92H-7,10

TULAMEEN COAL PROJECT

1978 PROGRESS REPORT

T. J. Adamson
CYPRUS ANVIL MINING CORPORATION
February 1979

VOL. II OF II
(Appendices V - IX)

APPENDIX V

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24 November 1978

To Whom It May Concern

This report is submitted in revised form to incorporate data and alternatives considered as of May 1978, to form part of the data base for the pre feasibility study currently being prepared on the Tulameen Coal Project.

Areas of revision include:

1) mine operation compatibility proposed plant operations (Techman, March 1978)

2) reduced stripping ratio during first 4 years of operations

3) utilizing tandem scrapers to repower after optimum utilization of single axle drive scrapers

4) utilizing latest revision of Caterpillar Tables for cost estimating.

A general knowledge of the project is assumed. More detailed information on some of the facts (geology, exploration data, etc.) may be obtained from various reports in Cyprus Anvil's possession.

Respectfully submitted

Murray O. Hampton, P. Eng.
Senior Engineer-Coal Project

24 November 1978

CYPRUS ANVIL

REPORT on

PRE FEASIBILITY STUDY

MINING PLAN

TULAMEEN COAL PROJECT

CYPRUS ANVIL MINING CORPORATION

Prepared By

Murray O. Hampton, P. Eng.
Faro, Yukon

February 1978

(Revised November 1978
incorporating data as of May 1978)

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ILLUSTRATIONS

TERMS OF REFERENCE

1. Based upon maps and geological sections, provided by Tom Adamson (Cyprus Anvil Exploration Department) from the 1976 trenching and drilling, a site visit and various discussions to develop an open pit mining plan for a portion of the Tulameen Coal Project.

2. Estimate operating and capital costs of mining designed pit and delivering coal to a preparation plant.

3. Propose a route and estimate cost for a road for trucks hauling clean coal from preparation plant to rail siding in Coalmont.

4. Investigate other forms of clean coal transport.

5. Suggest a reclamation plan and estimate cost of implementation.

LOCATION AND ACCESS (49°30' N. Lat., 120°45' W. Long.)

The Tulameen coalfield is located south of the Tulameen River between the settlements of Coalmont and Tulameen. A branch line of the Canadian Pacific Railway follows the north bank of the Tulameen River connecting Princeton, through Coalmont and Tulameen, to the mainline at Spences Bridge.

A narrow road connects Coalmont with Princeton, approximately 15 kilometres south east on the southern Trans Provincial Highway, and Merritt to the North.

The proposed minesite lies approximately 5 kilometres westerly of Coalmont or some 10 kilometres by existing bush road. A bridge crossing the Tulameen River exists at Coalmont.

CLIMATE

Snowfall can be expected from October through April. The snow pack has been measured near the proposed minesite since 1960. On the average, the snow pack is deepest in March and April. The fifteen year average snow depth for April is 124 centimetres, with maximum being 193 centimetres, and minimum of 74 centimetres. Snow normally lies on the ground through late May (mid May average 41 centimetres), and, on 3 of the years between 1960 and 1975, through June; the worst being 1972, with 74 centimetres when measured on June 27th.

Rainfall can be expected on about 60 days, and snowfall on about 50 days. An annual precipitation of 500 millimetres, of which 90% occurs as snow, can be expected.

Temperatures average to daily highs of 30° C. and daily lows of 7° C. in mid summer. Mid winter temperatures average -4° C. for daily high and -12° C. for daily low. Extremes from -40° C. to 40° C. have occurred. Except for snowpack, this weather summary is based on data from Osprey Lake and Princeton.

HISTORY

Only a very brief historical discussion will be included in this report and is included to explain the reasoning in establishing some of the concepts and parameters utilized in the plan.

Underground mining was carried out on the southwestern edge of the Tulameen coalfield from 1919, continuously into 1940 (Coalmont Collieries) and a small open pit (Mullins) operated from 1953 through 1957. Some 2.4 million short tons were extracted from underground and approximately one-quarter million short tons were taken from the open pit.

The underground workings ran into squeezing problems with depth, and apparently had problems with poor roof conditions in general. Only one seam was mined over a large area.

The Mullins open pit was operated with a tractor equipped with ripper and dozer, a track loader, and small dump trucks. No problem was encountered with ripping any of the rock in the pit (mainly shales). The open pit extracted part of the surface pillar left by the underground mining.

RESERVES

The reserves within the proposed pit are based on sections prepared by the Exploration Department on the results of the 1976 drilling and trenching program.

These reserves are accepted as "proven". However, one or two additional drill holes should be drilled prior to finalization of much of the hanging wall. This drilling would be to confirm the uniformity of dip beyond the present drill holes to assure the final wall geometry is valid. Such drilling could probably be postponed until about the fifth year of operation.

The portion of the coal zone being considered in this study is some 1500 metres in length with a thickness of 15 to 21 metres, and dips varying from 28° at the south end, to 45° at the north end. It is composed of several coal seams with interbedded clays and shales.

The proposed pit will extract some 10,000,000 tonnes of the coal zone.

PHYSIOGRAPHY

The proposed minesite is between 1300 and 1400 metres above sea level, while the valley floor at Coalmont is approximately 760 metres in elevation. The slope in the immediate area of the minesite is realtively gentle compared to the very steep slopes into the main valley bottoms.

The area is heavily timbered, primarily with mixed conifers ranging up to about 50 centimetres in diameter. The soil is quite thin, ranging from about 30 centimetres to 2 metres overlying the bedrock.

GEOLOGY

This brief discussion on geology is limited to those items directly influencing a mining operation. The coal zone consists of coal seams interbedded with coaly shale, shale and clays. The coal seams are close enough to form a single mineable zone 15 to 21 metres thick. Waste rock within the pit consists primarily of thinly bedded shales, siltstones and fine to coarse-grained sandstones. All of these sedimentary beds dip from 28° to 45° to the northeast. A small area of flat lying basaltic lava will probably be encountered at the northeastern corner of the pit. These volcanics are probably quite thin so should present only a short term problem to mining.

The hanging wall rocks form a stable pit wall that will stand for a long period at a steep angle, as is evident in the Mullin's pit.

No major fault zones were indicated by the 1976 exploration in the proposed pit area.

PRODUCTION LEVEL

The mining operation is proposed on a production level of eight hundred thousand metric tonnes of raw coal per annum. This rate is chosen to establish a sufficient mine life to warrant the required infrastructure associated with the operation.

Depending upon the preparation plant, this level of mine production should yield between 400,000 and 500,000 tonnes of clean coal per year. Such a volume should provide reasonable marketing possibilities under near future conditions.

The proposed pit at this production level would provide a mine life of some 12.5 years.

ENVIRONMENT

The steepness of the coal seam dip, the relative shortness of the proposed pit in relation to depth, and the configuration of topography make progressive reclamation of the mined area impractical. Further, in that the seam will not be exhausted by the proposed pit, it would be unsound planning from future economic and conservation viewpoints to backfill the proposed pit too hastily. By the time the proposed pit is mined, the economics of the day may make it feasible to expand the pit to greater depth or the seams may be mined by underground methods at that time.

In either case, it would be most undesirable to have had the pit backfilled. It is proposed therefore, to pile the waste rock in such a manner that it is stable and suitable for re-vegetation in the future. The dump site chosen is N.E. of the pit area where it will have minimal influence on the drainage systems.

The whole pit and dump area will have to be logged and cleared in accordance with land use requirements. As far as is practical, soil should be removed and stockpiled separately for use in future reclamation work.

Work areas should be maintained in an orderly, tidy and clean condition as the operation progresses. Such efforts will enhance the aesthetics of the operation and promote efficiency.

Reclamation is built into the mining plan, and in general, the cost forms a part of the operating cost. An additional sum of $250,000 should be accrued over the life time of the mine to provide for revegetation and final stabilization of the disturbed area.

If no further mining is planned in the immediate area, upon completion of operations, a serious look should be taken at the feasibility of establishing a lake in the pit and stocking it for fishing. Subject to available water inflow, an excellent lake should be possible. Such a lake would have dimensions of 1500 metres long, by 170 metres wide, and 65 metres deep.

ACCESS ROAD

It would be feasible to upgrade the existing Blakeburn Road into the proposed plant site, however, some very bad grades and corners exist on this route. A more favourable route appears to be possible through Fraser Culch. The latter route would be slightly shorter and it could be developed without the bad corners found on the Blakeburn Road.

Only a general cost estimate can be made at this time, more detailed examination of route possibilities on air photographs and on site will be required for selection of proper routing.

The bridge across the Tulameen River at Coalmont is rated for a legal load limit of 84,000 pounds (38 tonnes) G.V.W. on a five axle configuration. The right angle turn at the south approach of this bridge is also a restriction for the type of haulage truck utilized to transport coal from the plant to the railway siding.

ALTERNATE CLEAN COAL TRANSPORT

Apart from truck haulage three methods of clean coal transport are suggested. These are: 1) Slurry pipeline 2) Cable tramline and 3) Belt conveyor. The straight line distance from proposed plant site to the railway is approximately 4.5 kilometres with a vertical drop of some 580 metres. The distance and elevation change is well within the capabilities of the three methods.

A Slurry pipeline is rejected on the basis of:

1) the particle size of some of the coal will be too large for proper slurry flow,
2) freezing problems could be possible,
3) water would have to be recycled from bottom end back to plant site and
4) a separate dewatering facility remote from the plant would be required.

A cable tramline tends to require a high level of maintenance and often requires unexpectedly high numbers of operating personnel if either horizontal or vertical angles are required.

A conveyor belt system is normally a very efficient means of bulk handling and requires a very small number of operating and maintenance personnel.

The relatively high initial capital cost of a conveyor system would be partially offset by not requiring a truck fleet or bridge replacement and requiring considerably less upgrading of road access.

Operating costs of a truck fleet are expected to rise at a much faster rate than conveyor operation. Therefore, a conveyor system may prove on analysis to be the desirable option.

Subsequent investigations indicate truck haulage most economic (Techman, March 1978).

MINING EQUIPMENT

The major pieces of equipment used for this study were Caterpillar 631D scrapers, D9H tractors with rippers and dozer blades, and 16G graders. The only other major pieces of equipment are a sander, and water truck in season.

The 631's and D9's are felt to be compatible with the proposed operation. They are of a large enough size to handle the proposed volume with a reasonable number of pieces of equipment, while at the same time, being small enough to provide flexibility and facilitate sorting in the pit. The 16G grader is somewhat on a larger scale and is being proposed primarily as being sufficiently robust to aid in the sorting process. A secondary reason for proposing the 16G is that records show a reasonably heavy snowfall, which will need to be cleared efficiently.

The provision of adequate sand and water trucks are indicated by the weather records. Long periods of the winter are in the temperature ranges which maintain snow and ice in its most slippery state. Summer periods can be quite hot and dry which increases the dust problem inherent in a ripper and scraper operation.

MINING OPERATIONS

The mining study is based on the use of conventional scrapers, with tractors for ripping and push loading. Some sorting of material in the pit is desirable to reduce the load on the preparation plant. The relatively steep dip of the coal formation, and the configuration of the waste bands permits the sorting to be done most efficiently by scrapers, probably assisted to some extent by graders.

The scrapers will definitely be most efficient for the first few years of operation and may prove to be desirable for the entire mine life. However, the planned bench and ramping systems would be suitable for conversion to a truck and shovel operation if it became desirable at a future date. Medium sized equipment, as opposed to very large, is chosen to give more flexibility and to keep the capital cost of repair facilities down. The very large equipment requires much greater shop size, and much heavier shop cranes, which, in turn, necessitate stronger shop structures, escalating capital costs very rapidly. Similarily, to serve the very large mining equipment, mobile repair equipment must be larger, and more costly.

Another important factor in proposing the medium sized equipment is the labour supply. There is a much larger labour pool from which to draw experienced operators and maintenance personnel for the proposed equipment than for very large mining equipment.

The proposed equipment is common to the construction, forestry and mining industries, hence the greater pool of labour.

For the purposes of this study, Caterpillar equipment data has been utilized for the main components. The technical and cost data is most readily available on Caterpillar equipment and has been used for that reason. However, all comparable equipment of other manufacture should be considered in the final feasibility study.

A combination of high capital equipment cost and geometry of the deposit rule out the use of drag line, conveyor belt and bucket wheel types of operations.

EQUIPMENT MAINTENANCE

The only way productivity and cost of the operation of equipment can be controlled is with a thorough preventative maintenance program. To this end adequate shop facilities must be provided and a very important part of these is a year round washdown area. Without proper cleaning of equipment, preventative maintenance inspections can not be carried out and the whole program ceases to function in a meaningful way. These facilities will be considered together with the preparation plant estimates.

EQUIPMENT PROVISIONS

The decision whether to purchase or to lease equipment is largely a matter of availability of capital funds and the various tax ramifications. From an engineering plan point of view, the option makes no difference. From an operational point of view, the best option depends to a large extent on personalities and philosophies. If the operations personnel have a strong feeling of pride in ownership, and a strong belief in preventative maintenance, outright ownership is usually preferable.

Most lease agreements have clauses requiring certain inspections and the maintenance of equipment to standards acceptable to the lessor. Such lease maintenance requirements may force operating personnel, who may not be keen on maintenance, into doing the necessary repair work. However, some operators may feel that because the equipment is only leased, it is unimportant how it is treated on the job. Such an attitude would tend to reduce the effectiveness of the enforced maintenance on leased equipment.

DESIGN PARAMETERS

Access Ramp Grade	10% maximum
Footwall Slope (at dip of coal)	28° - 45°
Hanging Wall Slope	63.5% maximum
Raw Coal Reserves	10,000,000 tonnes
Annual Mining Rate	800,000 raw tonnes
Mine Life	12.5 years
Diesel Fuel	14.4¢/litre (65.3¢/gal)
Operation	3 shifts/day on waste & coal

5 days/week x 52 weeks/yr.=	260 days/yr
Statutory Holidays	12
Vacation	15
Unscheduled Allowance	3
Operate	230 days/yr
	690 shifts/yr.

6.5 operating hours/shift
50 operating minutes/op hour

Preparation Plant Situated at 5,485,600 N between 662,000 E and 662,400 E

PIT VOLUMES (Final)

Total Pit Volume	**34,441,800** m^3
Coal Volume (tonnes/1.64)	6,116,266 m^3
Waste Volume	**28,325,535** m^3
Coal	**10,030,676** tonnes
Overall Stripping Ratio	2.82 m^3/tonne

SUPERVISION

Included at this time are those personnel directly involved with the pit operation and mobile equipment maintenance. Some share of the cost of certain other positions may also be charged to the raw coal production when the overall personnel requirement is finalized to include preparation plant, haulage, and loading operations.

	Number	Salary	Overhead	Total Cost
Mine Superintendent	1	30,000	14%	34,200
Mine Foremen	3	25,000	14%	85,500
Surveyors	2	20,000	14%	45,600
Mechanical Superintendent	1	28,000	14%	31,920
Mechanical Foreman	1	25,000	14%	28,500
Total Annual Cost				225,720

Cost per raw tonne 225,720/800,000 $0.28/tonne

WASTE HAUL CYCLE

PROJECT YEAR TWELVE (637D)

3% RR

LOADED

750 m level	1.35 min	
1100 m + 10%	4.4 min	15 km/h
700 m level	1.3 min	

RTN

700 m level	1.05 min	
1000 m - 10%	1.62 min	37 km/h
750 m level	1.1 min	
Load and Unload	1.2 min	
	12.02 min	

50 min/hr = 4.16 cycle/hr

COAL CYCLE

PROJECT YEAR TWELVE (637D)

LOADED

750 m level	1.35 min	
1100 m + 10%	4.4 min	
150 m level	0.27 min	

RTN

150 m level	0.22 min	
1100 m level - 10%	1.78 min	
750 m level	1.1 min	
Load and Unload	1.2 min	
	10.32 min	4.84 cycle/hr

COAL HAUL (Project Year Twelve

800,000 tpy
÷ 690 shifts
1159 t/shift
÷ 6.5 hr/shift
178 t/hr
÷ 29 t/load
6.15 load/hr
÷ 4.84 load/hr/scraper
= 1.27 scrapers

WASTE HAUL (Project Year Twelve)

2,930,000 m^3/yr
÷ 690 shifts/yr
4,246 m^3/shift
÷ 6.5 hr/shift
653 m^3/hr
÷ 15 m^3/load
43.55 load/hr
÷ 4.16 load/hr/scraper
= 10.47 scrapers

PROJECT YEAR FIVE

COAL HAUL
(Mid Pit Maximum)

LOADED

680 m level	1.3 min
110 m + 9%	0.7
440 m level	0.9
	2.9 min

EMPTY RETURN

980 level	1.3 min
110 - 9% 37 km/h	0.2
680 level	0.95
	2.45 min

Loading	0.7 min
Unloading	0.7
Cycle time	6.75 min
50 min/hr	7.41 cycle/hr

	800,000	tonnes/year	
	690	shifts/year	
	1,159	tonnes/shift	
	29	tonnes/load	(load factor 0.74)
Require	40.0	loads/shift	
	6.5	hrs/shift	
	6.15	loads/hr	
	7.41	loads/hr/scraper	

Requires 0.83 scrapers/shift on coal

Loaded Haul		
	+9% 110 m	0.7 min
	level 1600 m	2.6
Return		
	level 1600 m	2 min
	-9% 110 m	0.2 min
		5.5 min
	Load & Unload	1.4
	Cycle	6.9 min
	50 min/hr	7.25 loads/hr/scraper

1,950,000 m^3/yr

690 shifts/yr

2,826 m^3/shift

15 m^3/load

188 loads/shift

6.5 hrs/shift

28.99 loads/hr

7.25

4.0 scrapers/shift

PROJECT YEARS 2-5 Inclusive

Stripping 1.95 million m^3/yr

	Shifts	Units	Hrs/shift	Cost/hr	Total
Scrapers	3	5	6.5	45.90	4,475
Dozers	3	3	6.5	42.16	2,466
Grader	3	1	6.5	20.00	390
Water/Sand Trk	3	1	6.5	15.00	293
					7,624
Operators	30 X 10 X 8				2,400
			$/day		10,024
			tonnes/day		3,433
			$/tonne		2.92
			Supervision		0.28
			Total $/tonne raw		3.20

PROJECT YEAR 13

	Shifts	Units	Hrs/shift	Cost/hr	Total
Scraper	3	1	6.5	58.49	1,141
Dozers	3	1	6.5	42.16	822
Grader	3	1	6.5	20.00	390
Water/Sand Truck	3	1	6.5	15.00	293
					2,646
Operators	12 X 10 X 8				960
			$/day		3,606
			tonnes/day		3,433
			$/tonne		1.05
			Supervision		.20
			Total $/tonne raw		1.25

PROJECT YEAR 6 2.93 million m^3/yr stripping

	Shifts	Units	Hrs/shift	Cost/hr	Total
Scrapers (631)	3	5	6.5	45.90	4,475
(637)	3	2	6.5	58.49	2,281
Dozers	3	3	6.5	42.16	2,466
Grader	3	1	6.5	20.00	390
Water/Sand Truck	3	1	6.5	15.00	293
					9,905
Operators	36 X 10 X 8				2,880
			$/day		12,785
			Tonnes/day		3,433
			$/tonne		3.72
			Supervision		.28
			Total $/tonne		4.00

PROJECT YEAR 12 2.93 million m^3/yr stripping

	Shifts	Units	Hrs/shift	Cost/hr	Total
Scrapers (637)	3	12	6.5	58.49	13,687
Dozers	3	3	6.5	42.16	2,466
Grader	3	1	6.5	20.00	390
Water/Sand Truck	3	1	6.5	15.00	293
					16,836
Operators	51 X 10 X 8				4,080
			$/day		20,916
			Tonnes/day		3,433
			$/tonne		6.09
			Supervision		.28
			Total $/tonne		6.37

CAPITAL COSTS ($000's)

MINE EQUIPMENT CAPITAL COST SCHEDULE

(stripping 1.95 million m^3/yr years 2-5, 2.93 million m^3/yr 6-12)

Year		Scrapers		Dozers		Graders		Water/Sand Truck	Total
2	631(7)	2,219	(4)	1,280	(3)	681	(2)	200	4,380
3		-		-		-		-	-
4		-		-		-		-	-
5		-		-		-		-	-
6	637(3)	1,173		-		-		-	1,173
7	Trade(7) 631-637	2,515		-		-		-	2,515
8	(1)	391	(3)	864	(2)	409			1,664
9	(1)	391		-		-		-	391
10	(1)	391		-		-		-	391
11	(1)	391		-		-		-	391
12	(1)	391		-		-		-	391
13		-		-		-		-	-

ROAD

Construction	8 km x 12.5	100
	4 km x 12.5	50
		$150

BRIDGE

Replacement	$500

May 24, 1978

HOURLY OPERATING COSTS

Machine Designation	631D Scraper	D9H Tractor	637D Scraper	16G Grader
Delivered Price	317,000	320,000	391,000	227,000
Depreciation $\left(\frac{\text{Price less tires}}{10000,10000,12000}\right)$	30.52	32.00	37.92	18.27
Fuel 0.144x70,70,110,40	10.08	10.08	15.84	5.76
Lube, Filters & Grease	0.43	0.67	0.60	0.70
Tires				
$\frac{\text{Cost}}{\text{Life}}$ $\frac{11800}{1500}$, ______, $\frac{11800}{1500}$, $\frac{7752}{3000}$	7.92	-	7.92	2.58
Repairs				
Depreciation X 90%, 90%, 90%, 60%	27.47	28.80	34.13	10.96
Ripper	-	2.61	-	-
Total Hourly Operating Cost	45.90	42.16	58.49	20.00
Operator	10.00	10.00	10.00	10.00

May 24, 1978

LEASING COST OF MINE EQUIPMENT

Project Years 2 - 5 Stripping 1.95 million M^3/yr

Scrapers	7 @ 8191.33/mo	57,339	
Dozers	4 @ 8173.08/mo	32,692	
Graders	3 @ 5190.79/mo	15,572	
		105,603	
plus 7% tax		112,996	
÷ 66666			$1.69/tonne raw

Project Year 6 Stripping 2.93 million M^3/yr

Add 3 (637's) @ 9300/mo		39,853	$2.14/tonne raw

Project Year 7

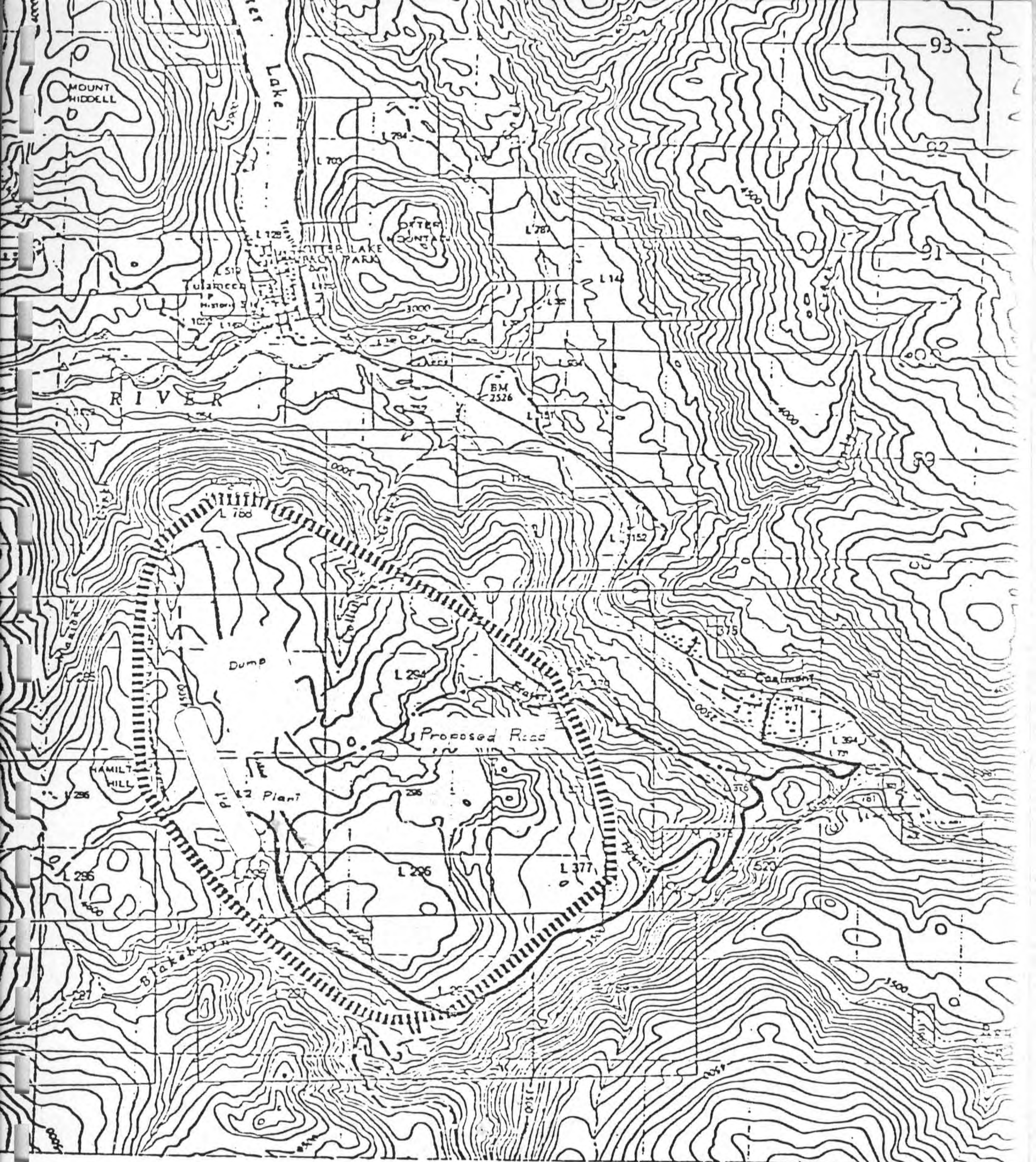
10 (637's) @ 9300/mo		93,000	
Dozers		33,000	
Graders		16,000	
		142,000	
plus 7% tax		151,940	$2.28/tonne raw

Project Year 12

15 (637's) @ 9300/mo		139,500	
Dozers		33,000	
Graders		16,000	
		188,500	
plus 7% tax		201,695	$3.03/tonne raw

Project Year 13

Scrapers	3 @ 9300	27,900	
Dozers	2 @ 8200	16,400	
Grader	2 @ 5200	10,400	
		54,700	
plus 7% tax		58,529	$0.88/tonne raw



CYPRUS ANVIL MINING CORPORATION

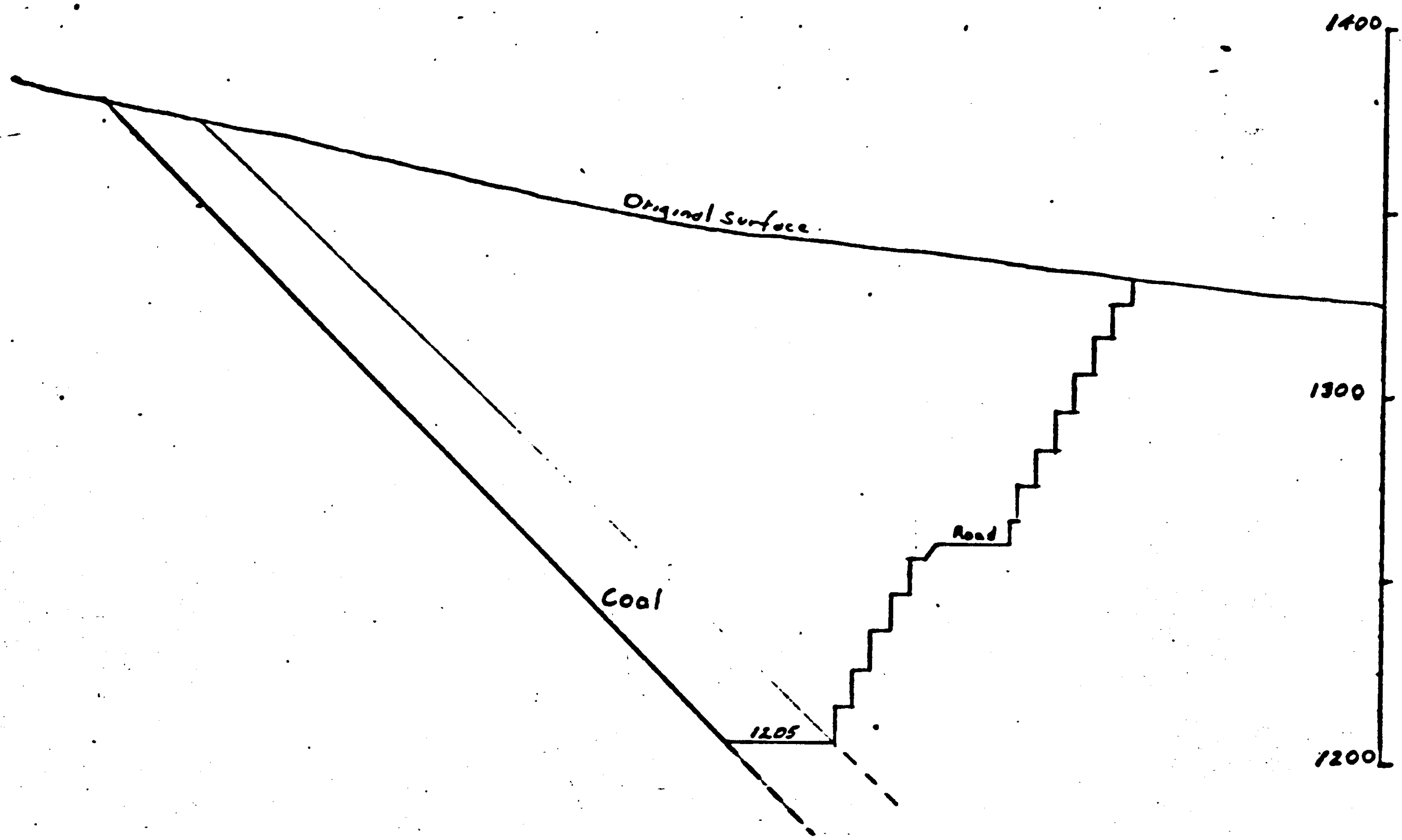
Tulameen Coal Project

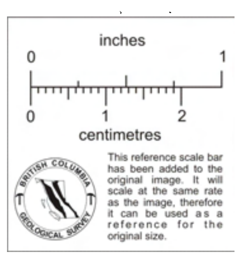
NTS 92H - 7, 10

Key Map

SCALE 1:50,000

FINAL PIT
CROSS SECTION
~5485900N
Scale 1:2000





4-Year Pit

Final Pit

Outline - Pit and Dump

APPENDIX VI

CYPRUS ANVIL CORPORATION

TULAMEEN COAL PROJECT

RAIL TRANSPORT COSTS

Project No. 3726

Prepared by: D. Krefting

December 1978

Approved by: D.B. McDougald, P.Eng.

