Table 7-3 Summary of Work Force

	Section	Staff	Worker	Total
Mine Management		2	-	2
Production	Underground	34	191	225
	Washing Plant	7	40	47
	Subtotal	41	231	272
Safety	Subtotal	16	7	23
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	4	8
	Accounting	5	8	13
	Subtotal	9	12	21
Administration	Subtotal	14	40	54
Total		112	346	458

7.2. Southwest Malibau Area

7.2.1. Basic Consideration

(1) Mineable Coal Seams and Mining Area

SE1 and SE2 Seams in the western part and SB1 Seam in the middle-eastern part have been selected as the mineable coal seams for the present mining study from the view points of thickness and extent of continuity.

Table 7-4 Mineable Coal Seams

Area	West	West	East
Coal Seam	SE2	SE1	SB1
Thickness : min.- max. (m)	1.20 - 2.61	1.05 - 4.86	1.10 - 5.23
Extent of Mineable Thickness	900	1,700	1,400

As a result of the selection of the mineable coal seams as above, mining area is separated into two areas, namely, western area for SE1 and SE2 Seams and eastern area for SB1 Seam.

(2) Recoverable Reserves

Recoverable reserves have been estimated according to the mine plan to be explained in the next section. Reserve calculation was made on raw coal basis in each panel and roadway.

(a) Mining area

Coal barriers of 15 m between upper and lower panels are not included in the reserves. The lowest level of mining area is 310 m in vertical distance from the uppermost roadway.

(b) Mining thickness

Maximum mining thickness was determined at 2.4 m in the present study. Average mining thickness of each coal seam is shown in Table 7-5.

Table 7-5 Average Mining Thickness

Coal seam	SE2	SE1	SB1
Number of outcrops	9	11	6
Total thickness (m)	14.65	18.81	11.20
Average thickness (m)	1.63	1.71	1.87
Thickness used in calculation(m)	1.60	1.70	1.90

(c) Recovery factor : mining panel - 95%, roadway - 100%

(d) Specific gravity : 1.4 (raw coal)

Table 7-6 shows the summary of recoverable reserves estimated according to the above criteria.

Table 7-6 Summary of Recoverable Reserves

Coal Seam	Mining (t)	Roadway (t)	Total (t)
SE2	356,200	62,400	418,600
SE1	589,000	93,600	682,600
Subtotal	945,200	156,000	1,101,200
SB1	605,900	105,500	711,400
Total	1,551,100	261,500	1,812,600

7.2.2. Mine Design and Mining Method

(1) Basic Idea of Mine Design

As stated previously, mining area is separated into two areas, namely, SB1 Seam in the middle-east (East Pit) and SE1 and SE2 Seams in the west (West Pit). The following basic idea of mine design is common to both pit.

(a) Vertical length of a mining panel is 50 m and 15 m of coal barrier is left unmined between upper and lower panels.

(b) Five levels of mining panels are planned in each pit. The elevation of top and bottom of mining panels are as follows :

		West Pit	East Pit
Top level (m)	:	680	700
Bottom level (m)	:	370	390

(c) In-seam roadways at higher levels are opened by means of adits from coal exposures, Coal reserves deeper than the lowest adit level are developed by means of rock slopes and cross cuts.

General layout of East and West Pit is shown in Figure 7-2.

(2) East Pit (SB1 Seam)

Figure 7-3-1 shows a mining plan of the East Pit of Southwest Malibau area.

Two slopes are constructed on the floor side (or northeastern side) of SB1 Seam at an inclination of 16 degrees and nearly parallel to the strike direction of the seam. One is used for intake of air and transportation of coal, workers and material, while the other is used mainly for exhaust of air.

From intake slope, crosscuts are driven to the coal seam at nine following levels. From exhaust slope, four crosscut are driven which are connected to the upper roadways of each mining panel.

(3) West Pit (SE1/SE2 Seams)

Figure 7-3-2 shows the mining plan of SE1 seam in the Weat Pit of Southwest Malibau area. Three entries of in-seam roadways at upper five levels are opened directly at exposures of the seams. Roadways of SE1 Seam at lower two levels 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.

For the access to coal seams deeper than 550 ml, three(3) plans have been studied with respect to the combination and the position of horizontal tunnels, slopes and crosscuts. The 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.

