Table 4-11 Estimation Premises for Transportation Cost of Limestone

Item	Sin Pun Site No. 2	Sin Pun Site No. 3	Krabi Site No. 4
Amount of Limestone Total (Million Ton) Annual (Thousand Ton)	10.9 436	10.9 436	10.2 407
Distance from mine to limestone storage gard (Average) [km]	18.6	11.0	11.0
Truck Life time [kW]	1,000,000	1,000,000	1,000,000
Capacity [ton]	25	25	25
Number	7	6	6
Fuel Ratio per coal ton	0.047 ℓ/ton km	0.047 ℓ/ton.km	0.047 ℓ/ton km
Oil cost			
Fuel Oil	0.33 U$/ℓ	0.33 U$/ℓ	0.33 U$/ℓ
Other Oil	Fuel Cost x 20%	Fuel Cost x 20%	Fuel Cost x 20%
Truck Cost (Baht)	2,860,000	2,860,000	2,860,000
Maintenance cost/year	Truck cost x 5%	Truck cost x 5%	Truck cost x 5%
Labour and annual cost Additioned for coal transportation	KU$	KU$	Base KU$
Driver (4,480 U$/Y)	21 91.08	18 80.64	18 80.64
Fitter (7,570 U$/Y)	10 75.70	8 60.56	7 52.99
Welder (5,650 U$/Y)	6 33.90	5 28.25	4 22.60
Relief (4,660 U$/Y)	3 13.98	3 13.98	2 9.32
	214.66	183.43	165.55
Discount Rate %	10.0	10.0	10.0
Truck Operation (Minutes) Loading	9 times operation 30	11 times operation 30	11 times operation 30
Going	30	20	20
Unloading	20	20	20
Return	20	15	15

(6) Cooling Water Supply (Site No. 2)

Concerning the cooling water system for condenser at Site No. 2, cooling tower type should be employed because there is no sea or no big river from which sufficient amount of cooling water can withdraw into once-through type condenser cooling system near candidated site.

From the estimation based on the meteological data and water quality data in Sin Pun area, 5 cycles of concentration was chosen, as a result 0.114 m^3/s of cooling water is required as a make up water for cooling water system.

Water quality data is shown in Table 4-12. In addition to the quantity of cooling water, 0.016 m^3/s of plant water supply should be considered into the quantity of raw water supply.

Accordingly 0.13 m^3/s of total raw water is necessary to provide for the project.

Table 4-12 Water Quality Analysis Results of Bang Kam Prat River Water

Items		Wier water	Dam Water		
			1 M.	6 M.	10 M.
Electrical conductivity (μs/cm)		140.7	19	20	140
pH		6.9	7.1	6.9	6.6
M-alkalinity	(mg $CaCO_3$/1)	60	50	54	60
Total hardness	(mg $CaCO_3$/1)	54	50	50	50
Ca-hardness	(mg $CaCO_3$/1)	44	38	38	38
Mg-hardness	(mg $CaCO_3$/1)	10	12	12	12
Silica	(mg SiO_2/1)	9.0	9.2	9.4	10.0
Chlorides	(mg Cl-/1)	7.0	9.0	8.0	6.0
Sulfatas	(mg SO_4^{2-}/1)	2.01	0.44	0.40	Trace
Total dissolved solid	(mg/1)	115	86	87	112
Turbidity	(mg/1)	20	4.5	6.0	12.0

Dam Water Analysis from 3 level at the depth, 1 meter, 6 meter and 10 meter

This quantity of raw water is available from the weir constructed by RID at the upper stream of Khlong Bang Kam Prat running adjacent to Site No. 2 (Refer to Appendix I). The water transmission route is shown in Fig. 4-11. The premises for the calculation of the cooling water supply cost are taken as shown in Table 4-13 Site No. 2 column.

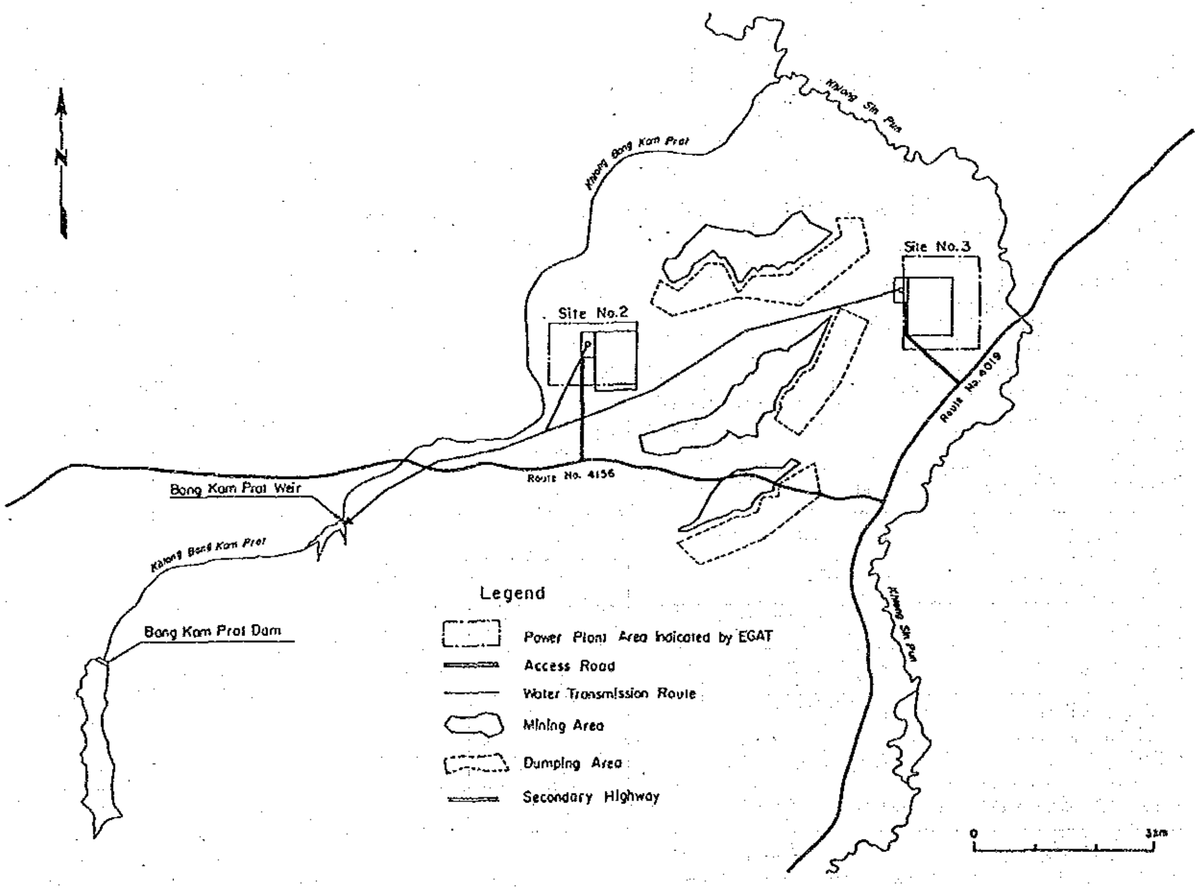


Fig. 4-11 Water Transmission Route and Access Road for Site No.2 and Site No.3

Table 4-13 Estimation Premises for Cooling Water Supply Cost

Item	Sin Pun Site No. 2	Sin Pun Site No. 3	Krabi Site No. 4
Quantity of Cooling Water	0.114 m^3/sec (Quantity of Make up water at cycles of concentration = 5)	<--- (")	
Major Facilities			
Cooling water intake & pump pit			
Cooling water intake pump	5 m^3/min x 50 m^H x 60 kW x 3	5 m^3/min x 60 m^H x 75 kW x 3	-
Screen or strainer	10 m^3/min x 2	<---	Screen
Cooling water intake pipe	0.4 mϕ x 6 km x 1 line	0.4 mϕ x 12 km x 1 line	-
Cooling water tank	7,000 m^3 x 2	<---	-
Make up pump	5 m^3/min x 30 m^H x 35 kW x 3	<---	-
Cooling tower	8,910 m^3/M x 2 (132 kW x 8)	<---	-
Cooling tower pit	1,500 m^3	<---	-
Circulation water pump	4,500 m^3/n x 17.5 H x 260 kW x 4	<---	6,700 m^3/h x 17 m x 380 kW x 4
Circulation water pipe	0.9 mϕ x 600 m	<---	10 mϕ x 160 m
Breed pump	0.6 m^3/min x 30 mH x 4 kW x 4	<---	-
Discharge canel	-	-	4 mW x 2.5 mH x 460 mL
Maintenance cost/Year	Facility cost x 1.3%	<---	<---
Utility and cost			
Electricity consumption & cost	15,478 x 10^3 kWh/year (1.26 Baht/kWh)	15,667 x 10^3 kWh/year (")	8,326 x 10^3 kWh/year (")
Chemical consumption & cost			
scaling & consumption & cost	4,680 kg/year (200 Baht/kg)	<---	-
slime control	2,880 kg/year (160 Baht/kg)	<---	-
Discount Rate %	10	<---	<---

(7) Land Utilization (Site No. 2)

The existing condition of the area are mainly forest and agricultural land, especially rubber plantation. Besides the area is part of the Khlong Bang Kam Prat irrigation project.

The number of houses directly affected by the land acquisition for the power plant has not yet been determined at this moment, but it seemed that about 10 houses would be included in the candidate site area.

According to the EGAT report "Preliminary Environmental Investigation of the Sin Pun Lignite Development", "with more than half of the project area for Sin Pun Lignite Development being in the national reserved forest, land legal right is rather limited in the area. Forest clearing for agriculture in these national reserved forest is extensive without land legal document. Average size of land holding legally as well as illegally is 15 rais per household."

(8) Ash Disposal Area (Site No. 2)

About 15.6 Million tons (19.5 million m^3) of ash is anticipated to be produced from A-FBC boiler through its 25 years plant operation at the Site No. 2.

Generally, in case of mine mouth power station, ash can be disposed into the space from where lignite has been mined in order to economize the ash disposal expenditure. But in this study, it was assumed that another ash disposal area for 25 years plant operation should be provided in order not to disturb the mining plan and should separately be constructed in three phases to have a flexibility in economical.

Necessary area for ash disposal during the 25 years plant operation is about 67 ha, when height of ash piled is designed about 50 m. This size of area is available just next of the power plant with 4 m - 10 m lower elevation than that of the power plant site. (See Fig. 4-3)

The ash is loaded to the dumpcart with 30 tons capacity and is transported to the ash disposal area. The distance of ash transportation is only about 1 km. Since there are some residents who utilize well water as their drinking water around the site, ash disposal area might be necessary to have an impermeable wall surrounding it in order to prevent an environmental pollution of ground water caused by dissolving component in water from the ash. An embankment having steel sheet piles in it will be recommended as an impermeable wall. The premises for the calculation of the ash disposal cost are taken as shown in Table 4-14 Site No. 2 column.

(9) Transmission Lines Route (Site No. 2)

(a) The Status Quo of the Transmission Lines in Region 3

The existing trunk transmission line of Region 3 is composed of transmission lines of 230 kV and 115 kV. The 230 kV transmission line extends from Hait Yai No. 2 near south Songkhla to Surat Thani via Phat Thalung, Naklon Si Thammarat and Khanom. It consists of two lines, and its transmission line distance is approximately 345 km. In addition, there are 230 kV lines with a distance 51.3 km between Surat Thani and Rajjaprabh hydraulic power station.

The 115 kV transmission line has been operated as the only trunk transmission line in this region till the 230 kV transmission line was constructed. At present, it still functions as the trunk line in the western part around Phuket. In the other parts within the Region 3, it has been operated as an important trunk transmission line compensating the 230 kV line.

Table 4-14 Estimation Premises for Ash Disposal Cost

Item		Sin Pun Site No. 2	Sin Pun Site No. 3	Krabi Site No. 4
1. Amount of Ash (dry)	Total (25 years)	15,590,000 ton (19,490,000 m^3)	<---	15,770,000 ton (19,710,000 m^3)
	Annual	624,000 ton (780,000 m^3)	<---	631,000 ton (788,000 m^3)
	Daily	2,136 ton (2,670 m^3)	<---	2,160 ton (2,700 m^3)
2. Distance from Ash silo to Disposal area (Average)		1.0 km	1.0 km	2.5 km
3. Truck	Life time	8 years	<---	<---
	Capacity	31.8 ton	<---	<---
	Number	4	<---	5
	Fuel Ratio (per Ash ton)	0.063 ℓ/ton.km	<---	<---
	Fuel Oil Cost	0.33 U$/ℓ	<---	<---
	Lubricant Oil Cost	Fuel Cost x 20%	<---	<---
	Truck Cost	5,400,000 Baht	<---	<---
	Maintenance Cost/year	Truck cost x 5%	<---	<---
4. Bulldozer	Life time	25 year	<---	<---
	Capacity	500 ton/h.50 m (228 ps)	<---	<---
	Number	1	<---	<---
	Fuel Ratio	28.3 ℓ/h (average)	<---	<---
	Fuel Oil Cost	0.33 U$/ℓ	<---	<---
	Lubricant Oil Cost	Fuel Cost x 20%	<---	<---
	Bulldozer Cost	32,900 K¥	<---	<---
	Maintenance Cost/year	Bull.Cost x 5%	<---	<---
5. Labour and annual cost driver		8 x 4480 = 35,840	<---	9 x 4,480 = 40,320
6. Discount Rate		10.0	<---	<---

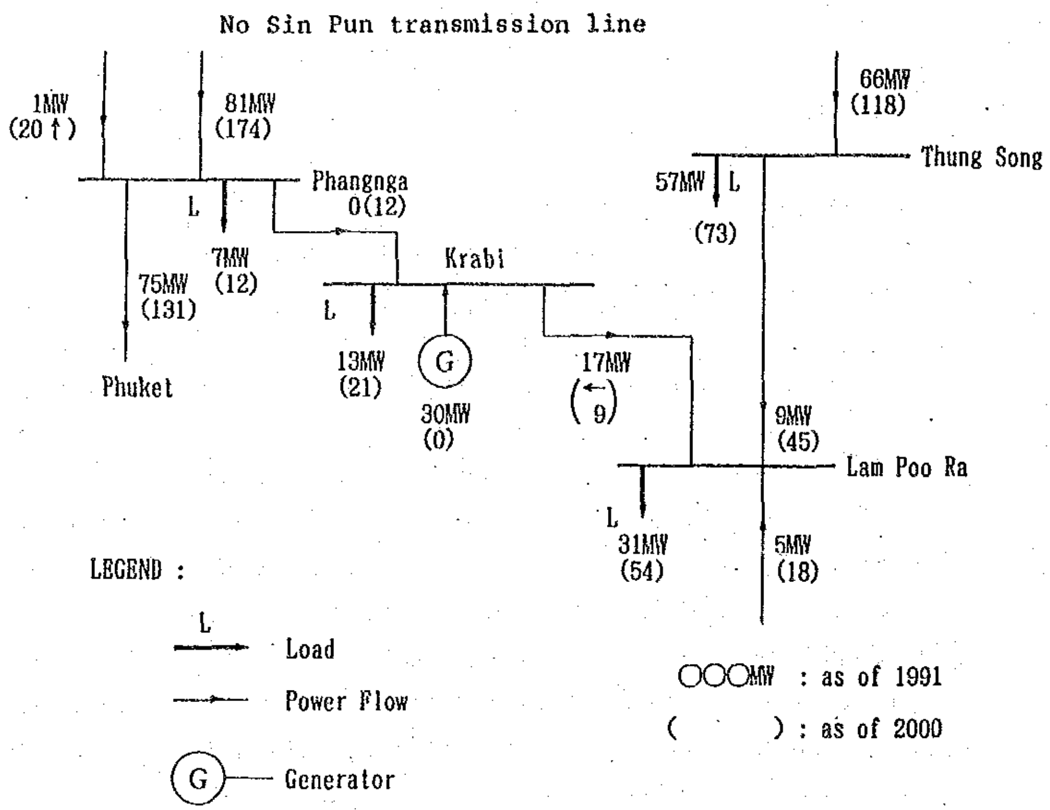
For the linkage with Region 1, the 230 kV and 115 kV transmission lines have two lines each. For the linkage with Malaysia, there is one line with 115/132 kV.

(b) Transmission Line Plan in Region 3

The transmission line expansion plan in this region has been being developed in the sixth five-year plan. It is being developed in step with the large scale of power generation plants such as Kaeng Krung, Khanom Combined Cycle and the seventh five-year plan of Saba Yoi. The plan is to construct two additional 230 kV lines in parallel with the existing 230 kV transmission line from Saba Yoi in the southern part to Surat Thani. For other plans, two 115 kV transmission lines are scheduled to be contruct in the western part from Kaeng Krung to Rajjaprabha and two lines from Nakhon Si Thammarat to Renut. Other plans cover Songkhla and southward. According to the PDP of EGAT, a new 230 kV substation near Krabi may also be planned. In addition to this transmission line plan, a 115 kV substation of the Thung Song substation will be reconstructed for 230 kV substation, and Lang Suan substation is planned to be built between Surat Thani and Chumphon. Substations are going to be built in addition to the installation of 115 kV transmission lines.

The expected power flow in the present year (1991) and in 2000 is shown below. As shown in the outline, the power flow is biased to the southern part since small power plants exist in the southwest part.

Fig. 4-12 Power Flow as of 1991 and 2000



(c) Transmission Lines around Sin Pun Area

No transmission lines of 115 kV or more exists near Sin Pun, there is no plan to build such transmission lines. Based on this, the following three methods can be considered to transmit electricity in the Sin Pun area.

Case 1) To transmit electricity to Thung Song, approximately 50 km in east-southeast,

Case 2) To transmit electricity to Krabi, approximately 60 km in southwest, and

Case 3) To transmit electricity to Thung Song and Krabi with one line each, Voltages of these transmission lines can be recommended to 115 kV and 230 kV.

Evaluation of Each Transmission Plan in Terms of Power Flow Improvement is as follows;

Case 1) Transmitting to Thung Song

Construction expense as capital cost can be reduced relatively and some parts of electricity generated by Sin Pun will be transmitted to Krabi through Thung Song, Lam Poo Ra. However, power flow will be almost balanced.

Case 2) Transmitting to Krabi

Since a few power supplies exist in the west part around Phuket, this route will become effective in 1996 when Krabi Thermal Plant is going to be retired. Since the capacity for operation is restricted to 80 MW, according to the heat capacity of conductors of the transmission line to Krabi and westward.

It is necessary to extend the transmission line between Krabi and Phangnga and between Krabi and Lampoora due to the poor heat capacity of conductors of the existing transmission lines.

Case 3) Transmitting with one line each to Thung Song and Krabi

It is feared that the existing facilities may be overloaded depending on the power flow condition of their transmission line. Therefore it is necessary to accommodate with the bus configuration of the switchyard in Krabi and apply some controlling method at power plants.

Though construction cost is relatively high, adequate supply to the western countries and to Thung Song can be provided. The existing facilities can also be used effectively.

In the present situation, case 1) is selected as the base of transmission line plan for site selection study of Site No. 2

(10) Access Road for the Site (Site No. 2)

There is the secondary highway route No. 4156 running in east-west direction on the south side of the site. It is desirable that an access road be connected to this secondary route. The length of the access road is approximately 1.7 km. (See Fig. 4-11)

(11) Availability of Utilize an Existing Facilities (Site No. 2)

Since No. 2 site is located in an agricultural area and is about 55 km and 70 km far from Thung Song and Krabi respectively, existing facilities available to utilize for the construction are few near this site. The electricity for construction should be newly supplied from Thung Yai, about 15 km far from the site, city water should be supplied by newly drilled well and sewage must be drained to small river after checking its quality because this river water is utilized for plantation and bathing of inhabitant nearby. Gravel may easily procure from the vicinity because there are many limestone outcrop around the site and cement works is in Thung Song.

Although small restaurants are in Thung Yai town, hotels are only available in Krabi or Thung Song.

It is recommendable to construct company houses in Thung Yai for convenience of employee's lives.

(12) Environmental Impact (Site No. 2)

1) Air Quality

(1) Particulate

It will be possible to achieve the proposed emission standard value (500 mg/m^3N) by the combination of mechanical cyclone and ESP or bag-filter.

(2) CO

It will be possible to achieve the proposed emission standard value (800 ppm) without any countermeasure from EPDC's experience.

(3) SO_2

It will be possible to achieve the proposed emission standard value (700 ppm) by in-furnace desulfurization.

(4) NOx

It will be possible to achieve the proposed emission standard value (1,000 $g/m^3/N$) without any countermeasure from EPDC's experience.

2) Water Quality

This plant site is located in inland area. Water from the plant, i.e. cooling water, discharge from ash pond, etc., discharges into a river. The impact for river water utilization on the lower river may be considered.

3) Solid Waste

Solid waste from the plant is mainly coal ash. The countermeasure for coal ash is water treatment from ash pond.

4) Others

As the plant site is not in urban area, odor, noise and vibration are not matter.

(13) Transportation of Equipment (Site No. 2)

The candidate transportation route of the materials and equipment is shown in Fig. 4-13.

The following routes have been checked in view point of the bridge condition

	Distance	Route No. (Road No.)
i) Songkhla international port to Site No. 2	258km	4083-4017-403-41-4019-4038-4156
ii) Phuket international port to Site No. 2	250km	402-4-4037-4156
iii) Krabi power station to Site No. 2	66km	4-4037-4156

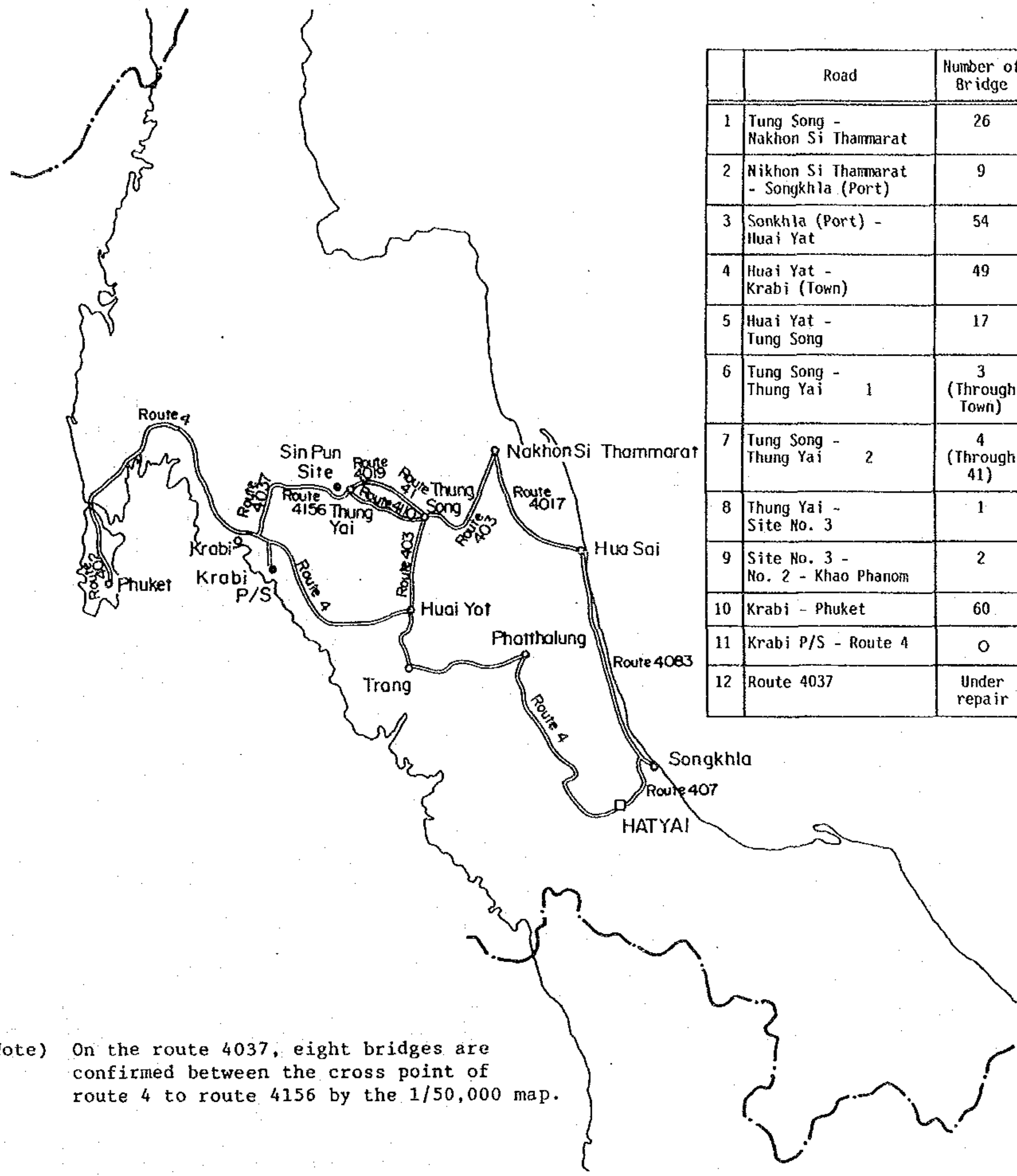
The condition of the road is paved all the way and good for the transportation of the general construction materials.

