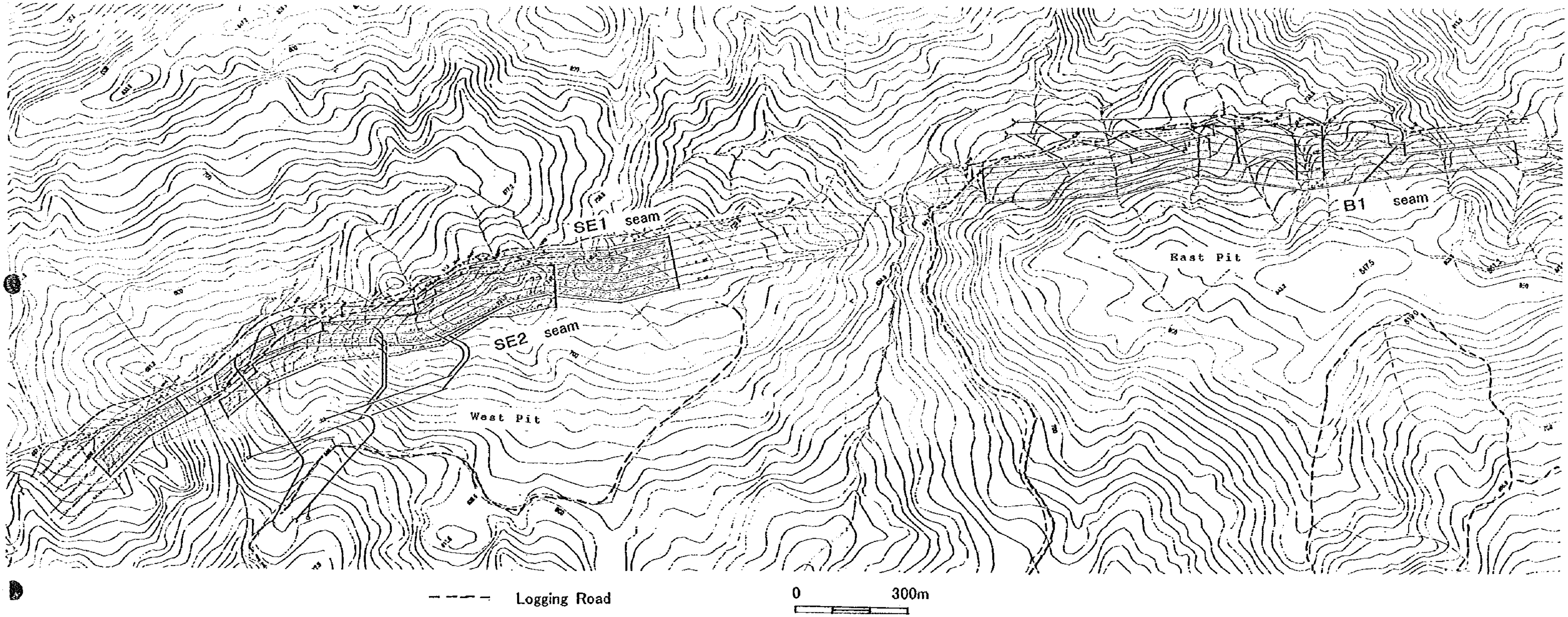


Figure 7-2 General Layout of S.W. Malibau Mine

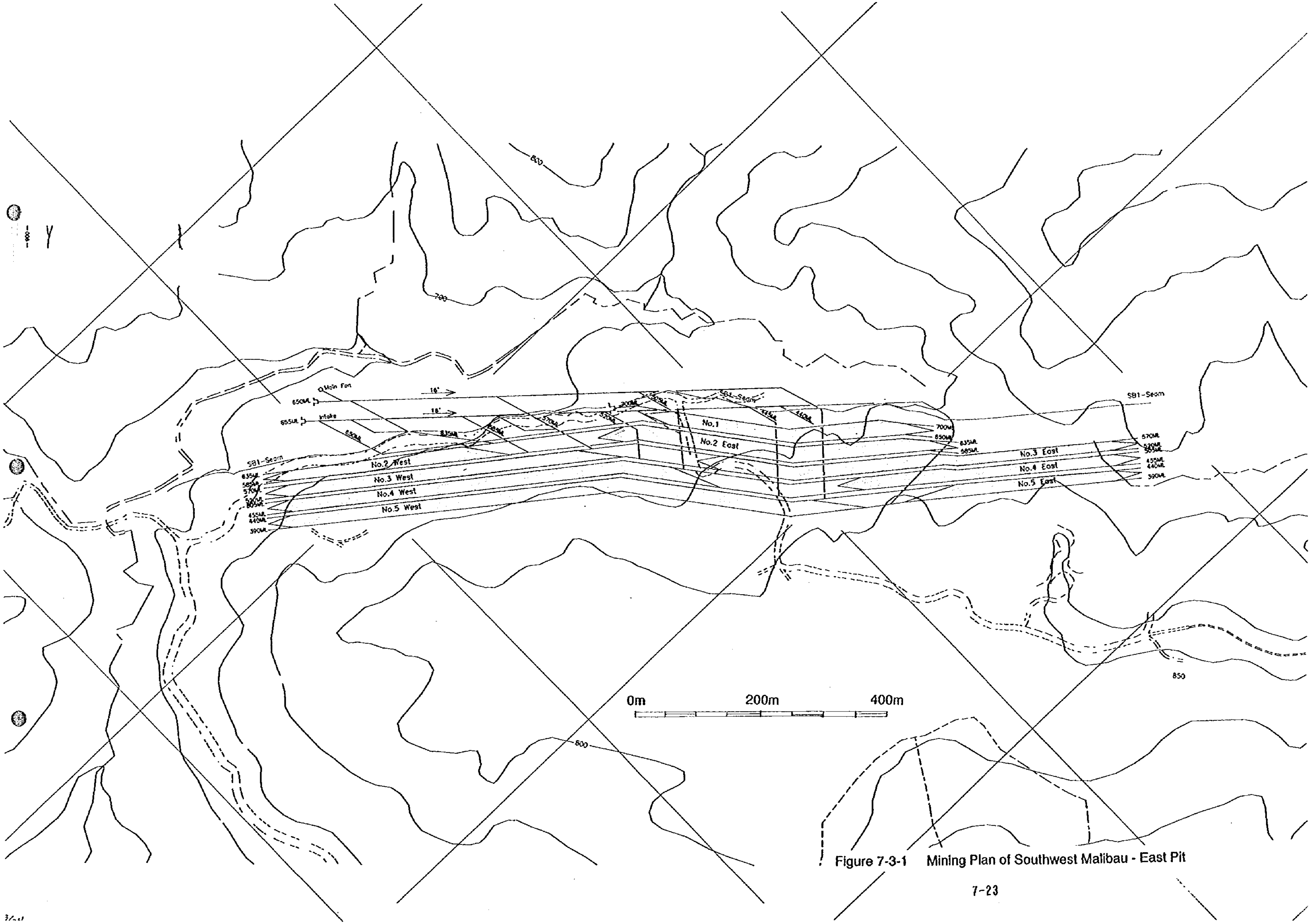


Figure 7-3-1 Mining Plan of Southwest Malibau - East Pit

(3) West Pit (SE1/SE2 Seams)

Figures 7-3-2 and 7-3-3 shows the mining plan of West Pit of Southwest Malibau Mine.

Entries of in-seam roadways at upper five levels (between 680 ml and 550 ml) are opened directly at exposures of the seams after making flat ground around the entries. Roadways of SE1 Seam at lower two levels (565 and 550 ml) are not opened on the surface but connected with those of SE2 Seam in underground through crosscuts, because the positions of entries at these two levels are too close to the river. In-seam roadways of SE2 Seam are used for ventilation, drainage and transportation of both SE1 and SE2 Seams.

For the access to coal seams deeper than 550 ml, three plans have been studied with respect to the combination and the position of horizontal tunnels, slopes and crosscuts. The positions of portals in three plans are selected at almost same places where the topography is relatively gentle and a possible transportation road may be close. Another common matter among three plans is that main horizontal tunnels and slopes are driven in a pair, of which one is used for intake of air and transportation of coal, workers and material and the other is used for exhaust of polluted air. These three plans are illustrated in Figure 7-4 and summarized as follows :

① Plan 1

Development system

Horizontal tunnels (main crosscuts) at 510 and 500 ml → Underground slopes on floor side (16 degrees) → Crosscuts to mining panels at 485, 435, 420 and 370 ml

Length of roadways in rock (m)

Main crosscut, 510 ml	:	695	(including connection road to main fan)
500 ml	:	580	
Intake slope	:	562	(including winding room and slope)
Exhaust slope	:	416	(including winding room and slope)
Crosscuts to panels	:	958	
Total		3,212 m	

② Plan 2

Development system

Slopes (18 degrees)→Crosscuts to mining panels at 500, 485, 435, 420 and 370 ml

Length of roadways in rock (m)

Intake slope	:	453
Exhaust slope	:	291
Crosscuts	:	1,745 (including connection road to main fan)
Total		2,489 m

③ Plan 3

Development system

Horizontal tunnels at 500 ml → Underground slopes on roof side (16 degrees)
→ Crosscuts to mining panels at 500, 485, 435, 420 and 370 ml

Length of roadways in rock (m)

Horizontal tunnels	:	693 (including connection road to main fan)
Intake slope	:	562 (including winding room and slope)
Exhaust slope	:	360 (including winding room and slope)
Crosscuts	:	1,381
Total	:	2,996 m

The comparison of the above three plans is summarized in Table 7-10 below.

Table 7-10 Comparison of Three Plans

	PLAN 1	PLAN 2	PLAN 3
Slope			
Inclination (degrees)	16	18	16
Top of slope	Underground	Surface	Underground
Relative position to coal seam	Floor side	Roof side	Roof side
Length of in-rock roadways (m)			
Slopes	978	744	922
Crosscut and others	2,233	1,745	2,074
Total	3,211	2,489	2,994

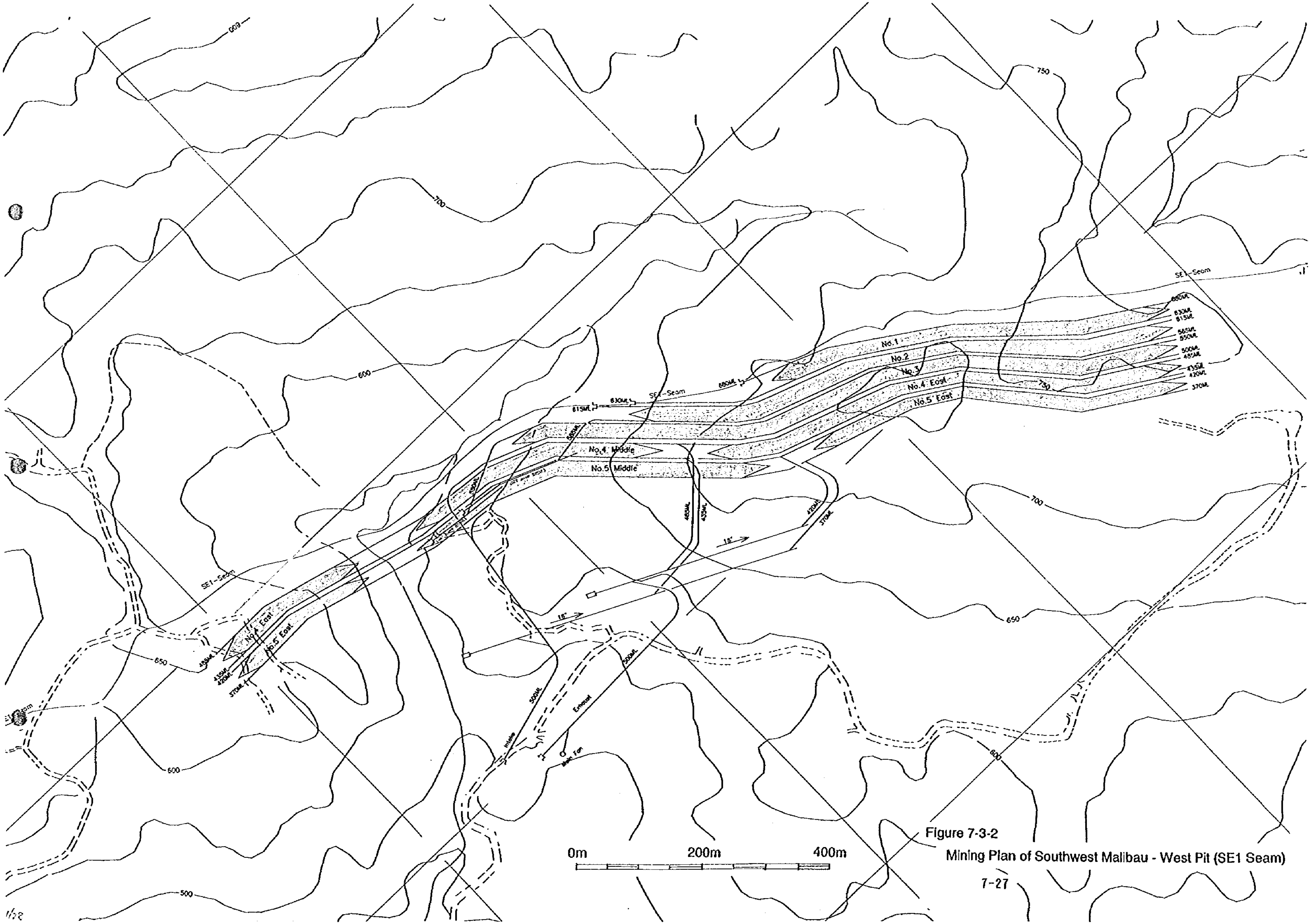


Figure 7-3-2

Mining Plan of Southwest Malibau - West Pit (SE1 Seam)

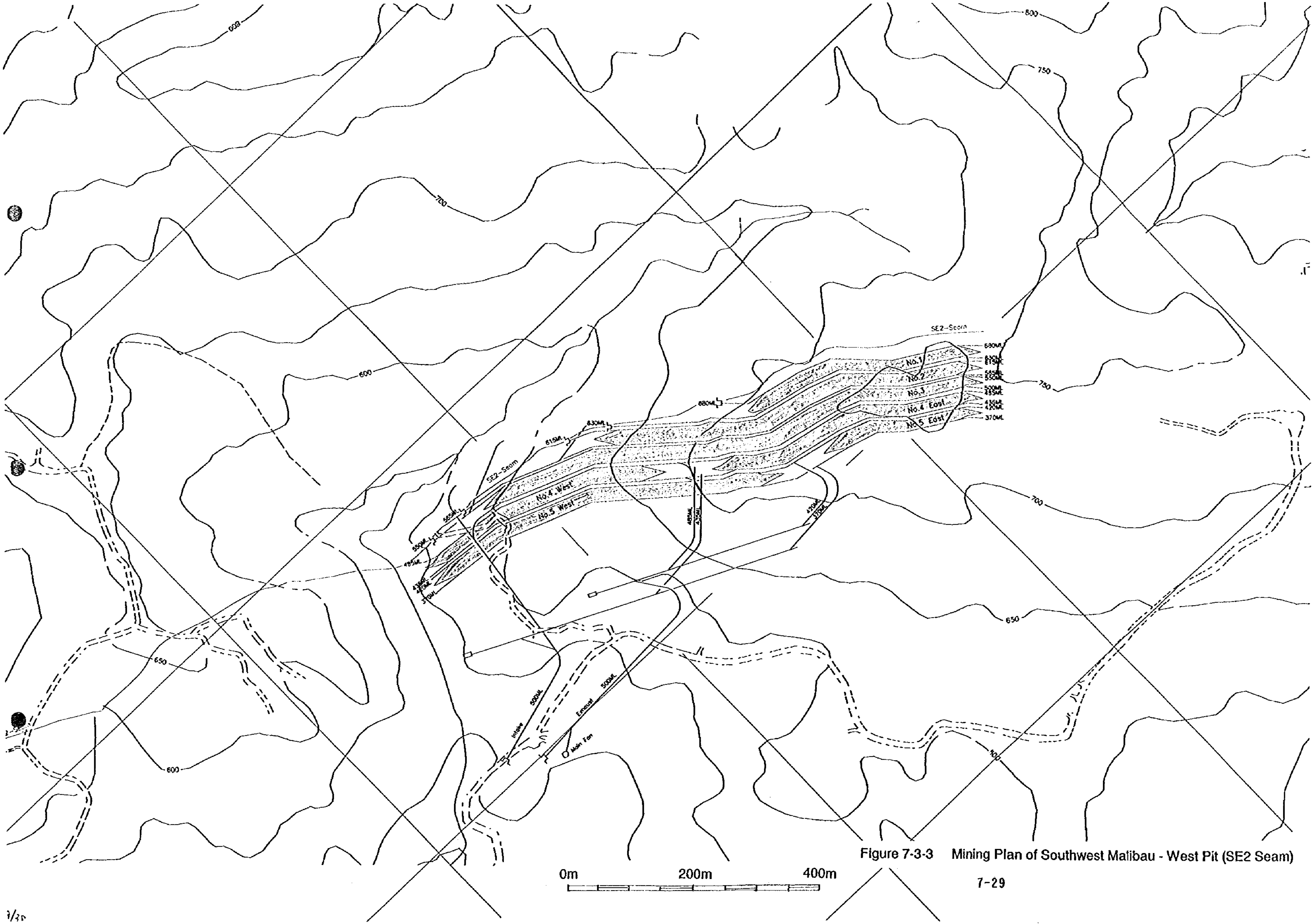


Figure 7-3-3 Mining Plan of Southwest Malibau - West Pit (SE2 Seam)