Plan 3 is adopted as a base case for development and production schedule and cost estimate as a result of the comparison.

(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 inclination and thickness of coal seam.

In this method, several working faces, called "kakkuchi", are arranged in the shape of saw teeth on a diagonal 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. Roof 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.

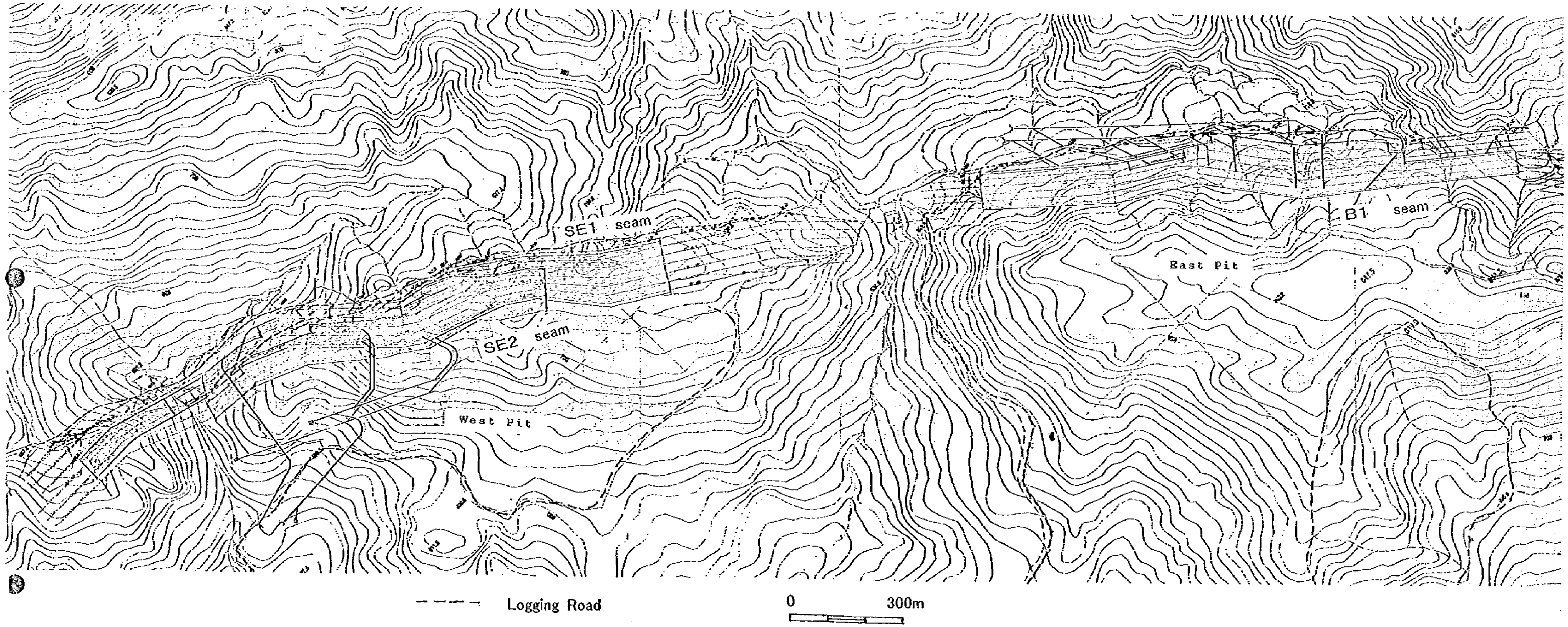

