4-1-1 Coal (Main fuel for power plant)

1) Domestic Coal

a. Maghara Coal Mine

a) Present Status

The rehabilitation works have been continued since the end of the war. According to the feasibility report submitted to Egypt by England at the end of March 1983, it is reported that the annual production of Maghara coal will be 600 x 10^3 tons and that 300 x 10^3 tons could be utilized for the iron industry and the remaining 300 x 10^3 tons for fuel of power plants, and the coal mining facilities and surface facilities will be built and the full scale production will be started from 1987.

b) Coal Reserve

The coal seams are located within 400 m depth below the main seam in a 2.5 km^2 area, and the coal reserve is as follows.

	Proved Reserve x 10^6T	Probable Reserve x 10^6T	Total x 10^6T
Coal reserve	39.9	11.9	51.8
Workable reserve	27.8	7.8	35.6

c) Coal Property

The coal samples were collected from the coal seam in the tunnel in the field survey and were analyzed in Japan. The coal analysis taken from the literature, the analysis of the collected samples, and the raw coal at the mine mouth which contains 11% of spoil are as shown on Tables 4-1 and 4-2.

Table 4-1 Maghara Coal Analyses

	Analysis from Egyptian literature	Sample collected in field survey	Average	Raw coal at mine mouth (11% spoil mixed
Proximate Analysis				
Inherent moisture (%)	4.9	5.14	5.02	4.5
Ash content (%)	6.5	3.96	5.23	14.3
Volatile matter (%)	50.7	50.51	50.60	45.8
Fixed carbon (%)	37.9	40.39	39.15	35.4
Calorific value (kcal/kg)	7,270	7,140	7,200	6,510

Table 4-2 Chemical Analysis of Maghara Coal

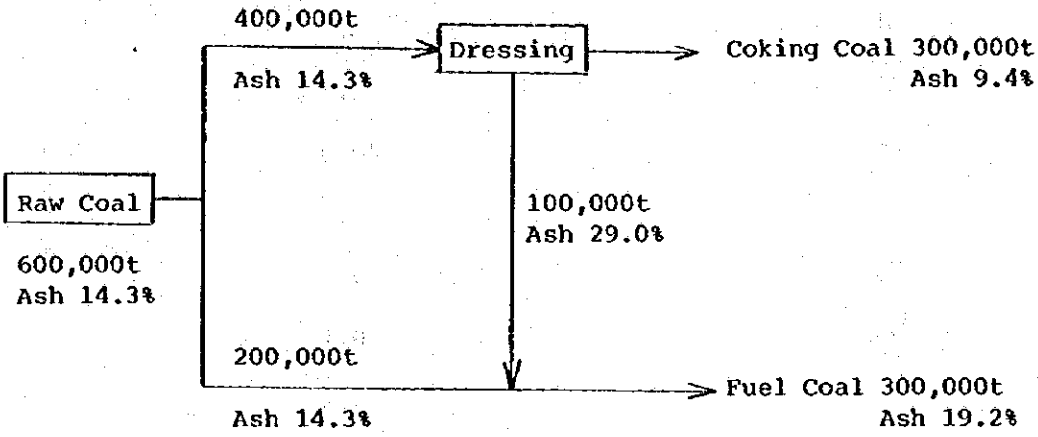
Constituent	Literature %	Analysis in Japan %	Remarks
Proximate Analysis			
Moisture	4.90	5.14	Literature: Call for offer for the reactivation of Maghara coal mine North Sinai, A.R.E.
Ash	6.50	3.96	
Volatile matter	50.70	50.51	
Fixed carbon	37.90	40.39	
Calorific value (kcal/kg)	7,270	7,140	
Ultimate Analysis			
Ash	6.50	4.17	
Carbon	70.66	73.74	
Hydrogen	5.67	5.83	
Nitrogen	1.04	1.22	
Sulphur	2.97	2.83	
Oxygen	8.26	12.21	
Fusibility of Ash			
Deformation	1,220 - 1,290	1,290	
Hemisphere	1,290 - 1,340	1,430	
Pour point	1,320 - 1,360	1,440	

Grindability (Hardgroove Index)	51
Coking Property	Strong
Color of Ash	Red-brown

Ultimate Analysis of Ash

Constituent	Literature	Analysis in Japan	Remarks
	%	%	
Si	-	6.5	
Al	-	3.3	
Fe	-	40.0	
Ca	-	4.4	
Mg	-	0.4	
Na	-	0.4	
S	-	6.2	
K	-	Trace	
V	-	"	
P	-	"	
Zn	-	"	
Cu	-	"	
Mo	-	"	
Mn	-	"	
Ni	-	"	
Pb	-	"	
Cr	-	"	

