Quintette Coal Limited

QUINTETTE PROJECT

PRELIMINARY

FEASIBILITY

REPORT

1975

Volume II

Section 1.0
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Appendix A
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Kilborn

QUINTETTE COAL LIMITED

QUINTETTE PROJECT

4.5 MILLION M.T.P.Y. COAL DEVELOPMENT

PRELIMINARY FEASIBILITY REPORT

VOLUME II - ENGINEERING REPORT

OCTOBER 1975

KILBORN LIMITED

CONSULTING ENGINEERS

VOLUME II - ENGINEERING REPORT

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LIST OF ABBREVIATIONS

Ft, ft	Feet
ft^2, sq.ft	Square Feet
ft^3, cu.ft	Cubic Feet
m	Metre
m^3, cu.m	Cubic Metre
M	Mesh (Tyler)
M.T.	Metric Tons
MTPY	Metric Tons per Year
MTPH	Metric Tons per Hour
USGPM	US Gallons per Minute
cfm	Cubic Feet per Minute
KV	Kilovolts - 1000 volts
KW	Kilowatts - 1000 watts
H.P.	Horsepower
R.C.	Raw Coal
C.C.	Clean Coal
U/G	Underground
O'size	Oversize
U'size	Undersize
H.P.	High Pressure
L.P.	Low Pressure
O'flow	Overflow
U'flow	Underflow
S.D.	Single Deck
D.D.	Double Deck
S.G.	Specific Gravity

1.0 GEOLOGY

The geological information, reserve calculations, and estimates of productive capacity presented in this report are based to some extent on preliminary evaluations of information recently received from the field and on sometimes incomplete re-evaluations of previously reported information.

1.1 REGIONAL GEOLOGY

The regional geology in the area of the Quintette property is shown on Map Sheets 6, 7 and 11 accompanying this report. This regional geology has been compiled from the detailed and reconnaissance mapping that has been done on the property and, while it is not complete in some areas, it does accurately reflect the style and distribution of the coal bearing formations on the Quintette property.

The Quintette property is located within the Rocky Mountain Foothills region and covers most of the land containing coal bearing formations in an area approximately 25 miles long and 10 miles wide in the Peace River district of northern British Columbia.

The "coal belt" is bounded, for the most part, to both the northeast and southwest by large thrust faults which also splay and transect the belt longitudinally, repeating the coal bearing sections a number of times in the 10-mile width.

The Commotion and Gething Formations are the economically important stratigraphic units in the Quintette coal field which extends from Chetwynd southeast to the Alberta-British Columbia border. In this area, coal development is best in the Gates member approximately from Bullmoose Creek southeast, although aggregate thicknesses of coal approaching 15 metres are not attained until the Wolverine River Valley is reached. In the Gething Formation, usually thin but consistent coal seams are developed from about the Chetwynd area southeast to at least the Monkman Pass road.

On the Quintette property, development of coal in both these formations is unusually good. In the Gates Member of the Commotion Formation the aggregate coal thickness (in four or five seams) is usually in the order of 15-20 metres. The Gething Formation usually has thin (2 to 4 metre), but consistent, seam development in the Skeeter-Chamberlain zone and variable seam thicknesses in the Bird and Middle coal zones. Near Quintette Mountain the Bird zone is about 9-10 metres thick.

1.2 REGIONAL STRATIGRAPHY

The stratigraphic succession exposed on the Quintette property ranges from Upper Jurassic to Lower Cretaceous in age and consists of inter-tonguing shales and sands of both marine and continental origin, with most of the coal-bearing strata being from a deltaic environment. The table of formations for the area is outlined on the following page, with formation thickness ranges and general coal zones as outlined by exploration to date. Coal seams of economic thickness and quality are found in the Gates Member of the Commotion Formation and the Gething Formation.

A brief description of the formations encountered at Quintette, from the oldest to youngest, is as follows:

1. Nikanassin Formation

   The Nikanassin Formation of the Minnes Group is generally accepted as being Upper Jurassic in age. The formation consists of cyclic beds of argillaceous fine-grained sand, siltstone, carbonaceous shale, and coal. The coal is poorly developed (usually less than 6" in thickness) and discontinuous. The formation generally occurs under low angle slopes which are tree and bush covered below 5000' and form grey-brown pebbly talus above 5000'. Gradation from the Nikanassin Formation to the Cadomin Formation is abrupt, with gradation from fine sand to coarse sand to the sharp contact of cobble conglomerate usually taking place within 20 feet. Only the upper portion of this formation is present at Quintette; however, it is reported to range from 500 to 1,500 feet in thickness.

GEOLOGICAL CORRELATION & BRIEF DESCRIPTION OF THE FORMATIONS IN QUINTETTE PROPERTY

Series	Stage	Group	Formation (thickness)	Coal zone	Columnar section	Description
Upper Creta.	Cenomanian	FORT ST. JOHN GROUP	Shaftesbury (500' - 1500')			Alternation of interbedded dirty gray shale and mudstone with a few thin sandy shales.
LOWER CRETACEOUS	ALBIAN		COMMOTION FORMATION: Boulder Creek Member (400'-500')			Coarse fine grained, well sorted sandstone, massive conglomerate, and non-marine gray shale with thin layers of carbonaceous materials.
			COMMOTION FORMATION: Hulcross Member (250'-350')			Dark-gray marine shale and sandy shale with a few sideritic concretions and kaolinitic mudstones.
			COMMOTION FORMATION: Gates Member (860'-950') — Upper Gates Interval; Babcock Member; D.E.F. Zone and Middle Gates Interval; Quintette Member	A B C D E F I J		Cyclic alternation of interbedded gray shale and coarse-fine grain sandstone, conglomerate and coal.
			Moosebar (425'-700')			Dark gray marine shale with sideritic concretions; glauconitic sandstone and pebbles at base.
	APTIAN ?	BULLHEAD GROUP	Gething (400'-680')	Bird; Skeeer; Chamberlain; Middle		Fine to coarse-grained, brown, calcareous, carbonaceous sand, coal, coaly shale, carbonaceous shale and conglomerate.
	BARREMIAN	BULLHEAD GROUP	Cadomin (100'-150')			Massive conglomerate containing chert and quartzite, pebbles, cobbles.
		MINNES GROUP	Nikanassin (1500'+)			Fine-grained sandstone, sandy shale and shale with a few thin-banded coal shales.

2. Cadomin Formation

The Cadomin Formation and Gething Formation comprise the Bullhead Group of the Lower Cretaceous Series. The Cadomin consists of well rounded cobbles and boulders of black, white and green chert, white and grey quartzite and quartz with minor flattened and rounded pebbles of the same material, all of which are bound by silicious cement. It is generally believed that this formation was deposited over an extensive area and thus the upper contact is defined at the first stratigraphic break in the massive conglomerate. Due to its resistant nature, the formation is usually well exposed. It weathers to a rusty gravel and forms one of the better stratigraphic markers on the property. Thicknesses range from 50 to 150 feet.

3. Gething Formation

The Gething Formation consists of alternating units of fine to coarse grained sandstone, carbonaceous shale, coal, sandy shale and conglomerate. The sandstones are thickly bedded to massive, with conglomeritic beds increasing towards the base of the formation. Four coal zones have been encountered during the course of exploration. The Gething is poorly exposed on the property, with the basal conglomerates forming the only distinctive marker. The formation varies in thickness from 400 to 680 feet. The upper contact of the Gething is defined by a thin bed of pebble conglomerate followed by a bed of glauconitic sandstone which signifies the start of marine sediments of the overlying Moosebar Formation. This glauconitic sandstone is probably equivalent to the Bluesky Formation of the Plains area.

4. Moosebar Formation

The Moosebar and Commotion Formations comprise the Ft. St. John Group of Lower Cretaceous age. The basal sequence of the Moosebar Formation consists of homogenous dark grey to black shale, with thin beds of sideritic concretions up to 1 foot in thickness and thin beds of bentonite and siltstone. The upper part of the formation consists of banded or fissile sandy shale, very fine sandstone and sandstone with intercalating thin shales. This later sequence forms the transition from marine sediments to massive continental sands at the base of the overlying Gates Member of the Commotion Formation. The variable nature of the transition sequence accounts for the overall variation in the formation which ranges from 400 to 700 feet in thickness. Exposure of Moosebar sediments is normally restricted to areas of high relief where creek channels or gulleys often cut along the strike of the beds.

5. Commotion Formation

Gates Member

The Gates Member (or Formation), which ranges in thickness from 860 to 950 feet, lies conformably over the Moosebar Formation and contains the bulk of the coal reserves explored to date on the Quintette property. The lower portion of the formation consists of massive, light-grey, medium grained sandstone, with minor carbonaceous and conglomeritic horizons, and is tentatively referred to as the Quintette Member. Four, and perhaps five, cyclic sequences of coal deposition occur above the

Quintette Member within about 300 feet of section. Cycles normally begin with laminated medium to fine grained sandstone and grade to carbonaceous shale and coal. Lenses of conglomerate may also be found in this section which weather to a light to medium orange rubble where exposed above the treeline. In general, coal seams developed in the upper 3 or 4 zones reach a maximum thickness of about 10 feet, whereas coal seams developed in the lower zone are usually those which show the greatest thickness (up to 12 to 40 feet) and continuity. Correlation of coal seams has been possible over distances up to 8 miles and with continued exploration it is felt correlation for the entire property will be possible.

A massive medium to coarse conglomeritic sandstone or pebble conglomerate sequence with an average thickness of about 60 feet overlies the first coal horizon (D seam) in the Middle Gates. This sequence, which is known as the Babcock Member, is very resistant as the conglomerates contain a high degree of chert and silicious cement and thus the Member forms a useful marker in locating the Middle Gates coal bearing horizon. A predominantly shale sequence referred to as the Upper Gates Member overlies the Babcock Member. It contains intercalating sandy shale or very fine sandstone and poorly developed coal. Three coal zones (A, B & C) have been located in this sequence; however, they have not yet been found to contain sufficient thickness, quality and continuity to be given economic consideration. A very thin bed of chert pebbles with feruginous cement marks the contact of the overlying marine sediments of the Hulcross Formation.

Hulcross Member

The Hulcross Member consists of between 250 and 350 feet of rubbly or blocky, medium to dark grey shale with thin interbeds of siltstone and very fine sandstone. Sandstone and siltstone interbeds are more prevalent near the top of the formation where a few kaolinite beds have also been observed. The formation is more homogenous near the base and contains sideritic concretions.

Boulder Creek Member

The Hulcross marine shale grades conformably into shale, graywacke and conglomerate of the Lower Boulder Creek Member. The middle part of the member consists of alternating medium to fine-grained sandstone and shale, while the upper part consists of massive conglomerate and conglomeritic sandstone. The Upper Boulder Creek lithology closely resembles that of the Babcock Member in the Gates. An average thickness of 550 feet has been measured in this member.

Shaftesbury Formation

The lower portion of the Shaftesbury Formation, consisting of dark-grey to black marine shale with minor siltstone, overlies the Boulder Creek Member and completes the stratigraphy exposed at Quintette. This formation closely resembles Hulcross shale. Exposures of the Shaftesbury Formation are restricted to the axes of major synclines at high elevations and to the northeastern border of the licence area.

1.3 REGIONAL GEOLOGICAL STRUCTURE

The regional structure within the Quintette property is best illustrated on the map sheets No. 6, 7 and 11 accompanying this report. These maps show that the primary structural controls are the large thrust faults which define the coal field. Within the Quintette property, in areas which contain the coal-bearing formations, the main geological structures are broad synclines and sharper anticlines which are separated by medium to high angle thrust faults and zones of highly deformed Nikanassin Formation. The faults dip to the southwest and have vertical displacement in the order of 100 metres. This probably indicates that they are splays from the major fault system which defines the northeastern boundary of the coal field and may underlie it.

Geological structures and topography, to a large extent, define the coal reserve areas within the Quintette property. This is most obvious in some of the proposed open pits where the coal reserves are entirely contained within synclines which form topographic highs. The Roman Mountain, Sheriff and Frame Pits are good examples of this. The underground reserves are located in large, structurally continuous blocks on the flanks of anticlines and synclines. It is important to note that faulting is not frequent within these structures, although it does become more frequent as the degree of structural deformation increases. For example, the Roman Mountain reserves, which are located in a tight chevron fold, are more often faulted than those in the much broader (flat) Babcock Mountain structure where the few faults that have been observed have displacements in the order of only 5 or 10 metres. In any case, the faulting that is present is not expected to have a significant effect on the mineability of the various reserves.

1.4 RESERVES

Since the original property was acquired in 1969 a number of areas within it have been drilled and tested and, as a consequence, large reserves of medium volatile coking coal have been identified in a variety of potential mining conditions. These conditions range from 2 to 6 metre thick, relatively flat-lying underground reserves to open pit reserves containing coal seams with average thicknesses ranging from about 1 to 9 metres.

Only indicated reserves in areas which have been tested with a significant amount of drilling, trenching, and/or adit drivage are summarized in this report. No attempt has been made to re-calculate the overall possible reserves of coal in place (previously estimated at 2.8 billion tonnes) within the entire property as the data from this year's exploration is still being analyzed.

The table on the following page summarizes the indicated reserves and estimated productive capacities of most of the areas in the Quintette property which have been tested by drilling, trenching, and/or adit drivage. In this table the reserves for the Nos. 2, 3 and 4 Mines have been combined as they are contiguous and revised plans, with main entries near Babcock Creek, have not yet been prepared for No. 2 Mine. It can be assumed that such new plans would show reserves similar to those now indicated and, on this basis, it can be estimated that the productive capacity of the No. 2 and No. 3 Mines together would be a total of about 3.5 million metric tons over 5 to 6 years. Care should also be used in evaluating the

reserves summarized in this table on the basis of their indicated strip ratios alone, as these ratios are very sensitive to the amount of rock dilution in the coal and they do not always reflect mining conditions, particularly at the Roman Mountain pit and on the east side of the Frame pit where geological conditions may affect mining costs as dips exceed 30 degrees and in some cases total seam thicknesses may approach 1.5 metres.

QUINTETTE PROPERTY

SUMMARY OF INDICATED RESERVES AND PRODUCTIVE CAPACITY

UNDERGROUND MINING RESERVES

Proposed Mine Site	Indicated Reserves In Place Within Mining Area M.T.x10^6	Estimated Raw Coal Productive Capacity* - First 20 Years M.T.x10^6	Preparation Plant Yield %	Estimated Clean Coal Productive Capacity -First 20 Years M.T.x10^6
Babcock No.1	122.0	54.0	69	37.3
Babcock No.2,3 & 4****	41.4	22.9	73	16.7
Wolverine				
- Perry Creek Anticline	94.47	22.0**	70	15.4
- Five Cabin Syncline	104.3	44.0	-not estimated-	

OPEN PIT MINING RESERVES

Proposed Mine Site	Strip Ratio Cubic Metres Per Metric Ton	Indicated Reserves In Place M.T.x10^6	Estimated Preparation Plant Recovery *** %	Estimated Clean Coal Productive Capacity At Stated Strip Ratio M.T.x 10^6
Babcock Area				
- Windy Pit	7.8	11.6	71	8.2
- Roman Mountain Pit	5.6	21.2	79	16.7
				24.9
Wolverine Area				
- Sheriff Pit	3.1	23.5	67	15.7
- Frame Pit	9.7	30.5	78	23.8
- Sheriff & Frame Pits combined	6.8			39.5

* Productive capacities estimated from preliminary data in previous reports by Denison Mines Limited and Mitsui Mining Company, extended to 20 years.

** Underground production from the Wolverine area is expected to come primarily from the Gates Member during the first stage of production.

*** Preparation plant recovery (yields) for open pit reserves are estimated by assuming that 90% of the coal only portion of the total raw coal mined will be recovered.

**** The productive capacity of No.2 and No.3 Mines together is estimated at 3.7 million tonnes per year over a period of 5 to 6 years.

1.4.1 Underground Reserves - Babcock No.1 Mine

Geological Notes

The Babcock No. 1 Mine area contains up to five seams, three of which may be considered to be mineable. The reserves occur in a relatively flat synclinal structure with dips in the order of 8 to 15 degrees. Significant faulting has only been observed in the northern corner of the reserve area and present mine plans take this into account. Other small faults along the northwest face of Babcock Mountain have been observed and the significance of these or similar faults to plans for mining has not been estimated in detail, but it is not expected to be great as the displacement on the faults is only 5 to 10 metres.

It should be noted that the reserve table accompanying this section refers to coal in place within the reserve block and the estimated clean coal yield does not imply a mining recovery factor, but relates only to the planned mining within this block in the first twenty years of the mine's operation. In fact, the total clean coal reserve in the first proposed mine set-up probably exceeds 50 million tonnes.

Data Base

a) Geological mapping with detailed work along the southwest and northwest sides and along Babcock Creek.

b) 13 to 15 diamond and rotary drill holes.

c) 10 successful adits (see also Windy Pit).

Illustrations accompanying this report

a) Five Cabin to Babcock area - Typical sections. Drawing No. QNTT-0593-R01.

b) See also mining plans in this report.

c) Geological Map, Sheet No. 7.

Method of Calculation

a) A specific gravity of 1.60 has been used for raw coal in place as detailed coal/rock ratios were not always recorded in the early drilling from this area and the seam sections include in-seam dilution.

b) Seam thicknesses of coal and included rock are the weighted averages from all the holes in the proposed mine area that were reported in the Denison Mines Limited Second Interim Report (1972).

c) The area accessed by the present mine plans refers to that area within the seam that is enclosed by the mine plans presented in the main body of this report (Kilborn Limited). An adjustment has been made for that part of the reserve that lies within the proposed Windy Pit.

d) Roof dilution is the weighted average of expected roof dilution as indicated in Denison's 1972 interim report. It is somewhat more than, but similar to that suggested by Mitsui Mining Company in their 1974 report.

e) Total raw coal in place includes coal plus in-seam and out-of-seam dilution.

f) As noted in the reserve table, productivities (raw and clean) were based on the data provided by Mitsui in their 1974 report.

BABCOCK NO. 1 UNDERGROUND MINE

SUMMARY OF RESERVES

(S.I. (Metric) Units)

Seam	Total In-Place Reserve of Coal & Mined Dilution* M.T.x10^6	Approx.Area Accessed by Present or Anticipated Mine Plans cu.m x 10^6	Weighted Average Thickness Of Coal Seam metres	Weighted Average Thickness Of Roof Dilution metres	Raw Coal In-Place In Mine Area (Sp.Gr.= 1.60) M.T.x10^6	Mined Roof Dilution In Place (Sp.Gr.= 1.90) M.T.x10^6	Total Raw Coal In Place in Mine Area M.T.x10^6
D	54.7	6.48	2.50	0.34	25.9	4.2	30.1
F	67.1	6.37	2.90	0.46	29.6	5.5	35.1
J	98.6	6.14	5.43	0.30	53.3	3.5	56.8
TOTALS	220.4				108.8	13.2	122.0

Anticipated raw coal production** in first 20 years = 54.0 million tonnes.

Estimated clean coal production capacity in first 20 years = 37.3 million tonnes.

* Raw coal reserves taken from Denison Mines Limited Second Interim Report, Babcock Area, May 1973.