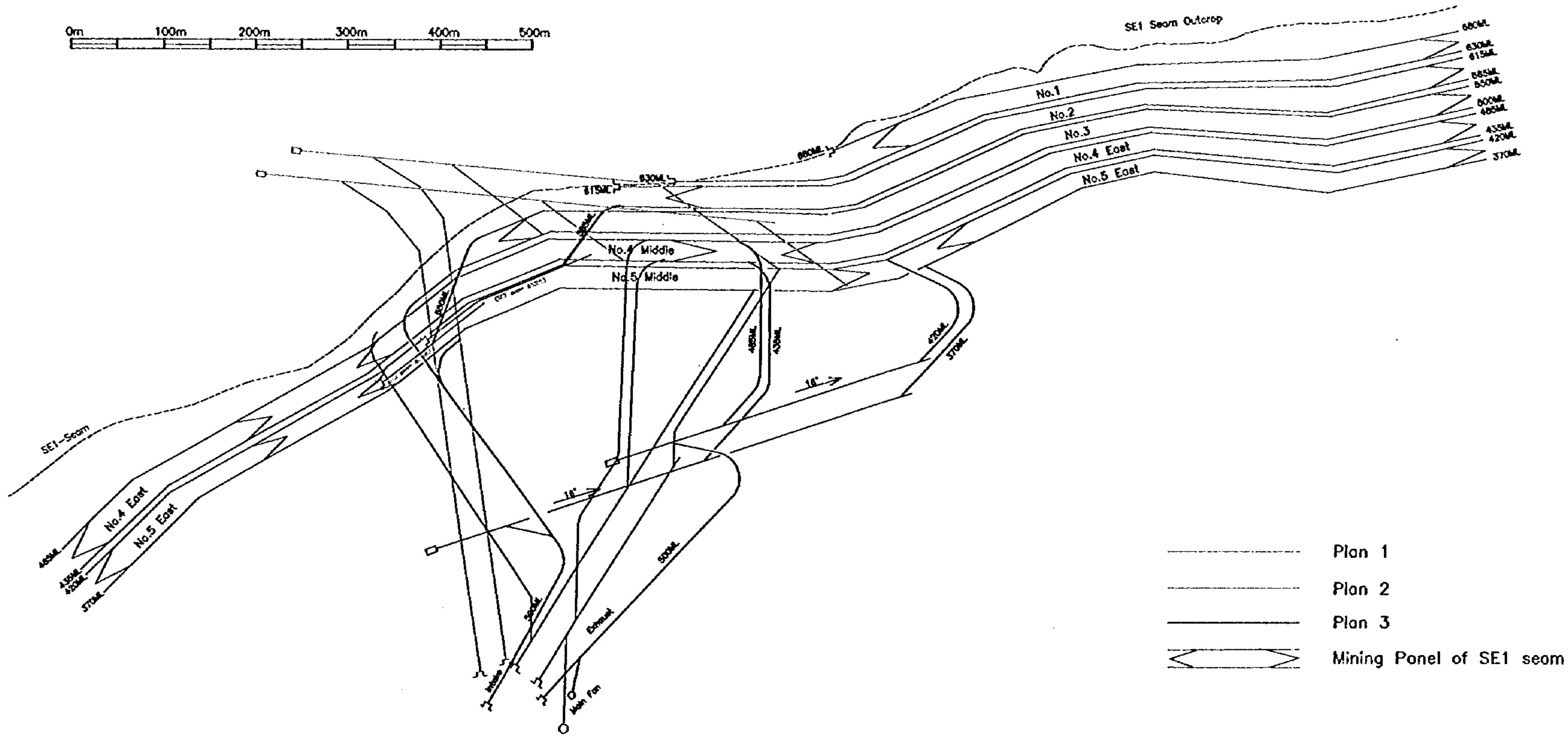


Figure 7-4 Three Plans of Mine Access - West Pit

The above table shows that the total length of in-rock roadways is shortest in Plan 2. However, the plan has two unfavorable points as follows :

(i) Difficulty in ventilation control

In this design, ventilation doors have to be placed in the exhaust slope. When mine cars are hauled up and down in the slope, it is difficult to open and close the ventilation doors and air leakage increases compared with horizontal roadway.

(ii) Problem in further development in future

The present plan is limited to 370 ml in depth. If coal reserves in deeper part are proved to be mineable, it is possible to mine them further with same winding machine. However, the extension of the slopes in the present plan penetrate the coal seams and crosscuts at deeper levels are required to be driven from the floor side. In such condition, a coal barrier has to be left extensively around the penetrated part to maintain the slopes and to prevent spontaneous combustion.

In the present mining plan, therefore, Plan 3 is adopted as a base case for development and production schedule and cost estimate.

(4) Mining Method

In this study, "step-cut and filling method" ("Kakkuchi barai" in Japanese) is applied to steeply dipping coal seams in the area. This mining method has been commonly used in the coal fields in Hokkaido, Japan, which have the similar geological condition with regard to steep dip and thickness of coal seam.

In this method, several working faces, called "kakkuchi", are arranged diagonally in the shape of saw teeth with an inclination of 27 to 30 degrees. Coal is broken by blasting and flows down on the plastic trough placed on the footwall side of a working face. Face is supported by wooden props and beams. Mined out space is filled by crushed rock or waste from washing plant. Normally, two shifts are used for mining and one shift is used for filling. While individual working faces are going downward, the overall mining face advances laterally. An illustration of Kakkuchi mining method is shown in Appendix 4.

In roadway driving, coal is broken by blasting and roof is supported by three pieces of steel beam and legs. The size of roadway section is same as in Silimpopon, namely, 4 m at roof, 5.2 m at floor and 3 m in height.

Coal from mining face and roadway driving is loaded into mine cars and hauled by battery locomotives in horizontal roadways and by a winding machine in slope. Chain conveyors are also used in a part of lower roadways of mining panels.

7.2.3. Coal Production

(1) Work Schedule

(a) Working days and shifts

Working days = 5 days/week x 52 weeks/year − public holiday (10 days)
= 250 days/year

Working shifts = 3 shifts/days x 8 hours/shift

(b) Number of teams in working face

Kakkuchi mining : 5 teams/shift x 3 shifts/day
5 kakkuchis are operated simultaneously in a mining panel of 50 m in vertical distance; 2 shifts for mining and 1 shift for filling.

Roadway driving : 2 teams/shift x 3 shifts/day

(c) Sequence of mine development

Mining operation starts in East Pit first, then shifts to West Pit continuously. When all roadways are completed in East Pit prior to the completion of kakkuchi mining, the roadway driving teams move to West Pit and are engaged in the same work.

(2) Advance Rate and Coal Production Rate

(a) Roadway driving

The advance rate and coal production rate in each type of roadways is as follows :

Table 7-11 Advance Rate and Coal Production in Roadway

	Advance Rate		Coal Production Rate	
	m/shift	m/day	t/m*	t/day
Slope in rock	1.0	3.0	-	-
Crosscut in rock	1.2	3.6	-	-
In-seam roadway	2.4	7.2	8.5 - 7.6 - 7.2	61.2 - 54.7 - 51.8
In-seam raise	2.0	6.0	8.5 - 7.6 - 7.2	51.0 - 45.6 - 43.2

* Depending on mining thickness. The table shows : SB1(1.9m) - SE1(1.7m) - SE2(1.6m)

(b) Kakkuchi mining

The advance rate of kakkuchi face is estimated as follows :

number of times of blasting : 5 times/shift

advance of a face by one blasting : 1.2 m

advance rate of a face : 6 m/shift, 12 m/day

total advance of 5 kakkuchis : 30 m/shift, 60 m/day

Using the above parameters, coal production rate of kakkuchi mining in each coal seam is estimated as shown below :

Table 7-12 Coal Production Rate of Kakkuchi Mining

Pit	Seam	Thickness (m)	Width (m)	Advance (m/day)	Recovery Rate (%)	Coal Production (t/day)
East	SB1	1.9	2.4	60	95	364
West	SE1	1.7	2.4	60	95	326 ⇒ 391*
West	SE2	1.6	2.4	60	95	306 ⇒ 367*

* After completion of roadway development at East Pit in 14th year, one team is moved to kakkuchi face as an additional work force, which improves the productivity by 20%.

(3) Coal Production Schedule

Based on the above standards and assumptions, coal production schedule has been established as shown in Table 7-13. Detailed schedule of roadway development and coal production is shown in Appendix 4.

The following table shows a summary of coal production of each pit

Table 7-14 Summary of Coal Production Schedule

Pit	Roadway		Mining		Total
	Year	Production (t)	Year	Production (t)	Production (t)
East	1 - 6	105,490	2 - 8	605,850	711,340
West	6 - 14	161,160	8 - 19	945,220	1,106,380
Total	1 - 14	266,650	2 - 19	1,551,070	1,817,720

According to this schedule, the average annual production during full production period is about 103,000 tonnes on raw coal basis. Estimated recoverable reserves of about 1.8 million tonnes will be exhausted after nineteen years mining operation.

7.2.4. Work Force

Table 7-15 is a summary of work force on registered basis in the whole mine organization.

Table 7-15 Summary of Work Force

Department	Section	Staff	Workers	Total
Mine Management		2	-	2
Production	Underground	25	155	180
	Washing Plant	4	20	24
	Subtotal	29	175	204
Safety	Subtotal	14	7	21
Mechanical & Electrical	Underground	12	28	40
	Surface	11	22	33
	Subtotal	23	50	73
Mine Engineering	Planning & Control	4	-	4
	Survey & Designing	3	6	9
	Subtotal	7	6	13
Accounting	Warehouse	4	2	6
	Accounting	3	4	7
	Subtotal	7	6	13
Administration	Subtotal	11	35	46
Total		93	279	372

Table 7-13 Production Schedule Southwest Malibau Mine (1,000t)

Pit	Item	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Total
East Pit	No. 1		[145d] 53.1																		53.1
East Pit	No. 2 West		[103d] 37.5	[15d] 5.5																	43.0
East Pit	No. 2 East			[182d] 66.3																	66.3
East Pit	No. 3 West			[53d] 19.3	[125d] 46.4																65.7
East Pit	No. 3 Eeast				[122d] 44.4	[111d] 40.2															84.6
East Pit	No. 4 West					[139d] 50.6	[92d] 33.4														84.0
East Pit	No. 4 Eeast						[154d] 56.2														56.2
East Pit	No. 5 West						[4d] 1.5	[250d] 91.0	[53d] 19.4												111.9
East Pit	No. 5 East								[113d] 41.1	594d											41.1
East Pit	W/F Total		90.6	91.1	90.8	90.8	91.1	91.0	60.5												605.9
East Pit	Develop Total	16.6	17.2	21.5	17.7	11.5	20.9														105.4
East Pit	East Pit Production Total	16.6	107.8	112.6	108.5	102.3	112.0	91.0	60.5												711.3
West Pit	E2 No. 1	306 tons/day							[84d] 25.2	[43d] 13.0 s207d											38.7
West Pit	E2 No. 2										[210d] 64.3 s35d										64.3
West Pit	E2 No. 3												[143d] 74.1	[33d] 10.2 s217d							84.3
West Pit	E2 No. 4 Wst	367 tons/day + 20% EP Production (Increase workers after road develop finish)													[104d] 38.5	[7d] 2.5					41.0
West Pit	E2 No. 4 Est															[120d] 44.1					44.1
West Pit	E2 No. 5 Wst																	[163d] 59.6			59.6
West Pit	E2 No. 5 Est																	[66d] 24.3			24.3
West Pit	E1 No. 1	326 tons/day								[207d] 67.5	[5d] 1.5 s245d										69.0
West Pit	E1 No. 2										[35d] 11.4	[250d] 81.5	[8d] 2.7 s24d								95.6
West Pit	E1 No. 3													[217d] 70.7	[145d] 47.4						118.1
West Pit	E1 No. 4 Wst	331 tons/day + 20% EP Production (Increase workers after road develop finish)														[81d] 26.2					26.2
West Pit	E1 No. 4 Mdl															[68d] 21.9	[64d] 21.3				43.2
West Pit	E1 No. 4 Est																[225d] 76.6	[22d] 6.4			83.0
West Pit	E1 No. 5 Wst																	[6d] 2.0	[71d] 23.8		25.8
West Pit	E1 No. 5 Mdl																		[192d] 63.5		63.5
West Pit	E1 No. 5 Est																		[60d] 18.6	[155d] [illegible]	64.5
West Pit	W/F Total								25.2	80.5	17.2	81.5	76.8	80.9	85.9	94.7	97.9	92.3	97.9	[illegible]	945.2
West Pit	Develop Total						1.1	27.1	19.5	8.3	20.1	20.2	16.1	24.9	17.8						161.2
West Pit	West Pit Total Production						1.1	27.1	45.2	88.8	97.3	101.7	92.9	105.8	103.7	94.7	97.9	92.3	97.9	[illegible]	1,106.4
	SW Malibau Total Product	16.6	107.8	112.6	108.5	102.3	113.9	118.1	105.7	88.8	97.3	101.7	92.9	105.8	103.7	94.7	97.9	92.3	97.9	[illegible]	1,817.7
		Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	

99/07/05

The number of work force allocated in each shift is as follows :

	Shift 1	Shift 2	Shift 3	Total
Staff	59	18	16	93
Workers	135	72	72	279
Mine Total	194	90	88	372

Among the departments in Table 7-15, a breakdown of production department, which plays an important role in mine operation, is given in Table 7-16 and explained below. Details of other departments are shown in Appendix 4.

Production Department

For estimate of registered number of workforce, the following attendance rate is applied, namely, 85% for direct production groups (mining and roadway driving) and 90% for other groups.

(a) Mining (Kakkuchi)

Five kakkuchis are operated in a panel and two workers are placed at each face. Additional two workers are allocated to assist mining work in distributing supporting materials and in loading product coal into mine cars.

Required workers : (5 x 2) + 2 = 12 → 15 registered / shift

(b) Roadway driving

Two roadway faces are driven usually and five workers are required at one driving face.

Required workers : 2 x 5 = 10 → 12 registered / shift

(c) Maintenance

Eight workers are required for maintenance of roadways and other various work.

Required workers : 8 → 9 registered / shift

(d) Transportation

Battery locomotives and mine cars are introduced for transportation in horizontal roadways. Basically, one locomotive is used in upper level road and two are used in

Table 7-16 Workforce of Production Department

Number of workers

		required workers				registered workers			
		shift 1	shift 2	shift 3	total	shift 1	shift 2	shift 3	total
U/G	Mining	12	12	12	36	15	15	15	45
	Headings	10	10	10	30	12	12	12	36
	Maintenance	8	8	8	24	9	9	9	27
	Transportation	11	11	11	33	12	12	12	36
	Fixed shift 1	8			8	9			9
	Office works	2			2	2			2
	Subtotal	51	41	41	133	59	48	48	155
W/P	Hand picking	12			12	13			13
	Operaters	6			6	7			7
	Subtotal	18			18	20			20
Department total		69	41	41	151	79	48	48	175

Number of staff (registered)

			shift 1	shift 2	shift 3	total
Depatment head			1			1
U/G	Superintendent		1			1
	Section chief		1			1
	Group chief		1	1	1	3
	General staff	Mining	2	2	2	6
		Heading	2	2	2	6
		Maintenance	1	1	1	3
		Transportation	1	1	1	3
		Fixed shift 1	1			1
	U/G subtotal		10	7	7	24
W/P	Superintendent		1			1
	Group chief		1			1
	General staff		2			2
	W/P subtotal		4			4
Department total			15	7	7	29

lower level. A battery locomotive is run by one operator and one conductor. For transportation in a slope, two conductor are required. Additionally, one battery locomotive is used in various work on the surface with one operator, one conductor and one helper. Therefore, the total number required is :

Horizontal road	:	(1 x 2) + (2 x 2) = 6	
Slope	:	1 x 2	= 2
Surface	:	1 x 3	= 3
Total	:		11 → 12 registered / shift

(e) Fixed shift 1

This group is engaged in various important work only in first shift and consists of eight skilled workers.

(f) Washing plant

In the present study, introduction of a simple washing plant is planned together with hand-picking system. One shift operation is enough for processing total run-of-mine coal judging from the planned capacity of the facilities.

Required workers : 12 (hand-picking) + 6 (plant operator)
= 18 → 20 registered / shift

The requirement of a washing plant is discussed later in the next section.

7.3. Estimate of Product Coal Quality

Evaluation of general coal quality in the study area has been previously stated in the section 6.2. based on the analytical results of all samples. In the mine development study, mining area and coal seams are selected and mineable thickness is limited. In this section, probable quality of product coal from proposed mine is estimated based on the mining plan and some assumptions.

7.3.1. Analytical Data

(1) Silimpopon Area

Only one analysis of Queen Seam is available in Phase 2 study. In order to increase the number of data, two data out of previous analytical results shown in Table 6-3 are also used to estimate the average coal quality of the Queen Seam as shown in Table 7-17.

Table 7-17 Analysis of Queen Seam

	KK011	Phase I*	1952	Average
Moisture (%)	1.7	1.0	1.6	1.4
Ash (%)	17.3	15.3	12.4	15.0
Volatile Matter (%)	39.0	42.9	44.8	42.2
Fixed Carbon (%)	42.0	40.8	41.2	41.3
Calorific Value (kcal/kg)	6,564	6,849	7,228	6,880
Total Sulphur (%)	1.83	2.14	2.52	2.16

* weighted average of samples of three plies

(2) Southwest Malibau Area

SB1 Seam in the east and SE1 and SE2 Seams in the west are selected as mineable coal seams and maximum mining thickness is limited to 2.4 m. The analytical data of these seams shown in Table 7-18, which are located within the mine planning area, were extracted from Table 6-1-2 and used for estimate of product coal quality.

Table 7-18 Analysis of Mining Seam in SW Malibau

Sample	YK031	SK015	YK027	SK025	SW37	SW36	SK020	NK141	NK104	Ave-rage
Seam	SE2	SE2	SE2	SE1	SE1	SE1	SE1	SB1	SB1	
Moist	4.8	4.4	3.2	4.9	3.3	2.9	3.5	4.4	3.7	3.9
Ash	9.4	6.2	4.8	7.6	15.7	2.9	15.2	5.1	21.2	9.8
V.M.	38.4	40.7	44.4	38.6	38.1	45.1	37.5	42.4	35.9	40.1
F.C.	47.4	48.7	47.6	48.9	42.9	49.1	43.8	48.1	39.2	46.2
kcal/kg	6,302	6,891	7,246	6,554	6,213	7,397	6,306	6,879	5,650	6,604
T.S.	1.27	0.36	0.45	0.72	0.97	0.65	0.41	0.27	0.87	0.66

7.3.2. Method of Estimate

Estimate of product coal quality of Silimpopon and Southwest Malibau mines has been made based on the average values in the above tables. However, the following adjustments and assumptions were applied to estimate the quality of run-of-mine and final products.

(1) Moisture content and calorific value

Because all samples were taken from outcrops, the analytical results have been possibly affected by weathering to some extent. In section 6.1, it is presumed that the moisture content of unweathered coal is 1.5% in Silimpopon and 3% in Southwest Malibau. According to this presumption, Silimpopon coal is regarded as unweathered, while Southwest Malibau coal is regarded as weathered.

The following modification was made to the average analytical values of Southwest Malibau coal in order to remove the effect of weathering :

Moisture (%) : 3.9 → 3.0, Ash (%) : 9.8 → 9.9,

Calorific value (kcal/kg) : 6,604 → 6,750

Calorific value is known from the relationship with ash content (see Figure 6-1).