According to the production program of Maghara coal, 300,000 tons of coal for chemicoke and 300,000 tons of fuel coal for the power plant are to be produced from 600,000 tons of total production, as follows.



d) Transportation

As the means of transporting coal over the distance of 225 km from Maghara Coal Mine to Ayun Musa, road transportation by expanding the existing road and rail transportation by building a new railway, are considered. In case of rail transportation, there is the possibility of supply stoppage due to moving dunes burying the railway in sand storms and cost is higher as compared with truck transportation by road, even with the cost of trucks and expansion of roads are taken into consideration, and therefore, transportation by trucks would be advisable. Since the delivery of coal is made generally in the power plant grounds, the method of transportation should be considered by the Maghara Coal Mine Authority, the supplier of the coal.

e) Cost of Coal

Summary of Feasibility Study Report on the Maghara coal mine prepared by B & W, England, reports that the estimated unit cost of the coal as received at the power plant is LE 48/ton (US$58.3/ton), however this is brigher than that of imported coal, about LE 47.1/ton (US$57.3/ton), from Australia, which shows disadvantageousness of domestic coal in terms of fuel cost.

Since the coal of low calorific valve after dressing process is used for the power plant, lower unit price should be considered for the feasibility study.

Therefore, the coal price of LE 44.0/ton (US$ 53.5), which is obtained as average price from the coal price mentioned above and production cost of coal at mine including transportation cost, LE 40.5/ton (US$ 49.2/ton), mentioned in the said report is finally adopted. This price also deems to be reasonable on the basis of the calorific value of the coal.

2) Imported Coal

The properties of coal to be fired in the 300 MW x 2 thermal power plant of the 1st stage are decided on the basis of Maghara Coal, but if the standard calorific value is assumed to be 6,500 kcal/kg, the annual requirement of coal would be 1,521,500 tons/annum (utilization factor: 80%, plant efficiency: 39%, station service power ratio: 6.4%, installed capacity: 320 MW x 2). As the supply capacity of Maghara coal is 300,000 tons/annum, the balance of 1,221,500 tons/

annum of blendable coal of nearly similar properties will have to be imported stably.

a. Countries of Origin

There are many coal producing countries that have been exporting or have plans to export coal, but in consideration of locations and stability of supply, Australia, U.S.A. (Eastern and Western), Canada (Eastern), South Africa, Poland and Columbia were studied for this Project, with respect to the production, export records and type and properties of coal.

Poland has enough exporting capacity, but the melting point of ash is as low as 1,100°C and poses problems as fuel for the power plant.

The Columbian coal mine for export purposes is still under development, and it is feared that stable supply of acquired quantity may not be secured.

As eastern Canada does not produce enough coal and shortage of coal is imported, it can not expect to export from essterm Canade at present and there is no plan to export near future. Therefore, Australia, Eastern and Western U.S.A. and South Africa are considered to be the probable coal supplier countries.

Other countries may be capable to develop and export coal depending upon the trend of demand, and so the properties of coal from various countries are shown on Table 4-16, for reference.

b. Stability of Supply

The yield and exported quantities of coal from the above supplier countries and other coal producing countries are as tabulated on Tables 4-3 and 4-4, and each of the countries has plans of expansion and new development of coal mines to meet the demand, and has enough capacity for stable supply of coal.

The ports of export of coal have enough capacities for export and would not limit the export quantities. Coal exporting port facilities and capacities are shown on Table 4-5. Therefore, if Australia, Eastern U.S.A. and South Africa are to be selected for source of coal, a stable supply of coal would be expected.

Table 4-3 Coal Yield by Countries

(Unit: 10^6 tons)

Year / Country	1975	1976	1977	1978	1979	1980	Remarks
Australia	64	62	70	71	75		
U.S.A.	594	621	632	608	709		
South Africa	-	-	-	90	104		
Canada	22	21	23	24	29		For reference
Poland	172	179	186	193	201		- " -
Columbia	-	-	-	-	-		Under planning

Data Source: Coal Project (1983), Project News Co., Japan

Table 4-4 Records of Export of Coal

(Unit: 10^6 tons)

Year / Country	1975	1976	1977	1978	1979	1980	Remarks
Australia	33	30	35	38	38	42	
U.S.A.	60	54	49	36	59	82	
(Canada)	12	12	13	14	14	14	Western Canada
South Africa	3	6	13	15	23	29	
(Poland)	39	39	39	40	41	31	
(Columbia)	-	-	-	-	-	-	

Data Source: Coal Project (1983), Project News Co., Japan

Major coal mine sites in the world and coal mine sites in major countries are shown on Fig 4-1 to Fig 4-8.

