railway and Highway Locations to Elk River Coal Project (Railway Mileage, 34.4 - 43.8) (Highway Mileage, 19.1 - 27.8)
- #1624 Preliminary Profile of Proposed Railway from Fording Railway Junction to Elk River Coal Project (Mile 0 to 21.9)
- #1625 Preliminary Profile of Proposed Railway from Fording Railway Junction to Elk River Coal Project (Mile 21.9 to 43.8)
- #1626 Preliminary Profile of Proposed Highway, Elkford to Elk River Coal Project (Mile 0 to 10) .
- #1627 Preliminary Profile of Proposed Highway, Elkford to Elk River Coal Project (Mile 10 to 20).
- #1628 Preliminary Profile of Proposed Highway, Elkford to Elk River Coal Project (Mile 20 to 27.8)

ELK RIVER COAL PROJECT

REPORT ON PREPARATION
AND
PRELIMINARY FLOWSHEET

Prepared for

Exploration und Bergbau GmbH
of Canada

by

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(MARCH 1975)

ELK RIVER COAL PROJECT
REPORT ON PREPARATION AND PRELIMINARY FLOWSHEET

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Drawing No. 1571-00 PRELIMINARY FLOWSHEET

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INTRODUCTION

The following is an evaluation of the Elk River coal quality and a preliminary plant design. Since the anticipated dilution is excessive, the plant performance was difficult to assess, so many reasonable assumptions had to be made based on other Western Canadian coal operations. In general, the Elk River coals are of similar quality to that of Fording River, although the product ash will be somewhat higher because all the seams in the series will be mined. During the forthcoming drilling and testing program, more emphasis should be placed on simulating the actual raw coal characteristics which will be encountered during mining so that washability data will be more realistic. In other words, future washability tests should be conducted on size ranges that would reflect more accurately the proposed plant feed conditions.

RAW COAL ASH CONTENT

Of primary importance in designing a wash plant for the Elk River coal is the proper determination of the raw coal ash content. Because of the extreme variability of the coal quality, a meaningful accurate figure cannot be determined. A better figure would be the range expected. Also, the extent and quality of dilution will in practice be highly variable.

Table 1 shows all the test results available from bulk samples, electrologs (histogram averages), and drill hole analyses. In addition, Table 3 shows a revised ash content which compensates for dilution. The nature of this dilution material was determined by visually observing several drill cores. As a result, the average plant feed ash content will be 30-35%.

TABLE 1

ELK RIVER COAL

RAW ASH DETERMINATIONS

	% Ash In		WT%-28M	Ash Total		% Ash In		WT%-28M	Ash Total
	+28M	-28M				+28M	-28M		
<u>#2N Bulk</u>	28.2	17.6	22.5	25.8	<u>#11</u>				
Total Range				12 - 30	Total Range				13 - 45
*H. Average				18%	H. Average				25%
Coal Science (Bulk)	14.1	12.3	14.0	14%	<u>#12 Bulk</u>	29.5	16.5	26.0	26.1
<u>#3 Bulk</u>	9.4	10.6	25.0	9.7	Total Range				14 - 40
Total Range				8.5 - 18	H. Average				27%
H. Average				10%	Coal Science (Bulk)	28.8	14.9	25.0	26.0
Coal Science (Bulk)	16.0	18.2	17.2	17%	<u>#13</u>				
<u>#4/4a Bulk</u>	30.1	18.3	16.8	28.1	Total Range				15 - 35
Total Range				11 - 30	H. Average				24%
H. Average				22%	Coal Science (Bulk)	33.9	27.1	11.3	32%
Coal Science (Bulk)	27.4	16.6	(9-20)	25%	<u>#14</u>				
<u>#6a Bulk</u>	19.7	12.1	12.9	18.7	Total Range				8 - 35
Total Range				15 - 22	H. Average				23%
H. Average				20%	Coal Science (Bulk)	23.8	16.2	13.0	22%
Coal Science (Bulk)	14.4	13.0	14.5	14%	<u>#15</u>				
<u>#7 Bulk</u>	23.6	13.5	15.9	22.0	Total Range				15 - 40
Total Range				15 - 40	H. Average				30%
H. Average				18%	Coal Science (Bulk)	32.1	12.3	14.3	29%
Coal Science (Bulk)	31.9	24.0	9.2	30%	<u>#16</u>				
<u>#8 Bulk</u>	26.5	13.2	20.5	23.8	Total Range				9 - 35
Total Range				10 - 35	H. Average				32%
H. Average				25%	Coal Science (Bulk)	15.5	11.3	14.7	14%
Coal Science (Bulk)	31.1	14.0	22.2	27%	<u>#17</u>				
<u>#9 Bulk</u>	16.9	9.5	22.0	15.3	Total Range				6 - 20
Total Range				10 - 35	H. Average				18%
H. Average				23%	Coal Science (Bulk)	6.3	14.2	8.5	8%
Coal Science (Bulk)	23.4	13.0	12.8	22%	<u>#18</u>				
<u>#10 Bulk</u>	19.4	11.6	16.7	18.1	Total Range				6 - 30
Total Range				7 - 25	Coal Science (Bulk)	23.2	15.4	15.0	21%
H. Average				18%	<u>#19</u>				
Coal Science (Bulk)	19.0	11.8	16.1	18%	Total Range				Unknown
					Coal Science (Bulk)	28.0	20.1	10.4	26%
					<u>#20</u>				
					Total Range				8 - 13

*(H. Average = histogram averages)

Unless noted otherwise, bulk samples were analyzed for North American Coal Co.

PHYSICAL COAL CHARACTERISTICS

Since the coal in the Elk Valley has been subjected to severe stress due to tectonic activity, the coal is very friable and generally exhibits a high grindability index. A friability test similar to the drop test used in iron ore pellet testing along with screen analyses of the product, will often indicate how bad the coal degradation will be during mining and stockpiling. It will also indicate the shape of the coal particles which must be cleaned. Most of the Western Canadian coals produce very flat particles rather than cubical particles, thus the efficiency of conventional coal cleaning equipment is not as good as it would be in the Eastern United States (i.e. the probability error on heavy media cyclones increases from 0.04 to 0.08). In addition, the coal weathers very quickly. The coal, although it is very hard when it is mined, relieves its internal stress and crumbles in a matter of days in a stockpile. Thus, it is most desirable to limit the size of the stockpile and to feed directly to the plant to the extent that blending requirements permit.

Tables 2 and 3 show the anticipated raw coal characteristics, and indicate the test results on clean coal. Because of the high dilution, it is quite apparent that the theoretical clean coal characteristics will never be achieved. Also, it is obvious that a much better mining scheme would include seams 2 to 12 excluding seams 5 and 6. Then the plant feed would be about 25% ash (just as Fording River's is) and a 9.5% ash product could be achieved. The coal would then have to be blended to achieve higher coke stability indices.

TABLE 2
ELK RIVER COAL

PHYSICAL CHARACTERISTICS*

<u>SEAM</u>	<u>RAW ASH</u>	<u>VM. (CLEAN)</u>	<u>FSI. (CLEAN)</u>	<u>HARDGROVES GRINDA-ABILITY</u>	<u>REPORT CLEAN ASH</u>	<u>NO. OF SPLITS</u>	<u>AVGE. COAL THICK-NESS</u>
1			Thin			1	
2	20%	19.8	7½	124	10.4	1 - 2	14
3	20%	19.5	6	131	8.2	1 - 3	6
4	25%	19.1	4-4½	89	8.5	1 - 2	28
4A	25%		5 - 6				
6	45%	18.9	4½	81	9.0	1 - 2	5
7	30%	19.4	6½	103	8.5	1 - 2	5
8	35%	20.2	5	97	6.8	2 - 4	20
9	25%	20.0	6	85	7.2	1 - 3	16
10	20%	21.9	5	88	6.3	2 - 3	26
11				Poor Quality		5	14
12	30%	24.2	8½	132	9.0	3 - 7	18
13	40%	24.3	9	106	10.1	1 - 4	19
14	50%	26.7	8	96	9.9	7	18
15	50%	26.3	8	97	9.3	5	17
16	55%	28.4	8½	78	9.6	4 - 5	13
17	45%	30.0	8½	70	7.5		15
18	50%	31.1	8½	89	10.6	4	14
19	45%	31.2	8½	71	9.1	2 - 5	8
20		30.0		No Data		6	
21				No Data			

*Based on Coal Science Report, October, 1971.

TABLE 3

ELK RIVER COAL

PROJECTED PLANT FEED FINES & ASH

<u>Seam</u>	<u>(%) of Reserve</u>	<u>Anticipated Dilution % of Raw Coal</u>	<u>Grindability</u>	<u>Estimated Fines Content of Coaly Fraction</u>	<u>Average Thickness of Recoverable Members</u>	<u>Dilution Material</u>	<u>Estimate Plant Feed Ash</u>
1					3'		
2	8.8	12.2	124	60%	14'	Coaly shale	20%
3	3.3	24.1	131	70%	6'	Shale	20%
4	15.9	14.1	89	30%	28'	Gray Shale	25%
4A				25%		Coaly Shale	25%
5	0.9	62.6			3'		
6	2.6	44.2	81	25%	5'	Gray Shale	45%
7	2.2	18.3	103	42%	5'	High Ash Coal & Coaly Shale	30%
8	9.1	18.4	97	37%	20'	Gray and Coaly Shale	35%
9	7.1	9.8	85	25%	16'	Gray and Coaly Shale	25%
10	10.5	8.9	88	30%	26'	Gray and Dark Shale	20%
11	2.4	21.6			14'	Siltstone	
12	6.1	21.9	132	70%	18'	Gray Shale	30%
13	6.4	33.6	106	45%	19'	Carb Shale and Siltstone	40%
14	5.6	33.7	96	35%	18'		50%
15	5.1	31.7	97	37%	17'		50%
16	3.5	63.3	78	25%	13'		55%
17	4.3	35.5	70	20%	15'		45%
18	3.7	60.0	89	30%	14'		50%
19	1.1	45.8	71	21%	8'		45%
20	0.9	50.7		No Data			
21	0.4	100.7		No Data			
Wt. Average		24.8		37.1%			32.8%

DILUTION

Since many of the seams are split by extensive partings, a considerable amount of dilution during mining will occur. Much of the dilution will be carbonaceous shale and coaly stringers in siltstone (the primary interbedding rock) so one can anticipate that most of the material will report to the coal cleaning plant. The dilution will not merely report to tailings, but will increase the ± 0.1 specific gravity material in the plant feed and will render washing very difficult. As a result, no less than a 1.0% increase in the product ash over the calculated value is anticipated.