The total weight of the equipment and materials for the coal fired power plant is generally about 35,000 tons for the 2 x 75 MW unit.

The heaviest equipment of the 2 x 75 MW unit is the generator stator weighted 100 ton at 88.3 MVA with the air cooled type (the generator stator of the hydrogen cooling is weighted 125 ton).

For the heavy equipment, the in-land route from the Songkhla international port and the Phuket international port is not suitable because the number of bridge is too much to reinforce the bridge, most of which have the beam with the thickness below 400 mm and 5~9 m pitch column.

Considering the above condition, the following transportation route was studied for the calculation purpose of the transportation cost.



	Road	Number of Bridge
1	Tung Song - Nakhon Si Thammarat	26
2	Nikhon Si Thammarat - Songkhla (Port)	9
3	Sonkhla (Port) - Huai Yat	54
4	Huai Yat - Krabi (Town)	49
5	Huai Yat - Tung Song	17
6	Tung Song - Thung Yai 1	3 (Through Town)
7	Tung Song - Thung Yai 2	4 (Through 41)
8	Thung Yai - Site No. 3	1
9	Site No. 3 - No. 2 - Khao Phanom	2
10	Krabi - Phuket	60
11	Krabi P/S - Route 4	O
12	Route 4037	Under repair

Note) On the route 4037, eight bridges are confirmed between the cross point of route 4 to route 4156 by the 1/50,000 map.

Fig. 4-13 Road Transportation and Bridge near Candidate Site

i) Unload the equipment at Phuket international port.

ii) Loading the equipment on the barge to the Krabi power station.

iii) Unload the equipment from the barge to the Site No. 2 by truck through the route (a) in Fig. 4-17

4.3.5 Site No. 3 (East of Bang Sai Lignite Resource)

(1) Meteorological Conditions (Site No. 3)

Site No. 3 has the same climate as Site No. 2. The meteorological data relevant to the site is shown in Table 4-4.

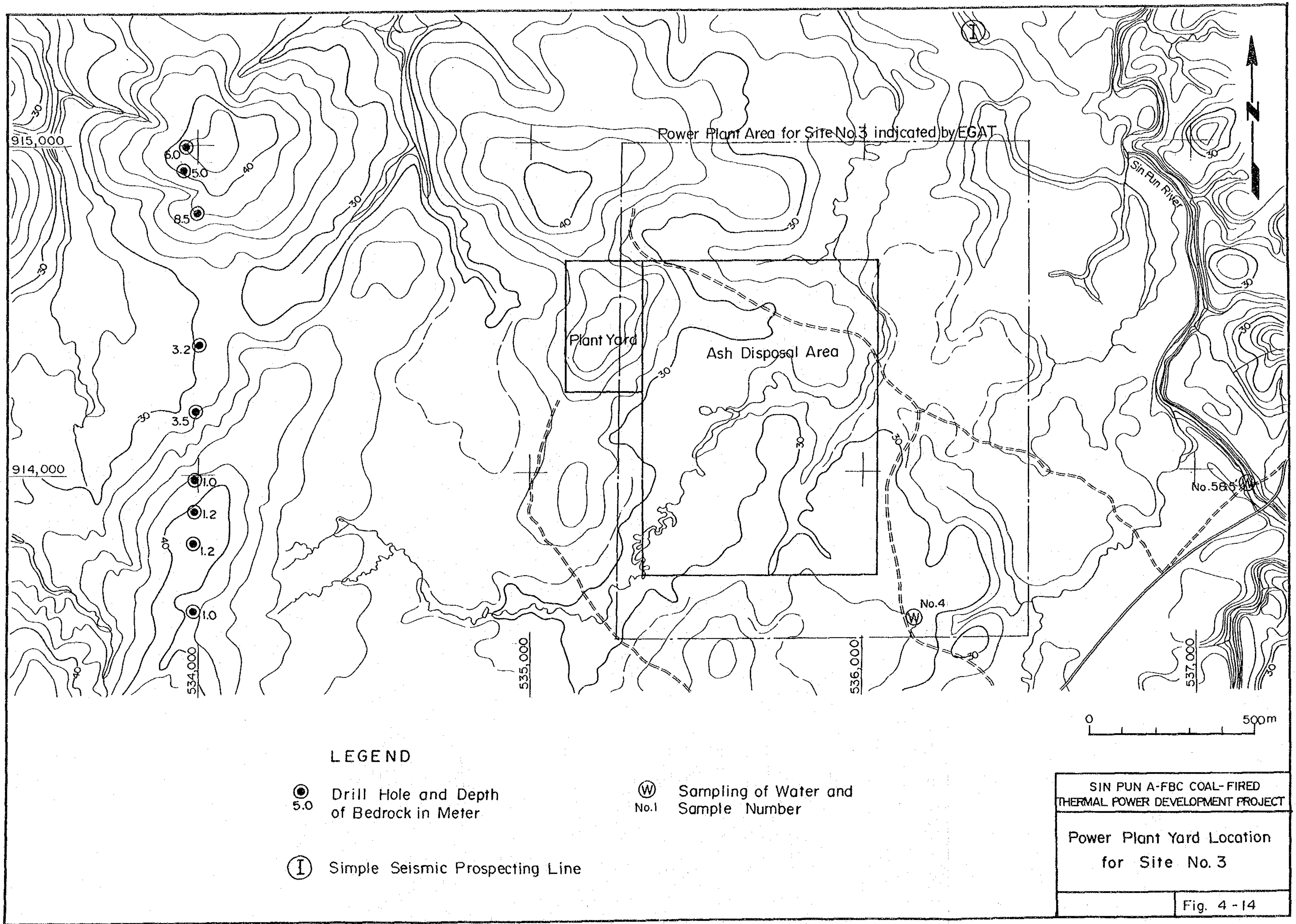
(2) Topographic Conditions and Tentative Yard Location (Site No. 3)

This candidate site is located on the left side of Khlong Sin Pun which runs toward the north. A hill, the crest elevation of which is about +40 m above mean sea level, lies along the west boundary of the area indicated by EGAT. The most part of the indicated area is a comparatively flat field, elevation of which varies +28 m ~ +30 m above mean sea level.

The tentative yard location is shown in Fig. 4-14.

It is proposed that the plant yard be located on the hill laying along the west boundary of the indicated area, although a part of the proposed plant yard protrudes from the west boundary. It is anticipated that the proposed plant yard prepared by excavation will provide the plant facilities with better foundation from geological viewpoint. The tentative elevation of the plant yard is +34.00 m above mean sea level, which is about 1.5 m higher than the maximum high water level (+32.514 m above mean sea level, 24 Nov. 1988) recorded at Wat Khong Liap gaging station of Khlong Sin Pun. It is recommended that the optimum elevation be studied considering the safety from a flood water inundation.

It is recommended tentatively that the ash disposal area be located in a comparatively flat field extending on the east side of the plant yard. It is surrounded with an impermeable wall the crest elevation of which is +34.00 m as high as the plant yard elevation.



Power Plant Area for Site No.3 indicated by EGAT
Plant Yard
Ash Disposal Area
Sin Pun River
N
915,000
914,000
534,000
535,000
536,000
537,000
No.4
No.5
0
500m
LEGEND
5.0 Drill Hole and Depth of Bedrock in Meter
No.1 Sampling of Water and Sample Number
Simple Seismic Prospecting Line
SIN PUN A-FBC COAL-FIRED THERMAL POWER DEVELOPMENT PROJECT
Power Plant Yard Location for Site No. 3
Fig. 4-14

(3) Geology (Site No. 3)

1) Outline of Geology of Project Area

The outline of the geology is the same as described in 4.3.4 (3) 1).

2) Geology of Site No. 3

As same as in the case of the site No. 2, the bedrock of the site No. 3 is inferred to be Muang En formation which consists of semiconsolidated and consolidated sedimentary rocks such as claystone, siltstone, mudstone, sandstone, conglomerate and limestone. According to the geologic map made by EGAT (1987), the bedrock is covered with alluvial deposit in the site.

Alluvial deposit which is composed of brown sandy silt and extremely weathered brownish-gray siltstone found in the site. In the proposed plant yard, the alluvial deposit is not distributed and the thickness of top soil and residual soil will be 2-3 m. The bedrock under the alluvial deposit which consists of Tertiary sedimentary rock will be highly weathered near the ground surface, however, it will be possible to use the bedrock for the foundation of the plant by the excavation of several meters depth near the ground surface. While the proposed ash disposal area is located in the part where elevation is relatively low near the Sin Pun river, therefore, alluvial deposit will be thickly distributed and the thickness will be roughly estimated to be 5-8 m. (see Fig. 4-14 and Table 4-6)

3) Result of Simple Seismic Prospecting

The prospecting line with the length of 30 m was located to the northeast of the site as shown in Fig. 4-14. The measurement was performed by the same methods as mentioned in 4.3.4 (3) 3).

The data were analyzed by Hagiwara's method as shown in Fig. 4-7. The result shows two velocity layers, 350 m/s layer and 1,200 m/s layers. The 1st layer with the thickness of 4 to 5 m will correspond to top soil and alluvial deposit. The 2nd layer will correspond to the highly weathered bedrock, Muang En formation.

4) Hydrogeology of Site No. 3

(a) Ground Water Level (The following description is the same as the site No. 2)

The hydrogeological investigations by EGAT indicated that the ground water level of the site is 1-6 m below the ground surface. The ground water levels in the wells observed at the time of field reconnaissance by JICA team were also 4-5 m below the ground surface. Judging from these data, it can be said that the ground water level of the site is rather high.

(b) Permeability (The following description is the same as the site No. 2)

The Permeability of the foundation rock of the site is very low (10^{-6}-10^{-7} cm/s) except for permeable limestone, sandstone and the highly weathered rock near the ground surface according to the packer test results carried out by EGAT.

(c) Water Chemistry

The results of measurements and analyses of surface water and ground water are indicated in Table 4-7. The water chemistry of this site is not so much different from that of site No. 2. The electric conductivity of sample No. 4 is rather smaller than that of the other data. This may mean the existence of the some different kinds of aquifers in Sin Pun area.

(4) Lignite Supply (Site No. 3)

All lignite for the site No. 3 is supplied from Sin Pun deposit for the A-FBC 2 x 75 MW.

The lignite is transported by 31.8 ton truck from the mine area to the coal storage yard in the site No. 3.

The transportation route of the lignite is shown in Fig. 4-8 with the route (B).

The premises for the calculation of the coal transportation are taken as shown in Table 4-8 Site No. 3 column.

(5) Limestone Supply (Site No. 3)

Limestone of Khao Tham Hora is recommended to apply for Site No. 3 also because of the same reason with the site No. 2. The transportation route of the limestone to the site No. 3 is shown in Fig. 4 Route (B).

The premises were taken for the calculation purpose of the transportation for limestone as shown in Table 4-11 Site No. 3 column.

(6) Cooling Water Supply (Site No. 3)

Concerning the cooling water system for condenser at Site No. 3, cooling tower type should be employed because there is no sea or no big river from which sufficient amount of cooling water can withdraw into once-through type condenser cooling system near candidated site.

With the same reason at Site No. 2, 0.13 m^3/s of total raw water is necessary to provide for the project.

This quantity of raw water is available from the weir at the upper stream of Khlong Bang Kam Prat as same as the case of Site No. 2.

The water conduct route is shown in Fig. 4-11.

It seems also possible to supply the water from Khlong Sin Pun running nearby Site No.3, however, it does not have any advantage over the proposed scheme from the viewpoint of economical planning. The premises for the calculation of the cooling water supply cost are taken as shown in Table 4-13 Site No. 3 column.

(7) Land Utilization (Site No. 3)

The existing condition of the area are mainly forest and agricultural land, especially rice field and rubber plantation. The number of houses directly affected by the land acquisition for the power plant has not yet been determined at this moment, but it seemed that about 5 houses would be included in the candidate site area. Compared with the site No. 2, this area is nearer to populated area i.e. the town of Thung Yai.

According to the EGAT report "Preliminary Environmental Investigation of the Sin Pun Lignite Development", "with more than half of the project area for Sin Pun Lignite Development being in the national reserved forest, land legal right is rather limited in the area. Forest clearing for agriculture in these national reserved forest is extensive without land legal document. Average size of land holding legally as well as illegally is 15 rais per household."

(8) Ash Disposal Area (Site No. 3)

About 15.6 million tons (19.5 million m^3) of ash is anticipated to be produced from A-FBC boiler through its 25 years plant operation in the Site No. 3. Necessary area for ash disposal through the 25 years plant operation is about 67 ha, when height of ash piled is designed about 50 m. This size of area is available just next of the power plant with about same elevations that of the power plant site. (See Fig. 4-14)

The ash is loaded to the dump truck with 30 tons capacity and is transported to the ash disposal area. The distance of ash transportation is only about 1 km. Since there are some residents who utilize well water as their drinking water around the site, ash disposal area might be necessary to have an impermeable wall surrounding it in order to prevent an environmental pollution of ground water caused by dissolving component in water from the ash. An embankment having steel sheet piles in it will be recommended as an impermeable wall. The premises for the calculation of the ash disposal cost are taken as shown in Table 4-14 Site No. 3 column.

(9) Transmission Lines Route (Site No. 3)

The condition is as same as site No. 2. The case 1), i.e. to transmit electricity to Thung Song is adopted for the site selection study.

(10) Access Road for the Site (Site No. 3)

There is the secondary highway route No. 4019 running in northeast-southwest direction on the south side of the site. It is desirable that an access road be connected to this secondary route. The length of the access road is approximately 1.7 km. (See Fig. 4-11)

(11) Availability of Utilize an Existing Facilities (Site No. 3)

Since No. 3 site is located in an agricultural area it is about 50 km and 80 km far from Thung Song and Krabi respectively, existing facilities available to utilize for the construction are few near this site. The electricity for construction should be newly supplied from Tung Yai, about 5 km far from this site, city water should be supplied by newly drilled well and sewage must be drained to Sin Pun river after checking its quality because this river water is utilised for plantation and bathing of inhabitant nearby. Gravel may easily procure from the vicinity because there are many limestone outcrop around the site and cement works is in Thung Song.

Although small restaurants are available in Thung Yai town, hotels are only available in Krabi or Thung Song.

It is recommendable to construct company houses in Thung Yai for convenience of employee's lives.

(12) Environmental Impact (Site No. 3)

1) Air Quality

(1) Particulate

It will be possible to achieve the proposed emission standard value (500 mg/m^3N) by the combination of mechanical cyclone and ESP or bag-filter.

(2) CO

It will be possible to achieve the proposed emission standard value (800 ppm) without any countermeasure from EPDC's experience.

(3) SO_2

It will be possible to achieve the proposed emission standard value (700 ppm) by in-furnace desulfurization.

(4) NOx

It will be possible to achieve the proposed emission standard value (1,000 mg/m^3N) without any countermeasure from EPDC's experience.

2) Water Quality

This plant site is located in inland area. Water from the plant, i.e. cooling water, discharge from ash pond, etc., discharges into a river. The impact for river water utilization on the lower river may be considered.

3) Solid Waste

Solid waste from the plant is mainly coal ash. The countermeasure for coal ash is water treatment from ash pond.

4) Others

As the plant site is not in urban area, odor, noise and vibration are not matter.

(13) Transportation of Equipment (Site No. 3)

The condition is as same as the site No. 2.

Therefore, the following transportation route was studied for the transportation cost of the equipment.

i) Unload the equipment at Phuket international port.
ii) Loading the equipment on the barge to the Krabi power station.
iii) Unload the equipment from the barge to the site No. 3 by truck through the route (A) in Fig. 4-17.

4.3.6 Site No. 4 (Krabi Power Station)

(1) Meteorological Conditions (Site No. 4)

As same as the sites in Sin Pun, this site has a tropical monsoon climate and weather patterns are governed by southwest monsoon system. The year can be roughly divided into the rainy season from May through November and the dry season from December through April. The meteorological data observed in this area are shown in Table 4-15.

Table 4-15 Meteorological Data near/ at Site No. 4

1) Temperature

(°C)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean	28.0	28.8	29.4	29.5	28.5	28.2	27.8	27.9	27.3	27.4	27.5	27.7
Max.	31.5	32.6	33.2	33.2	31.7	31.2	30.9	30.9	30.4	30.6	30.6	30.9
Min.	23.4	23.7	24.2	24.6	24.5	24.4	24.1	24.3	23.9	23.8	23.8	23.7

Station: Phuket Recording Period: 1951-1980

2) Rainfall

(mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
8	14	43	123	266	131	168	256	317	308	181	80	1,895

Station: Krabi Power Plant Recording Period: 1985 - 1990

3) Wind

(knot*)

	Jan.	Feb.	Mar.	Apr.	May	Jun.
Prevailing Wind Direction	NE	E	E	E	W	W
Mean Wind Speed	5.2	4.6	4.1	3.4	3.2	4.3
Max. Wind Speed	25 E	26 NE,E	30 NE,E	35 NE	30 W	40 SW
	Jul.	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Prevailing Wind Direction	W	W	W	W	NE	NE
Mean Wind Speed	4.2	5.0	4.0	3.3	3.9	5.3
Max. Wind Speed	45 SW	35 SW,W	40 W	40 W	27 NE	28 NE

Station: Phuket Recording Period: 1951 - 1980
* 1 knot = 0.514 m/sec

(2) Topographic Conditions and Tentative Yard Location (Site No. 4)

This candidate site is located on the north of the existing Krabi power plant. The elevation of the area ranges +5.00 m ~ +15.00 m above mean sea level.

The tentative yard location is shown in Fig. 4-15.

The selected plant yard can avoid the ash disposal area of the existing Krabi power plant which seems not to be desirable as power plant foundation. The elevation of the proposed plant yard is selected as +7.00 m above mean sea level as high as the plant yard of Krabi power plant.

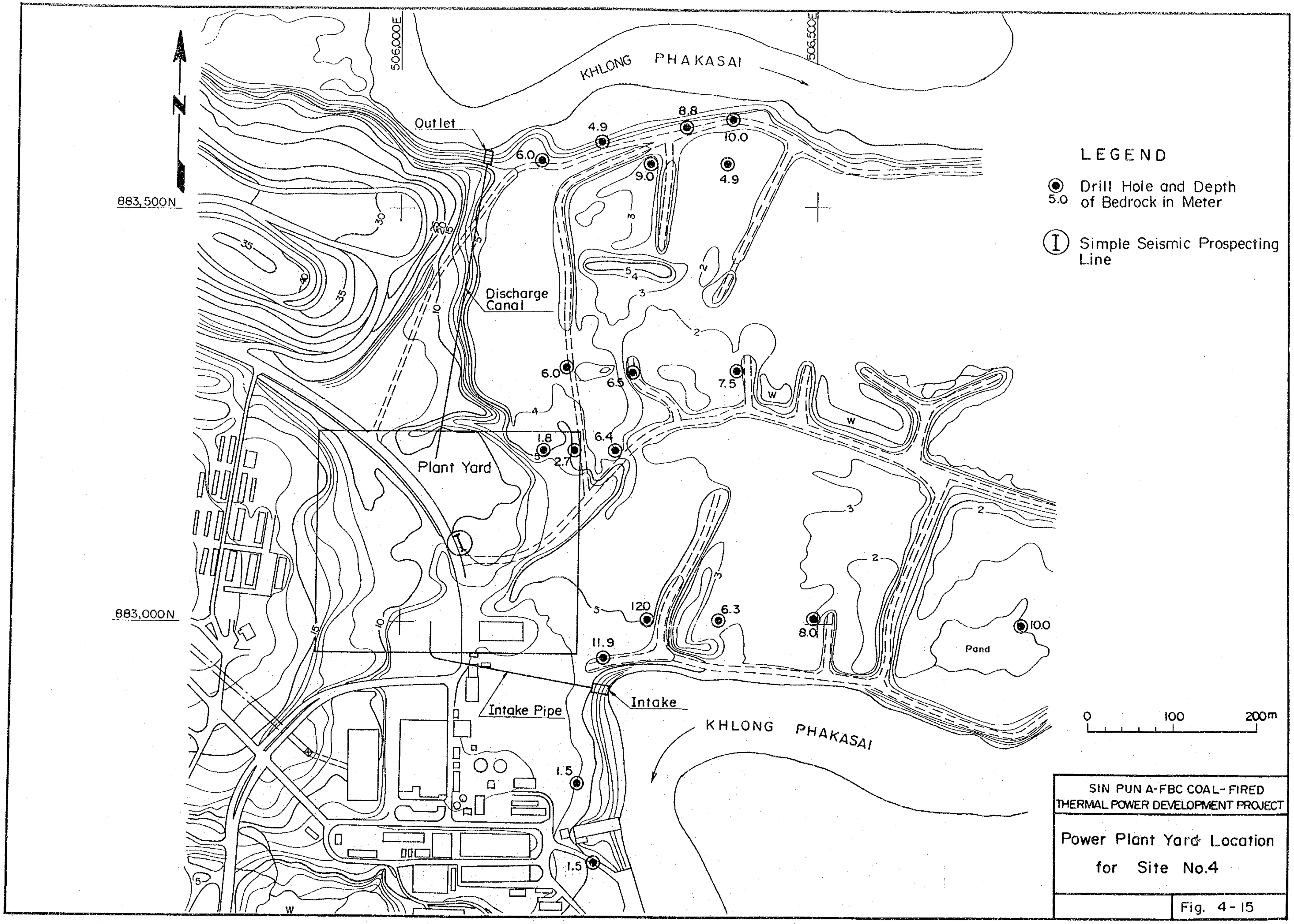
(3) Geology (Site No. 4)

1) Outline of Geology of Project Area

The straligraphy and lithology of the vicinity of the project area are summarized as Table 4-5 according to the Geological Maps of Thailand (1/250,000, published by DMR). The geological map of the project area shown in Fig. 4-4 is compiled on the basis of the geological maps of DMR and EGAT.