(2) Out-of-seam dilution (OSD)

During mining operation, mined coal is mixed with rock from outside of coal seam, mainly from the roof of the seam. Roof rock is mostly mudstone, partly carbonaceous, in both mine planning areas. At kakkuchi mining in Southwest Malibau area, some portion of filled rock in mined out space also gets into mined coal. In this study, the amount of OSD and its effect on coal quality is estimated on the following assumptions :

(a) Quality of raw coal : Silimpopon - 15% ash, 6,900 kcal/kg, specific gravity 1.32
SW Malibau - 10% ash, 6,750 kcal/kg, specific gravity 1.37

(b) Amount of OSD : 10% of raw coal in volume

(c) Quality of OSD : ash - 80%, 500 kcal/kg, specific gravity - 2.2

By applying the above parameters, quality of run-of-mine including OSD is estimated as shown in Table 7-19.

Table 7-19 Estimated Quality of Run-Of-Mine

	SILIMPOPON			SW MALIBAU		
	Raw Coal	OSD	ROM	Raw Coal	OSD	ROM
Volume	100	10	110	100	10	110
Spec. gravity	1.37	2.2	1.45	1.32	2.2	1.40
Weight	137	22	159	132	22	154
Ash %	15	80	25	10	80	20
kcal/kg	6,900	500	6,000	6,750	500	5,850

As indicated in the above table, ash content increases by 10% and calorific value decreases by 900 kcal/kg by contamination of 10% OSD (in volume).

(3) Hand-Picking and Washing Plant

As shown in Table 7-19, calorific value of run-of-mine is estimated at 6,000 kcal/kg in Silimpopon and 5,850 kcal/kg in Southwest Malibau. In this study, the calorific value of final products is expected to be at the level of 6,500 to 6,700 kcal/kg, although the coal of lower calorific value is certainly used in various markets.

In order to achieve the above target, installation of a washing plant is necessary supported by hand-picking process. The following is an idea of coal cleaning system in this study.

Screening	:	± 40 ~ 50 mm
		Oversize (20% of run-of-mine) → hand-picking
		Undersize (80%) → washing plant
Washing plant	:	Type - Baum Jig, capacity - 60 t/hour
Overall capacity	:	(60 + 15) t/hour x 6 hours/shift = 450 t/shift
		1 shift/day - 450 x 250 = 112,500 t/year
		2 shift/day - 450 x 2 x 250 = 225,000 t/year
Working shift	:	Silimpopon - 2 shifts/day, SW Malibau - 1 shift/day

In the above process, the overall yield, which is equivalent to final products (t) divided by run-of-mine (t), is estimated at 85%.

7.3.3. Coal Quality of Final Products

Based on the above assumptions, coal quality of final products was estimated. Possible specification of the final products from each mine is shown in Table 7-20 below :

Table 7-20 Estimate of Coal Specification (air dried b.)

	SILIMPOPON	SW MALIBAU
Moisture (%)	1.5	3.0
Ash (%)	17.0	13.0
Volatile Matter (%)	41.2	39.0
Calorific Value (kcal/kg)	6,700	6,500
Total Sulphur (%)	1.5	0.5
Nitrogen (%)	<1.2	<1.4
Ash Fusibility (IDT.℃)	>1,350	>1,250

Owing to a lack of reliable analytical data on sulphur forms, total sulphur content in the table was estimated on the assumption that 30% of total sulphur in mined coal could be removed by washing process.

The above specification is an example and shows the high case in calorific value. The coal of lower calorific value is also usable in various markets and can be produced by modification of processing system.

7.4. Transportation of Coal

The product coal from the mine is transported by truck and barge in this study. The possible transportation routes are shown in Figure 7-5.

In Silimpopon area, the loading point into barge is supposed to be at an old wharf which was used in former Silimpopon Colliery and is located at 7 km south of proposed mine portal in the present mine plan. A 7 km road is to be constructed along the track of old railway. The barge goes down the Silimpopon River to Cowie Harvour.

In Southwest Malibau area, coal is loaded into barge at Kalabakan. The total distance from proposed mine site to Kalabakan is 83 km, of which first 8 km is a track of old logging road in the mountain and to be reconstructed at adequate slope and width for transportation by truck. The remaining 75 km is a wide and flat gravel road which is being used as a main route for log transportation at present.

Kalabakan is a nearest village to the study area and a center of timber activities. Some sawmills and timber loading into barges are in operation. In the present plan, coal is also transferred to barges and go down Kalabakan River to Cowie Harbor.

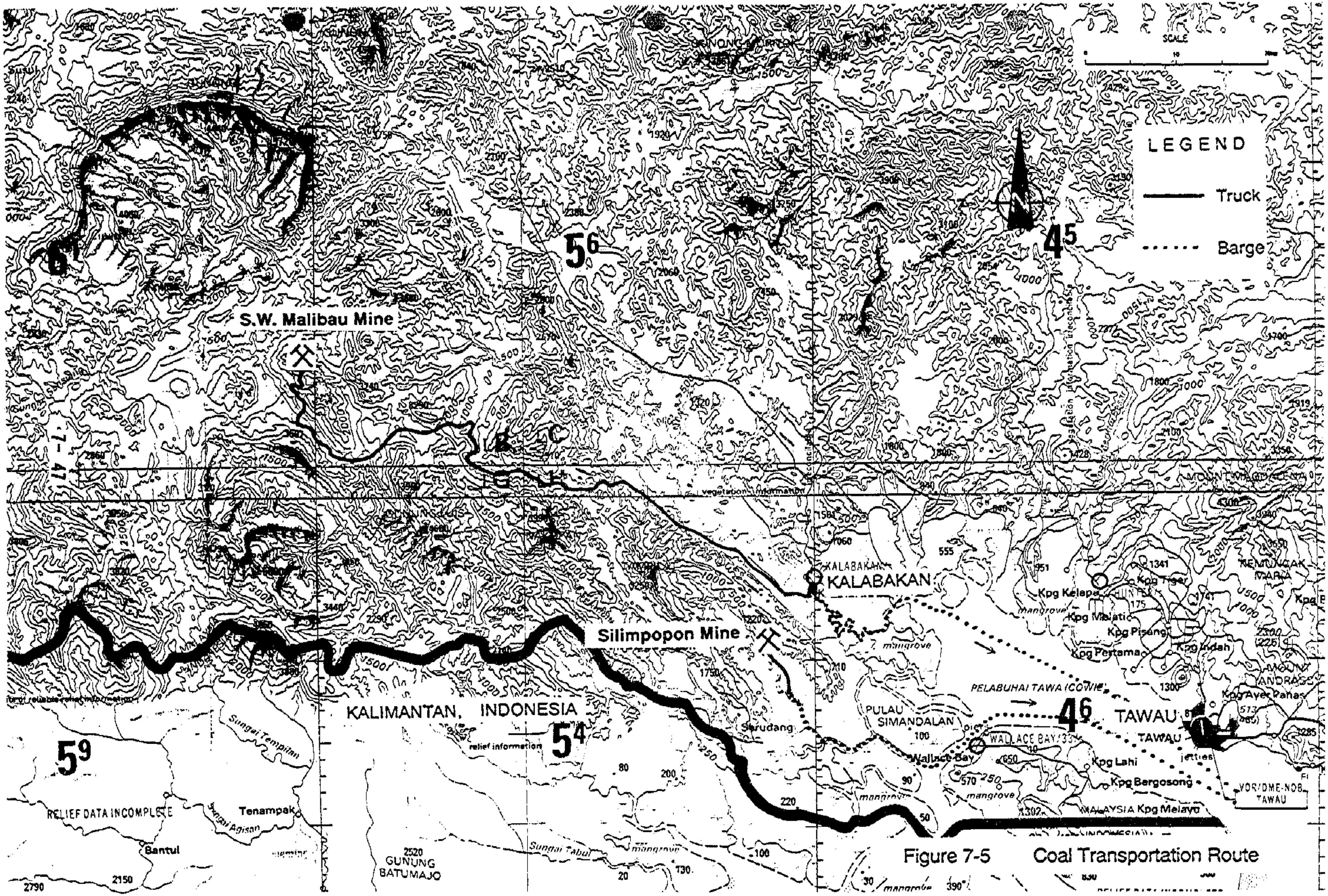


Figure 7-5 Coal Transportation Route

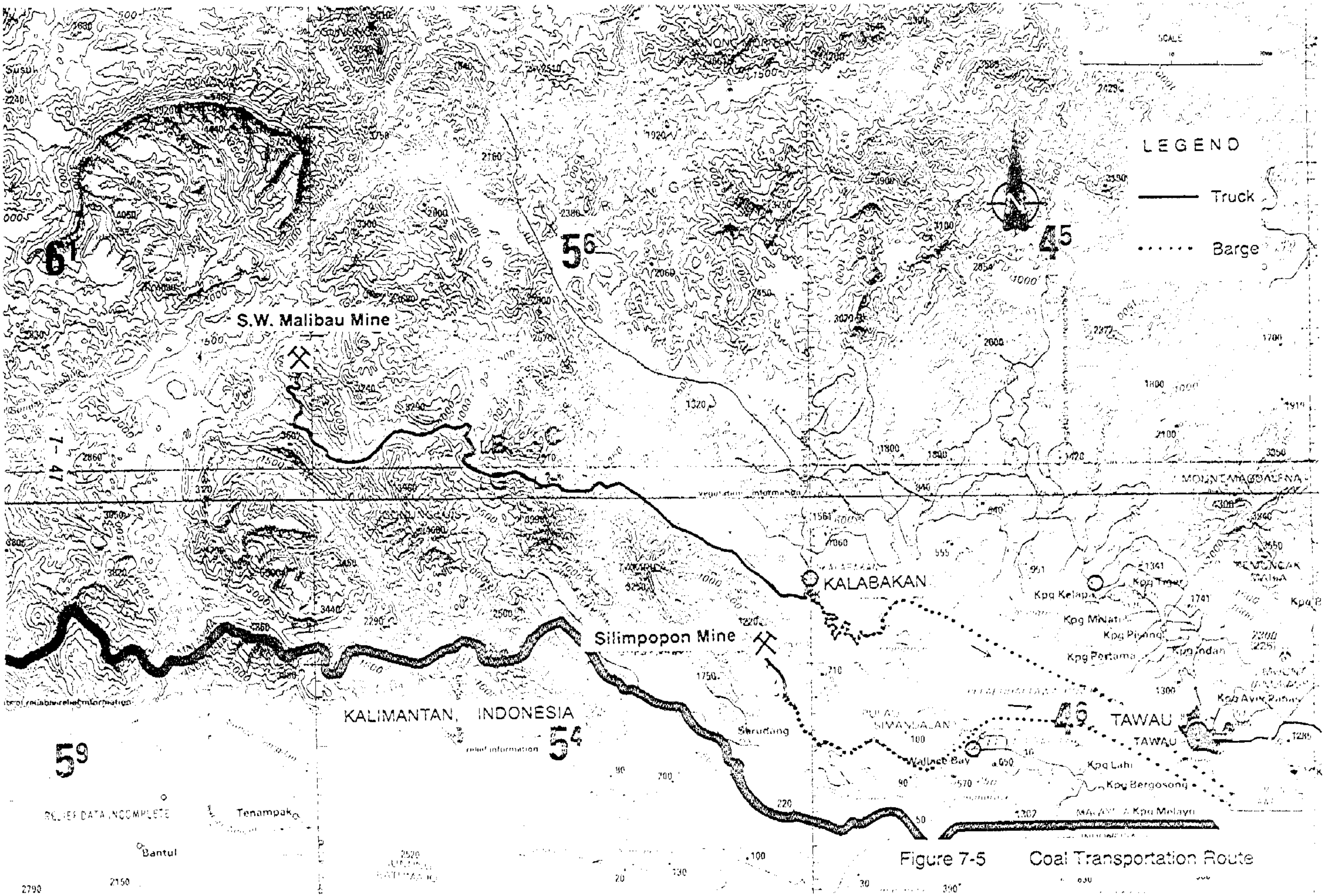


Figure 7-5 Coal Transportation Route

8. Economical Evaluation

8. Economical Evaluation

8.1. Estimate of Capital and Operating Costs

Because there has been no underground coal mine in Malaysia since 1932 when Silimpopon coal mine was closed, it is difficult to estimate the capital and operating costs of the proposed coal mine in this study. Therefore, many assumptions and applications of foreign standards have been used for this purpose. They include cost data used in Malaysia, application of similar coal mine in Indonesia and cost standard of Japanese industry.

Cost estimate of Silimpopon and Southwest Malibau mines are made separately according to each mine plan without any diversion of equipments from one mine to the other, while in Southwest Malibau, east and west pits are regarded as a single mine being operated continuously.

Operating cost was estimated on the basis of FOB at a loading point to barge. Royalty and tax are not included in the cost. All the cost figures are expressed in US dollars, of which exchange rate to local currency is 1 $ to 3.8 RM (ringgit).

8.1.1. Silimpopon Mine

(1) Capital Cost

Table 8-1 Summary of Capital Cost (1,000 US$)

Item	Initial	Replacement	Total
Surface Facilities	3,912	0	3,912
Vehicles and Heavy Equipment	1,000	2,000	3,000
Safety Equipment	893	905	1,798
U/G Main Transportation	1,105	0	1,150
U/G Road development and B/P	3,429	6,757	10,186
U/G Longwall	964	3,344	4,308
U/G Others	260	420	680
Total	11,608	13,426	25,034

The total capital costs to be spent in whole mine life amount to 25 million US $ including replacement of equipments as summarized in Table 8-1. Detail of each item is shown in Table 8-2.

(2) Operating Cost

(a) Labor Cost

Labor cost was estimated based on the work force schedule in the mine plan. The standard of salaries was referred to "salary guideline" being applied to a copper mine in Sabah, Malaysia. The following table is a summary of labor cost which also shows categories of work force and salary scale applied to each category.

Table 8-3 Summary of Labor Cost

	Number	Category/Grade	Salary Scale ($/month/person)	Total * (1000$/year)
Manager	2	Supervisory G15	(1355 + 1195)/2/3.8 = 336	9,676
Department Head	6	Supervisory G13	(1245 + 1045)/2/3.8 = 301	26,006
Superintendent	7	Supervisory G11	(1140 + 1000)/2/3.8 = 282	28,426
Section Chief	9	Supervisory G 9	(1040 + 910)/2/3.8 = 257	33,307
Group Chief	14	Supervisory G 7	(950 + 830)/2/3.8 = 234	47,174
General Staff	72	Supervisory G 5	(865 + 755)/2/3.8 = 213	220,838
Worker	346	Production G 5	(630+495+400)/3/3.8=134	667,642
Total	456			**1,033,069**

* Total amount includes 20% of basic salary as allowances for overtime, welfare, etc.

(b) Electricity

Applied standard :

Installed capacity - 1500 kw, Working ratio - 60 %

Unit price - Industrial Class 2 (0.23 RM/kw)

Table 8-2 Detailes of Capital Costs

(a) Surface facilities (US$)

	Facility and equipment	Number	Unit price	Total	Memo
1	Access road and site preparation			300,000	
2	Office , shower room, etc.	1	300$/m²	300,000	1000m², 1/3 of Japan
3	Warehouse	1	300$/m²	150,000	500m², 1/3 of Japan
4	Explosives magazine	1	300$/m²	60,000	200m², 1/3 of Japan
5	Workshop	1		400,000	including implements
6	Air compressor	1	250,000	500,000	300HP×2
7	Washing plant	1 set		600,000	Jig, conveyor, pumps
8	Main fan	1	150,000	150,000	200HP
9	Main winding machine	1	600,000	600,000	300~400HP
10	Submain winding machine	1	100,000	100,000	50~100HP
11	Clean water plant	1 set		100,000	
	Subtotal			3,260,000	
12	Others			652,000	20 % of Subtotal
Total				3,912,000	

(b) Vehicle and heavy equipment at surface (US$)

	Facility and equipment	Number	Unit price	Total	Memo
1	Commuter bus	2	100,000	200,000	Life - 8 years
2	Service truck	2	30,000	60,000	Life - 8 years
3	Patrol car	1	40,000	40,000	Life - 8 years
4	Bulldozer (D-85)	1	350,000	350,000	Life - 10 years
5	Front-end loader (WA-350)	1	200,000	200,000	Life - 10 years
6	Grader	1	150,000	150,000	Life - 10 years
	Total			1,000,000	

(c) Safety equipment in U/G (US$)

	Facility and equipment	Number	Unit price	Total	Memo
1	Safety lamp (YL2000)	300	500	150,000	Life - 5 years
	Lamp charger (YL-5240-40)	8	12,000	96,000	
2	CO mask	300	115	34,500	Life - 3 years
3	Dust mask	300	30	9,000	Life - 3 years
4	Methane detector (Toka)	70	1,360	95,200	
	Methane detector (Toka 100 %)	6	1,360	8,160	
5	Oxgen measure (GO-25KS)	6	2,100	12,600	
6	CO detector	6	1,400	8,400	
7	Oxygen breathing apparatus	30	12,000	360,000	Rescue team
8	Radio communicati0n system	1 set		70,000	
9	U/G telephone system	1 set		50,000	
	Total			893,860	

(d) U/G main transportation (US$)

	Faciliyt and equipment	Number	Unit price	Total	Memo
1	Mine car ($2\ m^3$)	200	5,000	100,000	
2	Flat car	10	5,000	50,000	
3	Menride slope train	1 set		200,000	
4	Battery locomotive	4	200,000	800,000	
	Total			1,150,000	

(e) Road development and Board & Pillar

	Facility and equipment	Number	Unit price	Total	Memo
1	Side-dump loader (ME632)	3	250,000	750,000	Life - 10 years
2	Side-dump loader (ME612)	6	150,000	900,000	Life - 10 years
3	Chain conveyor	8	50,000	400,000	Life - 10 years
4	Hydraulic prop (internal pump)	1,250	700	875,000	Life - 10 years
5	Electric winch (30 HP)	4	40,000	160,000	
6	Local fan	10	25,000	250,000	
7	Air auger	12	2,000	24,000	Life - 2 years
8	Rock hammer	6	3,000	18,000	Life - 2 years
9	Coal pick	12	1,000	12,000	Life - 2 years
10	Small pump	20	2,000	40,000	Life - 2 years
	Total			3,429,000	

(f) Longwall (US$)

	Facility and equipment	Number	Unit price	Total	Memo
1	Hydraulic prop	1,000	500	500,000	Life - 5 years
2	Link bar	1,000	100	100,000	Life - 5 years
3	High-pressure pump	2	50,000	100,000	Life - 10 years
4	Face conveyor	2	70,000	140,000	Life - 10 years
5	Chain conveyor	2	50,000	100,000	Life - 10 years
6	Air auger	8	2,000	16,000	Life - 2 years
7	Coal pick	8	1,000	8,000	Life - 2 years
	Total			964,000	

(g) U/G Others

	Facility and equipment	Number	Unit price	Total	Memo
1	Fixed drainage pump	2	30,000	60,000	Life - 10 years
2	Small back-hoe (for maintenance)	3	50,000	150,000	Life - 10 years
3	Survey instrument	one set		50,000	
	Total			260,000	

Electricity cost :

Working days : 250 days x 24 hr x 900 kw x 0.23 RM ÷ 3.8 RM/$ = 326,842 $/year

Holidays : 115 days x 24 hr x 300 kw x 0.23 RM ÷ 3.8 RM/$ = 50,116 $/year

Total **376,958 $/year**

(c) Consumables

① Road Development

Table 8-4 Materials for Road Development (US$/m)

	Number	Unit	Amount	Remarks
Steel support	1 set		150	3 pieces (1 beam, 2 legs)
Bracing wood	10	0.8	8.0	6"x 6", 3.5RM/ft, divide to 4
Wooden plate	18	0.5	9.0	6"x 6", 3.5RM/ft, divide to 6
Tension bar	10	0.2	2.0	
Detonator cap	40/30	1.5	60/45	rock/coal
Explosive	80/50	1.0	80/50	rock/coal
Slipper wood	2	8.9	17.8	
Rail		20.0	20.0	22.7 kg/m
Air pipe	1	7.9	7.9	excluding valves
Water pipe	1	3.3	3.3	excluding valves
Drainage pipe	1	3.3	3.3	
Power cable	1	80	80	
Others			10	hoses, tamping materials, etc.
Total			451.3 / 406.3*	rock/coal

* From 6th year, material costs of in-seam road are 50% and 20% off the above table excluding explosive and wooden materials, because these materials can be recovered from used road.