To offset this type of dilution, Fording River wastes the top three feet of the seam in their dragline pit. If the coal seam must be blasted along with the footwall material, as was the case with a ten foot rider seam in Cardinal River's 50B pit, the coal and rock would be so badly mixed that most of the seam would have to be wasted. This blasting practice must be avoided.

In mining any one seam, an acceptable upper ash limit (of say 40%) should be established, and coal with higher ash should be wasted. Generally, if higher ash coals are blended with lower ash coals, the plant recovery decreases markedly. Even though the M.K. Scurry reports and the work done by Birtley Engineering suggests that blending increases the recovery in the plant, this cannot be true because the washability of each coal in the blend then increases in near gravity material, and the coal cleaning efficiency is decreased. Similar studies at Fording River also suggested that blending would increase plant recovery, but plant tests on individual seams proved otherwise.

Since the Elk River coals are so variable, and since it will be impossible not to blend some of the seams; and since the grindability and ash content vary so much on the property, it would be more desirable to design a plant with two separate and different circuits with individual feeds from individual stockpiles.

The attached dilution table gives some indication as to the degree of change in the washability of the coal. Since there is considerable variability as to what the dilution material might be on each seam, it is reasonable to assume the same quality of dilution material for each seam. If further tests are conducted on the coal, it would be advantageous to do some washability tests on the material, since they will increase the \pm specific gravity material on the 1.80 float fraction, thereby rendering the coal more difficult to clean.

Results of Limited Drill Core Examination: Rock/Coal Interfaces

An examination of a limited number of core samples stored in Blairmore indicates that the type of interface rock that will be encountered will be approximately as noted hereunder.

- | | |
|---|-----|
| 1. Interface rock heavy and hard, breaks into large pieces which will mostly be excluded in the rotary breaker | 42% |
| 2. Interface rock which is heavy and hard but breaks into smaller pieces which will enter the plant but are easily separated in the plant | 41% |

3. Interface rock light, carbonaceous and soft, which will enter the plant and be difficult to separate 17%

Table 4 shows for comparison the nature of the rock-coal interface, based on 12 written drill hole logs. Table 5 shows the quantity of dilution rock, by seam that has been estimated for the mine.

TABLE 4

INCIDENCE OF TYPES OF ROCK-COAL INTERFACE
 BASED ON WRITTEN DRILL HOLE LOGS:
For Holes M70-17C to M70-30C Inclusive

<u>HIGHWALL</u>	Sandstone	6
"	Sandstone & Siltstone	22
"	Black Sandstone & Siltstone	2
"	Siltstone	17
"	Black Siltstone	24
"	Coaly Sandstone	24
"	Coaly Sandstone & Siltstone	3
"	Coaly Siltstone	21
"	Coaly Shale	2
		<u>99</u>
<u>FOOTWALL</u>	Sandstone	6
"	Sandstone & Siltstone	18
"	Black Sandstone & Siltstone	3
"	Siltstone	15
"	Black Siltstone	25
"	Coaly Sandstone	0
"	Coaly Sandstone & Siltstone	1
"	Coaly Siltstone	19
"	Coaly Shale	5
"	High Ash Coal	1
		<u>93</u>
<u>HIGHWALL</u>		
	Incidence coaly rock interface	
	- Sandstone or Siltstone	26%
<u>FOOTWALL</u>		
	Incidence coaly rock interface	
	- Sandstone or Siltstone	22%
	Incidence coaly shale interface	
	or high ash coal	4%
	Overall incidence of coaly rock	
	interface with coal	28%
	Balance - clean rock interface	72%

TABLE 5

TABLE OF COAL RECOVERIES BY SEAM

S E A M	RECOVERED RAW COAL			RECOVERED DILUTION ROCK	TOTAL REC'D MINE RUN PRODUCT	VOLUME DILUTION (%)	
	Short Tons	Cu. Yards	% of Total by Seam	Cu. Yards	(R.O.M.)	of	
					Cu. Yards	Raw	ROM
2	14,310,408	11,729,843	8.81	874,796	12,604,639	7.46	6.94
3	5,408,588	4,433,269	3.33	652,248	5,085,517	14.71	12.83
4	25,887,363	21,219,150	15.93	1,834,398	23,053,548	8.65	7.96
5	1,388,340	1,137,984	0.85	434,755	1,572,739	38.20	27.64
6	4,229,577	3,466,866	2.60	933,822	4,400,688	26.94	21.22
7	3,568,503	2,925,002	2.19	325,822	3,250,824	11.14	10.02
8	14,756,355	12,095,373	9.08	1,355,167	13,450,540	11.20	10.08
9	11,461,081	9,394,329	7.05	561,143	9,955,472	5.97	5.64
10	17,072,216	13,993,620	10.51	763,660	14,757,280	5.46	5.17
11	3,925,204	3,217,380	2.41	424,182	3,641,562	13.18	11.65
12	9,980,629	8,180,843	6.14	1,092,870	9,273,713	13.36	11.78
13	10,458,030	8,572,156	6.43	1,758,936	10,331,092	20.52	17.03
14	9,061,674	7,427,602	5.57	1,529,028	8,956,630	20.59	17.07
15	8,245,933	6,758,961	5.07	1,305,500	8,064,461	19.32	16.19
16	5,689,684	4,663,675	3.50	1,801,921	6,465,596	38.64	27.87
17	7,037,823	5,768,707	4.33	1,250,735	7,019,442	21.68	17.82
18	5,956,589	4,882,450	3.66	1,788,293	6,670,743	36.63	26.81
19	1,836,613	1,505,420	1.13	421,038	1,926,458	27.97	21.86
20	1,386,446	1,136,431	0.85	351,333	1,487,764	30.92	23.61
21	577,071	473,009	0.35	309,955	782,964	65.53	39.59
22	294,830	241,664	0.18	161,548	403,212	66.85	40.07
24	47,679	39,081	0.03	9,304	48,385	23.81	19.23
	162,580,636	133,262,815	100.00	19,940,454	153,203,269	14.96*	13.02*

*by volume

SG = 2.40 for dilution by weight 40,315,610⁺202,896,246⁺ 24.80 19.87
+S.T.

GRINDABILITY

The grindability of the coal should be a major indicator as to the size distribution of the plant feed. At Fording River it has been established that Hardgrove grindability index can range from 85-120 and the corresponding size range of plant feed is approximately as follows:

<u>H.G.</u> <u>Index</u>	<u>%-28 Mesh</u>
85	25 - 30%
95	30 - 40%
105	40 - 50%
120	- 60%

In actual practice, Fording's plant feed is very often 50% minus 28 mesh. Originally, some speculation as to the cause of the high fines blamed the mining technique. However, Fording has attempted to improve the size distribution by varying loading methods (i.e. using front end loaders and shovels instead of the dragline) with very little success.

GAMMA LOGS & VISUAL OBSERVATION OF CORES

Several holes were logged for gamma and density. Interpretation of the coaly sections would normally be limited to a gamma of about 40, therefore the seams would not be nearly as thick as those described. As an example, Exhibit 15 would have 16 feet of coal in Seam #13, 19.5 feet in #14, and 10 feet in Seam #11. The smaller coaly sections described would be called carbonaceous shales. Visual examination of the cores support this interpretation.

During a visit to the core shed at Blairmore, cores M70-20C showed all but 6(a) of Seam #6 group to be high ash coal and parting; M70-11C showed 8(b) to be poor coal; M70-24C showed the upper part of 19(a) as not acceptable; and Seam #16 to be generally of poor quality.

WASHABILITY

Since washability tests were only conducted on the coaly portions of the seams, they will not represent the actual conditions during operation. Western Canadian coal mining experience has indicated that the dilution associated with the plant feed has made what appeared to be good washabilities look poor. As a result several of the coal companies had to have their allowable product ash levels increased by about 1%.

The following summary applies to the individual seams to be cleaned and should give some insight as to the washability.

Seam #1

The seam is very thin and no information has been developed.

Seam #2 & #2N

The seam ash is highly variable and has an extremely high grindability index, so that the washability tests are probably not at all indicative of the actual conditions which will be experienced during washing. Dilution is only expected to be 12%, but the \pm 0.1 specific gravity material is already 29.4% at 1.50 specific gravity, so in general, this seam will not be easy to clean. This seam should be cleaned in the two-stage H.M. cyclone circuit. The ash content of the bulk sample tested was 14.0% whereas Seam #2N has an ash content of 25.8% and the

histogram indicates the ash should be about 18% in Seam #2. This seam should be retested with the shale partings included.

Seam #3

The raw ash content was reported to be in the 10% range in Exhibits 13 and 27, yet the bulk sample ash was 16.3%. This may be a good indicator of the variability of the coal. The ± 0.1 specific gravity is reported to be 12.7% at 1.50 specific gravity, but is actually 15.4% for 1.80 specific gravity float. Since the grindability index is once again very high, the washability will not represent the actual washing conditions. The coal is, however, very good, so recoveries should be fairly high. The froth flotation yield on 18% ash fines is reported as 91%, but in actual practice yields of 80% for this quality of coal are more reasonable.

Seam #4

The raw ash content on this seam will be about 25% with very little dilution. The coal is fairly hard (grindability of 89) so excess fines content will not be a problem. The washability should be quite accurate, and the near gravity material is 18.2% (corrected for 1.80 specific gravity float) so this coal should be amenable to single stage heavy media cleaning. The coaly section, however, contains many partings which were not accounted for when calculating the dilution factor. Whether or not partings were excluded from the bulk samples should be verified.