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1.0 INTRODUCTION AND SUMMARY

Cyprus Anvil Corporation are investigating the feasibility of developing the Tulameen coal deposits near Coalmont, British Columbia. Part of this assessment requires estimation of railway tariffs and loading costs. These aspects of the assessment are the subject of this report.

The proposed development will involve the mining and transporting of 420,000 tonnes per year of coal for purposes of export over a fifteen year period. In this analysis the production volume is converted to short tons (460,000 per year). All other references to tons in this report are short tons.

The rail system that will be used to transport this coal is comprised of CP Rail's branch line from Coalmont to Spences Bridge and their mainline from Spences Bridge to Port Coquitlam Yards and on into Pacific Coast Bulk Terminals at Port Moody. This routing and the general location of the development are shown in Figure 1-1.

An important consideration in the railway analysis is the condition of the trackage on the Princeton Subdivision. An inspection of the track condition and analysis of the operations indicated that the track, in its present condition, is capable of handling this relatively small volume of coal. Furthermore it appears that the track is already being improved as part of a planned upgrading program and as such this cost is not attributable to any specific traffic. These comments are predicated on the coal moving in cars of 80 tons capacity or less. One hundred ton cars and their resulting heavier axle loadings would necessitate upgrading this section of track.

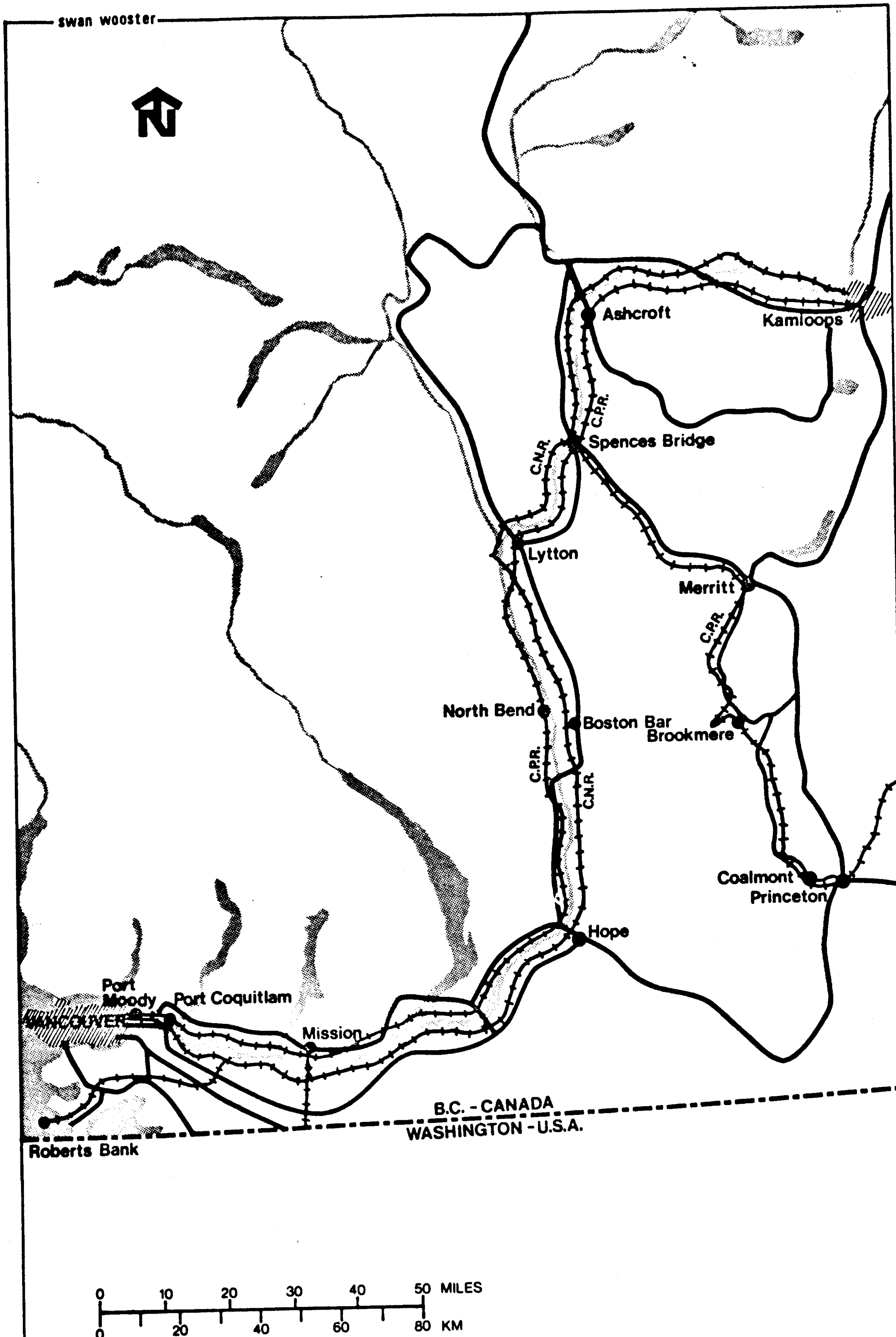
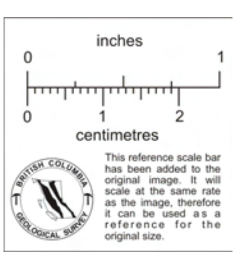


FIGURE 1-1 ROUTE LOCATION



The volume of coal considered herein could be handled by the railway as block shipments in existing trains or as solid train loads. Both systems would require similar numbers of cars and incur comparative levels of costs. Therefore the cost analysis concentrates on the solid train system.

In order to determine the effect of various cycle times on railway costs, three alternative loading speeds of 16, 8 and 4 hours per trainload were considered. These loading rates when combined with train operations result in achieveable cycle times of 54, 46 and 42 hours respectively. These times when combined with the throughput tonnage result in relatively small trains of less than 40 cars. Also, a 96 hour cycle was included in the analysis to assess the impact of a larger train size. This longer cycle time requires a 70 car train to transport the annual tonnage.

Train loading systems capable of meeting the specified rates of 16, 8 and 4 hours were considered. These required the use of different sizes of front end loaders operating from a truck-dumped stockpile. A fourth system, an overhead conveyor capable of loading the train in 4 hours, was also included. The cost per ton of these four systems were $0.53 for the 16 hour loading rate, $0.43 for the 8 hour rate and $0.59 for the 4 hour rate. The overhead conveyor system had a cost of $0.60. Loading the 70 car train would have a loading cost per ton of $0.64.

Railway operating unit costs were derived from published Statistics Canada data and applied to the proposed operating systems. The resultant unit costs are summarized on Figure 5-1 while the breakdown of railway costs on a per ton basis is summarized in Figure 6-1.

The estimated fair tariff for transporting the coal ranged from a low of $5.67 for the large 70 car train system to a high of $6.42 for the 39 car train with a 16 hour load time. Combining these with the estimated loading costs indicates that the 70 car train system combined with either a front end loader (Scheme C) or an overhead conveyor (Scheme D) loading system is the most economical.

Figure 1-2 summarizes the operating characteristics, variable rail costs and loading costs as determined in this analysis.

FIGURE 1-2 SUMMARY OF REPORT RESULTS

Loading Scheme:	A	B		C		D	
Cars Per Train	39	34	70	31	70	31	70
Loading Time (Hours)	16	8	16	4	8	4	8
Cycle Time (Hours)	54	46	96	42	96	42	96
Locomotives Per Train	4	3	6	3	6	3	6
Loading Cost Per Ton	$0.53	$0.43	$0.74	$0.59	$0.64	$0.60	$0.64
Rail Cost Per Ton	$6.42	$6.02	$5.83	$6.20	$5.67	$6.20	$5.67
Total Cost Per Ton	$6.95	$6.45	$6.57	$6.79	$6.31	$6.80	$6.31

All costs expressed in 1978 dollars.

Estimate prepared by Swan Wooster Engineering Co. Ltd.

2.0 RAILWAY TRACK CONDITIONS

The railway system considered in this analysis is comprised of the CP Rail Branch line between Coalmont and Spences Bridge (95 miles) - the Princeton Subdivision - and the CPR mainline from Spences Bridge through North Bend, Hope, Mission, Port Coquitlam Yard and then into Port Moody (165 miles) - the Cascade Subdivision.

It was assumed that the track structure of the CP Rail mainline would be more than adequate for the small volume of traffic being considered, therefore only the trackage between Coalmont and Spences Bridge was inspected in the field. To supplement this inspection, topographical mapping for the area and operating timetables for the region were analyzed. .

The inspection showed that the basic track structure is built on a well located, properly drained roadbed that has been topped with pit-run gravel ballast. The #1 standard creosoted cross ties are in good condition with varying remaining life spans as would be expected. The track shows evidence of an ongoing tie replacement program, in some locations new ties are piled on the shoulders waiting installation.

The 100 pound and 85 pound rails are supported on the ties by steel tie plates. The 100 pound rail, some of which has been installed fairly recently, is second hand and is in place from Coalmont (mile 82.3) to a point just west of Brookmere (mile 113). The remainder of the rail is 85 pound in fair to poor condition. All rails are connected with 4 hole, bolted joint bars and are fastened to the ties with 4 spikes per tie (2 on each rail) on tangents and 6 on curves.

The bridges on this part of the railway are mainly steel of several types, deck plate girders, deck trusses and through trusses. There are however also some treated, pile bent, timber trestles. All of the bridges appear to be well maintained and in good condition. The bridges at miles 102.7 and 120.3 have posted slow orders and therefore may require some work in the future. The timber trestles appear to have been renewed in the last five to ten years.

The vertical and horizontal alignment of the track structure is good by branch line standards particularly in the areas where the 100 pound rail is in place. There is some poor alignment evident in the 85 pound rail territory. This is also the area where a tie replacement program appears to be underway, new ties have been distributed and are beside the roadbed awaiting installation. Once these new ties are installed the track surface will probably be realigned.

The maximum adverse gradients on this section of track were assumed to be a 3 mile long, 1.4% grade against loaded or west-bound traffic and a 2 mile long, 1.2% grade against empty or east-bound traffic. The grades are located just east of Brookmere (about mile 102 to 105) and just south of Merritt (about mile 135 to 137) respectively. These grades are also the maximum grades between Port Moody and Coalmont and therefore are the ones that determine the locomotive power required for each train.

In general this section of branchline track was assumed to be adequate for the traffic being considered and as such would not require any specific expenditure of capital for upgrading beyond that already scheduled. The evidence as follows indicates that this branchline is already being upgraded to 100 pound rail throughout its length and the addition of this traffic should not affect this process.

a) The installation of 100 pound rail from Princeton towards Spences Bridge indicates a planned replacement program. If it were spot replacement one would expect that the track between Merritt and Spences Bridge would be renewed first as it carries the most traffic.

b) An indication of anticipated upgrading of the rail between Merritt and Spences Bridge is the recent changing of the rail in the road crossings from 85 pound to 100 pound.

c) The fact that the timber trestles have been renewed fairly recently (estimated to have been within the last 5 to 10 years) also indicates a planned continuous upgrading of the rail line.

d) The fact that there is evidence of a tie renewal program on the 85 pound territory indicates that the rail will probably be renewed in the near future. Tie renewal, track lining and surfacing are usually done just prior to changing rail.

It should be noted that the assumption of track adequacy for the proposed coal traffic is only valid if the coal moves in 80 ton carloads or less. Should heavier 100 ton capacity cars be used the track structure and probably some of the bridges would require upgrading.

3.0 RAILWAY OPERATING SYSTEM

The existing railway operations on the Princeton Sub-division (Coalmont to Spences Bridge) were assumed to be road switcher service every other day from Spences Bridge through to Penticton. This is supplemented by a further road switcher service on opposite days between Spences Bridge and Merritt so that Merritt has daily service. Most of the traffic handled by these trains would consist of forest products.

The mainline track between Spences Bridge and the Lower Mainland carries an average of some 15 to 20 trains per day with peak levels up to 50% higher. This traffic consists of 2 passenger trains, 2 local trains, 2 express or intermodal trains, 6 general traffic trains and up to 5 bulk commodity unit trains carrying either coal, potash or sulphur.

At these traffic levels there is sufficient capacity available to accommodate the additional train(s) required to transport 460,000 tons of coal per year from Coalmont to Port Moody. There could even be sufficient space in the existing trains to handle the coal cars without adding more trains to the system. The only capacity adjustment that may be required would be the extension of one or two sidings between Coalmont and Spences Bridge.

Two different types of trains could be used to transport coal from the Tulameen Mine to Port Moody. These two types, blocks of coal cars in existing trains and trainloads, are both discussed below.

Block System

For the block shipment system to be effective:

a) space must be available on a regular basis in existing trains;

b) schedules for existing trains must either be adjusted or be already such that a regular car cycle can be maintained.

Assuming a six day work week, 40 carloads of coal would enter the system on alternate days. This figure includes 10% spare capacity to allow for system delays and shut-downs.

The operation would commence as part of the regular road switcher service from Spences Bridge to Coalmont transporting the empty cars into the mine site for loading. During the next 23 hours the cars would be loaded while the road-switcher service carried on into Penticton, stopped overnight and returned.

The road switcher would then take the loaded cars and transport them to Spences Bridge. At Spences Bridge the block of cars would be set out for pick-up by the daily way-freight that operates between Calgary and Port Coquitlam. Once in the Port Coquitlam Yards the block of cars, still intact, would be transferred by switcher to Port Moody for unloading. These steps would then be reversed so that the empty cars could be returned to the mine site ready to start the next cycle.

This operation would require two car sets (80 cars total), one for the loading part of the cycle (Spences Bridge to Coalmont and return) and one for the unloading (Spences Bridge to Port Moody and return). This in effect would give a 4 day cycle for each car set. Figure 3-1 outlines a tentative schedule for a full cycle.

FIGURE 3-1 CYCLE TIME FOR BLOCK SHIPMENT OF COAL COALMONT TO PORT MOODY

Operation	Time (Hours) Loaded	Empty
Loading	23	-
Train Inspection, Switching, etc. at Coalmont	1	-
Coalmont to Spences Bridge	6	6
Switching, waiting for way freight, inspection, etc. at Spences Bridge	12	9
Spences Bridge - North Bend	2.5	2.5
Crew Change at North Bend	0.5	0.5
Northbend - Port Coquitlam	4.5	4.5
Switching, Inspection, etc. at Port Coquitlam	8.0	10.0
Port Coquitlam - Port Moody	1	1
Unloading	-	4
TOTAL	96	

Trainload System

The amount of railway equipment, required to transport a given volume of coal over a rail line is dependent on cycle time, and has a significant effect on cost. A major part of the railway equipment's cycle time spent in transit and in yards is relatively constant regardless of train size. The remainder of the cycle time spent loading and unloading will vary with train size.

In this analysis the impact of varying cycle times was assessed on the basis of 16, 8 and 4 hour loading times combined with a 4 hour unloading time. In this operation the unloading time was found to be relatively constant at 4 hours, within the expected train sizes. Loading times were related to three different proposed systems whereas unloading times were related to an existing operation.

The transit times were calculated using a computer model of the railway system. Yard and delay times were based on assumptions made by the consultant. The cycle times and resulting train sizes for these alternatives are summarized on Figure 3-2.

As the calculated train sizes were all relatively small, 39, 34 and 31 cars, a fourth cycle time, 4 days, was included to assess the impact on costs of large trains.

The solid train operation would commence with the dispatching of a train set from Port Coquitlam eastbound to the mine. The train would stop first at North Bend for a crew change. The crew boarding the train at North Bend would handle the train from North Bend to Coalmont and return. This would be a standard crew (engineman, conductor and 2 brakemen) for Scheme A (16 hour load) but would carry an extra engineer for the other loading schemes. The extra engineman is necessary to ensure continuous operation of the train. A similar system of crewing is used on the Canadian National Railway from Jasper Winniandy to handle unit coal trains loaded at MacIntyre Mines.

For 16 hour loading it was assumed that the crew would leave the train and be transported to Princeton for rest. On completion of loading the same crew would come back to return the train to North Bend. For all other schemes the crews would stay with the train and carry out any car moving necessary during loading.

The non-productive portion of the 4 day cycle would be spent in or near the Port Coquitlam yard. This would then ensure that the locomotives used in the transport of Tulameen coal would be used elsewhere during the non-productive portion of the cycle. If the train were held elsewhere the locomotives would either be held with the train or would have to travel empty back to Port Coquitlam as it is the only location on the system being considered that has a locomotive pool.

It should be noted that in all four schemes the train would have to be broken up so that the locomotives and cabooses could change ends. There is no provision for loop track loading in any scheme.

The locomotive requirements for these four differing trains were computed on the basis of a 1.4% controlling adverse grade. Because of the light trackage on the Princeton Subdivision 4 axle 2300 HP locomotives were assumed to be the basic power source rather than six axle 3000 HP units normally used in coal unit-train service. These locomotives should handle about 10 or 12 cars each on the controlling grade at a minimum operating speed of 12 miles per hour.

The solid train system cycle times and resulting train sizes are all summarized in Figure 3-2.

FIGURE 3-2 SOLID TRAIN CYCLE TIMES

Operation	16 Hour Load		8 Hour Load		Semi-Automated Loading		4 Day Cycle	
	Loaded	Empty	Loaded	Empty	Loaded	Empty	Loaded	Empty
Loading	16	-	8	-	4	-	8	-
Coalmont-Spences Bridge	4	4	4	4	4	4	4	4
Delay at Spences Bridge	1	0	1	0	1	0	1	0
Spences Bridge - North Bend	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Crew Change at North Bend	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
North Bend - Port Coquitlam	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Switching, Inspection, Etc.	4	4	4	4	4	4	4	52
Port Coquitlam - Port Moody	1	1	1	1	1	1	1	1
Unloading	-	4	-	4	-	4	-	6
Total Hours	54		46		42		96	
Train Size(1)	39		34		31		70	
Locomotives	4		3		3		6	

Notes: (1) Numbers of 80 ton cars calculated on the basis of a 330 day operating year.

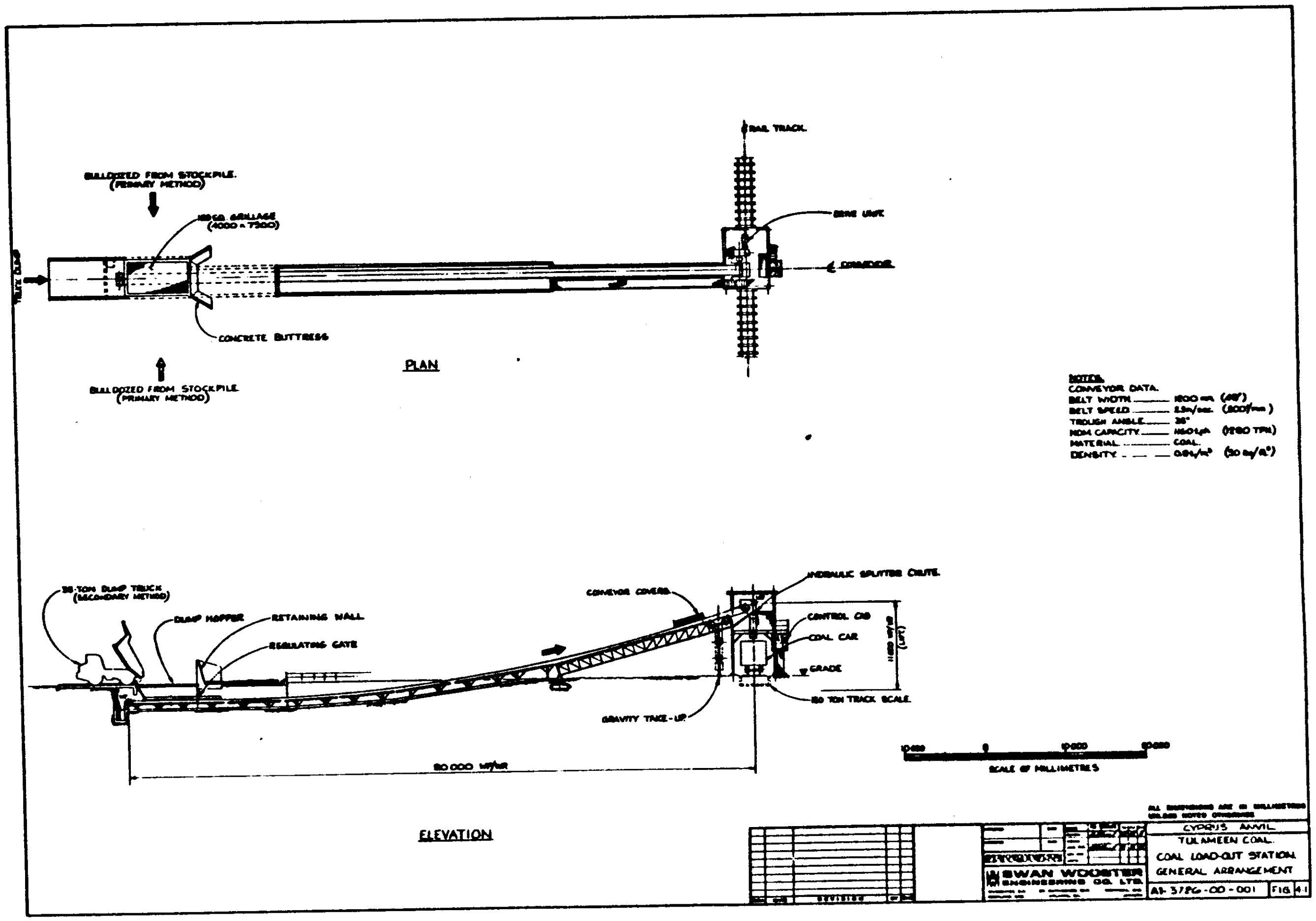
4.0 LOADING SYSTEMS

A brief order-of-magnitude analysis of possible loading systems has been undertaken to ensure selection of a practical and economical railway system. The selected loading system directly affects loading rates which can increase train cycle time thereby affecting train sizes and car requirements. To measure the effect of loading systems on the Tulameen coal movement three different loading times and two methods were considered. The loading times were 16, 8 and 4 hours per train load and the loading methods were by either front end loader or by a semi-automated overhead conveyor system. These times have been designated as Schemes A, B and C respectively for front end loading and the Scheme D for the overhead conveyor system.

The first method consists of front loaders reclaiming from a truck dumped stockpile and loading directly into the rail cars assisted by a built up ramp. The overhead conveyor system, Figure 4-1, operates with either dozer reclaiming or direct truck dumping into a ground level hopper. The coal travels by belt conveyor from this hopper and is deposited through a pant-leg chute system into the cars. Loading is controlled by an operator in the cab at the loadout point. Both systems will require two men to operate, one to run the loader or dozer and one to check the rail car loading and generally supervise operations.

For the basic loading systems two rail track layouts are possible. These are: (1) a single track with empty car storage on one side of the loading point and loaded car storage on the other side; and (2) two tracks with a similar configuration. This first scheme requires relocation of one road/rail crossing and about two-tenths of a mile of road in order to avoid traffic obstruction during loading operations. The second scheme avoids these highway problems but requires more handling of rail cars swan wooster

(16)



to move them past the loading point. A brief capital cost comparison indicated that the single track is cheaper and therefore is considered for all alternatives except the 70 car train system which requires double trackage because of the greater train length. The unit costs used in the estimates were $30 per foot for track supply and installation, $9000 for switch supply and installation, and a lump sum of $30,000 for road relocation.

All loadout systems require a level stockpile area. For purposes of this study the level empty ground on the south side of the CPR tracks at the west end of the existing Coalmont townsite was assumed to be the loadout site. In the front end loader alternative a ramp is included for easier rail car loading. The stockpile site work consists of provision of stockpile base, drainage ditches for run-off water and a settling pond. This civil work will be required for all systems.

Furthermore, a load cell type track scale is included for all loading systems, however, it may not be necessary. It is possible that car loading by volume may be acceptable. To establish loading limits the first few train sets could be weighed by the railway on their scales. Continuous checks could be accomplished by periodic random weighing of train sets.

Front end loaders were sized to match the loading rates required for Schemes A, B and C. The equipment sizes considered - 950, 966C and 988B - are based on Caterpillar Tractor Specifications. Other equipment models with comparable operating characteristics could also be used. All three of these are rubber-tired loaders equipped with oversize buckets, 4.5, 6 and 10 cubic yard capacity. The overhead conveyor system, designated Scheme D, does not require a rubber-tired front end loader but does require a dozer for stockpile reclamation. It was assumed that a D7 type crawler tractor would suffice.

Mobile equipment is necessary at the loadout site one shift per day, 330 days per year for either loading or stockpiling. For the 16 hour load time, 1 extra shift for each train cycle (150 shifts per year) was also included.

In Scheme A, 16 hour loading time, the locomotives and crew are not available for car moving. To overcome this it was assumed that the loader would be used to pull cars past the loading point.

The capital and operating costs for the four different schemes considered are summarized in Figure 4-2. These costs show that Scheme A, the longest loading time (16 hours), has a cost per ton of 53¢, Scheme B, 8 hours, costs 43¢ per ton, while Schemes C and D, the 4 hour systems (front end loader or overhead conveyor) cost 59¢ and 60¢ per ton respectively.

Loading the 70 car trains can be done by either Scheme B over a 16 hour period or Schemes C and D over an 8 hour period. This would cost an extra 32¢ using Scheme B for a total of 75¢ per ton. Using Schemes C or D would cost a total of 64¢.

FIGURE 4-2

SUMMARY
RAIL CAR LOADING SYSTEMS
(460,000 tons per year)

Item	SCHEMES A	B		C		D	
Cars per train	39	34	70	31	70	31	70
Average Loading Time (Hours)	16	8	16	4	8	4	8
Average Loading Rate (Tons Per Hour)	200	350		650		650	
Front End Loader(1)	950	966C		988B		D7	
Capital Costs(2)							
Loader	$120,000	$145,000	$120,000	$315,000	$315,000	$650,000	$650,000
Stockpile Site	50,000	50,000	50,000	50,000	50,000	-	-
Rail Trackage	165,000	165,000	295,000	165,000	295,000	165,000	295,000
Track Scale	100,000	100,000	100,000	100,000	100,000	75,000	100,000
TOTAL	$435,000	$460,000	$565,000	$630,000	$760,000	$890,000	$1,045,000
Cost Per Ton(3)	0.15	0.16	0.20	0.22	0.27	0.31	0.37
Annual Operating Costs(4)							
Loader/Dozer	42,000	40,000	80,000	87,000	87,000	50,000(5)	50,000(5)
Loader/Dozer Operator	63,000	40,000	80,000	40,000	40,000	40,000	40,000
Foreman/Scale Operator	70,000	45,000	90,000	45,000	45,000	45,000	45,000
TOTAL	175,000	125,000	250,000	172,000	172,000	135,000	135,000
Cost Per Ton	0.38	0.27	0.54	0.37	0.37	0.29	0.29
Total Cost Per Ton	$0.53	$0.43	$0.74	$0.59	$0.64	$0.60	$0.64

NOTES:
(1) Caterpillar tractor model numbers.
(2) All cost figures in 1979 last quarter Canadian Dollars.
(3) Amortized over 15 years at a 14% interest rate.
(4) Operating costs assume minimum hours of 1 shift (8 hours) per day, 330 days per year. 16 hour load time requires additional shift for each cycle.
(5) Includes operating and maintenance of loading system at 2% of capital cost.

5.0 RAILWAY OPERATING COSTS

Railway operating unit costs used in this analysis were derived from data published by Statistics Canada using the methodology described in this section of the report. These unit costs were then applied to the basic unit train operating schemes described in Section 3.0. The unit or solid train system was selected for costing over the system utilizing blocks of cars in existing trains as it will be more representative of the costs incurred regardless of the system used.

Each of the following major expense categories; Road Maintenance, Equipment Maintenance and Transportation, has an associated indirectly variable overhead cost. The overhead expenses include supervision, injuries to persons, maintenance of non-operating plant and other miscellaneous expenses directly related to the expense category but not to the operating unit. These costs are allocated on the basis of percentage markup.