** Raw coal production is based on preliminary data from Mitsui Mining Company, extended for 20 years. Estimated clean coal yield for this reserve area was about 73%. (Second Interim Report).

1.4.2 Underground Reserves - Babcock No.2, 3, and No.4 Mines

Geological Notes

The No.2, 3 and No.4 Mines are all contiguous and are located in the southwest flank of the Waterfall Creek Syncline within an area north and south of Babcock Creek. The reserve areas are steep with dips ranging from about 45 to 70 degrees. Only three coal seams are sufficiently thick (greater than 2.5 metres) to be considered economically interesting at this time. The reserves in these three seams, F, I, and J, are combined for all three mine sites in the Reserve Summary table accompanying this report as the final relationship between No.2 Mine and No.4 Mine has not been determined. It is expected that the final plans for No.2 Mine and No.3 Mine together will provide for approximately 3.5 million tonnes of clean coal productive capability. If mining is to extend over a twenty-year period in this area it will be necessary to continue mining into the No.4 Mine area, at least to the 3800 foot Main Entry level.

The detailed mapping and trenching that has been done on the surface outcrops of the coal measures in this area has not indicated any faulting which would interfere with plans for mining in this block. The average thicknesses of the three mineable coal seams range from just under 3 metres to about 5.4 metres, and in the No.3 and No.4 Mine area to the south-east, I and J seams merge into one coal zone about 8 to 9 metres thick.

Data Base

a) Detailed Geological mapping.

b) 12 trenches, 10 of which cover the complete section.

c) 2 diamond drill holes.

Illustrations accompanying this report

a) Representative section, No.2 and No.4 Mine
Drawing No. QNTT 75-0602-R01.

b) Representative section, No.3 and No.4 Mine
Drawing No. QNTT 75-0603-R01.

c) Geological Map, Sheet No. 7.

Method of Calculation

a) The reserves for this area have been re-formatted directly from data prepared by Mitsui Mining Company in their Geological Report of September, 1974.

b) Productive capacities have been estimated from data provided by Mitsui Mining Company in their feasibility report dated December, 1974.

BABCOCK NO. 2, 3, AND NO. 4 MINES - UNDERGROUND

SUMMARY OF RESERVES

(S.I. (Metric) Units)

Seam*	Average Coal Thickness*** Metres	Theoretical Reserves In Place** M.T.x 10^6	Mineable Clean Coal Reserves*** M.T.x 10^6
F West (No.2,4 Mines)	2.79	4.005	1.729
F East (No.3,4 Mines)	2.61	4.187	1.843
I West (No.2,4 Mines)	3.85	6.538	2.809
I East (No.3,4 Mines)	3.00	6.674	3.054
J West (No.2,4 Mines)	4.99	8.023	3.693
J East (No.3,4 Mines)	5.36	11.936	5.134
TOTALS		41.363	18.262

Estimated raw coal production capacity**** first 20 years = 22.9 million tonnes.

Estimated clean coal production capacity**** first 20 years = 16.7 million tonnes.

* The reserves for No.2 Mine are combined with No.4 Mine northwest of Babcock Creek and No.3 Mine reserves are combined with those from No.4 Mine southeast of the Creek.

** Theoretical reserves and other data in this table have been re-formatted from data prepared by Mitsui Mining Company in their 1974 Geological Report.

*** Average coal thickness is based on the coal only (no rock or included dilution) part of the seam section. Consequently, mineable clean coal reserves are for the coal only part of the section and do not reflect the raw coal tonnage which would be required to provide this amount of clean coal. About 90% of the "mineable clean coal" is expected as product from the preparation plant.

**** Production capacities estimated from preliminary data supplied by Mitsui Mining Company and extended for 20 years.

1.4.3 Underground Reserves

Wolverine Area - Perry Creek Anticline - East Limb

Geological Notes

The Wolverine underground reserves have been located in the east limb of the Perry Creek Anticline where it has a relatively stable slope with dips averaging about 15 degrees. The coal seams are located in both the Gates Member and the Gething Formation. In the Gates Member the basal coal seam, tentatively identified as the Gates No. 1 seam, is best developed over the entire reserve area. The Gates No. 2 seam, which is potentially mineable in only half the area, is located just above the Gates No. 1 seam and in the south corner of the reserve area they are separated by only a few metres of rock. Drilling on the west limb of the anticline indicates that the seams merge there into one coal zone about 7 metres thick.

The Gething II and III seams are probably equivalent to the Skeeter-Chamberlain zone which has been identified north of the Quintette property. These seams are each about 2 metres thick and appear to be quite extensive, although not all of the holes were drilled to this depth.

At the present time no faults have been identified which would interfere with mining in the area where reserves have been designated. The reserve area is, however, terminated by a syncline which may be faulted in places along its axis.

Productivities have been estimated only for the Gates Member and then only conceptually in this area. Mining in the Gething Formation would require inclined or vertical shafts and the F.S.I. of the seams there indicates that they may not be strongly coking. For these reasons, it is not anticipated that the Gething seams would be mined during the initial phase of production. Increased productivity (an additional million tonnes of raw coal per year) could be obtained from the Perry Creek Anticline if reserves are proven to extend as anticipated in the west flank of the structure. This would provide an annual clean coal potential of 1.5 million tonnes per year.

Data Base

a) Geological mapping.

b) 8 diamond drill holes.

Illustrations Accompanying this Report

a) Wolverine North, Cross Section D-D'
Drawing No. WLVR-73-0395-R02

b) Geological Map, Sheet No. 11

Method of Calculation

a) The data for this reserve has been extracted from the Denison Mines Limited report on the Wolverine area dated January, 1973.

b) The original calculations were based on planimetric measurements of adjoining areas of influence around each drill hole. The volume of coal was calculated by dividing these areas into sub-areas based on isopachs of seam thickness. Specific gravities used were based on the raw ash content of each total seam intersection.

WOLVERINE UNDERGROUND
PERRY CREEK ANTICLINE - EAST LIMB
SUMMARY OF RESERVES
(S.I. (Metric) Units)

Seam	Area of Coal Reserve $m^2 \times 10^6$	Weighted Average Seam Thickness (metres)	Cubic Metres of Coal $\times 10^6$	Weighted Average Specific Gravity	Coal in Place* M.T.$\times 10^6$	Mining Recovery (Estimated)** %	Net Raw Coal to be Mined M.T.$\times 10^6$	Preparation Plant Yield (Theoretical Less 5%)*** %	Net Clean Coal Reserve M.T.$\times 10^6$
Gates No.1	9.01	2.29	20.60	1.404	28.92	65	18.80	77.77	14.62
Gates No.2	4.67	2.59	12.10	1.483	17.94	60	10.76	59.46	6.40
Gething II	8.41	2.09	17.58	1.466	25.77	60	15.46	58.69	9.07
Gething III	8.41	1.90	15.98	1.376	21.99	60	13.19	88.39	11.66
TOTALS					94.62		58.21	71.83	41.75

Estimated raw coal production capacity****(1.1 million tonnes per year) for first 20 years = 22 million tonnes.

Estimated clean coal production capacity (0.75 million tonnes per year) for first 20 years = 15 million tonnes.

Production capacity could be increased to 1.5 million tonnes of clean coal if reserves on the west flank are substantiated.

* Reserve data re-formatted from report by Denison Mines Limited, January 1973.

** No mine plans have been developed for this area. Mining recoveries are conceptual only, based on conventional (room and pillar) extraction.

*** Dilution has not been estimated, except by decreasing theoretical yields by 5%.

**** Production from this area, in the first stage, is expected to come primarily from the Gates seams as the clean coal from these seams is expected to have better coking characteristics (F.S.I. 6 to 8.5) and they are closer to the surface.

1.4.4 Open Pit Reserves - Babcock Area
Windy Pit

Geological Notes

The Windy Pit area is the surface extension of the Babcock No. 1 Mine underground reserve. The area within the pit is essentially a broad, nearly flat syncline. Within the area there is one significant roll in the floor of Seam D which probably projects, down section, into a small fault in Seams J and K. Another small fault has been found in the Big Windy area and a fault complex has been discovered associated with the previous known fault in the Little Windy area.

Most of these faults do not have a significant effect on reserves. The Little Windy fault zone, however, may have an effect on coal oxidation through ground water circulation on the fault plane. Based on this concept, a liberal deduction for additional coal oxidation has been made on the plans for each seam in this area.

In 1975 a number of holes were drilled to test the zones of oxidation for each seam in this area. As a result, it has been established that the depth of oxidation on relatively well-sloped land is 50 feet or less, but that on the "flat" areas of Big and Little Windy the oxidation may be as deep as 200 feet. On the basis of the drilling results, oxidation maps were prepared for each seam and these were used to estimate the remaining fresh coal in the pit area.

Reserves have been calculated for a number of pit designs with different locations of the pit high-wall. These calculations have shown that an optimum strip ratio below about 7.5 cubic metres to 1 metric ton cannot be attained in this area, based on the data now available. One pit, near this optimum, has been calculated in detail using 1 inch = 200 ft bases and the location of this pit, which has a 7.8 to 1 strip ratio is shown on drawing No. QNTT 75-0579-R04 which accompanies this report. The reserves for this pit are summarized in the table in this section.

Data Base

a) Detailed geological mapping.
b) 30 drill holes (rotary and diamond).
c) 10 successful adits (see also Babcock No.1 Mine).

Illustrations accompanying this report

a) Windy Area (Pit Sections)
Drawing No. QNTT 75-0604-R01

b) Windy Area (Pit Plans)
Drawing No. QNTT 75-0579-R04

c) Geological Map Sheet No. 11.

Method of Calculation

a) Seams greater than 1 metre and rock bands less than 1 metre thick which were overlain and underlain by coal were included in the reserve.

b) A mining loss of 30cm of coal was assumed for each seam.

c) Oxidized coal was considered to be waste material.

d) Each seam was isopached and planimetered to obtain both the volume of coal and the volume of rock. Weighted average thicknesses were calculated using the total volume and total area of the seam, as calculated by this method.

e) The total volume of rock and coal was calculated by planimetering each 100 ft contour between the pit walls and the base of Seam K.

f) Coal and rock were tabulated separately and tonnages for each were calculated using specific gravities of 1.4 and 1.9 respectively.

g) Clean coal recoveries were estimated by assuming that 90% of the coal only portion of the mining section (calculated after deducting 30cm for mining loss) would be obtained as clean coal.

h) With the exception of Seam E, only those seam sections with a calculated clean coal recovery of 65% or better were included in reserves.

i) As dips are usually less than 10 degrees, no correction of seam thickness was made.

WINDY PIT

SUMMARY OF RESERVES

(S.I. (Metric) Units)

Seam	Area of Unoxidized Coal* Sq.m	Weighted Average Coal Thickness** metres	Weighted Average Thickness Mined Dilution metres	Cubic Metres Coal x 10^6	Cubic Metres Mined Dilution x 10^6	M.T. Mined Coal (Sp.Gr. 1.40) x 10^6	M.T. Mined Dilution (Sp.Gr. 1.90) x 10^6	Total M.T. Raw Coal Mined*** x 10^6
D	0.215	2.34	0.34	0.503	0.073	0.704	0.139	0.843
E	0.355	1.77	0.85****	0.628	0.302	0.880	0.573	1.453
F	0.396	1.79	0.34	0.709	0.135	0.992	0.256	1.248
G	0.426	1.19	0.09	0.507	0.038	0.710	0.073	0.783
J,K	0.830	5.07	0.88	4.208	0.730	5.891	1.388	7.279
TOTALS				6.555	1.278	9.177	2.429	11.606

Total Rock Volume (including all coal and mined dilution = 98,510,000 cubic metres.

$$\text{Strip Ratio} = \frac{\text{Total Rock Volume - (vol. coal mined + vol. mined dilution)}}{\text{(Tons of coal mined + tons dilution mined)}} = 7.8 \text{ cu.m/M.T.}$$

* Area of Unoxidized Coal = sum of measured plan areas uncorrected for dip as dips are generally less than 10 degrees.

** Weighted Average Coal Thickness = measured thicknesses less 30cm for mining loss as the coal only portion of the seam thickness, weighted by planimetry of coal isopachs.

*** Raw Coal Mined = mined coal + mined dilution.

**** Estimate of clean coal recovery is less than 65%, but Seam E is retained in reserves due to its exceptional quality (clean).

1.4.5 Open Pit Recovery - Babcock Area

Roman Mountain Pit

Geological Notes

The Roman Mountain pit is located within a fairly simple chevron fold whose structure is shown clearly on drawing QNTT-75-0594-R01 accompanying this report. This fold is somewhat complicated by small drag folds and minor faulting but it is not expected that these structures will impede mining. The drag folds may even increase coal thicknesses locally.

The main difficulty in mining this structure may be found in removing the three uppermost seams, D, E, and F, as total seam thicknesses are only about 1.5 to 2.5 metres. The entire abandonment of these upper seams would increase the strip ratio to about 7.4 cubic metres per metric ton and would reduce the clean coal reserve to about 13.4 million metric tons.

Data Base

a) Detailed geological mapping.
b) 4 trenches.
c) 11 rotary drill holes.
d) 2 diamond drill holes.

Illustrations accompanying this report

a) Roman Mountain Cross Sections
   Drawing No. QNTT 75-0794-R01
b) Geological Map Sheet No. 11.

Method of Calculation

a) The following criteria were used to deterine whether or not a seam would be included in reserves.

   i) Minimum average thickness of 1.5 metres including rock bands no greater than 1 metre.

   ii) Estimated clean coal recovery of 65% or better, based on 90% of the coal in the section being recovered.

b) Coal to a depth of 50 feet was assumed to be oxidized and was considered to be waste material.

c) Mining loss was assumed to be 30cm of coal from each seam.

d) The numerical average of the coal seam thicknesses and the dilution thicknesses were used for each seam, using only those data points from trenching and drilling which were considered completely reliable (some drilling and trenching was near faults or disturbed bedding). There was not sufficient data to justify preparing isopach maps for each seam.

e) Structure contour maps were prepared for each seam and the seam volumes were calculated by measuring areas of similar dip on these plans and correcting to true area by multiplying by the secants of the dips and by the coal and rock thicknesses.

f) The total volume of rock was calculated by planimetering the area of each 100 foot topographic contour between the land surface and, where appropriate, the structure contour of the base of Seam J.

g) Coal and rock were tabulated separately and tonnages for each were calculated by using specific gravities of 1.4 and 1.9 respectively.

ROMAN MOUNTAIN PIT

SUMMARY OF RESERVES

(S.I. (Metric) Units)

Seam	Area of Unoxidized Coal * Sq.metres	Average Coal Thick-ness ** metres	Average Thickness Mined Dilution metres	Cubic Metres Coal x 10^6	Cubic Metres Mined Dilution x 10^6	M.T. Coal Mined (Sp.Gr. 1.40) x 10^6	M.T. Mined Dilution Sp.Gr. (1.90) x 10^6	Total M.T. Raw Coal Mined *** x 10^6
D	386,011	2.13	0.31	.822	.119	1.151	.227	1.378
E	476,778	1.29	0.32	.615	.153	0.861	.290	1.151
F	832,132	1.53	0.16	1.273	.133	1.782	.253	2.035
I	1,256,048	3.15	0.45	3.957	.565	5.539	1.074	6.613
J	1,257,163	5.29	0.29	6.650	.365	9.311	.693	10.004
TOTALS				13.317	1.335	18.644	2.537	21.181

Total Rock Volume (including all coal and mined dilution) = 133,578,000 cubic metres.

$$\text{Strip Ratio} = \frac{\text{Total Rock Volume - (vol. coal + vol. mined dilution)}}{\text{(tonnes of coal mined + tonnes mined dilution)}} = 5.62 \text{ cu.m/metric ton.}$$

* Area of Seam = sum of measured plan areas corrected for dips (i.e. multiplied by secants).

** Average Coal Thickness = average seam thickness (approximate) less 30cm mining loss.

*** Raw Coal Mined = coal mined + mined dilution.

1.4.6 Open Pit Reserves - Wolverine Area

Sheriff Pit

Geological Notes

The Sheriff Pit is located on Mast Ridge, the topographic high which divides the headwaters of Mast Creek and the Wolverine River from those of the Murray River. The geological structure of the main reserve area consists of a rather complex syncline which overlies a large thrust fault. To the southwest a smaller syncline adjoins this structure and the reserves of both are combined in the reserve table for this area. No reserves have been located below the main fault and that area is a prime candidate for future exploration.

The Sheriff Pit contains two major coal seams, Seam E which is about 7 metres thick, and Seam J which is 8 to 9 metres thick. These two seams constitute the bulk of the reserves. While Seam E does not meet the general requirement for reserve status, as its estimated clean coal recovery is only about 58%, it is retained in the reserves as its inclusion does not reduce the overall estimated recovery below 65%. (Calculated recovery is 66.5%).

No oxidation drilling has yet been done on the Sheriff pit but Seam D was oxidized below 100 ft in the first hole that was drilled. For this reason, all of Seam D is considered oxidized in the present calculations and all other seams are assumed to be oxidized to a depth of 100 ft.

Data Base

a) Detailed geological mapping.
b) Approximately 8 trenches.
c) One rotary drill hole, with core.

Illustrations accompanying this report

a) Sheriff-Frame Cross Section, Drawing QNTT 75-0584-R01.
b) Geological Map Sheet No. 11.

Method of Calculation

The method of calculation of reserves for the Sheriff pit was essentially the same as that for the Roman Mountain pit, with the following exceptions:

a) Rock bands included in the mined section of Seams E and J may locally exceed 1 metre in thickness.

b) As noted, Seam E is not removed by the 65% estimated clean coal criterion.

c) Oxidation was taken to be 100 ft.

d) No data points were rejected. Most were from trenching.

SHERIFF PIT

SUMMARY OF RESERVES

(S.I. (Metric) Units)

Seam	Area of Unoxidized Coal * Sq.metres	Average Coal Thick-ness ** metres	Average Thickness Mined Dilution metres	Cubic Metres Coal x 10^6	Cubic Metres Mined Dilution x 10^6	M.T. Coal Mined (Sp.Gr. 1.40) x 10^6	M.T. Mined Dilution Sp.Gr. (1.90) x 10^6	Total M.T. Raw Coal Mined *** x 10^6
D_S	- SEAM D CONSIDERED ENTIRELY OXIDIZED -							
E_S Deputy Syncline	46,222	7.01	2.14****	0.324	0.099	0.454	0.188	0.642
Mesa Syncline	584,841	7.07	2.90****	4.135	1.696	5.789	3.222	9.011
G_S Deputy Syncline	96,902	1.51	0.23	0.146	0.022	0.205	0.042	0.247
Mesa Syncline	614,846	1.13	0.18	0.695	0.111	0.973	0.210	1.183
J_S Deputy Syncline	197,662	8.60	2.08	1.698	0.411	2.377	0.781	3.158
Mesa Syncline	603,411	8.96	1.49	5.406	0.899	7.569	1.708	9.277
TOTALS				12.404	3.238	17.367	6.151	23.518

Total Rock Volume (including all coal and mined dilution) = 88,006,750 cubic metres.

$$\text{Strip Ratio} = \frac{\text{Total Rock Volume - (vol. coal + vol. mined dilution)}}{\text{(tonnes of coal mined + tonnes mined dilution)}} = 3.1 \text{ cu.m/metric ton.}$$

* Area of Seam = sum of measured plan areas corrected for dips (i.e. multiplied by secants).