Locations of coal mines and major coal exporting ports are shown on Figs. 4-9.

Table 4-5 Coal Exporting Port Facilities and Capacities

Country	Name of Port	Max. Ship Tonnage (10^3 DWT)	Loading Capacity (10^3t/y)	Loaders t/hxNo.	Coal Storage Capacity (10^3 t)
Australia	New Castle	100	25,700	1,000x2 2,000x2 4,000x1	2,040
	Port Kembla	120	19,000	1,000x2 5,000x1	1,090
	Sydney	55	2,800	500x1	280
	Gladstone	60	28,000	2,000x1 4,000x1	1,300
	Hay Point Hay Point (Planned)	120	20,000 15,000	4,000x2 6,000x1	2,500
	Brisbane	60	1,500	1,200x1	240
	Abbot Point (Under construction)				
U.S.A.	Norfolk	100	40,000	1,680x1 8,000x2	1,000
	Newport News	100	26,000	4,500x2	800
	New Orleans	60	12,500		1,550
(Canada)*	Port Moody	65	-	1,000x2	100
Western	Roberts Bank	120	-	4,000x2	-
	Neptune Terminal	125	-	3,000x2	440
(Poland)	Gdansk	100		660x2 2,000x2	500
(Columbia)	Bahia Portete	(Planned)			
South Africa	Richards Bay	150	24,000 44,000 (future)	3,500x2	3,200

Data Source: Annual Report on Raw Coal (1981), Telex Report Co., Japan
*There is no coal exporting port in Eastern Canada.