It should be noted that none of the overheads nor any of the following variable operating costs include depreciation. Recovery of investment in equipment is allowed for in the amortized capital costs while that for plant is allowed for in plant ownership.

The basic road maintenance cost was derived from Statistics Canada data and includes an allowance for work equipment maintenance. The major accounts include track and roadway maintenance expense associated with repairing or renewing small sections of the basic plant. Major replacement or renewal is a capital expense and as such is allowed for in the plant ownership costs.

Once the basic road maintenance costs were derived they were increased to allow for the effects of greater than average curvature and gradients. They were not increased to allow for heavier than average carloads as the 80 ton net loads are not that different from the average loads of other traffic on the system.

Equipment supply costs include ownership costs for locomotives, cars and cabooses. Locomotive costs were based on a current supply cost of some $700,000 for a basic 2300 HP four axle engine weighing 250,000 lbs. Heavier 3000 HP engines were not considered because of their adverse impact on the light trackage on the Princeton Subdivision. It was assumed these engines would be available from the existing locomotive pool in Vancouver and would be returned to it for use elsewhere on arrival at Port Coquitlam. Basic pool locomotive availability was taken as 6000 hours per year. Using the purchase price, a 12% cost of money and a 15 year economic life, an hourly ownership cost was derived.

Car supply costs were based on supply of new 80 ton gondola cars at $37,000 each. As it was assumed these cars would be in dedicated service the annual ownership cost was then computed based on a 20 year economic life and a 12% cost of money.

It is recognized that these cars are less expensive than standard 80 ton triple cross hopper bottom dump cars, which have a current replacement value of some $43,000. However the cost of new gondolas was considered more applicable because the bottom dump feature is not required as Pacific Coast Bulk Terminals rotary dump the cars. Also the existing fleet of CPR triple cross hoppers only has sufficient cubic capacity to handle some 70 tons of coal per load at an average density of 50 pounds per cubic foot. If required, new 80 ton solid bottom gondola cars can be either purchased or leased by the shipper.

Caboose supply costs were included as an hourly charge based on a replacement cost of $80,000 each and a 20 year life and 12% cost of money.

Locomotive maintenance costs were derived from Statistics Canada data and were included on a locomotive unit mile basis. Car maintenance costs, on a car mile basis, were based on current leased car maintenance prices for equipment in unit train coal service. Caboose maintenance costs were assumed to be the same.

Fuel costs were calculated using an estimated current cost of fuel of $0.61 per gallon including overhead. Fuel consumption was calculated by the consultant's Railway Operations/Cost Model..[1]

Crew wages were computed for each of the basic systems described in Section 3.0, i.e. basic crew North Bend to Coalmont with crew stopover at Princeton and basic crew plus extra engineman North Bend to Coalmont and return. The basic pay rates assumed for the crews were 53.1¢ per mile for enginemen, 48.61¢ per mile for conductors and 42.98¢ per mile for trainmen. These basic units were then adjusted for extra units, terminal time, overtime and an allowance for vacation, sick time and holiday pay.

Train and enginehouse expenses, which include train locomotive supplies not included under locomotive maintenance and other locomotive associated expenses, were computed on a locomotive unit mile basis from Statistics Canada data.

Other train expenses and dispatching expenses, also computed from Statistics Canada data, were included on the basis of train miles generated.

(1) See Report on Railroad Access to the Peace River Coal Fields prepared by Swan Wooster Engineering in March 1977.

Switching expenses include a portion of all yard expenses as well as yard crew wages and associated locomotive operating expenses. Switching is required in the yard at Port Coquitlam to allow for car servicing as well as for transferring the cars from Port Coquitlam to Pacific Coast Bulk Terminals and back.

The other railway operating expenses included in this analysis are percentage markups to allow for traffic and general expenses, fixed overhead and plant ownership. All of these are allocated on the basis of dollar values of business, i.e. percent markup. Traffic and general expenses include the overall railway administration expenses, i.e. headquarters, staff, traffic solicitation, pensions, etc. Fixed overhead expenses (the costs designated as non-variable) must, however, be recovered from traffic handled and include fixed maintenance-of-way expenses, allowances for taxes, etc. The other category, plant ownership costs, is included as a markup on costs and is intended to cover profits, return on investment and recovery of capital invested in fixed plant.

The percentage markup for Traffic and General expenses was calculated by taking the 10 year average of the results of dividing the report expenditures in those categories by the total rail expenses excluding traffic and general, tax provision, depreciation and fixed overhead.

The fixed overhead allocation percent was derived also from a ten year average of a figure calculated by totalling the non-variable fixed overheads and dividing by the total rail expenses excluding fixed overhead and depreciation. The fixed overhead costs include maintenance of fences, snow-sheds, and signs, dismantling retired property, removing snow, ice and sand, crossing protection, drawbridge operations, other railway taxes and the 36% fixed portion of track structure and road maintenance expenses.

Plant ownership markups were estimated by taking the ten year average of the results obtained from dividing total rail revenues minus total rail expenses (excluding depreciation) by total rail expenses (excluding depreciation).

The basic unit costs derived for this analysis are summarized in Figure 5-1.

FIGURE 5-1

ESTIMATED UNIT COSTS FOR COAL TRAINS
CP RAIL - COALMONT TO PORT MOODY, B.C., 1978

Cost Classification	Output Unit	Directly Variable	Indirectly Variable	Total
Track Structure and Road Maintenance	Thousand Gross Ton Miles	56.0¢	11.8¢	67.8¢
Rolling Stock:				
.Locomotive Supply	Loco.Unit Hour	$17.13	NA	$17.13
.Locomotive Maintenance	Loco.Unit Mile	$ 0.86	$ 0.15	$ 1.01
.Coal Car Supply	Per Year			$ 4,954
.Coal Car Maintenance	Per Car Mile	3.1¢	0.5¢	3.6¢
.Caboose Supply	Caboose Hour	$ 1.79	-	$ 1.79
.Caboose Maintenance	Caboose Mile	3.1¢	0.5¢	3.6¢
Transportation:	Per Cycle			
Crew Cost	(16 hr. load)	$1,988 (1)	$ 356	$2,344
	(8 hr. load)	$2,120 (2)	$ 382	$2,502
	(4 hr. load)	$2,041 (3)	$ 367	$2,408
Fuel	Per Gallon	50.0¢	11.0¢	61.0¢
Train, Locomotive and Enginehouse Supplies	Loco.Unit Mile	23.5¢	5.2¢	28.7¢
Other Train Expenses	Train Mile	$ 0.88	$ 0.19	$ 1.07
Dispatching	Train Mile	43.3¢	9.5¢	52.8¢
Switching	Switch Engine Mile	$ 8.25	$ 1.82	$10.07
% Allocations:				
Traffic and General	Of Sub-Total	-	16.8%	-
Fixed Overhead	Of Sub-Total	-	9.0%	-
Plant Ownership	Of Sub-Total	-	18.2%	-

Note: All costs in 1978 fourth-quarter Canadian dollars.
(1) 16 hour loading time and crew stay over at Princeton.
(2) 4 hour loading time.
(3) 8 hour loading time.

6.0 CONCLUSIONS

Figure 6-1 shows the railway operating costs in dollars per ton for each of the four trainload operating systems considered. These costs show that the large train size, 70-eighty ton cars, loading every four days, was the least cost alternative at $5.67 per ton assuming an 8 hour loading time.

When the loading costs calculated in Section 4.0 of this report are added to the estimated train costs, the ranking does not change. The 70 car train is still the least cost at $6.31 when combined with the least cost loading system.

Therefore the most economic system combines either of the loading systems designed as Schemes C and D with the 70 car train operating on a 4 day (96 hour cycle). The loading systems are either a large front end loader loading cars from a stockpile or the overhead conveyor semi-automated system shown on Figure 4-1. The latter system would be the best alternative because it is the most efficient in terms of reliability and thereby minimizing costly delays in the railway system.

It should be noted that the $5.67 shown here as railway cost represents what is felt to be a fair, all-in tariff for coal transport from Tulameen to Pacific Coast Bulk Terminals, excluding any loading charges.

FIGURE 6-1 RAILWAY OPERATING COSTS

Item	Operating Data				
Train Size:					
Cars	39	34	31	70	70
Locomotives	4	3	3	6	6
Loading Time (hours)	16	8	4	8	16
Cycle Time (hours)	54	46	42	96	96
	Operating Cost ($ Per Ton)				
Track Structure and Road Maintenance	0.46	0.43	0.44	0.44	0.44
Locomotive Supply	0.88	0.60	0.58	0.59	0.73
Locomotive Maintenance	0.67	0.58	0.64	0.56	0.56
Car Supply	0.42	0.36	0.33	0.75	0.75
Car Maintenance	0.23	0.23	0.23	0.23	0.23
Caboose Supply	0.02	0.02	0.02	0.02	0.02
Caboose Maintenance	0.01	0.01	0.01	0.01	0.01
Crew	0.75	0.92	0.97	0.45	0.42
Fuel	0.47	0.47	0.47	0.47	0.47
Train and Enginehouse Supplies	0.19	0.16	0.18	0.16	0.16
Other Train	0.18	0.20	0.22	0.10	0.10
Dispatching	0.09	0.10	0.11	0.06	0.06
Switching	0.09	0.10	0.11	0.10	0.10
Sub-Total	4.46	4.18	4.31	3.94	4.05
Traffic and General	0.75	0.70	0.72	0.66	0.68
Fixed Overhead	0.40	0.38	0.39	0.35	0.36
Plant Ownership	0.81	0.76	0.78	0.72	0.74
TOTAL	$6.42	$6.02	$6.20	$5.67	$5.83

Note: Based on 80 tons per car.

APP. VII

APPENDIX VII

E-Logs 78-1, 2, 3

T-78-1 - Coal Lithology
T-78-2 - Coal Lithology/Neutron-Neutron
T-78-3 - Coal Lith/N-N/Coal Qual/S.Th.

BPB

NEUTRON-NEUTRON LOG

COMPANY Cyprus Anvil

BOREHOLE T 78-3 Tulameen

STATE B.C. COUNTRY Canada

Permanent Datum Ground Level Elev.____m.

Log measured from Ground Level zero m. above P.D.

Drilling measured from Ground Level zero m. above P.D.

GRID REF. E________ N________ R.L.________

Run No. / Depth Scale	1 / 120:1		
Date	27 July '78		
First Reading	175		
Last Reading	20		
Interval Measured	155		
Casing BPB	18		
Casing Driller	20		
Depth Reached	177'		
Bottom Driller	178'		
Mud Nature	Water & detergent		
S.G. / Viscosity			
Bit Size 1	5" to T.D.	to	to
2	to	to	to
3	to	to	to
Casing Size 1	5" id to 20'	to	to
2	to	to	to
Rm @ Meas Temp.	@	@	@
Rmf @ Meas Temp.	@	@	@
Rmc @ Meas Temp.	@	@	@
BHT			
Operating Time	4 hrs		
Truck No.	24/23		
Recorded By	D.Fishe.		
Witness	T.Adamson		

fold here

REMARKS

Scale Changes

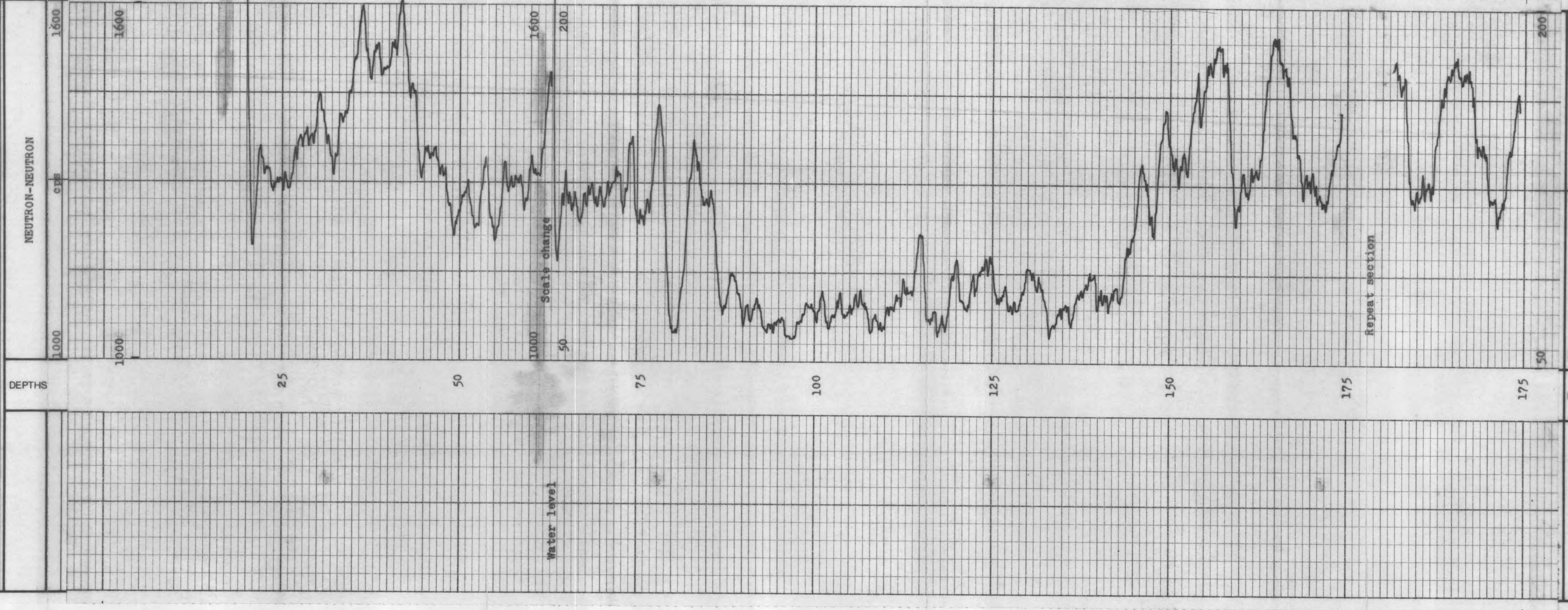
Type Log	Depth	Scale Up Hole	Scale Down
Neutron	64'	1000-1600 cps	50-200

Logging Data

Log	Depths From	Depths To	Speed	T.C.	Norm.	Sonde No.	Source No.
N-N	175	20	30 ft/m	2 sec		18	23

Equipment Data: Run No. / Tool Type / Tool Position / Other

Changes in Mud Type or Additional Samples: Date / Sample No. / Depth–Driller / Type Fluid in Hole / Dens. / Visc. / pH / Fluid Loss / Source of Sample / Rm @ Meas Temp. / Rmf @ Meas Temp. / Rmc @ Meas Temp. / Source Rmf / Rmc / Rm @ BHT / Rmf @ BHT / Rmc @ BHT



COMPANY Cyprus Anvil

BOREHOLE T 78-3

STATE B.C.

COUNTRY Canada

MY (B) 58360 R

BOREHOLE T 78-3

CLIENT Cyprus Anvil

AREA Tulameen B.C.

COUNTRY Canada

DATE LOGGED 27 July

DEPTH SCALE 24:1

2 OF 4 LOGS

COAL QUALITY LOG

BOREHOLE DATA	REFER TO LITHOLOGY LOG
OPERATION DATA	REFER TO LITHOLOGY LOG

EQUIPMENT AND RECORDING DATA

COAL COMBINATION SONDE

LOG	TAPING			SIDEWALL POSITION PANEL			CAL. COEFF.
	LOG TAPED	RECORD SPEED	DIRECT or REPLAY	SPEED	T.C. SECS	NORM.	
GAMMA RAY	No			7	2		1.5
L.S. DENSITY	No			7	1	8.65	

SOURCE, SONDE AND CALIBRATION

REFER TO LITHOLOGY LOG

SONDE TYPE: COAL COMBINATION SONDE

COAL QUALITY LOG INTERVALS

FROM	150
TO	65
INTERVAL	85
FROM	
TO	
INTERVAL	
INTERVAL TOTAL	=85

LOG SUITE: GAMMA RAY, L.S. DENSITY

REMARKS

GAMMA RAY
COAL BULK DENSITY
DEPTH
BOREHOLE T 78-3
CLIENT Cyprus Anvil
AREA Tulameen
COUNTRY Canada
COAL QUALITY LOG

BOREHOLE T 78-3
CLIENT Cyprus Anvil

AREA Tulameen B.C.
COUNTRY Canada
DATE LOGGED 27 July '78

DEPTH SCALE 24;1

3 OF 4 LOGS

SEAM THICKNESS LOG

BOREHOLE DATA — REFER TO LITHOLOGY LOG

OPERATION DATA — REFER TO LITHOLOGY LOG

EQUIPMENT AND RECORDING DATA

COAL COMBINATION SONDE:

SIDEWALL POSITION

LOG	TAPING			PANEL			CAL COEFF
	LOG TAPED	RECORD SPEED	DIRECT or REPLAY	SPEED	T.C. SECS	NORM	
CALIPER	No			6	1	-	
B.R. DENSITY	No			6	1	.84	

SOURCE, SONDE AND CALIBRATION
REFER TO LITHOLOGY LOG

SONDE TYPE:
COAL
COMBINATION
SONDE

SEAM THICKNESS LOG INTERVALS

FROM	150	
TO	65	
INTERVAL	85	
FROM		INTERVAL
TO		TOTAL
INTERVAL		=85

LOG SUITE:
CALIPER
B.R. DENSITY

REMARKS

B P B SEAM THICKNESS LOG

BOREHOLE T 78-3
CLIENT Cyprus Anvil
AREA Tulameen
COUNTRY Canada
SEAM THICKNESS LOG

BOREHOLE T 78-3

CLIENT Cyprus Anvil

AREA Tulameen B.C.

COUNTRY Canada

DATE LOGGED 27 July '78

DEPTH SCALE 120:1

1 OF 4 LOGS

COAL LITHOLOGY LOG

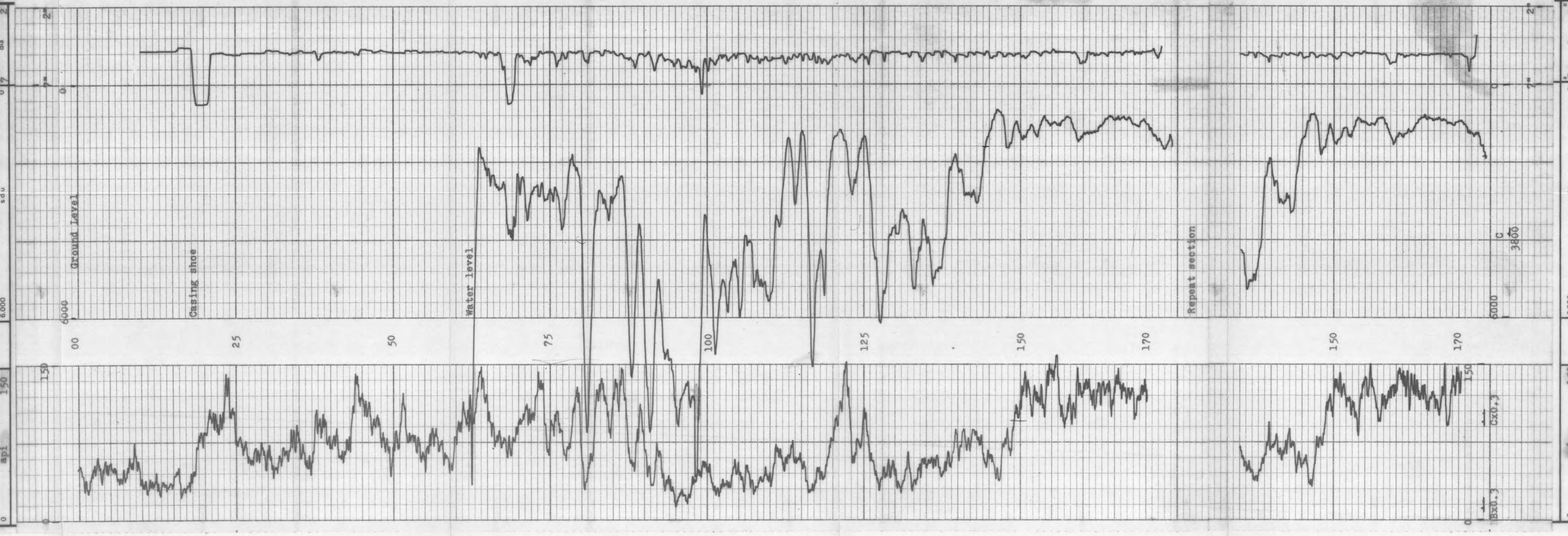
BOREHOLE DATA				
PERMANENT DATUM	Ground Level			
ELEVATION OF P.D.				
	BPB		DRILLER	
MEASUREMENTS FROM	G.L.		G.L.	
DEPTH REACHED	177'		178'	
CASING SHOE	18'		20'	
BIT SIZES	1	5" TO T.D.	2	TO
	3	TO	4	TO
CASING SIZES	1	5" id TO 20'	2	TO

SONDE TYPE: COAL COMBINATION SONDE

FLUID DATA	
NATURE	Water & detergent
S.G.	
LEVEL	64'
VISCOSITY	
Rm at meas.temp.	
B.H.T	

LOG SUITE: GAMMA RAY, L.S. DENSITY, CALIPER

OPERATION DATA	
FIRST READING	171'
LAST READING	0
INTERVAL LOGGED	171'
UNIT-TRUCK No.	24/23
ENGINEER	D.Fisher
WITNESS	T.Adamson



BOREHOLE T 78-3 CLIENT Cyprus Anvil AREA Tulameen B.C. COUNTRY Canada

COAL LITHOLOGY LOG

BOREHOLE T 78-1
CLIENT Cyprus Anvil

AREA Tulameen B.C.
COUNTRY Canada
DATE LOGGED 25 July 78

DEPTH SCALE 120:1

1 OF 1 LOG

COAL LITHOLOGY LOG

BOREHOLE DATA

	BPB	DRILLER
PERMANENT DATUM	Ground Level	
ELEVATION OF P.D		
MEASUREMENTS FROM	G.L.	G.L.
DEPTH REACHED	227'	290'
CASING SHOE	19'	21'
BIT SIZES	1 5" TO 290'	2 TO
	3 TO	4 TO
CASING SIZES	1 7" TO 21'	2 TO

FLUID DATA

NATURE	Water & detergent
S.G	
LEVEL	76 ft.
VISCOSITY	
Rm at meas temp.	
B.H.T	

SONDE TYPE
COAL COMBINATION SONDE

OPERATION DATA

FIRST READING	221'
LAST READING	0
INTERVAL LOGGED	221'
UNIT-TRUCK No	24/23
ENGINEER	D.Fisher
WITNESS	T.Adamson

LOG SUITE
GAMMA RAY
L.S. DENSITY
CALIPER

EQUIPMENT AND RECORDING DATA

COAL COMBINATION SONDE

LOG	EQUIPMENT: SONDE	EQUIPMENT: SOURCE	EQUIPMENT: CALIBRATOR	TAPING: LOG TAPED	TAPING: RECORD SPEED	TAPING: DIRECT or REPLAY	PANEL: SPEED	PANEL: T.C. SECS	PANEL: NORM	CAL COEFF	DEPTHS: FROM	DEPTHS: TO	DEPTHS: INTERVAL	SEAM LOG RUN
GAMMA RAY	119		05	No			30	1	1.6	1.6	221	0	221	No
L.S. DENSITY		23	40	No			30	.3	8.65		224	76	148	No
CALIPER	SIDEWALL POSITION													

COAL QUALITY/SEAM THICKNESS LOG INTERVALS (Refer to relevant log)

		INTERVAL TOTAL
FROM		
TO		
INTERVAL		=

ADDITIONAL SONDES RUN

SONDE	LOG	GENERAL SCALE LOG	DETAIL SCALE LOG

REFER TO ADDITIONAL HEADINGS

REMARKS

Hole blocked at 77' after first run . hole cleaned out but blocked at same point. Water level at 76', so no density log above this level, source removed for gamma ray log.

B P B COAL LITHOLOGY LOG

CALIBRATION DATA

JIG No 5 VALUE 270 @ 2" DIAM.
JIG MARK SHOWN AT ABOVE VALUE -3.33
JIG CAL DATE 20.7.78 JIG VALUE 380 SDU @ 1.48 g/cm³ ins cps
JIG No 40 SPAN 6000 NORM SDU/CPS = 8.65 ins cps

GAMMA RAY | DEPTH | COAL BULK DENSITY g/cm³ | CALIPER INCHES

HOLE SIZE CORRECTION DATA

GAMMA RAY | DEPTH | COAL BULK DENSITY g/cm³ | CALIPER INCHES

BOREHOLE T 78-1
CLIENT Cyprus Anvil
AREA Tulameen B.C.
COUNTRY Canada

COAL LITHOLOGY LOG

NEUTRON-NEUTRON LOG

BPB

COMPANY Cyprus Anvil
BOREHOLE T 78-2 Tulameen
STATE B.C. COUNTRY Canada

Permanent Datum Ground Level Elev. m.
Log measured from Ground Level zero m. above P.D.
Drilling measured from Ground Level zero m. above P.D.

GRID REF. E N R.L.

Run No. / Depth Scale	1 120:1		
Date	27 July '78		
First Reading	102'		
Last Reading	0'		
Interval Measured	102'		
Casing BPB	78'		
Casing Driller	80'		
Depth Reached	103'		
Bottom Driller	128'		
Mud Nature	Water & detergent		
S.G. Viscosity			
Bit Size 1	5" to T.D.	to	to
2	to	to	to
3	to	to	to
Casing Size 1	5" id to 80'	to	to
2	to	to	to
Rm @ Meas.Temp.	@	@	@
Rmf @ Meas.Temp.	@	@	@
Rmc @ Meas.Temp.	@	@	@
BHT			
Operating Time	1 hr.		
Truck No.	24/23		
Recorded By	D.Fisher		
Witness	T.Adamson		

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REMARKS

Changes in Mud Type or Additional Samples: Date | Sample No. | Depth-Driller | Type Fluid in Hole | Dens. | Visc. | ph. | Fluid Loss ml | Source of Sample | Rm @ Meas.Temp. | Rmf @ Meas.Temp. | Rmc @ Meas.Temp. | Source Rmf | Rmc | Rm @ BHT | Rmf @ BHT | Rmc @ BHT

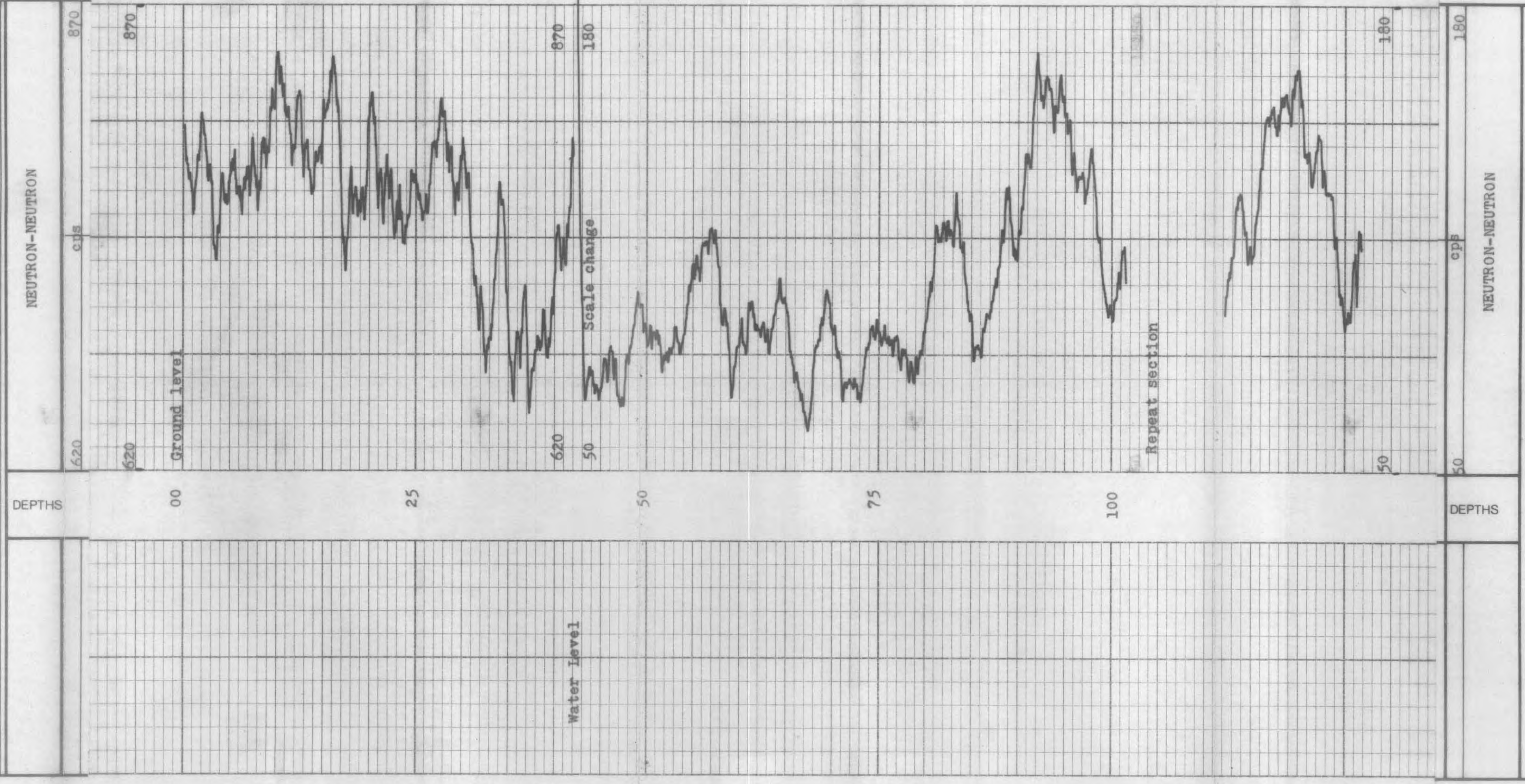
Scale Changes

Type Log	Depth	Scale Up Hole	Scale Down
Neutron	43'	620-870 cps	50-180

Equipment Data: Run No. | Tool Type | Tool Position | Other

Logging Data

Log	Depths From	Depths To	Speed ft/m	T.C. sec	Norm.	Sonde No.	Source No.
N-N	102	0	30	2	-	19	23



COMPANY Cyprus Anvil
BOREHOLE T 78-2 Tulameen
STATE British Columbia
COUNTRY Canada

BPB

BOREHOLE	T 78-2
CLIENT	Cyprus Anvil
AREA	Tulameen B.C.
COUNTRY	Canada
DATE LOGGED	27 July 78
DEPTH SCALE	120:1
	1 OF 2 LOGS

COAL LITHOLOGY LOG

BOREHOLE DATA

PERMANENT DATUM	Ground Level			
ELEVATION OF P.D.				
	BPB		DRILLER	
MEASUREMENTS FROM	G.L.		G.L.	
DEPTH REACHED	108'		128'	
CASING SHOE	78'		80'	
BIT SIZES	1	5" TO T.D.	2	TO
	3	TO	4	TO
CASING SIZES	1	5"id TO 80'	2	TO

SONDE TYPE: COAL COMBINATION SONDE

FLUID DATA

NATURE	Water & detergent
S.G.	
LEVEL	43'
VISCOSITY	
Rm at meas. temp.	
B.H.T.	