In Krabi area, sedimentary rocks of Permian - Carboniferous period, Mesozoic era and Tertiary period are distributed. The Krabi lignite beds are intercalated in the Tertiary group named Krabi group which was deposited mainly in shallow marine and some environment on the coastal area. The sedimentary rocks in plain region and coastal region are covered with alluvial deposit (or terrace and colluvial deposit) and beach deposit respectively.

The general strike of beds of Krabi group is in north-south direction and their dip changes from 20-40° E to 10-20° W due to folds. There are two major systems of NE-SW and NW-SE normal



SIN PUN A-FBC COAL-FIRED THERMAL POWER DEVELOPMENT PROJECT

Power Plant Yard Location for Site No.4

Fig. 4-15

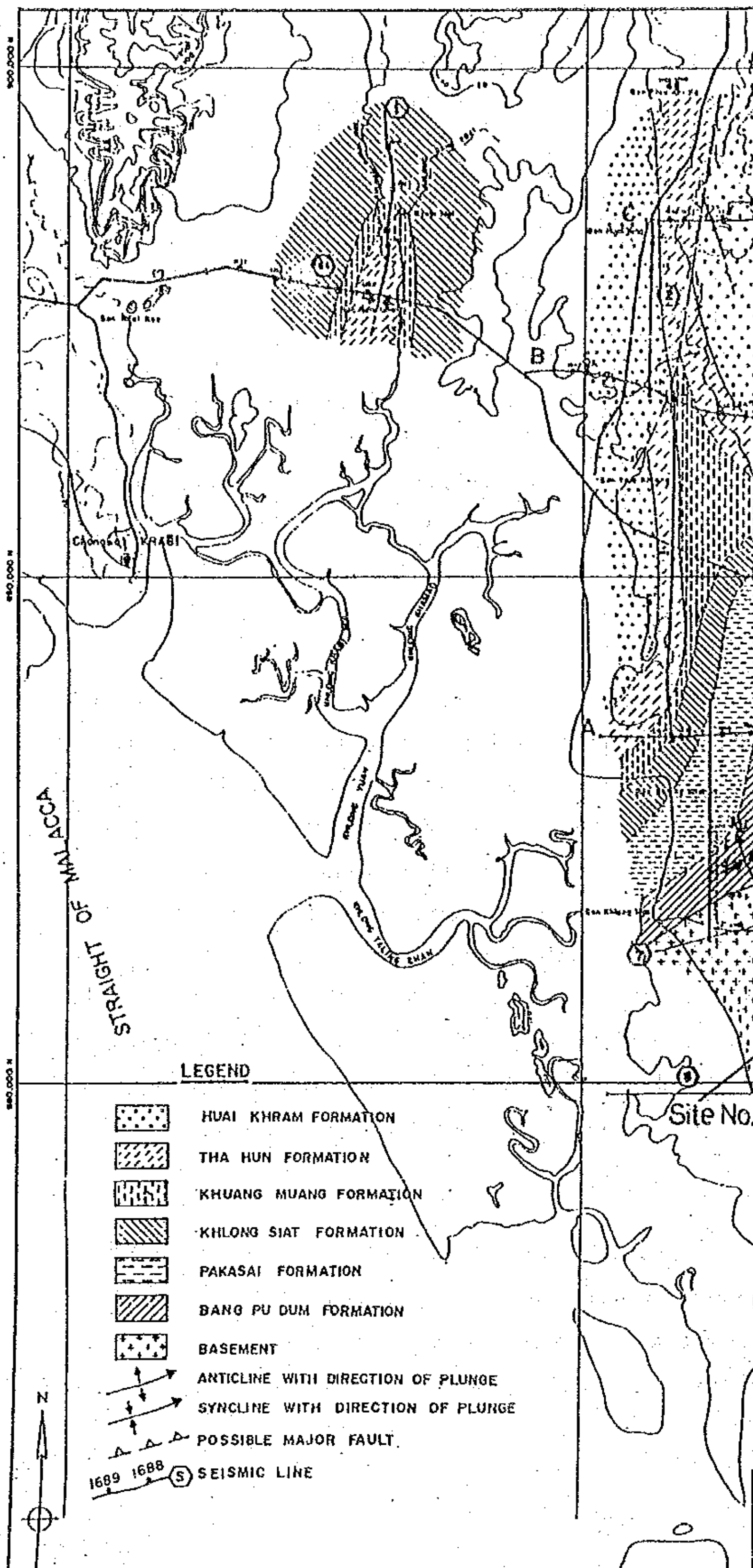
faults. These faults are said to have been formed in late Tertiary to early Quaternary (Chaodumrong et al., 1983).

2) Geology of Site No. 4

According to the drilling information performed by EGAT, the Krabi group can be classified into 6 formations shown in Fig. 4-16. The bedrock of the site No. 4 is inferred to be Bang Pu Dum formation which consists of semiconsolidated and consolidated sediments such as claystone, siltstone, sandstone. The general strike and dip of the strata is N-S 20°E. A NNE-SSW strike normal fault exists in the site. The length of the fault is about 6 km and the displacement is more than several tens of meters.

Some outcrops of gray siltstone are observed at the riverside of the Pakasai river near the existing intake, however, alluvial deposit of maximum more than 10 m thickness is distributed near and around the Pakasai river. In the proposed plant yard, alluvial deposit will be hardly distributed and the thickness of top soil and residual soil is estimated to be 1 to 2 m from the drilling data for lignite mine. (see Fig. 4-15) The bedrock which consists of Tertiary sedimentary rocks will be highly weathered near the ground surface, however, it will be possible to use the bedrock for the foundation of the plant by the excavation of several meters depth near the ground surface. (see Table 4-6)

Although there is no information about the geology of the proposed ash disposal area. Tertiary sedimentary rocks will be distributed and covered by top soil and residual soil (thickness: 1-2 m) without alluvial deposit judging from the landform of the area.



SIN PUN A-FBC COAL-FIRED THERMAL POWER DEVELOPMENT PROJECT

Geologic sketch Map at Elevation 50 m

Fig. 4-16

3) Result of Simple Seismic Prospecting

The prospecting line of 20 m length was located at the center of the site as shown in Fig. 4-15. The measurement was performed by the same methods as mentioned in 4.3.4 (3) 3). The prospecting line was shorter than the other two lines of Sin Pun Sites because this site was very noisy due to the operation of the existing power plant.

The data were analyzed by Hagiwara's method as shown in Fig. 4-7. The result shows two velocity layers, 500-600 m/s layer and 1,250 m/s layers. The 1st layer will correspond to top soil and highly weathered or artificially disturbed bedrock, Bang Pu Dum formation and its thickness is 1 to 3 m. The 2nd layer will correspond to the weathered bedrock.

4) Hydrogeology of Site No. 4

(a) Ground Water Level

The hydrogeological investigations by EGAT indicated that the ground water level of Krabi area was 0-6 m below the ground surface. The elevation of the site is very close to the sea level, therefore the depth of the ground water level is not more than 2 or 3 m.

(b) Permeability

There is no permeability test data, however, the permeability of the foundation rock of the site is estimated to be very low (10^{-6}-10^{-7} cm/s) on the analogy of the permeability of the similar strata of Sin Pun group and based on the fact that the spring water in Bang Pu Dum pit which is to the north of the site is very little.

(c) Water Chemistry

No water sample was collected from this site by JICA team. The existing data for the chemical composition of Pakasai river water indicates that the river water is blackish and the salinity changes in accordance with the tidal level.

(4) Lignite Supply (Site No. 4)

The lignite for the site No. 4 is supplied from Sin Pun deposit and Krabi deposit respectively.

The lignite of Sin Pun deposit is transported by 31.8 ton truck from the mine area to Sin Pun intermediate coal storage yard with the route shown in Fig. 4-8 with route (A).

From the above coal storage yard to the coal storage yard in the site No. 4, the lignite is transported by 11 ton truck.

The transportation route of the lignite from Sin Pun to Krabi power station is shown in Fig. 4-17 with route (A).

The premises for the calculation of the coal transportation cost are taken as shown in Table 4-18 Site No. 4 column.

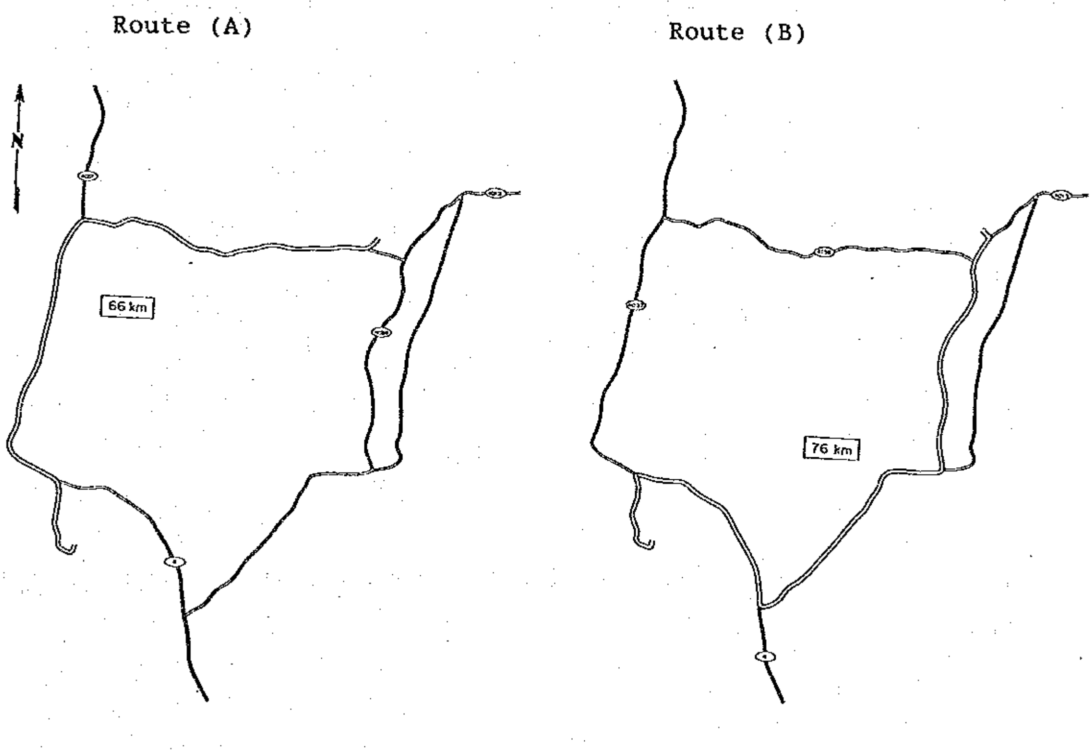


Fig. 4-17 Coal Transportation Route from Sin Pun to Krabi P/S

(5) Limestone Supply (Site No. 4)

The following two points are investigated for the limestone supply.

i) Khao Kaew
ii) Yod Po Sira Thong

Table 4-16 shows the results of reconnaissance.

Table 4-16 Results of Reconnaissance of Candidate Limestone Quarry for Krabi Site

Site Name	Khao Kaow	Yod Po Sira Thong (existing quarry)
No. in Map *	5	6
Distance from No. 4 Site	9km (to northwest)	• existing quarry 22km (to northwest) • crushing factory 19km (to northwest)
Quantity (Mt)	about 3	not clear
Geology		
Rock Name	Limestone	Limestone
Age	Permian (2.4~2.8 x 10^8 years before)	
Color	Pale brownish-gray	Dark gray
Feature	Partially including muddy limestone	Massive limestone with many calcite veins
Utilization of Limestone	Not used	Used for a quarry
Utilization of Nearby Land	There are some houses and field.	not clear
Road Condition	Unpaved road of 4 m width	National highway No. 4 (crushing factory)

*: see Fig. 4-4

The same test items with the limestone near Sin Pun are carried out for the above two limestones.

The results of each test are shown in Table 4-17. The comments on each test result are as follows;

Table 4-17 Analysis Result of Limestone for Krabi Site (Site No. 4)

Name of Limestone	Test Result	
	KHAO KAEW	YOD PO SILA THONG
Component Analysis		
$CaSO_4$ wt%	-	-
$CaCO_3$ wt%	94.5	90.6
CaO wt%	1.98	3.04
SiO_2 wt%	0.41	0.97
Al_2O_3 wt%	0.02	0.11
Fe_2O_3 wt%	0.024	0.053
$MgCO_3$ wt%	3.01	4.72
MgO wt%	0.05	0.14
Na_2O wt%	0.007	0.003
Differential Thermal Analysis		
Ignition Loss wt%	43.1	42.3
Decarboxylation Temp. °C	735.6	725.2
Reduction Ratio	3.7	3.2

1) Component Analysis

(a) The content of $CaCO_3$ is relatively high in both limestones at Khao Kaew and Yod Po Sira Thong for the desulfurizing materials.

(b) Silica content is not high to make the erosion problem on the inner tube materials of A-FBC.

(c) The content of Al, Fe and Na is not high to make the agglomeration problem in the fluidized bed.

(d) The content of Mg is relatively high. However, this amount of Mg does not affect on the desulfurizing effect of the limestone.

2) Differential Thermal Analysis

The profiles of the differential thermal analysis are shown in Fig. 4-18.

The decarboxylation temperature of both limestones are about 50 ~ 60°C lower than that of the limestones applied in Wakamatsu A-FBC.

3) Reduction Ratio

The passing rate of Khao Kaew and Yod Po Sira Thong limestone are relatively low with the value of 3.7% and 3.2% respectively.

Therefore, the both limestones could remain for long period in the fluidized bed with contributing to the desulfurization.

From the above points, both limestones can be judged available for A-FBC desulfurizing materials.

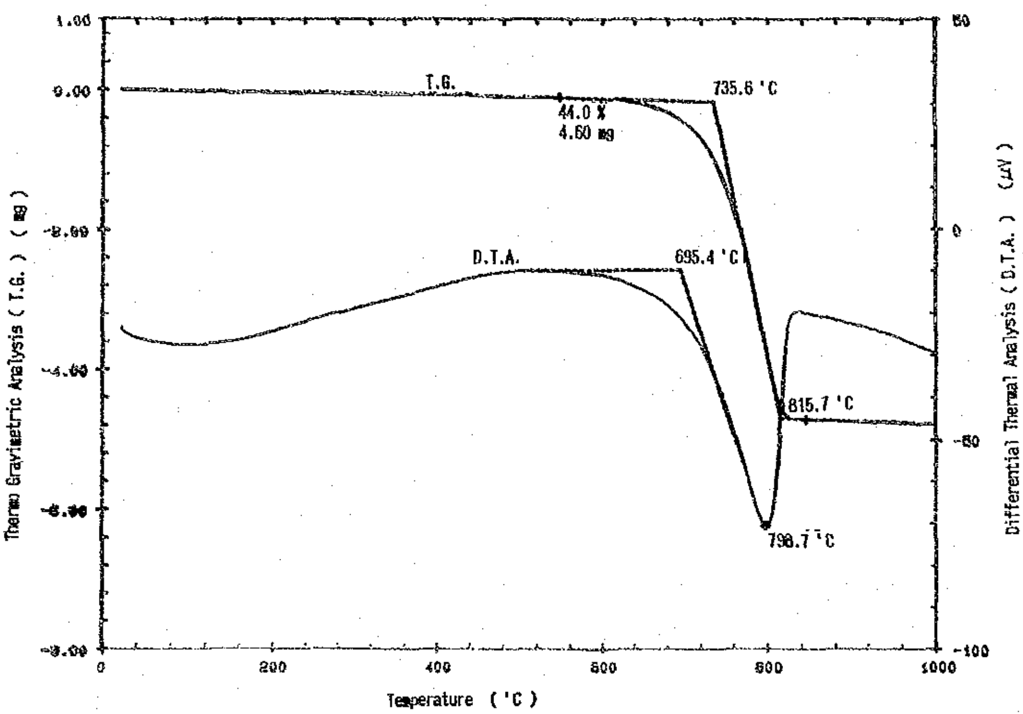
In the study, Khao Kaew has applied as the candidate place of limestone supply because of the short distance from Krabi power station.

The transportation route of the limestone to the site No. 4 is shown in Fig. 4-19.

The premises were taken for the calculation purpose of the transportation for limestone as shown in Table 4-8 Site No. 4 column.

Sample : KHAO KAOW

Sampling Time : 1.0 (sec)
Sample Weight : 10.472 (mg)
Heating Rate : 20.0 ('C/min)
Thermo Couple : PR



Sample : YOO PO SIRA THONG

Sampling Time : 1.0 (sec)
Sample Weight : 9.873 (mg)
Heating Rate : 20.0 ('C/min)
Thermo Couple : PR

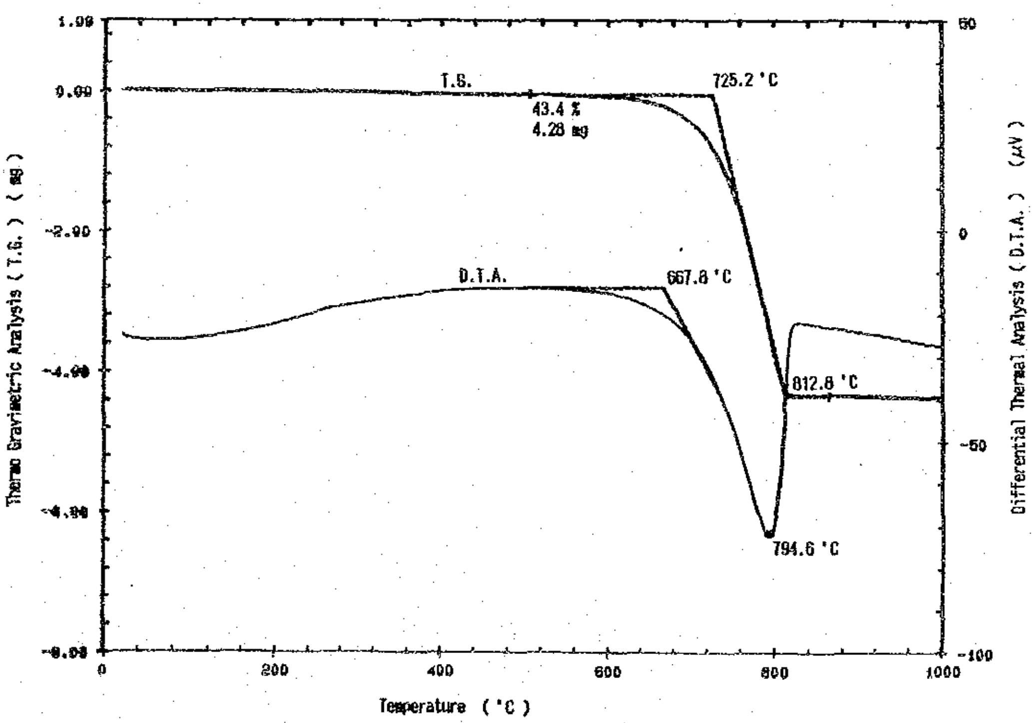


Fig. 4-18 Temperature Profile of Limestone in Krabi

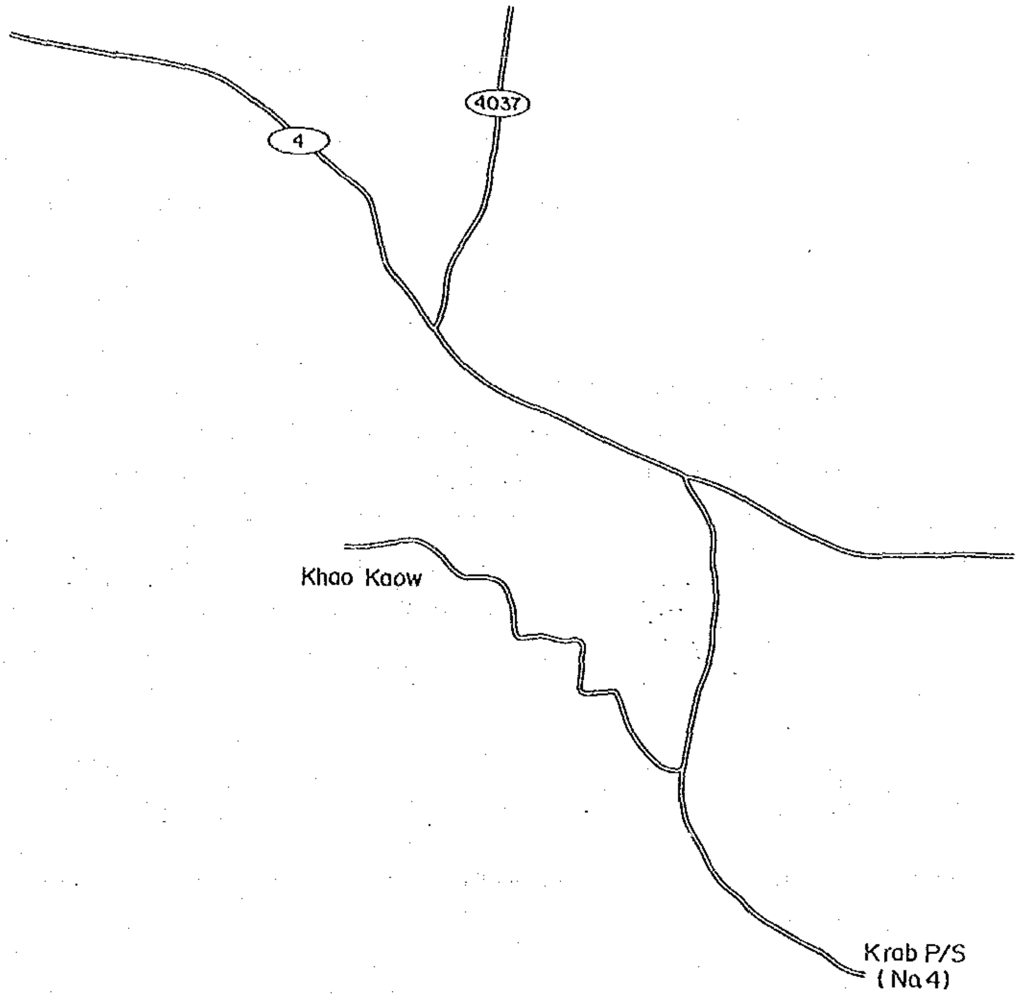


Fig. 4-19 Limestone Transportation Route for Site No.4

(6) Cooling Water Supply (Site No. 4)

Concerning the cooling water system for condenser at site No. 4, one-through type should be employed. It requires the quantity of cooling water for condenser at a total flow rate of 7.5 m^3/s when the design temperature rise of the cooling water discharged from the condenser is 7°C higher than ambient water temperature.