** Average Coal Thickness = actual thickness less 30cm mining loss.

*** Raw Coal Mined = mined coal + mined dilution.

**** In Seam E_S estimates of clean coal recovery are less than 65%, but the seam is still included in reserves.

1.4.7 Open Pit Reserves - Wolverine Area

Frame Pit

Geological Notes

The proposed Frame Pit is located almost adjacent to and southwest of the Sheriff Pit along Mast Ridge. This pit area is also located in a syncline (the Mast Syncline) but the structure is significantly larger and is not directly associated with significant faulting, although there are minor faults within it. Within the Mast Syncline there is a significant reduction in coal thickness in both Seams E and J compared with their stratigraphic equivalents in the Sheriff Pit.

In the Frame Pit area, five seams are developed, all of which are between about 2 and 3 metres thick. In-seam dilution seldom exceeds 0.5 metres and this results in an estimated clean coal recovery of about 77% and, despite the higher stripping ratio, would suggest that this pit should be mined in conjunction with the Sheriff pit to provide overall recoveries of about 70%.

Data Base

a) Detailed geological mapping.
b) Approximately 5 trenches.
c) One rotary drill hole with core.

Illustrations accompanying this report

a) Sheriff-Frame, Cross Section
Drawing No. QNTT-0584-R01.

b) Geological Map Sheets No. 6 and 11.

Method of Calculation

The reserves for the Frame pit area were calculated essentially as indicated for the Roman Mountain pit, with the following exception:

a) The oxidation level was assumed to be 100 ft.

FRAME PIT

SUMMARY OF RESERVES

(S.I. (Metric) Units)

Seam	Area of Unoxidized Coal * Sq.metres	Average Coal Thick-ness ** metres	Average Thickness Mined Dilution metres	Cubic Metres Coal x 10^6	Cubic Metres Mined Dilution x 10^6	M.T. Coal Mined (Sp.Gr. 1.40) x 10^6	M.T. Mined Dilution Sp.Gr. (1.90) x 10^6	Total M.T. Raw Coal Mined *** x 10^6
D_F	1,130,059	2.04	0.23	2.305	0.260	3.227	0.494	3.721
E_F	1,312,924	2.48	0.41	3.256	0.538	4.558	1.023	5.581
F_F	1,566,869	2.33	0.45	3.651	0.705	5.111	1.340	6.451
G_F	1,771,912	2.70	0.12	4.784	0.213	6.698	0.404	7.102
J_F	2,461,877	1.95	0.19	4.801	0.468	6.721	0.889	7.610
TOTALS				18.797	2.184	26.315	4.150	30.465

Total Rock Volume (including all coal and mined dilution) = 316,634,400 cubic metres.

$$\text{Strip Ratio} = \frac{\text{Total Rock Volume - (vol. coal + vol. mined dilution)}}{\text{(tonnes of coal mined + tonnes mined dilution)}} = 9.7 \text{ cu.m/metric ton.}$$

* Area of Seam = sum of measured plan areas corrected for dips (i.e. multiplied by secants).

** Average Coal Thickness = actual thickness less 30cm mining loss.

*** Raw Coal Mined = coal mined + mined dilution.

1.5 QUALITY

No attempt has been made, for this report, to re-calculate the quality of the clean coal product which is expected for the various reserves on the Quintette property. In the case of the Underground reserves this data has been presented in some detail in previous reports by Denison Mines Limited and Mitsui Mining Company. The quality of the Open Pit reserves in the Windy Pit is also fully documented from that earlier work as the pit is located on the outcrop extension of the Babcock No. 1 Mine. Only preliminary data is available for the Roman Mountain area, the Frame pit and the Sheriff pit. This data indicates that coal quality in these areas will be very similar to the Babcock area, although the volatile content may be about 1% higher and, in some cases, the Free Swelling index may also be higher.

As has been previous reported, the average clean coal product from the Babcock area is expected to have the following properties:

Moisture	6.0%
Ash	7.5%
Volatiles	21.2-23.2%
Phosphorous	0.03-0.05%
F.S.I.	6.5-7.5
Sulphur	0.31-0.51%

Alan A. Johnson
Chief Geologist
Coal Division
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SEC. 2

2.0 MINING

2.1 INTRODUCTION

This study investigates the engineering problems associated with organizing a surface and underground mine program capable of an ultimate capacity of 4.5 million tonnes annually. As indicated on Plates 2-1 and 2-2, the initial production of 3.0 million tonnes per year is mined from the Babcock area. Within three years of Babcock Plant start-up, production is expanded to 4.5 million tonnes per year by the addition of the Wolverine area mines and preparation plant.

The "Feasibility Report on the Babcock Project of Quintette Coal Company" by Mitsui Mining Company is the basic reference for the underground phase of this study. The following items are significant departures from the Mitsui Report.

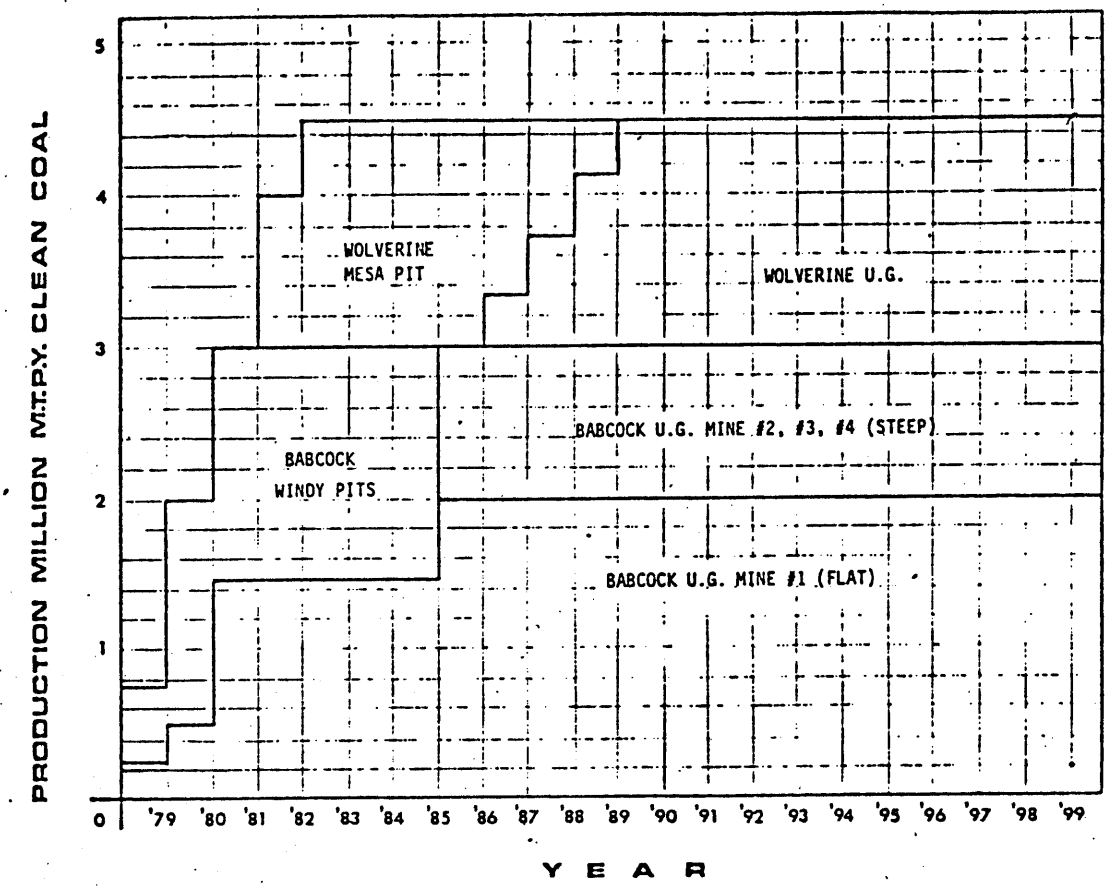
a) Redesign of mine entries to exclude hoists and provide access for mobile equipment, and to include an elevator shaft for man travel to the seams.

b) Addition of a seam exploration program in the Flat Area Development Schedule.

c) Adjustment of the Mitsui schedule to initiate hydraulic mining in D and F Seams, prior to J Seam.

d) Surface mined coal is included.

Dames & Moore, Consultants, provided design and operating data in their study which incorporated Windy and Roman Pits as simultaneous operations. Their report indicated that development of two pits required unacceptable initial capital costs. For this study, pertinent information has been extracted from the Dames & Moore report for capital and operating costs for Windy Pit.



PRODUCTION - CLEAN COAL (THOUSAND METRIC TONS)

BABCOCK MINES	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
WINDY PITS	500	1500	1500	—	—	—	1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9,500
U.G.MINE #1	250	500	1500	—	—	—	1500	2000	—	—	—	—	—	—	—	—	—	—	—	—	2000	36,250
U.G.MINE #2, #3, #4(STEEP)								1000	—	—	—	—	—	—	—	—	—	—	—	—	1000	14,000
SUB-TOTAL	750	2000	3000	3000	3000	3000	3000	3000	—	—	—	—	—	—	—	—	—	—	—	—	3000	59,750
WOLVERINE MINES																						
MESA PIT				1000	1500	—	—	1500	1125	750	375	-	-	-	-	-	-	-	-	-	-	9,250
UNDERGROUND									375	750	1125	1500	—	—	—	—	—	—	—	—	1500	17,250
TOTAL	750	2000	3000	4000	4500	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4500	86,250

ASSUMPTIONS:

Babcock Plant - 3.0 MTPY - Start-up October 1, 1979

Wolverine Plant - 1.5 MTPY - Start-up January 1, 1982

Construction Authorization - January 1, 1977

KILBORN

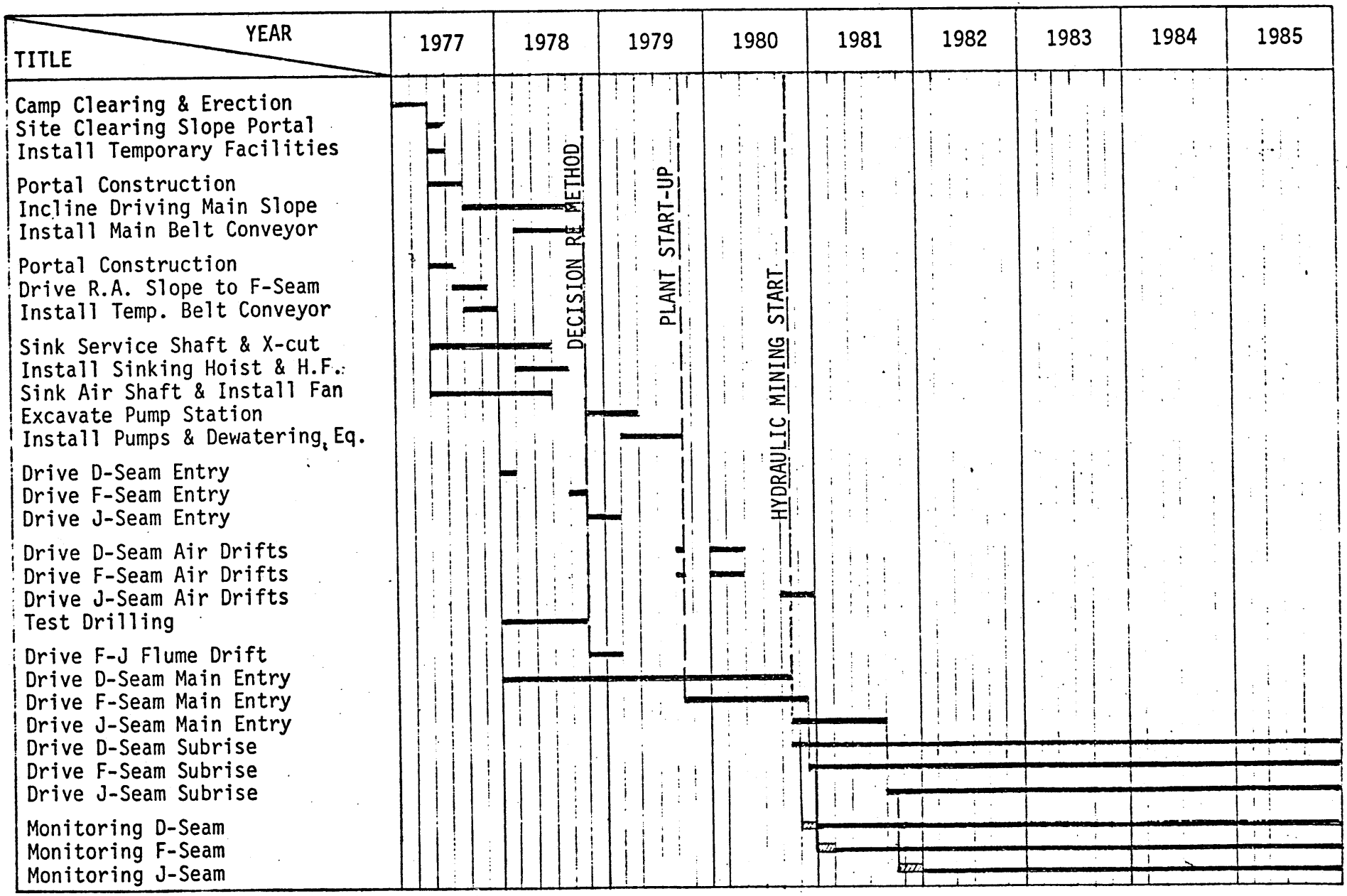
QUINTETTE PROJECT
MINE PRODUCTION
ALTERNATE 1
PLATE 2-1

QUINTETTE PROJECT

PROPOSED MINE DEVELOPMENT SCHEDULE

ALTERNATE I

PLATE 2-2U

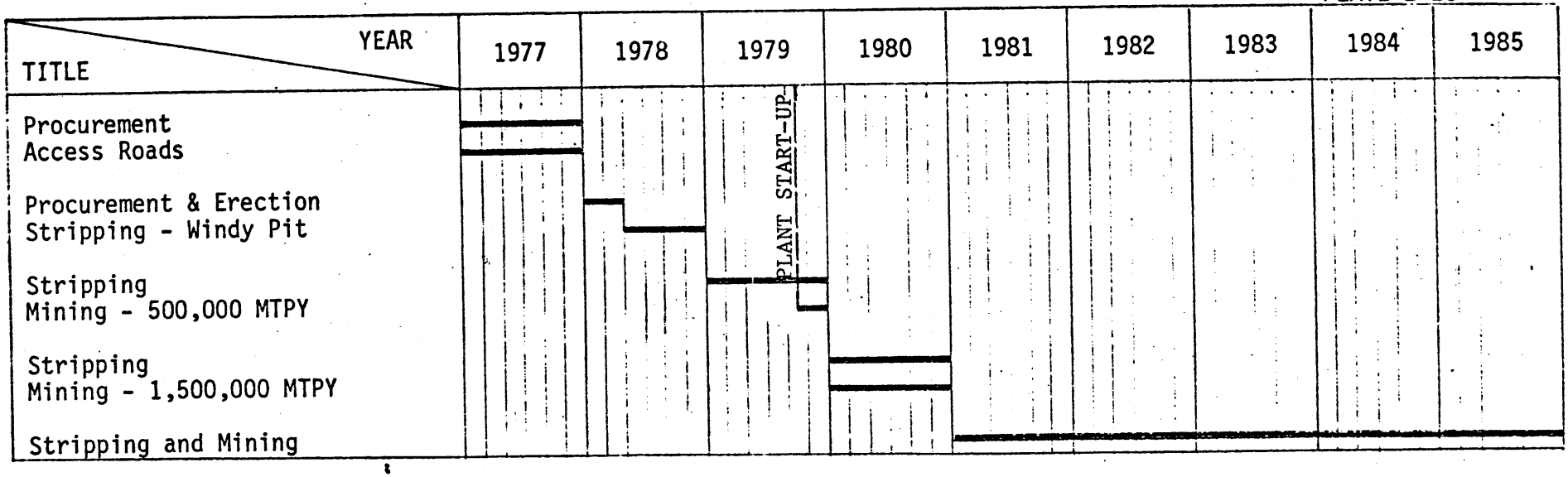


SEE DWG. 200-05F-5

ALTERNATE 1

PLATE 2-2S

SURFACE MINES



NOTE: Initial Coal Production to Plant in 4th Quarter, 1979.

2.2 UNDERGROUND MINING - BABCOCK FLAT AREA

2.2.1 Hydraulic Mining Development

The proposed development program incorporates a geological investigation of D seam to confirm its suitability for hydraulic mining methods. The openings required for this program are an integral part of the development and production programs. The development schedule requires 3.75 years to bring hydraulic mining areas into production, one year after start-up of the coal preparation plant.

Capital and operating cost estimates for this study are based on hydraulic mining. Should the initial development and geological investigation phase indicate that hydraulic mining is not practical in D and F seams, then these seams can be developed and mined with continuous miners while J seam is developed for hydro-cutting. No cost estimates are included for mining conventionally.

The out-of-seam development will be contracted work, involving the following primary mine openings:

a) Main Slope

This opening is driven from a portal (El. 4400' = 1341m) located adjacent to the Preparation Plant, down grade at minus 20% to the coal dewatering station. The Main Slope provides access to each of the coal seams. Services installed include the main coarse coal conveyor and fines slurry return lines from the dewatering plant to surface, main feeders for coal seam electrification, compressed air and other ancillary services.

The Main Slope and seam entries will be driven during but independently of the D seam exploration phase, in order to meet the hydraulic mining start-up schedule. Time for completion of the portal, slope and conveyor installation is 16 months.

b) D-F Seam Return Airway

In order to supply adequate ventilation and escape passages during the development phase, a slope is driven at minus 20 percent grade from a portal located 427 metres west of the Main Slope Portal (at El. 4480' = 1366m).

This airway serves as a development slope for D-F Seams. Credit coal from continuous miners is conveyed from the seam cross-cuts through the Return Slope to a stockpile area adjacent to the Portal. The Return Airway passes over the Main Slope, and development coal is dropped to the Main Slope Conveyor after Preparation Plant start-up. A loader-truck system reclaims stockpiled credit coal to the breaker station.

The D-seam exploration headings are driven from this slope, and three headings advanced through the seam until sufficient information is developed for a decision on the mining technique. Time required for the portal, slope, and East Boundary Exploration Drive is 18 months.

c) Service Shaft

Access to the seams for operating and supervisory personnel is provided through a service shaft which will also carry high pressure pump lines (monitor supply lines) and flume water lines, and electrical supply for the pump and dewatering stations.

This shaft and related surface plant is located about 1220m northwest of the Preparation Plant.

Using a contractor's sinking hoist, all out-seam rock development other than the Main Slope and D-F-J-seam entries is hoisted through the Service Shaft. Automatic elevator equipment is installed after the 24-month waste development phase.