Seam #4a

The raw coal characteristics on this seam are about the same as Seam #4. A slightly better recovery should be expected because of the lesser amount of near gravity material. The elementary ash versus specific gravity is erratic indicating poor separation during the washability test.

Seam #5

No data is available, and dilution will be high so it probably is impractical to mine.

Seam #6

The raw coal will be about 20% ash, and an additional 44.2% dilution is expected most of which will be grey shale. Since the coal is fairly hard and since the ± 0.1 specific gravity material is 18%, it may be reasonable to assume that a 50-55% recovery and a product ash of 9.5-10% can be achieved. Since the shaley material will not be excessively fine, a single stage H.M. washing may be adequate with perhaps a H.M. bath to remove the coarse shales. The washability data is again not representative because of the high dilution anticipated. Visual inspection of this seam in Hole 20C indicates that only the uppermost seam of the Seam #6 group was acceptable coal. Examination of additional cores must be made to determine whether Hole 20C is representative.

Seam #7

The Coal Science sample is very much higher in ash than

any of the previous samples, once again demonstrating the extreme variability of the coal. This seam also has a high grindability index (103) so an excessive amount of fines can be anticipated. Fortunately, the anticipated mining dilution is low so the washability may be fairly representative of actual washing conditions. The product ash will probably be 14-15% or higher at a recovery of 50%. Because of the high fines content and extreme amount of near gravity material, this coal is suited to a two-stage heavy media cyclone circuit.

Seam #8

The raw ash (35%) and near gravity material (19.5%) will yield a clean coal of 10-10.5% ash at a recovery of about 55-60% in the coarse coal circuit, and somewhat higher in the fines circuit. Because of the fairly high dilution, and intermediate fines content, the coal could be cleaned in a two-stage H.M. circuit or a single-stage circuit depending on the feed ash.

Seam #9

The raw coal ash content should be about 25% with very little dilution. The washability data shows a high ± 0.1 specific gravity at 1.45 cut point; however, at 1.50 the near gravity material is 18%, so the coal will lend itself to a single-stage heavy media cleaning. Once again, the washability should be fairly accurate and the coal should clean very similarly to Seam #4. Recovery on this seam should be about 70% with an ash content of 9.0-9.5%.

Seam #10

The bulk sample analyses on Seam #10 are consistent and once again the washability should be fairly accurate. This seam would also blend well with #4, and #9 and should lend itself to a single-stage cleaning. The elementary ash versus specific gravity is low at about 1.70 specific gravity in the washability tests.

Seam #11

This seam is a split of Seam #12.

Seam #12

Although the bulk samples are consistent, the drill holes indicate that the coal quality varies considerably. The grindability is extremely high (132) indicating an extensive amount of fines will be generated during mining. Because of the variability of this seam, it should be cleaned with two-stage cyclones although there is not a great deal of near gravity material. The seam could be handled the same as Seam #8. The elementary ash was once again very erratic indicating poor testing.

Seam #13

Because of the many splits in the seam, the raw coal ash content could run as high as 40%. Coupled with the high fines content is a high near gravity material (28%) on the 1.80 specific gravity float, so a clean coal ash of less than 10% would be difficult to achieve. This coal very definitely should be cleaned in two-stage heavy media cyclones.

Seam #14

The coaly fraction's ash content is about 23%; however, with the severe dilution anticipated the raw coal ash will be about 45-50%. Generally there does not appear to be an excess of near gravity material; however, the dilution cannot be accurately accounted for so it is likely that the coal should be cleaned in a two-stage system.

Seam #15

Once again, the raw ash content of the seam is highly variable, but the coal fractions are exceptionally dirty. The yield will most likely be 50% and the product ash about 10%. This coal also should be cleaned in a two-stage cyclone because of the dilution and because of the 20% near gravity material already in the coal.

Seam #16

The average ash content of this seam cannot be determined until further test work is done compensating for dilution. If the dilution is really 63.3% (see Table 3) then the plant feed may be totally unacceptable. This seam is only drilled at 8,000 foot intervals to date. Dilution at Sta. 260 which is the best showing is 45%. Dilution at Sta. 260 and Sta. 340 can be improved substantially by mining only two splits. Sta. 180 cannot be improved. The present washability data does not apply; however, the coal may be cleaned in a single-stage cyclone if the diluting rock is fairly coarse. Most of the rock could then be removed in a H.M. bath. Since the coal has a low grindability index, it will not produce a severe amount of fines.

Seam #17

The average raw coal ash content of Seam #17 should be about 45% including dilution, and the coal should clean easily in a single-stage H.M. unit. There is almost no near gravity material so dilution will not severely hamper recovery. Recovery should be about 50% with a product ash of less than 8%.

Seam #18

Seam #18 has a higher fines content, and a higher amount of dilution than Seam #17 so it too could be cleaned in a single-stage unit. The near gravity material is low and the washability should be quite accurate. Recovery should be about 50% at 9% ash.

Seam #19

This seam is split by four partings, so dilution will be extensive. The last two sections of the seam are very high in ash, and since the coal is very hard (low in fines), this seam may produce a fairly low ash product (less than 9%). It should also be amenable to single-stage cleaning, and a heavy media bath could have good application here.

Conclusions

Several of the seams have an excessive amount of near gravity material and should be cleaned in two-stage heavy media

cyclones. Others are very low in near gravity material and still others are very high in fines. Since the overall plant feed will be about 30-35% ash and vary between 20 and 45% and since the required annual production is four million short tons per year, it is feasible to split the plant into parallel circuits which will more nearly match the type of coal being fed to each circuit. The coarse coal split should be made as outlined in the following table. The fine coal should all be handled as outlined in the plant design section.

TABLE 6
PROPOSED PLANT FEED

<u>"Hard" Coal Circuit</u>				<u>"Soft" Coal Circuit</u>			
			(%)				(%)
Seam #	Avg. Thick-ness	Dilu-tion	Total Reser-ves	Seam #	Avg. Thick-ness	Dilu-tion	Total Reser-ves
#4&4a	28'	14.1	15.9	#2	14'	12.2	8.8
#6	5'	44.2	2.6	#3	6'	24.1	3.3
#9	16'	9.8	7.1	#7	16'	18.3	2.2
#10	26'	8.9	10.5	#8*	26'	18.4	9.1
#5*	3'	62.6	0.9	#12*	18'	21.9	6.1
#16*	13'	63.3	3.5	#13	19'	33.6	6.4
#17	15'	35.5	4.3	#15	15'	31.7	5.1
#18	14'	60.0	3.7	#11*	14'	21.6	2.4
#19	8'	45.8	1.1	#20	7'	50.7	0.9
				#21-24	22'	100.7	0.6
<hr/>				<hr/>			
Wt'd. Totals	142'	24.3	49.6		101'	26.5	50.4

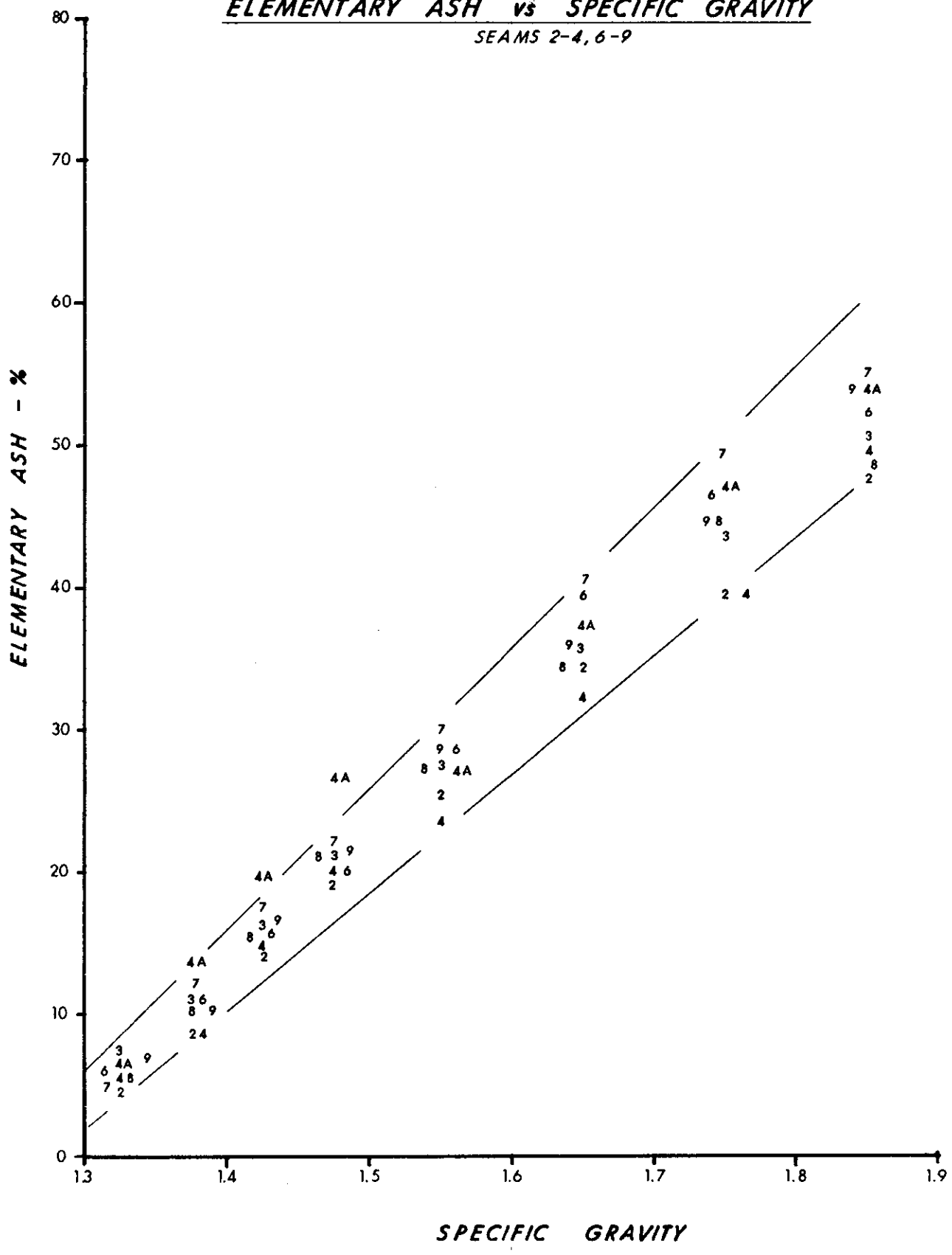
*could be cleaned in either circuit at various times

The seams with a high amount of near gravity material also have a high grindability index. This leads one to wonder if the data on this coal is valid or if the data is a function of drill core recovery. Also, the washability of the 28X100 mesh fraction should be checked so that an effective compound water cyclone circuit can be designed.