Figure 7-2 General Layout of Southwest Malibau Mine

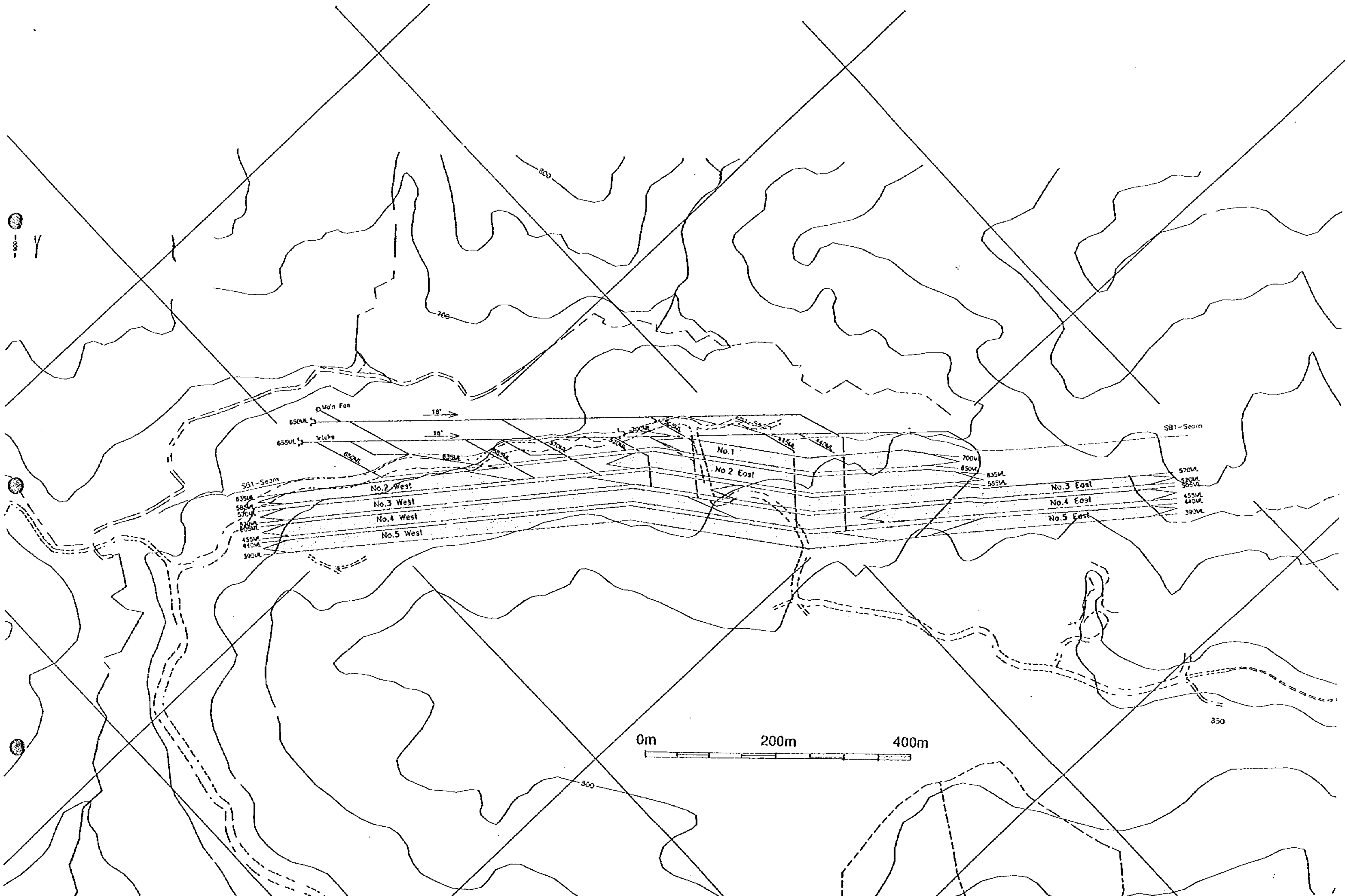

Figure 7-3-1 Mining Plan of Southwest Malibau - East Pit

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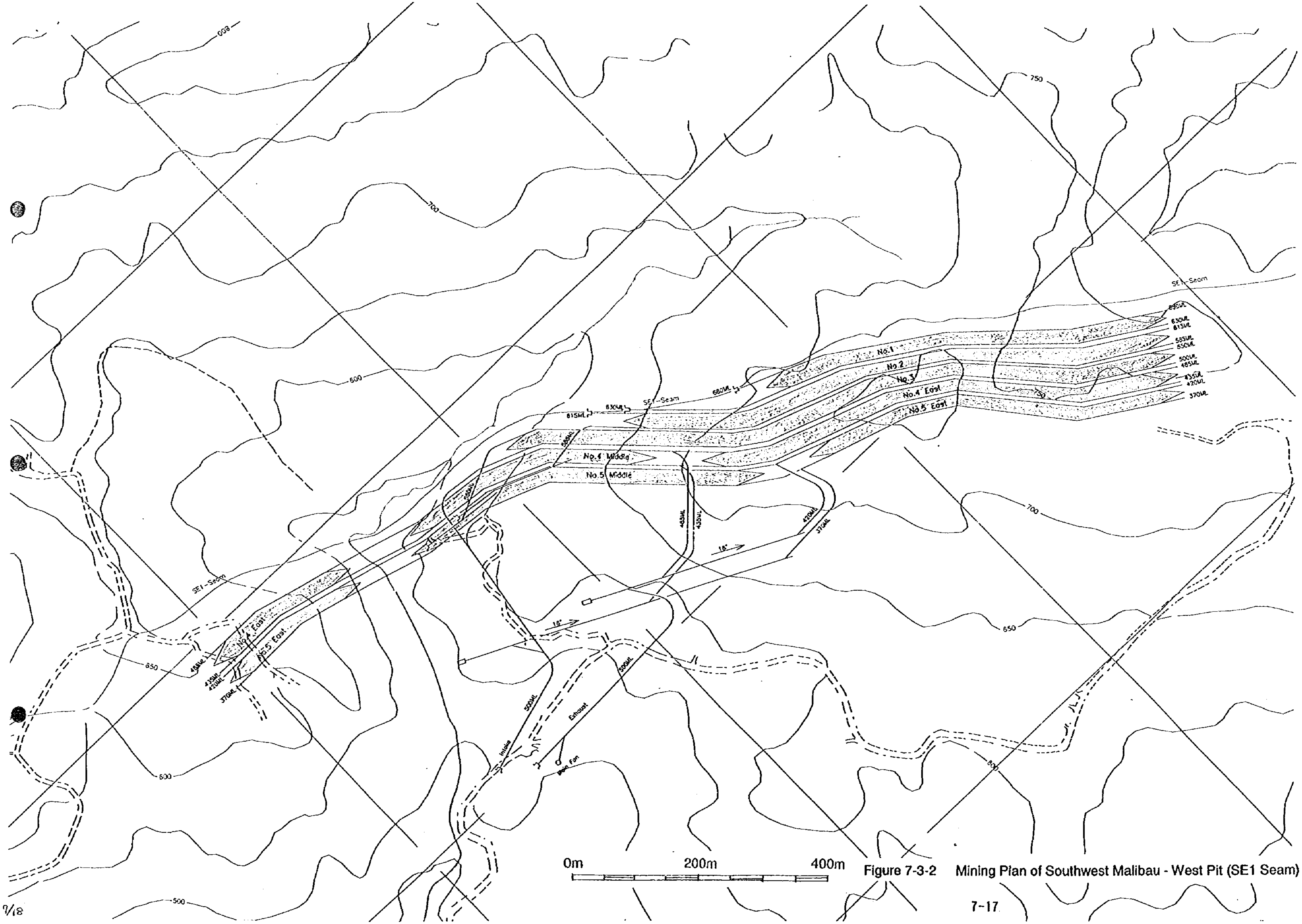

Figure 7-3-2 Mining Plan of Southwest Malibau - West Pit (SE1 Seam)

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) = 250days/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

(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 7-7 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

Table 7-8 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 7-9. Table 7-10 shows a summary of mining sequence and coal production of each pit :

Table 7-10 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 thousand 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 7-11 is a summary of the required number of work force on registered basis in the whole mine organization.