One compartment of this shaft is an intake airway to maintain positive fresh air to the dewatering station and upcast air to the Main Slope conveyor.

2.2.2 Hydraulic Mining

Hydraulic mining can be carried out economically on a friable coal seam with the bedding plane on a relatively uniform slope of sufficient gradient. The coal is broken up by a high velocity water stream and the coal-water mixture is transported in flumes down to a screening process. The coarse coal from the screening process is transported by conveyor to the surface and the fines are pumped in a slurry to surface for thickening. The thickener overflow water is returned to the hydraulic mining circuit.

In more detail for the Babcock Mine, the hydraulic mining circuit starts at the 2,000,000 US gallon reservoir which is part of the coal preparation plant circuit. From this point the clear water is pumped by four vertical turbine pumps through two 20 inch diameter pipes to a surge tank at the service shaft. Each pump is rated at 5000 US gallons/minute (maximum 4 operating).

The surge tank at the service shaft is designed to hold a quantity equal to the maximum rate of 20,000 USGPM for 15 minutes or 300,000 US gallons usable storage. Dead storage is over and above this capacity.

This surge tank feeds water to the monitor and fluming pumps and receives recirculated water under low flow conditions. The pumps are connected to a common header suction pipe, but each pump has its own individual low flow discharge pipe.

The monitor pumps are sized so that any monitor at the highest elevation in any seam can obtain 1320 USGPM at 1400 psi. The pipes from the pump to the monitor are 8 inch special high strength, manufactured to API specifications.

The monitor pumps discharge into a common header valved so that each pump can supply an individual monitor pipeline. The pumps are arranged to provide a standby for any of the four operating pumps.

The monitor operator can modulate his individual water requirements by remotely operating a valve in the pumphouse. This control valve has fail closed features. There are water hammer suppression valves and air release valves in each line.

Each pump is protected from over-heating by means of a low-flow bypass. A magnetic flow meter in the pump suction line provides the signals for low-flow operation as well as recording the quantity of water used.

The quantity of water to be supplied to each continuous miner is the calculated quantity required for fluming down a 6 degrees gradient with an unlined steel flume. Where the coal-water mixture enters the main flume, extra water must be added in order to carry the coal-water mixture down a 4 degree polyethylene lined flume.

The fluming pumps are each rated at 3700 USGPM in order to supply the water to two continuous miners and two monitors (one working only). Each pump has low-flow protection similar to the monitor pumps, and each line has water hammer suppression and air release valves.

The flumes are made from half pipes. The flumes in the sub-rises are 16 inch unlined and the main entry flumes are 32 inch lined. Both flumes are equipped with side boards. The flumes are made in sections 8 ft. long which overlap at the joints. The 3/4 inch polyethylene liner will be attached in the field.

The flumes and 8 inch water supply pipe are installed immediately behind continuous miners driving cross-cuts and sub-rises. The flume and pipe are used later by the monitor and both will be taken out as the monitor retreats.

The water and coal is flumed to a screening installation which separates the coarse coal for conveying to the surface. The minus 14 mesh fines are stored as a slurry in three sumps, each of 100,000 gallons. The excess water is allowed to overflow into three 480,000 US gallon overflow sumps. The slurry is kept in suspension by six agitating pumps in each overflow sump discharging into the corresponding slurry sump.

The slurry is pumped to surface by six reciprocating pumps specially designed for such service. These pumps discharge to a common valved header, connected to five 8 inch slurry lines which discharge to the raw coal thickener at the preparation plant. A separate mine drainage pump discharges through an 8 inch line to the same thickener.

The slurry pumps are designed to deliver 1500 USGPM each, 24 hours a day. The monitors work for a total of 12.5 hours a day. The fluming pumps work 4.5 hours a day at full capacity

and 8 hours a day at a reduced capacity. The overflow sumps provide storage capacity to equalize the mine pumping capacity from the intermittent operation of the fluming and monitor pumps.

The drain pump is capable of pumping water or slurry to surface on an intermittent basis.

The slurry lines and drain line discharge to a series of surface thickeners which in turn overflow to the 2,000,000 US gallon reservoir, thus completing the circuit. The reservoir on surface is designed to supply or store the water which is used in the intermittent operation of the monitor and fluming pumps.

All pipe lines have Victaulic connections except at the valves, pumps, and similar equipment. The Victaulic couplings on the high pressure pipes are type No. 800, specially designed for hydraulic coal mining. The pumps required for hydraulic mining operations in seams D, F and J of the Babcock No.1 Mine are indicated in Table 2.1.

TABLE 2.1

PUMPS AND MOTORS

FOR HYDRAULIC MINING

Service	Specifications			Pumps Required for Production in Clean Coal			
				MMTPY			
	USGPM	PSI	HP	0.5	1.0	1.5	2.0
(L) Water Lift	5000	240	1000	2	3	4	5
(M) Monitor	1350	2200	2500	2	3	4	5
(F) Flume	3700	600	2000	2	3	4	5
(A) Agitating	800	45	40	6	12	12	18
(S) Slurry	1550	450	700	3	4	5	6
(D) Drain	1550	450	700	2	2	2	2

NOTE: All pumps include one spare except the agitating pumps.

2.2.3 Coal Character and Production

Flat Area (No. 1 Mine)

The following table presents estimated mining thickness, the amount of dilution, the raw coal ash content and the specific gravity.

	D Seam	F Seam	J Seam
Seam Thickness	9.8'	8.6'	18.7'
Ash %	20.00	17.33	20.12
Specific Gravity	1.50	1.48	1.50
Dilution	9"	17"	6"
Dilution Sp. Gr.	2.2	2.2	2.2
Dilution Ash %	87.12	90.40	88.54
Mining Thickness	10.5'	10.0'	19.2'
Raw Coal Ash %	24.79	27.68	21.90
Raw Coal Sp. Gr.	1.55	1.58	1.51

For D and F seams there are two monitors planned for each seam. One monitor will be operating while the other will be either retreated or on standby.

For J seam, four monitors have been planned. Two units will be operating while the other two will either be retreated or on standby.

D and F Seam:

Monitor \ Shift		1	2	3	4	5	6
D	No. 1	MONITORING		RETREATING		MONITORING	
	No. 2	RETREATING		MONITORING		RETREATING	
F	No. 3	MONITORING	RETREATING		MONITORING		RETREATING
	No. 4	RETREATING	MONITORING		RETREATING		MONITORING

J Seam:

Monitor \ Shift	1	2	3	4	5	6
No. 1	MONITORING			RETREATING		
No. 2	RETREATING			MONITORING		
No. 3	MONITORING	RETREATING			MONITORING	
No. 4	RETREATING	MONITORING			RETREATING	

For every monitoring shift there will be two men per monitor. The manpower required to retreat monitor will be four per shift.

The total number of men for all seams is 24 men per shift or 72 men per day.

PRODUCTION OF COAL PER YEAR - PRELIMINARY SCHEDULE

(METRIC TONS)

	1978	1979	1980	1981	1982	1983	1984
Seam "D"	94,000	226,000	317,000 40,000	667,000	667,000	667,000	667,000
Seam "F"		37,000	350,000 28,000	645,000	672,000	672,000	672,000
Seam "J"			99,000	295,000 144,000	804,000	804,000	804,000
TOTAL PRODUCTION M.R.T.	94,000	263,000	834,000	1,751,000	2,143,000	2,143,000	2,143,000
TOTAL PRODUCTION OF CLEAN COAL	0	250,000	500,000	1,309,000	1,500,000	1,500,000	1,500,000
RAW COAL REQUIRED	0	357,000	714,000	2,142,000	2,142,000	2,142,000	2,142,000
CLEAN COAL REQUIRED	0	250,000	500,000	1,500,000	1,500,000	1,500,000	1,500,000
SHORT FALL RAW COAL	0	0	0	272,000	0	0	0
STOCKPILE RAW COAL	94,000	0	120,000	0	0	0	0

RAW COAL PRODUCTION FROM FLAT AREA

(METRIC TONS)

	SEAM "D"	SEAM "F"	SEAM "J"	TOTAL
Main Entry (ft)	203,600	155,700	157,700	517,000
Raw Coal Produced (t)	1,485,000	1,198,000	1,214,000	3,897,000
M.E. Crosscut (ft)	51,000	38,900	39,500	129,400
Raw Coal Produced (t)	250,000	201,000	204,000	655,000
Subrise (ft)	425,700	449,000	455,000	1,329,700
Raw Coal Produced (t)	2,828,000	3,098,000	3,140,000	9,066,000
S.R. Crosscut (ft)	212,900	225,000	228,000	665,900
Raw Coal Produced (t)	1,062,000	1,165,000	1,181,000	3,408,000
Monitor Retreat (ft)	425,700	449,000	455,000	1,329,700
Raw Coal Produced (t)	12,402,000	12,302,000	27,255,000	51,959,000
Workable Days	5,304	5,767	4,968	16,039
Workable Years	22.7	24.6	21.2	68.5
Workable Reserve (t)	18,027,000	17,964,000	32,994,000	68,985,000
Monitor Coal (%)	68.8	68.5	82.6	75.32

MINING RECOVERY INSIDE OF PANEL

1. D-Seam

Working thickness = 10.5 ft (Panel 1 & 2)

Sp. gr. = 1.55

200' x 118' x 10.5' = 247,800 cu.ft.

(247,800 ÷ 35.315) x 1.55 = 10,875 tonnes

6 x 200 + 4.5 x 100 = 1,650 tonnes (by subrise driving)

(10,875 - 1650) x 0.57 = 5,251 tonnes (by monitoring)

0.57 = recovery by monitoring

5,251 ÷ 200 = 26 tonnes/foot (reserve for monitoring)

PANEL	AREA (sq ft)	MINEABLE AREA (sq ft)	FOOTAGE OF SUBRISE (ft)
1	11,220,000	8,976,000	76,200
2	7,035,000	5,628,000	51,500
3	11,403,000	9,122,000	77,000
4	9,571,000	7,657,000	65,000
5	3,245,000	2,596,000	22,000
6	8,194,000	6,555,000	56,000
7	11,516,000	9,213,000	78,000

Mineable area (sq ft) = Area (sq ft) x 80%

Total recovery inside of panel:

Area = 80%

Mining = (1650 + 5251) ÷ 10,875 = 63.5%

Total Recovery = 0.8 x 0.635 = 50.8%

SUMMARY OF RAW COAL PRODUCTION IN D-SEAM

(METRIC TONS)

	PANEL 1	PANEL 2	PANEL 3	PANEL 4	PANEL 5	PANEL 6	PANEL 7	TOTAL
Main Entry (ft)	73,800	7,600	49,100	14,100	31,000	8,800	19,200	203,600
Raw Coal (t/ft)	6.7	6.7	7.7	7.7	7.7	7.7	7.7	
Raw Coal Produced (t)	494,000	51,000	378,000	108,000	238,000	68,000	148,000	1,485,000
M.E. Crosscut (ft)	18,300	2,200	12,300	3,500	7,700	2,200	4,800	51,000
Raw Coal (t/ft)	4.5	4.5	5.2	5.2	5.2	5.2	5.2	
Raw Coal Produced (t)	82,000	10,000	64,000	18,000	40,000	11,000	25,000	250,000
Subrise (ft)	76,200	51,500	77,000	65,000	22,000	56,000	78,000	425,700
Raw Coal (t/ft)	6.0	6.0	6.9	6.9	6.9	6.9	6.9	
Raw Coal Produced (t)	457,000	309,000	539,000	449,000	152,000	384,000	538,000	2,828,000
S.R. Crosscut (ft)	38,100	25,800	39,000	32,000	11,000	28,000	39,000	212,900
Raw Coal (t/ft)	4.5	4.5	5.2	5.2	5.2	5.2	5.2	
Raw Coal Produced (t)	171,000	116,000	203,000	166,000	57,000	146,000	203,000	1,062,000
Monitor Retreat (ft)	76,200	51,500	77,000	65,000	22,000	56,000	78,000	425,700
Raw Coal (t/ft)	26.0	26.0	30.47	30.47	30.47	30.47	30.47	
Raw Coal Produced (t)	1,981,000	1,339,000	2,347,000	1,981,000	670,000	1,707,000	2,377,000	12,402,000
No. of Monitor Unit	1	1	1	1	1	1	1	
R.Coal Produced (t/day)	2,100	2,100	2,440	2,440	2,440	2,440	2,440	
Monitor Retreat (ft/day)	80	80	80	80	80	80	80	
S.R. Heading (ft/day)	80	80	80	80	80	80	80	
R.Coal Produced (t/day)	550	550	550	550	550	550	550	
S.R.C. Heading (ft/day)	40	40	40	40	40	40	40	
R.Coal Produced (t/day)	202	202	202	202	202	202	202	
Monitoring & S.R.Heading								
R.Coal Produced (t/day)	2,852	2,852	3,192	3,192	3,192	3,192	3,192	
Workable Days	943	638	962	812	275	700	974	5,304
Workable Years	4.0	2.7	4.1	3.5	1.2	3.0	4.2	22.7
Workable Reserve (t)	3,185,000	1,825,000	3,531,000	2,722,000	1,157,000	2,316,000	3,291,000	18,027,000
Monitor Coal (%)	62.2	73.4	66.5	72.8	57.9	73.7	72.2	68.8

2. F-Seam (Ref. Dwg. 200-05F-3)

Working thickness = 10 ft

Sp. gr. = 1.58

200' x 118' x 10' = 236,000 cu.ft.

(236,000 ÷ 35.315) x 1.58 = 10,957 tonnes

6.9 x 200 + 5.18 x 100 = 1,898 tonnes (by subrise driving)

(10,957 - 1898) x 0.60 = 5,480 tonnes (by monitoring)

0.60 = recovery by monitoring

5,480 ÷ 200 = 27.4 tonnes/foot (reserve for monitoring)

PANEL	AREA (sq ft)	MINEABLE AREA (sq ft)	FOOTAGE OF SUBRISE (ft)
1	17,100,000	13,680,000	136,000
2	20,504,000	16,403,000	139,000
3	3,338,000	2,670,000	23,000
4	10,010,000	8,008,000	68,000
5	12,175,000	9,740,000	83,000

Mineable area (sq ft) = Area (sq ft) x 80%

Total recovery inside of panel:

Area = 80%

Mining = (1898 + 5480) ÷ 10,957 = 67%

Total Recovery = 0.8 x 0.67 = 53.6%

SUMMARY OF RAW COAL PRODUCTION IN F-SEAM

(METRIC TONS)

	PANEL 1	PANEL 2	PANEL 3	PANEL 4	PANEL 5	PANEL 6	PANEL 7	TOTAL
Main Entry (ft)	42,600	48,000	33,200	10,900	21,000	-	-	155,700
Raw Coal (t/ft)	7.7	7.7	7.7	7.7	7.7	-	-	
Raw Coal Produced (t)	328,000	370,000	254,000	84,000	162,000	-	-	1,198,000
M.E. Crosscut (ft)	10,600	12,000	8,300	2,700	5,300	-	-	38,900
Raw Coal (t/ft)	5.16	5.16	5.16	5.16	5.16	-	-	
Raw Coal Produced (t)	55,000	62,000	43,000	14,000	27,000	-	-	201,000
Subrise (ft)	136,000	139,000	23,000	68,000	83,000	-	-	449,000
Raw Coal (t/ft)	6.9	6.9	6.9	6.9	6.9	-	-	
Raw Coal Produced (t)	938,000	959,000	159,000	469,000	573,000	-	-	3,098,000
S.R. Crosscut (ft)	68,000	70,000	12,000	34,000	41,000	-	-	225,000
Raw Coal (t/ft)	5.18	5.18	5.18	5.18	5.18	-	-	
Raw Coal Produced (t)	352,000	363,000	62,000	176,000	212,000	-	-	1,165,000
Monitor Retreat (ft)	136,000	139,000	23,000	68,000	83,000	-	-	449,000
Raw Coal (t/ft)	27.4	27.4	27.4	27.4	27.4	-	-	
Raw Coal Produced (t)	3,726,000	3,809,000	630,000	1,863,000	2,274,000	-	-	12,302,000
No. of Monitor Unit	1	1	1	1	1	-	-	
R.Coal Produced (t/day)	2,133	2,133	2,133	2,133	2,133	-	-	
Monitor Retreat (ft/day)	77.8	77.8	77.8	77.8	77.8	-	-	
S.R. Heading (ft/day)	77.8	77.8	77.8	77.8	77.8	-	-	
R.Coal Produced (t/day)	538	538	538	538	538	-	-	
S.R.C. Heading (ft/day)	38.9	38.9	38.9	38.9	38.9	-	-	
R.Coal Produced (t/day)	202	202	202	202	202	-	-	
Monitoring & S.R.Heading								
R.Coal Produced (t/day)	2,873	2,873	2,873	2,873	2,873	-	-	
Workable Days	1,747	1,786	295	873	1,066	-	-	5,767
Workable Years	7.5	7.6	1.3	3.7	4.5	-	-	24.6
Workable Reserve (t)	5,399,000	5,563,000	1,148,000	2,606,000	3,248,000	-	-	17,964,000
Monitor Coal (%)	69.0	68.5	54.9	71.5	70.0	-	-	68.5

3. J-Seam (Ref. Dwg. 200-05F-4)

Working thickness = 19.2 ft

Sp. gr. = 1.51

200' x 118' x 19.2' = 453,120 cu.ft.