The cooling water will be supplied from Khlong Phakasai running around the project site. Referring to the draft final report of "A Study on Impacts of Thermal Discharge and Ash Pond Effluent on the Receiving Environment from 75 MW Lignite Krabi Thermal Power Plant", it is proposed to arrange the intake at the south of the plant yard (i.e. the downstream of the river) and the outlet at the north of that (i.e. the upstream of the river), as shown in Fig. 4-15. The premises for the calculation of the cooling water supply cost are taken as shown in Table 4-13 Site No. 4 column.

(7) Land Utilization (Site No. 4)

Since the area is within the existing thermal power plant, there would be no problem.

(8) Ash Disposal Area (Site No. 4)

About 15.8 million tons (19.7 million m^3) of ash is anticipated to be produced from A-FBC boiler through its 25 years operation at the Site No. 4.

Necessary area for ash disposal during the 25 years plant operation is about 68 ha, when height of ash piled is designed about 50 m. This size of area is not available just next of the power plant site because the site is surrounded by Khlong Phakasai, it is available at 2.5 km far from the new power plant site. (Fig. 4-20)

The ash is transported to the ash disposal area by means of dumpcart with 30 tons capacity.

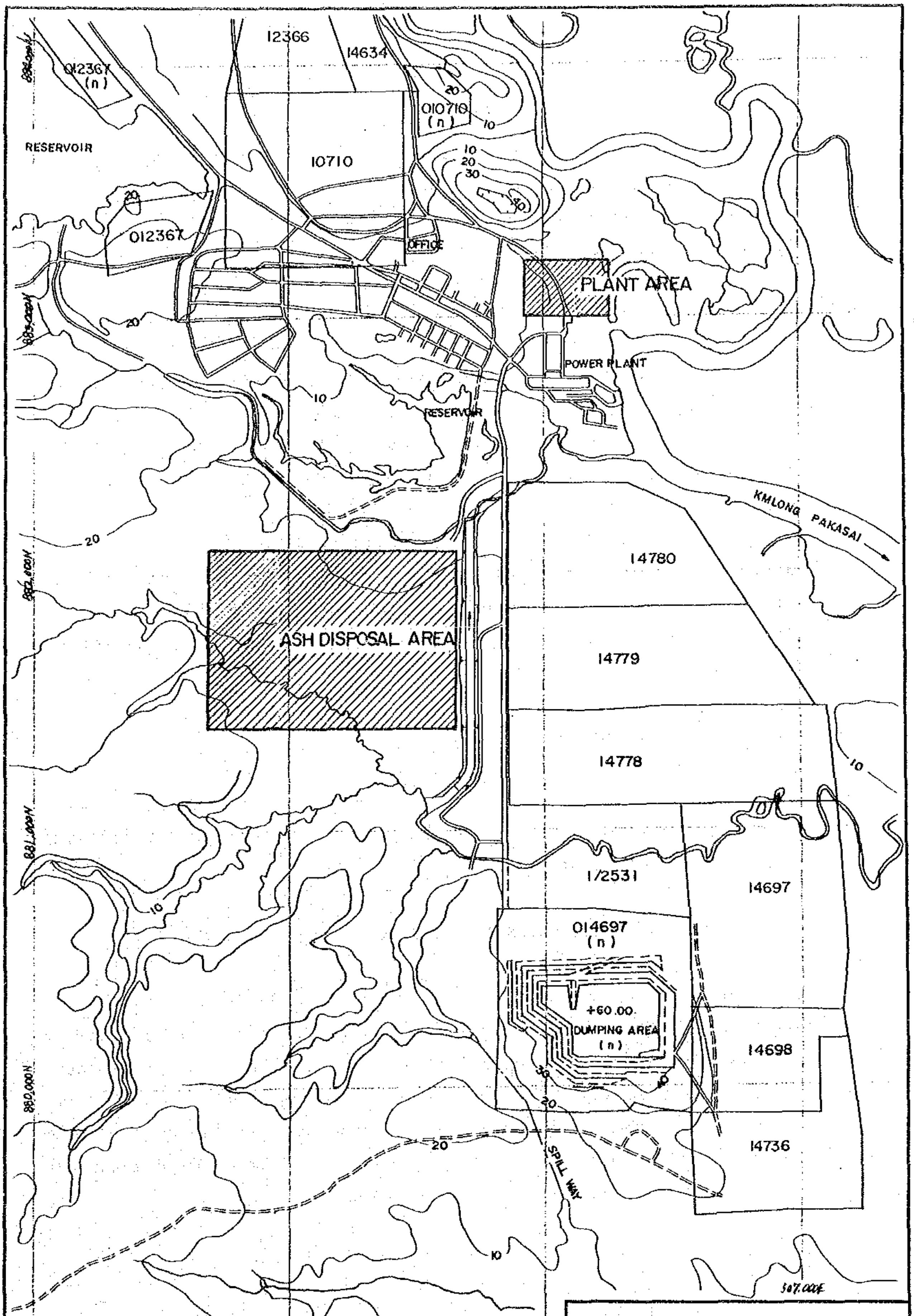


Fig.4-20
Ash Disposal Area
for Krabi No.4 Site

There might be no subterranean water pollution problem caused by dissolving component in water from the ash disposed because non of residents utilize the well water as their drinking water. The premises for the calculation of the ash disposal cost are taken as shown in Table 4-14 Site No. 4 column.

(9) Transmission Lines Route (Site No. 4)

Presently in the Krabi area, one 115 kV transmission line part extends from the Krabi power plant to the Phangnga and Lam Poo Ra substation. The existing transmission lines can be utilised for the transmission from Krabi, if the bus composition of switchyard and the controlling method at power plants are appropriate.

However, it is necessary to discuss with EGAT, as the same situation with Sin Pun, on the expansion of transmission line to Phangnga and Lam Poo Ra, depending on the values of electricity supply to the western area.

(10) Access Road for the Site (Site No. 4)

Since the project site is located in the precincts of Krabi power plant, an access road is recommendable to be connected to the existing road in Krabi power plant.

(11) Availability of Utilize and Existing Facilities (Site No. 4)

Since No. 4 site is located in the existing Krabi power station, electric facilities, city water, sewage for construction are easily available to utilize the existing facilities. Gravel pit is located 15 km from the power station and cement works is in Thung Song. Restaurants and hotels for the engineers and workers during construction are available in Krabi town about 30 km far from the power station.

Besides there is unloading jetty in the power station which can be used for transporting the parts and construction materials by utilizing Khlong Pakasai.

After commissioning the new thermal power station, all of the company houses, repair shops and welfare facilities for present power station can be utilised as that of new power station.

From this point of view, this site has the most advantage compared to the other sites in connection with availability of existing facilities.

(12) Environmental Impact (Site No. 4)

1) Air Quality

(1) Particulate

It will be possible to achieve the proposed emission standard value (500 mg/m^3N) by the combination of mechanical cyclone and ESP or bag-filter.

(2) CO

It will be possible to achieve the proposed emission standard value (800 ppm) without any countermeasure from EPDC's experience.

(3) SO_2

It will be possible to achieve the proposed emission standard value (700 ppm) by in-furnace desulfurization.

(4) NOx

It will be possible to achieve the proposed emission standard value (1,000 mg/m^3N) without any countermeasure from EPDC's experience.

2) Water Quality

As this plant site is located in near a river-mouth, the impact of discharge water from the plant for the river will be slighter than site No. 2 and No. 3.

3) Solid Waste

Solid waste from the plant is mainly coal ash. The countermeasure for coal ash is water treatment from ash pond.

4) Others

As the plant site is not in urban area, odor, noise and vibration are not matter.

(13) Transportation of Equipment (Site No. 4)

The following transportation route was studied for the calculation purpose of the transportation cost.

i) Unload the equipment at Phuket international port.
ii) Loading the equipment on the barge to the Krabi power station.
iii) Unload the equipment from the barge to the site No. 4 by truck.

5. OUTLINE AND DEVELOPMENT EFFECT OF COAL-FIRED THERMAL POWER PLANT

CHAPTER 5 OUTLINE AND DEVELOPMENT EFFECT OF COAL-FIRED THERMAL POWER PLANT

CONTENTS

5. Outline and Development Effect of Coal-Fired Thermal Power Plant

5.1 Outline

The recent continuously growing demand for power in Thailand reached a peak of 7,094 MW in 1990. In the fast several years, the maximum power demand has annually increased by about 15%. Providing for this situation, EGAT has projected large-scale power developments for the southern area. They include construction of two 75 MW thermal power plants in the Sin Pun area, one scheduled for completion in 2003, the other in 2004. these plans are based on the efficient use of domestic energies such as lignite, hydro, and natural gas.

The Sin Pun area in the southern part of Thailand is affluent in lignite. And lignite-fired power plans have been studied. However, lignite is a low-grade coal - lower heating value, sulfur-rich, high moisture content, and ash-rich. Considering these shortcomings of lignite, EGAT has planned to develop a thermal power plant comprising a Atmospheric-pressure bubbling-fluidized bed boiler, which is effective in preventing environmental pollution and is adaptable to a wide variety of coal qualities. These plans are scheduled to be in the Sin Pun area of southern Thailand or in the Krabi area, where lignite-fired power plants are now located.

The principal particulars of this type of power plant:

(1) Boiler type: Atmospheric-pressure bubbling-fluidized bed boiler
(2) Output: 75 MW x 2
(3) Coal properties (average):

Sin Pun coal/Krabi coal

	Sin Pun Coal	Krabi coal
i) Heating value (kcal/kg) (LHV)	2,787	1,600
ii) Ash content (%)	21.08	36.45
iii) Total moisture content (%)	32.67	26.14
iv) Sulfur content (%)	7.0	1.8

5.2 Development Effect

Economic and financial analyses will reveal the development effect of coal-fired thermal power plants. That is, the profitability - the relationship between the cost and the income from consumers - is a major concern in the evaluation of the developing effect. However, indirect effects on the economy should not be disregarded. This large-scale thermal power plant developing project will play an important role in the nation's energy policy, including energy-developing projects, and will favorably affect domestic industries.

5.2.1 Role of Energy Policy and Coal-Fired Thermal Power Plant Developing Project

The Thai economic policy aims at an ever-stable and continuous growth of the Thai economy. To achieve continuous economic growth, the efficient use and stable supply of energy is imperative. Developing energies alternative to oil will facilitate the following: curtailing expenditure of foreign currencies because of a reduction of oil imports; improving the nation's self-supporting structure because of efficient use of domestic natural resources; furthering energy diversification and ensuring stable energy supply.

Coal-fired thermal power plants will hold the key to the solutions of power shortage problems; the nation's existing supply capacity will be unable to satisfy the forecasted drastic increase in demand in the near future. Furthermore, coal-fired thermal power plants, which will facilitate increasing the nation's total supply capacity and improving the reliability of the power supply system, will enable a long-term and stable power supply.

5.2.1.1 Coal-Fired Thermal Power Plant Developing Project for Stable Power Supply

(1) The recent significant increase in the demand for power in the southern area is comparable to demands throughout the country. In 1990, the peak power demand reached 533 MW. In the past three years, the average annual peak power and average annual power consumption have increased by about 13.7% and 15.4%, respectively.

To satisfy this quick increase in demand EGAT prepared a plan in October 1990 called PDP90-03 Power Development Plan. It includes main power developments for the southern area: Khanom Combined Cycle 100 MW x 2, Kaeng Krung Hydroelectric Power Plant 40 MW x 2, Saba Yoi Lignite Thermal Power Plant 300 MW x 3, and Sin Pun Lignite Thermal Power Plant 75 MW x 2. This plan urges the construction of lignite-fired thermal power plants until 2000, and increases in the percentage of imported coal after those plants are completed.

(2) The important matters are to establish a power supply system capable of satisfying the continuously increasing demand for electricity in urban areas, to electrify suburban areas, and to expand the existing distribution systems for those areas. In a long-term view, coal-fired thermal power plants as a base load power source will facilitate system reinforcement and the reduction of generation cost and improvement in profitability resulting from the pursuit of appropriate scale/structures of business organizations and power supply facilities.

(3) The profitability of thermal power plants depends on the power-generation scale and the skill of plant operators. During periods of growing demand that require reinforcement of generation units and improvement in the efficiencies of boilers and turbines, scale merits can be expected. In ordinary coal-fired power plants, doubling the capacity is said to yield cost reduction by about 20%. Continuous construction of coal thermal power plants and the associated accumulation of operation know-how will lead to cost-saving from operation by well-trained operators. And this will result in the reduction of total generation cost.

5.2.1.2 Improving the Self-Generation Percentage

Important national policies include improving the self-generation percentage based on the development of domestic natural resources and curtailing the expenditure of foreign currencies by reducing the imports of oil. The introduction of domestic-coal-fired thermal power plants means an increase in the self-generation percentage.

Coal-fired thermal power plants, which facilitate the creation of a new domestic demand for coal, are an important means to improve the self-energy supply percentage of Thailand.

5.2.2 Coal-Fired Thermal Power Plant Developing Project and its Industry-Related Effects

5.2.2.1 Indirect Development Effect

Power generation profoundly relates to production by other industries, such as the electrical, machine producing, basic metals, mining, and construction industries.

The construction of domestic-lignite-fired thermal power plants will need another type of fuel-feeding equipment. The construction of large generation facilities and equipment needing another type of power feeding structures will induce new production opportunities in the coal, machine producing, and construction industries; enlarge the industry-related effects; and favorably affect the Thai economy. The synergistic effects of investment for constructing related facilities for coal-fired thermal power generation will indirectly, but significantly, affect the growth of the economy. These effects will be intensified by an increase in the number of coal-fired thermal power plants and an increase in the percentage of domestic production of coal and machinery. Large-scale coal-fired thermal power generation projects requiring construction of generation facilities and a reform of the surrounding social base will provide the local social structure with added vitalities, employment opportunities, a higher economic standard by the people, and a sound growth of the local economy.

5.2.2.2 Domestic Coal Supply and Productivity Improvement

The coal-fired thermal power plant developing project will bring about an increase in the demand for domestic coal, resulting in an increase in the self-energy-supply percentage furthermore, it will vitalize the coal industry with economic effects: new demands for coal for power generation will induce investments in the development of new mines and their infrastructures and in modernization to increase productivity. The expansion in production will accompany scale merits.

The degree of the industry-related effects of the coal industry is comparable to that of the electric power industry. With an increase in the demands for domestic coal for power generation, the industry-related effects will increase.

These indirect effects, which will yield better productivity in the coal industry, will enable a stable supply of cheaper coal for the power generation industry.

6. PRELIMINARY POWER STATION LAYOUT

CHAPTER 6 MINING DEVELOPMENT

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6. Mining Development

6.1 General

EGAT has planned the construction of 150 MW new power plant FBC type in the Krabi Area. Coal consumption of this power plant is expected 1,000,000 tons of lignite per year. Eighty percent of lignite is supplied from Sin Pun and the remaining 20% from current Krabi Mine. In order to supply lignite, mining developments have been planned in Sin Pun coal field and Krabi Area. The overall goal of this study is to assess the technical and economic feasibility of an open cut mine development in the Sin Pun and Krabi coal fields to meet the coal requirements of 150 MW capacity power station on the basis of EGAT's Sin Pun Coal Deposits Geological Report (1987), Feasibility Study on Krabi Mine Expansion Project for Power Plant Unit 4 (1988) and Sin Pun Conceptual Mining Study (1991).

The scope of the study covers as follows:

- Review of the latest geological model of the deposit and the result of the geotechnical and hydrogeological investigation.

- Economic ranking of the coal resource using an ER (Economic Ratio) analysis.

- Selection of an appropriate mining method and Mine Development Schedule.

- Mining Cost

Essential areas of the study can be summarized as follows:

(1) Sin Pun Basin and Krabi Mine can supply enough coal for this power plant to require for the period of more than 25 years.

(2) The problem of the quality will not come out of blending Sin Pun coal and Krabi coal.

(3) Sin Pun coal deposits can be mined by the ordinary mining method, but it is necessary to attend to a drainage.

(4) There is few difference in each production cost deriving from the production capacity (17.1MT) for 100MW power plant and the capacity (25MT) for 150MW power plant.

(5) In Sin Pun Area, it is necessary at an early stage to obtain the social consensus of the inhabitant concerning the expropriation for the land, the removal to another place, the environment and the transportation of the coal.

6.2 Sin Pun Coal Field

6.2.1 Introduction

6.2.1.1 Location and Access

The Sin Pun Coal field is located in the central part of Peninsula of Thailand at latitude 8°7'N to 8°26'N and longitude 99°14'E to 99°23'E (Fig. 6-1). It covers the junction of three provinces as follows:

- Phrasaeng District of Surat Thani Province.
- Thung Yai and Chawang District of Nakhon Sri Thammarat Province.
- Khao Phanom District of Krabi Province.

Thung Yai is the nearest small village away to the northeast about 7 kilometers along sealed road No. 4156 and No. 4019. The nearest popular town is Thung Song about 45 kilometers along sealed road No. 4019 and Highway No. 41 from Thung Yai. Thung Song is connected by railway to Bangkok about 1,000 kilometers to the north and by daily bus along Highway No. 4 and No. 41. EGAT's Krabi Mine is to the southwest about 80 kilometers connecting by gravelly road.

The nearest commercial airport is at Surat Thani about 100 kilometers by sealed road. There are daily air service from and to Bangkok.

6.2.1.2 Previous Studies

The first geological work of the Sin Pun coal field included 11 test-pits was by Lignite Authority (Krabi Mine) in 1967. Five of them found lignite subcrop. Fifty boreholes were carried out in the field by Krabi Mine on behalf of Lignite Authority between 1967 and 1969. The result of drilling revealed a lignite seam of about 10 meters thickness at depths ranging between 2 to 57 meters with dip angle 2 to 30 degrees and 4,100 to 4,847 kcal/kg heating value in dry-basis.

In 1983/1984 exploration program, EGAT made geological mapped in the Sin Pun Area and subsequently drilled 156 boreholes with a total of 10,520 meters.

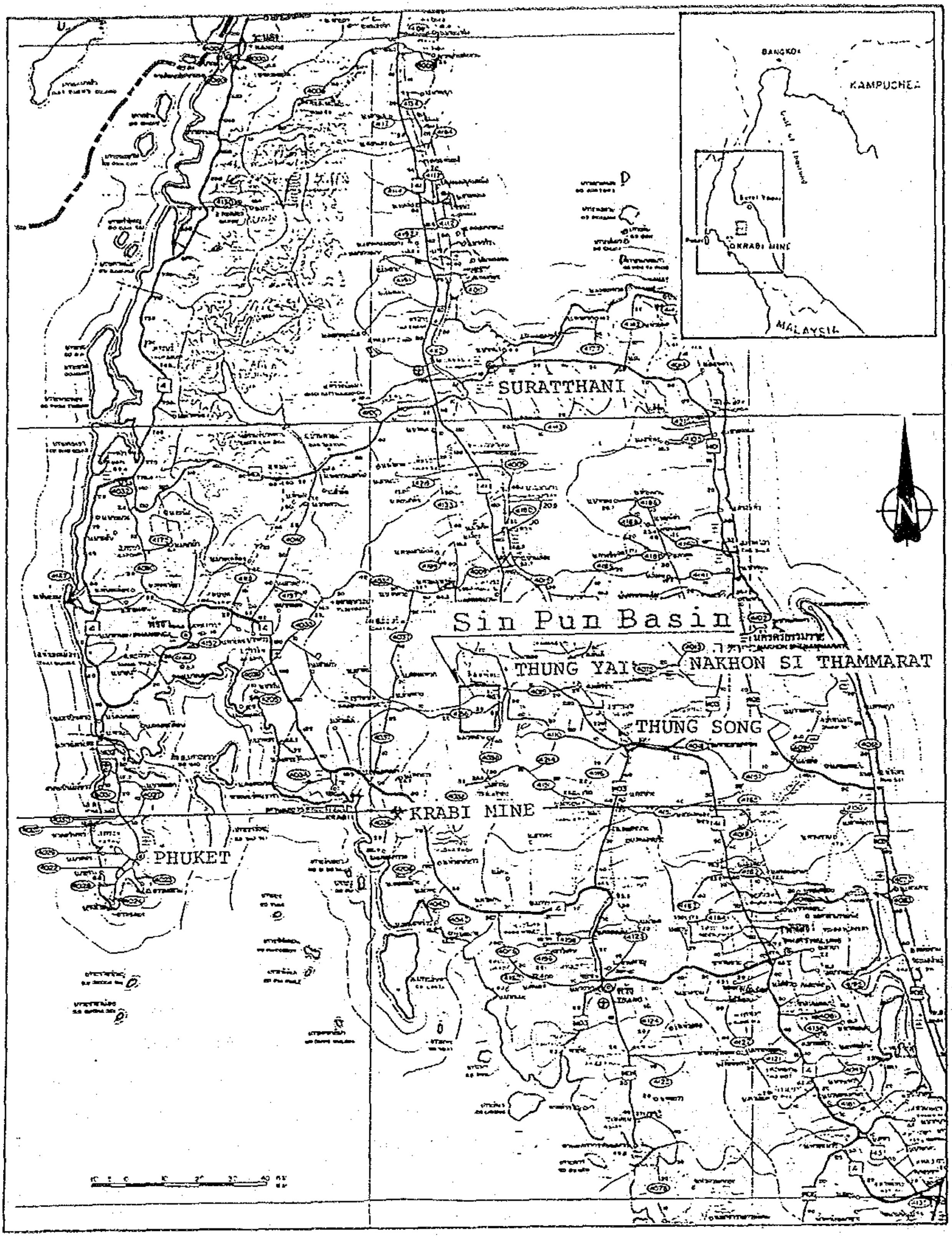


Fig. 6-1 Sin Pun Location Map

EGAT estimated 16.7 million tons of lignite resource with average stripping ratio 1:3.93 m^3/ton, 4,100 to 4,750 kcal/kg heating value, 22.73 to 30.00% ash content in dry basis.

In 1984, The Thailand-Australia, Lignite Mines Development Project (ADAB project) included 83 drill holes evaluated that there were sufficient economic coal resources at Sin Pun to support at least 75 MW of power station capacity.

In 1984, the Sin Pun Area was reserved as national lignite study area by the Department of Mineral Resources (DMR), the Ministry of Industry.

In 1985, Solid Fuel Exploration Project at Sin Pun was conducted by DMR including 433 boreholes with geophysical logging. Forty-three million tons of lignite quantity was calculated with 2,530 to 5,050 kcal/kg heating value, 17.4 to 51.1% ash and 2.0 to 5.0% sulphur content in dry basis.

In 1985/86, a comprehensive exploration work was carried by EGAT included 621 boreholes. The geological coal resource was increased to 65.2 million tons: 48.7 MT of measured, 13.7 MT of indicated and 2.8 MT of inferred resources.

In 1988/86 EGAT made a geotechnical and hydrogeological survey of the Sin Pun coal field using data obtained in the 1985/86 exploration.

6.2.2 Deposit Appraisal

6.2.2.1 Description Site

The coal field is bordered by range of small hill with height about 200 meters (MSL) to the north and east, to the south and west high mountain ranges, which is trended in north-south direction with height about 300 - 400 meters (MSL).

The landform of southern half of the area is characterized by terrace with average height about 80 meters (MSL), while the northern half of the area is flood plain of the Klong Sin Pun and Ta Pi Rivers with moderately rolling landform, height about 40 meters (MSL).