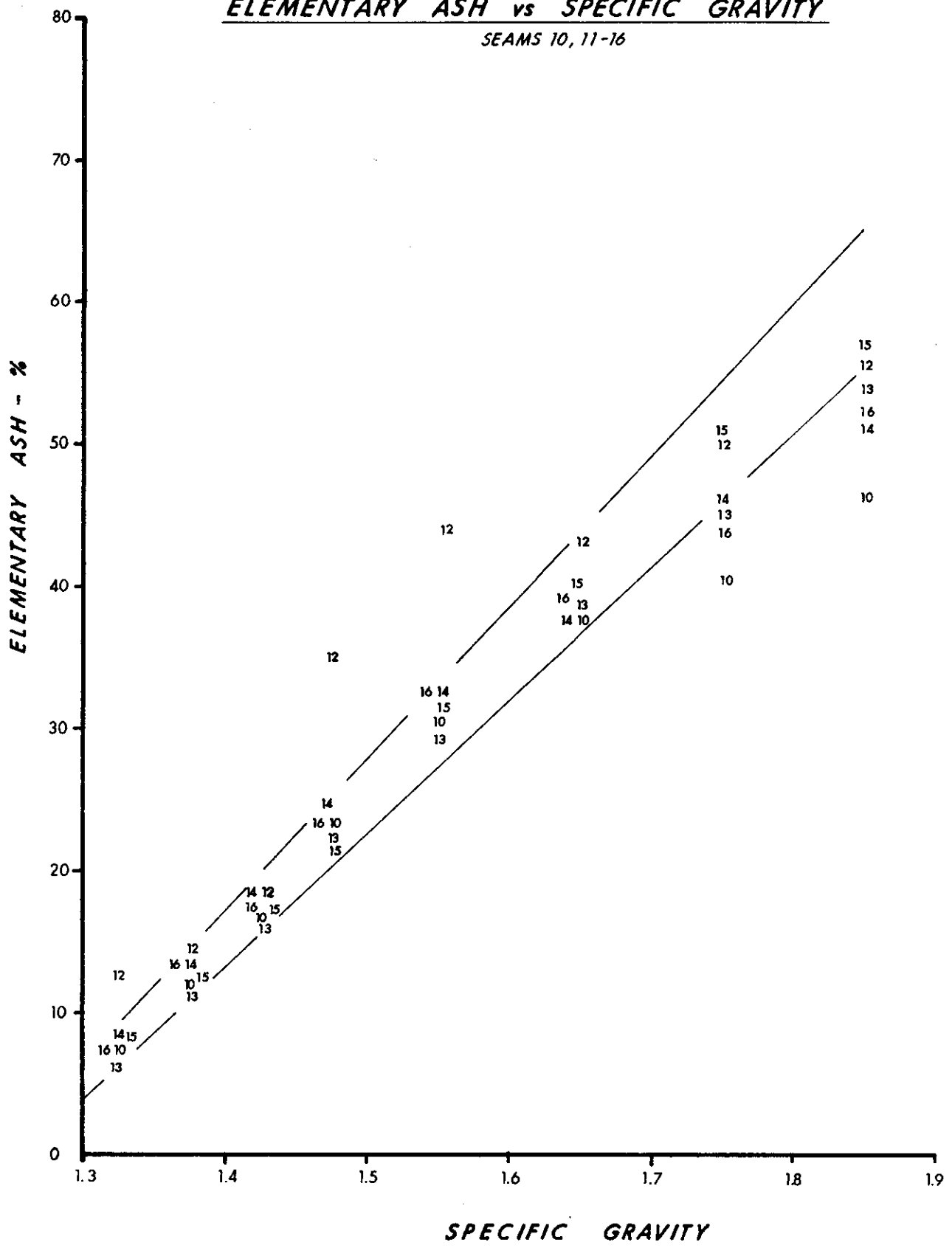
For purposes of evaluating the sink float data, the elementary ash versus specific gravity for each seam was plotted. (Figures 1, 2 and 3). If the results do not plot as a straight line, one can assume that the tests were in error. Because of the scatter over the 19 seams, the average results were used for design. These average results are almost a constant for all the Western Canadian coking coals, so it is reasonable to predict the washability of the fines fractions based on tests conducted over other properties.

In order to design the plant, some assumptions about the coal must be made, so the average type of coal in the 3/4" to 28 mesh range is assumed to be about the same as Seams #4 #4a, #9, #14 and #15 (33.7% of the reserves). Although these washabilities are biased to the poor side, they probably compensate for the increased near gravity material due to dilution. Also, the washability is corrected by adding 10% plus 1.90 specific gravity rock to the coal to come up with a 35% ash plant feed. The washability is then as follows: (Tables 7 and 8).

ELEMENTARY ASH vs SPECIFIC GRAVITY
 SEAMS 2-4, 6-9



ELEMENTARY ASH vs SPECIFIC GRAVITY
SEAMS 10, 11-16



ELEMENTARY ASH vs SPECIFIC GRAVITY
SEAMS 17-19

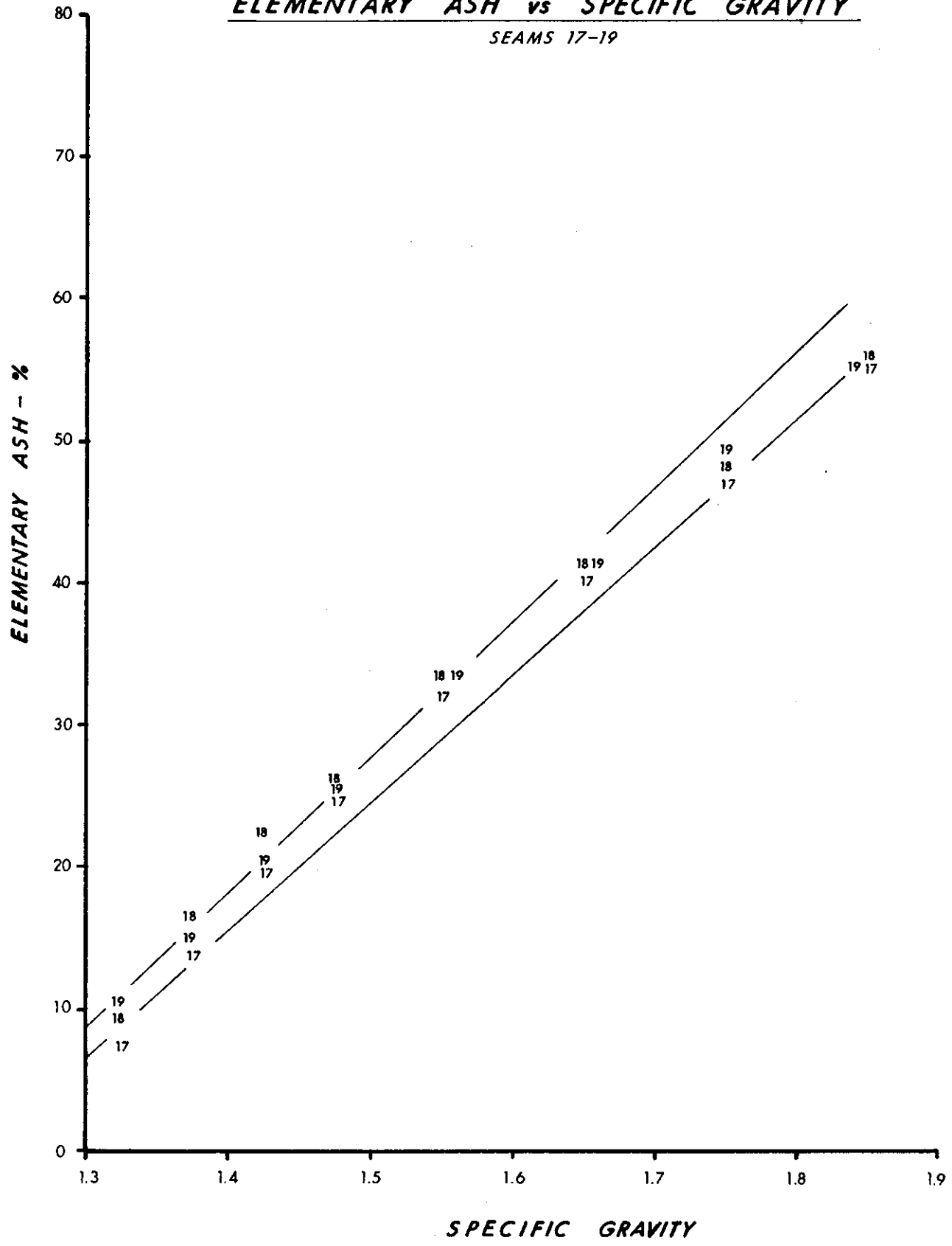


TABLE 7

3/4" x 28 Mesh Washability

<u>S.G. Fraction</u>	<u>(%) WT.</u>	<u>(%) Ash.</u>	<u>(%) Cum.Wt.</u>	<u>(%) Cum.Ash.</u>
- 1.30	25.2	2.7	25.2	2.7
1.30 - 1.35	9.0	5.3	34.2	3.4
1.35 - 1.40	16.5	9.5	50.7	5.4
1.40 - 1.45	5.7	14.4	56.4	6.3
1.45 - 1.50	2.9	19.0	59.3	6.9
1.50 - 1.60	3.2	25.5	62.5	7.9
1.60 - 1.70	1.3	34.5	63.8	8.4
1.70 - 1.80	0.7	43.5	64.5	8.8
1.80 - 1.90	0.9	53.0	65.4	9.4
+ 1.90	34.6	82.5	100.0	35.0