(453,120 ÷ 35.315) x 1.51 = 19,373 tonnes

6.9 x 200 + 5.18 x 100 = 1,898 tonnes (by subrise driving)

(19,373 - 1898) x 0.68 = 11,980 tonnes (by monitoring)

0.68 = recovery by monitoring

11,980 ÷ 200 = 59.9 tonnes/foot (reserve for monitoring)

PANEL	AREA (sq ft)	MINEABLE AREA (sq ft)	FOOTAGE OF SUBRISE (ft)
1	16,543,000	13,234,000	112,000
2	19,513,000	15,610,000	132,000
3	12,823,000	10,258,000	87,000
4	18,256,000	14,605,000	124,000

Mineable area (sq ft) = Area (sq ft) x 80%

Total recovery inside of panel:

Area = 80%

Mining = (1898 + 11,980) ÷ 19,373 = 71.6%

Total Recovery = 0.8 x 0.716 = 57.28%

SUMMARY OF RAW COAL PRODUCTION IN J-SEAM

(METRIC TONS)

	PANEL 1	PANEL 2	PANEL 3	PANEL 4	PANEL 5	PANEL 6	PANEL 7	TOTAL
Main Entry (ft)	44,100	47,800	40,400	25,400	-	-	-	157,700
Raw Coal (t/ft)	7.7	7.7	7.7	7.7	-	-	-	
Raw Coal Produced (t)	340,000	368,000	311,000	195,000	-	-	-	1,214,000
M.E. Crosscut (ft)	11,000	12,000	10,100	6,400	-	-	-	39,500
Raw Coal (t/ft)	5.16	5.16	5.16	5.16	-	-	-	
Raw Coal Produced (t)	57,000	62,000	52,000	33,000	-	-	-	204,000
Subrise (ft)	112,000	132,000	87,000	124,000	-	-	-	455,000
Raw Coal (t/ft)	6.9	6.9	6.9	6.9	-	-	-	
Raw Coal Produced (t)	773,000	911,000	600,000	856,000	-	-	-	3,140,000
S.R. Crosscut (ft)	56,000	66,000	44,000	62,000	-	-	-	228,000
Raw Coal (t/ft)	5.18	5.18	5.18	5.18	-	-	-	
Raw Coal Produced (t)	290,000	342,000	228,000	321,000	-	-	-	1,181,000
Monitor Retreat (ft)	112,000	132,000	87,000	124,000	-	-	-	455,000
Raw Coal (t/ft)	59.9	59.9	59.9	59.9	-	-	-	
Raw Coal Produced (t)	6,709,000	7,907,000	5,211,000	7,428,000	-	-	-	27,255,000
No. of Monitor Unit	2	2	2	2	-	-	-	
R.Coal Produced (t/day)	5,486	5,486	5,486	5,486	-	-	-	
Monitor Retreat (ft/day)	91.5	91.5	91.5	91.5	-	-	-	
S.R. Heading (ft/day)	91.5	91.5	91.5	91.5	-	-	-	
R.Coal Produced (t/day)	630	630	630	630	-	-	-	
S.R.C. Heading (ft/day)	45.8	45.8	45.8	45.8	-	-	-	
R.Coal Produced (t/day)	234	234	234	234	-	-	-	
Monitoring & S.R.Heading								
R.Coal Produced (t/day)	6,350	6,350	6,350	6,350	-	-	-	
Workable Days	1,223	1,441	950	1,354	-	-	-	4,968
Workable Years	5.2	6.2	4.1	5.8	-	-	-	21.2
Workable Reserve (t)	8,169,000	9,590,000	6,402,000	8,833,000	-	-	-	32,994,000
Monitor Coal (%)	82.1	82.5	81.4	84.1	-	-	-	82.6

2.3 SURFACE MINING

2.3.1 Introduction

Reserve estimates have been provided by Denison Mines Limited for Babcock and Wolverine areas. This information is included in Section 1 of this Volume, and is the basic reference for any continuing studies of surface mining.

A preliminary but reasonably detailed study of Windy and Roman Mountain Pits was made by Dames & Moore, Consultants, whose contribution is included elsewhere in this Report. Their study was based on limited data which was augmented by information from the 1975 Field Exploration program conducted by Denison Mines (B.C.) Limited.

Their initial concept of two pits developing and operating simultaneously resulted in high initial capital costs per tonne of scheduled reserve and indicated potential difficulties in supervising two relatively small and widely separated operations.

The information supplied by Dames & Moore has been modified and incorporated in the proposed operation of Windy Pit to produce 1.5 million clean tonnes (2.143 million raw) coal.

2.3.2 Pit Operations

Windy Pit is located 5km northwest of the Babcock surface plant, at an elevation of 1700 metres.

Reserves calculated indicate that sufficient open pit coal is available for the proposed production schedule. These reserves are based on an arbitrary 6.2 cu.m rock in place to 1 tonne raw coal stripping ratio, which is comparable to operating ratios at several Western surface coal mines.

Annual raw coal production (Plate 2-1) of 2,140,000 tonnes requires removal of 13,268,000 cu.m rock. It is assumed that the flat dip and wide exposure of the seams will provide adequate working faces for the selected production rate.

Because of extensive seam exposure in Windy Pit, preproduction work can be limited to access road preparation and removal of approximately 2 million cu.m waste. The stripping and mining equipment listed in Table 2-3-A is to be purchased, erected and commissioned during the 31 months from project authorization to late 1979 startup. Mining equipment delivery thus becomes a critical factor in the total project schedule.

The gentle dip and the thickness of the Windy seams suggest a ripper-loader-truck operation, as portrayed in Dames & Moore Plate 1A, for coal extraction. All waste rock will be blasted and loaded in such a manner that will not interfere with coal production.

COAL LOADING OPERATIONS

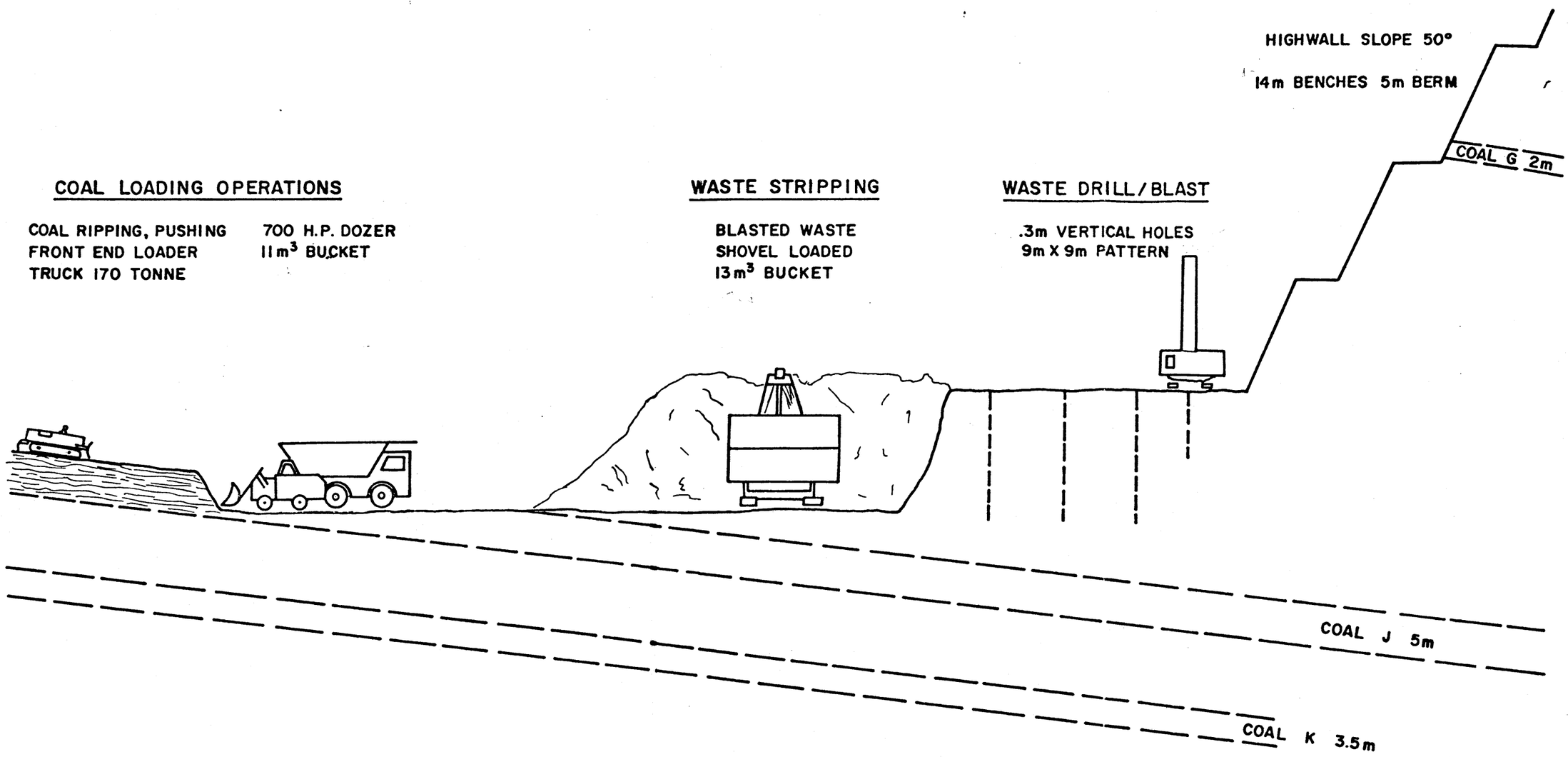
COAL RIPPING, PUSHING — 700 H.P. DOZER
FRONT END LOADER — 11 m^3 BUCKET
TRUCK 170 TONNE

WASTE STRIPPING

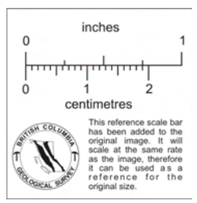
BLASTED WASTE
SHOVEL LOADED
13 m^3 BUCKET

WASTE DRILL/BLAST

.3m VERTICAL HOLES
9m X 9m PATTERN



COMPOSITE SECTION



DAMES & MOORE

SCHEMATIC MINING METHOD WINDY PIT

DESIGNED: J.E.T.
CHECKED: W.D.B.
DRAFTED: L.S.

SCALE: 1:50
DATE: OCT. 3, 1975
JOB NO: 6594-001-31

PLATE 1A

There is sufficient dump area available in close proximity to the pit to accommodate scheduled waste. Mining of J seam provides an obvious refill opportunity, and this method is proposed wherever practical. Further study should be made of dump locations to ensure that they do not interefere with coal reserves and that they are in accord with government regulations.

There is a small vehicles access road along the steep south-west flank of Babcock Mountain, but the topography of the opposite northeast flank provides a more suitable slope for the haul road. There are no switchbacks required in the 7.5km haul distance.

Allowance has been made for the presence of "oxidized" coal. This will be stored separately in anticipation of thermal coal markets, but otherwise this study treats oxidized coal as waste.

Employment of contracted forces may be considered for the initial phases, however, for this case, preproduction work is limited and would be attractive to contractors only if included with on-going production or stripping contracts.

TABLE 2-3-A

EQUIPMENT SELECTION

All of the equipment listed below is of standard manufacture and of the types currently in use in North American surface coal mines.

Item	Quantity	Type
Primary Drills	2	Electric Crawler
Secondary Drills	2	Crawler-mounted
Shovels (13 cu.m)	3	Electric Crawler
F.E. Loaders	2	11.5 cu.m Wheel Tractor
Haul Units	15	Coal and Rock Trucks
Dozers	7	D-8; D-9 Rippers
Graders	3	Road

2.3.3 Facilities

An office-shop-warehouse complex is located on the haulroad near Windy Pit to provide supervisory and logistical support to the pit in addition to the central shops and offices in the Preparation Plant area.

Drainage control structures will be constructed to assist in waste dump and pit slope stabilization.

Primary electric power is supplied to Windy at 44,000 volts, to be transformed in the pit to 6900 volts. Power distribution is described in Section 3.0.

2.3.4 Pit Operation Design Criteria

a. Strip ratio = 6.2 cu.m/tonne raw coal in place, therefore waste removal (6.2)(2,140,000) = 13,268,000 cu.m annually for 7 years = 92,876,000 cu.m total.

b. Assuming weight/cu.ft = 168 lbs. and a swell factor of 1.3:

$$\text{Loose weight/cu.ft} = \frac{168}{1.3} = 129$$

The conversion to tonnes/cu.m

$$= \frac{27 \text{ cu.ft}}{\text{cu.yd}} \times \frac{129 \text{ lbs}}{\text{cu.ft}} \times \frac{1.31 \text{ cu.yd}}{\text{cu.m}} \times \frac{1}{2206 \text{ lbs/tonne}}$$

= 2.07 tonnes/cu.m, loose.

c. Haul units for rock are rated at 160 short tons, i.e. 145 tonnes.

d. Productivity guidelines:

One rock shovel can dig about 4.5 million cu.m annually.

One shovel requires about 4 trucks for an average haul.

Availability is not less than 0.8 overall.

Refer to Appendix D for detailed equipment selection calculations.

2.3.5 Geotechnical and Environmental Comment

A 50 deg. slope angle selected for Windy Pit represents a reasonable starting point; more detailed evaluation of the rock fabric and in-situ bulk properties will be required. The high wall in the Windy pit will be comprised of bedded strata dipping gently into Babcock Mountain.

Dump site selection will be influenced by the depth of overburden cover, subsurface bedrock topography, surface water regime, as well as haulage road location.

A major environmental problem associated with this operation is the placement of waste material dumps. Of particular interest are the items of erosion control, interference with water courses, and seepage into ground and surface waters. The Pollution Control Act prohibits the discharge either directly or indirectly into air, water or land of any contaminant that may impair environmental quality; settling ponds may be required to prevent high levels of suspended solids entering the water regimes.

2.3.6 Coal Reserves and Stripping

Where reference is made in this Report to mineable reserves, they are assumed to be defined by the following criteria:

a) Minimum mining thicknesses of
   (i) Windy area - 1 metre
   (ii) Roman Mountain - 1.5 metres
   i.e. such thicknesses of coal or waste are regarded as mineable separately. (Single exception, hole QBD-7511-K seam).

b) Specific gravities of
   (i) Coal - 1.38 (1 cu.m = 1.38 tonne)
   (ii) Internal Waste - 2.29 (1 cu.m = 2.29 tonne)

c) Waste volumes include overburden, inter-seam waste of over mineable thickness, oxidized coal and losses of 0.15m from the top and bottom of each seam. Waste is expressed in cubic metres.

d) Raw coal tonnages include both coal and internal waste, since these will together form the feed to the washing plant. The losses associated with mining a particular coal horizon have been assumed to be all coal. This is a conservative approach and by inspection of the seam sections provided, is correct in the majority of cases.

e) All coal down to a depth of 25 metres below the natural surface is assumed to have been oxidized, and has been treated as waste material, to be stockpiled separately.

f) At the ends of the open-pits the area of influence has been adjusted to compensate for the end effects of the open-pits.

2.4 WOLVERINE

Provision has been made in the capital cost estimate for establishing surface and underground mines in the Wolverine River area north of the Babcock project. Current data on reserves is found in Section 1.0 of this Volume.

Preliminary drilling has indicated substantial reserves, however the limited available information restricts this phase of the study to the economic impact of an additional 1.5 million clean tonnes annually.

The parameters used to develop capital and operating costs for Babcock area mines were applied to Wolverine, consequently Wolverine costs are merely an order-of-magnitude. The differences in capital cost assigned to Windy Pit and Sheriff Pit are the result of improved data on Windy that was not applied to Sheriff.

The study assumes that raw coal will be transported from the Sheriff Mine to an adjacent preparation plant.

2.5 PRODUCTION SCHEDULE

Development of surface and underground mines is integrated to ensure adequate coal production during the complex and difficult underground development phase. Project authorization is required in December 1976 to mobilize forces and equipment for surface mine preparation if the production start-up in 1979 is to be met. Preproduction work at Windy is restricted to haulroad construction and limited waste removal. Sufficient time has been allocated for equipment deliveries, but site erection will be subject to rail and access road construction schedules.

Contractors' forces are proposed for both surface and underground development, and it is possible that these forces will assist in the initial production years. At several other new Western Canadian properties, contractors have participated in equipment mobilization, labour supply during development, and labour training for extended periods into the production phase.

Underground development can supply no more than one-third of raw plant feed prior to startup of the underground transport and dewatering systems.

Completion of the bottom facilities, including the coal dewatering plant, coincides with start-up of the Coal Preparation Plant. This allows the development work to use fluming for the transport of development coal.

Assuming hydraulic mining is viable in D and F seams, then development of those seams will continue towards hydraulic techniques. Flumes will replace conveyors for transport of coal from the continuous miners in D and F seam cross-cuts and sub-rises to the dewatering plant.

J seam development begins one year after plant start-up, coincident with initial monitoring of coal in D and F sub-rises.

Underground development will produce a surface stockpile of 263,000 raw tonnes, augmented by an undetermined tonnage from surface mine preparation. This stockpile is adequate to assist surface and monitor coal sources in meeting the initial production schedule.

Future Production

Open pit production is replaced by underground mines in both Babcock and Wolverine areas in 1985-86.

Development of Mines 2, 3 and 4 begins in Babcock in 1984, and production is increased to 3 million MTPY from underground.

Wolverine underground production begins in 1987, totally replacing surface production by 1990. Because of the limited information available for Wolverine underground seams, production and cost data from Babcock estimates are assumed to apply to Wolverine area mines.

2.6 MANPOWER

2.6.1 Underground Mine

The contracted labour force of approximately 200 men will be augmented by the owner's crews as soon as training areas are available in the coal seams. The operating force will build up to 346 salaried and hourly personnel, including mine operating and maintenance personnel.

2.6.2 Surface Mines

Windy Pit requires 231 operating and maintenance personnel.

5.0 OFF-SITE FACILITIES

5.1 ACCESS ROADS

(Ref. Dwg. 100-10F-1)

Access roads to the plant sites and townsite included in the estimate are based on the routes shown on the area plan.

The basic route concept assumes that all the plant construction materials and major supplies are shipped via Dawson Creek, B.C. From Dawson Creek an existing 36 ft. wide unpaved road is used, to a location adjacent to Quality Lake, a distance of approximately 50 miles. At this location a new road is constructed to the Babcock plantsite and the proposed townsite.

The new road is routed over Tumbler Ridge, across the Flatbed Creek, and will follow the Railway right-of-way to the plantsite. It is proposed to use a common right-of-way for the road, railway and power transmission lines, where practical, in order to reduce costs and improve maintenance access.

An allowance has been made to upgrade the existing road to Quality Creek. The allowance includes resurfacing of the road with 12" of gravel, some repair to culverts, etc., and an amount for maintenance during the plant construction period.

The new road construction is based on cleared right-of-way widths as follows:

Railway only	80 feet
Railway plus power lines	100 feet
Railway, power lines and road	170 feet

Where creek crossings, bridges or other natural obstacles are encountered, the access road will make use of the steeper gradients or curvatures permitted, in order to obtain any economic advantages. The basic road section will be a 30 ft. wide top and a 10 ft. wide shoulder on each side. The road surface will be gravel except within the townsite limits or in any special hard-standing areas.

It has been assumed that sufficient road construction materials are readily available from the areas immediately adjacent to the proposed route.

An amount has been included in the estimate for the access road from the townsite to the Wolverine Plant. For the purposes of this report, the distance to the Wolverine Plant is assumed to be 10 miles, and the unit prices will be the same as developed for the Babcock Plant road.

The road section for the estimate has been assumed at a maximum of 5 ft. of excavation or compacted fill, with an 18" layer of Granular B, and a 6" topping of Granular A.

The total area required for clearing for the right-of-way for roads, railway and power, for the plantsites to the townsite, is approximately 870 acres. This figure does not include any allowances for the railway and power from Chetwynd to the townsite.

5.2 RAILROAD

(Ref. Dwg. 100-10F-1)

Total railroad distance between the proposed Quintette mine location and port facilities at Prince Rupert is 762 miles. Out of this mileage, new lines will have to be constructed at either end of the existing CNR line:

1) Chetwynd to Mine Site

2) Prince Rupert to Ridley Island.

1) Mine Site

Included in the estimate is the approximate cost of construction of a new railroad by British Columbia Railway.

Based on the Babcock plant location shown, the required line is in the order of 81 miles, connecting to the existing CNR line at a point southwest of Chetwynd.

The proposed route was established using small scale contour maps of the area and aerial photography to within 20 miles of the Babcock plant site. The final routing will have to be modified, if necessary, after more accurate surveys are carried out. The routing might also be influenced by soil investigations at river crossings and final site elevations.

At present, it is assumed that the final plant site grade will be at El.±4350 ft. with the railroad at El.±4250 ft. in the loading area.

This latter part will consist of two parallel tracks of about 6000 ft. length, allowing a loading and an empty train of up to 100 cars to be accommodated simultaneously.