406.3 - (150 + 20 + 7.7 + 3.3 + 3.3) x 0.5 + 80 x 0.8 = 250.2 US$/m

② Board and Pillar

Table 8-5 Materials for Board and Pillar (US$ / m)

	Number	Unit Price	Amount	Remarks
Wooden plate	10	0.5	5.0	
Detonator cap	20	1.5	30.0	
Explosives	20	1.0	20.0	
Others			5.0	air hose, water hose, etc.
Total			**60.0**	

③ Longwall

Table 8-6 Materials for Longwall (US$ / t)

	Number	Unit Price	Amount	Remarks
Wooden plate	1	0.5	0.5	
Bamboo net	1	0.5	0.5	
Detonator cap	1	1.5	1.5	
Explosives	1	1.0	1.0	
Others		0.5	0.5	air hose, water hose, etc.
Total			**4.0**	

④ Spare Parts : 500,000 $/year - fixed amount

(d) Coal Transportation

Product coal from Silimpopon mine is transported to supposed loading point to barge which is located 7 km south of the mine.

Unit cost : RM 4 / km · 20 t truck → RM 0.2 / t. km
Total cost : RM 0.2 / t.km x 7 km ÷ 3.8 RM/$ = 0.37 $/t → 0.5 $/t (incl. loading cost)

Table 8-7 shows a summary of operating costs. Total amount through the mine life is estimated at 74.6 million dollars. The average operating cost is 20.4 $/t for raw coal and 24.0 $/t for clean coal.

Table 8-7 **Summary of Operating Costs**

	Unit Cost ($)	Unit	Amount	Total (1,000$)
Labour	1,033,069	$/year	24 years	24,103
Electricity	376,958	$/year	24 years	9,048
Consumables				39,941
Roadway (Rock)	451.3	$/m	648 m	(292)
Roadway (Coal)	406.3→250.2	$/m	49,540 m	(13,888)
Board and Pillar	60	$/m	59,650 m	(3,579)
Longwall	4	$/t	2,608,000 t	(10,432)
Spare Parts	500,000	$/year	24 years	(11,750)
Transportation	0.5	$/t	3,110,000 t	1,555
TOTAL				74,647

8.1.2. Southwest Malibau Mine

(1) Capital Cost

The total capital costs in whole mine life are estimated at 12.4 million US$ including replacement of equipments as summarized in Table 8-8. Details of each item is shown in Table 8-9.

Table 8-8 Summary of Capital Cost

Item	Initial	Replacement	Total
Surface Facilities	3,564	0	3,564
Vehicles and Heavy Equipments	1,000	1,300	2,300
Safety Equipments	822	591	1,413
U/G Main Transportation	1,150	0	1,150
U/G Road Development	1,066	1,254	2,320
U/G Longwall	282	930	1,212
U/G Others	260	210	470
Total	8,144	4,285	12,429

Table 8-9 Details of Capital Costs

(a) Surface facilities (US$)

	Facility and equipment	Number	Unit price	Total	Memo
1	Access road and site preparation			300,000	
2	Office, shower room, etc.	1	300$/m²	240,000	800m², 1/3 of Japan
3	Warehouse	1	300$/m²	120,000	400m², 1/3 of Japan
4	Explosives magazine	1	300$/m²	60,000	200m², 1/3 of Japan
5	Ware house	1		200,000	including implements
6	Air compressor	1	250,000	500,000	300HP×2
7	Washing plant	1 set		600,000	Jig, conveyor, pumps
8	Main fan	1	150,000	150,000	200HP
9	Main winding machine	1	600,000	600,000	300~400HP
10	Submain main winding machine	1	100,000	100,000	50~100HP
11	Clean water plant	1 set		100,000	
	Subtotal			2,970,000	
12	Others			594,000	20 % of Subtotal
Total				3,564,000	

(b) Vehicles and heavy equipments at surface (US$)

	Facility and equipment	Number	Unit price	Total	Memo
1	Commuter bus	2	100,000	200,000	Life - 8 years
2	Service truck	2	30,000	60,000	Life - 8 years
3	Patrol car	1	40,000	40,000	Life - 8 years
4	Bulldozer (D-85)	1	350,000	350,000	Life - 10 years
5	Front-end loader (WA-350)	1	200,000	200,000	Life - 10 years
6	Grader	1	150,000	150,000	Life - 10 years
	Total			1,000,000	

(c) Safety equipment in U/G (US$)

	Faciliyt and equipment	Number	Unit price	Total	Memo
1	Safety lamp (YL2000)	250	500	125,000	Life - 5 years
	Lamp charger (YL-5240-40)	7	12,000	84,000	
2	CO mask	250	115	28,750	Life - 3 years
3	Dust mask	250	30	7,500	Life - 3 years
4	Methane detector (Toka)	50	1,360	68,000	
	Methane detector (Toka 100 %)	6	1,360	8,160	
5	Oxygen measure (GO-25KS)	6	2,100	12,600	
6	CO detector	6	1,400	8,400	
7	Oxygen breathing apparatus	30	12,000	360,000	Rescue team
8	Radio communicatin system	1 set		70,000	
9	U/G telephone system	1 set		50,000	
	Total			822,410	

(d) U/G main transportation (US$)

	Faciliyt and equipment	Number	Unit price	Total	Memo
1	Mine car (2 m^3)	200	5,000	100,000	
2	Flat car	10	5,000	50,000	
3	Menride slope train	1 set		200,000	
4	Battery locomotive	4	200,000	800,000	
				1,150,000	

(e) U/G road development

	Facility and equipment	Number	Unit price	Total	Memo
1	Side-dump loader (ME632)	3	250,000	750,000	Life - 10 years
2	Local fan	4	25,000	100,000	
3	Air auger	6	2,000	12,000	Life - 2 years
4	Rock hammer	6	3,000	18,000	Life - 2 years
5	Coal pick	6	1,000	6,000	Life - 2 years
6	Small pump	10	2,000	20,000	Life - 2 years
	Total			1,066,000	

(f) U/G Longwall (US$)

	Facility and equipment	Number	Unit price	Total	Memo
1	Plastic trough (Sanko)	200	150	30,000	Life - 1 year
2	Chain conveyor	4	50,000	200,000	Life - 10 years
3	Air auger	8	2,000	16,000	Life - 2 years
4	Coal pick	8	1,000	8,000	Life - 2 years
5	Hydraulic prop (for material recovery)	40	700	28,000	Life - 10 years
	Total			282,000	

(g) U/G Others

	Facility and equipment	Number	Unit price	Total	Memo
1	Fixed drainage pump	2	30,000	60,000	Life - 10 years
2	Small back-hoe (for maintenance)	3	50,000	150,000	Life - 10 years
3	Survey Imstrument	1 set		50,000	
				260,000	

(2) Operating Cost

(a) Labor Cost

Labor cost was estimated based on the work force schedule in the mine plan. The standard of salaries was referred to "salary guideline" being applied to a copper mine in Sabah, Malaysia. The following table is a summary of labor cost which also shows the categories of work force and salary scale applied to each categories.

Table 8-10 Summary of Labor Cost ($/year)

	Number	Category/Grade	Salary Scale ($/month/person)	Total * (1000$/year)
Manager	2	Supervisory G15	(1355 + 1195)/2/3.8 = 336	9,676
Department Head	6	Supervisory G13	(1245 + 1045)/2/3.8 = 301	26,006
Superintendent	7	Supervisory G11	(1140 + 1000)/2/3.8 = 282	28,426
Section Chief	8	Supervisory G 9	(1040 + 910)/2/3.8 = 257	33,307
Group Chief	13	Supervisory G 7	(950 + 830)/2/3.8 = 234	36,504
General Staff	57	Supervisory G 5	(865 + 755)/2/3.8 = 213	145,692
Worker	279	Production G 5	(630+495+400)/3/3.8=134	448,632
Total	372			**728,243**

* Total amount includes 20% of basic salary as allowances for overtime, welfare, etc.

(b) Electricity

Applied standard :

Installed capacity - 1500 kw, Working ratio - 60 %,

Unit price - 0.23 RM/kw (Industrial Class 2)

Electricity cost :

Working days : 250 days x 24 hr x 900 kw x 0.23 RM÷3.8 RM/$ = 326,842 $/year

Holidays : 115 days x 24 hr x 300 kw x 0.23 RM÷3.8 RM/$ = 50,116 $/year

Total **376,958 $/year**

(c) Consumables

① Road Development

Table 8-11 Materials for Road Development (US$/m)

	Number	Unit	Amount	Remarks
Steel support	1 set		150	3 pieces (1 beam, 2 legs)
Bracing wood	10	0.8	8.0	6"x 6", 3.5RM/ft, divide to 4
Wooden plate	18	0.5	9.0	6"x 6", 3.5RM/ft, divide to 6
Tension bar	10	0.2	2.0	
Detonator cap	40/30	1.5	60/45	rock/coal
Explosive	80/50	1.0	80/50	rock/coal
Slipper wood	2	8.9	17.8	
Rail		20.0	20.0	22.7 kg/m
Air pipe	1	7.9	7.9	excluding valves
Water pipe	1	3.3	3.3	excluding valves
Drainage pipe	1	3.3	3.3	
Power cable	1	80	80	
Others			10	hoses, tamping materials, etc.
Total			451.3* / 406.3*	rock/coal

* From 7th year, material costs of road development are 50% off (support ~ pipe) and 20% off (power cable) the above table excluding explosive and wooden materials, because these materials can be recovered from used road.

Rock : 451.3 - (150 + 20 + 7.7 + 3.3 + 3.3) x 0.5 + 80 x 0.8 = 292.5 US$/m

Coal : 406.3 - (150 + 20 + 7.7 + 3.3 + 3.3) x 0.5 + 80 x 0.8 = 250.2 US$/m

② Raise Driving

Table 8-12 Materials for Raise (US$/m)

	Number	Unit Price	Amount	Remarks
Wooden Beam & Prop	3	16	38	
Wooden Plate	8	0.5	4	
Detonator Cap	10	1.5	15	
Explosive	10	1	10	
Others		1	1	
Total			68	

③ Mining Face

Table 8-13 Materials for Mining Face (US$/t)

	Number	Unit Price	Amount	Remarks
Wooden Beam & Prop	0.42	16.0	6.7	
Wooden Plate	1.14	0.5	0.6	
Detonator cap	1	1.5	1.5	
Explosives	1	1.0	1.0	
Others		0.5	0.5	air hose, water hose,
Total			10.3	

④ Spare Parts and Others : 200,000 $/year - fixed amount

(d) Coal Transportation (Truck)

Mine site to Kalabakan : 83 km

Unit cost : RM 4 / km, 20 t. truck → RM 0.2 / t. km

Transportation cost : RM 0.2 / t.km x 83 km ÷ 3.8 RM/$ = 4.37 $/t

→ 4.5 $/t (Including loading cost)

The following table is a summary of operating costs in Southwest Malibau Mine. Total amount through the mine life is estimated at 58.6 million dollars. The average operating cost is 32.2 $/t for raw coal and 37.9 $/t for clean coal.

Table 8-14 Summary of Operating Costs

	Unit Cost ($)	Unit	Amount	Total (1000$)
Labour	728,243	$/year	19 years	**13,056**
Electricity	376,958	$/year	19 years	**6,762**
Consumables				**31,847**
Roadway (rock)	451.3→292.5	$/m	6,609 m	(2,983)
Roadway (coal)	406.3→250.2	$/m	29,911 m	(9,098)
Raise	68	$/m	2,500 m	(170)
Mining Face	10.3	$/t	1,551	(15,976)
Spare Parts	200,000	$/year	19 years	(3,620)
Transportation	4.5	$/t	1,545,000 t	**6,952**
TOTAL				**58,617**

8.1.3. Summary

The following table is a summary and a comparison of the costs of Silimpopon and Southwest Malibau Mines.

Table 8-15 Summary and Comparison of Costs

		Silimpopon	SW Malibau
Mine Life	(years)	24	19
Production			
	Raw Coal (t)	3,658,900	1,817,700
	Clean Coal (t)	3,110,100	1,544,800
	Ave. Prod. (clean c. t/y)	138,000	87,000
Costs			
	Capital Costs ($)	25,034,000	12,429,000
	Operating Costs ($)	74,647,000	58,617,000
	Total Costs ($)	99,681,000	71,046,000
Unit Cost	per clean coal t.		
	Capital Cost ($/t)	8.1	8.1
	Operating Cost ($/t)	24.0	37.9
	Total Cost ($/t)	32.1	46.0

8.2. Economical Analysis

8.2.1. Assumptions

Economical analysis was attempted on mine development plan of Silimpopon and Southwest Malibau areas. The development plan in this study is still preliminary and many assumptions and conditions were applied in the economical analysis. The following are the common conditions for the study :

1) Currency : US$, exchange rate to local currency : 1 US$ = 3.8 RM
2) Evaluation period : Whole period of mine operation
3) Cost and coal price : FOB at loading point to barge
4) Royalty and tax is not included in cost

5) Escalation is not applied for cost and price

(1) Cost (C)

Cost is equivalent to the sum of investment and operating cost. The same amount as the mine plan is used as summarized below :

(a) Operating Cost

	Silimpopon		SW-Malibau	
	1,000 $	($/t)	1,000 $	($/t)
Labour cost	24,103	(7.7)	13,056	(8.5)
Electricity cost	9,048	(2.9)	6,762	(4.4)
Consumables	39,941	(12.8)	31,847	(20.6)
Transportation	1,556	(0.5)	6,952	(4.5)
Total	74,647	(24.0)	58,617	(37.9)

(b) Investment

	Silimpopon		SW-Malibau	
	1,000 $	($/t)	1,000 $	($/t)
Initial investment	11,608	(3.7)	8,144	(5.3)
Replacement	13,470	(4.3)	4,285	(2.8)
Total	25,078	(8.1)	12,429	(8.0)
Total cost (a + b)	99,725	(32.1)	71,046	(46.0)

Annual expenditure schedule is shown in Table 8-16 and 8-17.

(2) Benefit (B)

Benefit is equivalent to coal sales revenue in FOB price at loading point to barge. In this study, standard price in 1999 (29.95 $/t) for imported Australian coal (6,700 kcal/kg) was referred and 30 $/t was adopted. The total benefit in two areas is as follows :

Silimpopon	:	$ 93,306,000
SW-Malibau	:	$ 46,356,000

Table 8-16 Economic Analysis (Silimpopon, Base Case)

Silimpopon Financial Analysis (Case-1)
TOTAL CASHFLOW (before TAX) Rrojected 99-6