The climate around the coal field in the central part of Peninsular of Thailand is divided into two seasons; a dry season and a wet season. The dry season from January to May is characterized by sunny and hot with little rain or breeze. The tropical weather causes a long rainy season from May to December. The onsite meteorological data recorded by EGAT during their 1985/86 exploration period is summarized in Table 6-1.

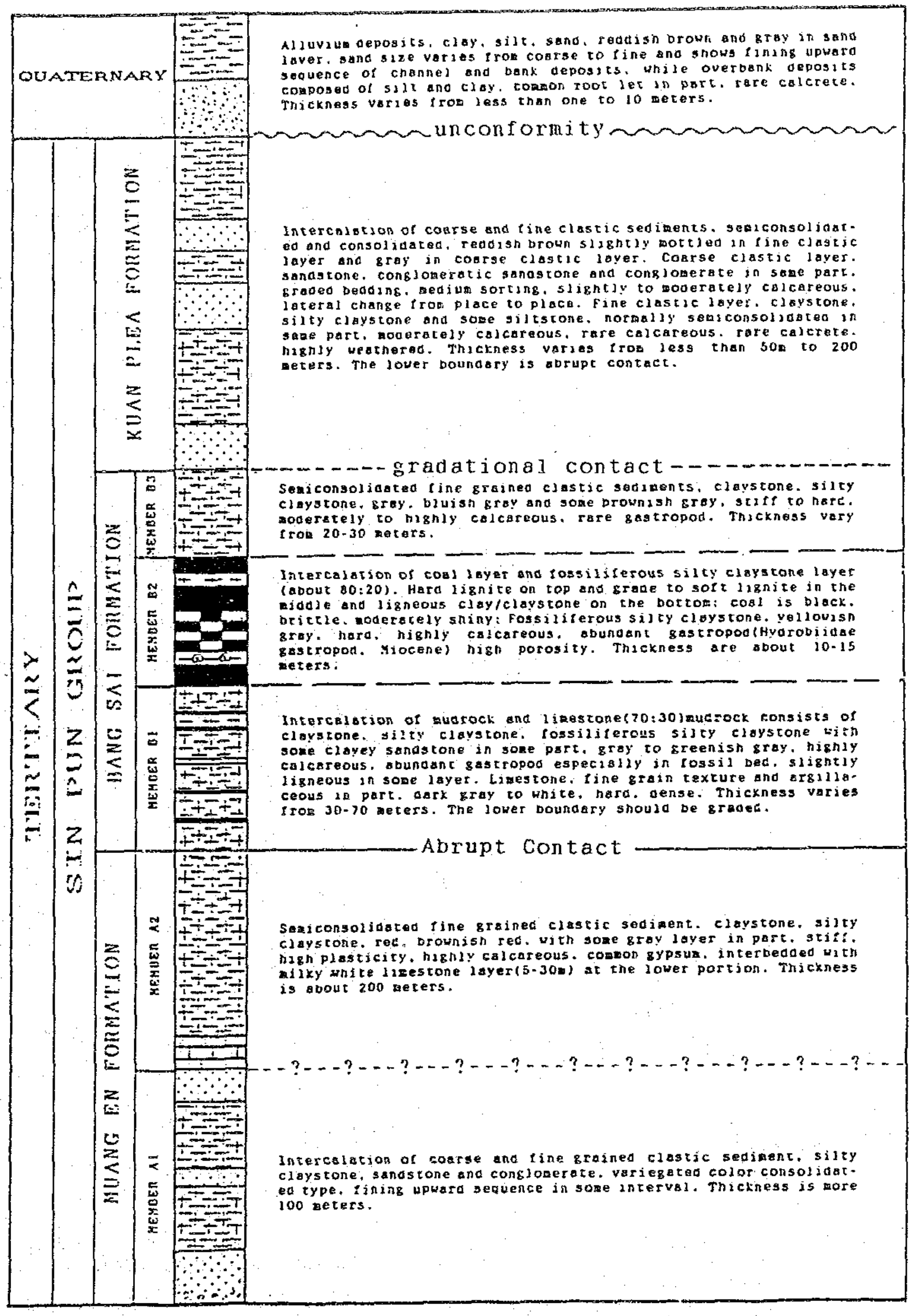
Table 6-1 Meteorological Data in the Sin Pun Area

	Temperature			Rainfall	
	Mean (°C)	Ext Max (°C)	Ex Min (°C)	Monthly Rainfall (mm)	No. of Rain Day (day)
Jan.	25.9	32.5	19.3	6.0	2
Feb.	26.5	34.8	18.2	23.5	2
Mar.	28.3	36.4	20.2	63.3	3
Apr.	29.1	36.3	21.9	83.2	7
May	28.2	33.3	23.0	380.7	19
Jun.	27.7	33.1	22.3	101.4	6
Jul.	27.6	33.1	22.0	278.5	19
Aug.	26.9	31.8	22.0	262.4	17
Sep.	27.1	31.7	22.4	213.3	16
Oct.	27.3	32.1	22.6	257.6	11
Nov.	26.7	31.3	22.0	59.3	8
Dec.	25.7	31.4	19.9	104.9	9

Temperature: 1986-1989
Rainfall : 1991

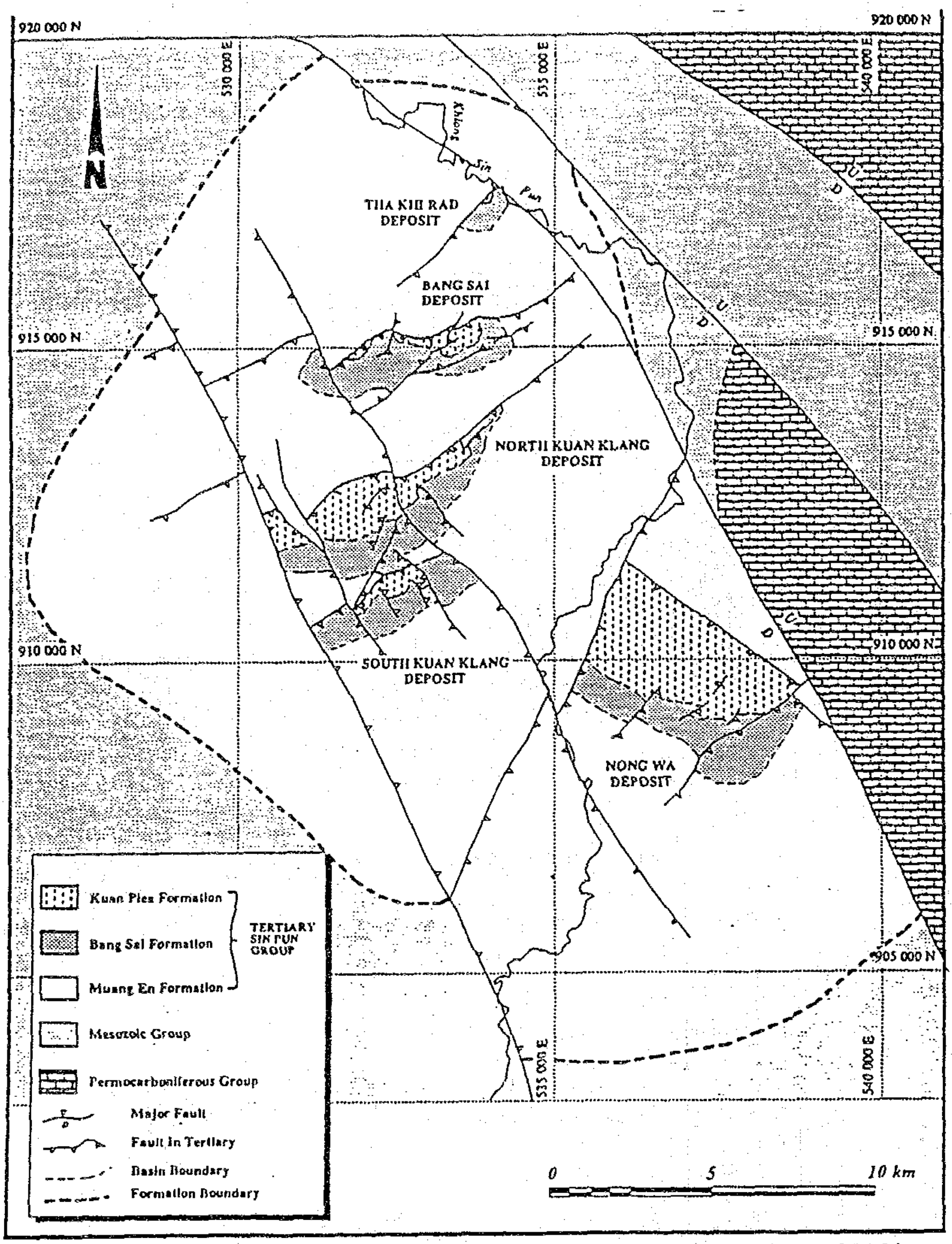
The Sin Pun River flows from south to north along the eastern side of the Sin Pun basin and down to the Ta Pi River. The catchment area of the Sin Pun River is 830 square kilometers and the average annual inflow volume is 312 million cubic meters. The small tributaries join the Sin Pun River form both sides.

The area is covered by national reserved forest and plantation of rubber, oil palm and rice. The higher land is used as farm and stock-rasing. While the national reserved forest is cut and owned by people to make it plantation illegally.



simplified from Sin Pun Concetual Mining Study,EGAT May 1991

Fig. 6-2a Stratigraphy of Sin Pun Area



after EGAT-SIN PUN CONCEPTUAL MINING STUDY (May 1991)

Fig. 6-2b Sin Pun Basin Geology

6.2.2.2 Regional Geology

(1) Regional Stratigraphy

The Sin Pun Basin is one of Tertiary coal basins in Peninsula of Thailand. The previous geological study reveals that it is an half graben intermontane basin with the depositional environment under fluviatile and lacustrine.

The basement rocks is composed of Mesozoic red-colored sedimentary rocks and Permocarboniferous limestone. The Tertiary sequence consists mainly of fine to coarse clastic rocks with thin lenticular limestone and gypsum. Lignite seams are interbeded in the Tertiary sediments. The whole thickness of the Tertiary sequence is unknown but estimated more than 600 meters. The fossil of gastropoda shell shows Miocene in age. The Sin Pun Area is covered throughout with Quaternary alluvium deposits varying less than one meter to 10 metes in thick. It consists of unconsolidated sediment: clay, silt and sand.

(2) Tertiary Rocks

The Tertiary sediments called Sin Pun Group is divided into three formations; the Muang En Formation, the Ban Sai Formation and the Kuan Plea Formation. (Fig. 6-2a and 6-2b)

Muang En Formation

This is the lowest unit of the Sin Pun Group and consists of semiconsolidated and consolidated rocks such as claystone, siltstone, mudstone, sandstone, conglomerate and limestone. This formation is characterized by red in color and no fossils and divided two members; the Member A1 and The Member A2. Thickness of the formation is more than 300 meters.

Bang Sai Formation

This is the coal bearing formation which consists mainly mudstone and two lignite seams named "P" and "M" seams. This formation varies from 60 to 120 meters in thick and is divided into three members.

Kuan Plea Formation

This is the uppermost unit and composed of claystone, siltstone, sandstone and conglomerate. The thickness varies from 50 to 200 meters.

(3) Coal Deposits

There are five coal deposits in Sin Pun Basin; The Khi Rad, Bang Sai, North Kuan Klang, South Kuan Klang and Nong Wa deposits from north to south.

Two coal seams are known in each coal deposit:

P seam: (Fig. 6-3)

This coal seam is the upper coal seam interbeded in the Member B2 of the Bang Sai Formation. The thickness varies 10 to 15 meters in the area closed to subcrop and tends to gradually thin or split along down dip direction until disappearing from the stratigraphic sequence. P seam is characterized by hard lignite on the top, gradually changed to soft lignite and ligneous clay on the bottom. Mudstone partings including shell fossils are interbeded in P seam (Fig. 6-3).

M seam:

This coal seam is the lower coal seam interbeded in the Member B1 of the Bang Sai Formation. This seam is poorly developed with 1 to 2 meters in thick.

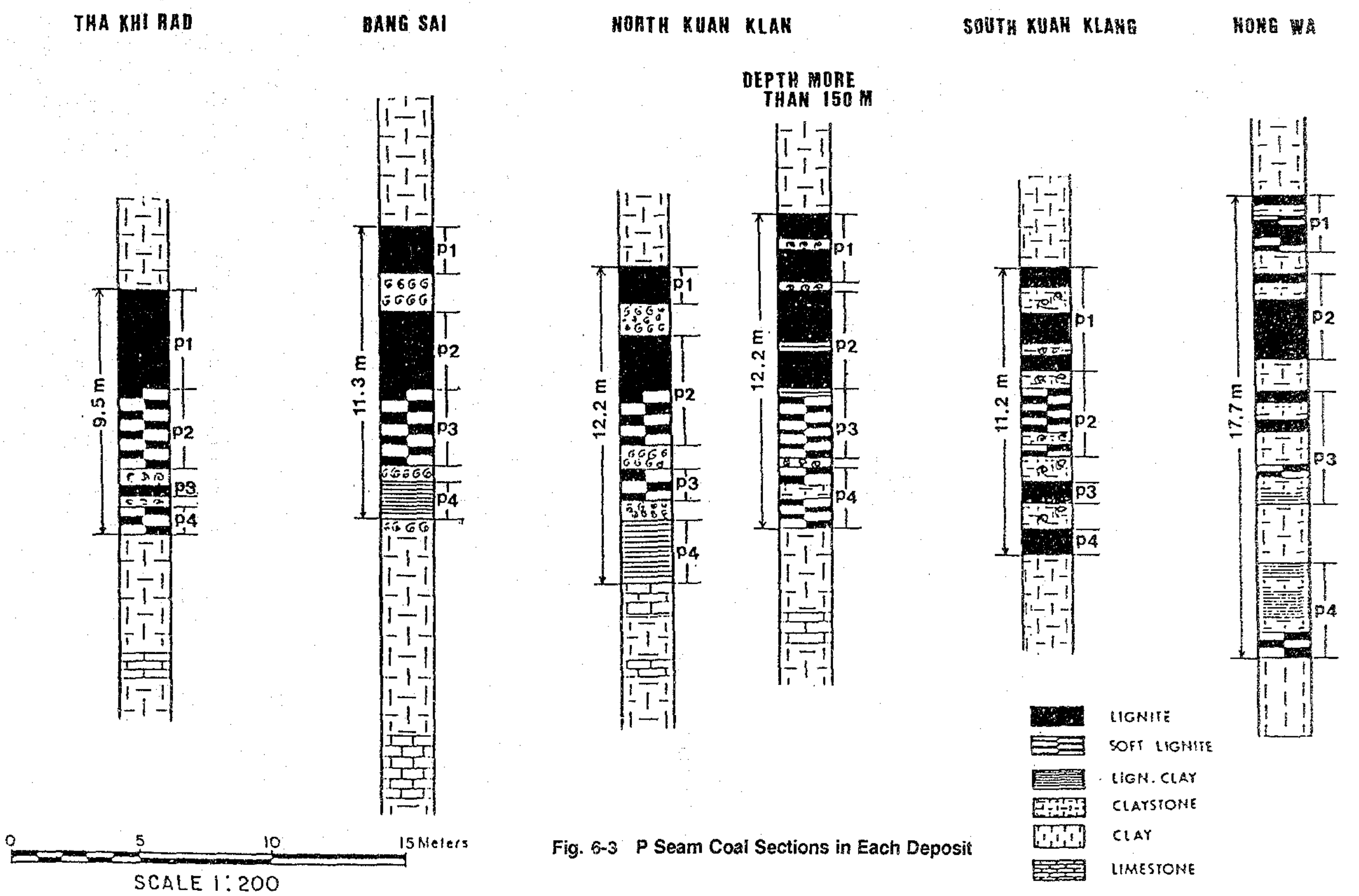


Fig. 6-3 P Seam Coal Sections in Each Deposit

(4) Structure

There are three normal fault systems in Sin Pun Basin: the oldest fault system (FA), the second old fault system (FB) and The youngest fault system (FC).

The oldest fault system (FA) has a NE-SW strike and dips SE with steep dip angle. This fault system forms the northwestern limits of each of the five coal deposits and are cut by other two younger fault systems. The second oldest fault system (FB) trends NE-SW and dips SE and NW with dip angle 70 - 80 degrees. This fault system affects all of coal deposits. The youngest fault system (FC), has a NW-SE strike and dips NE and SW with dip angle about 70 - 80 degrees, are the major trend of the structure developed by the reactivation of the major Khlong Marui fault zone and others. This system divides Sin Pun Basin into four blocks, while it affects mainly North Kuan Klang and South Kuan Klang deposits forms the northeastern limit of Nong Wa Deposit.

6.2.2.3 Geology of Each Deposit

<u>Tha Khi Rad Deposit</u> (Fig. 6-4)

This deposit on the western bank of the Sin Pun River is the smallest of the five deposits. Its area is about 0.168 square kilometers. The strata trend northeast-southwest and dip northwest with angle 10 to 20 degrees.

P seam, main workable seam in this deposit, is characterized by hard lignite on the top and gradually changed to soft lignite and ligneous clay on the bottom respectively. Partings with 0.3 to 2 meters thick are interbeded in P seam. The thickness is about 10 meters near outcrop and thins to the deeper part with a average thickness of 8.4 meters.

Two faults (FA, FB) cut through the deposit and form the limitation of down dip extension.

This deposit is covered with Quaternary sediment about 10 meters and the total length of outcrop is about 0.7 kilometers. The maximum thickness of overburden is 60 meters.

Bang Sai Deposit (Fig. 6-4 and Photo 6-1)

This deposit is about 2 kilometers to the south of the Tha Khi Rad deposit and the third large deposit with the area of 1.06 square kilometers. The strata trend northeast-southwest and east-west from place to place and dip north with angle less than 10 to 20 degrees.

P seam, main workable seam in this deposit, is characterized by hard lignite on the top and gradually changed to soft lignite and ligneous clay on the bottom respectively. P seam contains shell-fossiliferous partings of 0.3 to 2 meters in cumulative thickness. This seam varies in thickness from 19.4 to 0.2 meters with a average thickness of 10.2 meters and thins along down dip direction until disappearing at depth 60 - 120 meters from ground surface.

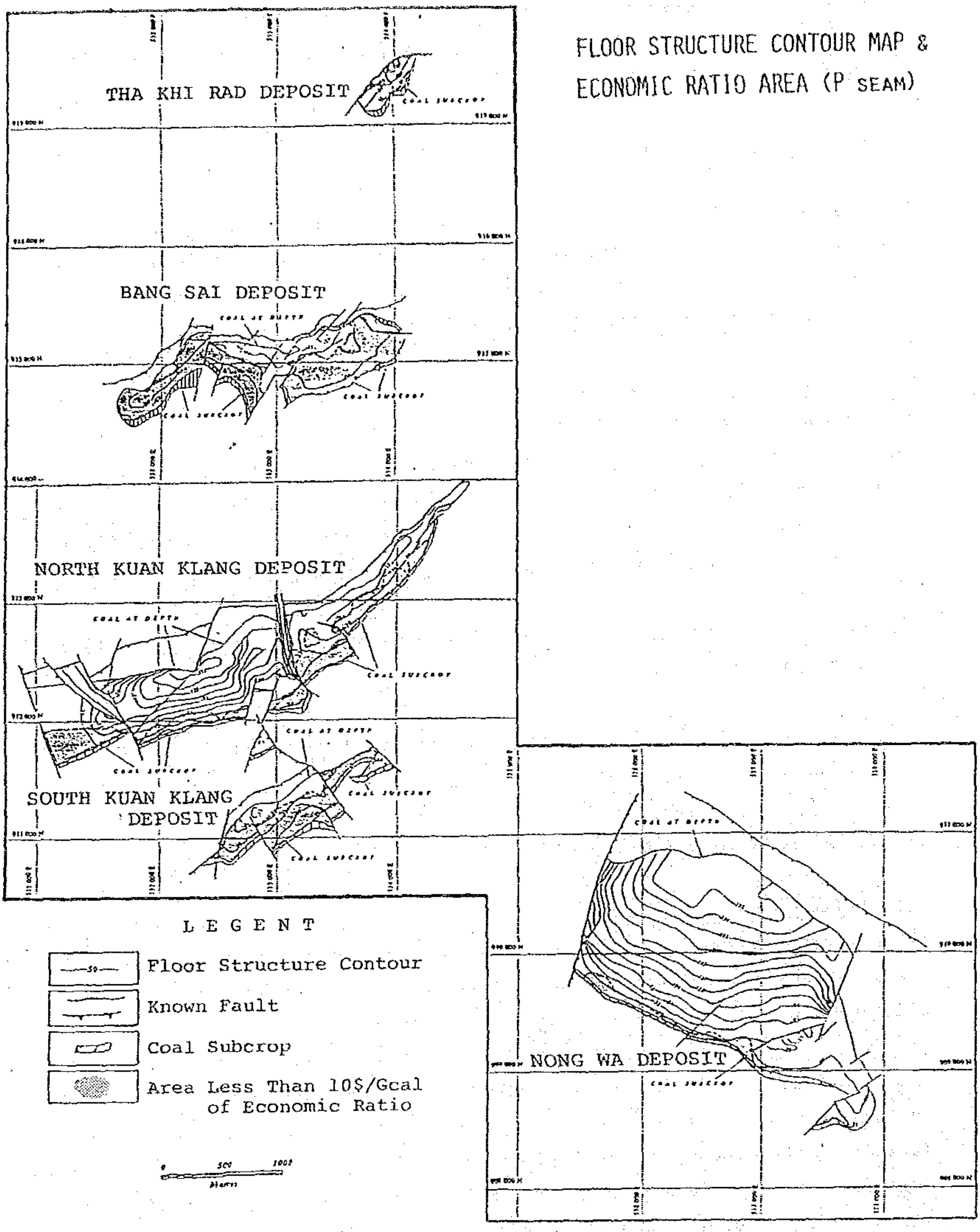
The FA fault system limits the northern boundary and ten numbers of faults (FB) divides the deposit.

The thickness of overburden varies from 20 to 100 meters and the total length of outcrop is about 3.0 kilometers.