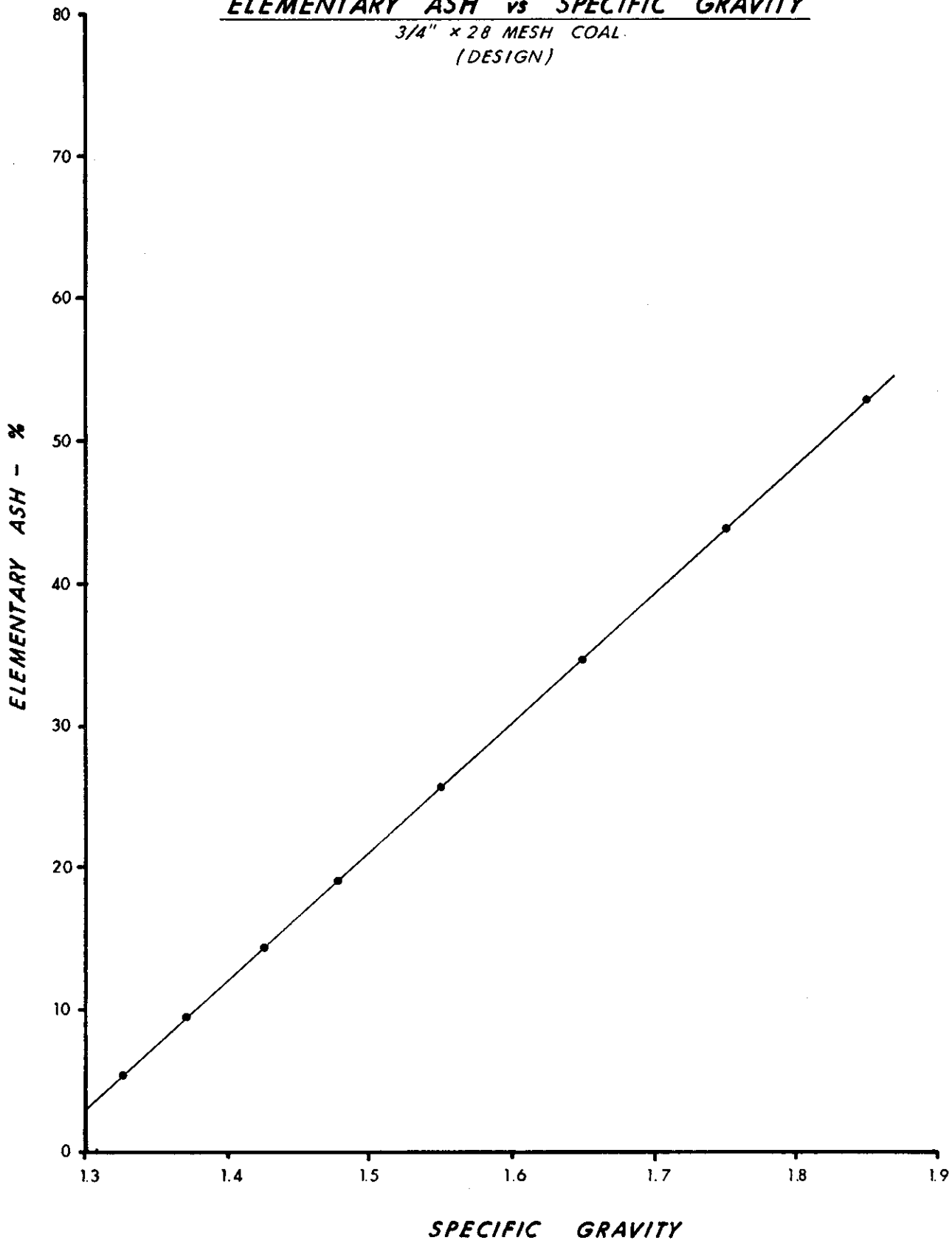
In addition, the washability of the -28 mesh coal is necessary to predict the performance of the two-stage compound water cyclones. Since no such washabilities were carried out on this property, those of similar coals have been substituted here. To produce a plant feed of 32.8% overall, the 35% fines fraction will have a 28.7% ash content.

TABLE 8

28 Mesh X 0 Washability

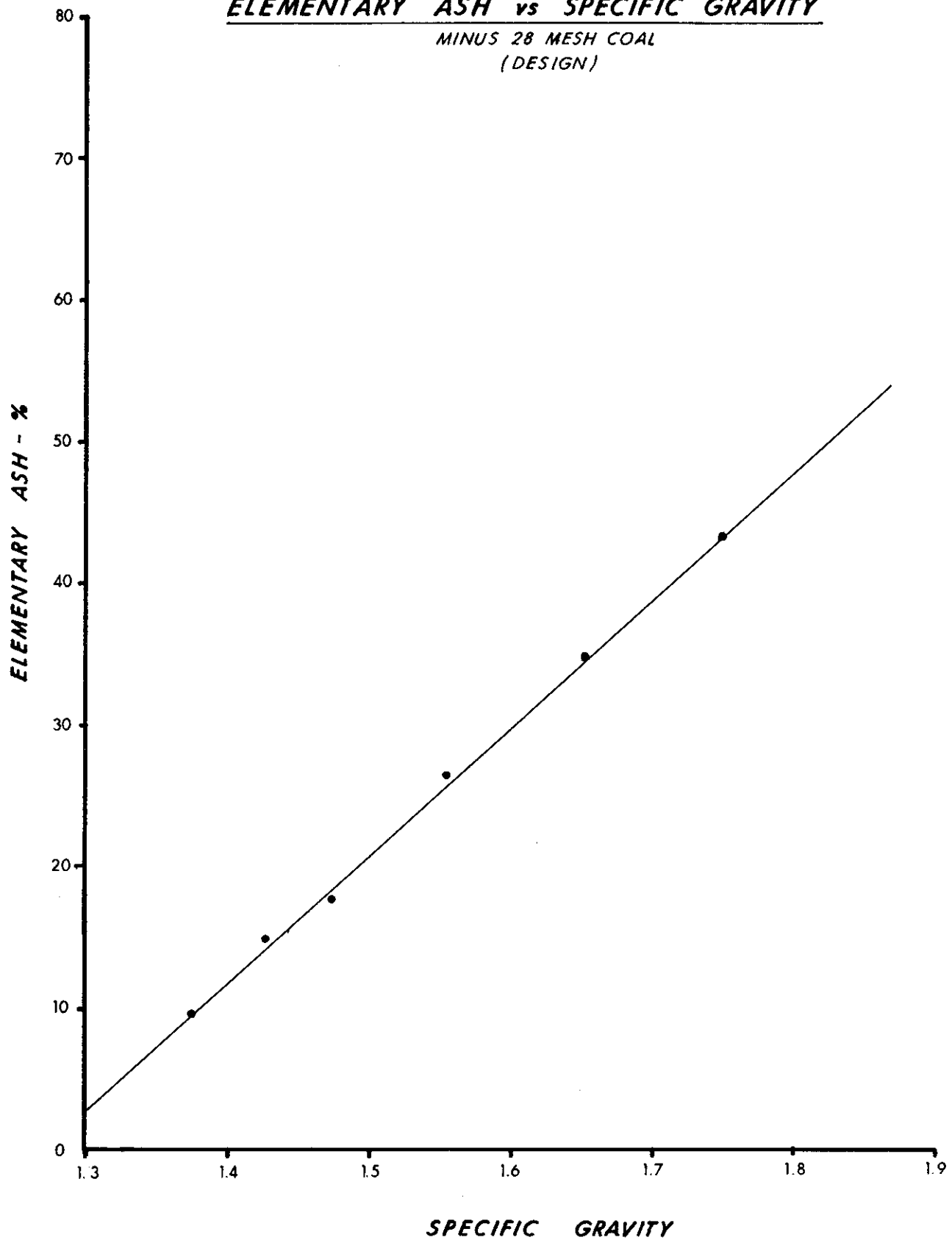
<u>S.G. Fraction</u>	<u>(%) WT.</u>	<u>(%) Ash.</u>	<u>(%) Cum.Wt.</u>	<u>(%) Cum.Ash.</u>
- 1.35	44.7	4.3	44.7	4.3
1.35 - 1.40	10.5	9.8	55.2	5.3
1.40 - 1.45	6.2	15.0	61.4	6.3
1.45 - 1.50	2.5	17.7	63.9	6.8
1.50 - 1.60	4.8	26.5	68.7	8.2
1.60 - 1.70	1.7	34.8	70.4	8.8
1.70 - 1.80	1.1	43.1	71.5	9.3
+ 1.80	28.5	77.4	100.0	28.7

ELEMENTARY ASH vs SPECIFIC GRAVITY
3/4" x 28 MESH COAL.
(DESIGN)



ELEMENTARY ASH vs SPECIFIC GRAVITY

MINUS 28 MESH COAL
(DESIGN)



PLANT CAPACITY

In order to produce 4.0 million short tons per year of clean coal, the plant should be fed at a rate of 1,280 short tons per hour. This is almost double Fording River Coal's present plant feed rate for two million long tons per year production; however, the dilution at Fording is not nearly as extensive as it will be at Elk River.