Table 7-9 Production Schedule Southwest Malibau Mine

Pit	Item	Tons	Y1		Y2		Y3		Y4		Y5		Y6		Y7		Y8		Y9		Y10	
			days	tons	days	tons	days	tons	days	tons	days	tons	days	tons	days	tons	days	tons	days	tons	days	tons
East Pit	No. 1	53,067			[145d]	53,067																
East Pit	No. 2 West	42,959			[103d]	37,492	[15d]	5,467														
East Pit	No. 2 East	66,334					[182d]	66,334														
East Pit	No. 3 West	65,702					[53d]	19,292	[128d]	46,410												
East Pit	No. 3 Eeast	84,655							[122d]	44,408	[111d]	40,247										
East Pit	No. 4 West	84,023									[139d]	50,596	[92d]	33,427								
East Pit	No. 4 Eeast	56,226											[154d]	56,226								
East Pit	No. 5 West	111,820											[4d]	1,456	[250d]	91,000	[53d]	19,366				
East Pit	No. 5 East	41,064															[113d]	41,064	S84d			
East Pit	W/F Total	605,850				90,559		91,093		90,818		90,843		91,109		91,000		60,420				
East Pit	Develop Total	105,490		16,580		17,252		21,506		17,714		11,519		20,919								
East Pit	East Pit Production Total			16,580		107,811		112,599		108,532		102,362		112,028		91,000		60,420				
West Pit	E2 No. 1	38,730															[54d]	25,704	[45d]	13,026 s297d		
West Pit	E2 No. 2	64,265	306 tons/day																		[210d]	64,265 s55d
West Pit	E2 No. 3	84,269																				
West Pit	E2 No. 4 Wst	41,070																				
West Pit	E2 No. 4 Est	44,050	367 tons/day + 20% LP Productin [Increse workers after road development]																			
West Pit	E2 No. 5 Wst	59,584																				
West Pit	E2 No. 5 Est	24,259																				
West Pit	E1 No. 1	68,951																	[297d]	67,652	[5d]	1,439 s245d
West Pit	E1 No. 2	95,640	326 tons/day																		[35d]	11,410
West Pit	E1 No. 3	118,137																				
West Pit	E1 No. 4 Wst	26,228																				
West Pit	E1 No. 4 Mdl	43,185																				
West Pit	E1 No. 4 Est	83,092	391 tons/day + 20% LP Productin [Increse workers after road development]																			
West Pit	E1 No. 5 Wst	25,775																				
West Pit	E1 No. 5 Mdl	63,534																				
West Pit	E1 No. 5 Est	64,439																				
West Pit	W/F Total	945,219																25,704		80,508		77,155
West Pit	Develop Total													2,158		27,073		19,524		8,337		20,071
West Pit	West Pit Total Production													2,158		27,073		45,228		88,845		97,226
	SW Malibau Total Product			16,580		107,811		113,599		108,532		102,362		119,186		118,073		105,655		88,845		97,226

Pit	Item	Y11		Y12		Y13		Y14		Y15		Y16		Y17		Y18		Y19		Total Tons
		days	tons	days	tons	days	tons	days	tons	days	tons	days	tons	days	tons	days	tons	days	tons	
East Pit	No. 1																			53,067
East Pit	No. 2 West																			42,959
East Pit	No. 2 East																			66,334
East Pit	No. 3 West																			65,702
East Pit	No. 3 Eeast																			84,655
East Pit	No. 4 West																			84,023
East Pit	No. 4 Eeast																			56,226
East Pit	No. 5 West																			111,820
East Pit	No. 5 East																			41,064
East Pit	W/F Total																			605,850
East Pit	Develop Total																			105,490
East Pit	East Pit Production Total																			711,340
West Pit	E2 No. 1																			38,730
West Pit	E2 No. 2																			64,266
West Pit	E2 No. 3			[242d]	74,052	[33d] s317d	10,217													84,269
West Pit	E2 No. 4 Wst							[105d]	38,535	[7d]	2,535									41,070
West Pit	E2 No. 4 Est									[120d]	44,050									44,050
West Pit	E2 No. 5 Wst													[162d]	59,584					59,584
West Pit	E2 No. 5 Est													[66d]	24,259					24,259
West Pit	E1 No. 1																			68,951
West Pit	E1 No. 2	[250d]	81,500	[8d]	2,730 s240															95,640
West Pit	E1 No. 3					[313d]	70,742	[145d]	47,395											118,137
West Pit	E1 No. 4 Wst									[67d]	26,228									26,228
West Pit	E1 No. 4 Mdl									[56d]	21,896	[51d]	21,289							43,185
West Pit	E1 No. 4 Est											[195d]	76,636	[17d]	6,456					83,092
West Pit	E1 No. 5 Wst													[5d]	1,955	[61d]	23,820			25,775
West Pit	E1 No. 5 Mdl															[162d]	63,534			63,534
West Pit	E1 No. 5 Est															[27d]	10,557	[138d]	53,882	64,439
West Pit	W/F Total		81,500		76,762		80,959		85,930		94,709		97,925		92,254		97,911		53,892	945,219
West Pit	Develop Total		20,229		16,059		24,067		17,811											161,159
West Pit	West Pit Total Production		101,729		92,871		105,026		103,741		94,709		97,925		92,254		97,911		53,882	1,106,378
	SW Malibau Total Product		101,729		92,871		105,026		103,741		94,709		97,925		92,254		97,911		53,892	1,817,718

Table 7-11 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

7.3. Estimate of Product Coal Quality

7.3.1. Analytical Data

(1) Silimpopon Area

Only one analysis of Queen Seam is available in Phase 2. Two previous data are also used to estimate the average coal quality of the Queen Seam as shown in Table 7-12.