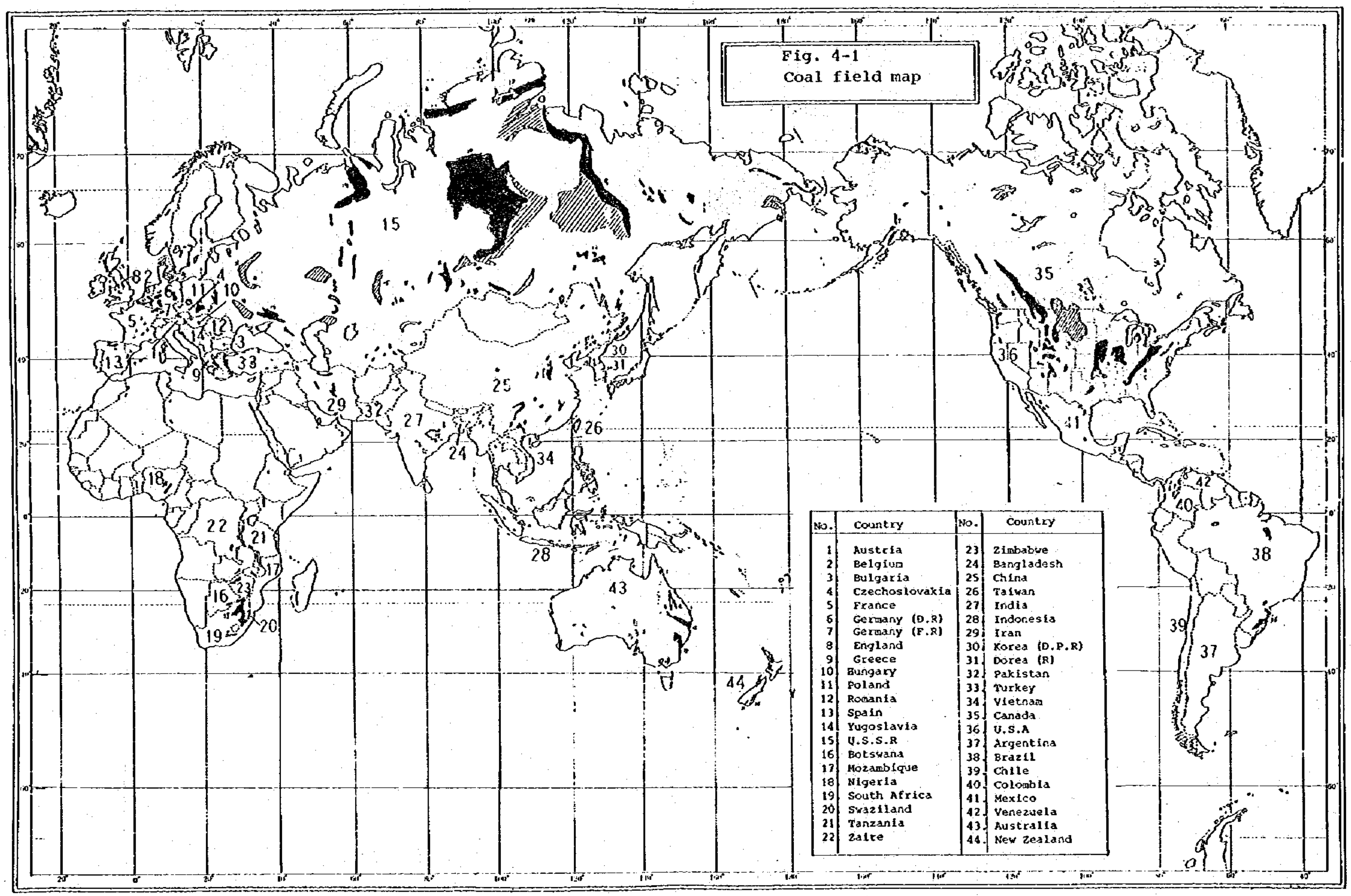


Fig. 4-1
Coal field map

No.	Country	No.	Country
1	Austria	23	Zimbabwe
2	Belgium	24	Bangladesh
3	Bulgaria	25	China
4	Czechoslovakia	26	Taiwan
5	France	27	India
6	Germany (D.R)	28	Indonesia
7	Germany (F.R)	29	Iran
8	England	30	Korea (D.P.R)
9	Greece	31	Dorea (R)
10	Bungary	32	Pakistan
11	Poland	33	Turkey
12	Romania	34	Vietnam
13	Spain	35	Canada
14	Yugoslavia	36	U.S.A
15	U.S.S.R	37	Argentina
16	Botswana	38	Brazil
17	Mozambique	39	Chile
18	Nigeria	40	Colombia
19	South Africa	41	Mexico
20	Swaziland	42	Venezuela
21	Tanzania	43	Australia
22	Zaire	44	New Zealand

Coal Reserve In World

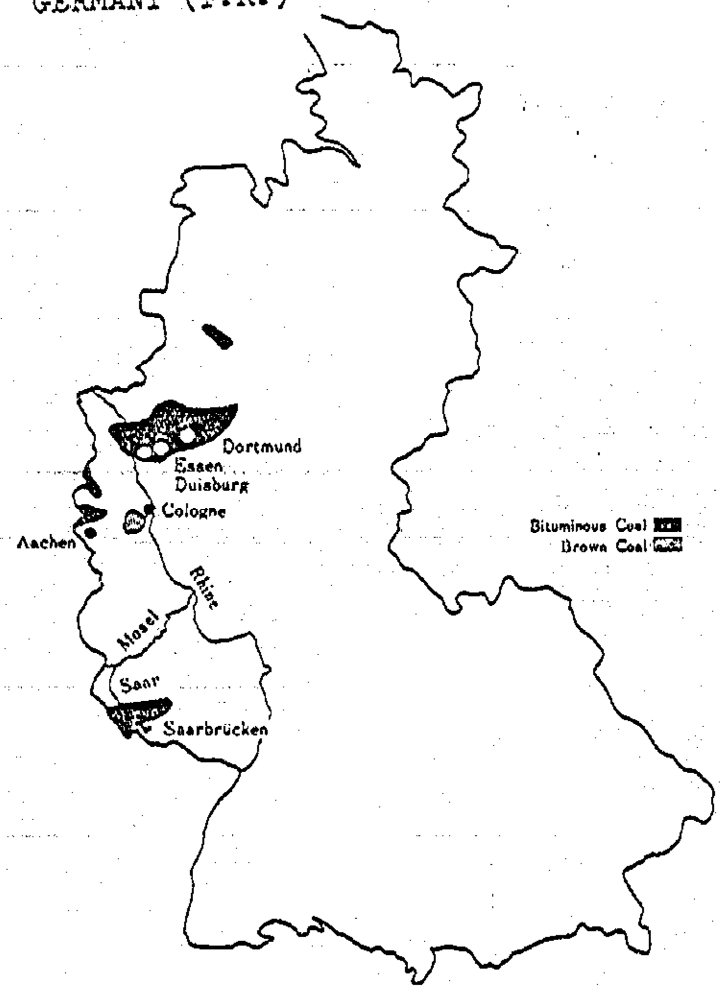
(unit: 10^6 tons)