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total	
Production Factor																											
Development (Rock)	meters	618																								618.0	
Development (Coal)	meters	480	2,100	3,595	3,345	3,310	2,341	2,339	3,414	2,421	2,601	2,513	1,800	1,800	1,745	1,596	1,800	1,803	1,671	2,418	2,031	2,018	224			47,485.0	
Board & Pillar	meters	0	4,022	2,378	6,020	2,114	3,078	6,392	1,200	1,600	2,575	2,855	800	2,905	2,195	1,670	2,600	2,400	2,600	1,869	2,201	0	3,952	2,988	1,230	59,611.0	
ROM (Open cut)	1,000 ton																									0.0	
ROM (Development, Board & Pillar)	1,000 ton	3.6	61.7	59.5	103.5	59.5	57.3	106.1	41.0	36.2	58.4	52.9	23.2	45.1	37.6	28.1	41.9	40.3	35.9	30.1	34.8	11.9	41.7	27.7	12.8	1,050.8	
ROM (Longwall)	1,000 ton	0.0	45.5	103.9	58.6	101.0	108.2	60.0	111.1	116.4	98.3	116.5	139.4	130.9	117.5	133.6	129.8	131.7	120.0	126.3	126.0	147.5	131.9	136.5	117.5	2,608.1	
ROM (Total)	1,000 ton	3.6	107.2	163.4	162.1	160.5	165.5	166.1	152.1	152.6	156.7	169.4	162.6	176.0	155.1	161.7	171.7	172.0	155.9	156.4	160.8	159.4	173.6	164.2	130.3	3,658.9	
CC Production (YR=85%)	1,000 ton	3.1	91.1	138.9	137.8	136.4	140.7	141.2	129.3	129.7	133.2	144.0	138.2	149.6	131.8	137.4	145.9	146.2	132.5	132.9	136.7	135.5	147.6	139.6	110.8	3,110.1	
CC Production (with sensitivity)	0 %	3.1	91.1	138.9	137.8	136.4	140.7	141.2	129.3	129.7	133.2	144.0	138.2	149.6	131.8	137.5	146.0	146.2	132.5	132.9	136.7	135.5	147.6	139.6	110.8	3,110.1	
Investment (x 1,000US$)																											
Parmanent Facility		3,912																								3,912	
Transportation, others		1,000								300		700						300			700					3,000	
Safety		894			44		150	44			44	150		44			194			44		194			44	1,812	
U/G Transportation		1,150																								1,150	
U/G Development, B&P		844	2,458	94		94		94		94		844	2,175	94		94		94		94		844	2,175	94		10,186	
U/G Longwall			964		24		24	600	24		24		964		24		24	600	24		24		964		24	4,308	
U/G Others		50	210										210										210			680	
Total Investment		7,850	3,632	94	68	94	174	738	24	394	68	1,694	3,319	138	24	94	218	994	24	138	724	1,038	3,319	94	68	25,078	8.06 US$/ton
Operating Cost (x 1,000 US$)	Cost factors																										
Labour Cost		344	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1033.00	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	24,103	
Electricity		377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	9,018	
Development (Rock)	451.3 $/meter	292	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	292	
Development (Coal) First stage	406.3 $/meter	195	853	1,461	1,359	1,357																				5,225	
Development (Coal) Second stage	250.2 $/meter						586	585	854	606	651	636	450	450	437	399	450	451	418	612	508	512	56	0	0	8,661	
Board & Pillar	60.0 $/meter	0	241	143	361	127	185	384	72	96	155	171	48	174	132	100	156	144	156	112	132	0	237	179	74	3,579	
Longwall	4.0 $/ton	0	182	416	234	404	433	240	444	466	393	466	558	524	470	531	519	527	480	505	501	590	528	516	470	10,433	
Spare parts		250	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	11,750	
Transportation	0.5 $/ton	2	46	69	69	68	70	71	65	65	67	72	69	75	66	69	73	73	66	66	68	68	74	70	55	1,556	
Total Operating cost (x 1,000US$)		1,460	3,232	3,999	3,933	3,866	3,184	3,190	3,345	3,143	3,176	3,255	3,035	3,133	3,015	3,012	3,108	3,105	3,030	3,205	3,122	3,080	2,805	2,705	2,509	74,647	24.00 US$/ton
Total Operating cost (with sensitivity	0 %	1,460	3,232	3,999	3,933	3,866	3,184	3,190	3,345	3,143	3,176	3,255	3,035	3,133	3,015	3,012	3,108	3,105	3,030	3,205	3,122	3,080	2,805	2,705	2,509	74,647	
Cash Outflow (x 1,000US$)		9,310	6,864	4,093	4,001	3,960	3,358	3,928	3,369	3,537	3,244	4,949	6,384	3,271	3,039	3,106	3,326	4,099	3,054	3,343	3,846	4,118	6,154	2,799	2,577	99,725	32.06 US$/ton
Accumlative (x 1,000US$)		9,310	16,174	20,267	24,267	28,227	31,585	35,513	38,882	42,419	45,662	50,611	56,995	60,266	63,305	66,411	69,736	73,835	76,889	80,232	84,078	88,195	94,349	97,148	99,725		
Production cost (US$)	US$/ton	3,012	75	29	29	29	24	28	26	27	24	31	46	22	23	23	23	28	23	25	28	30	42	20	23		
Cash Inflow																											
COAL PRICE (US$/ton)	30.00 US$/t	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00		
Coal Sales (x 1,000$)		92	2,734	4,167	4,134	4,093	4,220	4,236	3,879	3,891	3,996	4,320	4,146	4,488	3,955	4,124	4,379	4,386	3,976	3,988	4,100	4,065	4,427	4,187	3,323	93,306	
Subsidy (x 1,000$)	0.00 US$/t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Less Royalty		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
REVENUE (x 1,000$)		92	2,734	4,167	4,134	4,093	4,220	4,236	3,879	3,891	3,996	4,320	4,146	4,488	3,955	4,124	4,379	4,386	3,976	3,988	4,100	4,065	4,427	4,187	3,323	93,306	
CASH FLOW		-9,218	-4,130	74	134	133	862	309	510	354	753	-629	-2,238	1,218	916	1,018	1,054	287	922	646	254	-53	-1,727	1,388	747	-6,419	
ACCUMULATE		-9,218	-13,348	-13,274	-13,140	-13,007	-12,145	-11,837	-11,327	-10,973	-10,220	-10,849	-13,087	-11,870	-10,954	-9,936	-8,882	-8,595	-7,673	-7,028	-6,774	-6,826	-8,553	-7,165	-6,419		
	IRR= -4.59 %																										
(DCF factor)	(0.954)	1.000	1.048	1.099	1.151	1.207	1.265	1.326	1.389	1.456	1.526	1.600	1.677	1.757	1.842	1.931	2.023	2.121	2.223	2.330	2.442	2.559	2.682	2.811	2.947		
NPV	(i= -4.59 %)	-9,218	-4,329	81	154	161	1,090	409	709	516	1,149	-1,006	-3,753	2,140	1,687	1,965	2,132	609	2,019	1,504	620	-134	-4,633	3,902	2,200	3	

Table 8-17 Economic Analysis (SW Malibau, Base Case)

SW Malibau Financial Analysis (Case-1)
TOTAL CASHFLOW (before TAX) Rrojected 99-7

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total	
Production Factor																						
Development (Rock)	meters	818.9	631.6	442.4	681.6	1,008.6			456.0	1,045.8	395.2	429.0	669.6								6,608.7	
Development (Coal)	meters	1,880	1,875	2,380	2,009	1,280	919	3,536	2,514	1,097	2,666	2,561	2,010	2,988	2,193						29,914.0	
Raise	meters	91	206	200	100	100	300	159	141	0	100	200	200	500	200						2,500.0	
ROM (Open cut)	1,000 ton																				0.0	
ROM (Development, Raise)	1,000 ton	16.6	17.2	21.5	17.7	11.6	28.1	27.1	19.6	8.3	20.0	20.2	16.1	24.8	17.8	0.0	0.0	0.0	0.0	0.0	266.6	
ROM (Longwall)	1,000 ton	0.0	90.6	91.1	90.8	90.8	91.1	91.0	86.1	80.5	77.2	81.5	76.8	81.0	85.9	91.7	97.9	92.3	97.9	53.9	1,551.1	
ROM (Total)	1,000 ton	16.6	107.8	112.6	108.5	102.4	119.2	118.1	105.7	88.8	97.2	101.7	92.9	105.8	103.7	91.7	97.9	92.3	97.9	53.9	1,817.7	
CC Production (YR=85%)	1,000 ton	14.1	91.6	95.7	92.2	87.0	101.3	100.4	89.8	75.5	82.6	86.4	79.0	89.9	88.1	80.5	83.2	78.5	83.2	45.8	1,515.0	
CC Production (with sensitivity)	0 %	14.1	91.6	95.7	92.2	87.0	101.3	100.4	89.9	75.5	82.6	86.5	79.0	89.9	88.2	80.5	83.2	78.5	83.2	45.8	1,515.1	
Investment (x 1,000US$)																						
Parmanent Facility		3,561																			3,561	
Transportation, others		1,000								300		700						300			2,300	
Safety		822			36		125	36			36	125		36			161			36	1,413	
U/G Transportation		1,150																			1,150	
U/G Development, B&P		1,066		56		56		56		56		56	750	56		56		56		56	2,320	
U/G Longwall			282	30	51	30	51	30	51	30	51	30	282	30	51	30	51	30	51	30	1,212	
U/G Others		50	210										210								470	
Total Investment		7,652	492	86	90	86	179	122	54	386	90	914	1,242	122	54	86	215	386	54	122	12,429	8.04 US$/ton
Operating Cost (x 1,000 US$)	Cost factors																					
Labour Cost		243	728	728	728	728	728	728	728	728	728	728	728	728	728	728	728	728	728	437	13,056	
Electricity		127	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	226	6,762	
Development (Rock)	451.3 $/meter	383	285	200	308	455	0	0	206	472	178	194	302	0	0	0	0	0	0	0	2,983	
Development (Coal) First stage	406.3 $/meter	764	762	967	816	520	373														4,202	
Development (Coal) Second stage	250.2 $/meter							885	629	274	667	642	503	748	549	0	0	0	0	0	4,897	
Raise	68.0 $/meter	6	14	14	7	7	20	11	10	0	7	14	14	34	14	0	0	0	0	0	172	
Longwall	10.3 $/ton	0	933	938	935	935	938	937	887	829	795	839	791	834	885	975	1,008	951	1,008	555	15,973	
Spare parts		100	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	120	3,620	
Transportation	4.5 $/ton	63	412	431	415	392	456	452	404	340	372	389	355	405	397	362	374	353	374	206	6,952	
Total Operating cost (x 1,000US$)		1,686	3,711	3,855	3,786	3,614	3,092	3,590	3,441	3,220	3,324	3,383	3,270	3,326	3,150	2,642	2,687	2,609	2,687	1,514	58,617	37.94 US$/ton
Total Operating cost (with sensitivity	0 %	1,686	3,711	3,855	3,786	3,614	3,092	3,590	3,441	3,220	3,324	3,383	3,270	3,326	3,150	2,642	2,687	2,609	2,687	1,514	58,617	
Cash Outflow (x 1,000US$)		9,338	4,203	3,941	3,876	3,700	3,271	3,712	3,495	3,606	3,414	4,294	4,512	3,448	3,204	2,728	2,902	2,995	2,741	1,666	71,046	45.98 US$/ton
Accumlative (x 1,000US$)		9,338	13,541	17,482	21,358	25,058	28,329	32,041	35,536	39,142	42,556	46,850	51,362	54,810	58,014	60,742	63,644	66,639	69,380	71,046		
Production cost (US$)	US$/ton	662	46	41	42	43	32	37	39	48	41	50	57	38	36	34	35	38	33	36		
Cash Inflow																						
COAL PRICE (US$/ton)	30.00 US$/t	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00		
Coal Sales (x 1,000$)		423	2,749	2,871	2,767	2,611	3,040	3,012	2,696	2,264	2,479	2,594	2,369	2,698	2,645	2,415	2,497	2,354	2,497	1,375	46,356	
Subsidy (x 1,000$)	0.00 US$/t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Less Royalty		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
REVENUE (x 1,000$)		423	2,749	2,871	2,767	2,611	3,040	3,012	2,696	2,264	2,479	2,594	2,369	2,698	2,645	2,415	2,497	2,354	2,497	1,375	46,356	
CASH FLOW		-8,915	-1,454	-1,070	-1,109	-1,089	-231	-700	-799	-1,342	-935	-1,700	-2,143	-750	-559	-313	-405	-641	-244	-291	-24,690	
ACCUMULATE		-8,915	-10,369	-11,439	-12,548	-13,637	-13,868	-14,568	-15,367	-16,709	-17,644	-19,344	-21,487	-22,237	-22,796	-23,109	-23,514	-24,155	-24,399	-24,690		

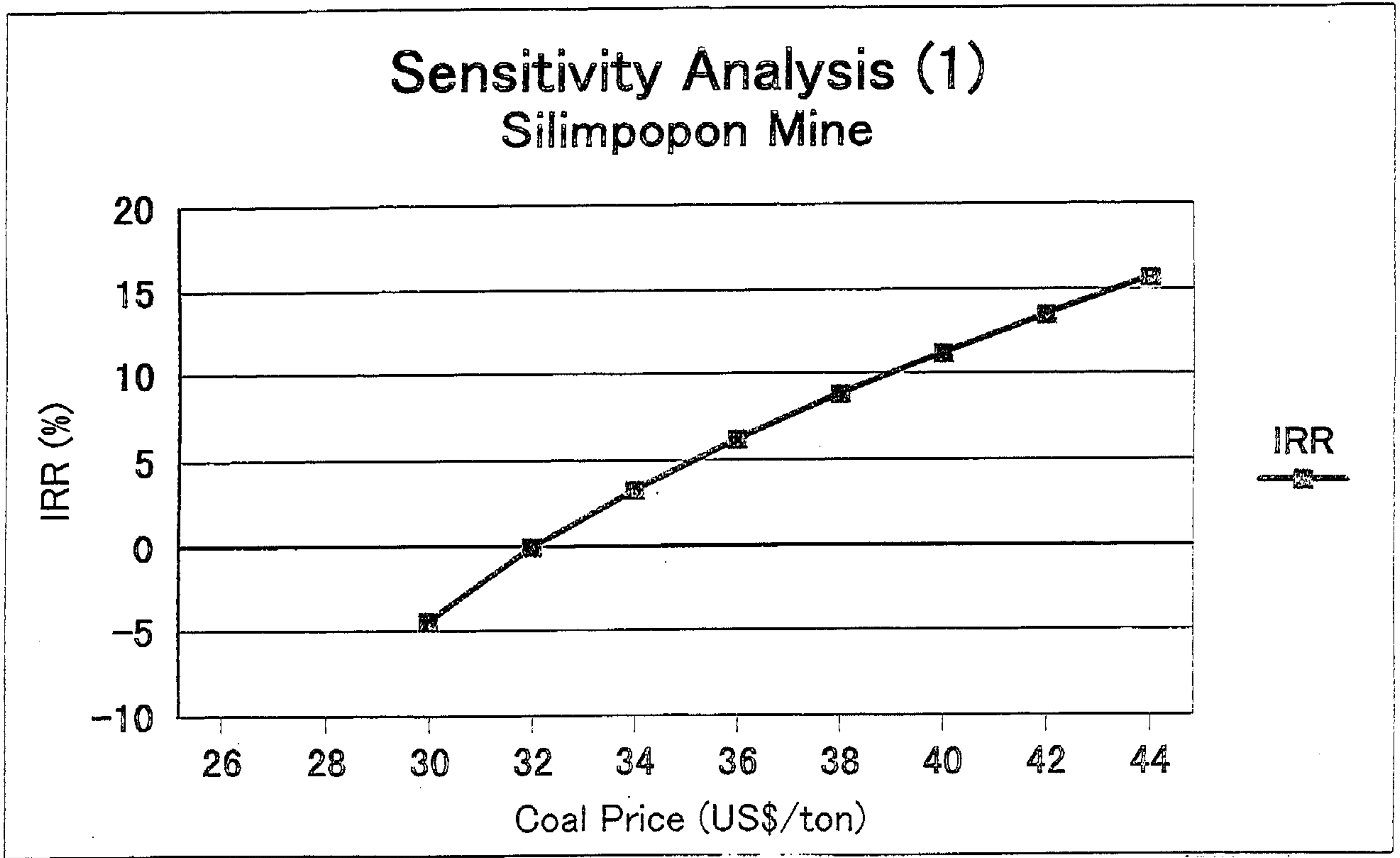


Figure 8-1-1 Sensitivity Analysis(1)--Silimpopon Mine

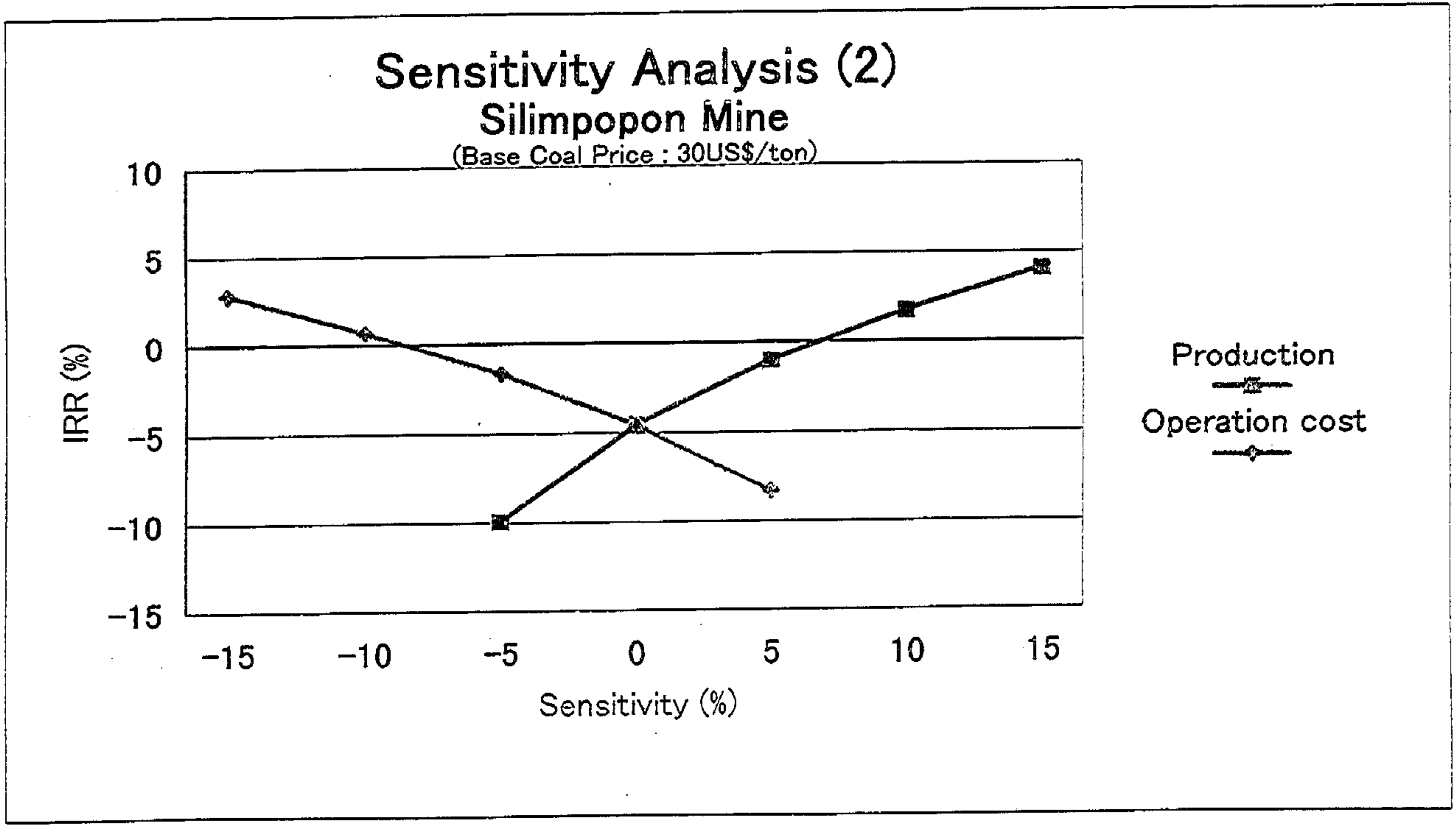


Figure 8-1-2 Sensitivity Analysis(2)--Silimpopon Mine

8.2.2. Result of Analysis

(1) Base Case

Economic analysis was conducted by applying the above mentioned figures to cost (C) and benefit (B) as "base case". The result is shown in Table 8-16 (Silimpopon) and Table 8-17 (S-W Malibau) and summarized as follows.

		Silimpopon	SW-Malibau
B−C	:	−$ 6,419,000	−24,690,000
B / C	:	0.94	0.65
EIRR*	:	−4.59 %	—

* Economic internal rate of return

Judging from the above result, the mine development in both area is not economical under the condition in base case. Particularly, mine development in SW-Malibau is difficult without a big improvement in conditions from the economical point of view.

(2) Sensitivity Analysis

In order to examine the effect of variation in some factors, sensitivity analysis was carried out on Silimpopon area, where the result of economic analysis was comparatively favorable than SW-Malibau. Analysis was made on the following three factors. Variation of foreign exchange rate was not examined, because the rate is fixed at 1 US$ = 3.8 RM at present.