North Kuan Klang Deposit (Fig. 6-4 and Photo 6-1)

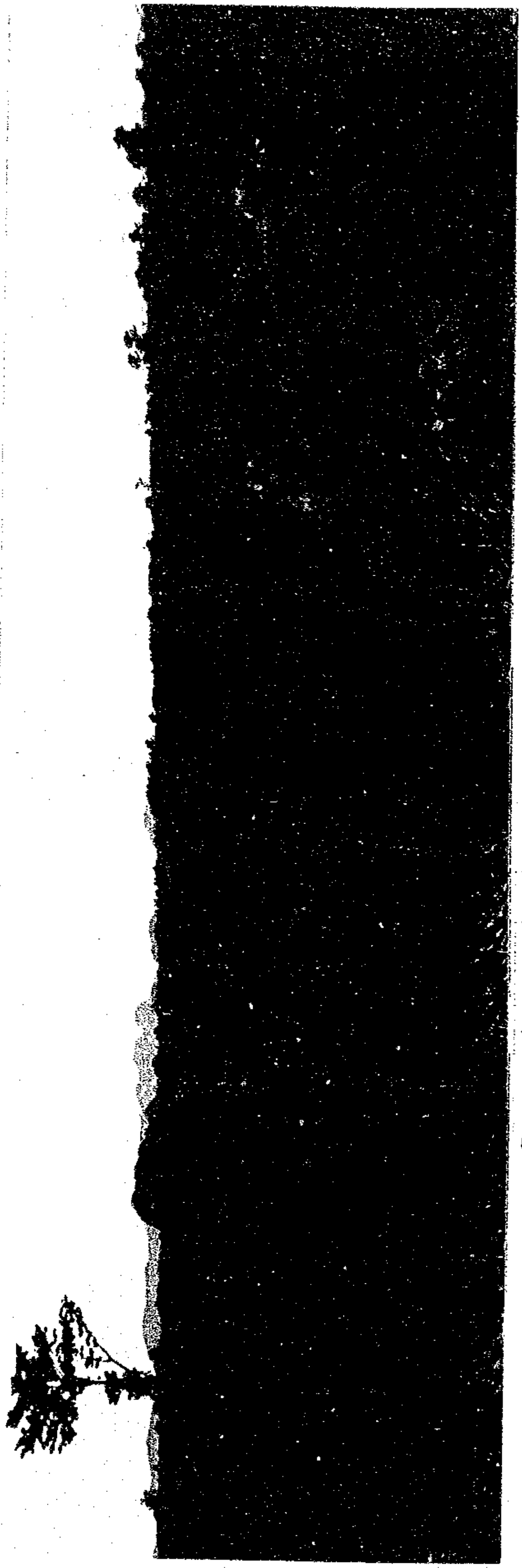
This deposit is about 1 kilometer to the south of the Bang Sai deposit and the second large deposit with the area of 2.10 square kilometers. The strata change gradually the strike ENE-WSW to NE-SW from the west side to the east side and dip north with angle less than 10 to 30 degrees.

The lithofacies of P seam is quite similar to one in Bang Sai Deposit but the partings varies from 9.3 to 0.1 meters and is composed of fossiliferous lutites. This seam varies in thickness from 17.1 to 0.2 meters with a average thickness of 9.7 meters while it thins along down dip direction until disappearing at depth 100 - 250 meters from ground surface. M seam seems to be well developed throughout the deposit with 0.5 - 0.2 meters thick.



modified from Sin Pun Conceptual Mining Study, May 1991

Fig. 6-4 Floor Structure Contour Map & Economic Ratio Area (P Seam)



Bang Sai Deposit (Sin Pun Area) Facing North

North Kuan Klang Deposit (Sin Pun Area) Facing North

Bang Sai Deposit (Fig. 6-4 and Photo 6-1)

This deposit is about 2 kilometers to the south of the Tha Khi Rad deposit and the third large deposit with the area of 1.06 square kilometers. The strata trend northeast-southwest and east-west from place to place and dip north with angle less than 10 to 20 degrees.

P seam, main workable seam in this deposit, is characterized by hard lignite on the top and gradually changed to soft lignite and ligneous clay on the bottom respectively. P seam contains shell-fossiliferous partings of 0.3 to 2 meters in cumulative thickness. This seam varies in thickness from 19.4 to 0.2 meters with a average thickness of 10.2 meters and thins along down dip direction until disappearing at depth 60 - 120 meters from ground surface.

The FA fault system limits the northern boundary and ten numbers of faults (FB) divides the deposit.

The thickness of overburden varies from 20 to 100 meters and the total length of outcrop is about 3.0 kilometers.

North Kuan Klang Deposit (Fig. 6-4 and Photo 6-1)

This deposit is about 1 kilometer to the south of the Bang Sai deposit and the second large deposit with the area of 2.10 square kilometers. The strata change gradually the strike ENE-WSW to NE-SW from the west side to the east side and dip north with angle less than 10 to 30 degrees.

The lithofacies of P seam is quite similar to one in Bang Sai Deposit but the partings varies from 9.3 to 0.1 meters and is composed of fossiliferous lutites. This seam varies in thickness from 17.1 to 0.2 meters with a average thickness of 9.7 meters while it thins along down dip direction until disappearing at depth 100 - 250 meters from ground surface. M seam seems to be well developed throughout the deposit with 0.5 - 0.2 meters thick.
The FA fault system limits the northern boundary and twelve numbers of faults (FB, FC) cut through the deposit. Major FC-typed faults divides the deposit three blocks and affect the strike of the strata.

The thickness of overburden varies from 20 to more than 250 meters and the total length of outcrop is about 4.3 kilometers.

South Kuan Klang Deposit (Fig. 6-4)

This deposit is about 0.5 kilometer to the south of Bang Sai deposit and the forth large deposit with the area of 0.535 square kilometers. The strata trend NE-SW and dip northwest with angle about 10 to 20 degrees.

The lithofacies of P seam is similar to one in Bang Sai and North Kuan Klang deposits and its cumulative parting varies from 12.4 to 0.1 meters and is composed of fossiliferous lutites. This seam varies in thickness from 19.3 to 0.5 meters with a average thickness of 11.9 meters while it thins along down dip direction until disappearing at depth 70 - 150 meters from ground surface. M seam seems to be locally developed as thick as 2.0 - 3.0 meters thick.

The FA fault system limits the northern boundary and one FB typed fault and four numbers of faults (FC) cut through the deposit.

The thickness of overburden varies from 20 to more than 100 meters and the total length of outcrop is about 2.1 kilometers.

Nong Wa Deposit (Fig. 6-4)

This deposit is on the eastern bank of the Sin Pun River and the largest deposit with the area of 3.46 square kilometers. The strata trend northwest-southeast and dip northwest with angle about 10 to 30 degrees.

The lithofacies of P seam is quite difference from other four deposits with more splitting in the coal zone and its cumulative parting varies from 15.8 to 0.1 meters and is composed of fossiliferous lutites. This seam varies in thickness form 23.0 to 0.1 meters with a average thickness of 11.7 meters while it thins along down dip direction until disappearing at depth 200 - 350 meters from ground surface. M seam seems to be poorly developed with less than one meter thick.

The FA and FC fault systems limit the northwestern and northeastern boundaries respectively and seven FB-type faults cut through the deposit.

The thickness of overburden varies from 20 to more than 300 meters and the total length of outcrop is about 3.1 kilometers.

6.2.2.4 Geological Database

EGAT made a report on conceptual mining study in Sin Pun Area, May 1991 by using the VULCAN software system. Basic geological data for computer analysis are as follows:

- 927 open holes with geophysical logs;
- 224 touch cored holes for coal quality analysis;
- 49 fully cored holes for geotechnical and stratigraphic analysis.

Data quantity with borehole spacing of generally 100 meters or less a grid cell of 50 m x 50 m was considered proper for grid modelling.

The following P seam maps are output in each deposit:

- structure - zone roof, zone floor;
- isopachs - coal zone, cumulative coal, parting, overburden;
- coal qualities - ash, net specific energy, sulfur, total moisture, density.

M seam seems to be considered uneconomic with the following conditions:

- thin and discontinuous;
- located below P seam at a relatively high incremental strip ratio;
- a lower coal quality than P seam.

6.2.2.5 Insitu Coal Quality

EGAT sampled coal from drilling cores by a "ply by ply" method analyzed under the following criteria:

- ply was determined with every lithology change exceeded 0.3 meters,
- parting with thickness exceeded one meter is not sampled,
- every core-loss interval is estimated with most probable lithology.

Most of samples were analyzed under Australian Standard. The following items of coal testing/analysis were performed in Lab. of Mine Operation Dept. of EGAT, Mae Moh Lab. of EGAT, Australian Coal Industry Research Lab. Ltd., Laboratories in USA and Krabi Coal Lab. of EGAT:

- proximate analysis including total sulphur and specific energy,
- ultimate analysis
- forms of sulphur
- hardgrove grindability index
- relative density
- ash analysis
- ash fusion temperature
- trace element analyses
- relatively ignition temperature

The average insitu quality of the coal within the P seam is as follows:

Net Specific Energy	2,716	kcal/kg
Ash Content	21.1	%
Total Moisture	32.70	%
Relative Density	1.4	g/cc
Sulphur Content	5.47	%
Volatile Matter	28.10	%
Fixed Carbon	17.70	%

P seam Coal Quality in each deposit and other detailed analyses data are shown in Table 6-2a and 6-2b respectively.

6.2.2.6 Coal Resources

Coal quantity was computed by the software VOLRES of VULCAN system. The criteria used in resource calculation were as follows:

Table 6-2a Coal Quality Distribution in Sin Pun Basin (I)

Parameters (as received)	Tha Khi Rad			Bang Sai			North Kuan Klang		
	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
Net Specific Energy (kcal/kg)	2,953	2,950	2,946	3,241	2,825	1,683	3,307	2,924	2,240
Ash Content (%)	17.36	17.30	17.25	37.97	19.29	12.32	29.04	17.61	11.18
Total Moisture (%)	33.97	33.95	33.93	35.84	33.25	26.98	36.28	33.86	29.84
Volatile Matter (%)	-	31.27	-	37.36	27.95	23.14	32.77	28.55	19.62
Fixed Carbon (%)	-	19.48	-	23.43	17.19	11.31	24.31	17.71	11.50
Sulphur Content (%)	9.25	9.17	8.99	10.84	6.54	4.47	10.79	7.19	3.74
Relative Density (g/cc)	1.39	1.39	1.39	1.65	1.41	1.32	1.54	1.39	1.30

Parameters (as received)	South Kuan Klan			Nong Wa			Total		
	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
Net Specific Energy (kcal/kg)	3,239	3,032	2,316	3,329	2,450	1,477	3,329	2,716	1,477
Ash Content (%)	32.00	16.21	12.36	39.72	25.44	10.81	39.72	21.08	10.81
Total Moisture (%)	35.82	34.41	28.92	36.43	31.16	26.44	36.43	32.70	26.44
Volatile Matter (%)	35.95	29.03	17.41	34.49	23.73	11.52	37.36	28.11	11.52
Fixed Carbon (%)	24.03	18.73	12.45	24.72	15.21	3.01	24.72	17.66	3.01
Sulphur Content (%)	9.08	6.95	4.86	5.55	3.03	0.83	10.84	5.47	0.83
Relative Density (g/cc)	1.57	1.37	1.32	1.67	1.49	1.30	1.67	1.43	1.30

after Sin Pun Conceptual Mining Study, May 1991

Table 6-2b Coal Quality Distribution in Sin Pun Basin (II)

Parameters	Max	Mean	Min
Ultimate Analysis (daf %)			
C	69.0	64.0	51.9
H	6.3	5.0	3.0
H	1.4	1.2	0.7
S	16.8	12.9	5.7
O	38.6	16.9	8.3
CO3 (ad)	26.7	5.9	0.2
Sulphur (adb %)			
Pyrite	1.16	0.52	0.16
Sulfate	1.75	0.69	0.21
Organic	7.46	5.33	2.14
Total	8.66	6.55	2.60
Ash Analysis (%)			
Si03	94.00	24.04	3.60
Al203	20.30	7.29	0.90
Fe203	23.00	7.52	1.03
CaO	74.20	32.42	4.71
MgO	6.30	2.17	0.01
Na20	1.40	0.63	0.21
K20	2.51	0.99	0.38
Ti02	0.67	0.23	0.01
Mn304	0.10	0.04	0.01
S03	47.40	26.90	5.48
P203	0.60	0.29	0.07
Ash Fusion Temp. (° C)			
Deformation	1,470	1,269	1,090
Sphere	1,540	1,329	1,110
Hemisdhere	1,550	1,340	1,120
Flow	1,550	1,368	1,140
Trace Element Analysis			
F (ug/g)	500	163	55
As	320	120	27
B	210	102	35
U	66	13	0.4
Hardgrove Grindability Index (HGI)	118	101	79
Relative ignition Temperature. (° C)	180	161	146

- coal thickness from the individual borehole calculated by using 60% ash (db) cut off and a coal portion thickness more than 0.3 meters, because the material which contains ash content higher than this value is non-lignitic material by the rock type assumption.
- the coal density used the coal relative density grid which their data points are calculated from the percentage of ash (db). (Relative Density = 1.13 + 0.01 x ash)
- 50 x 50 square meters grid cell is used to generate the relevant grid models.
- the Standing Committee on Coalfield Geology of New South Wales was adapted for the coal resource assessment in Sin Pun Basin.

The coal resources is categorized with Measured, Indicated and Inferred and shown as follows:

Table 6-3 Coal Resources in Sin Pun Basin

Deposit	Resources			Av. Net Calorific Value
	Measured (MT)	Indicated (MT)	Inferred (MT)	(kcal/kg)
Tha Khi Rad	1.00	-	-	2,950
Bang Sai	10.03	-	-	2,825
North Kuan Klang	17.21	-	2.76	2,924
South Kuan Klang	5.34	-	-	3,032
Nong Wa	15.17	13.66	-	2,450
Total	48.75	13.66	2.76	2,716
		65.17		

The relationships between depth and calorific value per resources category in each deposit are summarized in Table 6-4a to 6-4g and illustrated in graphs, Fig. 6-5a to 6-5g. The measured coal resource except in Nong Wa deposit have calorific value more than 2,500 kcal/kg while the indicated resource of 13.66 MT in Nong Wa deposit lies at very deep place with overburden thickness mostly greater than 200 meters (Table 6-4g and Fig. 6-5g). The inferred resource of 2.76 MT in North Kuan Klang deposit seems to exist outside the EGAT concession boundary.

Table 6-4a Measured Resourced of Tha Khi Rad Deposit, Sin Pun Basin

Cal.Value(kcal/kg) / Depth from Surf.	500 ~ 1500	1500 ~ 2000	2000 ~ 2500	2500 ~ 3000	3000 ~ 4000	TOTAL tons
0 ~ 25 (m)	0	0	0	96,400	0	96,400
25 ~ 50	0	0	0	900,500	0	900,500
50 ~ 75	0	0	0	2,500	0	2,500
75 ~ 100	0	0	0	0	0	0
100 ~ 125	0	0	0	0	0	0
125 ~ 150	0	0	0	0	0	0
150 ~ 175	0	0	0	0	0	0
175 ~ 200	0	0	0	0	0	0
200 ~ 250	0	0	0	0	0	0
250 ~ 300	0	0	0	0	0	0
300 ~ 400	0	0	0	0	0	0
Total (tons)	0	0	0	999,400	0	999,400

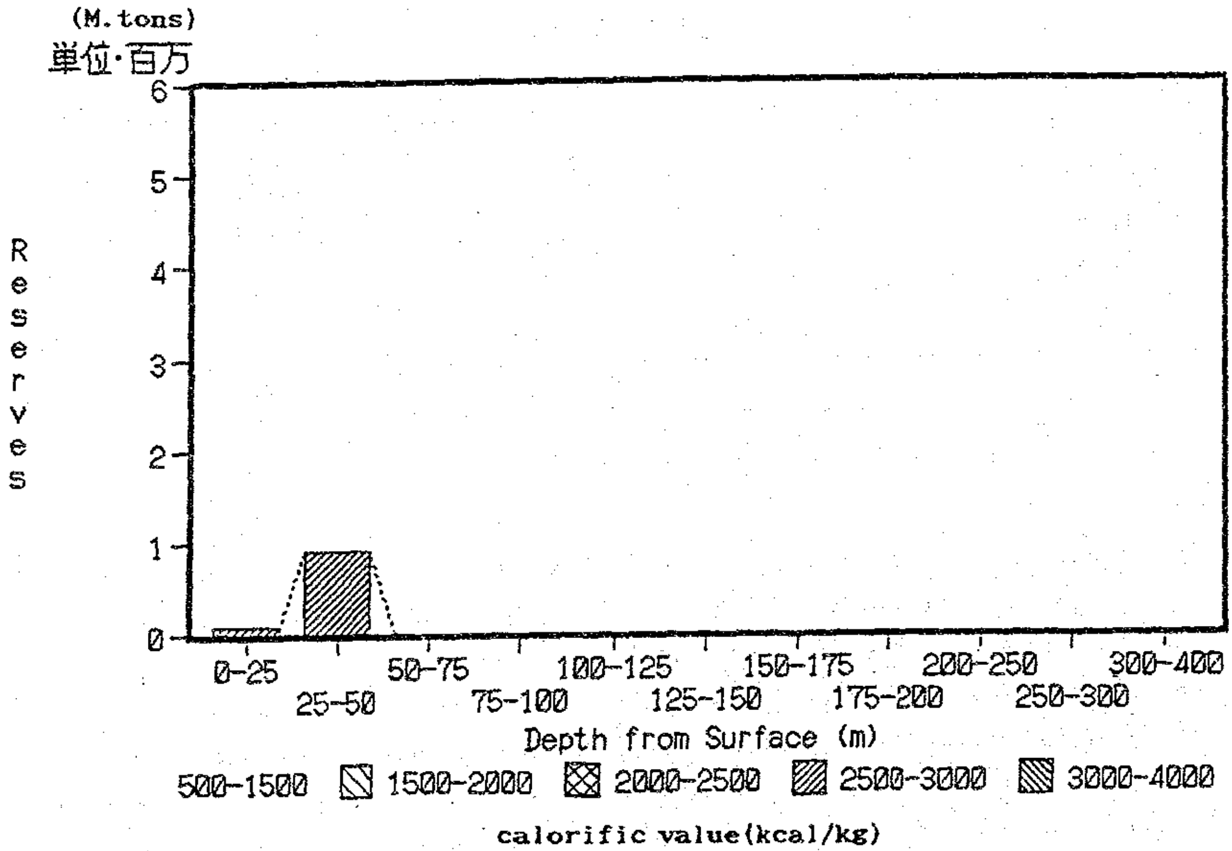


Fig. 6-5a Measured Res. of Tha Khi Rad Deposit Classified by Calorific Value (kcal/kg)

Table 6-4b Measured Resourced of Bang Sai Deposit, Sin Pun Basin

Cal.Value(kcal/kg) / Depth from Surf.	500 ~ 1500	1500 ~ 2000	2000 ~ 2500	2500 ~ 3000	3000 ~ 4000	TOTAL tons
0 ~ 25 (m)	0	0	96,700	2,286,700	1,052,800	3,440,200
25 ~ 50	0	0	31,000	3,784,600	958,000	4,773,600
50 ~ 75	0	0	46,700	1,000,000	32,600	1,079,300
75 ~ 100	0	7,900	124,800	599,700	0	732,400
100 ~ 125	0	0	0	0	0	0
125 ~ 150	0	0	0	0	0	0
150 ~ 175	0	0	0	0	0	0
175 ~ 200	0	0	0	0	0	0
200 ~ 250	0	0	0	0	0	0
250 ~ 300	0	0	0	0	0	0
300 ~ 400	0	0	0	0	0	0
Total (tons)	0	7,900	301,200	7,673,000	2.043,400	10.025,500

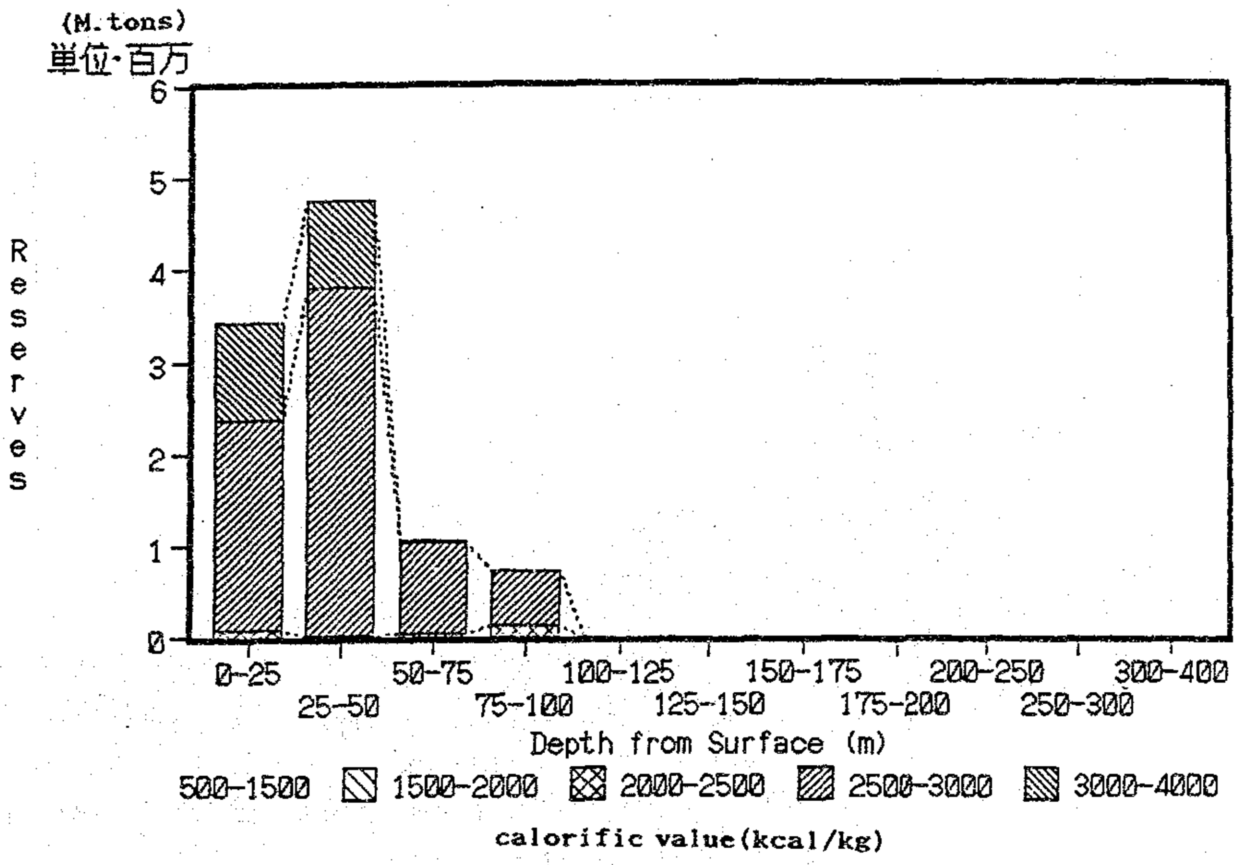


Fig. 6-5b Measured Resources of Bang Sai Deposit Classified by Calorific Value (kcal/kg)

Table 6-4c Measured Resourced of North Kuan Klang Deposit, Sin Pun Basin

Cal.Value(kcal/kg) / Depth from Surf.	500 ~ 1500	1500 ~ 2000	2000 ~ 2500	2500 ~ 3000	3000 ~ 4000	TOTAL tons
0 ~ 25 (m)	0	0	1,200	1,352,400	1,477,900	2,831,500
25 ~ 50	0	0	74,200	2,777,100	962,500	3,813,800
50 ~ 75	0	0	216,700	2,551,500	721,100	3,489,300
75 ~ 100	0	0	4,800	1,124,500	562,600	1,691,900
100 ~ 125	0	0	0	1,298,100	376,500	1,674,600
125 ~ 150	0	0	0	1,062,600	182,600	1,245,200
150 ~ 175	0	0	0	864,900	80,300	945,200
175 ~ 200	0	0	0	643,800	88,000	731,800
200 ~ 250	0	0	0	786,700	1,600	788,300
250 ~ 300	0	0	0	0	0	0
300 ~ 400	0	0	0	0	0	0
						0
Total (tons)	0	0	296,900	12,461,600	4,453,100	17,211,600