No.	Country	Workable Reserve	Probable Reserve
1	Austria	33	36
2	Belgium	440	2,617
3	Bulgaria	1,880	1,550
4	Czechoslovakia	4,416	6,472
5	France	574	227
6	Germany (D.R.)	7,500	-
7	Germany (F.R.)	34,536	186,300
8	England	45,000	145,000
9	Greese	512	379
10	Hungary	1,545	1,736
11	Poland	30,600	91,200
12	Romania	413	520
13	Spain	636	3,295
14	Yugoslavia	8,740	1,987
15	U.S.S.R	165,470	4,432,400
16	Botswana	3,500	100,000
17	Mozambique	240	155
18	Nigeria	132	801
19	South Africa	25,290	33,762
20	Swaziland	1,820	3,000
21	Tanzania	200	1,500
22	Zaire	600	-
23	Zimbabwe	734	5,820
24	Bangladesh	242	1
25	China	99,000	1,326,000
26	Taiwan	109	-
27	India	13,134	91,232
28	Indonesia	234	6,293
29	Iran	193	-
30	Korea (D.P.R.)	534	4,416
31	Korea (R)	116	1,049
32	Pakistan	394	-
33	Turkey	757	1,016
34	Vietnam	150	700
35	Canada	4,368	366,215
36	U.S.A	190,890	2,519,200
37	Argentina	117	3,398
38	Brazil	910	11,408
39	Chile	924	3,517
40	Colombia	1,029	7,726
41	Mexico	1,500	1,690
42	Venezuela	139	8,054
43	Australia	36,302	611,600
44	New Zealand	162	2,179

(Data Source: Coal Note 1982)

Fig. 4—2 Germany and Poland

GERMANY (F.R.)