Result of analysis are shown in Figure 8-1-1 and 8-1-2. Effect of variation on EIRR are as follows :

(a) Coal price	+$2	→	IRR +4.5%
(b) Annual Production	+10%	→	IRR +6.5%
(c) Operating cost	−10%	→	IRR +5.5%

The following is a consideration on the possibility of variation of the above factors :

(a) Coal price

In general, coal price is affected by prevailing international market price. The price of US$ 30 in the base case is a standard price in 1999 for imported Australian coal. It falls every year by $ 3 to 4; 37.35 $/t in 1997 and 34.50 $/t in 1998. One of the reason of price down is that growth rate of steaming coal consumption stays at lower level than anticipated due to the recession in Asian countries. It is said that US$ 30 is a marginal level for coal producers, particularly for underground coal mine and that the economic recession is going to be recovered from now on. In consideration of these circumstances, it is possible that the market price of coal will move upward from the bottom price in these few years.

(b) Annual production

① Alteration of mining method
In Silimpopon area, a combination of Longwall (L/W) and Board and Pillar methods (B/P) is adopted in the mining plan. In B/P method, which is applied to prevent inflow of river water by lowering mining recovery ratio, productivity and production tonnage are lower than L/W method. In the present plan, B/P is to be applied in the area under the every river and stream shown in a old topographic map. It is possible that the actual area for B/P may be smaller than in the present plan by investigating present position and condition of river flows.

② Improvement of productivity by learning effect
Productivity in mining and road driving was designed at relatively lower level throughout the whole period of operation, taking into account of no experience of underground mining. However, improvement of productivity can be expected after the practice in a certain period.

(c) Operating cost

① Increase in annual production leads to decrease in unit cost per tonne. Although some cost items, such as electricity for production, consumables and transportation, are proportional to production amount, decrease in unit cost is roughly estimated at 3.3%

by 10% increase in annual production.

② If B/P is changed to L/W method as previously stated, equipment for B/P becomes unnecessary, then amount of investment can be reduced.

③ Price of new equipments are included in the investment cost and they are replaced at every fixed period. However, in a small scale mine like in this plan, it is possible to some extent that used equipments are utilized and replacement time is extended.

④ Possibility of opencut mining still remains in this area, although any opencut operation is not included in the present plan due to insufficient available data. If any reserves mineable by opencut are found in future exploration, application of opencut mining, even if small amount, will improve the economy in early stage.

(3) Alternative Case (High Case)

Result of sensitivity analysis and consideration of variable factors indicates that these factors will probably move to favorable side in future. Accordingly, an alternative case was examined as a high case on the assumption that all factors improve by 10 % as shown below.

Coal price	:	+ 10 % (30 → 33 $/t)
Production	:	+ 10 % (3,110,100 → 3,421,100 t)
Operating cost	:	− 10 % (74,647,000 → 67,178,000 $)

The total production in high case exceeds the recoverable reserves estimated in the mine plan. Although recoverable reserves in high case has not been estimated, it also increases by adopting L/W in place of B/P. Not only operation cost but also investment will possibly decrease as stated in previous section. In this analysis, decrease in operating cost represent total cost decrease.

Economic analysis in high case is shown in Table 8-18. Comparison between two cases is shown below :

		Base Case	High Case
B − C	:	−6,419,000 $	+30,894,000 $
B / C	:	0.94	1.33
EIRR	:	−4.59 %	+13.79 %

8.2.3. Evaluation of Mine Development Potential

(1) Economic Evaluation

Based on the result of economic analysis, mine development potential in the study areas is evaluated as summarized below :

① Southwest Malibau Area
The potential for mine development in the area is low from the economical viewpoint without any significant improvement in variable factors, such as coal price. This is caused by high mining cost due to unfavorable geological condition and high transportation cost due to remote location.

② Silimpopon Area
In this area, economical mine development is also difficult at present under the conditions adopted in Base Case. However, as stated in the section of sensitivity analysis, these conditions are expected to move to economically favorable side. If the conditions applied in High Case are realized in future, there is possibility of economical mine development in this area. Exploration and mining study in the area is worthy of further continuation.

(2) Derivative Effect of Mine Development

The above-mentioned evaluation was made only from economical viewpoint. However, the indirect effects derived from mine development must be considered. The expected effects are as follows :

① Utilization of indigenous resources
Mine development and coal production/utilization agrees with the nation's energy policy.

Table 8-18 Economic Analysis (Silimpopon, High Case)

Silimpopon Financial Analysis (Case-2) with sensitivity
TOTAL CASHFLOW (before TAX) Rejected 99-7

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total	
Production Factor																											
Development (Rock)	meters	618																								618.0	
Development (Coal)	meters	480	2,100	3,595	3,345	3,340	2,341	2,339	3,414	2,421	2,601	2,543	1,800	1,800	1,745	1,596	1,800	1,803	1,671	2,418	2,031	2,018	224			47,485.0	
Board & Pillar	meters	0	4,022	2,378	6,020	2,114	3,078	6,392	1,200	1,600	2,575	2,855	800	2,905	2,195	1,670	2,600	2,400	2,600	1,869	2,201	0	3,952	2,988	1,230	59,644.0	
ROM (Open cut)	1,000 ton																									0.0	
ROM (Development, Board & Pillar)	1,000 ton	3.6	61.7	59.5	103.5	59.5	57.3	106.1	41.0	36.2	58.4	52.9	23.2	45.1	37.6	28.1	41.9	40.3	35.9	30.1	34.8	11.9	41.7	27.7	12.8	1,050.8	
ROM (Longwall)	1,000 ton	0.0	45.5	103.9	58.6	101.0	108.2	60.0	111.1	116.4	98.3	116.5	139.4	130.9	117.5	133.6	129.8	131.7	120.0	126.3	126.0	147.5	131.9	136.5	117.5	2,608.1	
ROM (Total)	1,000 ton	3.6	107.2	163.4	162.1	160.5	165.5	166.1	152.1	152.6	156.7	169.4	162.6	176.0	155.1	161.7	171.7	172.0	155.9	156.4	160.8	159.4	173.6	164.2	130.3	3,658.9	
CC Production (YR=85%)	1,000 ton	3.1	91.1	138.9	137.8	136.4	140.7	141.2	129.3	129.7	133.2	144.0	138.2	149.6	131.8	137.4	145.9	146.2	132.5	132.9	136.7	135.5	147.6	139.6	110.8	3,110.1	
CC Production (with sensitivity)	10 %	3.4	100.2	152.8	151.6	150.1	154.7	155.3	142.2	142.7	146.5	158.4	152.0	161.6	145.0	151.2	160.5	160.8	145.8	146.2	150.4	149.0	162.3	153.5	121.8	3,421.1	
Investment (x 1,000US$)																											
Parmanent Facility		3,912																								3,912	
Transportation, others		1,000								300		700						300			700					3,000	
Safety		894			44		150	44			44	150		44			191			44		194			44	1,812	
U/G Transportation		1,150																								1,150	
U/G Development, B&P		844	2,458	94		94		94		94		844	2,175	94		94		94		94		844	2,175	94		10,186	
U/G Longwall			964		24		24	600	24		24		964		24		24	600	24		24		964		24	4,308	
U/G Others		50	210										210										210			680	
Total Investment		7,850	3,632	94	68	94	174	738	24	394	68	1,694	3,349	138	24	94	218	994	24	138	724	1,038	3,349	94	68	25,078	7.33 US$/ton
Operating Cost (x 1,000 US$)	Cost factors																										
Labour Cost		344	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1033.00	1,033	1,033	1,033	1,033	1,033	1,033	1,033	1,033	24,103	
Electricity		377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	9,018	
Development (Rock)	451.3 $/meter	292	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	292	
Development (Coal) First stage	406.3 $/meter	195	853	1,461	1,359	1,357																				5,225	
Development (Coal) Second stage	250.2 $/meter						586	585	854	606	651	636	450	450	437	399	450	451	418	612	508	512	56	0	0	8,661	
Board & Pillar	60.0 $/meter	0	241	143	361	127	185	384	72	96	155	171	48	174	132	100	156	144	156	112	132	0	237	179	74	3,579	
Longwall	4.0 $/ton	0	182	416	234	404	433	240	444	466	393	466	558	524	470	534	519	527	480	505	504	590	528	516	470	10,433	
Spare parts		250	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	11,750	
Transportation	0.5 $/ton	2	46	69	69	68	70	71	65	65	67	72	69	75	66	69	73	73	66	66	68	68	74	70	55	1,556	
Total Operating cost (x 1,000US$)		1,460	3,232	3,999	3,933	3,866	3,184	3,190	3,345	3,143	3,176	3,255	3,035	3,133	3,015	3,012	3,108	3,105	3,030	3,205	3,122	3,080	2,805	2,705	2,509	74,617	
Total Operating cost (with sensitivity	-10 %	1,314	2,909	3,599	3,510	3,479	2,866	2,871	3,011	2,829	2,858	2,930	2,732	2,820	2,714	2,711	2,797	2,795	2,727	2,885	2,810	2,772	2,525	2,435	2,258	67,187	19.61 US$/ton
Cash Outflow (x 1,000US$)		9,164	6,541	3,693	3,608	3,573	3,040	3,609	3,035	3,223	2,926	4,624	6,081	2,958	2,738	2,805	3,015	3,789	2,751	3,023	3,534	3,810	5,874	2,529	2,326	92,265	26.97 US$/ton
Accumlative (x 1,000US$)		9,164	15,705	19,398	23,005	26,578	29,618	33,227	36,262	39,485	42,410	47,034	53,115	56,073	58,811	61,616	64,630	68,419	71,170	74,193	77,727	81,536	87,410	89,939	92,265		
Production cost (US$)	US$/ton	2,719	65	24	24	24	20	23	21	23	20	29	40	18	19	19	19	24	19	21	24	26	36	16	19		
Cash Inflow																											
COAL PRICE (US$/ton)	36.00 US$/t	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00		
Coal Sales (x 1,000$)		121	3,608	5,500	5,456	5,403	5,571	5,591	5,120	5,136	5,274	5,702	5,473	5,924	5,221	5,443	5,779	5,790	5,248	5,264	5,413	5,365	5,844	5,527	4,386	123,159	
Subsidy (x 1,000$)	0.00 US$/t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Less Royalty		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
REVENUE (x 1,000$)		121	3,608	5,500	5,456	5,403	5,571	5,591	5,120	5,136	5,274	5,702	5,473	5,924	5,221	5,443	5,779	5,790	5,248	5,264	5,413	5,365	5,844	5,527	4,386	123,159	
CASH FLOW		-9,043	-2,933	1,807	1,849	1,830	2,531	1,983	2,085	1,913	2,349	1,078	-608	2,967	2,483	2,638	2,765	2,001	2,497	2,242	1,879	1,556	-30	2,998	2,061	30,891	
ACCUMULATE		-9,043	-11,976	-10,169	-8,320	-6,490	-3,959	-1,977	108	2,021	4,370	5,448	4,840	7,806	10,289	12,927	15,692	17,693	20,190	22,431	24,310	25,866	25,836	28,834	30,894		
	IRR= 13.79 %																										
(DCF factor)	(1.138)	1.000	0.879	0.772	0.679	0.596	0.524	0.461	0.405	0.356	0.313	0.275	0.241	0.212	0.186	0.164	0.144	0.127	0.111	0.098	0.086	0.075	0.066	0.058	0.051		
NPV	(i= 13.79 %)	-9,043	-2,578	1,396	1,255	1,092	1,327	913	844	681	734	296	-147	629	463	432	398	253	278	219	161	117	-2	175	106	-0	

Even if the amount is small, it contributes the saving of foreign currency to be paid for imported coal. In addition, it is expected that with this as a trigger, other project will be induced.

② Generation of employment opportunity

In the present plan, proposed Silimpopon Mine requires 460 employees. This number seems to be significant for the local community in consideration of additional works related to mine development.

③ Development of infrastructure

Preparation of infrastructure such as road, electricity supply and residential area is expected to be facilitated.

④ Activation of local economy

In addition to the above-mentioned individual effects, a new mine development contributes to the overall activation of local economy.

⑤ Cultivation of expertise and know-how

Through experience in underground mine operation, expertise and know-how are cultivated and utilizes in various fields.

9. Initial Environmental Examination (IEE)

9. Initial Environmental Examination (IEE)

9.1. Environmental Regulations and Administrative Organizations

9.1.1. Environmental Quality Act and Subsidiary Legislation

The concrete and inclusive regulations to maintain environmental quality in Malaysia began with the enactment of the Environmental Quality Act in March 1974. This Act has been considered as the environmental standard law for the federation. Amendment of the Environmental Quality Act was proclaimed in 1984, and subsidiary legislation have been successively added to comply with the need.

Environmental Quality Act consists of following chapters:

Part 1. Preliminary
Part 2. Administration
Part 3. Licenses
Part 4. Prohibition and control of pollution
Part 5. Appeal and appeal board
Part 6. Miscellaneous

Environmental Quality Act (EQA) declares in its preamble that this Act is related to the prevention, abatement, control of pollution and enhancement of the environment, for purposes connected therewith. Under the EQA, every industrial proposal which may cause pollution must apply for licenses to the Director General in advance as well as payment of prescribed fee and submission of the necessary information.

The contents of the Environmental Quality Act and subsidiary legislations are organized and published in Environmental Quality Act & Subsidiary Legislations, as at 25th August 1998, International Law Book Services, Kuala Lumpur.

Preceding the development, Environmental Impact Assessment (EIA) is required for activities prescribed under the Environmental Quality Order in 1987. According to this Order, 19 industrial activities, such as agriculture, fisheries, airport, ports, and mining, are prescribed for the EIA. The scale of an industrial activity (area, capacity, etc.) to be regulated is also provided for each category.

For a mining project that fall under the following condition, EIA is necessary before the developmental planning:

(a) Mining of minerals in new areas where the mining lease covers a total area in excess of 250 hectares.

(b) Ore processing, including concentrating for aluminum, copper, gold, or tantalum.

(c) Sand dredging involving an area of 50 hectares or more.

The procedure and timing of the Environmental Impact Assessment (EIA) is described minutely in Environmental Impact Assessment (EIA) Procedure and Requirements in Malaysia (Department of Environment, Governments of Malaysia, 1994), Environmental Requirements: A Guide For Investors (Department of Environment, Governments of Malaysia, 1994), and A Handbook of Environment Impact Assessment Guidelines (Department of Environment, Governments of Malaysia, 1987).

Environmental legislations related to mine development are as follows:

(1) Air Pollution:

Environmental Quality (Clean Air) Regulations (1978)

(2) Water Pollution:

Environmental Quality (Sewage & Industrial Effluents) Regulations (1979)

Development of Criteria and Standards for Air Quality (1989)

(3) Forest Protection

National Forestry Act (1984)

(4) Wild Life Protection

Wild Animals and Birds Protection Ordinance (1995)

The Protection of Wild Life Act (1972)

The Fisheries Act (1985)

National Park Act (1980)

(5) Noise

Guidelines for Siting and Zoning of Industries (1995)

Factory and Machinery (Noise Exposure) Regulations (1989)

9.1.2. Administrative Organizations

The Department of Environment (DOE) belongs to Ministry of Science, Technology and The Environment, and bears environmental preservation policy throughout the Federation based on the Environmental Quality Act (EQA) 1974.

According to the EQA, Director General of DOE has the responsibility and authority for the regulations relating to pollution. In addition, establishment of the Environmental Quality Council, which consists of members of the Cabinet and academic staff, is prescribed to advise the Minister on matters pertaining to the EQA.

The DOE divided the whole country into eight areas, and established State office in each area to gather observational data, supervise regulations, gather information, and to adjust environmental policy with the State Government. The DOE office in Sabah is located in the state capital, Kota Kinabalu.

The environmental administration is divided among the Federal Government and the State Governments as follows:

Federal Government: Regulations relating to air pollution, water pollution, and toxic waste.

State Governments: Regulation relating to land use and developmental activities, protection of wild life and designation of parks and reserves.

The State Government of Sabah has enacted Conservation of Environmental Enactment in 1996, and also established Department of Environmental Conservation under the Ministry of Culture, Tourism and Environment to proceed environmental administration based on the standards of DOE. The State Government of Sabah also has Department of Forestry, which authorizes permission for felling of trees.

The investigated area is in Yayasan Sabah Concession Area of Yayasan Sabah (Sabah Foundation). Yayasan Sabah is an institution of the state and has concessions for forest area exceeding 1 million hectare, in southeastern Sabah.

9.2. Natural and Social Environment of the Study Area

9.2.1. Characteristics of Natural Environment of Sabah

The State of Sabah is located in the northern part of Borneo, the world's third largest island with an area of 740,000 km^2.

Borneo biogeographically belongs to the India-Malaya Zone, which indicates that the biology of Borneo is similar to that of Java, Sumatra and Peninsular Malaysia than its neighboring Sulawesi Island.

It is reported that 50 percent of the world's plants exists in the tropical forests. Also 3,500 species (39 percent of the species known in northern Borneo) are reported as indigenous to Sabah, Sarawak of northern Borneo, and Brunei.

Borneo is also inhabited by various kinds of animals. For example, 137 species of amphibians are known to inhabit in northern Borneo. This number is extremely large compared to other areas (Peninsular Malaysia: 89, Sumatra: 80, Java: 50, Philippine: 38).

Although significant portion of these forest, the breeding ground of these animals, have already been exploited, virgin forests are still preserved in many parts of Sabah. The Malaysian Government and the State of Sabah are eagerly working to protect the natural environment of these areas.

In the late 1980's, BHP Minerals started a coal exploration project in the Maliau basin, located to the west of the investigated area, but the project was canceled considering the result of the EIA (Environmental impact Assessment). This basin area still preserves intact primitive forests, and was designated as natural conservation area in 1997.

9.2.2. Present Natural and Social Environment of the Study Area

The forest in the investigated area belongs to the dipterocarp forests, which are most commonly observed in the area below 1,000 m elevation in Borneo. The dipterocarp trees characterize this type of forests, and they grow over 50 m tall. Most of the natural tropical forests in these areas have already been exploited by the timber industry. In the three areas selected from the investigated area for detailed survey, the Silimpopon area is drained by the Silimpopon River, whose mouth lies at the Gulf of Cowie. The rivers draining SW Malibau flow toward the north, connecting with other rivers from Kinabatangan area, and empty into the Suru Sea, the northeastern offshore of Sabah. The Kalabakan River draining Malibau area also empties into the Gulf of Cowie. The Silimpopon and Kalabakan Rivers are contaminated with yellowish brown silt from the timber industries upstream. Although Kinabatangan River basin is uninvestigated, it is presumably in the same condition as the Silimpopon and Kalabakan Rivers.