TABLE 9
PREPARATION PLANT OPERATING PARAMETERS

(24 Hour, 7 Day/Week Operation)

Days/Year	365 days
Scheduled Holidays	24 days
Unscheduled Delays	10 days
Unscheduled Weather Delays	<u>3 days</u>
Total Days Available to Produce	328 days
Average Plant Availability	<u>0.71</u>
Days Operated	232.5 days
Hours per Day	<u>24</u>
Total Hours Operated/Year	5,580 Hrs.
Tons Per Hour of Feed	1,280 tph.
Total Tons of Feed per Year	7,143,000
Plant Recovery	<u>0.55</u>
Total Short Tons per Year	4,000,000

A single plant with a feed rate this high is very cumbersome and complex to operate. It is highly inflexible and

cannot handle drastic changes in feed without having excess capacity built into each circuit. A much easier type of plant to operate would be one split into two separate parallel plants for coarse coal, with a common fines circuit. One side of the plant ("Hard coal section) would process coal which was generally easier to wash, and which will contain coarser coal and rock. The other side ("Soft" coal section) will clean the extremely fine, high near gravity type of coal. The proposed plant feed split will be 550 tph. to the two-stage cleaning circuit, and 750 tph. to the single-stage circuit. Since no accurate allowance can be made for mining conditions, the plant fines circuit will be designed for 50% minus 28 mesh, or 650 tph. Also, since the washability data for the minus 28 mesh coal has not been developed, it is assumed that the coal quality will be highly variable (just as the coarse fractions are) so two-stage compound water cyclones should be installed to clean the 28 x 65 mesh coal, and froth flotation for the fines. Because of surface oxidation of stockpiled coals, froth flotation has proved difficult in Western Canadian coals.

Size Distribution

The anticipated plant feed size distributions are included as Figure 6. The coarser $+3/8$ " coal should clean well in a static heavy media bath such as the Link-Belt Teska unit and the majority of the hard coarse parting material will be rejected. The softer coal seams will not produce a significant amount of $+3/8$ " coal so the only effective alternative for cleaning this type of coal is heavy media cyclones. Since the amount of near gravity material is over 20%, it would be advantageous to use two-stages operating at 0.10 specific gravity difference. The feed

The Tyler Standard Screen Scale

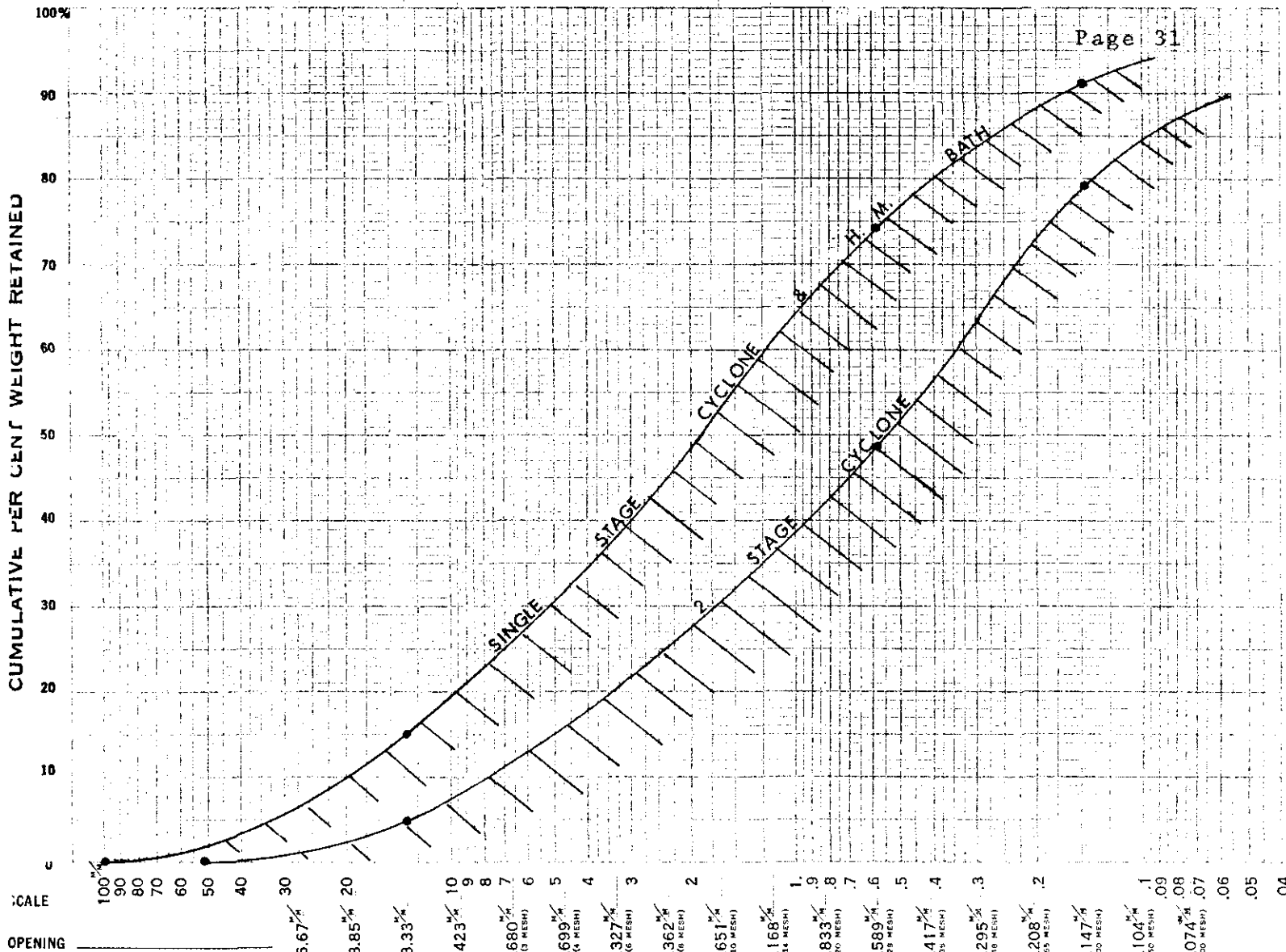
Form No. L-6
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Cumulative Logarithmic Diagram of Screen Analysis on Sample of FIGURE 6

Name ELK RIVER PLANT FEED

Date 18-2-75

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SCREEN SCALE RATIO 1.414												
Openings		Tyler Mesh	U. S. No.	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights
Milli-meters	Inches											
26.67	1.050											
18.85	.742											
13.33	.525											
9.423	.371											
6.680	.263	3										
4.699	.185	4	4									
3.327	.131	6	6									
2.362	.093	8	8									
1.651	.065	10	12									
1.168	.048	14	16									
.833	.0328	20	20									
.589	.0232	28	30									
.417	.0164	35	40									
.295	.0116	48	50									
.208	.0082	65	70									
.147	.0058	100	100									
.104	.0041	150	140									
.074	.0029	200	200									
SS	.074	200	200									
Totals,												

split should be similar to that shown in the following table.

Because of the high and variable amounts of dilution, a single-stage heavy media cyclone would not function properly since the percentage split between coal and refuse might vary from 40-80% clean coal.

Design Throughput

The following table shows the design throughput to produce four million short tons of clean coal per year.

TABLE 10DESIGN THROUGHPUT

<u>Unit</u>	<u>Coal Size</u>	<u>TPH Feed</u>	<u>Max. Product</u>	<u>Max. Refuse</u>
<u>"HARD" COAL CIRCUIT</u>				
H.M. Bath	4' x 3/8"	180 tph.	120 tph.	80 tph.
H.M. Cyclones	3/8" x 28M	420 tph.	330 tph.	210 tph.
<u>"SOFT" COAL CIRCUIT</u>				
Stage 1 H.M. Cyclone (1.60 S.G.)	2" x 28M	330 tph.	265 tph.	200 tph.
Stage 2 H.M. Cyclone	2" x 28M	200 tph.	70 tph.	160 tph.
<u>COMBINED FINES CIRCUIT</u>				
2 Stage Compound Water Cyclones	28M x 0	650 tph.	300 tph.	135 tph.*
Froth Flotation	65M x 0	295 tph.	175 tph.	210 tph.
*Second Stage				

PRODUCT EVALUATION

Since the dilution has some effect on the washability, and since the bulk samples do not always represent the plant feed for the entire seam, some reasonable assumptions have been made about the general characteristics of the plant feed, and the average washabilities used to design the plant.