2) Prince Rupert Bulk Terminal

The cost for this portion of the railroad is included in the port facilities study by Swan Wooster Engineering Co. Ltd.

About 4 miles of track is required to connect the CNR line to the marine bulk terminal on Ridley Island. This will also allow two trains on site - one approaching the dumper and one empty and waiting to depart.

For the purpose of this study it is assumed that the following criteria will be confirmed as the project progresses:

a) Gradient - 1.75% max.

b) Loading Area Gradient - 0.5% max.

c) Unit Car Length (100 T capacity) - approximately 59'-0" hitch to hitch.

d) Maximum train - 100 cars.

e) Maximum cycle time - 4 days.

f) Railroad route will coincide with the power transmission line and access roads where practical.

5.3 PORT FACILITIES

(Ref. Swan Wooster Report dated September 30, 1975)

The port facilities for the shipping of the Quintette coal are still being negotiated and a resolution may not be available at the time of this report. Assumptions have been made, therefore, based on the present status of negotiations and previous reports by Governmental agencies and the private sector of the industry, for the purpose of making suitable allowances for a capital cost estimate. It is also assumed that whatever the final negotiations conclude, the size, location and operational features will remain as described.

The proposed terminal has an initial capacity to handle 6,000,000 tonnes per year, with storage facilities for 500,000 tonnes. The ultimate capacity is in the range of 8,000,000 to 10,000,000 tonnes per year.

The site chosen from the various alternatives was Ridley Island, near to Prince Rupert, British Columbia. This selection was made after a review of the data given in the Federal/Provincial Committee report on Tsimpsean Peninsula Port Development dated February 1975.

The port occupies an area of approximately 70 acres, and is designed to accommodate vessels of 150,000 D.W. tons.

The coal receiving configuration includes a loop track system of approximately 21,000 feet of trackage, allowing two unit trains on the property at any given time.

A rotary car dumper is proposed, with a peak capacity of twenty-five 100 ton cars per hour, and an average rate of 100 cars unloaded in six hours. The coal is handled to and from the storage pile initially by a single rail mounted stacker-wheel reclaimer system with a peak capacity of 4500 tons per hour. As the port facility expands, a second parallel system will be installed to increase the handling capacity and provide the maintenance back-up.

The ship-loading equipment is similarly designed in parallel systems with a cross-over feature to give maximum flexibility.

Quadrant beam shiploaders are proposed which will operate over a single berth, so as to load 150,000 tons without requiring movement of the vessel.

The port facility is complete with administration buildings, sampling and control systems, car washing station, pollution control and the normal utilities and services.

Power for the port is provided by extending the existing B.C. Hydro system from Watson Island, a distance of some 3½ miles.

Water is obtained from the Port Edward dam on Wolf Creek, which is presently supplying the village of Port Edward.

Sewage disposal is by means of a self-contained treatment plant with an outfall into the ocean.

Storm drainage is collected in a settlement pond with an outfall to the ocean. The settlement pond also serves for pollution control and fire-protection water.

Road access to the port follows a route from Port Edward via the Zinardi Rapids, along the C.N.R., to the receiving area.

5.4 POWER SUPPLY

Power for the Quintette project will be supplied by the British Columbia Hydro and Power Authority (B.C.H.P.A.).

The proposed new transmission line as selected by B.C.H.P.A. will commence at the existing Chetwynd sub-station and proceed to the proposed townsite and continue on to the plantsites. The proposed route was chosen from four alternatives, to utilize the economic advantage of rights-of-way already prepared for the Sukunka development.

The selected route proceeds in a southerly direction from Chetwynd to the general location of Oetco Flats. The route then changes to the southeasterly direction and continues on the western side of Gwillim Lake, Mt. Meikle and Mt. Bergeron, to the proposed townsite at the junction of the Wolverine and Murray Rivers. At the Townsite, separate transmission lines are proposed. The Babcock supply system will continue in a southerly direction, generally following the Flatbed and Babcock Creeks to the plantsite. The Wolverine supply system will extend in a westerly direction along the course of the Wolverine River for a distance of approximately 10 miles.

The transmission line covers approximately 60 miles from Chetwynd to the Townsite, and a further 21 miles from the Townsite to the Babcock Plant.

It is proposed to use a 138 KV transmission line supported by a wood pole wishbone style system.

To achieve the proposed 1979 plant production target date, the land acquisition, engineering and surveying should commence during July of 1977.

The transmission line route will be coordinated with the railway and access roads wherever possible to achieve maximum benefits for construction and maintenance, and reduce the costs of rights-of-way.

Construction of the B.C. Hydro transmission line is to be considered separately from the Townsite and Plantsite distribution systems. Locations for the various sub-stations have been arbitrarily chosen, for the purposes of this preliminary report, however the final sites will be confirmed as the project progresses.

The estimated cost figures prepared by B.C. Hydro did not include the line to the Wolverine Plant. It has been assumed that similar unit prices will apply for the additional line, and the estimate adjusted proportionately.

8.0 ENVIRONMENTAL CONSIDERATIONS

In the investigation for the Quintette Coal Project, an important consideration is the assessment of the project on the environment and the necessary measures to control and minimize the impact.

The Province of British Columbia has an established Environment and Land Use Secretariat which, in consultation with the Ministry of Mines and Petroleum Resources, has developed a set of guidelines governing various aspects of coal development. These guidelines cover a broad range of factors concerning environmental protection and restoration, as well as socio-economic factors.

In accordance with the requirements of the British Columbia Government, environmental studies have been undertaken, utilizing the services of B.C. Research (the technical operation of the British Columbia Research Council). The reports will cover two main stages of investigations:-

Phase 1 - Present Environment and Environmental Impacts and Mitigations

Phase 2 - Detailed Impact Study.

PHASE 1

The report is in the final stages of preparation and will be issued as aoon as it becomes available. This stage includes:

A) Present Environment

1) Climate and Meteorology - Summary of Regional Weather Patterns and Climate Data

2) Hydrology and Water Quality

3) Topography

4) Geology - Overburden and Soils

5) Vegetation

6) Fish and Wildlife

7) Archaeology and Historic Sites

8) Outdoor Recreation and Parks

9) Agricultural Potential and Present Land Use.

The report is based on field investigations and information available from Client and Governmental agencies.

(B) Environmental Impacts and Mitigations

1) Topographic change - Mines, Waste, Townsite, Tailings, Roads, etc.

2) Animal Habitat

3) Physical Emissions

4) Chemical Emissions

5) Preliminary conclusions and recommendations, outline of studies required for Phase II detailed studies.

Preliminary Plant Design

In addition to the above-mentioned studies by B.C. Research, full consideration was given to all aspects of pollution prevention and mitigation at the process development stage and incorporated in the flowsheets.

These include:-

A) Air Quality

1) Particulate Matter

All interconnecting conveyor galleries are totally enclosed. Discharge conveyors and coal silos are equipped with dust collection systems which maintain a negative pressure using dry bag filter type dust collectors. The filtered air is discharged to the atmosphere and the collected fines returned to the circuit.

2) Gaseous Emissions

The only gaseous emission from the process will be from the coal dryers. The off-gases will be cleaned by high energy water scrubbers which produce a water vapour emission.

B) Water Quality

Process water is recycled via tailings pond and reclaim pumphouse.

C) Waste Rock

Studies will be conducted to find the most suitable areas for waste rock disposal. Future use of open pits for dumping purposes will be considered.

D) Townsite - Sewage Treatment

No industrial waste is envisaged at this location. A single package sewage treatment plant is located west of the town-site.

10.0 PROJECT CAPITAL COST

10.1 PREPRODUCTION CAPITAL COST

The estimated total capital cost for the development of the Quintette Project at a rated capacity of 4.5 million MTPY to December 31, 1981, is as follows:

Description	Amount	Total
BABCOCK MINE		
Open Pits - Windy Area	$22,010,000	
Underground Mine No.1 (Flat)	73,449,000	
Surface Plant	76,148,000	$171,607,000
WOLVERINE MINE		
Open Pits	20,396,000	
Surface Plant	35,700,000	56,096,000
TOWNSITE		65,000,000
OFF-SITE FACILITIES		
Access Roads	8,600,000	
Power Supply	8,550,000	
Railroad - Construction	62,125,000	
- Equipment	45,890,000	
Port Facilities - Prince Rupert	42,600,000	167,765,000
PROJECT OVERHEADS		28,891,000
Sub-Total		$489,359,000
CONTINGENCY		48,941,000
ESCALATION		206,100,000
Sub-Total		$744,400,000
Net Credit for Coal Sales		143,750,000
Total		600,650,000
Allowance - Interest and Financing		133,433,000
TOTAL		$734,083,000

The forecast annual expenditure during the preproduction period is indicated on Table 10-1.

The estimate of cost is complete and includes the related mining costs to develop the Babcock Plant at a rated capacity of 3.0 million MTPY by October 1, 1979 and the Wolverine Plant at 1.5 million MTPY by December 1981. The mine development required to sustain the plant operation is indicated in Fig. 10-1.

The summary details of the capital cost estimate are in Appendix A.

The criteria on which the estimate is based are as follows:

- 1975 - 3rd quarter prices with escalation at 10% per annum.
- Complete cost for all infrastructures including
  - . access roads
  - . power supply line
  - . railway construction
  - . railway equipment
  - . port facilities at Prince Rupert.
- Net allowance of $25/tonne for coal produced and shipped during the period.
- Allowance for Owner's overhead costs including the following:

Inventory and spare parts	$3,000,000
Working Capital, plant start-up	$2,000,000
Staff Recruitment	$2,000,000

- Federal Sales tax, 5% on non-production material, supplies and equipment.

- B.C. Provincial tax, 5%.

- Capital Cost for development of Townsite for approximately 1250 personnel.

- Estimate for port facilities by Swan Wooster, Consulting Engineers, Vancouver.

- Estimate for power supply lines to the sites by British Columbia Hydro and Power Authority.

- Estimate for railway line construction and railway equipment by British Columbia Railway.

- Allowance for interest and financing charges at 12% per annum with 75% of project cost financed by debt capital and 25% by equity.

TABLE 10-1

QUINTETTE COAL LIMITED

ALTERNATE NO. 1

FORECAST OF EXPENDITURES PRE-PRODUCTION

Description	Total	1976	1977	1978	1979	1980	1981
BABCOCK MINE							
Open Pits - Windy Area	22,010		6,551	6,551	8,908		
U/G Mine No. 1 (Flat)	73,449		9,650	17,091	19,895	19,013	7,800
Surface Plant	76,148	1,000	20,000	30,000	25,148		
Sub-Total	171,607	1,000	36,201	53,642	53,951	19,013	7,800
WOLVERINE MINE							
Open Pits	20,396				4,000	6,000	10,396
Surface Plant	35,700					15,000	20,700
Sub-Total	56,096				4,000	21,000	31,096
TOWNSITE	65,000		5,000	10,000	13,000	21,000	16,000
OFF-SITE FACILITIES							
Access Roads	8,600	500	4,100	2,000	1,000	1,000	
Power Supply	8,550		2,250	4,150	1,150	500	500
Railroad - Const.	62,125	2,000	10,000	20,000	24,000	3,000	3,125
- Equip.	45,890		5,000	11,000	14,600	3,500	11,790
Port Facilities	42,600	600	8,000	16,000	18,000		
Sub-Total	167,765	3,100	29,350	53,150	58,750	8,000	15,415
PROJECT OVERHEADS (1)	28,891	7,600	2,000	3,000	12,291	1,500	2,500
Total	489,359	11,700	72,551	119,792	141,992	70,513	72,811
CONTINGENCY	48,941	1,200	7,200	12,000	14,200	7,100	7,241
Total	538,300	12,900	79,751	131,792	156,192	77,613	80,052
ESCALATION	206,100	1,300	16,000	39,500	62,500	38,800	48,000
Total	744,100	14,200	95,751	171,292	218,692	116,413	128,052
NET CREDIT FOR COAL SALES	143,750				18,750	50,000	75,000
Total	600,650	14,200	95,751	171,292	199,942	66,413	53,052
INTEREST AND FINANCE	133,433	-	-	3,426	25,472	45,590	58,945
TOTAL (YEARLY)	734,083	14,200	95,751	174,718	225,414	112,003	111,997
TOTAL (CUMULATIVE)			109,951	284,669	510,083	622,086	734,083

(1) Includes allowance of $2,000,000 for working capital.

10.2 POST PRODUCTION CAPITAL COST

Indicated in Table 10-2 is the estimated on-going capital expenditure required to sustain a clean coal output of 4.5 million MTPY to 1999. In the case of the Babcock development, the production from the Underground Mines 2, 3 and 4 is to commence in 1984 at which time the production from the open pit is assumed to be complete.

In the case of the Wolverine development, the production from the underground mines is to commence in 1987 when production from the open pit mines is assumed to decrease.

Included in the estimate of post start-up capital expenditures is a nominal annual allowance for capital expenditures for the surface plant.

The forecast total capital expenditure from 1982 to 1999 is

Babcock Development	$ 91,805,000
Wolverine Development	$ 69,600,000
Total	$156,905,000

TABLE 10-2

ALTERNATE NO. 1

ESTIMATE OF POST PRODUCTION CAPITAL EXPENDITURE ($'000)

	BABCOCK MINES				WOLVERINE			TOTAL
Year	Open Pits	U/G #1 (Flat)	U/G #2 (Steep)	Surface Plant	Open Pits	Under-ground	Surface Plant	
1982	-	7,705	-	1,000			500	9,205
83	-	500	15,900	500			300	17,200
84	-	500	15,800	1,000			300	17,600
85	-	500	11,000	500			300	12,300
86	-	500	11,000	500		5,000	300	17,300
87	(5,000)	500	9,600	500		10,000	300	15,900
88	-	500	2,400	500		15,000	300	18,700
89	-	500	500	1,000	(5,000)	15,000	300	12,300
1990	-	500	700	500		15,000	300	17,000
91	-	500	300	500		500	300	2,100
92	-	500	300	500		500	300	2,100
93	-	500	300	500		500	300	2,100
94	-	500	300	1,000		500	300	2,600
95	-	500	300	500		500	300	2,100
96	-	500	300	500		500	300	2,100
97	-	500	300	500		500	300	2,100
98	-	500	300	500		500	300	2,100
99	-	500	300	500		500	300	2,100
TOTAL	(5,000)	16,205	69,600	11,000	(5,000)	64,500	5,600	156,905

APPENDIX A

APPENDIX A

CAPITAL COST DETAILS

BABCOCK MINE

WINDY OPEN PIT

Item	Description		Amount	Total
1.	Production Equipment			
	Drills	(2) x $ 416,000	832,000	
	Shovels	(3) x 1,321,000	3,963,000	
	Loaders	(2) x 386,000	772,000	
	Trucks	(15)	7,620,000	
	Dozers	(7)	1,485,000	
	Graders	(3)	462,000	
	Service Units - allowance		-	
	Mine Vehicles - allowance		219,000	
	Communications		50,000	
	Secondary Drills (2)		116,000	$15,519,000
2.	Construct Roadway			
	L = 4.3 miles (6.8 km)			411,000
3.	Electrical			
	Power Line - 44 KV		150,000	
	Transformation and dist.		400,000	550,000
4.	Miscellaneous Structures			200,000
5.	Preproduction Excavation for			
	Pit Preparation - Allowance			2,500,000
6.	Construction Overheads			
	Camp Operation		180,000	
	Engineering, Procurement and Management		1,000,000	
	Exploration and Testing		100,000	
	Insurance		250,000	
	Taxes		1,300,000	2,830,000
	TOTAL			$22,010,000

BABCOCK MINE #1 UNDERGROUND

Item	Description	Amount	Total
1.	Mine Development Excavations		
	Main Slope Portal	$ 150,000	
	Main Slope Heading, 10' x 20' L = 3144'	1,730,000	
	Shaft	810,000	
	Pump and Dewatering Station (865,000 cu.ft.)	1,298,000	
	Flume Drifts to Coal Seams	1,130,000	
	Return Airways	1,817,000	
	- Shafts, 16 ft. dia.		
	- Airways, 10 ft x 16 ft		
	Main Entries and Crosscuts	16,860,000	
	- D-Seam, 92,160 ft.		
	- F-Seam, 48,400 ft.		
	Communications	70,000	$23,865,000
2.	Mine Development Equipment		
	Main Slope Conveyors	1,637,000	
	Development Conveyors	2,965,000	
	Continuous Miners and Misc. Equipment	2,963,000	
	Miners (8)		
	Roof Bolters (2)		
	Shuttle Cars (8)		
	Compressors (4)		
	Electrical Distribution, D-Seam	643,000	8,208,000
3.	Monitor and Flume Water Pumphouse - Structure and Piping		
	Sitework	137,000	
	Building - Structure	782,000	
	- Services	68,000	
	Piping	876,000	1,863,000
4.	Hydraulic Mining Equipment		
	Flume Water Pumps (5)	650,000	
	Return Water Pumps (5)	230,000	
	Monitor Feed Pumps (5)	550,000	
	Slurry Pumps (6)	1,869,000	
	Storage Tanks	220,000	
	Miscellaneous	284,000	
	Installation	334,000	4,137,000

Item	Description		Amount	Total
5.	Piping			
	Pump Lines to Monitor and Flume Water P.H.		913,000	
	Monitor and Flume Water Piping to D, F and J Seams			
	Mat'l Supply, 104,000 ft.	$3,806,000		
	Installation	2,280,000		
	Misc. Piping	400,000		
	Testing	200,000	6,686,000	
	Slurry Lines to Prep.Plant		751,000	8,350,000
6.	Flumes			
	Main Entries, 20,100 @ $133		2,673,000	
	Subrise 46,000 @ $ 50		2,300,000	4,973,000
7.	Ventilation			
	Main Fans (5)		460,000	
	Air Heating Equipment		322,000	
	Building		40,000	
	Electrical		110,000	932,000
8.	Production Equipment			
	Face Equipment		1,195,000	
	Cont. Miners	(4)		
	Load-Haul-Dump	(3)		
	Compressors	(4)		
	Fans, etc.			
	Monitors	(8)	160,000	1,355,000
9.	Electrical Supply and Distribution			
	O.H. Line from Main Substation		662,000	
	Monitor & Fluming Water P.H.		211,000	
	Dewatering Pump Station		645,000	
	Power Supply, F-Seam		642,000	
	Power Supply, J-Seam		1,191,000	
	Miscellaneous		31,000	3,382,000
10.	Personnel Transport System			1,910,000

Item	Description		Amount	Total
11.	Mine Development Production Phase			
	Main Entries & Crosscuts			
	- F Seam 4,800 ft	$ 576,000		
	- J Seam 45,100 ft	6,314,000	$ 6,890,000	
	Sub-rises			
	- D Seam 7,000 ft	$ 840,000		
	- F Seam 7,000 ft	840,000		
	- J Seam 9,000 ft	1,260,000	2,940,000	
	Airways			
	- D Seam 5,000 ft	$ 600,000		
	- F Seam 4,050 ft	486,000		
	- J Seam 4,950 ft	793,000	1,779,000	$11,609,000
12.	Miscellaneous			
	Dewatering Station - Underground Screens, Conveyors		750,000	
	Pumphouse for Low Lift Return Pumps		200,000	950,000
13.	Construction Overheads			
	Camp Construction	$ 900,000		
	Camp Operation	1,700,000	2,600,000	
	Temporary Construction Facilities - Power Plant		1,020,000	
	Exploration and Test Drilling		300,000	
	Engineering Procurement and Construction Management		2,200,000	
	Miscellaneous - allow for grouting		500,000	
			$6,620,000	
	Taxes - Provincial 5% of Supply Cost, say 5% x $40 M.		2,000,000	
	- Federal - allow		500,000	
	Insurance		500,000	9,620,000
TOTAL				$81,154,000

NOTE:-

The foregoing is the estimated total cost to complete the development of Babcock No. 1 Underground Mine. For purpose of the estimate for pre-production capital cost the assumed expenditure to December 31, 1981 is $73,449,000. The balance of $7,705,000 is considered a post-production capital expenditure incurred in 1982.