LOG SUITE: GAMMA RAY, L.S. DENSITY, CALIPER

OPERATION DATA

FIRST READING	102'
LAST READING	17'
INTERVAL LOGGED	85'
UNIT-TRUCK No.	24/23
ENGINEER	D.Fisher
WITNESS	T.Adamson

EQUIPMENT AND RECORDING DATA

COAL COMBINATION SONDE

LOG	EQUIPMENT: SONDE	SOURCE	CALIBRATOR	TAPING: LOG TAPED	RECORD SPEED	DIRECT or REPLAY	PANEL: SPEED	T.C. SECS	NORM	CAL COEFF	DEPTHS: FROM	TO	INTERVAL	SEAM LOG RUN
GAMMA RAY	119		05	No			30	1		1.5	102	17	85	No
L.S. DENSITY		23	40	No			30	.3	8.65		105	21	84	No
CALIPER	SIDEWALL POSITION			No			30	.3	-		100	70	30	No

COAL QUALITY/SEAM THICKNESS LOG INTERVALS (Refer to relevant log)

FROM		INTERVAL TOTAL
TO		
INTERVAL		

ADDITIONAL SONDES RUN

SONDE	LOG	GENERAL SCALE LOG	DETAIL SCALE LOG	
Neutron		120:1		REFER TO ADDITIONAL HEADINGS

REMARKS

After gamma & LSD log hole then blocked at 103', initially 108'.
Irregularities between LSD rpt. section and general due to massive caving.
Rpt. section 1' higher than main log.

B P B COAL LITHOLOGY LOG

CALIBRATION DATA

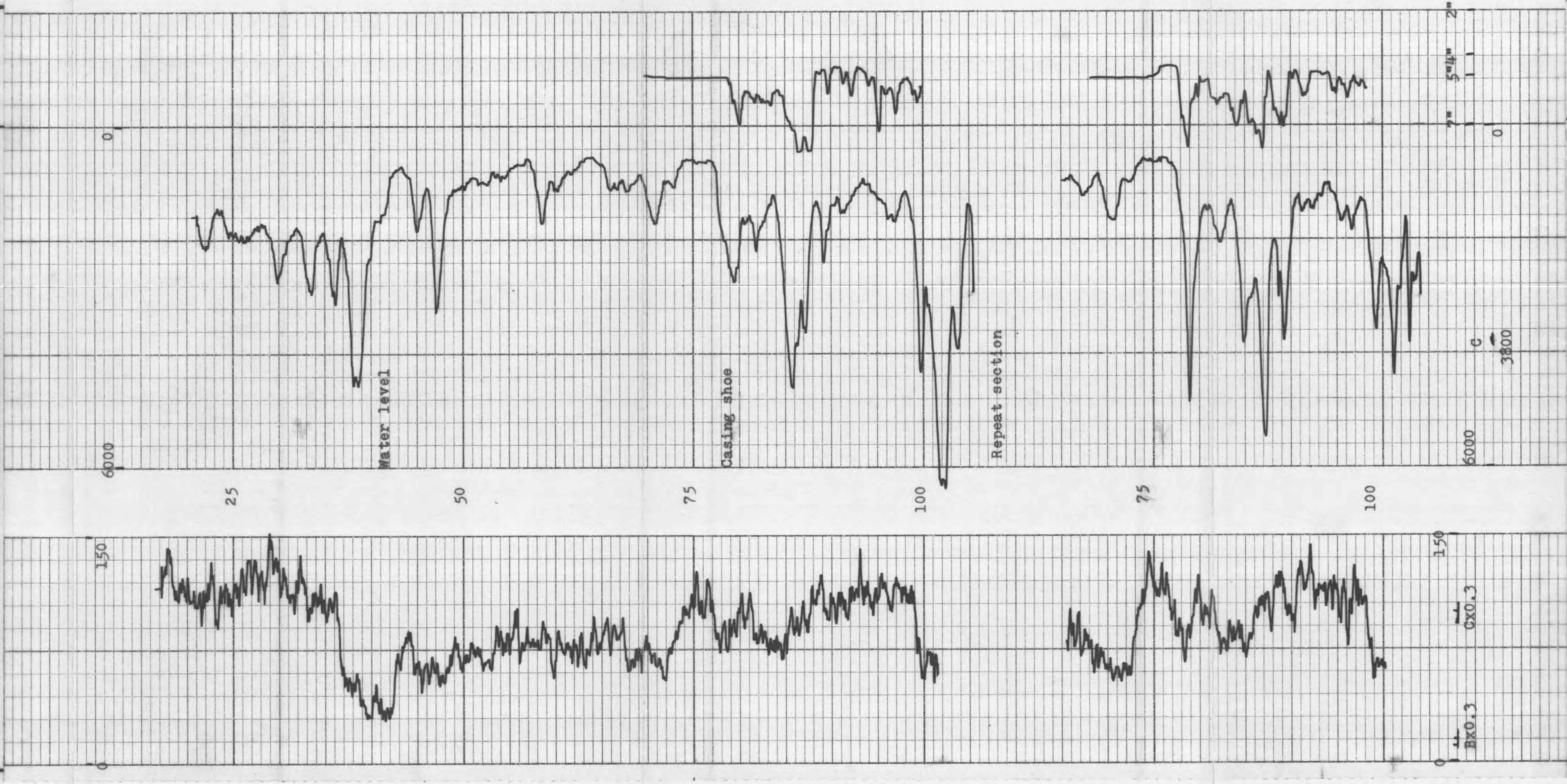
JIG No. 05	VALUE 270 @ 2" DIAM	JIG CAL. DATE 20.7.78	JIG VALUE 3800 SDU @ 1.48 g/cm³
JIG MARK SHOWN AT ABOVE VALUE – 3.33		JIG No. 40	SPAN 6000 NORM SDU/CPS = 8.65
		2 ins 440 cps	7 ins 865 cps

GAMMA RAY — DEPTH — COAL BULK DENSITY g/cm³ — CALIPER INCHES

HOLE SIZE CORRECTION DATA

1.20 1.25 1.30 1.35 1.4 1.45 1.5 1.55 1.6 1.7 1.8 1.9 2.0 2.2 2.4 3.0

0 api 150 — 6,000 s.d.u. 0 — 7" dia 2"



BOREHOLE	T 78-2
CLIENT	Cyprus Anvil
AREA	Tulameen B.C.
COUNTRY	Canada

GAMMA RAY — DEPTH — COAL BULK DENSITY g/cm³ — CALIPER INCHES

0 api 150 — 6000 sdu 0 — 7 dia 2

COAL LITHOLOGY LOG

BPB

E-Logs 78-4A, 5, 6, 7

T-78-4A, 5, 6, 7
- Coal Lithology
- Neutron-Neutron

NEUTRON-NEUTRON LOG

BPB

COMPANY Cyprus Anvil
BOREHOLE T 78-7 Tulameen
STATE B.C. COUNTRY Canada

Permanent Datum Ground Level Elev. m.
Log measured from Ground Level zero m. above P.D.
Drilling measured from Ground Level zero m. above P.D.

GRID REF. E N R.L.

Run No. / Depth Scale	1 / 120:1		
Date	2nd August 1978		
First Reading	265'		
Last Reading	24'		
Interval Measured	241'		
Casing BPB	110'		
Casing Driller	110'		
Depth Reached	267'		
Bottom Driller	270'		
Mud Nature	Natural		
S.G. / Viscosity			
Bit Size 1	5" to t.d.	to	to
2	to	to	to
3	to	to	to
Casing Size 1	5" id to 110'	to	to
2	to	to	to
Rm @ Meas Temp.	@	@	@
Rmf @ Meas Temp.	@	@	@
Rmc @ Meas Temp.	@	@	@
BHT			
Operating Time	2 hrs		
Truck No.	24/23		
Recorded By	D.Fisher		
Witness	T.Adamson		

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REMARKS

Changes in Mud Type or Additional Samples: Date / Sample No. / Depth-Driller / Type Fluid in Hole / Dens. / Visc. / pH / Fluid Loss / Source of Sample / Rm @ Meas Temp / Rmf @ Meas Temp / Rmc @ Meas Temp / Source Rmf / Rmc / Rm @ BHT / Rmf @ BHT / Rmc @ BHT

Scale Changes

Type Log	Depth	Scale Up Hole	Scale Down
Neutron	60'	520-780 cps	60-320

Equipment Data

Run No.	Tool Type	Tool Position	Other

Logging Data

Log	Depths ft From	To	Speed ft/m	T.C. sec	Norm.	Sonde No.	Source No.
N-N	265	24	30	2		19	23

NEUTRON-NEUTRON
cps
DEPTHS

COMPANY Cyprus Anvil
BOREHOLE T 78-7 Tulameen
STATE British Columbia
COUNTRY Canada

BOREHOLE T 78-4A
CLIENT Cyprus Anvil

AREA Tulameen B.C.
COUNTRY Canada
DATE LOGGED 30.7.78

DEPTH SCALE 120:1

1 OF 2 LOGS

COAL LITHOLOGY LOG

BOREHOLE DATA				
PERMANENT DATUM	Ground Level			
ELEVATION OF P.D.				
	BPB		DRILLER	
MEASUREMENTS FROM	G.L.		G.L.	
DEPTH REACHED	205'		230'	
CASING SHOE	135'		136'	
BIT SIZES	1	5" TO T.D.	2	TO
	3	TO	4	TO
CASING SIZES	1	5"id TO 136'	2	TO

SONDE TYPE:
COAL COMBINATION SONDE

FLUID DATA	
NATURE	Water
S.G.	
LEVEL	35' outside casing
VISCOSITY	
Rm at meas.temp.	
B.H.T	

LOG SUITE:
GAMMA RAY
L.S. DENSITY
CALIPER

OPERATION DATA	
FIRST READING	199'
LAST READING	33'
INTERVAL LOGGED	166'
UNIT-TRUCK No.	24/23
ENGINEER	D.Fisher
WITNESS	

EQUIPMENT AND RECORDING DATA

ADDITIONAL SONDES RUN

REMARKS

B P B COAL LITHOLOGY LOG

CALIBRATION DATA

GAMMA RAY | DEPTH | COAL BULK DENSITY | CALIPER INCHES

HOLE SIZE CORRECTION DATA

GAMMA RAY | DEPTH | COAL BULK DENSITY | CALIPER INCHES

BOREHOLE T 78-4A
CLIENT Cyprus Anvil
AREA Tulameen B.C.
COUNTRY Canada

COAL LITHOLOGY LOG

NEUTRON-NEUTRON LOG

COMPANY Cyprus Anvil
BOREHOLE T 78-4A Tulameen
STATE B.C. COUNTRY Canada

Permanent Datum Ground Level Elev. ____ m.
Log measured from Ground Level zero m. above P.D.
Drilling measured from Ground Level zero m. above P.D.

GRID REF E ____ N ____ R.L. ____

Run No. / Depth Scale	1 / 120:1		
Date	30 July 1978		
First Reading	200'		
Last Reading	34'		
Interval Measured	166'		
Casing BPB	135'		
Casing Driller	136'		
Depth Reached	205'		
Bottom Driller	230'		
Mud Nature	Water		
S.G. / Viscosity			
Bit Size 1	5" to t.d.	to	to
2	to	to	to
3	to	to	to
Casing Size 1	5" id to 136	to	to
2	to	to	to
Rm @ Meas Temp.	@	@	@
Rmf @ Meas Temp.	@	@	@
Rmc @ Meas Temp.	@	@	@
BHT			
Operating Time	1½ hrs		
Truck No.	24/23		
Recorded By	D.Fisher		
Witness			

fold here

Logging Data

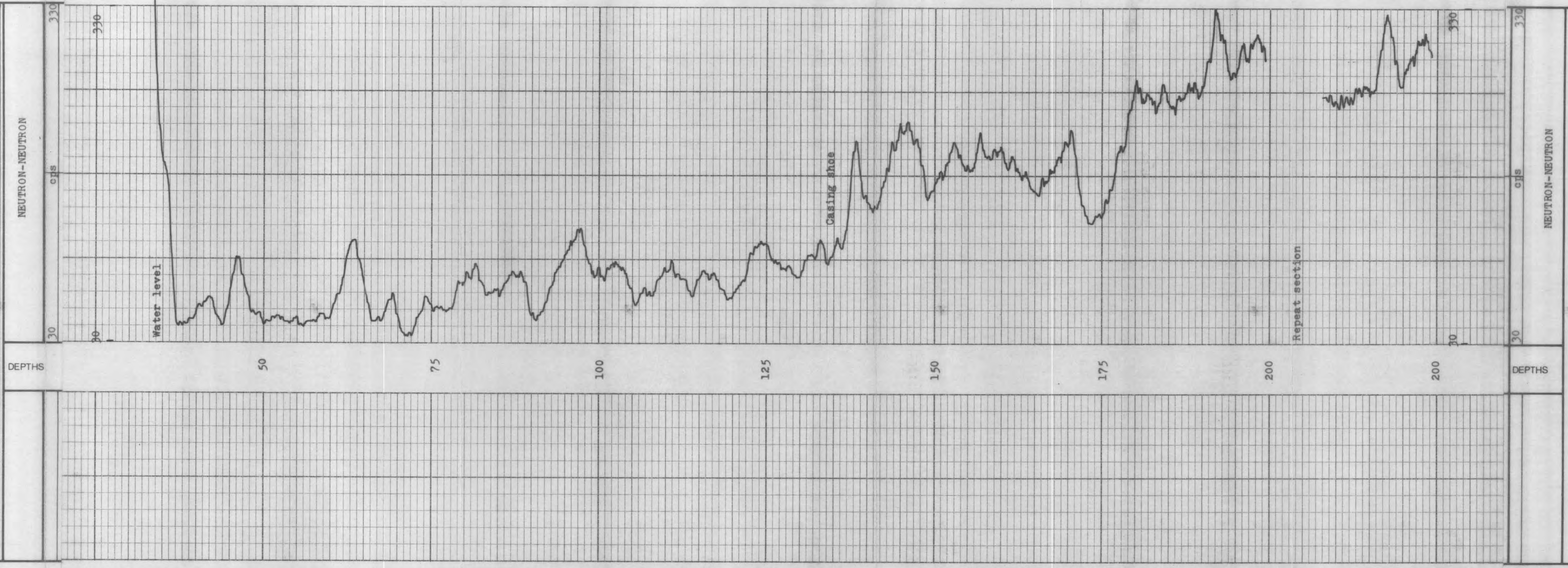
Log	Depths From	Depths To	Speed	T.C.	Norm.	Sources	Source No.
N-N	200	34	30	2		19	23

Scale Changes: Type Log | Depth | Scale Up Hole | Scale Down

Equipment Data: Run No. | Tool Type | Tool Position | Other

REMARKS

Changes in Mud Type or Additional Samples: Date | Sample No. | Depth-Driller | Type Fluid in Hole | Dens. / Visc. | ph / Fluid Loss | Source of Sample | Rm @ Meas Temp. | Rmf @ Meas Temp. | Rmc @ Meas Temp. | Source Rmf / Rmc | Rm @ BHT | Rmf @ BHT | Rmc @ BHT



COMPANY Cyprus Anvil
BOREHOLE T 78-4A
STATE British Columbia
COUNTRY Canada

MY (B) 58360 R

BOREHOLE T 78-5
CLIENT Cyprus Anvil

AREA Tulameen B.C.
COUNTRY Canada
DATE LOGGED 29 July '78

DEPTH SCALE 120:1

1 OF 2 LOGS

COAL LITHOLOGY LOG

SONDE TYPE:
COAL COMBINATION SONDE

LOG SUITE:
GAMMA RAY
L.S. DENSITY
CALIPER

BOREHOLE DATA

PERMANENT DATUM	Ground Level			
ELEVATION OF P.D.				
	BPB		DRILLER	
MEASUREMENTS FROM	G.L.		G.L.	
DEPTH REACHED	143'		144'	
CASING SHOE	83'		83'	
BIT SIZES	1	5" TO T.D.	2	TO
	3	TO	4	TO
CASING SIZES	1	5"id TO 83	2	TO

FLUID DATA

NATURE	Natural
S.G.	
LEVEL	22'
VISCOSITY	
Rm at meas.temp.	
B.H.T.	

OPERATION DATA

FIRST READING	137'
LAST READING	18'
INTERVAL LOGGED	117'
UNIT-TRUCK No.	24/23
ENGINEER	D.Fisher
WITNESS	T.Adamson

EQUIPMENT AND RECORDING DATA

LOG	SONDE	SOURCE	CALIBRATOR	LOG TAPED	SPEED	T.C. SECS	NORM	CAL COEFF	FROM	TO	INTERVAL	SEAM LOG RUN
GAMMA RAY	119		05	No	30	1		1.6	137	18	119	No
L.S. DENSITY		23	40	No	30	3	7.40		141	22	119	No
CALIPER		SIDEWALL POSITION		No	30	3			140	70	70	No

COAL QUALITY (SEAM THICKNESS LOG INTERVALS) (Refer to relevant log)
FROM
TO
INTERVAL

ADDITIONAL SONDES RUN

SONDE	LOG	GENERAL SCALE	DETAIL LOG SCALE
Neutron		120:1	

REFER TO ADDITIONAL HEADINGS

REMARKS

INTERVAL
TOTAL

BPB COAL LITHOLOGY LOG

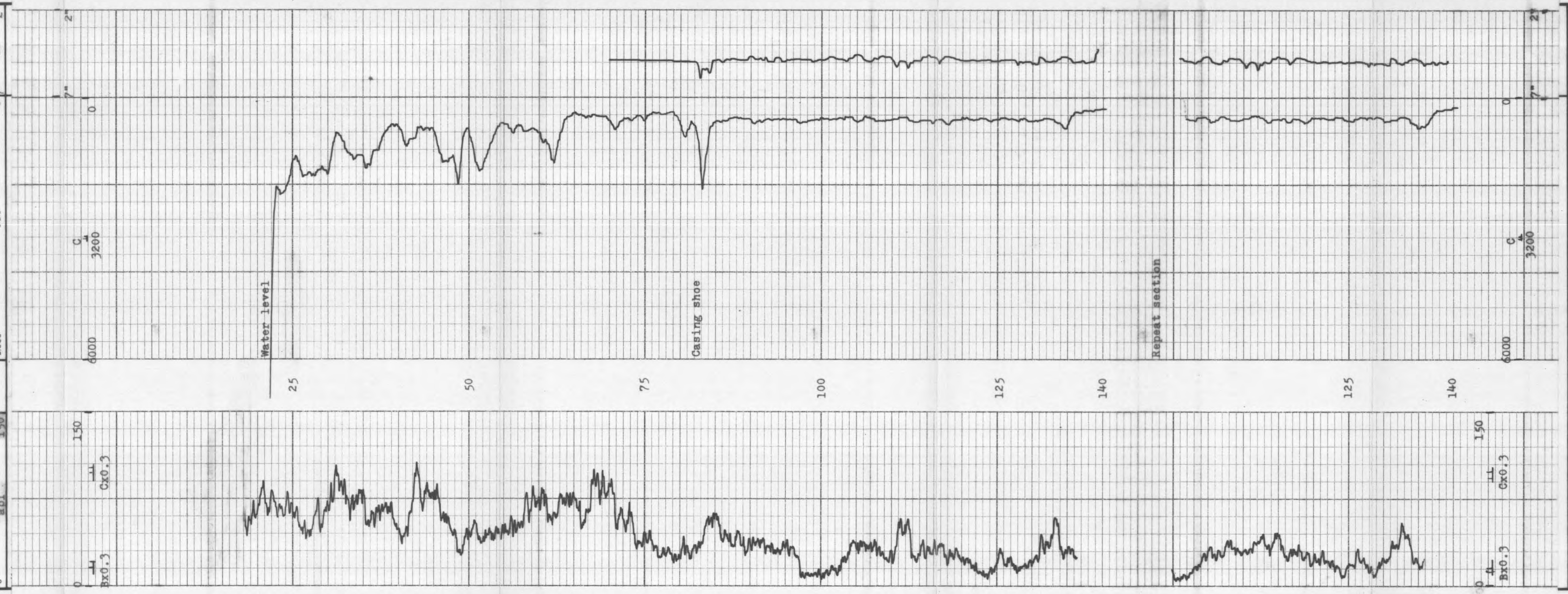
CALIBRATION DATA

JIG CAL DATE 29.7.78 JIG VALUE 3200 SDU 1.5 g/cm³ 2 ins 442 cps
JIG No 40 SPAN 6000 NORM 7.40 7 ins 862 cps

JIG No 5 VALUE 2790 2" DIAM
JIG MARK SHOWN AT ABOVE VALUE -3.38

GAMMA RAY | DEPTH | COAL BULK DENSITY | CALIPER INCHES

HOLE SIZE CORRECTION DATA



BOREHOLE T 78-5
CLIENT Cyprus Anvil
AREA Tulameen B.C.
COUNTRY Canada

COAL LITHOLOGY LOG

BPB

NEUTRON-NEUTRON LOG

COMPANY Cyprus Anvil
BOREHOLE T 78-5 Tulameen
STATE B.C. COUNTRY Canada

Permanent Datum Ground Level Elev. ____ m.
Log measured from Ground Level zero m. above P.D.
Drilling measured from Ground Level zero m. above P.D.

GRID REF E ____ N ____ R.L. ____

Run No. / Depth Scale	1 / 120:1		
Date	29 July 1978		
First Reading	140'		
Last Reading	22'		
Interval Measured	118'		
Casing BPB	83'		
Casing Driller	83'		
Depth Reached	143'		
Bottom Driller	144'		
Mud Nature	Natural		
SG / Viscosity			
Bit Size 1	5" to T.D.	to	to
2	to	to	to
3	to	to	to
Casing Size 1	5" id to 83	to	to
2	to	to	to
Rm @ Meas Temp	@	@	@
Rmf @ Meas Temp	@	@	@
Rmc @ Meas Temp	@	@	@
BHT			
Operating Time	2 hrs		
Truck No.	24/23		
Recorded By	D.Fisher		
Witness	T.Adamson		

fold here

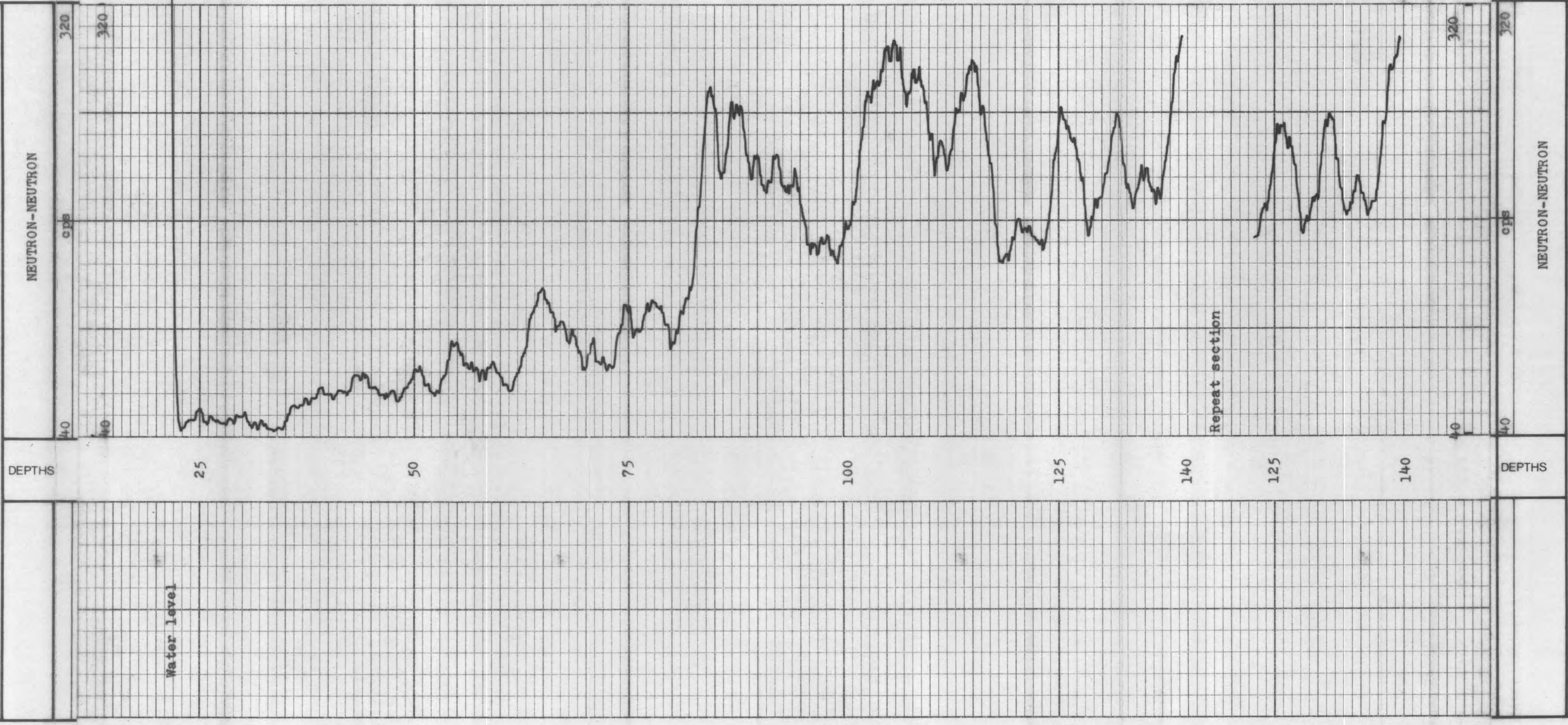
REMARKS
Changes in Mud Type or Additional Samples: Date / Sample No. / Depth—Driller / Type Fluid in Hole / Dens. / Visc. / ph. / Fluid Loss ml / Source of Sample / Rm @ Meas Temp / Rmf @ Meas Temp / Rmc @ Meas Temp / Source Rmf / Rmc / Rm @ BHT / Rmf @ BHT / Rmc @ BHT

Scale Changes: Type Log / Depth / Scale Up Hole / Scale Down

Equipment Data: Run No. / Tool Type / Tool Position / Other

Logging Data:

Log	Depths From	Depths To	Speed	T.C.	Norm.	Sensitivity	Source No.
N-N	140	22	30	2		19	23



COMPANY Cyprus Anvil
BOREHOLE T 78-5
STATE B.C.
COUNTRY Canada

MY (8) 58360 R

BOREHOLE T 78-6
CLIENT Cyprus Anvil

AREA Tulameen B.C.
COUNTRY Canada
DATE LOGGED 1 August'78

DEPTH SCALE 120:1

1 OF 2 LOGS

COAL LITHOLOGY LOG

BOREHOLE DATA				
PERMANENT DATUM	Ground Level			
ELEVATION OF P.D.				
	BPB		DRILLER	
MEASUREMENTS FROM	G.L.		G.L.	
DEPTH REACHED	316'		340'	
CASING SHOE	81'		83'	
BIT SIZES	1	5" TO T.D.	2	TO
	3	TO	4	TO
CASING SIZES	1	5" id TO 83'	2	TO

SONDE TYPE:
COAL COMBINATION SONDE

FLUID DATA	
NATURE	Natural
S.G.	
LEVEL	20'
VISCOSITY	
Rm at meas. temp.	
B.H.T	

LOG SUITE:
GAMMA RAY
L.S. DENSITY
CALIPER

OPERATION DATA	
FIRST READING	310'
LAST READING	17'
INTERVAL LOGGED	293'
UNIT-TRUCK No.	24/23
ENGINEER	D.Fisher
WITNESS	T.Adamson

EQUIPMENT AND RECORDING DATA

COAL COMBINATION SONDE

LOG	EQUIPMENT			TAPING			PANEL			CAL COEFF	DEPTHS			SEAM LOG RUN
	SONDE	SOURCE	CALIBRATOR	LOG TAPED	RECORD SPEED	DIRECT or REPLAY	SPEED	T.C. SECS	NORM		FROM	TO	INTERVAL	
GAMMA RAY	119 SIDEWALL POSITION		05	No			30	1		1.6	310	17	293	No
L.S. DENSITY		23	40	No			30	.33	7.4		314	21	293	No
CALIPER				No			30	.33			311	72	239	No

COAL QUALITY/SEAM THICKNESS LOG INTERVALS (Refer to relevant log)

FROM		INTERVAL TOTAL
TO		
INTERVAL		=

ADDITIONAL SONDES RUN

SONDE	LOG	GENERAL SCALE LOG	DETAIL SCALE LOG	
Neutron		120:1		REFER TO ADDITIONAL HEADINGS

REMARKS

Sonde caught in casing on gamma, LSD run at 66'.
Caliper run approx. 2' high due to drill head falling.