In the area investigated in detail, a large plantation of oil palms is prosperous in Silimpopon and its surrounding areas. It is operated by the Sabah Softwoods Sdy. Bhd., which is a joint venture of Yayasan Sabah (60 percent) and Northern Borneo Timer Bhd. (40 percent). Native forests and its fauna have been lost and a dense network of plantation roads has been constructed and is causing soil degradation. The Silimpopon River is colored yellowish brown because of the suspended silt.

The selective felling in the past once destroyed the primary forests in the SW Malibau and Malibau Areas, but at present, reforestation is underway and secondary forests cover these areas. The fauna, also lost by the deforestation, is considered to be in the state of recovery. The devastated logging roads constructed at that time have been buried by the landslides in many places, and some of the bridges have been washed away. These roads are barely accessible only on foot. From this devastation, soil erosion has been accelerated and rivers are yellowish brown from the silt.

There are no native residents in the investigated area. At present, total of a few hundred residents are presumed to be living in the plantation and timber yards.

9.3. Environmental Impact of Mine Development and Countermeasures

9.3.1. Substance of Development Plan

The expected impact on environment to be caused by the planned mine development was evaluated in the Silimpopon and SW Malibau Areas.

Considering the shape of the coal seams, underground mining is planned for the Silimpopon and the SW Malibau areas.

Product coal is assumed to be transported by trucks from Silimpopon mine to an old wharf site in the downstream of the Silimpopon river and from SW Malibau mine to Kalabakan. Then the coal will be moved on barges and go down the Silimpopon and the Kalabakan Rivers to Cowie Bay.

9.3.2 Impact on the Environment

Mine development would directly affect natural environment, for instance, by destruction of forests and water contamination caused by the excavation of the pits and tunnels. Construction of the surface facilities need felling of trees and will also cause soil erosion. In addition, if new place of residence for mine workers is established in the area, the environmental impact on surrounding area should also be considered.

Impact on environment by the mining can be classified as follows:

(1) Mine site:
Impact on environment of the mine site and its adjacent areas from the operation of underground mining and surface facilities including washing plant.

(a) Outflow of a wastewater containing silt from the stripping. Collapse of the cut slopes resulting in debris flow to rivers during and after the operation.
(b) Water flow from excavated tunnels and outflow of wastewater containing silt from washing plant and waste dump.
(c). Outflow of silt caused by stripping due to construction of surface facilities
(d). Noise from mining equipment (generator, loaders, etc.).

(2). Transportation road
Environmental impact due to road construction from mine site to main road network and coal transportation to loading point to barge.

(a) Debris flow caused by landslides and soil erosion from the developed roads.
(b) Noise and air pollution from vehicles (trucks etc.).

(3) Place of residence:

Environmental impact on surrounding area caused by their living.

(a) Water pollution by living waste water

(b) Forest destruction by felling of trees

9.3.3. Results of the Examination and Countermeasures

(1). Silimpopon Area

As mentioned earlier, a large plantation of oil palm is operating in Silimpopon and its surrounding area and dense network of plantation roads have been constructed for cultivation. Most of the native forest and its fauna have already been destroyed, therefore additional impact on ecosystem due to the mining activities is considered rather small.

The Silimpopon River has already been contaminated with silt from the plantation roads, and additional soil erosion from the mine development may accelerate the resedimentation of the silt downstream. Therefore countermeasures for wastewater from mine and washing plant and for outflow water from the waste dump should be carefully examined, and stripping for construction of the surface facilities should also be minimized.

By using existing plantation road for transportation, additional impact on environment can be reduced.

Because the mine site is located not far from existing villages such as Kalabakan, there is low possibility to establish a new residential place for mine workers in the development area.

(2). SW Malibau Area

As mentioned earlier, forests in SW Malibau were once subjected to the selective logging, but they recovered to a state of secondary forests at present. Therefore, if mining development is to be proposed, impact on forests and its fauna should be minimized.

The mine development area is in a steep mountain range with a dominant weathered soil. For this reason, it will be difficult to stop soil erosion once it starts from stripping, and debris flow from the repeated landslides is also a problem to be concerned. For prevention, selection of the site for tunnel opening and arrangements of the surface mining facilities should be carefully examined.

In addition, these secondary forested areas are extremely vulnerable to fire because they contain flammable dead trees. Considering its steep landform, once the fire occurs, it may spread over vast areas. Therefore strict fire control is required in the mining facilities.

For the transportation road, an overall improvement of the old logging road is needed for 8 km from the mining area to the main road. The logging road have been left devastated, buried by landslides in many places, and some of the bridges have been washed away. This road is barely accessible by foot. Soil erosion is proceeding strongly along the road and collapsed slopes, and the rivers draining this area are yellowish brown with the suspended silt. Therefore constructing macadamized road and drainage ditches to prevent soil erosion should be examined, because additional soil degradation is expected to result from the mine development.

In consideration of topographic condition and distance to the mine site, residential area for mine workers will be placed on the side of the main road. Because the area along the main road, which is currently used for timber transportation, has been developed already, additional environmental impact by mine development is considered to be limited.

(3). Port Facilities

If the loading facilities to barges are constructed near the existing facilities for timber shipment in Kalabakan and an old wharf site in the Silimpopon River, additional impact on ecosystem is considered to be limited, because timber barges go down the Kalabakan and Silimpopon River at present.

9.3.4. Conclusion

Development of the coal resources in Silimpopon Area

This area has already been developed for the oil palm plantation and its landform is relatively flat. Underground mining is planned for this area, but stripping for construction of the tunnel and surface facilities should be minimized to prevent additional soil erosion. If these measures for reducing impact on environment can be implemented, environmental problems caused by the mine development are considered to be minimal.

Development of the coal mine in SW Malibau Area

The selective logging in the past once destroyed primary forest in this area, but at present, reforestation is underway and secondary forest covers this area. For this reason, impact on the forest and its fauna due to the mining activities should be minimized.

Eight kilometers of road construction is needed from the main road to the mine site through steep and rugged mountainous terrain with developed weathered soil. Thus it will be difficult to stop the degradation of soil once the erosion occurs. Therefore design of the transportation road, location of portals and layout of surface facilities should be carefully examined. In addition, these secondary forested areas are extremely vulnerable to fire. Considering its steep landform, once the fire occurs, it can spread over vast areas. Therefore strict fire-prevention measures are required in the mining facilities.

Port Facilities

If the loading facilities for barges are constructed near the existing facilities for timber shipment in Kalabakan and an old wharf site in the Silimpopon River, additional impact on ecosystem is considered to be limited.

Others

Besides the above matters, the possible environmental impacts resulting from the mine development are assessed as follows.

(a) Surface subsidence

Underground mining causes surface subsidence to some degree. On the surface of the proposed mining area, however, there is no particular thing to be protected from subsidence. Furthermore, the mining methods to be applied in the area, namely, step-cut mining with filling in Southwest Malibau area and board-and-pillar mining beneath the river in Silimpopon area, make the impact to the surface minimal. Surface subsidence is believed to be not a serious problem in the area.

(b) Air pollution (Dust)

Appropriate measures to prevent dust scattering are necessary during coal transportation and at loading and unloading site.

(c) Noise and vibration

The impact of noise and vibration from mine operation is no need to be considered, because of remote location of mine site from residential area.

(d) Others

There is no historical and cultural heritage as well as remarkable landscape to be protected from the mining activities.

The result of the Initial Environmental Examination (IEE) of the investigated area is summarized in Table 9-1.

9.4. Items in Terms of Reference(TOR) of Environmental Impact Assessment(EIA)

If the mining activities are to proceed in the future, the EIA should be enforced at the stage of the Feasible Study after the completion of exploration programme. Particularly in SW Malibau Area, impact on the environment should be assessed thoroughly, after careful design of the mining facilities and the transportation roads.

The Terms of Reference (TOR) of the Environmental Impact Assessment (EIA) is necessary to include the following items:

(1). Impact on ecology, fishery, and other water usage, due to change of drainage pattern rom the mining development

(2). Impact on natural drainage due to outflow of silt caused by stripping and soil erosion.

(3). Impact on natural drainage due to waste water from the tunnel and coal dressing facilities. Seepage of water from the waste dump.

(4). Noise and vibration from mine operation

(5). Impact from the accommodations following mining development (sewage, felling of trees, hunting wild animals, danger of fires).

(6). Impact from the transportation and port facilities

(7). Impact on the existing infrastructure (existing roads, port facilities, residents, etc.).

(8). Impact on the environment during the construction

(9). Impact on historical and cultural heritage

Table 9-1 Initial Environmental Examination (IEE) Summary

Items		Degree of impact * (a) ** Silimpopon	(b) ** SWMalibau	Environmental Hazards	Coutermeasures
1) Mine Development Area Road construction		W	M	(a) Considering the relatively flat landform, major collapse is unlikely to occur.	Make the road slope gentle. Construct macamadized road and drainage ditches to prevent soil erosion.
				(b) Once the soil erosion occur on a steep location, it cannot be stopped.	Make the road slope gentle. Construct macamadized road and drainage ditches to prevent soil erosion.
Undergrou-nd mining	Drainage	W	W	Outflow of muddy wastewater	Select the location of portal to prevent direct inflow of mine water to nearby rivers.
	Mining	W	W	Underground mining causes surface subsidence. No paticular thing to be protected from subsidence.	Make surface subsidence small. Following mining method is applied (a) board-and -pillar mining beneath the river (b) step-cut mining with filling
Construction of the surface facilities		W	M	(a) Considering the relatively flat landform, major collapse is unlikely to occur.	Minimize stripping as possible, and construct drainage ditches to prevent outflow of silt.
				(b) Once the soil erosion occur on a steep location, it cannot be stopped.	Minimize stripping as possible, and construct drainage ditches to prevent outflow of silt.
Surface facilities	Washing plant	M	M	Discharge of wastewater from washing plant to river	Construction of the wastewater treatment facility
	Hevy mine equipment	W	W	Noise and vibration from mine equipment (generater, loaders, etc.)	
	Waste dump	W	W	Outflow water from the dump	Construction of drainage ditches to drain surface water
	Accomodation	-		(a) Low possibility to establish in mine area, because mine site is located not far from existing villages.	
			W	(b) Possibility to establish the area along existing main road. The area has been developed already, therefore additional influence is small.	Countermeasure to prevent water polution by living waste water and forest disturbance from felling of trees
	Others		M	(b) Secondary forested area is vulnerable to fire. Considering its steep landform, once the fire occurs, it may spread over vast areas.	Strict fire control is required in the mine facilities
2) Transportation road Construction		W	M	(a) By improving the existing road, additional construction is unnecessary. (b) Once the soil erosion occurs on a steep location, it cannot be stopped. (Approximately 8km of road construction is needed from the main road to mine site)	Construct macamadized road and drainage ditches to prevent soil erosion Make the road slope gentle. Construct macamadized road and drainage ditches to prevent soil erosion.
Transportation		M	M	Coal dust scattering during coal transportation and at loading and unloading sites.	Countermeasure to prevent coal dust scattering
3) Port facilities Construction of an embercation facilities		W	W	embercation facilities are planned at (a) the old wharf site in the Silimpopon River (b) Kalabakan near the present timber facility in the Kalabakan River Both of rivers are used for timber transportation by barges, therefore, additional influences upon ecosystem is small.	

*W: week, M: moderate ** (a): Silimpopon (b): Southwest Malibau

10. Conclusions and Recommendations

10. Conclusion and Recommendation

10.1. Summary and Conclusion

The present study was carried out for the following purposes :

(a) Geological assessment of coal resources in the study area with regard to coal seam conditions, quantity of coal resources and coal quality.
(b) Preliminary study on coal mine development in the selected areas.
(c) Economical evaluation of mine development plan
(d) Initial environmental examination
(e) Evaluation of potential of coal mine development

Geological work occupied the major part of the study period and subsequent studies were carried out based on the result of the geological assessment. However, these studies are still in a preliminary stage and the results are not definite conclusions but may be modified by further investigation in the future.

The following is a summary of the result of each study :

(1) Geological assessment of coal resources

(a) Coal seam condition

As a result of Phase 1 study, three areas were selected for detailed exploration in Phase 2. Characteristics of coal seam condition of each area is as follows:

Malibau area

A large number of coal seams are present in a widely extended coal zone, but most of them are less than 1 m thick. The dip of coal seam is 40 degrees on the average.

Southwest Malibau area

Eleven coal seams are present and they are much thicker than those of Malibau area. They are dipping very steeply, 70 degrees on the average.

Silimpopon area

Only one coal seam, Queen Seam, has a mineable thickness and lies in a gentle synclinal structure with a dip of about 10 degrees.

(b) Coal resources

Estimated In-situ coal resources (Indicated class) are as follows:

Malibau area	: 17,901,000 t	
Southwest Malibau area	: 26,230,000 t	
Silimpopon area	: 14,092,000 t	(by P.Collenete 1954)

(c) Coal quality

Quality of coal in the area is characterized by low to medium ash, high volatile, high calory, low to medium sulphur and low nitrogen and shows the suitability as steaming coal. The result of ash analysis also indicates no problematic property for combustion in boiler.

(2) Preliminary Plan of Coal Mine Development

Based on the geological assessment of coal resources, the preliminary mine plan in Silimpopon and Southwest Malibau areas was prepared. Malibau area was excluded from the mine plan area, because coal seams are too thin to be mined economically. The following is the summary of the plan in these two areas.

	Silimpopon	Southwest Malibau
Mine life	24 years	19 years
Mine access	Slope (rock → in-seam)	Rock slope/cross cut
Mining method	Longwall (L/W) Board and pillar (B/P)	Step-cut and filling
Total production	3,110,100 t	1,545,000 t
Annual production	138,000 t	87,000 t
Washing yield	85%	85%
Haulage distance	7 km	83 km
No. of Workers	458	372

(3) Economic Analysis of Mine Development Plan

(a) Mine Development Cost

Many assumptions and applications of foreign standards have been used for this purpose. They include cost data of coal mines in Indonesia and application of standards in Malaysian and Japanese industries. The result is summarized as follows :

		Silimpopon	Southwest Malibau
Investment	:	25,078,000 $ (8.1 $/t)	12,429,000 $ (8.0 $/t)
Operating cost	:	74,647,000 $ (24.0 $/t)	58,617,000$ (37.9$/t)
Total cost	:	99,725,000 $ (32.1 $/t)	71,046,000$ (46.0$/t)

(b) Economic Analysis

In this analysis, "cost (C)" is equivalent to total development cost and "benefit (B)" is equivalent to coal sales revenue in supposed FOB price at loading point to barge (30 $/t). The result is as follows :

		Silimpopon		Southwest Malibau
		Base case	High case	Base case
B−C	:	−6,419,000 $	+30,894 $	−24,690,000 U$
B/C	:	0.94	1.33	0.65
EIRR	:	−4.59 %	+13.79 %	−

Base case : Cost estimated in the mining plan and the above FOB price are used.

High case : Coal price, annual production rate and operating cost are assumed to be improved at 10% respectively.

(4) Initial Environmental Examination

The surface of the mine plan area is gentle hilly land with oil palm plantation in Silimpopon and remote mountain land covered by secondary jungle in Southwest Malibau. There is no native resident in and around both areas. The impact on such natural and social environment caused by small scale underground mine development will be minimal. The following are the items to be considered in mine development.

(a) Water pollution : Outflow of soil by road and surface facility construction and waste water from a washing plant

(b) Surface subsidence : Effect to the surface by underground mining

(c) Air pollution : Scatter of coal dust during transportation and loading

(d) Noise and vibration : Influence by machine on the mine site and blasting

(e) Environmental pollution around residential area of mine workers

Those influence to the environment can be minimized by taking appropriate measures. There is no historic spot and cultural heritage around the area.

(5) Evaluation of Potential for Coal Mine Development

Judging from the economical point of view, mine development potential in Southwest Malibau is low at present. However, if coal development is realized in adjacent Maliau Basin in the future, the possibility of mine development will be reconsidered as a satellite mine of Maliau with an advantage of common use of infrastructure.

Silimpopon has a relatively high economical potential for mine development in the future, if the conditions adopted in the mine plan move to the favorable way as shown in high case. The possible effects on local community also must be taken into consideration. Utilization of high sulphur coal in the area is a subject for examination in the future.

10.2. Recommendation

Based on the results and the conclusions obtained through this study, the following recommendations are made about the activities related to further exploration and future development of coal resources in this area .

(1) Exploration and feasibility study on mine development in Silmpopon area

In this study, Silimpopon area was evaluated to have some potential for future mine development. However, the evaluation was mostly based on the data in the previous report. Because the accuracy of those data is uncertain, more detailed exploration is necessary for more reliable evaluation. It is highly evaluated from this viewpoint that four exploratory boreholes are going to be drilled this year by GSD. The following points should be noted in the future exploration and feasibility study.

(a) To obtain reliable and large scale topographic map

(b) Investigation of coal outcrops

- Confirmation of outcrop location in the previous report
- Trenching in the northen part, where the Queen Seam is thick, to investigate the possibility of opencut mining

(c) Drilling

- Thinning and splitting trend in the west and to the south
- Shallow drilling near the surface

(d) Coal analysis

- Analysis of forms of sulphur to estimate removable sulphur by washing

(e) Feasibility study

- Selection of mining method, applicability of L/W mining as much as possible
- Utilization of high sulphur coal

(2) Preparation of a master plan on coal resources development including surrounding area

Not only the evaluation of individual areas, but also a comprehensive plan of coal resources development including surrounding areas is recommended. By this study, the evaluation of individual areas may be changed. It will be also useful for consideration of effective environmental measures for whole area.

(3) Exploration in Maliau Basin

In the above master plan, Maliau Basin will be a core of the development plan. Although the known information is limited for the study team, the coal seam condition and magnitude of the coal resources in the area is thought to be sustainable for a large scale underground mine. It is important meaning to obtain the reliable information on coal resources in the area by further exploration including drilling, for the purpose of establishing future energy strategy in the country or the State of Sabah. Needless to say, environmental consideration is a major premise for this activity.

Appendix 1

GSD's Resource/Reserve Classification System
(Extract)

JABATAN PENYIASATAN KAJIBUMI
MALAYSIA
Geological Survey Department
Malaysia

MANUAL ON GEOLOGICAL SURVEY DEPARTMENT MALAYSIA'S RESERVE/RESOURCE CLASSIFICATION SYSTEM

NO. LAPORAN : EM

KEMENTERIAN PERUSAHAAN UTAMA
Ministry of Primary Industries

MANUAL ON GEOLOGICAL SURVEY DEPARTMENT
MALAYSIA'S RESERVE/RESOURCE CLASSIFICATION SYSTEM

1.0 INTRODUCTION

There are several different reserve classification systems in use today, all based on differing principles. Presently individual officers of the Geological Survey Department Malaysia (Kajibumi) have adopted, with minor modifications, the reserve classification system drawn up by the US Bureau of Mines (USBM) for its general usage. However, specifically for reserve classification of the country's coal resources, the Malaysian Coal Classification System has been devised (Table 1).