BABCOCK MINE

SURFACE FACILITIES

Item	Description		Amount	Total
1.	Site Development and Yard Services			
	Site Preparation including grading and drainage		$1,069,000	
	Road Construction		180,000	
	Parking Area		98,000	
	Fencing		227,000	
	Mobile Equipment		710,000	
	Sanitary Sewers		264,000	
	Yard Fire System		483,000	
	Water Supply			
	- Reservoir	464,000		
	- Distribution	536,000	1,000,000	
	Potable Water		291,000	
	Electrical			
	- Substation	1,634,000		
	- Distribution	643,000	2,277,000	
	Communications		75,000	
	Fuel Oil System		186,000	$6,860,000
2.	Raw Coal Storage Facilities			
	Site Preparation		245,000	
	Structures		4,107,000	
	Mechanical		639,000	
	Electrical		122,000	5,113,000
3.	Breaker Station			
	Sitework		113,000	
	Building - Structure		1,473,000	
	- Services		69,000	
	Mechanical		1,344,000	
	Electrical		198,000	3,197,000

Item	Description	Amount	Total
4.	Coal Wash Plant		
	Sitework	34,000	
	Building - Structure	3,506,000	
	- Services	594,000	
	Mechanical	4,755,000	
	Piping	500,000	
	Electrical	600,000	
	Instrumentation	230,000	10,219,000
5.	Dryer Plant		
	Sitework	47,000	
	Building - Structure	995,000	
	- Services	115,000	
	Equipment	2,112,000	
	Piping	10,000	
	Electrical	139,000	3,418,000
6.	Thickening		
	Sitework	311,000	
	Building - Structures	3,820,000	
	- Services	120,000	
	Mechanical	2,688,000	
	Electrical	135,000	7,074,000
7.	Clean Coal Storage and Loadout		
	Sitework	255,000	
	Building - Structure	5,682,000	
	- Services	88,000	
	Mechanical	2,183,000	
	Electrical	444,000	8,652,000
8.	Ancillary Buildings		
	Office and Changehouse		
	Sitework	147,000	
	Building - Structure	1,780,000	
	- Services	822,000	2,749,000
	Service Building		
	Sitework	72,000	
	Building - Structures	2,640,000	
	- Services	842,000	
	Mechanical	502,000	4,056,000

Item	Description	Amount	Total
9.	Powerhouse		
	Sitework	13,000	
	Building - Structure	196,000	
	- Services	46,000	
	Mechanical	380,000	
	Piping	50,000	
	Electrical	10,000	695,000
10.	Laboratory		150,000
11.	Tailings Disposal and Water Reclaim		2,142,000
12.	Slurry Storage - Emergency		
	Sitework	235,000	
	Building - Structures	1,910,000	
	- Services	120,000	
	Equipment	151,000	
	Electrical	47,000	2,463,000
13.	Construction Overheads		
	Construction Camp		
	Construction	1,600,000	
	Operation	2,600,000	
	Temporary Construction Facilities		
	Construction	400,000	
	Operation	160,000	
	Site Maintenance	200,000	
	Construction Equipment	500,000	
	Project Insurance	500,000	
	Allowance - Overtime & Loss Time	2,400,000	
	Engineering and Supervision	7,100,000	
	Foundation Exploration & Testing	200,000	
	Taxes - Provincial	2,000,000	
	- Federal	1,500,000	
	Miscellaneous	200,000	19,360,000
	TOTAL		$76,148,000

WOLVERINE MINE

SHERIFF OPEN PIT

Item	Description			Amount	Total
1.	Production Equipment				
	Drills	(2)	2 x $416,000	832,000	
	Shovels	(3)		3,963,000	
	Loaders	(2)		750,000	
	Dozers	(5)		1,085,000	
	Trucks	(12)		6,500,000	
	Misc. Equipment				
	Graders	(3)	$462,000		
	Air Tracks	(2)	116,000		
	Service Trucks		108,000		
	Communications		50,000	736,000	$13,866,000
2.	Construct Roadway				
	L = 6 miles				600,000
3.	Electrical				
	Power Line - 44 KV			200,000	
	Transformation and distribution			400,000	600,000
4.	Miscellaneous Structures				300,000
5.	Preproduction Excavation for				
	Pit Preparation - Allowance				2,500,000
6.	Construction Overheads				
	Camp Operation			180,000	
	Engineering and Procurement			700,000	
	Exploration and Testing			100,000	
	Insurance			250,000	
	Taxes - allowance			1,300,000	2,530,000
	TOTAL				$20,396,000

WOLVERINE MINE

SURFACE PLANT

Item	Description	Amount	Total
1.	Site Development		
	Site Preparation	$ 400,000	
	Road Construction	100,000	
	Parking Area	97,000	
	Fencing	150,000	
	Mobile Equipment	300,000	
	Sanitary Sewers	200,000	
	Water Supply	400,000	
	Potable Water	150,000	
	Electrical - Substation	836,000	
	- Distribution	265,000	
	Communications	50,000	
	Fuel Oil System	150,000	$2,998,000
2.	Raw Coal Storage		
	Site Preparation	200,000	
	Structures	2,200,000	
	Mechanical	400,000	
	Electrical	70,000	2,870,000
3.	Breaker Station		3,197,000
4.	Coal Wash Plant		6,219,000
5.	Dryer Plant		2,000,000
6.	Thickening		3,700,000
7.	Product Storage		3,000,000
8.	Ancillary Buildings		
	Office and Changehouse	500,000	
	Service Building	1,000,000	1,500,000
9.	Powerhouse		600,000

Item	Description	Amount	Total
10.	Laboratory		$ 100,000
11.	Tailings Disposal and Water Reclaim		1,500,000
12.	Construction Overheads		
	Construction Camp		
	Camp Relocation	200,000	
	Operation	1,000,000	
	Temporary Facilities	500,000	
	Project Insurance	200,000	
	Allowance - Overtime & Loss Time	1,000,000	
	Engineering and Supervision	3,000,000	
	Foundation Exploration & Testing	150,000	
	Taxes - allowance	2,000,000	8,050,000
	TOTAL - SURFACE PLANT		$35,734,000
		Assume	$35,700,000

TOWNSITE

Item	Description				Amount	Total
1.	Site Preparation					$ 180,000
2.	Road Construction - 50,000 lin.ft.					2,500,000
3.	Accommodation					
	Item	No.	Area s.f.	Unit Price		
	Single Status	300	400	12,000	3,600,000	
	One Bedroom	70	800	24,000	1,680,000	
	Two "	150	1000	30,000	4,500,000	
	Three "	380	1200	36,000	13,680,000	
	Four "	50	1400	42,000	2,100,000	
	Five "	10	1600	48,000	480,000	
	Mobile	40	-	25,000	1,000,000	
	Furnishings - Single status				360,000	27,400,000
4.	Commercial					
	Medical Clinic)					
	Hotel)					
	Supermarket)					
	Bank)					
	Drug Store)					
	Laundromat)					
	Beauty Salon)	78,000		$30.00	2,340,000	
	Liquor Store)					
	Beer Store)					
	Misc. Stores)					
	Mall)					
	Municipal)					
	Theatre	8,000)		$40.00	440,000	
	Bowling Alley	3,000)				2,780,000

Item	Description		Amount	Total
5.	Institutional			
	Hospital (15 beds)			
	- Structure		200,000	
	- Furnishings		50,000	
	Schools			
	- Structures)			
	- Furnishings)		1,900,000	2,150,000
6.	Recreational			
	Curling Rink (4 sheets)		100,000	
	Hockey Rink		300,000	
	Swimming Pool		450,000	
	Ski Hill		50,000	
	Golf Course		100,000	1,000,000
7.	Site Services			
	Water Supply - wells		150,000	
	Water Distribution		1,075,000	
	Sanitary Sewers		1,625,000	
	Sewage Disposal		200,000	
	Storm Sewers		500,000	
	Electrical - Substation	$690,000		
	- Distr'n	1,527,000	2,217,000	5,767,000
8.	Miscellaneous			
	Airstrip			
	- Runway, 6000 ft. gravel surface		950,000	
	- Structure		100,000	
	- Lighting and Beacon		170,000	1,220,000
	Communications			500,000

Item	Description	Amount	Total
9.	Construction Indirects		
	Construction facilities (300 man camp)		
	- Camp construction	1,200,000	
	- Camp operation	1,600,000	
	Engineering and Construction Management	3,800,000	
	Construction Power	300,000	
	Site Maintenance prior to plant start-up	100,000	
	Project Insurance	500,000	
	Allowance for Provincial and Federal Taxes	2,500,000	10,000,000
	TOTAL FOR TOWNSITE (Capacity 1000 Mine Personnel)		$53,497,000
	COST PER PERSON = $53,500.		
	ESTIMATED MINE PERSONNEL FOR BABCOCK MINE IN 1980 = 850, OR ESTIMATED COST IS		$45,000,000

Estimated additional manpower required for Wolverine Mine operations is -

Mine - Open Pit	231
Preparation Plant	142
Supervisory	28
Total	401
	say 400

Assume average cost for accommodation, including extension of existing services is $50,000/worker.

Estimated Total Cost
400 x $50,000 = $20,000,000

TOTAL CAPITAL COST FOR TOWNSITE FOR BABCOCK AND WOLVERINE = $65,000,000

OFF-SITE FACILITIES

SUMMARY

Item	Description	Babcock	Wolverine	Total
1.	Access Road	$ 6,600,000	$ 2,000,000	$ 8,600,000
2.	Power Supply	7,550,000	1,000,000	8,550,000
3.	Railway Construction	56,000,000	6,125,000	62,125,000
4.	Railway Equipment	30,600,000	15,290,000	45,890,000
5.	Port Facilities	42,600,000	-	42,600,000
	TOTAL	$143,350,000	$24,415,000	$167,765,000

BABCOCK MINE

OFF-SITE FACILITIES

Item	Description		Amount	Total
1.	Access Road			
	Upgrade Existing Road		1,500,000	
	Construct New Road to Townsite and Babcock Plant		4,600,000	
	Allowance for Engineering and Surveys		500,000	$ 6,600,000
2.	Power Supply (B.C.Hydro & Power Authority)			
	138 KV Power Line, Chetwynd to Babcock Plant Site. L = 72 miles			7,550,000
3.	Railway Construction (British Columbia Railway)			
	Lands & Legal Surveys		1,000,000	
	Construct Rail Sub-grade		29,500,000	
	Allowance for Bridge Structures		6,000,000	
	Track and Ballast		12,500,000	
	Engineering		7,000,000	56,000,000
4.	Railway Equipment			
	Coal Cars	432 @ $36,700	15,854,000	
	Motive Power	24 @ 490,000	11,760,000	
	Caboose	4 @ 46,600	186,000	
	Taxes - allowance		2,800,000	30,600,000
5.	Port Facilities - Prince Rupert (Swan Wooster Engineering Co. Ltd.)			
	Road Access		3,400,000	
	Rail Access		1,700,000	
	Site Development	9,500,000		
	less Allowance Phase II	3,000,000	6,500,000	
	Services		1,300,000	
	Marine Structures		10,200,000	
	Materials Handling Equipment Phase I		17,000,000	
	Engineering		2,500,000	
	Taxes		included	42,600,000
	TOTAL OFF-SITE FACILITIES			$143,350,000

WOLVERINE MINE

OFF-SITE FACILITIES

Item	Description		Amount	Total
1.	Access Road			
	Townsite to Plant Site		1,500,000	
	Allowance for Bridge Structure		500,000	$ 2,000,000
2.	Power Supply - 138 KV Line			
	Townsite to Plant Site			1,000,000
3.	Railway Construction			
	Lands & Legal Surveys		125,000	
	Construct Sub-grade		3,500,000	
	Bridge Structure		200,000	
	Track and Ballast		1,600,000	
	Engineering		700,000	6,125,000
4.	Railway Equipment			
	Coal Cars	216 @ $36,700	7,927,000	
	Motive Power	12 @ 490,000	5,880,000	
	Caboose	2 @ 46,600	93,000	
	Taxes - allowance		1,390,000	15,290,000
	TOTAL OFF-SITE FACILITIES			$24,415,000

PROJECT OVERHEADS

SUMMARY

Babcock Development	$21,891,000
Wolverine Development	5,000,000
Allowance for Working Capital	2,000,000
TOTAL	$28,891,000

BABCOCK MINE

PROJECT OVERHEADS

Item	Description	Amount	Total
1.	Owner's Overhead		
	(a) Project Development to Dec. 1976	$7,600,000	
	(b) Overhead, Jan.1/77 to Dec.1979	3,541,000	
	(c) Lease Expense,Jan.1/77 to Dec.1979	750,000	
	(d) Regional Office	200,000	$12,091,000
2.	Personnel Recruitment and Transport to Site		2,000,000
3.	Allowance for Project Security		800,000
4.	Salaries Pre Plant Start-up		4,000,000
5.	Allowance for Inventory and Spares		3,000,000
	TOTAL PROJECT OVERHEADS		$21,891,000

WOLVERINE MINE

PROJECT OVERHEADS

Item	Description	Total
1.	Owner's Overhead - allowance	$ 1,000,000
2.	Personnel Recruitment and Transport to Site	800,000
3.	Allowance for Project Security	200,000
4.	Salaries Pre Plant Start-up	1,000,000
5.	Allowance for Inventory and Spares	2,000,000
	TOTAL PROJECT OVERHEADS	$5,000,000

APPENDIX E

APPENDIX E

GEOLOGICAL DRAWINGS

Windy Area - Pit Plans	QNTT 75-0579-R04
Windy Area - Sections	QNTT 75-0604-R01
Five Cabin to Babcock Area - Typical Sections	QNTT 75-0593-R01
Representative Section - No. 2 & 4 Mine	QNTT 75-0602-R01
Representative Section - No. 3 & 4 Mine	QNTT 75-0603-R01
Roman Mountain - Cross Sections	QNTT 75-0594-R01
Sheriff-Frame - Cross Sections	QNTT 75-0584-R01
Wolverine North - Cross Section D-D	WLVR 73-0395-R02

Geological Map

Mine Location and Boundary Plan	Sheet 6
Mine Location and Boundary Plan	Sheet 7
Mine Location and Boundary Plan	Sheet 11

WINDY AREA
FIT PLANS

DENISON MINES (BC) LIMITED
(COAL DIVISION)
CALGARY ALBERTA

DR Nov. '75

ONTT 75-0579-R04

LEGEND

Coal Seam
Fault
Drill Hole
Cross Sections

0 400 800 1200
scale 1" = 400'

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centimetres

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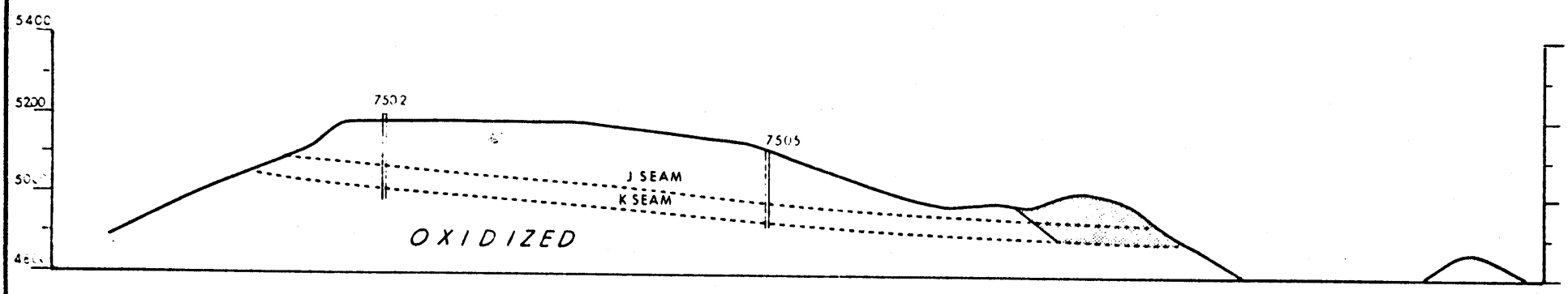
BRITISH COLUMBIA GEOLOGICAL SURVEY



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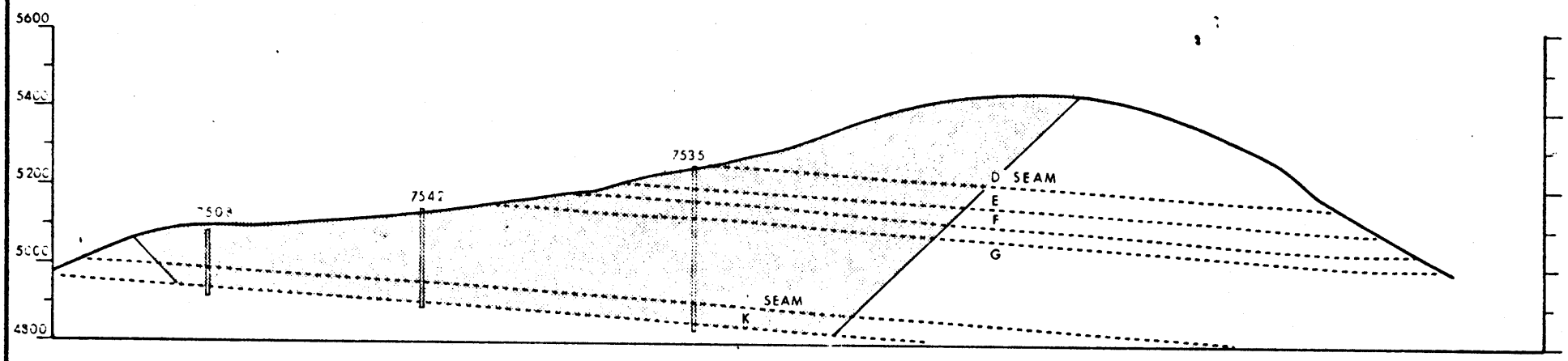