B P B COAL LITHOLOGY LOG

CALIBRATION DATA

JIG No. 5 VALUE 270 @ 2" DIAM.	JIG CAL. DATE 29.7.78 JIG VALUE 3200 SDU @ 1.54 g/cm³	2 ins 444 cps
JIG MARK SHOWN AT ABOVE VALUE -3.33	JIG No. 40 SPAN 6000 NORM $\frac{SDU}{CPS}$ = 7.40	7 ins 865 cps

GAMMA RAY	DEPTH	COAL BULK DENSITY g/cm³	CALIPER INCHES

HOLE SIZE CORRECTION DATA

GAMMA RAY	DEPTH	COAL BULK DENSITY	CALIPER INCHES

BOREHOLE T 78-6 AREA Tulameen B.C.
CLIENT Cyprus Anvil COUNTRY Canada

COAL LITHOLOGY LOG

NEUTRON-NEUTRON LOG

COMPANY Cyprus Anvil
BOREHOLE T 78-6 Tulameen
STATE B.C. COUNTRY Canada

Permanent Datum Ground Level Elev. ___ m.
Log measured from Ground Level zero m. above P.D.
Drilling measured from Ground Level zero m. above P.D.

GRID REF. E ___ N ___ R.L. ___

Run No. / Depth Scale	1 / 120:1		
Date	1st August 1978		
First Reading	315'		
Last Reading	19'		
Interval Measured	296'		
Casing BPB	81'		
Casing Driller	83'		
Depth Reached	316'		
Bottom Driller	340'		
Mud Nature	Natural		
S.G. / Viscosity			
Bit Size 1	5" to T.D.	to	to
2	to	to	to
3	to	to	to
Casing Size 1	5"id to 83'	to	to
2	to	to	to
Rm @ Meas Temp.	@	@	@
Rmf @ Meas Temp.	@	@	@
Rmc @ Meas Temp.	@	@	@
BHT			
Operating Time	1½ hrs		
Truck No.	24/23		
Recorded By	D.Fisher		
Witness	T.Adamson		

Logging Data

Log	Depths ft From	To	Speed ft/m	T.C. sec	Norm.	Sonde No.	Source No.
N-N	315	19	30	2		19	23

REMARKS

COMPANY Cyprus Anvil
BOREHOLE T 78-6 Tulameen
STATE B.C.
COUNTRY Canada

BOREHOLE T 78-7
CLIENT Cyprus Anvil

AREA Tulameen B.C.
COUNTRY Canada
DATE LOGGED

DEPTH SCALE 120:1

1 OF 2 LOGS

COAL LITHOLOGY LOG

BOREHOLE DATA

PERMANENT DATUM	Ground Level			
ELEVATION OF P.D.				
	BPB		DRILLER	
MEASUREMENTS FROM	G.L.		G.L.	
DEPTH REACHED	267'		270'	
CASING SHOE	110'		110'	
BIT SIZES	1	5" TO T.D.	2	TO
	3	TO	4	TO
CASING SIZES	1	5"id TO 110	2	TO

FLUID DATA

NATURE	Natural
S.G.	
LEVEL	12'
VISCOSITY	
Rm at meas.temp.	
B.H.T	

SONDE TYPE:
COAL COMBINATION SONDE

LOG SUITE:
GAMMA RAY
L.S. DENSITY
CALIPER

OPERATION DATA

FIRST READING	261'
LAST READING	13'
INTERVAL LOGGED	248'
UNIT-TRUCK No.	24/23
ENGINEER	D.Fisher
WITNESS	T.Adamson

EQUIPMENT AND RECORDING DATA

COAL COMBINATION SONDE

LOG	EQUIPMENT: SONDE	EQUIPMENT: SOURCE	EQUIPMENT: CALIBRATOR	TAPING: LOG TAPED	TAPING: RECORD SPEED	TAPING: DIRECT or REPLAY	PANEL: SPEED	PANEL: T.C. SECS	PANEL: NORM	CAL COEFF.	DEPTHS: FROM	DEPTHS: TO	DEPTHS: INTERVAL	SEAM LOG RUN
GAMMA RAY	119		05	No			30	1		1.6	261	13	248	No
L.S. DENSITY		23	40	No			30	.33	7.40		265	16	249	No
CALIPER	SIDEWALL POSITION			No			30	.33			263	100	163	No

COAL QUALITY/SEAM THICKNESS LOG INTERVALS (Refer to relevant log)

FROM		INTERVAL
TO		TOTAL
INTERVAL		

ADDITIONAL SONDES RUN

SONDE	LOG	GENERAL SCALE LOG	DETAIL SCALE LOG	
Neutron		120:1		REFER TO ADDITIONAL HEADINGS

REMARKS

B P B COAL LITHOLOGY LOG

CALIBRATION DATA

JIG No. 5 VALUE 270 @ 2" DIAM	JIG CAL DATE 29.7.78 JIG VALUE 3200 SDU @ 1.54 g/cm³	2 ins 443 cps
JIG MARK SHOWN AT ABOVE VALUE 3.33	JIG No. 40 SPAN 6000 NORM $\frac{SDU}{CPS}$ = 7.40	7 ins 868 cps

GAMMA RAY | DEPTH | COAL BULK DENSITY g/cm³ | CALIPER INCHES

HOLE SIZE CORRECTION DATA

GAMMA RAY | DEPTH | COAL BULK DENSITY g/cm³ | CALIPER INCHES

BOREHOLE T 78-7
CLIENT Cyprus Anvil
AREA Tulameen
COUNTRY Canada

COAL LITHOLOGY LOG

APPENDIX VIII

A REPORT

ON

A SEISMIC SURVEY

Tulameen Coalfield

Coalmont, British Columbia

FOR

CYPRUS ANVIL MINING CORPORATION

Vancouver, British Columbia

BY

PETER E. WALCOTT & ASSOCIATES LIMITED

Vancouver, British Columbia

DECEMBER 1978

TABLE OF CONTENTS.

APPENDIX

INTRODUCTION.

Between September 9th and 24th, 1978, Peter E. Walcott & Associates Limited carried out a seismic survey for Cyprus Anvil Mining Corporation in an effort to determine the rippability of the material in their proposed open pit on the Tulameen Coalfield, Coalmont, British Columbia.

The field work was carried out on four lines cut at the time of the survey using both a sledgehammer and dynamite as the source of energy.

Four reverse profiles were shot on each section using the refraction method. More dynamite and caps were used than originally estimated as poor coupling with the ground and the wind and tall trees combination severely restricted the use of the hammer.

The results are presented in tabular form giving thickness and velocities of the various layers. The time distance curves (re-plotted from the records) are also provided. The position of the determinations are also shown on an overlay of the proposed pit outline.

The elevations of the sections were determined at 50 foot intervals using a hydrostatic level. These are shown on the plot of the time-distance curves.

GEOLOGY.

The reader is referred to a report by Mr. T. Adamson of Cyprus Anvil Mining Corporation.

Briefly the Tulameen basin consists of an elongate, oval-shaped synclinally folded sequence of Tertiary sediments and volcanics unconformably overlaying a basement of Upper Triassic Nicola Group volcanics and sediments.

The Tertiary sedimentary strata - Unit 3 - can be broken down into a lower sandstone unit (3a), the coal bearing member consisting of shales, mudstone tuffs, flows, and coal (3b), and an upper sandstone unit (3c). The respective thickness of these units are in the order of 100, 130 and 600 metres respectively.

Units 3b and 3 c dip about 45° to the east in the vicinity of the proposed pit and were encountered in all the exploratory drill holes in the pit area.

DISCUSSION AND INTERPRETATION OF RESULTS.

The entire process of refraction seismic interpretation can be illustrated by a simple yet important case of the single horizontal discontinuity shown in Figure 1.

Let the horizontal discontinuity be at a depth d at which the velocity increases abruptly from V_1 to V_2.

Let X denote the horizontal distance between source and receiver, and let T be the time of travel of the distance.

When the detector is located very close to the source in comparison with the depth d, the first waves to reach the detector will travel horizontally in the upper layer at a velocity V_1 and will arrive at times $T_1 = \frac{X}{V_1}$. Therefore the time/distance curve starts out as a straight line through the origin with slope $^1/V_1$.

At a certain distance X_c, a wave that has been refracted along the discontinuity will arrive at the receiver at the same time as the direct one. This will occur when the time gained in travelling the path BC is greater than the time lost in travelling AB and CD. At all distances greater than X_c, the refracted wave constitutes the first arrival.

Thus, its time of travel is given by

$$T_2 = \frac{AB}{V_1} + \frac{BC}{V_2} + \frac{CD}{V_1}$$

But by geometry $AB = CD = \frac{d}{\text{Cos } i}$

and $BC = X = \frac{2d}{\text{Cos } i}$

Also, Snell's Law gives the relationship of the critical angle i_c to the velocities, i.e. $\text{Sin } i_c = \frac{V_1}{V_2}$

Thus by substitution $T_2 = \frac{2d}{V_1 \cos_i} + \frac{X}{V_2} - \frac{2d \tan i}{V_2}$

and by trigonometrical simplification gives $T_2 = \frac{X}{V_2} + \frac{2d \cos i}{V_1}$ *

DISCUSSION AND INTERPRETATION OF RESULTS cont'd

This latter equation shows that beyond the critical distances, the slope of the time/distance curve will be given by $1/V_2$. Thus the presence of a subsurface discontinuity will be represented by a break in the time/distance curve between the two segments.

Now at the critical distance X_c $T_1 = T_2$ and by substitution for cos i in *, the equation becomes

$$\frac{X_c}{V_1} = \frac{X_x}{V_2} + 2d \frac{V_2^2 - V_1^2}{V_1 \quad V_2}$$

whence $d = \frac{X_c}{2}\sqrt{\frac{V_2 - V_1}{V_2 + V_1}}$

Certain minor correction factors have to be applied, but need not be considered here. Thus in general the thickness of each layer may be written

$$d_{n-1} = \frac{X_{cn-1}}{2}\sqrt{\frac{V_n - V_{n-1}}{V_n + V_{n-1}}} + \text{Correction}$$

These correction terms have been ignored by the writer in computing the results presented here.

Now plane parallel boundaries rarely occur in nature. Usually there exists some dip of the velocity discontinuity relative to the plane of the surface. The dip will be expressed in a higher apparent velocity, V_u, when the impact source moves updip, and a lower apparent velocity, V_d, when the source progresses downdip.

The true velocity of the second layer is given by the relationship $V_2 = \frac{2 \cos \theta}{\frac{1}{V_u} + \frac{1}{V_d}}$

where θ is the dip angle.

This expression will approximate to $\frac{2}{\frac{1}{V_u} + \frac{1}{V_d}}$

to within 4% when the dip angle is less than 15 degrees.

DISCUSSION AND INTERPRETATION OF RESULTS cont'd

* Relationship between Velocity and Rippability.

The velocities of seismic waves differ greatly for different subsurface materials depending on such factors as hardness, density and degree of consolidation. In general sediementary rocks with velocities up to 8,000 ft/sec. are rippable, with velocities from 8,000 to 10,000 ft/sec. are marginal, and those with velocities above 10,000 are non-rippable.

Interpretation of profiles.

Initially some test work was carried out using an impact source in the trench near section #3. Here two velocity ranges were encountered, one in the 2,500 to 3,400 ft./sec. range believed to correspond to the unconsolidated gravel, etc. above the coal member, and one around 5,300 ft./sec. correspondong to the coal member.

The results from the four sections, sections #2,3, 4 and 5 are shown as time-distance plots on Map No.'s W-262-2 to 5. Second arrivals have been plotted in most cases for the dynamite sources to confirm first arrival plots and to allow extrapolation of the latter in the event they were missed which happened on occasions.

The plots on all sections show good overall similarity as expected from the uniform stratigraphy. The time distance curves show numerous kinks particularly on the V_3 segments going so far as to suggest higher velocity layers V_4 on occasions. However these are generally not confirmed on the reverse shots, and no evidence for such was indicated in the drill holes. The kinks have thus been attributed to variations in thickness in the overburden and gravelly layers and to irregularities in the coal bearing formation. The writer played around with correcting for elevation differences on two sections but basically the kinks remained.

As a result he interpreted the data on the basis of a three layer model, the inverse velocities of which are shown by the average slopes of the time distance curves on Maps W-262-2 to 5 and listed in Table 1.

The velocities are generally similar indicating fairly gentle dips. As the lithologic units dip about 45° to the east it would appear that there is no significant velocity difference between units 3b and 3c.

DISCUSSION AND INTERPRETATION OF RESULTS cont'd

These velocities have been averaged as explained previously to give the velocities used in computation of the thickness of the various layers, and as shown on the cross sections on Maps W-262-2 to 5.

Critical distances of 400 and 900 feet, and an assumed velocity of 12,000 ft./sec. were used to calculate the minimum thickness of Unit 3, d_3, as shown in Table 1.

All the average V_3 velocities are less than 8000 ft./sec. indicating this unit to be rippable down to the depth shown in Table 1. Although the average depth investigated was around 275 feet and the depth of the planned excavation is circa 390' the writer considers a change in the factors affecting the velocity of Unit 3 unlikely and expects the material to be rippable to the bottom.

It should be noted here that evidence for the existence of the second layer is not always strong, and the V_1 - V_2 segment could possibly be fitted by a parabolic or similar path.

Also no consideration was given to the presence of blind zones or velocity inversions which can increase the depth of investigation. However neither of these affect the outcome of the final result, the rippability of the coal-member.

SUMMARY & CONCLUSIONS.

Between September 9th and 24th, 1978, Peter E. Walcott and Associates Limited carried out a seismic survey for Cyprus Anvil Mining Corporation to try and determine the rippability of the material contained within the proposed pit of their planned coalmine near Coalmont, British Columbia.

The survey indicated the presence of three layers exhibiting different seismic velocities. All of these velocities were well within the confines of those considered rippable.

As a result the writer sees no reason why the planned excavation cannot be accomplished by tracked machines even though the depth of the pit will be greater than the depth investigated by this survey.

Respectfully submitted,

PETER E. WALCOTT & ASSOCIATES LIMITED

Peter E. Walcott, P.Eng.
Geophysicist

Vancouver,
British Columbia

December 1978

APPENDIX

TABLE OF RESULTS

Symbols used are as follows:

V_1	=	Velocity of 1st layer
V_2	=	" " 2nd "
V_3	=	" " 3rd "
V_4	=	Assumed velocity of basement.
d_1	=	Thickness of 1st layer
d_2	=	" " 2nd "
d_3	=	" " 3rd "
D	=	Depth to basement

Note: All velocities are given in feet per second, and all depths in feet.

TABLE OF SEISMIC RESULTS

	LOCATION	DIRN.	V_1	V_2	V_3	V_4	d_1	d_2	d_3	D
Section #2	0	E	1,270	3.100	6,700		14	20	>111	>145
	5E	W	1,250	4,800	6,000		10	24	>111	>145
			1,260	3,765	6,330	12,000				
	5E	E	1,200	3,600	7,300		7	29	> 93	>129
	10E	W	1,180	3,300	8,200		7	48	>93	>148
			1,190	3,445	7,725	12,000				
	10E	E	900	2,900	6,750		4	38	>108	>150
	15E	W	1,300	5,000	6,400		11	35	>108	>154
			1,065	3,670	6,570	12,000				
	15E	E	1,250	3,600	6,250		9	28	>108	>145
	20E	W	1,100	3,000	7,000		7	31	>108	>146
			1,170	3,275	6,605	12,000				
	5E	E	1,200	3,600	7,300		7	23	>236	>266
	15E	W	1,300	5,000	6,400		11	32	>236	>279
			1,250	4,185	6,820	12,000				

TABLE OF SEISMIC RESULTS

	LOCATION	DIRN.	V_1	V_2	V_3	V_4	d_1	d_2	d_3	D
Section #3	0	E	1,025	3,800	6,900		4	20	>103	>127
	5E	W	1,465	2,470	7,050		3	19	>103	>125
			1,205	2,995	6,975	12,000				
	5E	E	1,465	2,665	6,700		3	23	>99	>125
	10E	W	1,250	2,815	7,900		7	32	>99	>138
			1,350	2,740	7,250	12,000				
	10E	E	1,190	2,665	6,150		7	42	>110	>159
	15E	W	1,140	3,205	6,750		6	29	>110	>145
			1,165	2,910	6,435	12,000				
	15E	E	1,225	2,925	6,800		5	30	>107	>142
	20E	W	1,465	2,350	6,500		4	24	>107	>135
			1,335	2,605	6,645	12,000				
	5E	E	1,465	2,665	6,700		3	22	>239	>264
	15E	W	1,140	3,205	6,750		5	30	>239	>274
			1,280	2,910	6,725	12,000				

TABLE OF SEISMIC RESULTS

	LOCATION	DIRN.	V_1	V_2	V_3	V_4	d_1	d_2	d_3	D
Section #4	0	E	725	2,510	6,850		3	16	>101	>120
	5E	W	1,215	3,000	7,500		8	33	>101	>142
			910	2,735	7,160	12,000				
	5E	E	1,175	2,500	6,400		10	20	>117	>147
	10E	W	1,175	2,700	5,500		6	23	>117	>146
			1,175	2,595	5,915	12,000				
	10E	E	800	2,050	5,500		3	15	>118	>136
	15E	W	1,125	3,635	6,200		7	33	>118	>153
			935	2,620	5,830	12,000				
	15E	E	1,500	3,495	5,100		6	12	>120	>138
	20E	W	1,050	2,985	6,300		7	29	>120	>156
			1,235	3,220	5,635	12,000				
	5E	E	1,175	2,500	6,400		11	19	>251	>281
	15E	W	1,125	3,635	6,200		7	32	>251	>290
			1,150	2,965	6,300	12,000				

TABLE OF SEISMIC RESULTS

	LOCATION	DIRN.	V_1	V_2	V_3	V_4	d_1	d_2	d_3	D
Section #5	0	E	1,110	2,550	6,500		5	18	>109	>132
	5E	W	1,230	3,000	6,500		5	22	>109	>136
			1,165	2,755	6,500	12,000				
	5E	E	1,500	3,400	6,400		10	13	>241	>264
	10E	W	1,250	3,100	6,950		12	27	>107	>146
			1,365	3,245	6,665	12,000				
	10E	E	1,150	3,150	5,600		15	26	>117	>158
	15E	W	1,100	-	6,250		22	-	>117	>139
			1,125	3,150	5,905	12,000				
	15E	W	1,160	-	6,000	-	27	-	-	-

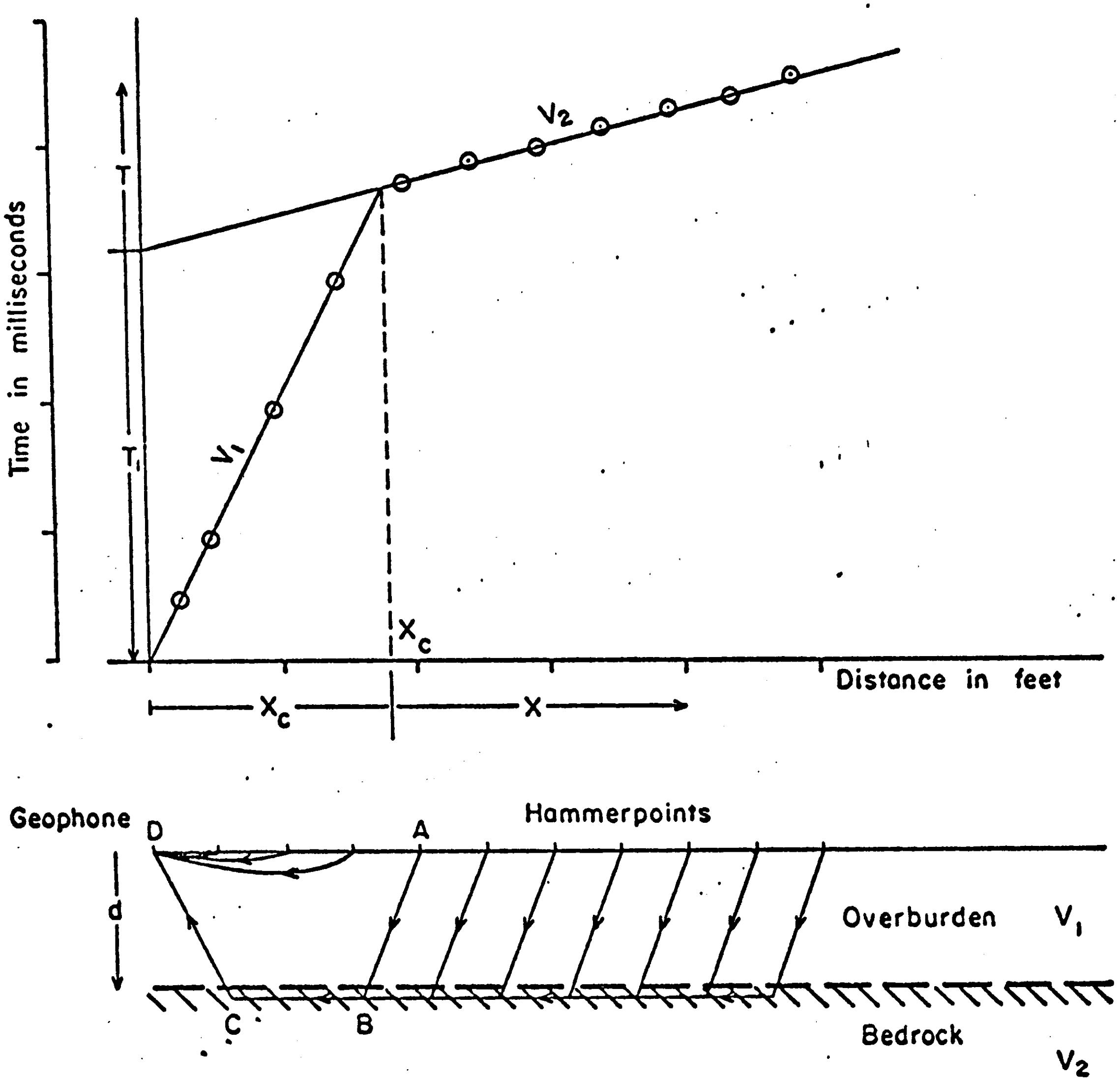

Time in milliseconds
T
T_1
V_1
V_2
X_c
Distance in feet
X_c
X
Geophone
D
A
Hammerpoints
d
Overburden V_1
C
B
Bedrock
V_2

FIGURE I

Maps Nos. W-262-1, 2, 3

CYPRUS ANVIL MINING CORP.

TULAMEEN COAL PROJECT

SEISMIC SURVEY

TIME – DISTANCE PLOT

SECTION # 3

MAP No W-262-3
TO ACCOMPANY A REPORT BY
PETER E. WALCOTT, P. Eng. ; DATED - DEC. 1978

PETER E. WALCOTT & ASSOC. LTD.
SEPTEMBER - 1978

CYPRUS ANVIL MINING CORP.

TULAMEEN COAL PROJECT

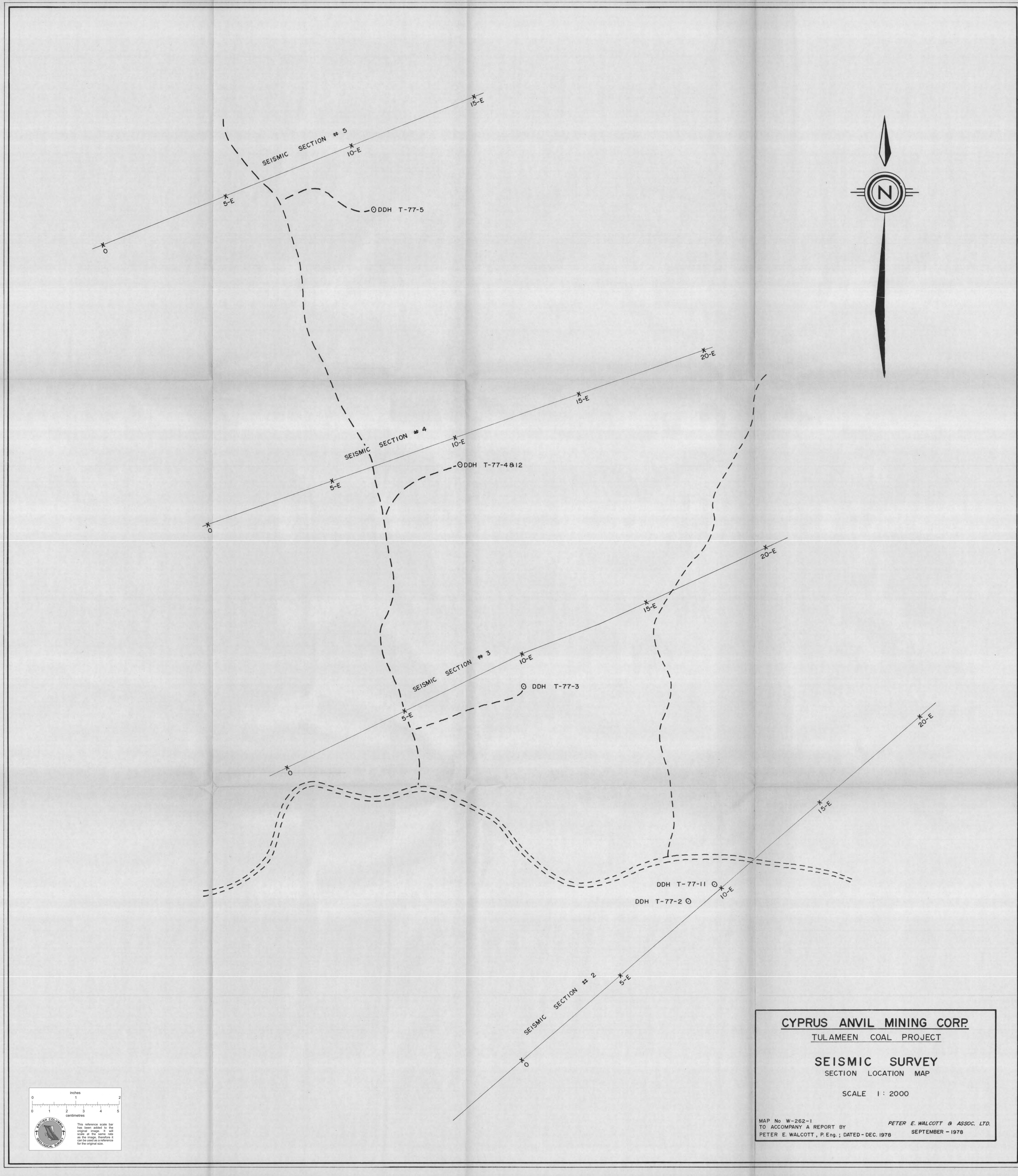
SEISMIC SURVEY

TIME – DISTANCE PLOT

SECTION # 2

MAP No W-262-2
TO ACCOMPANY A REPORT BY
PETER E. WALCOTT, P. Eng.; DATED - DEC. 1978

PETER E. WALCOTT & ASSOC. LTD.
SEPTEMBER - 1978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0
5-E
10-E
15-E
DDH T-77-5
SEISMIC SECTION # 4
0
5-E
10-E
15-E
20-E
DDH T-77-4&12
SEISMIC SECTION # 3
0
5-E
10-E
15-E
20-E
DDH T-77-3
SEISMIC SECTION # 2
0
5-E
10-E
15-E
20-E
DDH T-77-11
DDH T-77-2
N
inches
0 1 2
0 1 2 3 4 5
centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
CYPRUS ANVIL MINING CORP.
TULAMEEN COAL PROJECT
SEISMIC SURVEY
SECTION LOCATION MAP
SCALE 1 : 2000
MAP No W-262-1
TO ACCOMPANY A REPORT BY
PETER E. WALCOTT, P. Eng.; DATED - DEC. 1978
PETER E. WALCOTT & ASSOC. LTD.
SEPTEMBER - 1978

Maps Nos. W-262-4, 5

CYPRUS ANVIL MINING CORP.

TULAMEEN COAL PROJECT

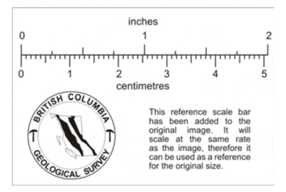
SEISMIC SURVEY

TIME – DISTANCE PLOT

SECTION # 4

MAP No W-262-4
TO ACCOMPANY A REPORT BY
PETER E. WALCOTT, P. Eng.; DATED-DEC. 1978

PETER E. WALCOTT & ASSOC. LTD.
SEPTEMBER – 1978



CYPRUS ANVIL MINING CORP.