Using this Malaysian Coal Classification System as a basis, the Federal Institute for Geoscience and Natural Resources Germany (BGR) had, between 1987-1995, further developed the coal classification into more comprehensive formats (Extended Resource Classification System : Kelter, 1991; A new reserve/resource classification : Kelter and Bandelow, 1992). The final version, originally referred to as the UN - 3D Reserve/Resource Classification System was submitted to the Economic Commission Europe, UN for adoption. After a series of meetings of experts from Europe, Canada, USA and Australia, the system was finally adopted by UN/ECE at its meeting in Hanover in December 1995 as the UN International Framework Classification For Reserves/Resources (Table 2). The intention is to encourage countries to fit their national classification systems into this international framework.

Kajibumi, which is the custodian of Malaysia's mineral-related information, has no reserve classification system of its own at the moment other than the specific scheme to cater for coal. As such, a national, practical, general purpose reserve/resource classification system, capable of meeting the needs of the department and the mineral industry, is necessary. For this purpose, Kajibumi has adopted the UN International Framework Classification for Reserves/Resources as a basis for structuring a national classification scheme (the UN Framework Classification is included as appendix I of this manual).

2.0 KAJIBUMI'S RESERVE/RESOURCE CLASSIFICATION SYSTEM

The structure of Kajibumi's reserve/resource classification scheme is shown in Table 3. In essence, the overall features of the UN Framework Classification is retained, except that:-

(a) Additional reserve/resource classes (123) and (223) are included in Kajibumi's classification scheme to cater for non-metallic minerals such as clays and construction sand and gravel which require low mining investment. The economic viability of such deposits can often be established with minimal investigation and simple cost-benefit estimates during the prefeasibility study stage.

(b) Economic viability category "3" (intrinsically economic : meaning economic to potentially economic) is introduced to replace economic viability categories "1-2" (economic to potentially economic, ie: intrinsically economic) and "?" (economic viability undetermined) in the UN Framework Classification so as to harmonize the economic viability categories with the codings for resource classes under various stages of Geological Study (compare tables 2 and 3).

As in the UN Framework Classification, the main features of the Kajibumi Classification System are :-

(a) Mineral reserves/resources are classified based on

- four stages of Geological Assessment
- three levels of Feasibility Assessment
- three categories of Economic Viability

(b) There are eight classes of mineral reserves and resources (see tables 3 & 4).

(c) Each reserve/resource class is codified based on the stage of geological and feasibility assessment and its economic viability (see tables 3 & 4).

For details of the classification and codification, the reader is referred to appendix 1 : UN Framework Classification.

The significant features of this classication system are :

(a) It can accommodate the reserve/resource figures estimated through Kajibumi's existing exploration methodologies.

(b) It can accommodate the reserve/resource figures supplied by exploration/mining companies.

(c) It is practical and readily understood.

(d) It conforms to the UN Framework Classification.

3.0 DEFINITION OF TERMS USED IN THE KAJIBUMI CLASSIFICATION SYSTEM

The definitions of terms used in the Kajibumi System largely conform to those terminologies introduced in the UN Framework Classification.

The definitions used are as follows:-

(a) Definitions of Stages of Feasibility Assessment

Mining Report : A **Mining Report** is understood as the current documentation of the state of development and exploitation of a deposit during its economic life including current mining plans. It is generally made by the operator of the mine. The study takes into consideration the quantity and quality of the minerals extracted during the reporting time, changes in Economic Viability categories due to changes in prices and costs, development of relevant technology, newly imposed environmental or other regulations, and data on exploration conducted concurrently with mining.

It presents the current status of the deposit, providing a detailed and accurate, up-to-date statement on the reserves and the remaining resources.

Feasibility Study : **A Feasibility Study** assesses in detail the technical soundness and Economic Viability of a mining project, and serves as the basis for the investment decision and as a bankable document for project financing. The study constitutes an audit of all geological, engineering, environmental, legal and economic information accumulated on the project. Generally, a separate environmental impact study is required.

Cost data must be reasonably accurate (usually within ± 10%), and no further investigations should be necessary to make the investment decision. The information basis associated with this level of accuracy comprises the reserve figures based on the results of Detailed Exploration, technological pilot tests and capital and operating cost calculations such as quotations of equipment suppliers.

A detailed list of the items addressed in a Feasibility Study is given in Appendix I.

Prefeasibility Study : A Prefeasibility Study provides a preliminary assessment of the Economic Viability of a deposit and forms the basis for justifying further investigations (Detailed Exploration and Feasibility Study). It usually follows a successful exploration campaign, and summarizes all geological, engineering, environmental, legal and economic information accumulated to date on the project.

In projects that have reached a relatively advanced stage, the Prefeasibility Study should have error limits of $\pm$ 25%. In less advanced projects higher errors are to be expected. Various terms are in use internationally for Prefeasibility Studies reflecting the actual accuracy level. The data required to achieve this level of accuracy are reserves/resources figures based on Detailed and General Exploration, technological tests at laboratory scale and cost estimates e.g. from catalogues or based on comparable mining operations.

The Prefeasibility Study addresses the items listed under the Feasibility Study, although not in as much detail.

For the low investment mining of non-metalic mineral commodoties such as construction sand and gravel, clays etc. which requires only minimal investigation, a comprehensive prefeasibility study is not necessary for the assessment of economic viability. In such cases, a "prefeasibility study" consisting of a simple cost-benefit estimate will be sufficient to establish the economic viability of a deposit.

Geological Study : A **Geological Study** is an initial evaluation of Economic Viability. This is obtained by applying meaningful cut-off values for grade, thickness, depth, and costs estimated from comparable mining operations.

Economic Viability categories, however, cannot in general be defined from the Geological Study because of the lack of details necessary for an Economic Viability evaluation. The resource quantities estimated may indicate that the deposit is of intrinsic economic interest, i.e. in the range of economic to potentially economic.

A Geological Study is generally carried out in the following four main stages: Reconnaissance, Prospecting, General Exploration and Detailed Exploration (for definition of each stage see below). The purpose of the Geological Study is to identity mineralization, to establish continuity, quantity, and quality of a mineral deposit, and thereby define an investment opportunity.

(b) Definitions of Stages of Geological Study

Reconnaissance : A Reconnaissance Study identifies areas of enhanced mineral potential on a regional scale based primarily on results of regional geological studies, regional geological mapping, airborne and indirect methods, preliminary field inspection, as well as geological inference and extrapolation. The objective is to identity mineralized areas worthy of further investigation towards deposit identification. Estimates of quantities should only be made if sufficient data are available and when an analogy with known deposits of similar geological character is possible, and then only within an order of magnitude.

Prospecting : Prospecting is the systematic process of searching for a mineral deposit by narrowing down areas of promising enhanced mineral potential. The methods utilized are otucrop identification, geological mapping, and indirect methods such as geophysical and geochemical studies. Limited trenching, drilling, and sampling may be carried out. The objective is to identity a deposit which will be the target for further exploration. Estimates of quantities are inferred, based on interpretation of geological, geophysical and geochemical results.

General Exploration : **General Exploration** involves the initial delineation of an identified deposit. Methods used include surface mapping, widely spaced sampling, trenching and drilling for preliminary evaluation of mineral quantity and quality (including mineralogical tests on laboratory scale if required), and limited interpolation based on indirect methods of investigation. The objective is to establish the main geological features of a deposit, giving a reasonable indication of continuity and providing an initial estimate of size, shape, structure and grade. The degree of accuracy should be sufficient for deciding whether a Prefeasibility Study and Detailed Exploration are warranted.

Detailed Exploration : **Detailed Exploration** involves the detailed three-dimensional delineation of a known deposit achieved through sampling, such as from outcrops, trenches, boreholes, shafts and tunnels. Sampling grids are closely spaced such that size, shape, structure, grade, and other relevant characteristics of the deposit are established with a high degree of accuracy. Processing tests involving bulk sampling may be required. A decision whether to conduct a Feasibility Study can be made from the information provided by Detailed Exploration.

(c) Definitions of Economic Viability Categories

Economic : Quantities, reported in tonnes/volume with grade/quality, demonstrated by means of a Prefeasibility Study, Feasibility Study or Mining Report, in order of increasing accuracy, that justify extraction under the technological, economic, environmental and other relevant conditions, realistically assumed at the time of the determination.

Potentially Economic : Quantities, reported in tonnes/volume with grade/quality, demonstrated by means of a Prefeasibility Study, Feasibility Study or Mining Report, in order of increasing accuracy, not justifying extraction under the technological, economic, environmental and other relevant conditions, realistically assumed at the time of the determination, but possibly so in the future.

Intrinsically Economic : (Economic to Potentially Economic)	Quantities, reported in tonnes/volume with grade/quality, estimated by means of a Geological Study. Since the Geological Study includes only a preliminary evaluation of Economic Viability, no distinction can be made between economic and potentially economic. These Resources are therefore said to Intrinsically Economic and lie in the range of economic to potentially economic.

(d) Definitions of Mineral Reserve/Resource Terms

Proved Mineral Reserve (111) :	Demonstrated to be economically mineable by a Feasibility Study or actual mining activity usually undertaken in areas of Detailed Exploration.
Probable Mineral Reserve (121+122+123)	Demonstrated to be economically mineable by a Prefeasibility Study usually carried out in areas of Detailed Exploration and General Exploration or in areas covered by Prospecting for certain non-metallic minerals which require low mining investment and minimal investigation.
Feasibility Mineral Resource (211) :	Demonstrated to be potentially economic by a Feasibility Study or prior mining activity usually carried out in areas of Detailed Exploration.

Prefeasibility Mineral Resource (221+222+223) :	Demonstrated to be potentially economic by a Prefeasibility Study usually carried out in areas of Detailed Exploration and General Exploration or in areas covered by Prospecting for certain non-metallic minerals which require low mining investment and minimal investigation.
Measured Mineral Resource (331) :	Estimated to be of intrinsic economic interest based on Detailed Exploration establishing all relevant characteristics of a deposit with a high degree of accuracy.
Indicated Mineral Resource (332) :	Estimated to be of intrinsic economic interest based on General Exploration establishing the main geological features of a deposit providing an initial estimate of size, shape, structure and grade.
Inferred Mineral Resource (333) :	Estimated to be of intrinsic economic interest based on Prospecting having the objective to identify a deposit. Estimates of quantities are inferred, based on outcrop identification, geological mapping, indirect methods and limited sampling.
Reconnaissance Mineral Resource (334) :	Based on Reconnaissance, having the objective to identify areas of enhanced mineral potential. Estimates of quantities should only be made if sufficient data are available and when an analogy with known deposits of similar geological character is possible and then only within an order of magnitude.

e) Total Mineral Resource :	All naturally occurring concentrations of mineral raw material of economic interest and with specified geological certainty.
(f) Mineral : 'Reserve	The economically mineable part of Total Mineral Resource as demonstrated by Feasibility Assessment.
(g) Remaining Mineral : Resource	Balance of the Total Mineral Resource that has not been identified as a Mineral Reserve.
(h) Uneconomic Deposit	Mineral raw material of estimated quantity that are too low in grade or for other reasons are not considered potentially economic. Thus Uneconomic deposit is not part of Mineral Resource.
(g) Mineral Occurrence :	An indication of mineralization that is worthy of further investigation. The term Mineral Occurrence does not imply any measure of volume/tonnage or grade/quality and is thus not part of a Mineral Resource.

5.7.3 Limiting factors

(a) For high calcium limestone, $CaCO_3$ >95%.

(b) For high magnesium limestone, MgO >17% ($MgCO_3$ >35%).

(c) Limestone has many industrial applications. The following are the $CaCO_3/MgCO_3$ requirements for some major end uses:-

(i)	Agriculture	: $CaCO_3$ >80%. or $MgCO_3$ > 31%
(ii)	Acid neutralization	: $CaCO^3$ >95%.
(iii)	Glass	: $CaCO_3$ >98%.
(iv)	High calcium lime	: $CaCO_3$ >90%, <5% $MgCO_3$.
(v)	High magnesium lime	: $MgCO_3$ >40%.
(vi)	Portland cement	: $CaCO_3$ >75%, $MgCO_3$ <5%.
(vii)	Refractory dolomite	: $MgCO_3$ >40%.
(viii)	Open hearth furnace	: $CaCO_3$ >98%.

5.8 Coal

5.8.1 Definition

"Coal" is a readily combustible rock containing >50% by weight of carbonaceous material.

5.8.2 Exploration guidelines

Field method is essentially geological mapping and sampling supported by geophysical investigations and core drilling.

Coal is derived from the compaction and induration and/or metamorphism of plant remains. The deposits may be tabular or lenticular in shape.

5.8.3 Limiting factors

For classification purposes, the coal should meet the following requirements:-

(a) Seam thickness of more than 0.6 metre.

(b) Ash content of raw coal less than 50%.

(c) "Overburden : coal thickness" ratio (for opencast mining) less than 10:1.

(d) Net calorific value of raw coal more than 11,000 kj/kg.

(e) In addition, different categories of coal have their own individual requirements with respect to:-

   (i) Ash content.

   (ii) Net calorific value.

   (iii) Total sulphur content.

Table 3: Geological Survey Department Malaysia Reserve/Resource Classification

	Detailed Exploration	General Exploration	Prospecting	Reconnaissance
Feasibility Study and/or Mining Report	1 Proved mineral reserve (111) 2 Feasibility mineral resource (211)			
Prefeasibility Study	1 Probable mineral reserve (121) 2 Prefeasibility mineral resource (221)	+ (122) + (222)	+ (123) + (223)	
Geological Study	3 Measured mineral resource (331)	3 Indicated mineral resource (332)	3 Inferred mineral resource (333)	3 Reconnaissance mineral resource (334)

Note:-

(a) Economic viability categories: 1 = economic 2 = potentially economic
3 = intrinsically economic (economic to potentially economic)

(b) Codified reserve/resource classes (123) and (223) are for non-metallic minerals such as construction sand and gravel, clays etc. which require low mining investment. The economic viability of such deposits can often be established with minimal investigation and simple cost-benefit estimates during the "prefeasibility study" stage. In such cases, comprehensive prefeasibility studies are not necessary.

Appendix 2

Coal Graphic Logs

Appendix 2-1 Malibau
Appendix 2-2 Southwest Malibau
Appendix 2-3 Silimpopon
Appendix 2-4 Sesui West
Appendix 2-5 Gunong Luis
Appendix 2-6 Serudong

Appendix 3

Compilation Map of Mapping Sheets

Appendix 3-1 Malibau Area
- 3-1-T1 Malibau Area (T1)
- 3-1-T2 Malibau Area (T2)
- 3-1-T3 Malibau Area (T3)
- 3-1-T4 Malibau Area (T4)
- 3-1-T5 Malibau Area (T5)
- 3-1-T6 Malibau Area (T6)
- 3-1-T7 Malibau Area (T7)
- 3-1-T8 Malibau Area (T8)
- 3-1-T9 Malibau Area (T9)
- 3-1-T10 Malibau Area (T10)

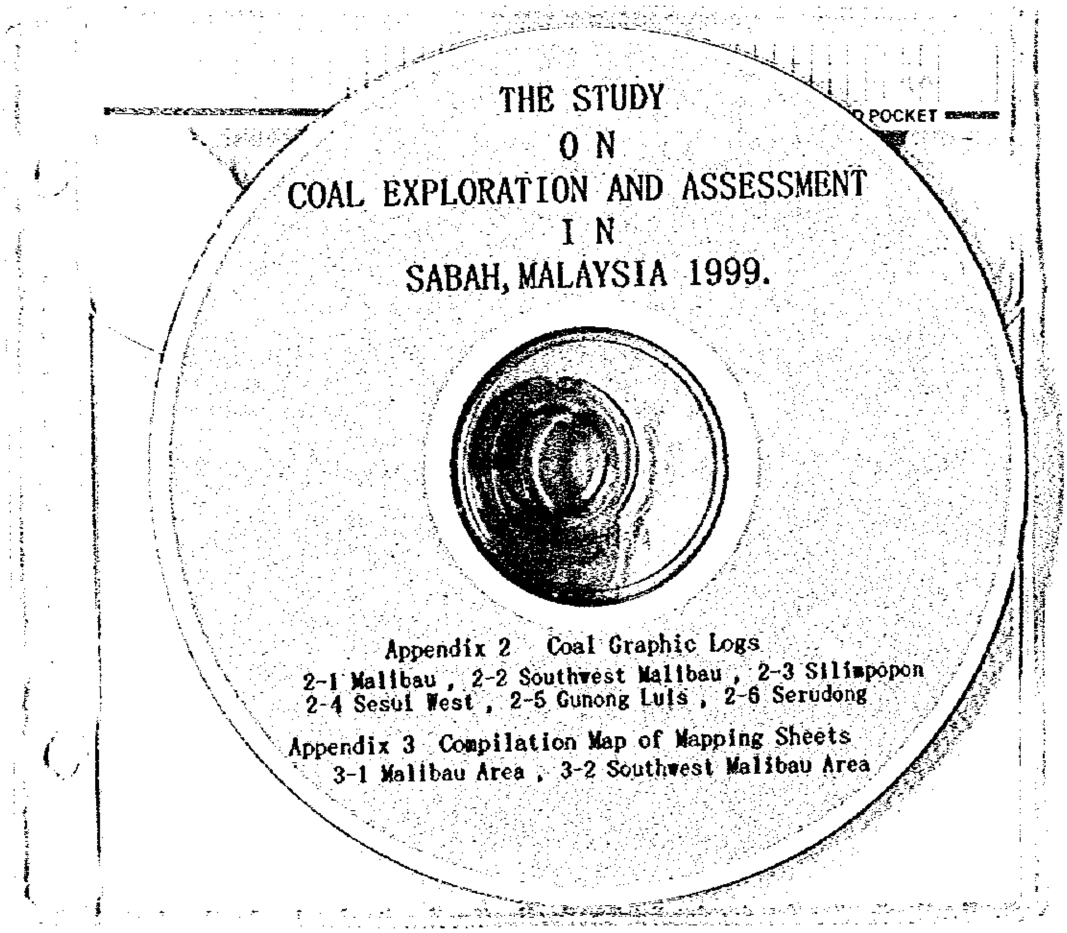
Appendix 3-2 Southwest Malibau Area
- 3-2-T1B S.W. Malibau Area (T1B)
- 3-2-T2B S.W. Malibau Area (T2B)
- 3-2-T3B S.W. Malibau Area (T3B)
- 3-2-T4B S.W. Malibau Area (T4B)

図書付属資料調査結果

図書資料名：マレイシア国サバ州石炭探査・評価調査最終報告書

付属CD-ROM

拡張子　DWG のデータを読むには AutoCad などの
CAD(Computer Aided Designing) ソフトが必要です。



Appendix 4

Basic Data of Mining Plan