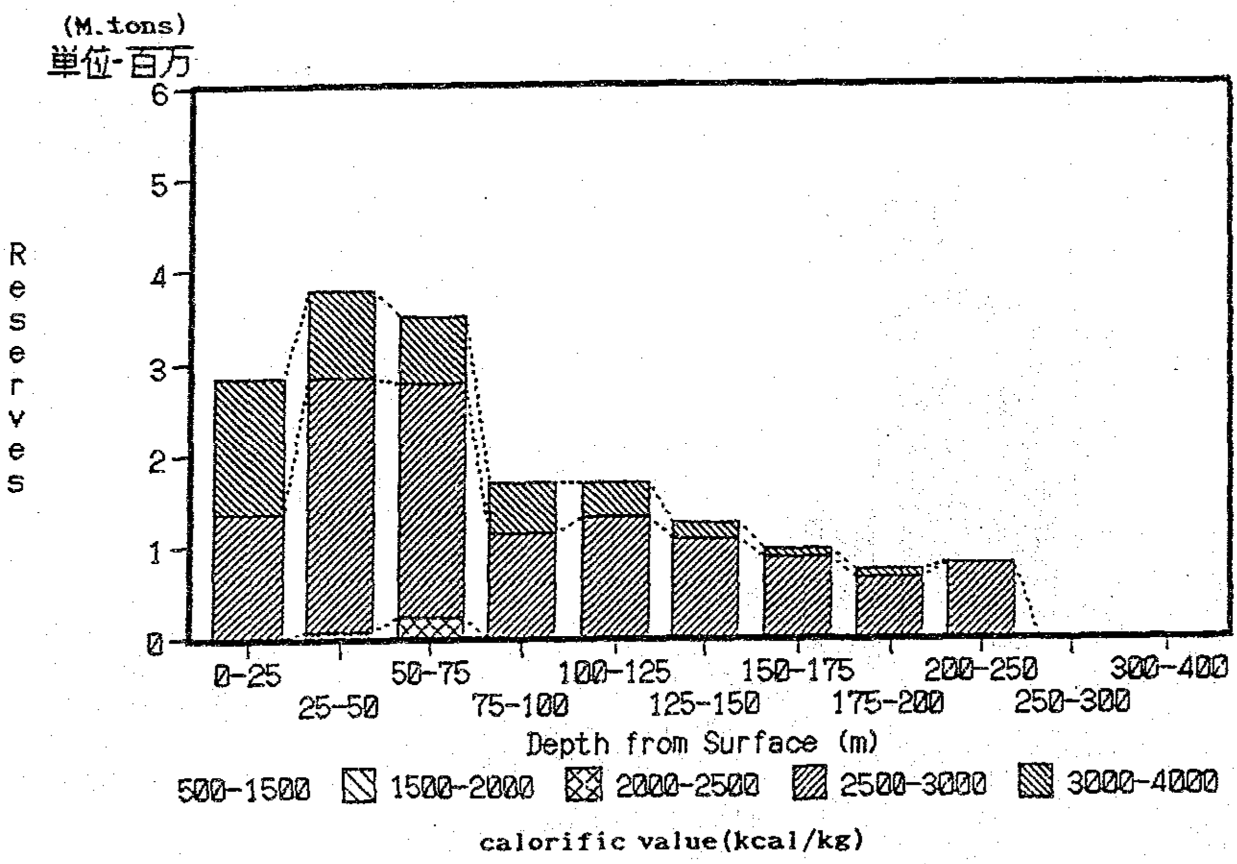


Fig. 6-5c Measured Res. of North Kuan Klang Dep. Classified by Calorific Value (kcal/kg)

Table 6-4d　　Measured Resourced of North Kuan Klang Deposit, Sin Pun Basin

Cal.Value(kcal/kg) / Depth from Surf.	500 ~ 1500	1500 ~ 2000	2000 ~ 2500	2500 ~ 3000	3000 ~ 4000	TOTAL tons
0 ~ 25 (m)	0	0	0	25,000	2,031,400	2,056,400
25 ~ 50	0	0	0	282,400	78,100	360,500
50 ~ 75	0	0	0	335,000	0	335,000
75 ~ 100	0	0	4,400	7,900	0	12,300
100 ~ 125	0	0	0	0	0	0
125 ~ 150	0	0	0	0	0	0
150 ~ 175	0	0	0	0	0	0
175 ~ 200	0	0	0	0	0	0
200 ~ 250	0	0	0	0	0	0
250 ~ 300	0	0	0	0	0	0
300 ~ 400	0	0	0	0	0	0
Total (tons)	0	0	4,400	650.300	2,109.500	2,764,200

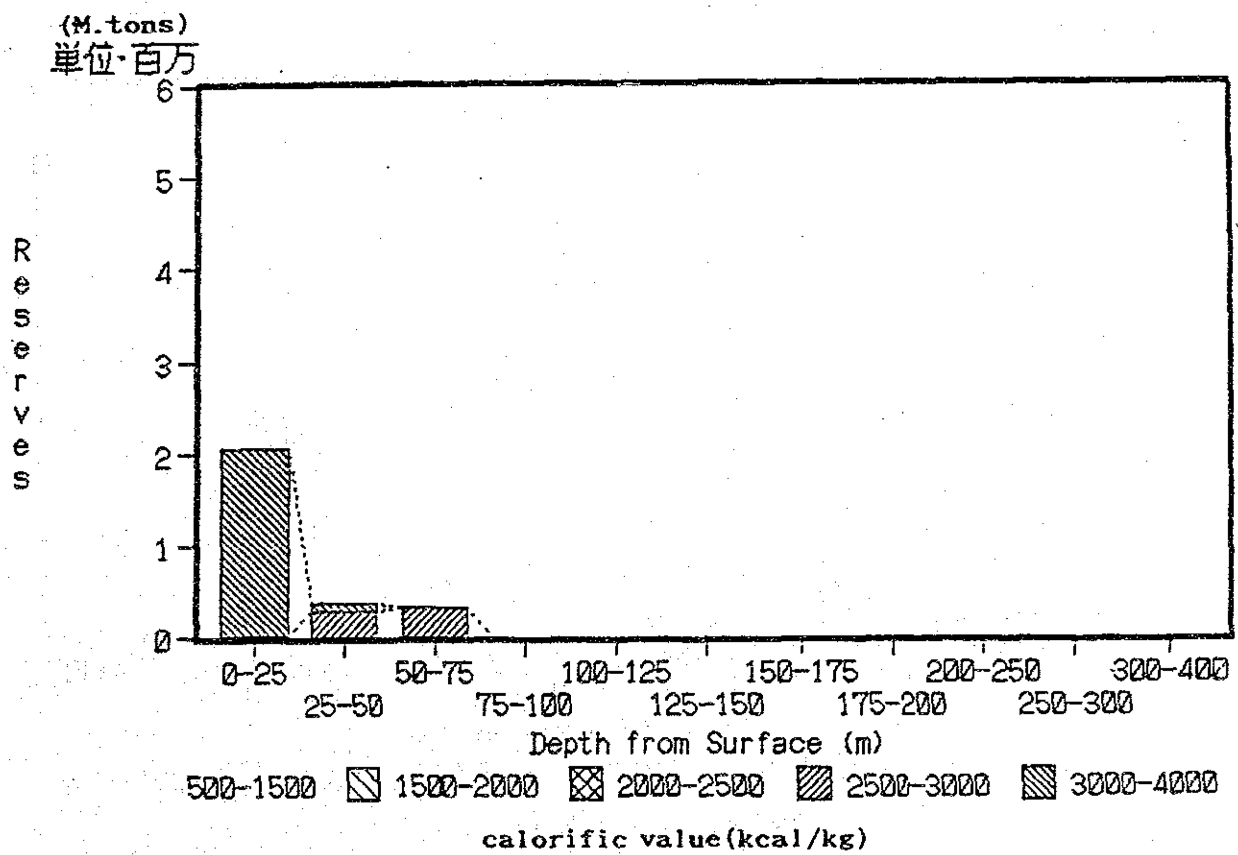


Fig. 6-5d　　Measured Res. of North Kuan Klang Dep. Classified by Calorific Value (kcal/kg)

Table 6-4e　　Measured Resourced of South Kuan Klang Deposit, Sin Pun Basin

Cal. Value(kcal/kg) / Depth from Surf.	500 ~ 1500	1500 ~ 2000	2000 ~ 2500	2500 ~ 3000	3000 ~ 4000	TOTAL tons
0 ~ 25 (m)	0	0	48,700	374,300	1,463.000	1,886,000
25 ~ 50	0	0	0	32,000	1,477,900	1,509,900
50 ~ 75	0	0	0	7,100	1,245,700	1.252,800
75 ~ 100	0	0	0	0	623,500	623,500
100 ~ 125	0	0	0	0	66,800	66,800
125 ~ 150	0	0	0	0	0	0
150 ~ 175	0	0	0	0	0	0
175 ~ 200	0	0	0	0	0	0
200 ~ 250	0	0	0	0	0	0
250 ~ 300	0	0	0	0	0	0
300 ~ 400	0	0	0	0	0	0
Total (tons)	0	0	48,700	413,400	4,876.900	5,339,000

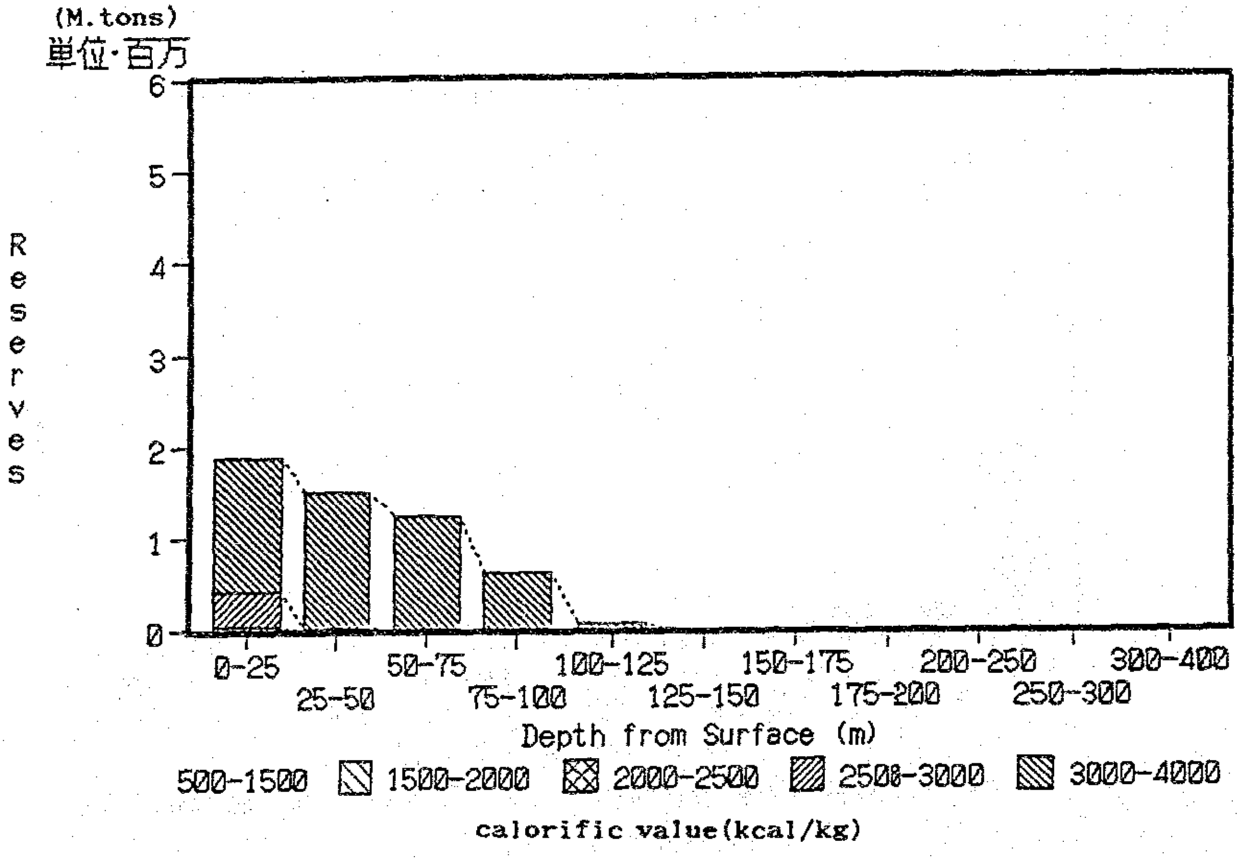


Fig. 6-5e　　Measured Res. of South Kuan Klang Dep. Classified by Calorific Value (kcal/kg)

Table 6-4f Measured Resourced of Nong Wa Deposit, Sin Pun Basin

Cal.Value(kcal/kg) / Depth from Surf.	500 ~ 1500	1500 ~ 2000	2000 ~ 2500	2500 ~ 3000	3000 ~ 4000	TOTAL tons
0 ~ 25 (m)	0	248,600	566,800	709,900	112,400	1,637,700
25 ~ 50	600	365,400	1,267,100	718,600	159,000	2,510,700
50 ~ 75	0	150,800	1,366,800	265,600	81,600	1,864,800
75 ~ 100	0	361,200	1,330,700	335,100	0	2,027,000
100 ~ 125	0	445,700	1,105,000	388,500	28,900	1,968,100
125 ~ 150	0	244,500	843,000	558,000	19,900	1,665,400
150 ~ 175	0	186,700	608,100	554,600	65,000	1,414,400
175 ~ 200	0	153,000	467,000	1,148,600	77,200	1,845,800
200 ~ 250	0	14,100	600	221,300	0	236,000
250 ~ 300	0	0	0	0	0	0
300 ~ 400	0	0	0	0	0	0
Total (tons)	600	2,170,000	7,555,100	4,900,200	544,000	15,169,900

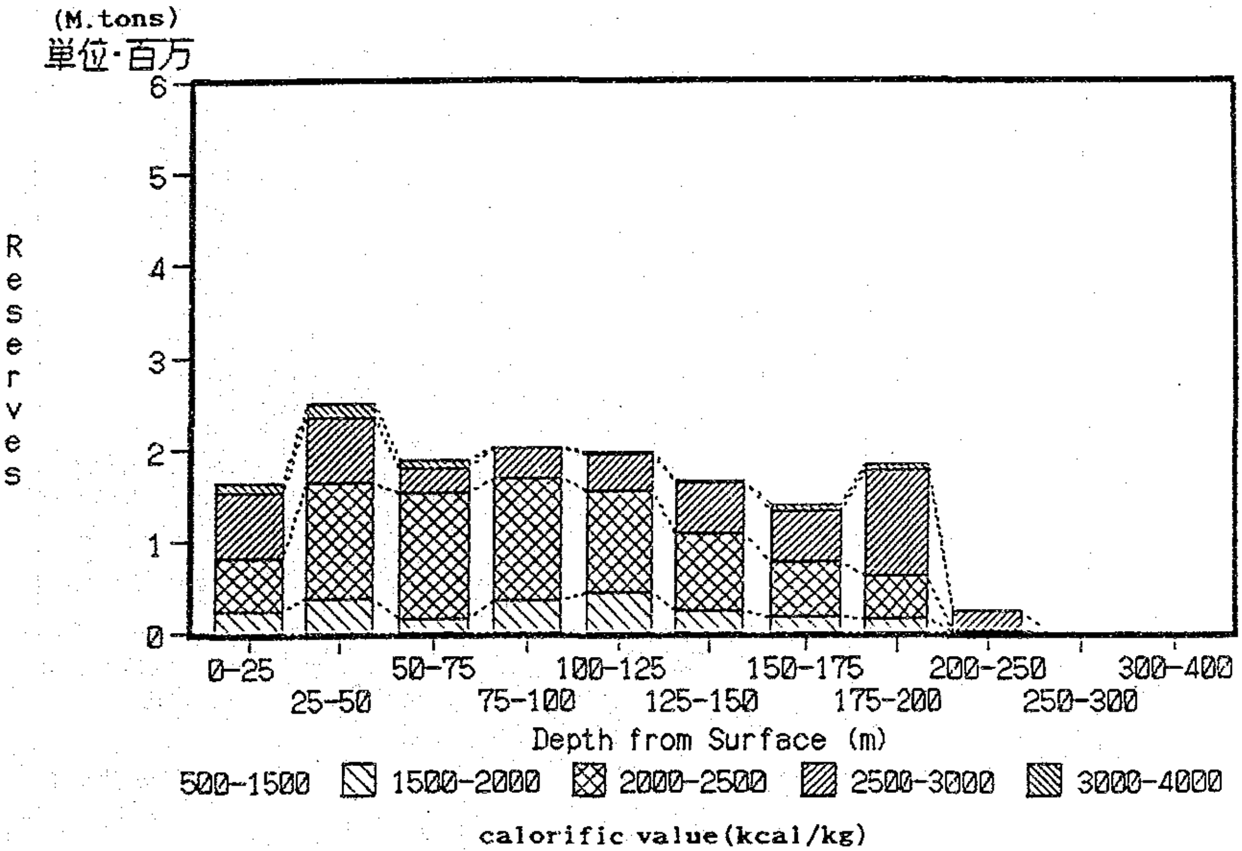


Fig. 6-5f Measured Resources of Nong Wa Deposit Classified by Calorific Value (kcal/kg)

Table 6-4g Measured Resourced of Nong Wa Deposit, Sin Pun Basin

Cal.Value(kcal/kg) / Depth from Surf.	500 ~ 1500	1500 ~ 2000	2000 ~ 2500	2500 ~ 3000	3000 ~ 4000	TOTAL
0 ~ 25 (m)	0	0	0	0	0	0
25 ~ 50	600	0	0	0	0	600
50 ~ 75	0	0	0	0	0	0
75 ~ 100	0	0	0	0	0	0
100 ~ 125	0	0	1,900	700	0	2,600
125 ~ 150	0	4,600	133,000	121,200	0	258,800
150 ~ 175	0	18,700	91,600	724,800	0	835,100
175 ~ 200	0	14,400	296,700	1,394,800	0	1,705,900
200 ~ 250	0	12,300	1,142,700	2,045,100	0	3,200,100
250 ~ 300	0	0	1,368,600	4,351,100	0	5,719,700
300 ~ 400	0	0	899,800	1,042,000	0	1,941,800
Total	600	50,000	3,934,300	9,679,700	0	13,664,600

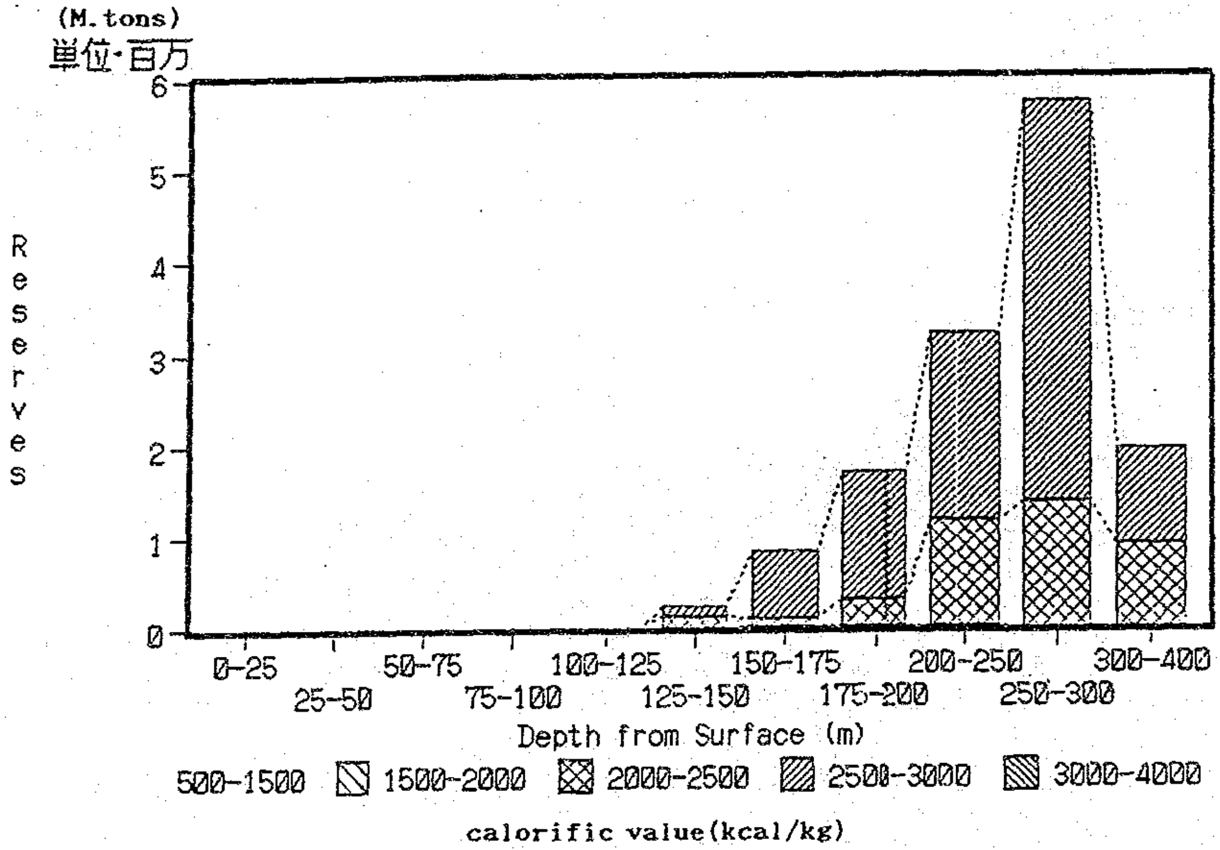


Fig. 6-5g Indicated Resources of Nong Wa Deposit Classified by Calorific Value (kcal/kg)

6.2.2.7 Hydrogeological Evaluation and Wall Slope

The Thailand Australia Lignite Mine Development Project (TALMDP) has revealed that Sin Pun field consists of semiconsolidated and consolidated rocks and is distinguished for the high ground-water levels with artesian pressures. From a point of mining safety on the base of hydrogeology, the geological factors were incorporated as follows:

Parameter		Range
Pit Depth		25 - 150 m
Strata Dip - Highwall :		15 - 25 degree
Lowwall :		10 - 30 degree
Ground-water condition :	Saturated to completely dewatered	

The study has suggested dewatering for a relief from artesian groundwater pressures and a down of ground-water level in order to achieve the stable wall slope angles. It is recommended that dewatering wells around the perimeter of each pit be planned. The number of the dewatering wells in proposed mining deposits is requested in each pit as follows:

Bang Sai Deposit	36
North Kuan Klang	72
South Kuan Klang	18
Total	116

EGAT's experiences on open pit mining operation at the Krabi mine should be put to practical use for the development of Sin Pun basin. As the mining is progressed, collecting data on a quantity of dewater and the ground-water level will be useful in further studying on the stabilizing the wall slopes.

The geotechnical designing study has recommended the criterion on wall slopes as follows:

Highwall	13 - 15	degree
Lowwall	0 - 20	degree
Endwall	12	degree

Those figures seem to be so conservative that angles of each wall slope are able to increase a bit more on the basis of the existing mining slopes at Krabi Mine.