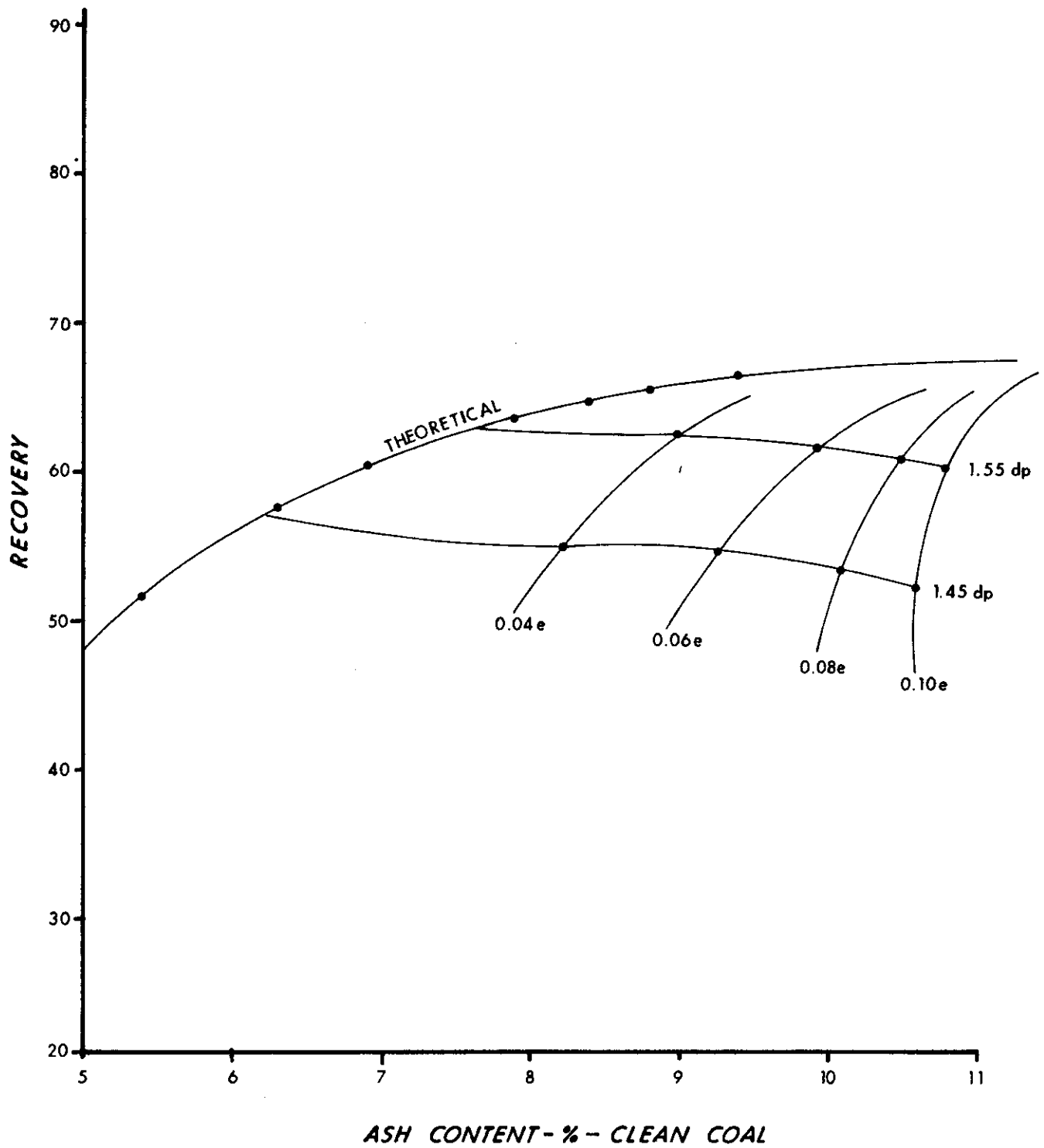
Figures 7 and 8 are plant performance curves for those washabilities. For purposes of design, it is assumed that the washability of the heavy media bath coal, and the coal being fed the H.M. cyclones in the coarse coal section of the plant are the same. This will not in fact be true since most of the dilution will report to the bath.

Further testing on the various coal seams should be conducted with the final flowsheet in mind. In this report the performance curve for the two-stage compound water cyclones was derived for another coal deposit since no washability data was available for the 28 mesh by 100 mesh fractions. This fraction constitutes a large portion of the total tonnage and should be thoroughly tested. In addition, the size consist of each fraction should be such that it more nearly approximates actual plant feed conditions. The bulk samples previously tested are considerably coarser than the actual plant feed will be.

With these assumptions, the product should be as follows:

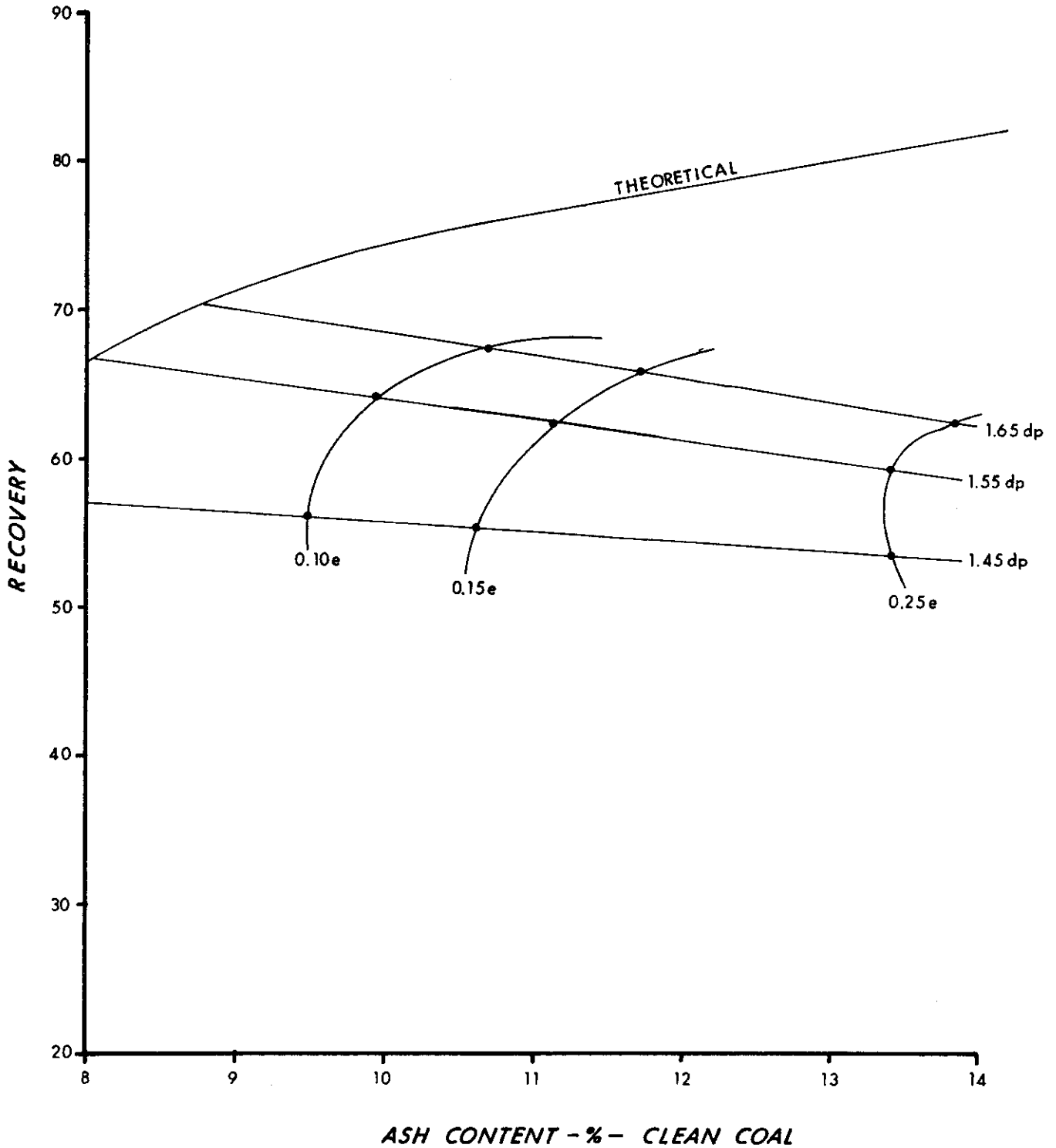
PERFORMANCE EVALUATION CURVE

3/4" x 28 MESH
35% ASH RAW COAL



PERFORMANCE EVALUATION CURVE

MINUS 28 MESH COAL
28.7% ASH



HEAVY MEDIA BATH

FEED	150 tph, 4" x 3/8", 35% Ash
PRODUCT	10.8% Ash, 0.10 probability error 59% Recovery, 1.55 specific gravity
REFUSE	69.8% Ash

HEAVY MEDIA CYCLONES (coarse section)

FEED	405 tph, 3/8" x 28 Mesh, 35% Ash
PRODUCT	9.25% Ash, 0.06 probability error 53.5% Recovery, 1.45 specific gravity
REFUSE	64.6% Ash

HEAVY MEDIA CYCLONES (fines section)

FEED	275 tph, 2" x 28 Mesh, 35.0% Ash
PRODUCT	10.1% Ash, 0.08 probability error 52.5% Recovery, 1.45 specific gravity
REFUSE	62.5% Ash

COMPOUND WATER CYCLONES

FEED	450 tph., 28 Mesh x 0, 28.7% Ash
PRODUCT	11.4% Ash, 0.15 probability error 37.5% Recovery*, 1.60 specific gravity
REFUSE	60.8% Ash**, (21% reject)***

FROTH FLOTATION

FEED	187 tph., 65 Mesh x 0, 28.1% Ash
PRODUCT	11.5% Ash 50% Recovery
REFUSE	44.7% Ash

*This is percent reporting to clean coal after the sieve bend screens

**Refuse from second stage c.w. cyclone.

***Balance of coal is froth flotation cell feed.

The combined product would then be as follows on 1,280 tph. of plant feed:

TABLE 11

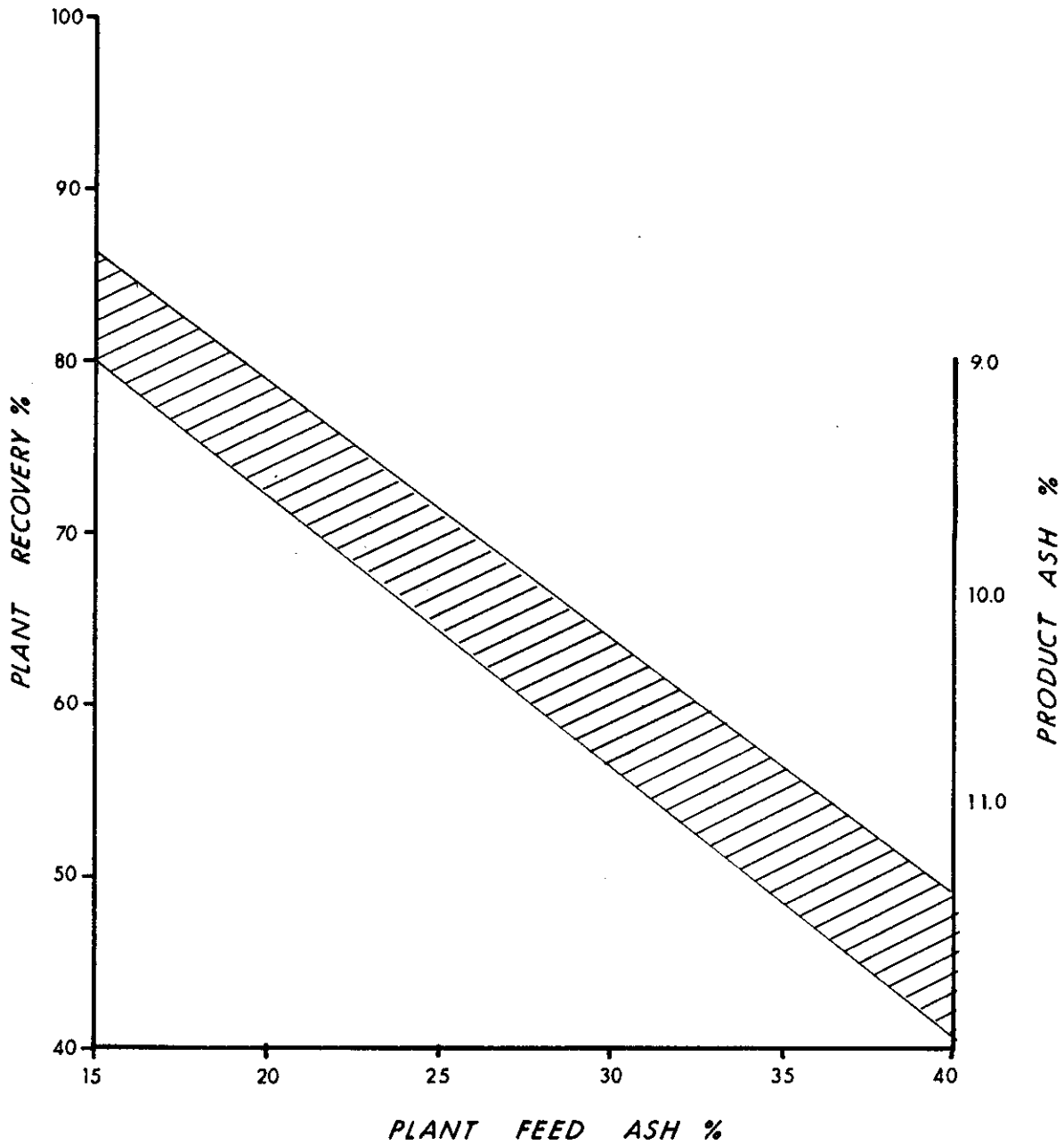
Average Plant Feed & Product

	<u>Feed TPH</u>	<u>Product TPH</u>	<u>Product ASH %</u>
Heavy Media Bath	150	88.5	10.8
Coarse Heavy Media Cyclones	405	217	9.25
Fine Heavy Media Cyclones	275	144	10.1
Compound Water Cyclones	450	169	11.4
Froth Flotation		<u>93.5</u>	<u>11.5</u>
Total	1,280	712.0	10.4

Plant recovery would be 55.6% at a product of 10.4% ash. With normal operating judgement error and less than perfect plant equipment performance, this ash could range to 11.0%.

The probability errors chosen for this evaluation are conservative since one might expect a heavy media cyclone circuit to operate to 0.04 error on Pennsylvania coals. In the coarse circuit, 0.06 was chosen for H.M. cyclones because of the high ash feed and severe amount of refuse. 0.08 was used in the fine H.M. cyclone circuit because of the anticipated extensive amount of near gravity material and the flat nature of soft Western Canadian coals. The compound water cyclones may cut at lower specific gravities; however, the nature of the coal is such that recoveries would be reduced drastically with only small decreases in product ash. Also, if the size distribution of the 28 x 100 mesh material becomes weighted to the finer sizes due to degradation in the pumps, the probable error may approach 0.20.

PLANT RECOVERY & PRODUCT ASH AS A FUNCTION
OF PLANT FEED ASH



Froth flotation performance might be better; however, there is no data available on flotation of 65M x 0 coal with a 28% ash feed.

Figure 9 shows the plant recovery and product ash as a function of plant feed ash. From this it becomes very apparent that the dilution should be minimized in order to produce a suitable product at acceptable recoveries.

Tailings Facilities

The plant will produce 1,055,000 tons of fine coal tailings annually which must be impounded behind a tailings dam. This material will be deposited as follows:

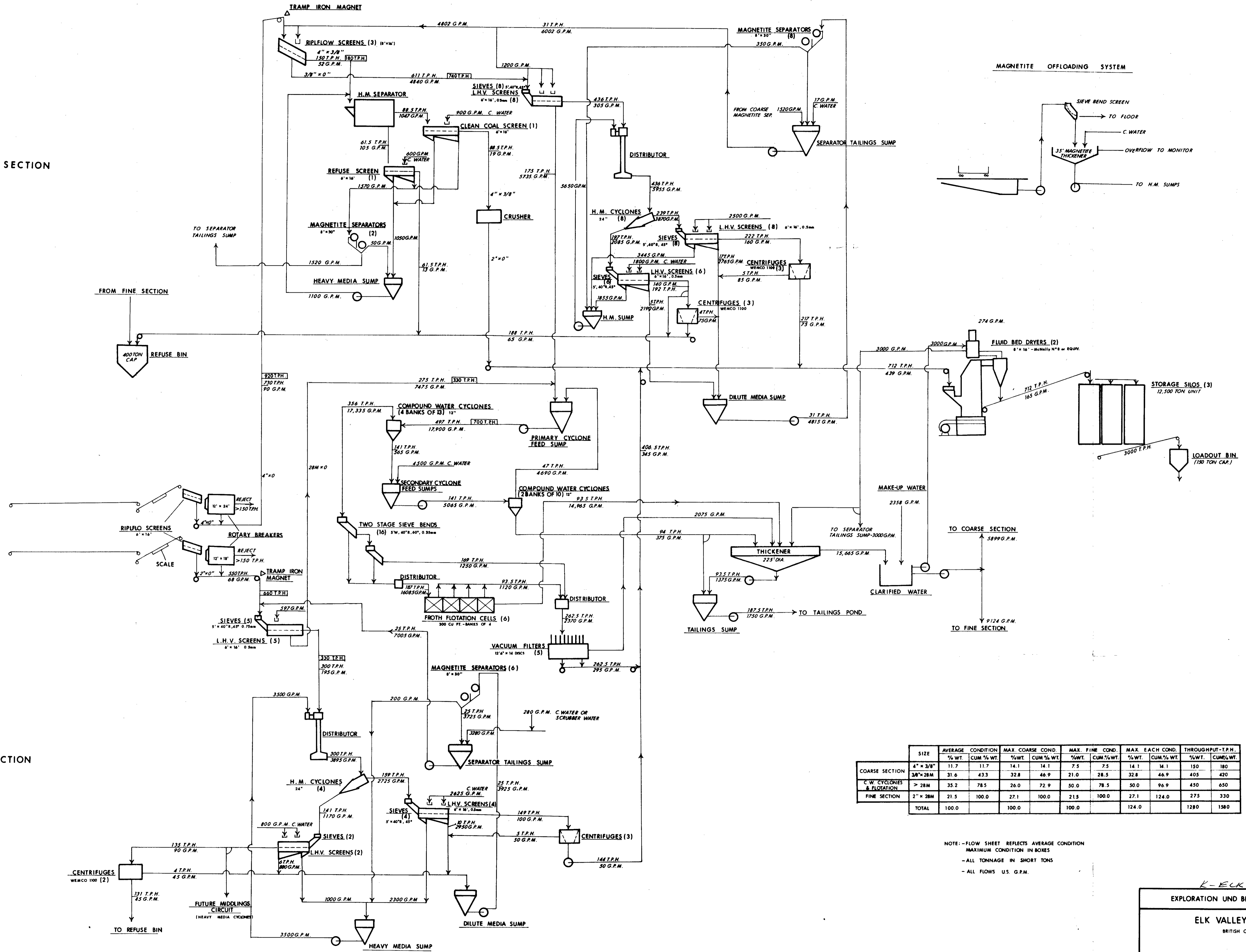
SOLIDS VOLUME:	1,055,000 @ 2.0 S.G.*	=	626,187 c.y.
VOID VOLUME :	(between solid particles)		
	40% of total	=	417,458 c.y.
ICE VOLUME :	(swell due to ice deposition in winter)		
	10% greater than normal	=	105,000 c.y.
CONTINGENCY :	15%	=	<u>172,300 c.y.</u>
	TOTAL		1,320,945 c.y.

Ice will form on the deposited tailings during the winter which is buried and does not thaw during the summer. Also a contingency volume of 15% should be added for variations in operating conditions, and decreased specific gravity of plant tailings.

*This can be as low as 1.65 S.G.

"HARD" COAL SECTION

"SOFT" COAL SECTION



SIZE	AVERAGE CONDITION		MAX. COARSE COND.		MAX. FINE COND.		MAX. EACH COND.		THROUGHPUT-T.P.H.	
	%WT.	CUM.%WT.	%WT.	CUM.%WT.	%WT.	CUM.%WT.	%WT.	CUM.%WT.	%WT.	CUM.%WT.
COARSE SECTION	11.7	11.7	14.1	14.1	7.5	7.5	14.1	14.1	150	180
28" x 28" L.V. CYCLONES & FLOTATION	31.6	43.3	32.8	46.9	21.0	28.5	32.8	46.9	405	420
FINE SECTION	21.5	100.0	27.1	100.0	21.5	100.0	27.1	124.0	273	330
TOTAL	100.0		100.0		100.0		124.0		1280	1380

NOTE: - FLOW SHEET REFLECTS AVERAGE CONDITION
 - MAXIMUM CONDITION IN BONES
 - ALL TONNAGE IN SHORT TONS
 - ALL FLOWS U.S. G.P.M.

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K-Elk River 75 (2)

EXPLORATION UND BERGBAU GMBH OF CANADA

ELK VALLEY COAL PROJECT
 BRITISH COLUMBIA, CANADA

PRELIMINARY FLOW SHEET

SCALE: NOT TO SCALE	DRAWING NO. 1571-00
DATE: MARCH, 1975	PROJECT NO. TM-113
TECHMAN LTD.	