TULAMEEN COAL PROJECT

SEISMIC SURVEY

TIME – DISTANCE PLOT

SECTION # 5

MAP No W-262-5
TO ACCOMPANY A REPORT BY
PETER E. WALCOTT, P. Eng., DATED - DEC. 1978

PETER E. WALCOTT & ASSOC. LTD.
SEPTEMBER - 1978

APPENDIX IX

APP. IX

TULAMEEN ENVIRONMENTAL PROGRESS REPORT - 1978

Similkameen Mining District

British Columbia

N. T. S.	92 H - 7, 10
Latitude:	49^{o} 30' N
Longitude:	120^{o} 45' W

By

P. M. DEAN

CYPRUS ANVIL MINING CORPORATION

November 22, 1978

Field Work Done During the Periods: April 24 - 26, 1978
May 15 - 19, 1978
July 10 - August 6, 1978

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TULAMEEN ENVIRONMENTAL PROGRESS REPORT - 1978

1.0 INTRODUCTION

A preliminary feasibility study carried out on the Tulameen coal prospect during the Spring of 1978 indicated that the property was close to being economically viable. Accordingly, it was decided that some environmental investigations should be initiated which would be required when the time came to prepare a Stage I Environmental Impact Assessment. It was also decided that much of the environmental work could be done "in-house", thereby avoiding at least in part the excessive fees charged by consulting companies, and at the same time building up some "in-house" environmental expertise. The technical skills and general familiarity with environmental problems which will be gained on this project may serve the company well in future projects, when environmental issues will effect mining companies much more dramatically than they do today.

During this first season, environmental investigations on the Tulameen Project have consisted largely of compiling the existing biophysical data available from various government sources. Some field time was spent on water quantity and quality investigations, and on initial descriptions of the plant communities present on the property. A substantial amount of office time has been spent in the acquisition of general environmental material and in learning specific technical field procedures in hydrology, forestry, agriculture, plant ecology, etc. This learning experience is continuing, and given enough time, we should be able to carry out all but the most highly technical investigations required for the Stage I assessment without recourse to consulting companies.

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It should be emphasized that the work I am doing, as outlined in this progress report, only concerns itself with the biophysical aspects of the environmental assessment. The Stage I report must also include an assessment of the socio-economic impacts of the development, and it remains to be decided whether this also will be done "in-house" or contracted to a consulting company. The work requires a person with an economics background and an interest in community social and economic planning. The socio-economic impact assessment will not require the lead time that some aspects of the biophysical assessment requires, and can be carried out over a relatively brief period of time.

The collection of some of the data required for the Stage I biophysical assessment requires substantial outlays of money for automatic monitering equipment, and these costs are best delayed until the viability of the project is assured. When potential markets have been found for the coal, final feasibility studies are completed, and a schedule for construction has been finalized, then meteorological equipment, automatic stream stage recorders, etc. can be purchased and installed. Investigations of revegetation and reclamation procedures, plus whatever other environmental work the government may require, can also be carried out at this later time. In the meantime, it is worthwhile to continue the water quantity and quality studies, some biological investigations, and other aspects of the work which are inexpensive and in progress now.

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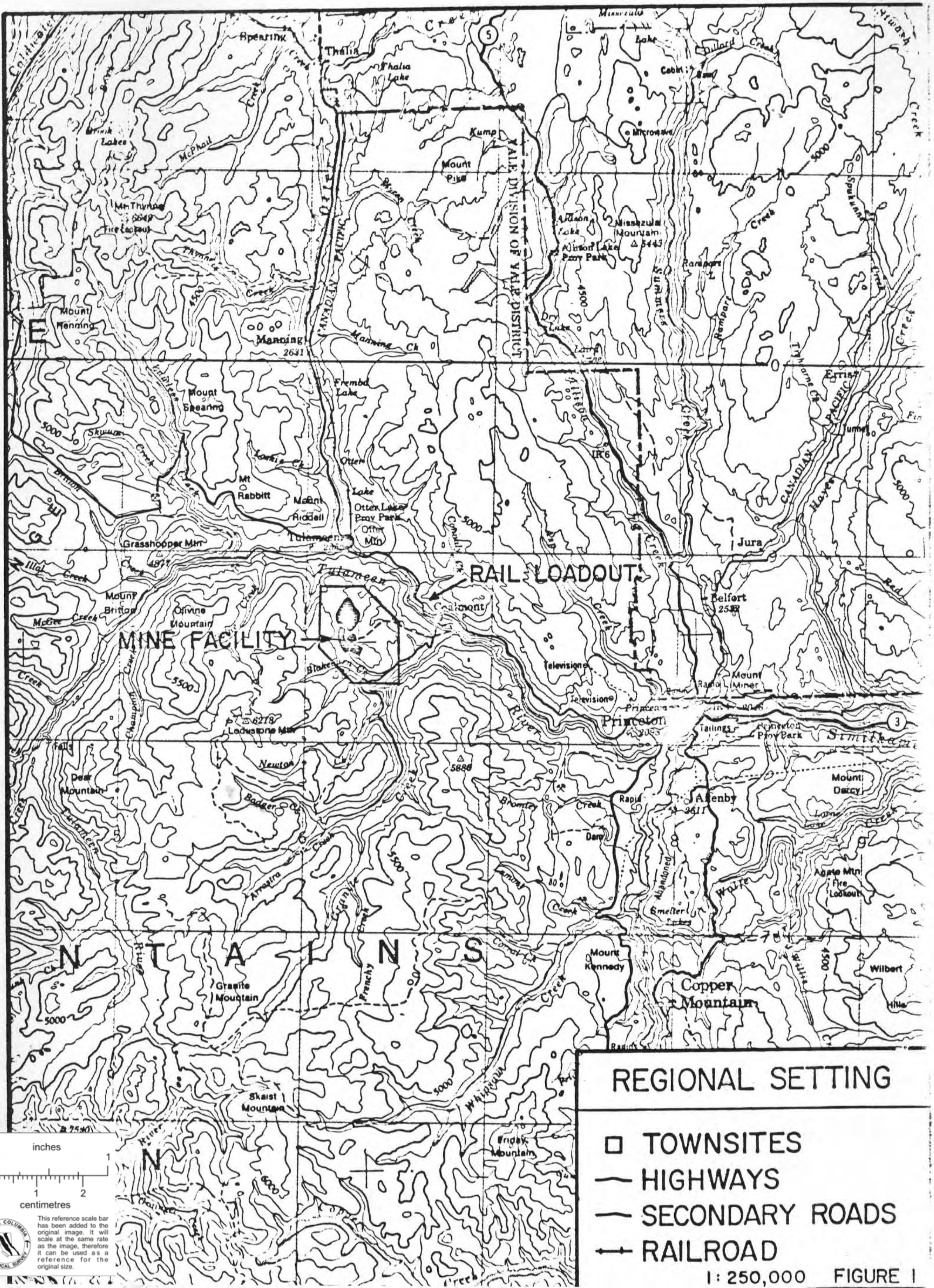
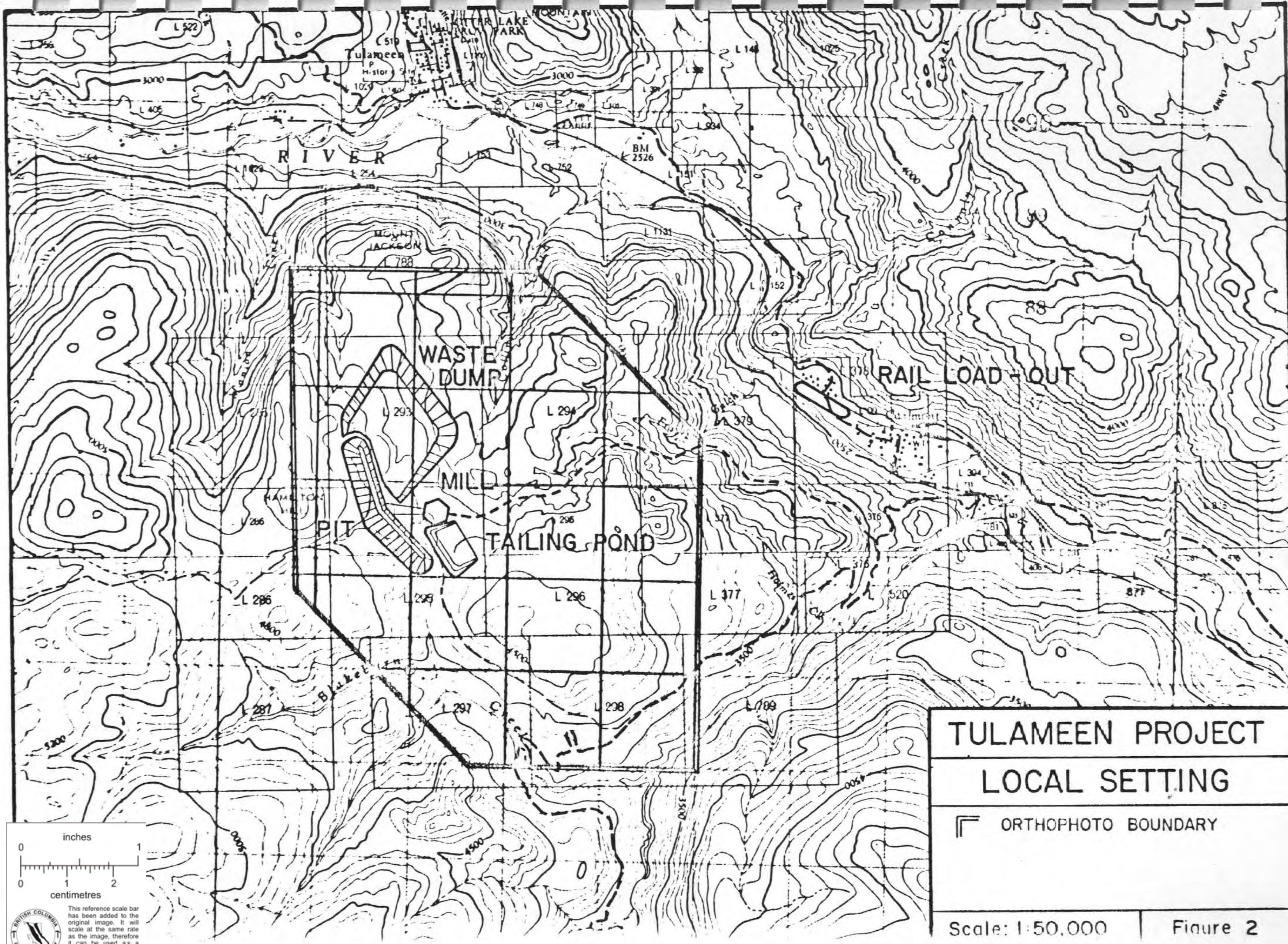

RAIL LOADOUT
MINE FACILITY
Coalmont
Tulameen
Princeton
Allenby
Copper Mountain
Jura
Belfort
Thalia
Manning
Mount Pike
Mount Rabbitt
Mount Riddell
Otter Lake Prov Park
Grasshopper Mtn
Mount Britton
Olivine Mountain
Lodestone Mtn
Granite Mountain
Skaist Mountain
Friday Mountain
Mount Kennedy
Mount Miner
Mount Darcy
Agate Mtn Fire Lookout
Wilbert Hills
Deer Mountain
Mount Henning
Mount Spearing
Mt Thynne Fire Lookout
Missezula Mountain
Allison Lake Prov Park
Princeton Prov Park
Tailings
Smelter Lakes
YALE DIVISION OF YALE DISTRICT
CANADIAN PACIFIC
Tulameen River
Similkameen
N T A I N S
REGIONAL SETTING
TOWNSITES
HIGHWAYS
SECONDARY ROADS
RAILROAD
1:250,000
FIGURE 1



TULAMEEN PROJECT

LOCAL SETTING

ORTHOPHOTO BOUNDARY

Scale: 1:50,000

Figure 2

2.0 DISCUSSION OF SPECIFIC ASPECTS OF BIOPHYSICAL INVESTIGATIONS

2.1 CLIMATE

The nearest government meteorological stations to the property are at Princeton, Merritt, and Osprey Lake. None of these stations are likely to be paricularly representative of weather conditions at the minesite, but they are useful for indicating long range climatic cycles, and the data from these stations will aid in interpretting site-specific data when we begin to collect it. Weather data for the past 20 to 30 years is available for these locations.

Snow depth data has been collected at a station on Hamilton Hill since 1960. This data consists of snow depth and water equivalent values measured 6 times during the winter and is used by the government to predict run-off. This data is particularly useful to us as it relates to the water flow in Blakeburn Creek, the proposed water supply for the development. When we have collected stream flow data through this winter we can compare the flow data with snow pack data for the year and thereby predict possible minimum flow volumes which may be expected in drought years.

At least one full year before the Stage I assessment is prepared we will have to purchase and install a meteorological station at some suitable permanent location at the minesite. Schultz International Ltd. have estimated the cost of this equipment at $5,000.00. It may be possible to obtain the co-operation of Environment Canada in supplying or setting up this equipment, since it would add a useful new location to their weather station grid. This possibility will be investigated after our Prospectus is submitted to the government and it becomes clear that the project is going to proceed.

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2.2 WATER RESOURCE

2.2.1 Water Required by Development

The water balance of the proposed mine and mill as outlined in the Techman Feasibility Report is summarized in Figure 3. It can be seen that the mill will require 5043 Imperial gallons of water per minute during normal operation. Of this total amount, 4980 gpm will be returned to the tailings pond and 63 gpm will be permanently lost from the system as moisture in the coal product and in the reject. An additional 20 gpm or so will be required for domestic use in toilets, showers, etc., providing a total "make-up" water requirement of 83 gpm, assuming total recovery from the tailings pond.

Clearly there will not be total recovery from the tailings pond, since there will be losses through seepage and evaporation, offset perhaps by some influx of surface run-off and groundwater. Techman have allowed 117 gpm for these losses, giving a total average water requirement of 200 gpm. This water requirement may prove to be conservative during the summer months, when evaporation alone may exceed 117 gpm. Rates of evaporation are virtually impossible to predict because of the numerous variables involved, but if we take some average annual evaporation figures from Grey (1973) for various parts of Alberta, and recalculate them for the size of tailings pond suggested in the Techman report, we end up with average evaporation rates ranging from 97 gpm to 183 gpm during the summer months. These figures based on Alberta conditions may not be completely applicable to the Tulameen area, but nevertheless it seems inevitable that evaporation will account for a substantial water loss. If we assume some water loss through seepage as well, then it appears that the peak water requirement might greatly exceed 200 gpm. This peak water requirement will of course occur at midsummer, when the water flow in Blakeburn Creek is at its lowest level.

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TULAMEEN COAL DEVELOPMENT

WATER BALANCE

(IMP. GALLONS PER MINUTE)

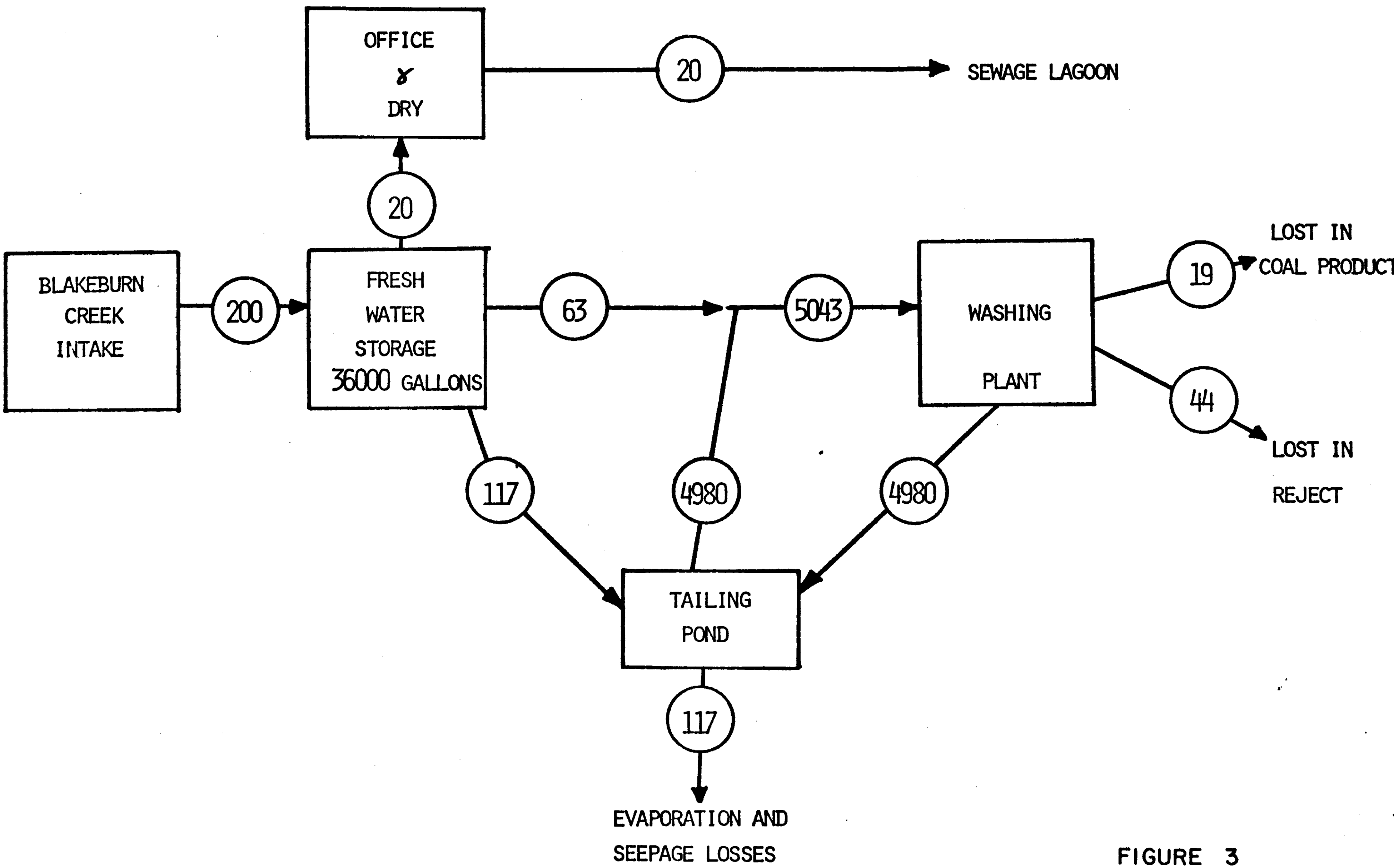

FIGURE 3

The evaporation from the tailings pond can be minimized by reducing the surface area as much as is practical and by leaving or planting a windbreak of trees as close to the perimeter of the pond as possible. Seepage losses can only be eliminated by using pond liners, which may not be economically feasible.

To summarize, the make-up water estimate of 200 gpm suggested by Techman is probably valid as a year round average, but may prove to be rather modest during the summer months.

2.2.2 Water Sources

The best water source for the operation is Blakeburn Creek at a point just below the influx of the last main tributary from the west (site A on Figure 4). This location allows a reasonable pumping distance of 1600 meters and a head of 180 meters, but the water flow at this site during minimum months may not be sufficient to supply the water quantities required. Blakeburn Creek is inaccessible to fish because of canyons and waterfalls close to Granite Creek, and there are no existing water licences on the Creek, so there should be no conflict of water use at this site. A possible disadvantage of this location is that it is downslope from the drainage from both the open pit and the tailings pond, and is therefore vulnerable to pollution from our own operation. An alternate choice is Granite Creek at the junction of Blakeburn Creek, a distance of 3 kilometers from the minesite and 430 meters below it in elevation. A steep canyon on the lower part of Blakeburn Creek makes access to this site very difficult. The only viable third choice would be the Tulameen River, requiring a pumping distance of about 9 kilometers and a head of almost 600 meters.

2.2.3 Stream Discharge Records

The Water Survey of Canada has maintained stream gauging stations on Otter Creek at Tulameen and on the Tulameen River at Princeton for many years. In addition, the B. C. Water Resources Branch has measured the flow rate of Granite Creek at the mouth during the summer months since 1973. The data for Granite Creek is of most benefit to us, since its headwaters includes the Blakeburn Creek tributary and the flow variations in the two creeks should be similar. It is interesting to note that the minimum flow measured in Granite Creek in the three years for which records are available is 2.7 ft^3/sec. (1009 gpm). If this figure is reduced proportionally to account for the smaller Blakeburn drainage area, it suggests that the flow in Blakeburn Creek could drop as low as 126 gpm. As our data base for Blakeburn Creek grows, we should be able to extrapolate to other years using this Granite Creek data.

We have measured the discharge in Blakeburn Creek at periodic intervals since April of this year (Table I). Measurements taken before September are not accurate, since the water velocity had to be estimated. After that date a current meter was used, and the stream bed was modified by the construction of a small cement weir so that the cross sectional area of the water channel could be measured accurately during low flow regimes.

The minimum flow so far measured is 431 gpm on October 19th, but during early August, before the acquisition of the current meter, the flow dropped to about half this amount. It remains to be seen what happens to the pattern of flow during the winter months.

One possible way of overcoming the problem of insufficient water flow in the creek during certain months would be to dam the creek to produce a reservoir. Because of the relatively steep topography around the intake site, a dam of modest height would not impound

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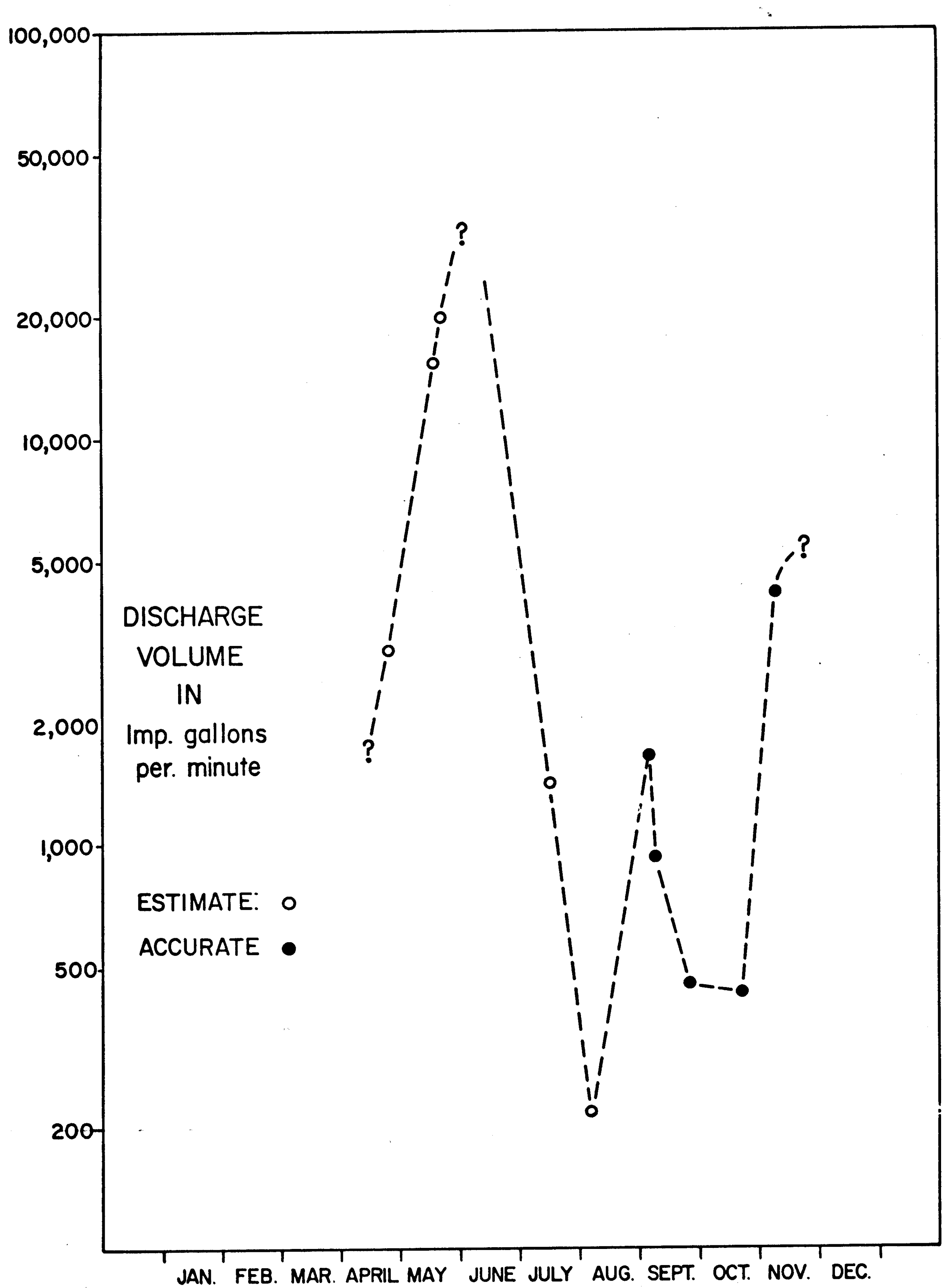

Table I: Instantaneous Discharge Measurements
BLACKBURN CREEK — 1978

a great deal of water. A dam 5 meters high, for example, would produce a reservoir about 80 meters long by 20 meters wide which would contain only 570,000 gallons of water, a two day supply. A dam of this height would be 12 meters long at the top and 5 meters long at the creek level. Because of the terrain at the site, the maximum height dam that is possible, without incurring excessive costs, is 7 meters, and a dam of this height would produce a reservoir impounding about 1,100,000 gallons.

2.2.4 Water Quality

Baseline, pre-development water quality information is required in the Stage I Environmental Report for all streams which may be effected by the proposed development. We have begun to collect water quality data at the following locations (Figure 4):

Site A: Blakeburn Creek at the proposed intake site. This location is down-drainage from both the open pit and the tailings pond, and will be the stream most effected by the operation.

Site B: Granite Creek 1 kilometer above the influx of Blakeburn Creek.

Site C: Granite Creek at the mouth.

Site D: Tulameen River 1 kilometer below the influx of Granite Creek.

Site E: Tulameen River 1 kilometer above the influx of Collins Gulch.

Site F: Collins Gulch about 1 kilometer below the proposed waste dump location.