6.2.3 JICA Work in Sin Pun Area

JICA Sin Pun A-FBC Coal-Fired Thermal Development Project carried out 10 large-diameter cored drillings in order to get Sin Pun coal for combustion test in Japan. Seven of 10 holes were conducted at Bang Sai deposit and three holes at North Kuan Klang deposit (Fig. 6-7 and Photo 6-2, 6-3). Typical coal sections of the sampling drills in the Bang Sai and North Kuan Klong deposits are shown in Fig. 6-6.

A pitting (7m wide x 20m length) was made for the collection of a bulk sample from Bang Sai deposit(Fig. 6-8 and Photo 6-4).

Total 15 ton coal sampled from both 10 drill holes and a pitting were shipped to Japan from Bangkok in March 1992.

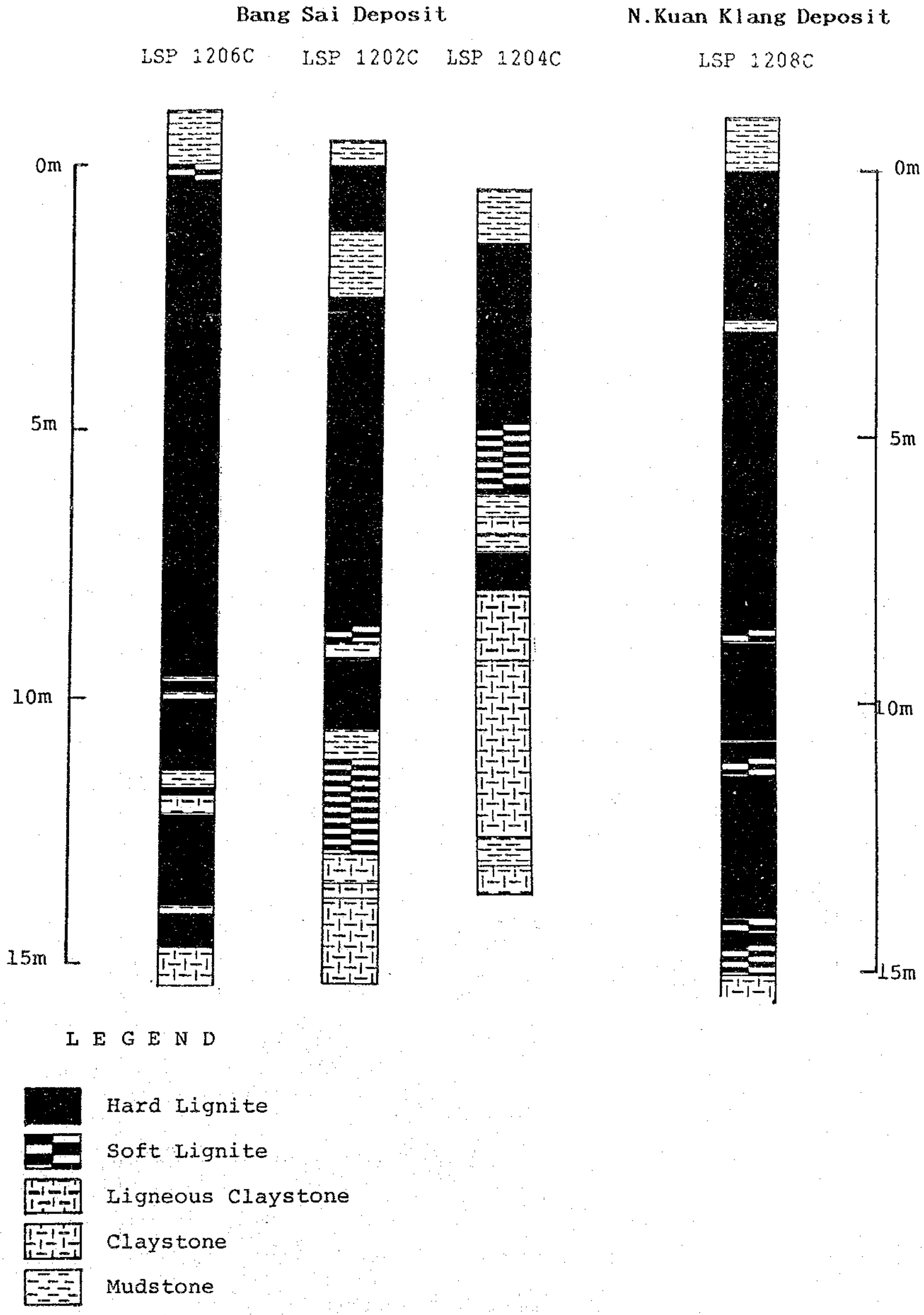


Fig. 6-6 Typical Coal Sections of JICA Sampling Drills in Sin Pun Basin

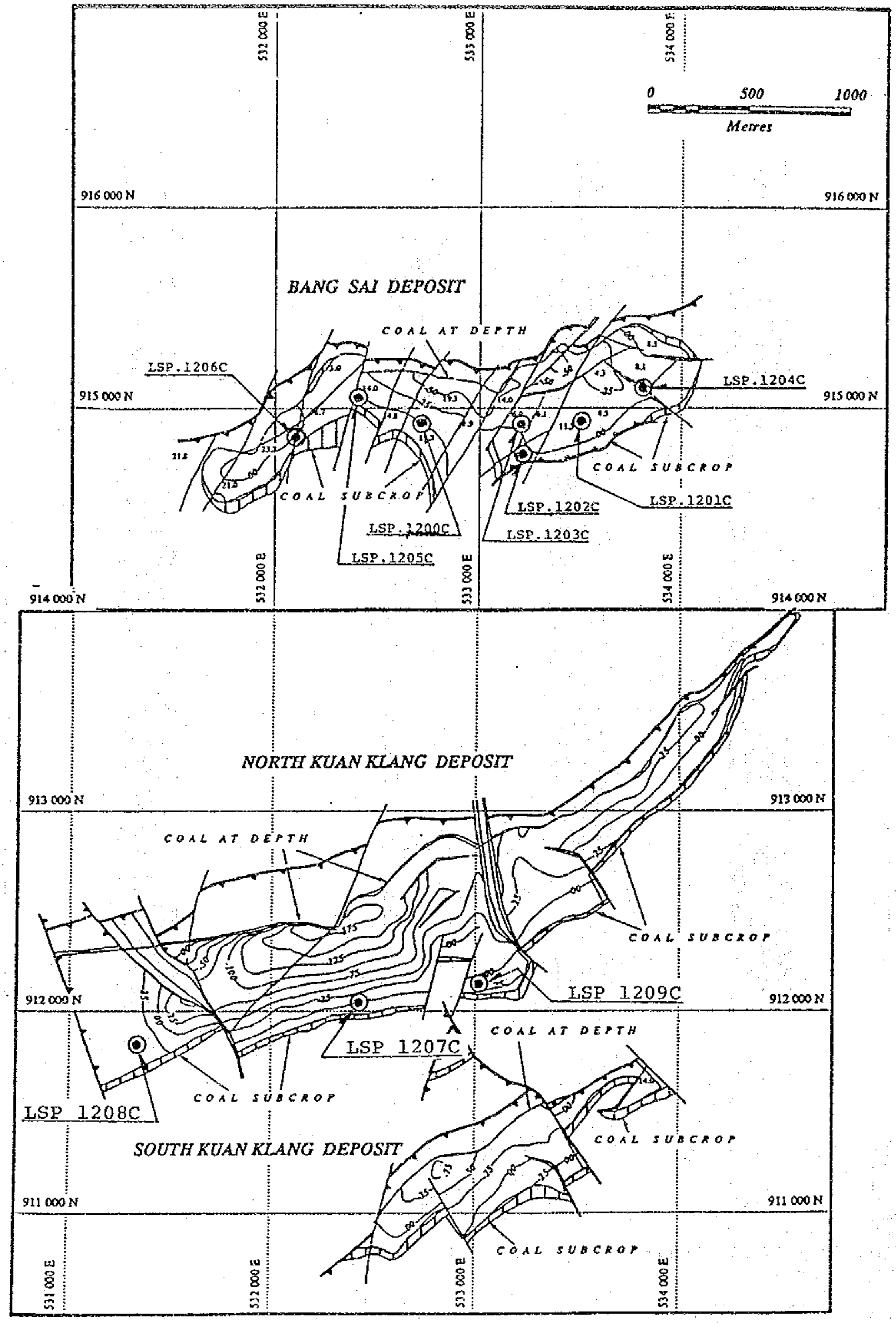
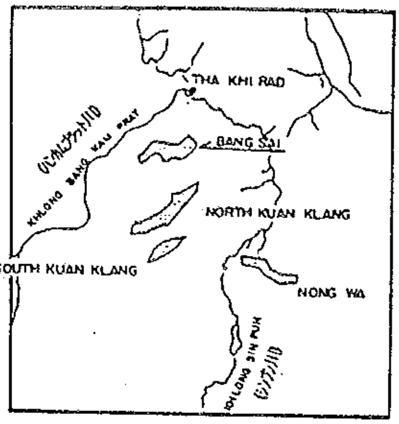
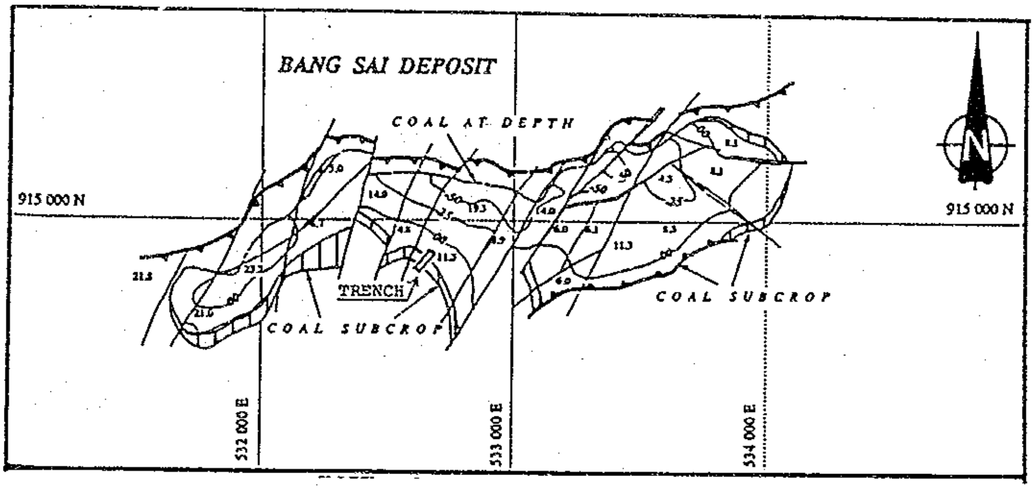


Fig. 6-7 JICA Sampling Drills in Sin Pun Area

Trench for Bulk Sample
at Bang Sai Deposit





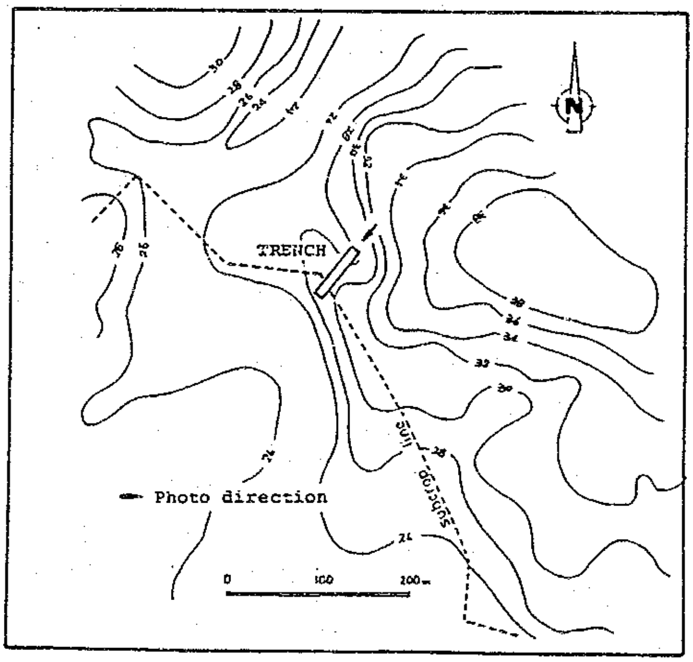
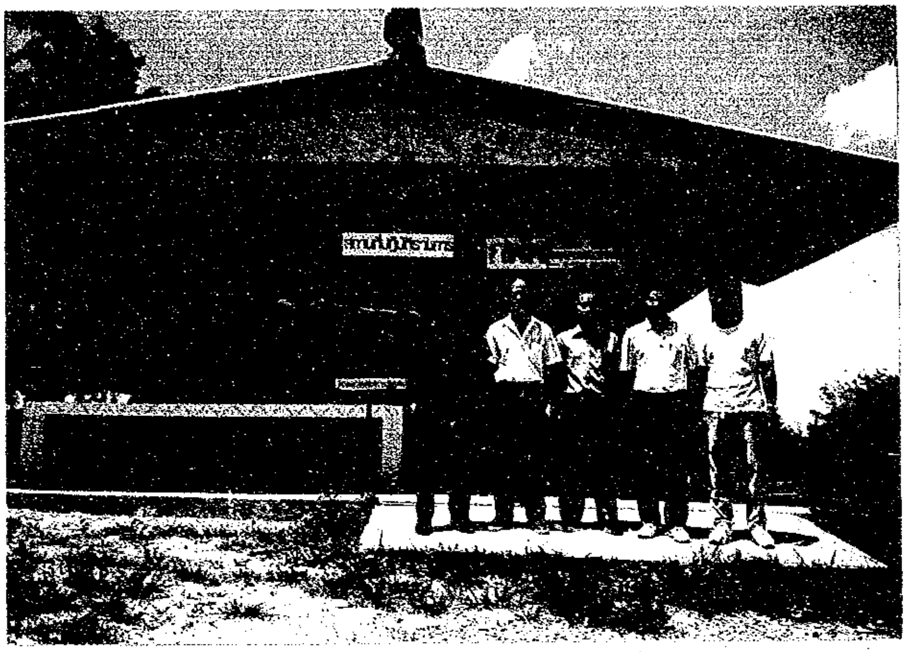
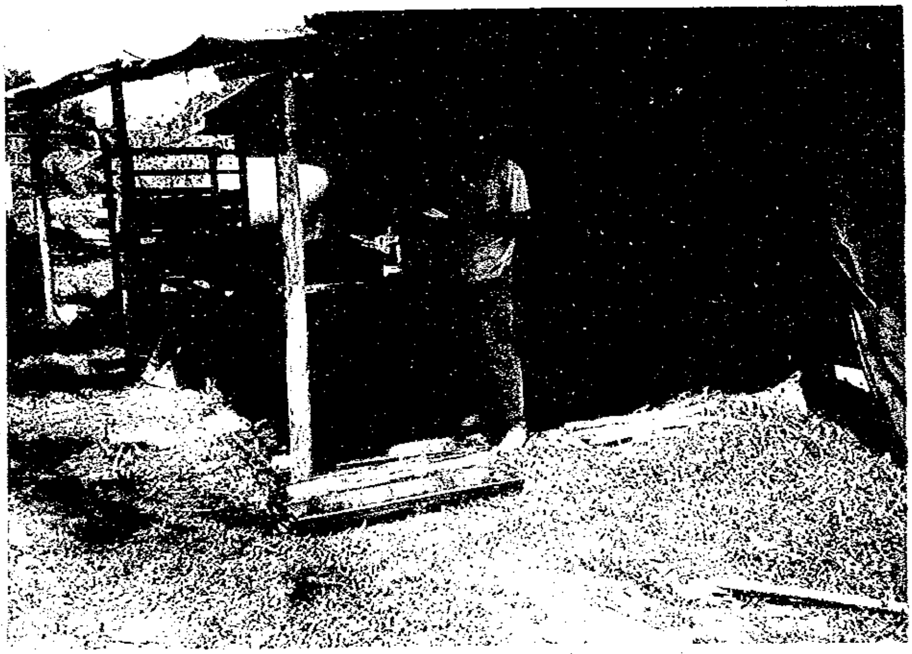


Fig. 6-8 Trench for Bulk Sample at Bang Sai Deposit



EGAT Bench Scale Sampling Office
at Sin Pun Project Area



Core-logging place beside the office

Truck Mounted Drill Machine at Bang Sai Deposit

Lignite core(3m) pushed out
the core interbarrel.

Core in 1m Core Boxes

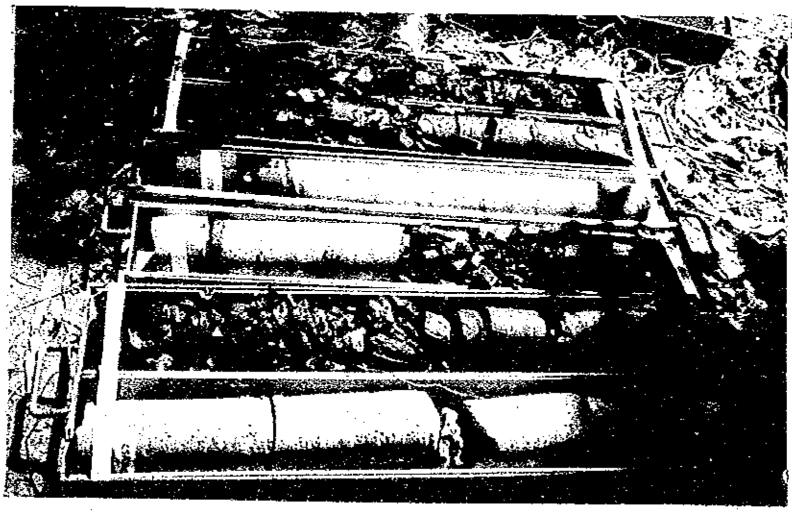


Photo 6-4

Trench for bulk-sampling of lignite at Bang Sai Deposite
(facing southwest)

6.3 Krabi Coal Mine

6.3.1 Introduction

6.3.1.1 Location and Access

Krabi opencast mine is situated in the Krabi Basin located in Krabi Province, on the western coast of the central part of Thailand Peninsular. The Krabi Basin covers an area of about 600 square kilometers (28 km in length x 13 km in with) from longitude 98° 50' E to 98° 55' E and latitude 7° 58' N to 8° 3' N (Fig. 6.9).

Krabi town is the nearest popular town about 27 kilometers to the northwest along sealed road and some 990 kilometers to the south of Bangkok along the Petchkasaem Highway. Sin Pun coal field is to the northeast about 80 kilometers connecting by gravelly road.

The nearest commercial airport is at Phuket about 160 kilometers by sealed road. There are daily air service from and to Bangkok.

6.3.1.2 Mine Development History

Krabi coal field consists of five deposits: Klong Tone, Bang Pu Dum, Bang Mark, Wai Lek and Mu Na (Fig. 6-10). The Bang Pu deposit was first reported by Mr. Robert Young, from Penang Syndicated in 1902 and he got a permission for coal exploration and mining from the Department of Mineral Resources (DMR) in 1904. Krabi Coal Syndicate was organized and commenced mining the coal from the Bang Pu Dum deposit. All won coal were sold to the Federated Malay States. In July 1915, Mr. John H. Heal, a inspector, from Royal Thai Minerals, conducted a 50-foot-deep shaft and great deal of boreholes and pitting and reported the coal in the Krabi Basin is of very inferior quality.

King Rama VII understood that coal would be an important source energy and restricted Krabi coal for the government used only in 1927.

After World War II, the Lignite Authority ran a open pit mine in the Krabi basin. In 1964, The existing 3 x 20 MW power plants were constructed for

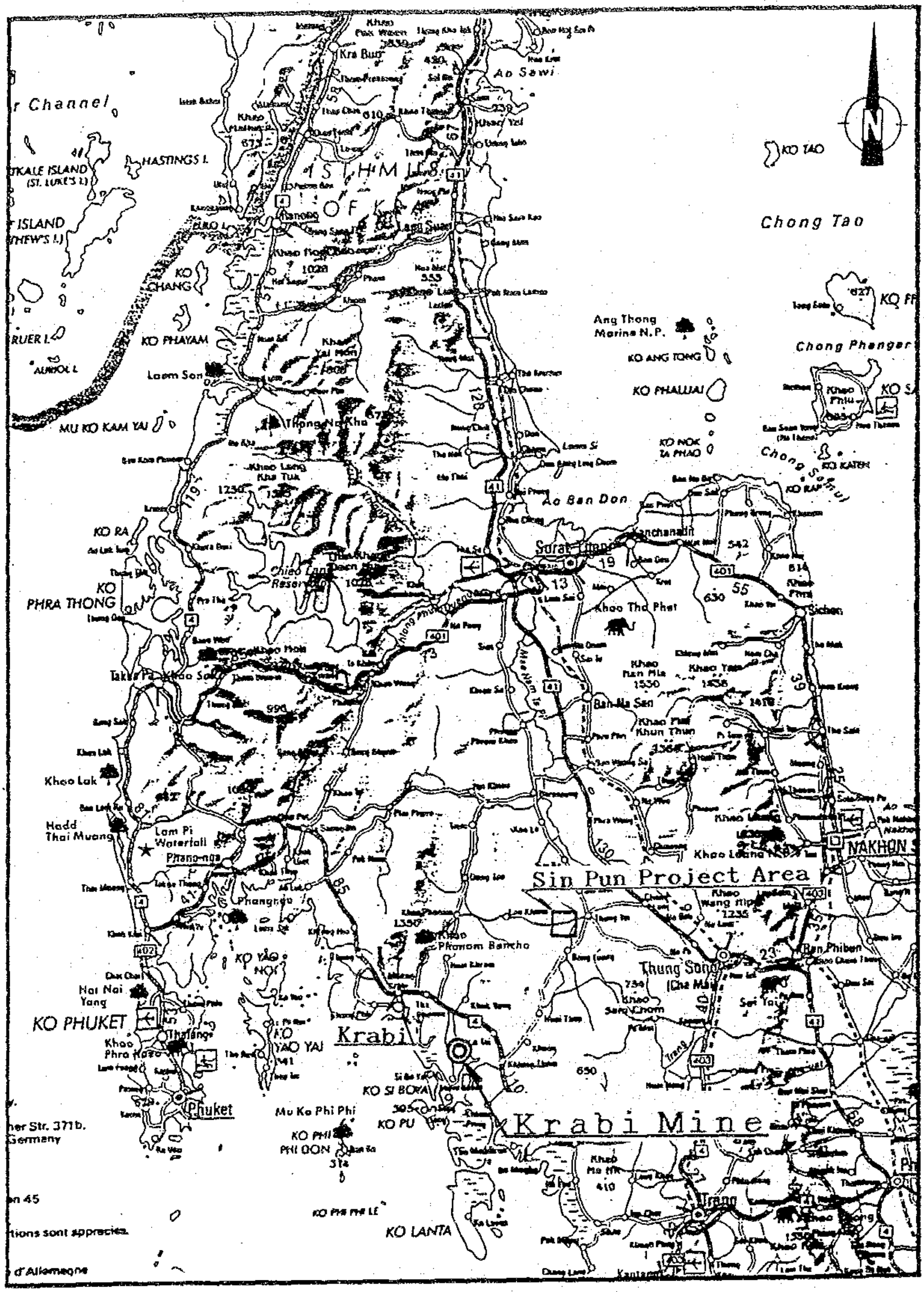


Fig. 6-9 Krabi Mine Location Map