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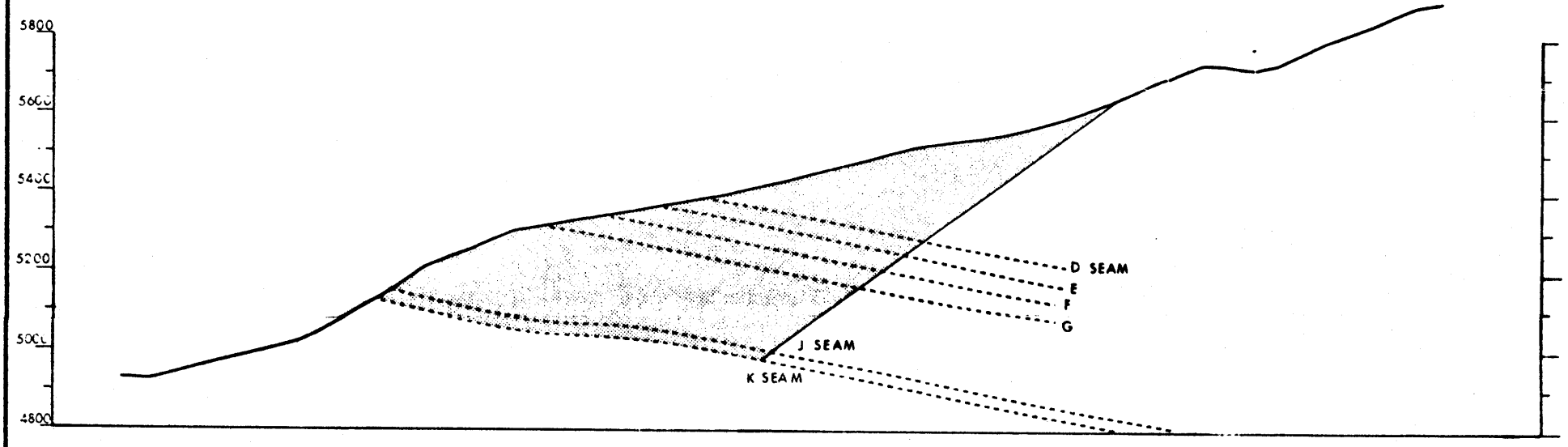

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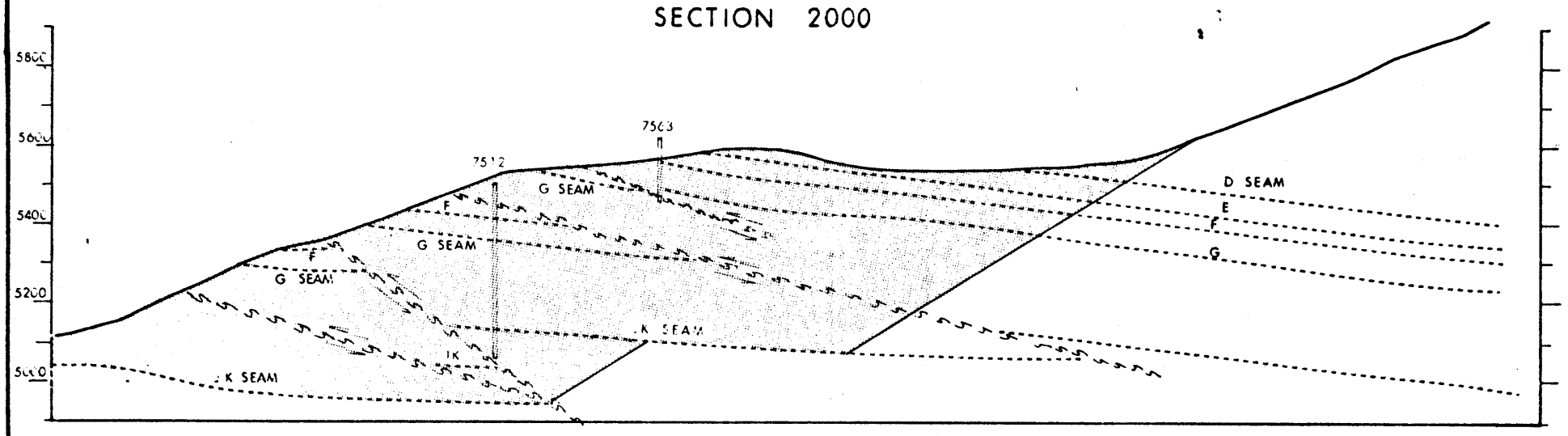
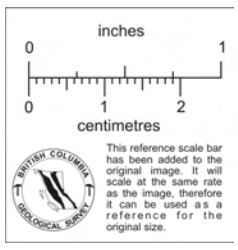


SECTION 2600

← N. W.

S. E. →



DENISON MINES LIMITED
(COAL DIVISION)
CALGARY ALBERTA

WINDY AREA

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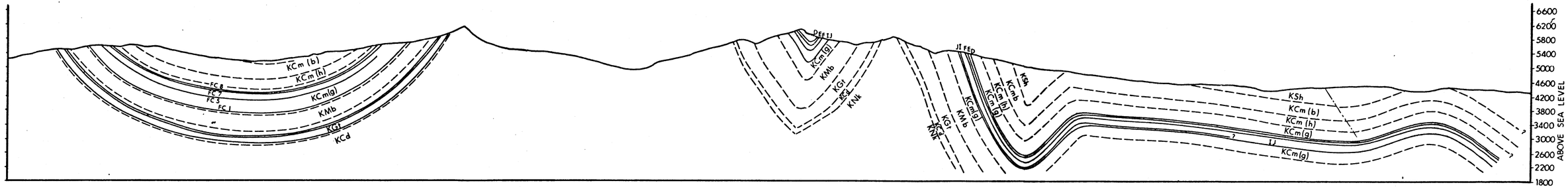
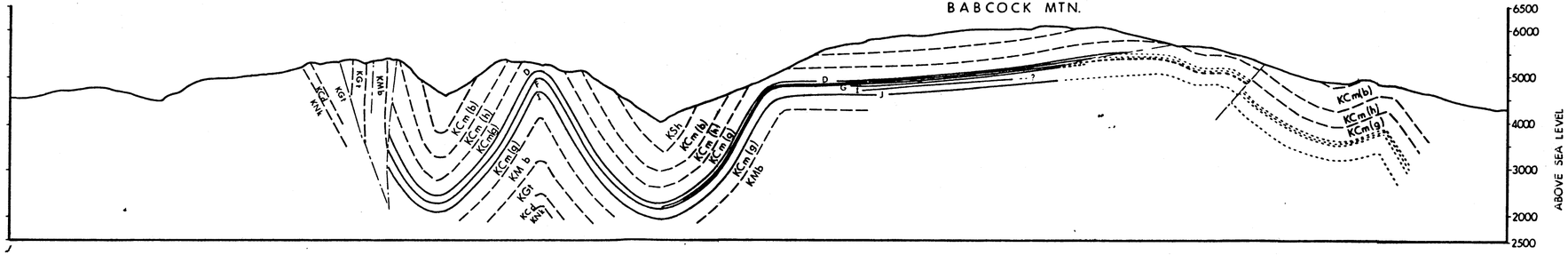
APPROVED BY	DRAWING NO QNTT 75-0604-R01	



SECTION K-K'



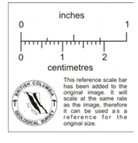
SECTION J-J'

LEGEND

CRETACEOUS

- KSh — Shaftesbury formation
- KCm(b) — Commotion formation (Boulder Creek member)
- KCm(h) — Commotion formation (Hullcross member)
- KCm(g) — Commotion formation (Gates member)
- KMb — Moosebar formation
- KGt — Gething formation
- KCd — Cadomin formation
- KNk — Nikanassin formation

Coal seam
Boundary of member
Fault



DENISON MINES (B.C.) LIMITED
(COAL DIVISION)
CALGARY ALBERTA

FIVE CABIN TO BABCOCK AREA TYPICAL SECTIONS

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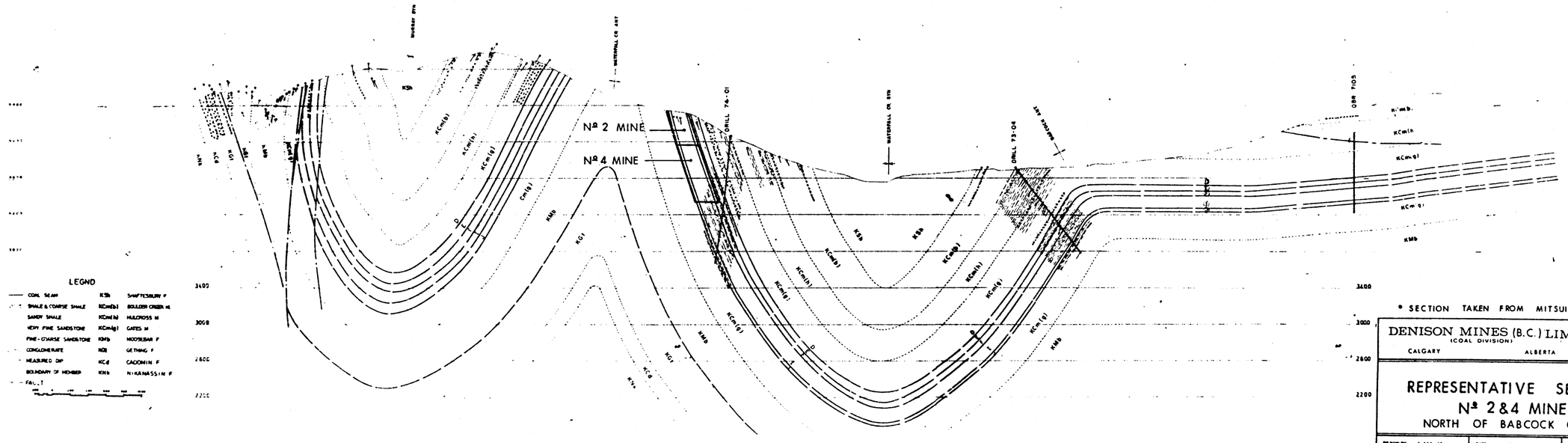
APPROVED BY:	DRAWING NO: QNTT 75 - 0593 - R01	

CROSS SECTION 116



LEGND

COAL SEAM	KSh	SHAFTESBURY F
SHALE & COARSE SHALE	KCm(b)	BOULDER CREEK M.
SANDY SHALE	KCm(h)	HULCROSS M
VERY FINE SANDSTONE	KCm(g)	GATES M
FINE - COARSE SANDSTONE	KMb	MOOSEBAR F
CONGLOMERATE	KGt	GETHING F
MEASURED DIP	KCd	CADOMIN F
BOUNDARY OF MEMBER	KNh	NIKANASSIN F
FAULT		

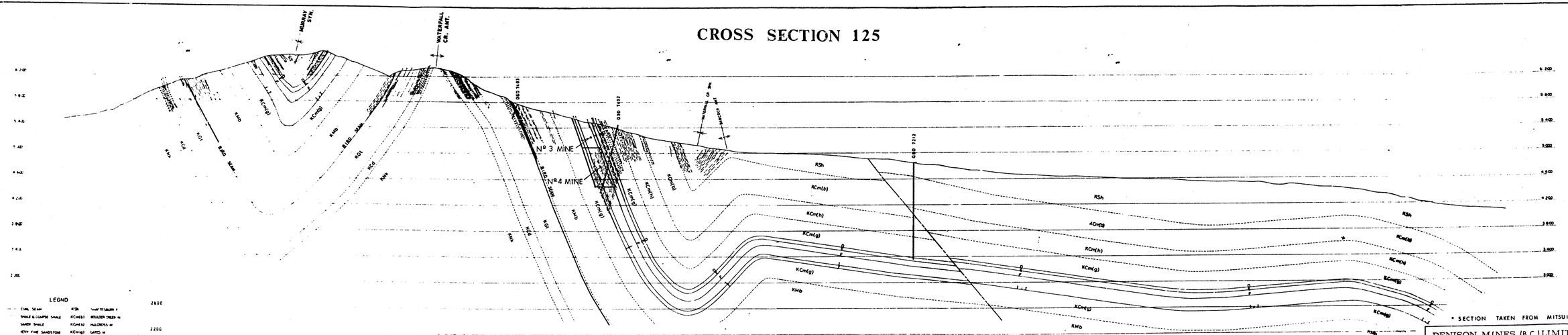
* SECTION TAKEN FROM MITSUI MINING STUDY

DENISON MINES (B.C.) LIMITED
(COAL DIVISION)
CALGARY ALBERTA

REPRESENTATIVE SECTION
Nº 2&4 MINE
NORTH OF BABCOCK CREEK

DRAWN BY: J.W.K.	DATE NOV., 75	SCALE 1" = 1000'
APPROVED BY:	DRAWING NO QNTT 75-0602-R01	

CROSS SECTION 125



LEGND

* SECTION TAKEN FROM MITSUI MINING

DENISON MINES (B.C.) LIMITED
(COAL DIVISION)
CALGARY ALBERTA

REPRESENTATIVE SECTION
Nº 3 & 4 MINE
SOUTH OF BABCOCK CREEK

DRAWN BY J.W.K.	DATE NOV., 75	SCALE 1" = 1000'
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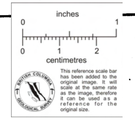
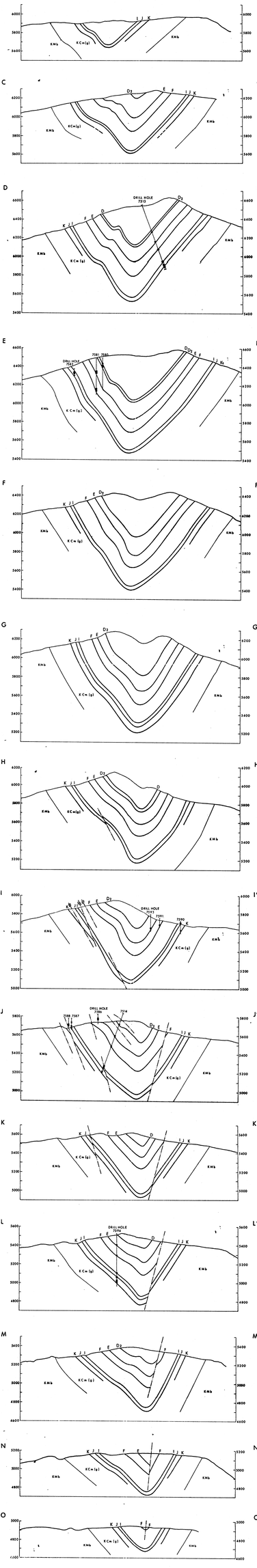




* BASED ON DATA PREPARED BY MITSUI MINING

KMb — Moosebar formation

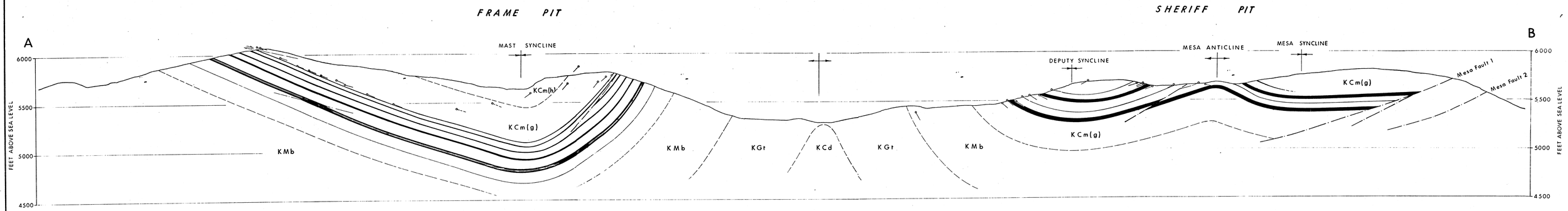
KCm(g) — Commotion formation (Gates member)

7581 — Drill Hole Projected To Section Plane

DENISON MINES (B.C.) LIMITED
COAL DIVISION
CALGARY ALBERTA

ROMAN MOUNTAIN CROSS SECTIONS

DRAWN BY: Tressen	DATE: Nov. 14 '75	SCALE: 1"=400'
APPROVED BY:	DRAWING NO.: ONTT 75-0596-R01	

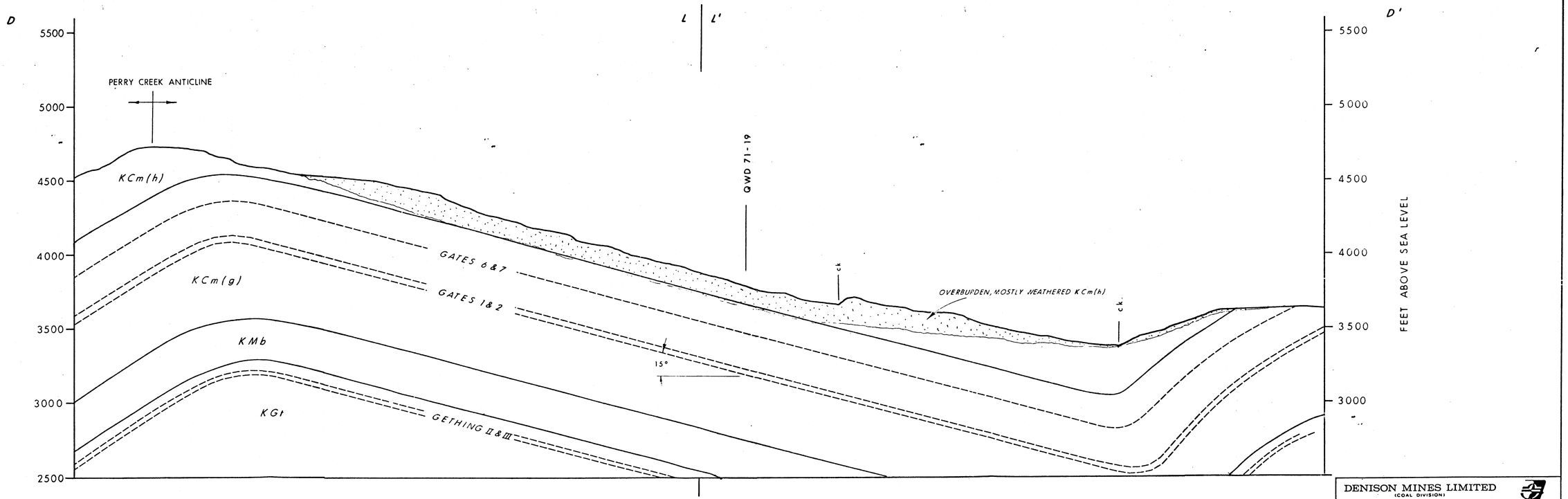


KCm(h) Commotion formation (Hullcross member)
KCm(g) Commotion formation (Gates member)
KMb Moosebar formation
KGt Gething formation
KCd Cadomin formation

DENISON MINES (B.C.) LIMITED
(COAL DIVISION)
CALGARY ALBERTA

SHERIFF - FRAME CROSS - SECTION

DRAWN BY: E. LOTE	DATE: Oct. '75	SCALE: 1" = 400'
APPROVED BY:	DRAWING NO: QNTT 75 - 0584 - R01	



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DENISON MINES LIMITED
(COAL DIVISION)
CALGARY ALBERTA

WOLVERINE NORTH
CROSS SECTION D-D'

DRAWN BY: E. Hoth	DATE: Feb '73	SCALE: 1" = 400'
APPROVED BY:	DRAWING NO: WLVR 73-0395-R02	