These locations have been chosen to provide water quality data upstream and downstream from the sources of potential pollution on all effected streams. The samples have been analyzed for most of the parameters suggested in "Guidelines for Coal Development",

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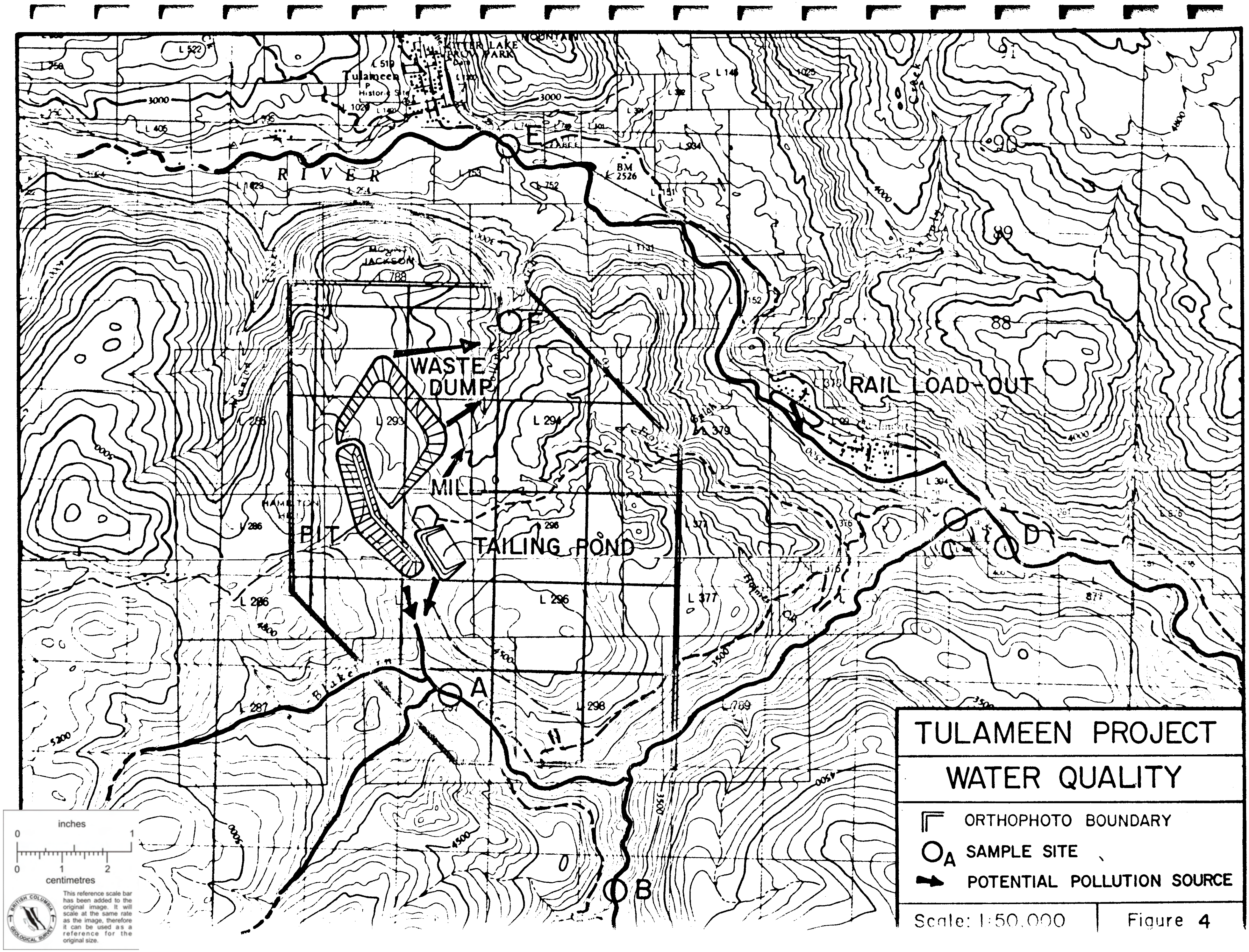
TULAMEEN PROJECT
WATER QUALITY
ORTHOPHOTO BOUNDARY
SAMPLE SITE
POTENTIAL POLLUTION SOURCE
Scale: 1:50,000
Figure 4
WASTE DUMP
MILL
PIT
TAILING POND
RAIL LOAD-OUT
RIVER
Tulameen
A
B
C
D
E
F
inches
centimetres
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BRITISH COLUMBIA GEOLOGICAL SURVEY

TABLE II WATER QUALITY DATA

SAMPLE SITE AND DATE

Water Quality Parameter	Site A 17 May 1978	Site A 14 July 1978	Site B 15 July 1978	Site C 15 July 1978	Site D 15 July 1978	Site E 15 July 1978	Site F 15 July 1978
pH	7.30	7.93	8.10	8.10	7.88	7.93	7.93
Sus Solids (mg/l)	5.6	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Diss Solids (mg/l)	93	77	62	85	62	31	98
Tot Hardness (mg/$CaCO_3$)	40.3	63.2	68.5	73.4	59.1	45.1	61.3
Turbidity (NTU)	2.5	0.37	0.78	0.53	0.33	0.30	1.05
Conductivity (umhos/cm)	70	118	125	133	107	78	148
$NO_2 + NO_3$ (mg/lN)	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	0.02
Tot PO_4 (mg/lP)	0.05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02
SO_4 (ppm)	2	2.5	11.0	4.5	8.2	2.8	8.5
Cl (ppm)	0.60	1.0	0.28	0.50	0.72	0.45	0.60
Tot Fe (ppb)	340	19	37	< 1	< 1	13	27
Tot Mn (ppb)	< 10	5	10	10	10	5	10
Tot Pb (ppb)	< 1	5	2	2	2	1	2
Tot Zn (ppb)	< 1	3	1	2	2	1	< 1
Tot As (ppb)	4.4	2	< 1	< 1	1	< 1	< 1
Tot Cu (ppb)	3	4	< 2	< 2	< 2	< 2	2
Tot Hg (ppb)	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Analysis carried out by: Chemex Labs Ltd.,
212 Brooksbank Ave.,
North Vancouver, B. C.
V7J 2C1

and also for certain metals which might be expected to occur naturally in streams in the Tulameen area (Table II). The results up to now indicate that the streams are completely unpolluted, as would be expected in this sparsely populated and non-industrial area. Until the project is closer to the construction phase, samples will be taken twice each year, once at low water in the late summer and once during the spring run-off. The analytical work is being done by Chemex Labs Ltd., 212 Brooksbank Avenue, North Vancouver, B. C.

2.3 VEGETATION

2.3.1 Introduction

The Tulameen coal property lies on the eastern flanks of the Cascades in an area which is subject to both coastal and interior climatic influences. The transitional nature of the area is reflected in the vegetation, which includes a wide variety of species typical of both wet coastal and dry interior environments. Using the classification system of Krajina (1973), the majority of the development area lies within the "subalpine engelmann spruce-subalpine fir" forest region, with the "interior douglas fir" and "ponderosa pine-bunch grass" communities appearing at lower elevations. Under the system proposed by Rowe (1972), the higher parts of the property lie within the "subalpine forest region", while areas at a lower elevation lie within the "montane forest region".

The elevation differences characteristic of these two forest types are somewhat blurred on the Tulameen property by site differences, with the montane forest favouring more exposed and drier locations, regardless of elevation.

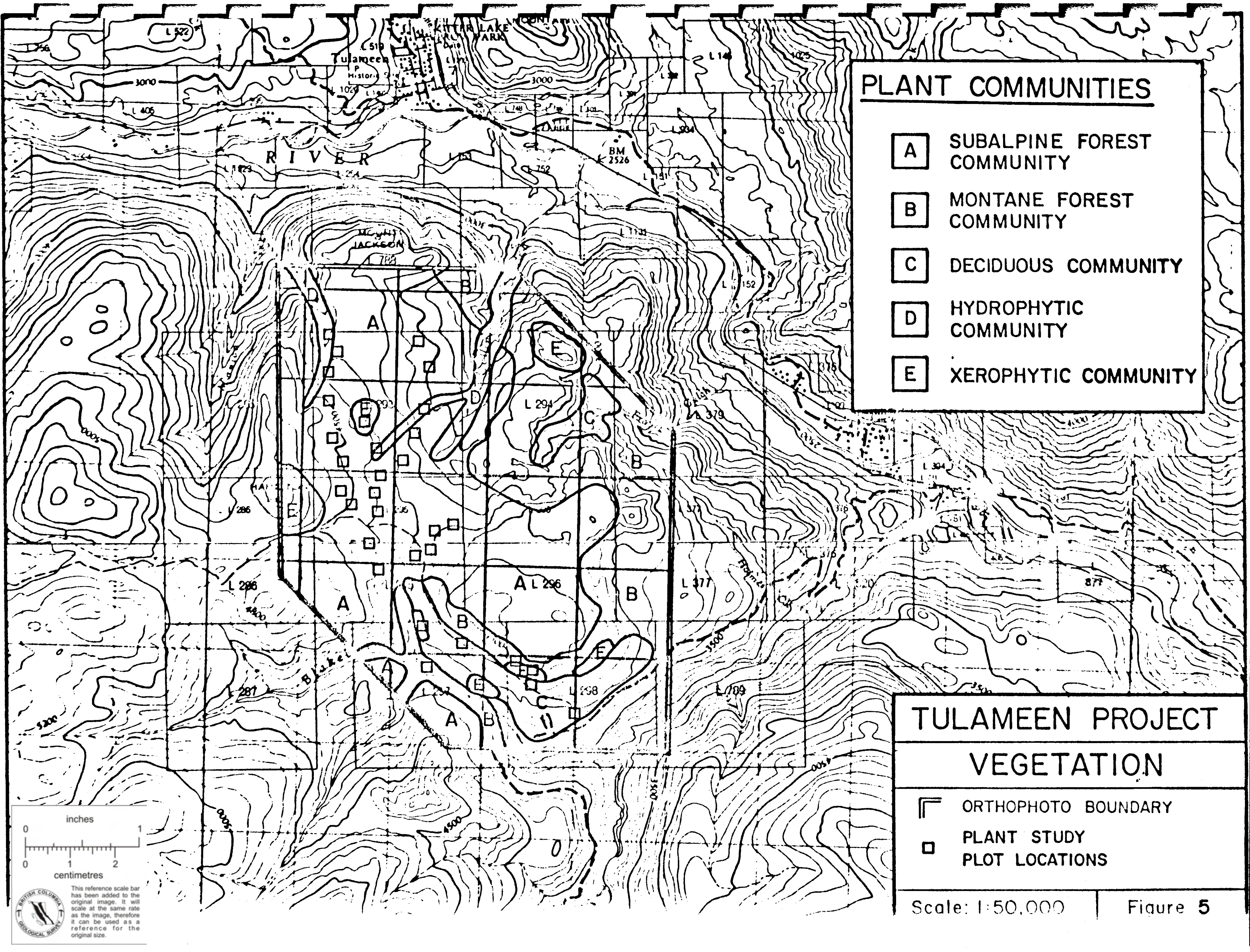
The plant communities which characterize these forest types in virgin areas have been moderately to severely altered in the project area by a long history of human activities, including mining, ranching, and logging. The extensive effect that these activities have had is illustrated by the fact that typical climax forest types occupy less than 20% of the 450 hectare area which will be directly effected by the development. Much of the area appears to be kept in a permanent subclimax stage by the frequent fires and by intensive grazing, which presumably destroys the tree seedlings.

2.3.2 Vegetation Analysis Methods:

The existing plant communities on the property were studied by locating 30 sample plots, 10 meters by 20 meters in size, scattered over the area where the most intensive development will take place. Each plot was subjectively located to include a typical sample of the vegetation at that locality, and every plant community which occurs on the property is represented by two or more plots. The problem of subjectively vs. randomly selected sample plots is discussed in some detail in a paper by Beil (1974), and most of his arguments in favour of the subjective approach apply equally well to our situation. The abundant roads, mine workings, and other man-made clearings in the development area also favour a subjective over a random approach.

In each sample plot, plant species are listed by strata, and cover abundance is estimated for shrub and herb species making up 10% or more of a particular strata. All trees over 10 cm dbh are enumerated by species and diameter. Increment cores and height measurements have been done on one or more mature trees on most plots, and age, volume and average wood production per year for the past 20 year period has been calculated for these trees. In addition, elevation, slope angle and direction, bedrock type, and where possible, soil conditions have been described for each site. The data for each plot is recorded on sheets with a standard format.

A list of all plant species identified to date on the property is included as Appendix Ia.



PLANT COMMUNITIES
A SUBALPINE FOREST COMMUNITY
B MONTANE FOREST COMMUNITY
C DECIDUOUS COMMUNITY
D HYDROPHYTIC COMMUNITY
E XEROPHYTIC COMMUNITY
TULAMEEN PROJECT
VEGETATION
ORTHOPHOTO BOUNDARY
PLANT STUDY PLOT LOCATIONS
Scale: 1:50,000
Figure 5
Tulameen
RIVER
JACKSON
inches
0
1
centimetres
0
1
2
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY

2.3.3 Discussion of Plant Communities

Five plant communities are recognized on the property, each characterized by a distinctive association of species (Figure 5). Of these five communities, two represent widespread forest types which are recognized over large parts of southern B. C., two are local specialized communities on very wet and very dry sites, and one is a somewhat artificial vegetation association which has grown up on disturbed areas around the old mine workings and townsite. The proposed development lies almost entirely within areas occupied by subalpine forest, and the other plant associations would be little effected.

2.3.3.1 Subalpine forest community:

Climax forest communities of this type are characterized by alpine fir and engelmann spruce, and these trees are dominant in small sections of the forest existing on the Tulameen coal property. Most of the area however has been either burned or logged during the past one hundred years, and is now occupied by pioneer subclimax tree communities dominated by lodgepole pine, with alpine fir and spruce regeneration. Relict douglas fir occur on some well drained sites within the subalpine forest community. Much of this community is open and park-like, with the understory consisting chiefly of low shrubs and herbs, most notably *Pachistima myrsinites* and *Vaccinium scoparium*, but damper areas contain thickets of alder and other tall shrubs. Species occuring within this community on the Tulameen property are summarized in Appendix Ib.

2.3.3.2 Montane forest community

This forest type is characterized by open, park-like stands of interior douglas fir and ponderosa pine, with bunch grass and low shrubby vegetation between. Lodgepole pine is a pioneer subclimax tree species in this community as well as in the subalpine forests, and as a result, it is often difficult to clearly distinguish the two forest types on the Tulameen coal property. The montane forest type occupies better drained, more exposed sites, generally below 1200 meter elevation. Species occuring in this community, on the Tulameen property are summarized in Appendix Ic.

2.3.3.3 Deciduous woodland community

This plant association appears to be a relatively permanent subclimax type occupying terrain where montane forest would normally occur. Bebb's willow, douglas maple, and aspen dominate the tree stratum, with mountain alder and water birch occuring in wetter areas. A great variety of shrubs and herbaceous species occur in the understory and in open meadow areas between the tree thickets. This community occupies the abandoned townsite of Blakeburn and other heavily disturbed areas. There appears to be no regeneration of coniferous trees within this deciduous community, except perhaps at the edges where it contacts areas of montane forest. Because of its southern exposure and wide variety of deciduous vegetation, this plant association is an important winter range area for deer and other game species, and is heavily utilized by domestic cattle during the summer months. It also harbours a greater variety of birdlife and small mammals than the other forest types that occur on the Tulameen property. Plant species which have been identified up to now in this plant community are summarized in Appendix Id.

2.3.3.4 Hydrophytic communities: stream margins, seepage meadows, etc.

Locations on the property with high humidity and year round water availability are occupied by a distinctive group of plants which are more typical of the coastal forest than the dry interior. Tree species include douglas fir, engelmann spruce and occasionally red cedar. Mountain alder is always present as a tall shrub or small tree, and red-osier dogwood is also invariably abundant. Other shrub species which occur only or mainly in these wet habitats are devil's club, thimbleberry, water birch, black twinberry, squashberry, and swamp currant. Many herbaceous plants are restricted to these sites as well, and these are listed in detail in Appendix Ie.

2.3.3.5 Xerophytic communities: exposed rocky bluffs, talus slopes, etc.

The driest and most exposed sites on the property are occupied by a relatively restricted group of xeric adapted plants. This habitat type grades into the montane forest community and shares many plant species with it. Typical of this community, and restricted to it, is the western juniper, *Juniperus scopulorum*. Douglas fir, ponderosa pine and aspen also occur on these dry sites but are more abundant and better developed elsewhere. Common juniper, kinnikinnick, and squaw currant are the most abundant shrubs, and all reach their best development in this plant association. Other plants typical of this habitat, and for the most part restricted to it, are columbia lewisia, the fern *Woodsia oregana*, lance-leaved stonecrop, and arrowleaf balsamroot. Other species occuring in this community are summarized in Appendix If.

2.3.4 Summary

The vegetation studies carried out during 1978 represent only a start and more work is needed before we have a thorough knowledge of the structure and relationships of the plant communities that will be effected by the development. Nevertheless, the following conclusions can be safely made at this time:

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1. All plant communities and individual species which have been identified on the property up to now are common and widespread in southwestern B. C.

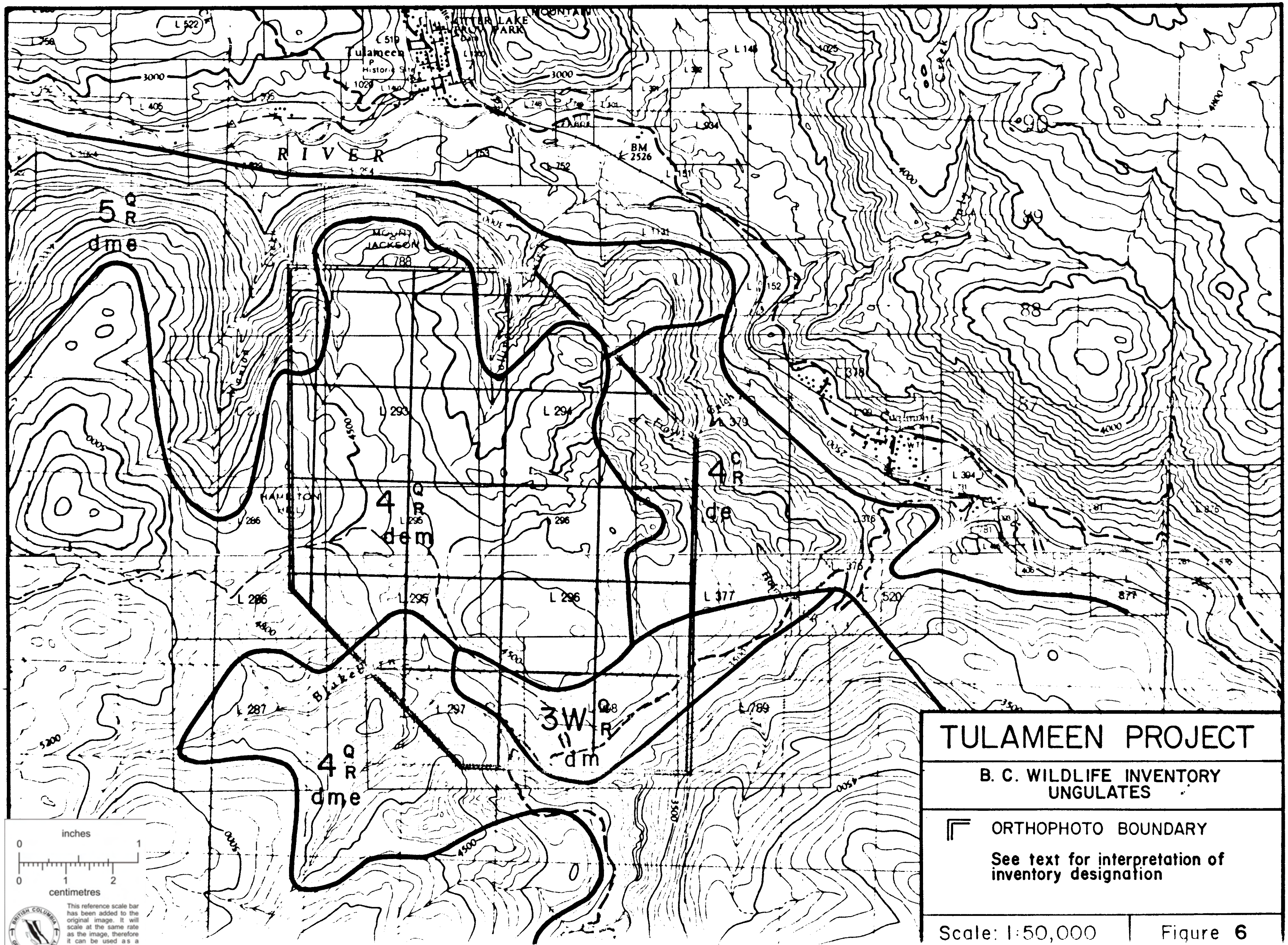
2. Most of the area that will be effected by the new development has already been moderately to severly effected by previous human activities over the past 100 years.

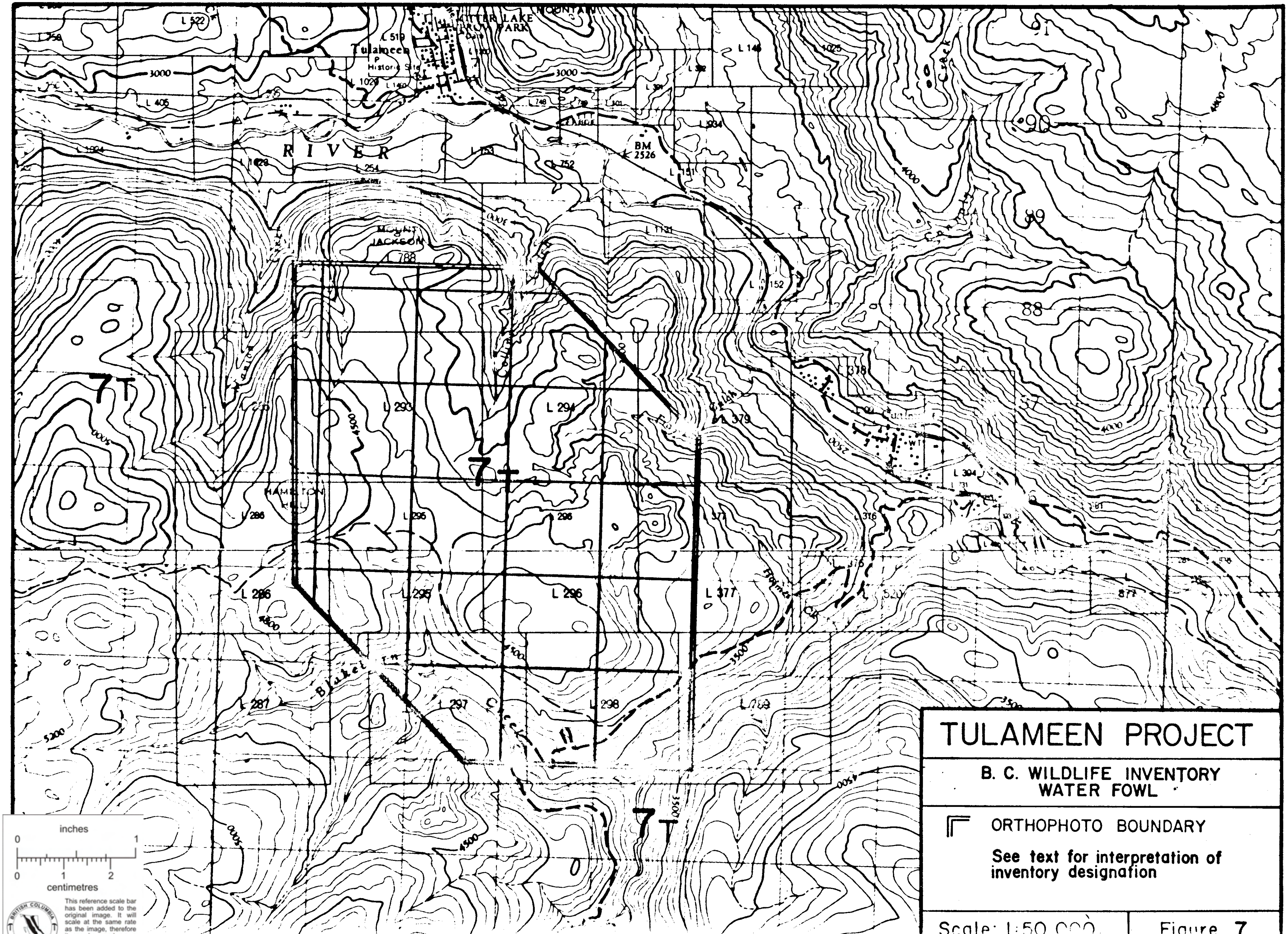
3. Most of the plant communities on the property are at a subclimax successional stage dominated by pioneer species. These same pioneer species, especially lodgepole pine, can be used in our revegetation plans so that we can regenerate in a relatively short period of time a forest similar in character to the one we remove. In other words, we are not destroying climax plant communities which have taken hundreds of years to develop.

4. The plant community of greatest value as range for both wild ungulates and domestic beef cattle is the "deciduous woodland community" which will be little effected by the development. Oddly enough, this plant community dominates in the areas which have been most drastically effected by man in the past, and represents the greatest divergence from a natural plant association.

2.4 WILDLIFE

No investigations of wildlife were carried out during 1978, and the only site-specific data collected this season is a few random observations which were made in the course of other work. Some wildlife information is available from B. C. Wildlife Inventory maps, which attempt to rate geographic areas according to their carrying capacity for ungulates and for waterfowl. These maps do not represent actual existing population levels, but rather define potential population carrying capacities, assuming good. non-intensive wildlife management practises.


TULAMEEN PROJECT
B. C. WILDLIFE INVENTORY
UNGULATES
ORTHOPHOTO BOUNDARY
See text for interpretation of inventory designation
Scale: 1:50,000
Figure 6
Tulameen
RIVER
JACKSON
BM 2526
5 Q R dme
4 Q R dem
4 C R de
4 Q R dme
3W Q R dm
L 293
L 294
L 295
L 296
L 297
L 377
L 287
L 789
inches
centimetres


TULAMEEN PROJECT
B. C. WILDLIFE INVENTORY
WATER FOWL
ORTHOPHOTO BOUNDARY
See text for interpretation of inventory designation
Scale: 1:50,000
Figure 7
Tulameen
Historic Site
RIVER
MOUNT JACKSON
HAMILTON
BM 2526
7T
7T
7T
Blakeburn Creek
Holmes Cr.
3000
4000
4500
5000
3500

On the B. C. Wildlife Inventory ungulate map, Figure 6, the area of the main mine development is classed as $4\frac{Q}{R}$, which indicates moderate to severe limitations for the production of ungulates, due to snow depth and rock outcrops. This area will sustain a population equivalent to 20 to 40 ungulate units per square mile. (Note that a mule deer = 1.2 ungulate units, an elk, 4.0 ungulate units, and a moose, 6.0 ungulate units). Mule deer, elk and moose would be expected to occur in the area, in that order of abundance. The Blakeburn townsite area, which would be little effected by the mine development as now envisioned, has a higher rating of $3W\frac{Q}{R}$. This rating indicates a potential carrying capacity of 40 to 60 ungulate units per square mile, with the same limitations as the last. In addition, this area is an important winter range for deer and moose because of the southern exposure and abundant deciduous vegetation.

Mule deer were commonly observed on the property during April and May in groups of 1 to 12 individuals. Most of the sightings were made in the area classed as $3W\frac{Q}{R}$. During July, deer appeared to be generally absent, only one or two individuals being seen during the month of field work. It seems likely that they mainly utilize the area during the winter months, moving to higher ground as the snow melts in the spring. Droppings of either moose or elk were observed at one location on the property, and tracks of black bears were present in snow during the Spring, but neither species was seen "in the flesh". These casual observations made during this first season would seem to suggest that the ungulate populations presently utilizing the area of the Tulameen coal leases are much lower than the potential carrying capacities suggested by the Canada Land Inventory.

The mammals in the following list have been observed on the property during the field work in 1978:

mule deer	(*Odocoileus hemionus hemionus* Rafinesque)
black bear	(*Ursus americanus* Pallas)

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yellow-bellied marmot	(Marmota flaviventris avara Bangs)
cascade mantled groundsquirrel	(Spermophilus saturatus Rhoads)
columbian groundsquirrel	(Spermophilus columbianus columbianus Ord.)
northwestern chipmunk	(Eutamias amoenis affinis Allen)
red squirrel	(Tamiasciuris hudsonicus streatori Allen)
mountain cottontail	(Sylvagus nuttalli nuttalli Bachman)

The B. C. Wildlife Inventory map for waterfowl capability (Figure 7) rates the area as "7t", which indicates severe limitations due to adverse topography. There are no ponds or lakes in the area of the development and therefore no waterfowl currently utilize it. The tentative reclamation plans call for flooding of the open pit at the termination of mining operations, and if this takes place the value of the habitat for waterfowl will be marginally enhanced.

Bird species identified on the property during 1978 include the following:

robin	(Turdus migratorius)
varied thrush	(Ixoreus naevius)
myrtle warbler	(Dendroica coronata)
white-crowned sparrow	(Zonotrichia leucophrys)
oregon junco	(Junco oreganus)
black-capped chickadee	(Parus atricapillus)
blue grouse	(Dendragopus obscurus)
yellow-bellied sapsucker	(Sphyrapicus varius)
red-shafted flicker	(Colaptes cafer)
dipper	(Cinclus mexicanus)

raven	(*Corvas corax*)
western tanger	(*Piranga ludoviciana*)
sparrow hawk	(*Falco sparverius*)

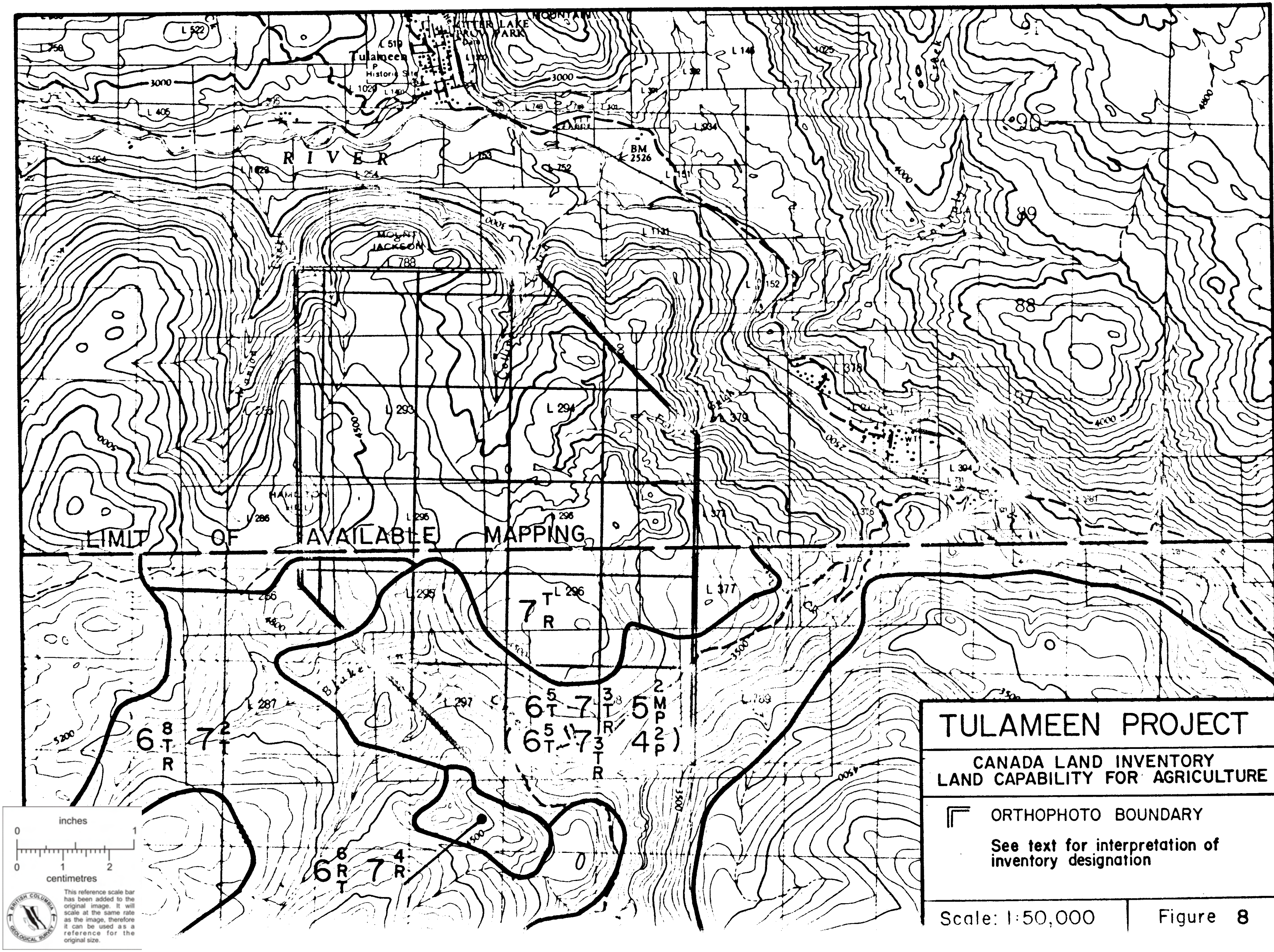
Undoubtably numerous other species of birds utilize the area, but only the above species have been positively identified up to now.