POLAND

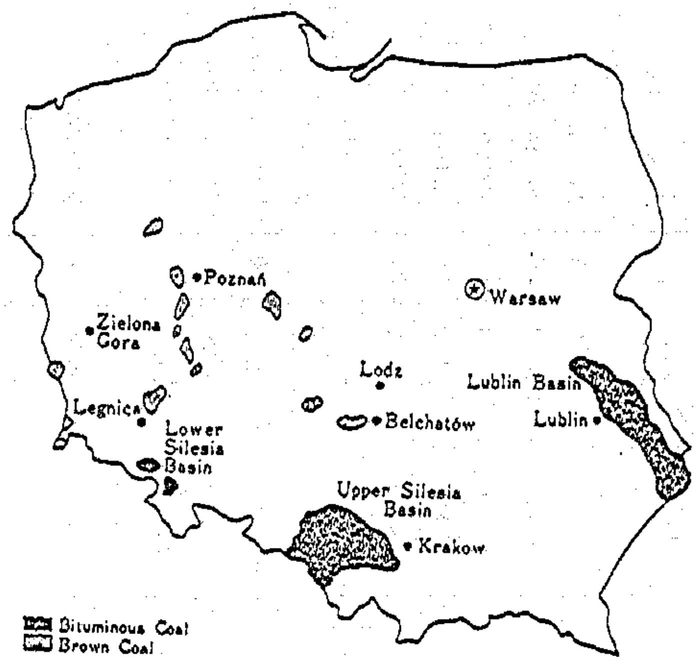


Fig. 4 — 3 Canada

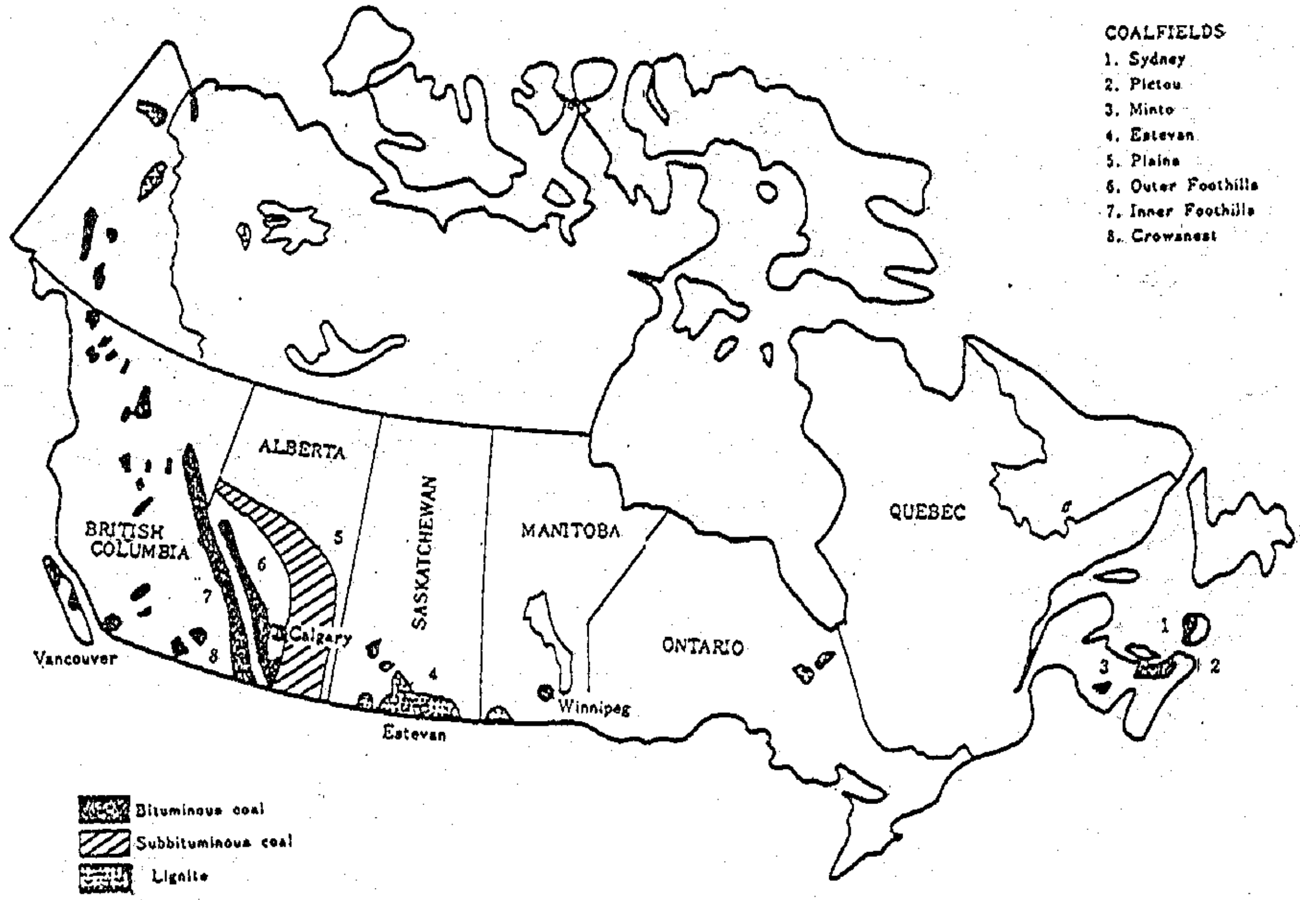


Fig. 4 — 4 U.S.S.R.