Table 7-12 Analysis of Queen Seam

	KK011	Phase 1*	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 following analytical data of the samples located within the mine planning area are extracted for calculating average values (Table 7-13).

Table 7-13 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	41.4	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) Adjustment of moisture content and calorific value to remove the influence of weathering.

(2) Out-of-seam dilution (OSD) is assumed to be 10% of raw coal in volume (Table 7-14)

Table 7-14 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

(3) Hand-Picking and Washing Plant

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.

In the above process, the overall yield is estimated at 85%.

7.3.3. Coal Quality of Final Products

Based on the above assumptions, coal quality of final products is estimated. Possible specification of the final products from each mine is shown in Table 7-15 below :

Table 7-15 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 would be removed by washing process.

The above specification is an example and shows the highest case in calorific value. The coal of lower calorific value is also used in various market 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 7-4.

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 seven km road is to be constructed along the track of old railway. The barge goes down the Silimpopon River to Cowie Harvor.

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.

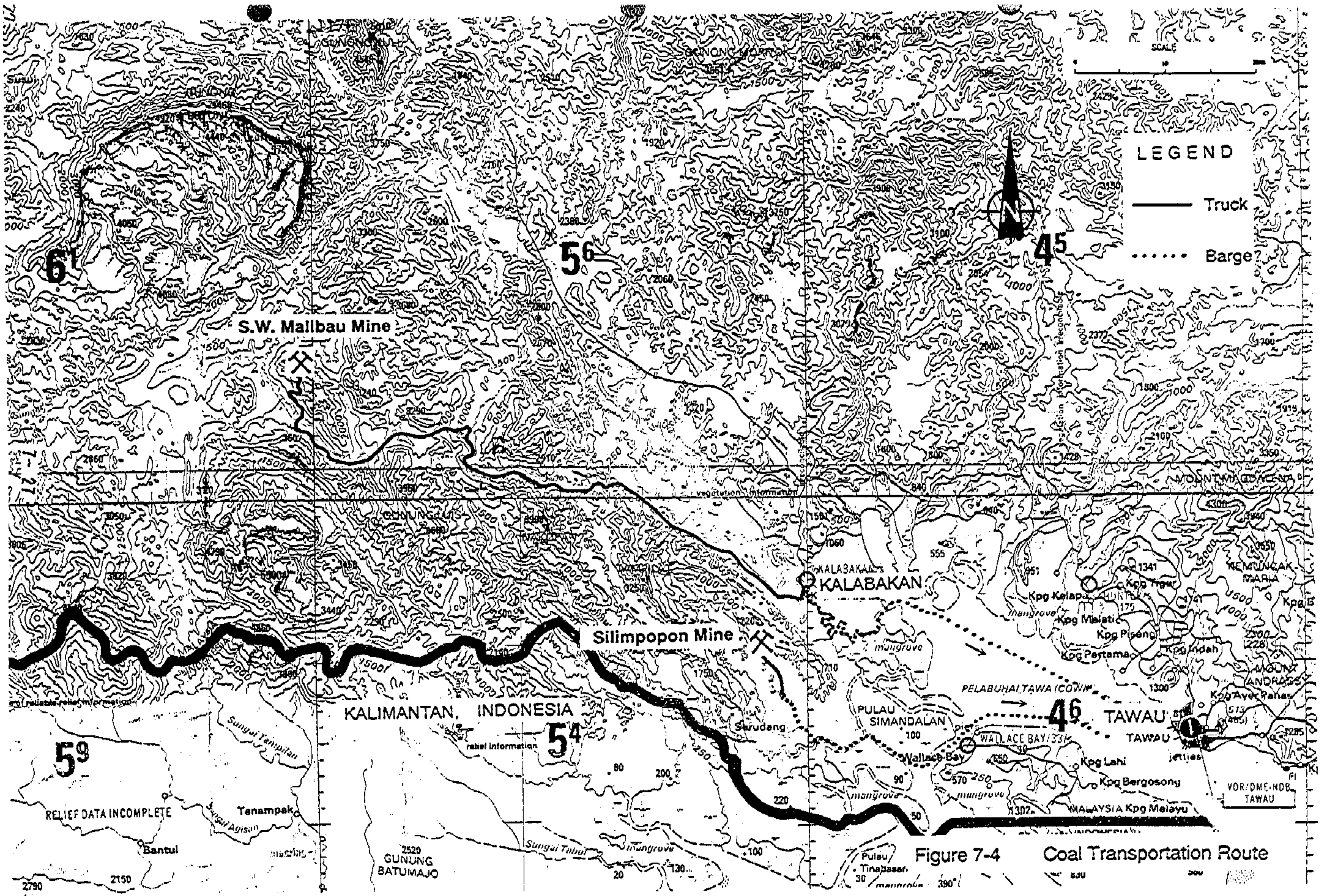

Figure 7-4 Coal Transportation Route

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.

Operating cost was estimated on the basis of FOB at loading point to barge. Royalty and tax are not included in the cost. All the cost figures are expressed in US $, 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

(2) Operating Cost

Table 8-2 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

Table 8-3 Summary of Capital Cost (1,000 US$)

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

(2) Operating Cost

Table 8-4 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

Table 8-5 is a summary and a comparison of the costs of Silimpopon and Southwest Malibau Mines.

Table 8-5 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

1) Currency : US$, exchange rate to local currency : 1 US$ = 3.8 RM
2) Evaluation period : Whole period of mine operation
   (Silimpopon: 24 years , S.W.Malibau: 19 years)
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

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	Southwest Malibau
	1,000 $ ($/t)	1,000$ ($/t)
Labour fee	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	Southwest 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)

(2) Benefit

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

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".

		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 of 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.

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. One of the reason of price down is that growth rate of steaming coal 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, on the other hand, 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.

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 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 minable 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)

An alternative case was examined as "High Case" on the assumption that all factors improved by 10% as shown below.

Coal Price	:	+10 % (30 → 33 $/t)
Production	:	+10 % (3,110,100 → 3,421,100 $)
Operating Cost	:	−10 % (74,647,000 → 67,187,000 $)

Following is a comparison of these two cases:

		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. 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)

9.1. 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 1985, and subsidiary legislations have been successively added to comply with the need.

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.

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.

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 ha, in southeastern Sabah.

9.2. 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 1,000m elevation in Borneo. The dipterocarp trees characterize this type of forests, and they grow over 50m 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 Kalabalan 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.

In the area investigated in detail, a large plantation of oil palms is prosperous in Silimpopon and its surrounding areas. 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 the Mine Development and Countermeasures

9.3.1. 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:

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 from felling of trees

9.3.2. Results of the Examination and Countermeasures

(1). Silimpopon Area

As mentioned earlier, a large plantation of oil palm is operating in Silimpopon and itssurrounding 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. 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, 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. 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. Soil erosion is proceeding strongly along the road and collapsed slopes, and the rivers draining this area are yellowish brown with the suspended silt. 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.

9.3.3. Conclusion

Development of the coal resources in the 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 the 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. 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. Therefore strict fire-prevention measures are required in the mining facilities. Also to reduce the danger of forest fires, measures to limit the number of residents in the mining area should be done, such as constructing the accommodations for mine workers along the main roads.

(1)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.

(2)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.

10. Conclusion and Recommendation

10.1. Summary and Conclusion

(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 in thickness. 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

In-situ coal resources (Indicated class) estimated in this study is 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 seam conditions, the preliminary mine plan in Silimpopon and Southwest Malibau areas has been 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 $
B/C	:	0.94	1.33	0.65
EIRR	:	−4.59 %	+13.79 %	−

Base case : Cost estimated in mining plan and coal price at FOB 30 $/t 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

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 that some exploratory boreholes are going to be drilled this year by GSD from this view point. 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
  (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 (estimate of removable sulphur by washing

(e) Feasibility study

- Selection of mining method (related to the river flow)
- 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 area ma be changed. It is also useful for consideration of effective environmental measures for whole area.

(3) Exploration in Maliau Basin

In the above master plan, Maliau area 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 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.

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