No rare or endangered species of wildlife have been observed on the property, nor are any likely to occur. The value of the area as habitat for wildlife species of recreational significance is moderately to severely limited due to deep snow, rock outcrops, and lack of ponds and lakes. It therefore seems unlikely at this early stage that any serious conflicts will develop between the proposed coal mining operation and the utilization of the area as range for wildlife.

2.5 AGRICULTURE

The area of the proposed mine facility is utilized for grazing at various times of the year by local ranchers in the Coalmont area. The cattle mainly use the open meadowlands around Blakeburn Creek and townsite, but occasionally they stray into the more heavily forested areas east of Hamilton Hill. If our development goes ahead, about 400 hectares of this more marginal grazing land would be removed from ranching use.

The Canada Land Inventory classes the area east of Hamilton Hill as 7^{T}_{R}, which indicates no capability for agriculture or permanent pasture due to topographic constraints and bedrock outcrops (Figure 8). The classification for the Blakeburn Creek valley area indicates that 70% contains some natural pasture, but only a small part of this can be improved by range management practises. The main constraints again are the ruggedness of the topography, the presence of bedrock outcrops, the stoniness of the soil, and the lack of soil moisture.



TULAMEEN PROJECT

CANADA LAND INVENTORY
LAND CAPABILITY FOR AGRICULTURE

Scale: 1:50,000

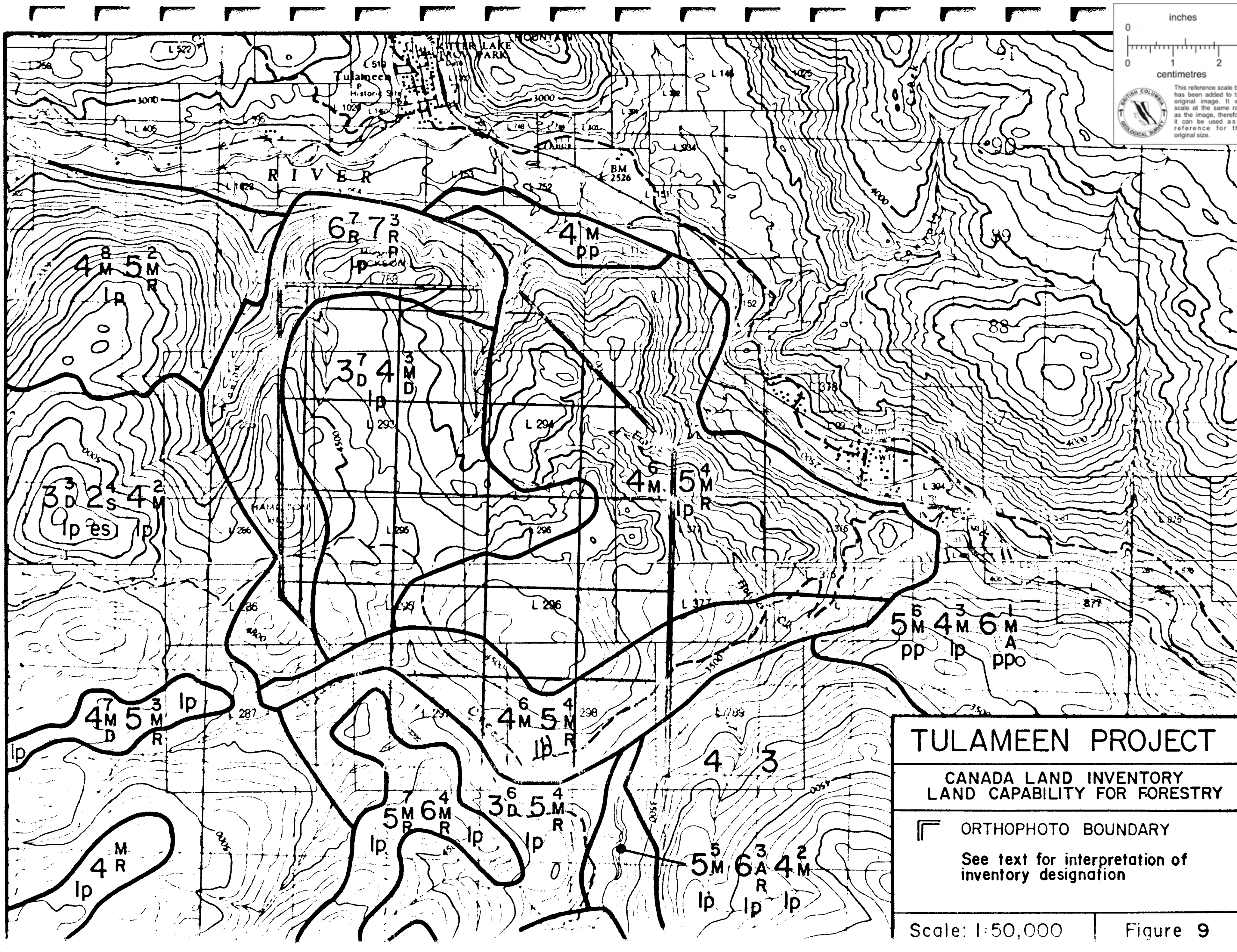
Figure 8

The area in Coalmont which we would use for our rail loading facility appears to lie within an agricultural land reserve. Approximately 4 hectares of valley bottom land would be required for the rail siding and other structures. This new construction would lie to a large extent on land previously used as the terminus of the abandoned aerial tramway, an area which presently is not arable because of numerous derelict building foundations, roadways, and so on. It is doubtful if this land could be economically rehabilitated into productive farmland, and therefore our loading facility does not represent an alienation of arable land from agricultural use, in spite of the land reserve classification.

2.6 FOREST RESOURCES

The B. C. Forest Service produces maps of forest cover at scales of 1" = 1,320' for forest lands in some parts of the province. These maps summarize data on tree species, stocking, age, and height, and in addition estimate site quality for the production of commercial timber. These maps provide a detailed and useful forest inventory which would be difficult to improve on without carrying out work of an excessively detailed nature. The data from these B. C. Forest Service maps has been replotted at our orthophoto scale of 1:5,000 (Map 1).

These forest cover maps have been evaluated for the 450 hectare area which will be effected by the proposed development, and the results for various parameters are discussed briefly here. The site quality is classed as "good" for about 50% of the development area, with 37% classed as "moderate". The balance is considered to be poor or non-productive. About 53% of the area contains no trees of marketable size. In the species classification, 44% of the forest area is dominated by lodgepole pine, and an additional 29% is characterized by mixed forest with lodgepole pine, douglas fir, and spruce. Non-commercial brush makes up 9% of the area and forest dominated by douglas fir and spruce, which are the main commercial species, make up 18%. The forest has not been logged in any systematic way, although


TULAMEEN PROJECT
CANADA LAND INVENTORY
LAND CAPABILITY FOR FORESTRY
ORTHOPHOTO BOUNDARY
See text for interpretation of inventory designation
Scale: 1:50,000
Figure 9
Tulameen
RIVER
Historic Site
BM 2526
HAMILTON HILL
3000
4000
3500
4500
L 522
L 519
L 405
L 1029
L 752
L 293
L 294
L 295
L 296
L 297
L 298
L 377
L 789
L 875

a certain amount of timber has been cut in various parts of the area for use in the former coal mines. The mature trees range in age from 80 to 100 years, suggesting that a forest fire probably swept through the area about 100 years ago. Over all, the area would appear to be only of modest value for the production of commercial timber.

The Canada Land Inventory classes the area as 70% land having moderate limitations to the growth of commercial forest, and 30% land having moderately severe limitations, with the physical restraints being shallowness of soils and lack of soil moisture (Figure 9). The average sustained yield capability is estimated to be 5.2 cubic meters per hectare per year (75 cubic feet per acre per year).

Timber cleared from exploration sites and access roads during 1977 and 1978 was cut and piled at various locations on the property at the request of the B. C. Forest Service, who have attempted to sell it on our behalf. They have been unsuccessful in finding a buyer, mainly due to the poor quality of the logs, and they have now informed us that the timber will be burned. This timber represents a reasonable cross-section of the trees available on our minesite area, and its unsaleability is an indication of the value of the timber resource.

Increment cores, size and species abundances, and other data collected from our vegetation plots are generally consistant with the data on the B. C. Department of Forestry Forest Cover Maps.

2.7 HERITAGE RESOURCES

Three sites of possible historic value are present in the general vicinity of Coalmont and the Tulameen coal property: "the ghost towns" of Granite Creek and Blakeburn, and the Hudson Bay trail.

Granite Creek was founded in 1885 when placer gold was discovered in the vicinity, and for a brief period of time became the third largest

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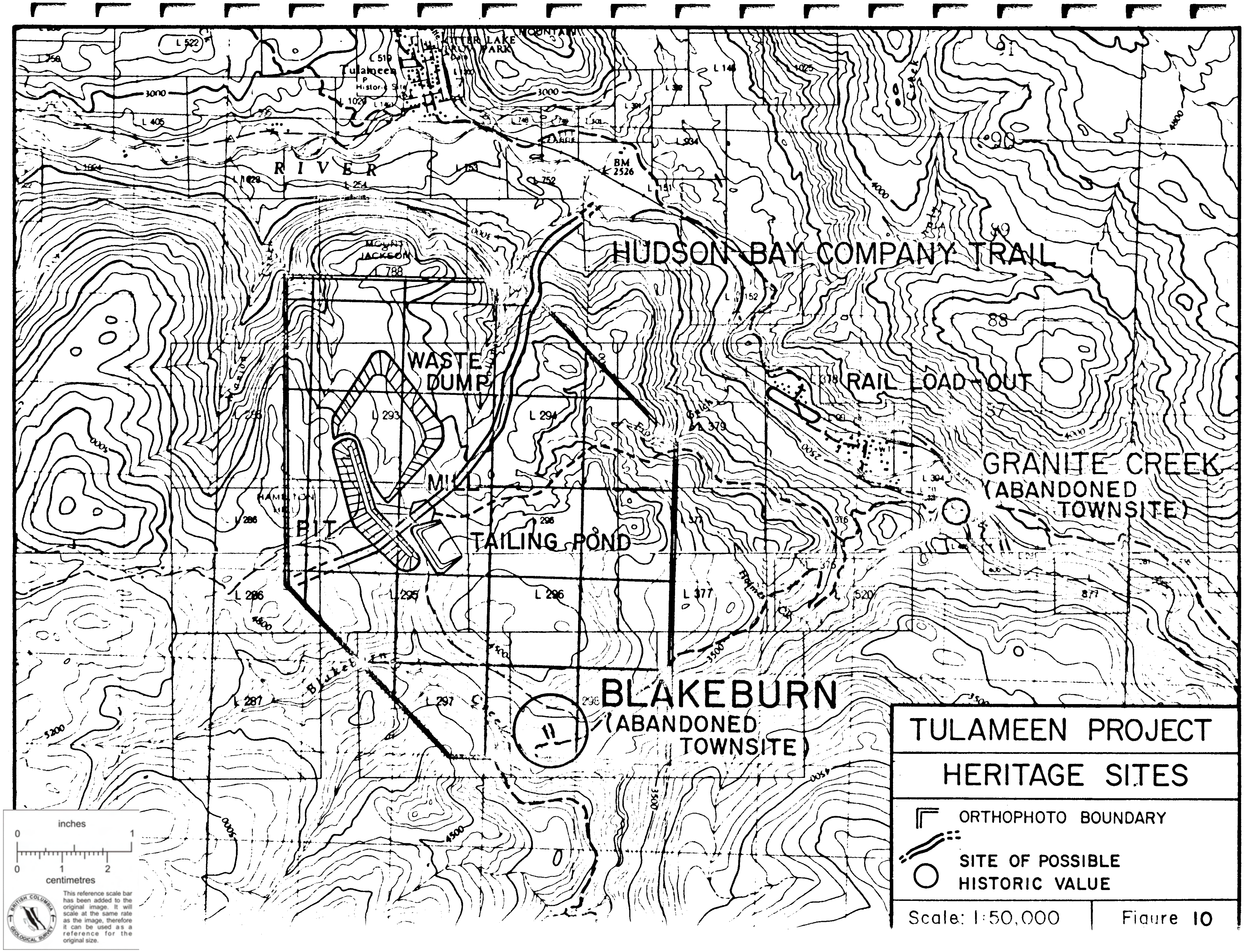

Tulameen
OTTER LAKE
RIVER
MOUNT JACKSON
HUDSON BAY COMPANY TRAIL
WASTE DUMP
MILL
PIT
TAILING POND
RAIL LOAD-OUT
GRANITE CREEK
(ABANDONED TOWNSITE)
BLAKEBURN
(ABANDONED TOWNSITE)
TULAMEEN PROJECT
HERITAGE SITES
ORTHOPHOTO BOUNDARY
SITE OF POSSIBLE HISTORIC VALUE
Scale: 1:50,000
Figure 10
inches
centimetres
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY

city in B. C. It has been abandoned since 1912 but a few log buildings still remain and the site is maintained by the B. C. Forest Service. The site will not be effected in any significant way by our coal development.

Blakeburn was occupied by employees of Coalmont Collieries during a period from about 1918 to 1940, when the mine ceased operations. Most of the houses and other structures were dismantled during the Second World War by people scavenging lumber, and little now remains of the town other than foundations and outhouses. The site would appear to have little historical value. Our mine plan as now envisioned would not effect the Blakeburn townsite, but future expansion to recover reserves left in the old workings would encroach on the edges of the former townsite.

The Hudson Bay trail was one of the main access routes to the interior during the middle to late 1800's, and the trace of the trail is still visible on the ground at some places. The trail has been flagged by the B. C. Historical Society and is used by hikers during the summer months. The trail crosses through the middle of our proposed mine and mill site, and a portion of it amounting to about one mile will be destroyed when mining commences.

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3.0 SUMMARY STATEMENT

The environmental work carried out up to now suggests that the Tulameen coal project is unlikely to have any serious negative impacts on the natural environment. Conflicts of land use are minimal and the costs associated with these conflicts will be minor compared to the economic benefits the development will have on the area. There is every indication that the mine areas can be reclaimed to a satisfactorily level of usefulness and that no permanent or long term damage will be inflicted on the local ecology.

On the other hand, the mine is located in an area that is close to population centers, and is fairly intensively used for recreational purposes. As a result, the development will be subjected to intensive public scrutiny, and much care will have to be exercised in dealing with environmental problems. Aesthetic considerations should play a part in designing the positioning of the mine structures, and landscaping and reclamation of all cleared areas should be carried out concurrently with mining wherever possible. If the topography and existing forest cover in the area of the deposits is used to advantage it should be possible to develop and operate the mine and mill with no degradation of the scenic environment.

Respectfully submitted,

P. M. DEAN

November 22, 1979.

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STATEMENT OF QUALIFICATIONS

I, PETER DEAN, of 965 Lillooet Road, North Vancouver, British Columbia, state that:

1) I graduated from the University of British Columbia in 1967 with a BSc degree, major in Zoology;

2) I attended U. B. C. for 2 additional years in 1970 to 1972 and completed course work equivalent to a BSc major in Geology;

3) That I have been employed continuously as a geologist since 1972;

4) That I am currently employed by Cyprus Anvil Mining Corporation as a geologist and environmental co-ordinator.

P M Dean

PETER DEAN.

INVENTORY OF PLANTS IDENTIFIED TO OCTOBER, 1978

ON TULAMEEN PROPERTY

ACERACEAE:

Acer glabrum Torr. var. douglasii (Hook) Dippel (douglas maple)

ARALIACEAE:

Oploponax horridum (Smith) Miq. (devil's club)

BERBERIDACEAE:

Berberis aquifolium Pursh (tall oregongrape)

BETULACEAE:

Alnus tenuifolia Nuttall (mountain alder)

Betula occidentalis Hooker (water birch)

BORAGINACEAE:

Cynoglossum officionale L. (common hound's tooth)

Hackelia deflexa (Wahlenb.) Opiz. (nodding stickweed)

CAPRIFOLIACEAE:

Linnaea borealis L. (twin flower)

Lonicera utahensis Wats. (Utah honeysuckle)

Lonicera involucrata (Rich.) Banks (black twinberry)

Sambucus cerulea Raf. (blue elderberry)

Symphoricarpos oreophilus (mountain snowberry)

Viburnum edule (Michx.) Raf. (squashberry)

CARYOPHYLLACEAE:

Arenaria macrophylla Hook (big leaf sandwort)

Cerastium arvense L. (field chickweed)

CELASTRACEAE:

Pachistima myrsinites (Pursh.) Raff. (myrtle boxwood)

COMPOSITAE:

Achillea millefolium L. (yarrow)

Anaphalis margaritacea (L.) B. & H. (pearly-everlasting)

Arnica cordifolia Hook (heart-leaf arnica)

Arnica fulgens Pursh. (orange arnica)

Balsamorhiza sagittata (Pursh) Nutt (arrowleaf balsamroot)

Erigeron philidelphicus L. (fleabane)

Hieracium albiflorum Hook (white-flowered hawkweed)

Matricaria matricarioides (Less.) Porter (pineapple weed)

Taraxacum officionale Weber (common dandelion)

Tragopogon dubius Scop. (yellow solsify)

CORNACEAE:

Cornus canadensis L. (bunch berry)

Cornus stolonifera Michx. var. occidentalis (T. & G.) Hitchc. (red-osier dogwood)

CRASSULACEAE:

Sedum lanceolatum Torr. (lance-leaved stonecrop)

CUPRESSACEAE:

Juniperus commonis L. var. montana Ait. (common juniper)

Juniperus scopulorum Sarg. (western juniper)

Thuja plicata Donn. (red cedar)

ELAEGNACEAE:

Shepherdia canadensis (L.) Nutt (soopolallie)

EQUISETACEAE:

Equisetum sp. (horsetail)

ERICACEAE:

Arctostaphylos uva-ursi (L.) Spreng. (kinnikinnick)

Chimaphila umbellata (Prince's-pine)

Pterospora andromeda Nutt. (pinedrops)

Pyrola uniflora L. (wood nymph)

Pyrola asarifolia Michx. (leafless pyrola)

Pyrola secunda L. (one-sided wintergreen)

Vaccinium scoparium Lieberg (grouseberry)

GROSSULARIACEAE:

Ribes cereum Dougl. (squaw currant)

Ribes inerme Rydb. (whitestem gooseberry)

Ribes lacustre (Pers.) Poir. (swamp currant)

Ribes viscosissimum Pursh (sticky currant)

HYDROPHYLLACEAE:

Hydrophyllum capitatum Dougl. (ballhead waterleaf)

Phacelia hastata Dougl. (silver-leaved phacelia)

LABIATAE:

Prunella vulgaris L. (self-heal)

LILIACEAE:

Clintonia uniflora (Schult) Kunth (clintonia)

Erythronium grandiflorum Pursh var. grandiflorum (avalanche lily)

Lilium columbianum Hanson (tiger lily)

Smilacina racemosa (L.) Desf. (false Solomon's seal)

Streptopus amplexifolius (L.) DC. (twisted-stalk)

Veratrum viride Ait. (false hellebore)

LORANTHACEAE:

Arceuthobium campylopodum Engelm. (dwarf mistletoe)

ONAGRACEAE:

Epilobium angustifolium L. (fireweed)

ORCHIDACEAE:

Goodyera oblongifolia Raf. (rattlesnake plantain)

PINACEAE:

Abies lasiocarpa (Hook.) Nutt. (alpine fir)

Picea engelmanni Parry (engelmann spruce)

Pinus ponderosa Dougl. (ponderosa pine)

Pinus contorta Dougl. (lodgepole pine)

Pseudotsuga menziessii (Mirbel) Franco var. glauca (Beissn.) Franco (interior douglas fir)

POLYGONACEAE:

Eriogonum heracleoides Nutt. (parsnip-flowered eriogonum)

POLYPODIACEAE:

Dryopteris austriaca (Jacq.) Woynar. (wood fern)

Woodsia oregana D. C. Eat. (woodsia)

PORTULACACEAE:

Claytonia lanceolata Pursh. var. lanceolata (spring beauty)

Lewisia columbiana (Howell) Robins. (columbia lewisia)

RANUNCULACEAE:

Actea rubra (Ait.) Willd. (baneberry)

Aquilegia formosa Fisch. (red columbine)

Ranunculus glaberrimus Hook. (sagebrush buttercup)

Ranunculus occidentalis Nutt. (western buttercup)

RHAMNACEAE:

Ceanothus velutinus Dougl. (sticky-laurel)

ROSACEAE:

Amelanchier alnifolia Nutt. (serviceberry)

Fragaria vesca L. (woods strawberry)

Fragaria virginiana Duchesne (blueleaf strawberry)

Geum macrophyllum Willd. (large leaved avens)

Potentilla arguta Pursch. (glandular cinquefoil)

Potentilla glandulosa Lindl. (sticky cinquefoil)

Potentilla gracilis Dougl. (cinquefoil)

Prunus virginiana L. (common chokecherry)

Sorbus sp. (mountain ash)

Spirea betulifolia Pall. (birch-leaved spirea)

Rosa nutkana Presl (rose)

Rubus idaeus L. (red raspberry)

Rubus leucodermis Dougl. (black raspberry)

Rubus parviflorus Nutt. (thimbleberry)

SALICACEAE:

Populus tremuloides Michx.	(trembling aspen)
Salix bebbiana Sargent	(Bebb's willow)

SAXAFRAGACEAE:

Saxifraga bronchialis L.	(spotted saxifrage)
Saxifraga punctata L.	(dotted saxifrage)
Tiarella trifoliata L.	(coolwort)

SCROPHULARIACEAE:

Castilleja miniata Dougl.	(sçarlet paintbrush)
Collinsia sparsiflora Fisch. & Mey	(blue-eyed Mary)
Linaria vulgaris Hill	(butter and eggs)
Mimulus guttatus DC.	(yellow monkey-flower)
Pedicularis bracteosa Benth.	(bracted lousewort)
Verbascum thapsus L.	(great mullein)
Veronica americana Schwein.	(brooklime)

UMBELLIFERAE:

Angelica arguta Nutt.	(sharptooth angelica)
Heracleum lanatum Michx.	(cow-parsnip)
Lomatium sp.	(lomatium)
Sanicula graveolens Poepp.	(Sierra sanicle)

URTICACEAE:

Urtica dioica L.	(stinging nettle)

VIOLACEAE:

Viola glabella Nutt.	(stream violet)

SUBALPINE FOREST COMMUNITY

TREE STRATUM:

climax forest:	Abies lasiocarpa and Picea engelmanni
subclimax:	Pinus contorta Pseudotsuga menziessii

TALL SHRUB STRATUM: often absent or sparse

abundant:	Alnus tenuifolia Lonicera utahensis
common:	Salix bebbiana Sorbus sp. Amelanchier alnufolia Spirea betulifolia
less common:	Ribes viscossissimum Ribes lacustre Viburnum edule Cornus stolonifera Rubus parviflorus Shepherdia canadensis Vaccinium membraraceum Juniperus communis Sambucus cerulea *

LOW SHRUB STRATUM:

abundant:	Pachistima myrsinites Vaccinium scoparium
common:	Linnaea borealis
less common:	Berberis aquifolium Rosa nutkana Symphoricarpos oreophilus

HERBACEOUS PLANTS:

abundant:	*Pyrola secunda*
	Arnica cordifolia
	Goodyera oblongifolia
	Lupinus arcticus
common:	*Clintonia uniflora*
	Ozmorhiza chilensis
	Actea rubra
	Aquilegia formosa
	Lilium columbianum
	Pedicularis bracteosa
	Pedicularis racemosa
	Pyrola asarifolia
less common:	*Pterospora andromeda*
	Chimaphila umbellata
	Hieracium albiflorum
	Smilacina racemosa
	Cornus canadensis
	Tiarella trifoliata
	Fragaria vesca
	Fragaria virginiana
	Dryopteris austriaca *

* Species which are present in this community but which did not occur in the study plots.

MONTANE FOREST COMMUNITY

TREE STRATUM:

- climax forest:
  - Pseudotsuga menziessii
  - Pinus ponderosa
- subclimax:
  - Pinus contorta
  - Populus tremuloides

TALL SHRUB STRATUM:

- abundant:
  - Juniperus commonis
  - Amelanchier alnifolia
  - Ceanothus velutinus
- less common:
  - Shepherdia canadensis
  - Rubus idaeus
  - Ribes cereum

LOW SHRUB STRATUM:

- abundant:
  - Arctostaphylos uva-ursi
  - Pachistima myrsinites
- common:
  - Spirea betulifolia
  - Lonicera utahensis
  - Berberis aquifolium

HERBACEOUS PLANTS

- abundant:
  - "grass"
- less common:
  - Achillea millefolium
  - Hieracium gracile
  - Tragopogon dubius
  - Lupinus arcticus
  - Arnica cordifolia
  - Balsamorhiza sagittata *
  - Erigeron philidelphicus *
  - Castilleja miniata *
  - Hieracium albiflorum
  - Taraxacum officionale
  - Cirsium sp.
  - Ranunculus occidentalis
  - Fragaria vesca
  - Fragaria virginiana

DECIDUOUS WOODLAND COMMUNITY

TREE STRATUM:

Salix bebbiana
Acer glabrum douglassii
Populus tremuloides
Alnus tenuifolia
Betula occidentalis

TALL SHRUB STRATUM:

Cornus stolonifera
Amelanchier alnifolia
Lonicera involucrata
Sambucus cerulea
Prunus virginiana

LOW SHRUB STRATUM:

Symphoricarpos oreophilus
Ribes lacustre
Ribes inerme
Ribes viscosissimum
Rubus leucodermis
Rosa nutkana
Shepherdia canadensis
Ceanothus velutinus

HERBACEOUS PLANTS:

"grass"
Fragaria vesca
Fragaria virginiana
Achillea millefolium
Taraxacum officionale
Aquilegia formosa
Urtica dioica
Arenaria macrophylla
Hackelia deflexa *
Cynoglossum officionale *
Potentilla glandulosa *
Potentilla gracilus *
Viola glabella
Anaphalis margaritacea *
Arnica fulgens *
Erigeron philidelphicus *
Matricaria matricarioides *
Hydrophyllum capitatum *
Prunella vulgaris *
Eriogonum heracleoides *
Linaria vulgaris *
Collinsia sparsiflora *
Verbascum thapsus *
Sanicula graveolens *
Tragopogon dubius
Phacelia hastata *
Epilobium angustifolium *
Claytonia lanceolata *
Ranunculus occidentalis
Ranunculus glaberrimus *
Lomatium sp. *

* Species which are present in this community but which did not occur in the study plots.

HYDROPHYTIC COMMUNITIES

TREE STRATUM:

- Picea engelmanni
- Pseudotsuga menziessii
- Thuja plicata

TALL SHRUB STRATUM:

- Alnus tenuifolia
- Betula occidentalis *
- Cornus stolonifera
- Lonicera involucrata *

LOW SHRUB STRATUM:

- Oploponax horridum *
- Viburnum edule
- Ribes lacustre
- Rubus parviflorus

HERBACEOUS PLANTS:

- Cerastium arvense *
- Equisetum sp. *
- Prunella vulgaris *
- Streptopus amplexifolius *
- Fragaria vesca
- Geum macrophyllum *
- Potentilla arguta *
- Saxifraga bronchialis *
- Saxifraga punctata *
- Tiarella trifoliata
- Smilacina racemosa
- Mimulus guttatus *
- Veronica americana *
- Angelica arguta *
- Heracleum lanatum *
- Viola glabella
- Veratrum viride *
- Dryopteris austriaca *

* Species which are present in this community but which did not occur in the study plots.

XEROPHYTIC COMMUNITIES: EXPOSED ROCKY BLUFFS, TALUS SLOPES, ETC.

TREE STRATUM:

Pinus ponderosa
Pseudotsuga menziessii
Juniperus scopulorum
Populus tremuloides

TALL SHRUB STRATUM:

Juniperus commonis
Amelanchier alnifolia
Shepherdia canadensis
Ceanothus velutinus
Rosa nutkana
Ribes cereum
Rubus idaeus
Prunus virginiana *

LOW SHRUB STRATUM:

Arctostaphylos uva-ursi
Pachistima myrsinites
Berberis aquilinium

HERBACEOUS PLANTS:

"grass"
Woodsia oregana
Sedum lanceolatum *
Lewisia columbiana *

* Species which are present in this community but which did not occur in the study plots.

Forest Cover Map