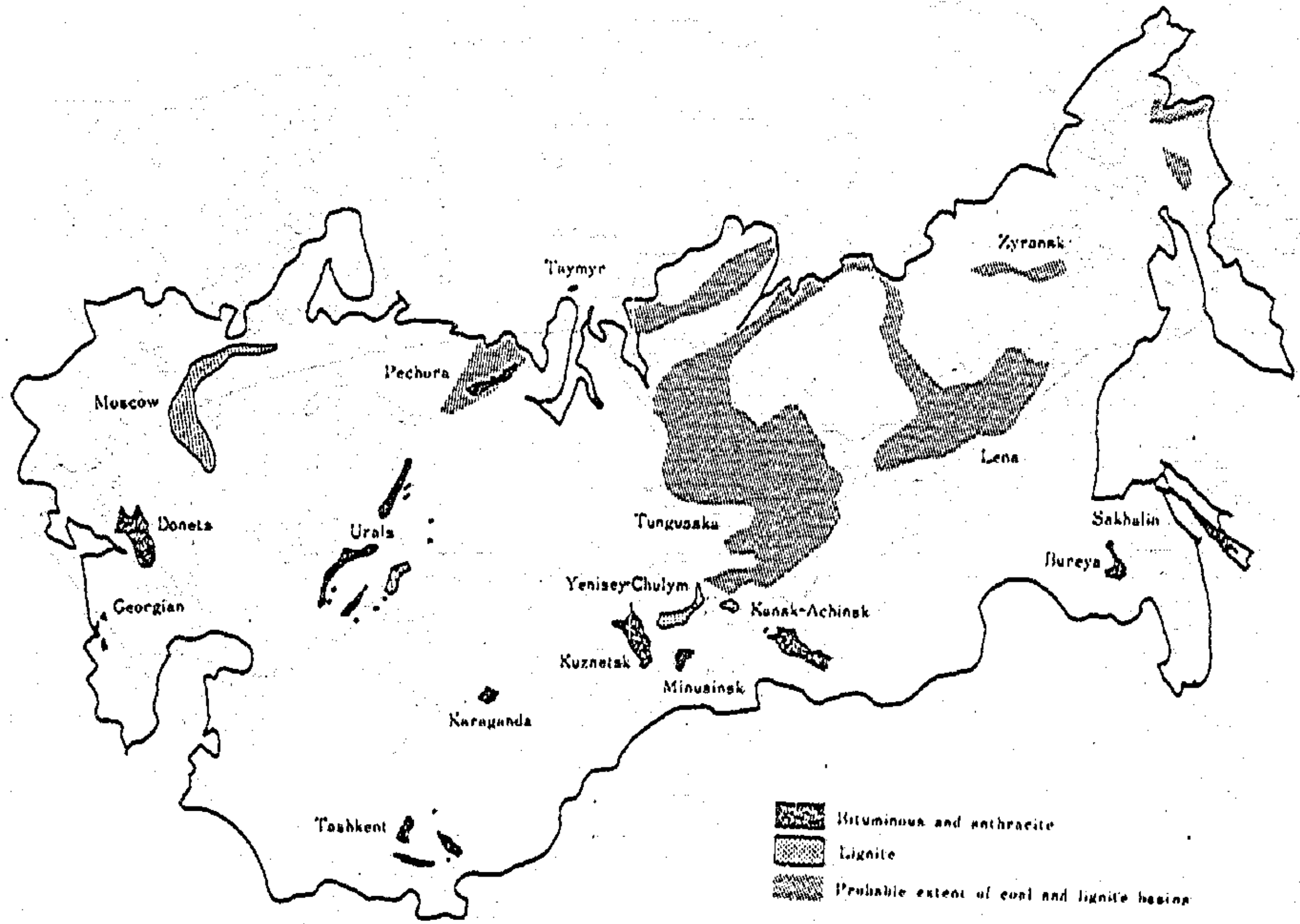

Zyransk
Taymyr
Pechora
Moscow
Lena
Tunguska
Sakhalin
Bureya
Donets
Urals
Georgian
Yenisey-Chulym
Kansk-Achinsk
Kuznetsk
Minusinsk
Karaganda
Tashkent
Bituminous and anthracite
Lignite
Probable extent of coal and lignite basins

Fig. 4—5 China

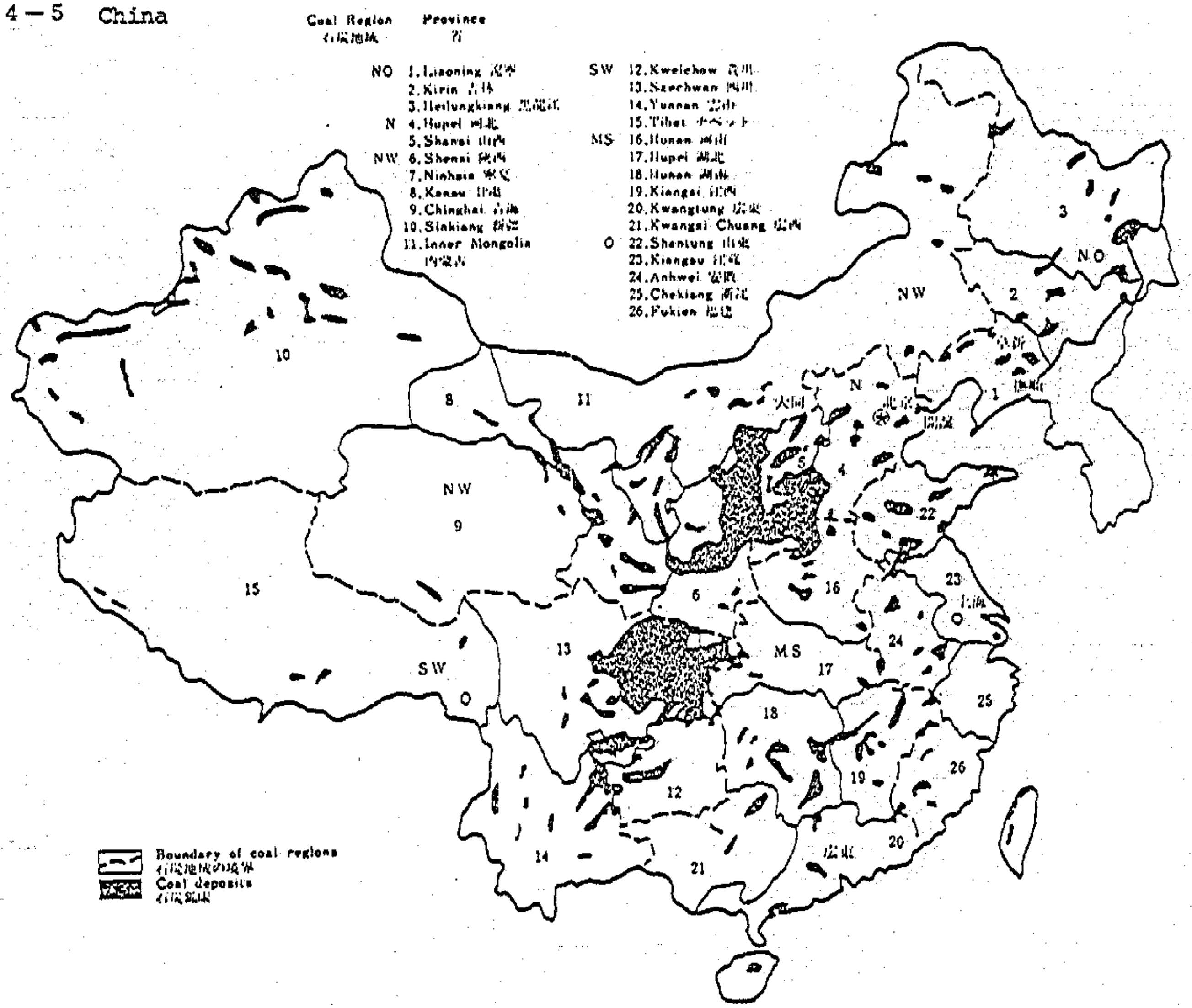

Coal Region 石炭地域
Province 省
NO 1. Liaoning 辽寧
2. Kirin 吉林
3. Heilungkiang 黒龍江
N 4. Hupei 河北
5. Shansi 山西
NW 6. Shensi 陝西
7. Ninhsia 寧夏
8. Kansu 甘粛
9. Chinghai 青海
10. Sinkiang 新疆
11. Inner Mongolia 内蒙古
SW 12. Kweichow 貴州
13. Szechwan 四川
14. Yunnan 雲南
15. Tibet チベット
MS 16. Honan 河南
17. Hupei 湖北
18. Hunan 湖南
19. Kiangsi 江西
20. Kwangtung 広東
21. Kwangsi Chuang 広西
O 22. Shantung 山東
23. Kiangsu 江蘇
24. Anhwei 安徽
25. Chekiang 浙江
26. Fukien 福建
Boundary of coal regions
石炭地域の境界
Coal deposits
石炭鉱床

Fig. 4 — 6 U.K. and India

U.K.

INDIA

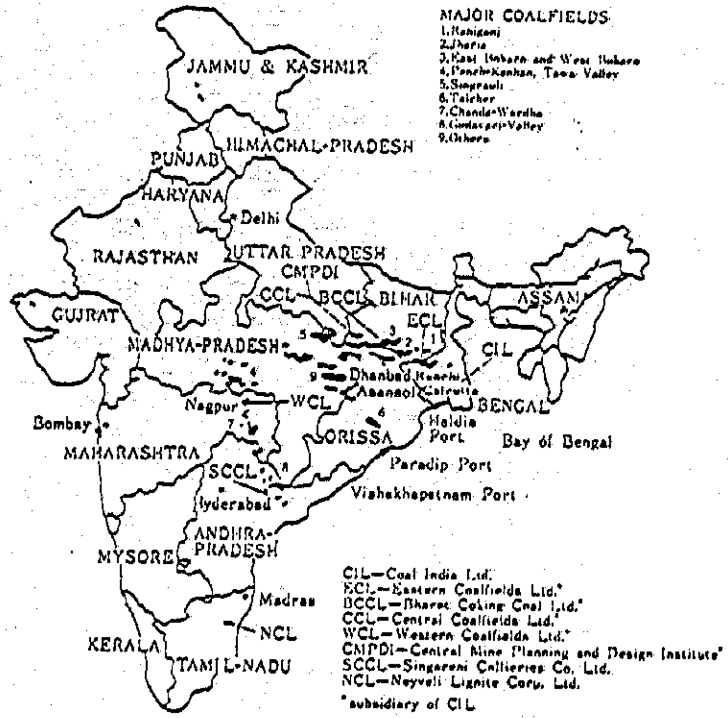
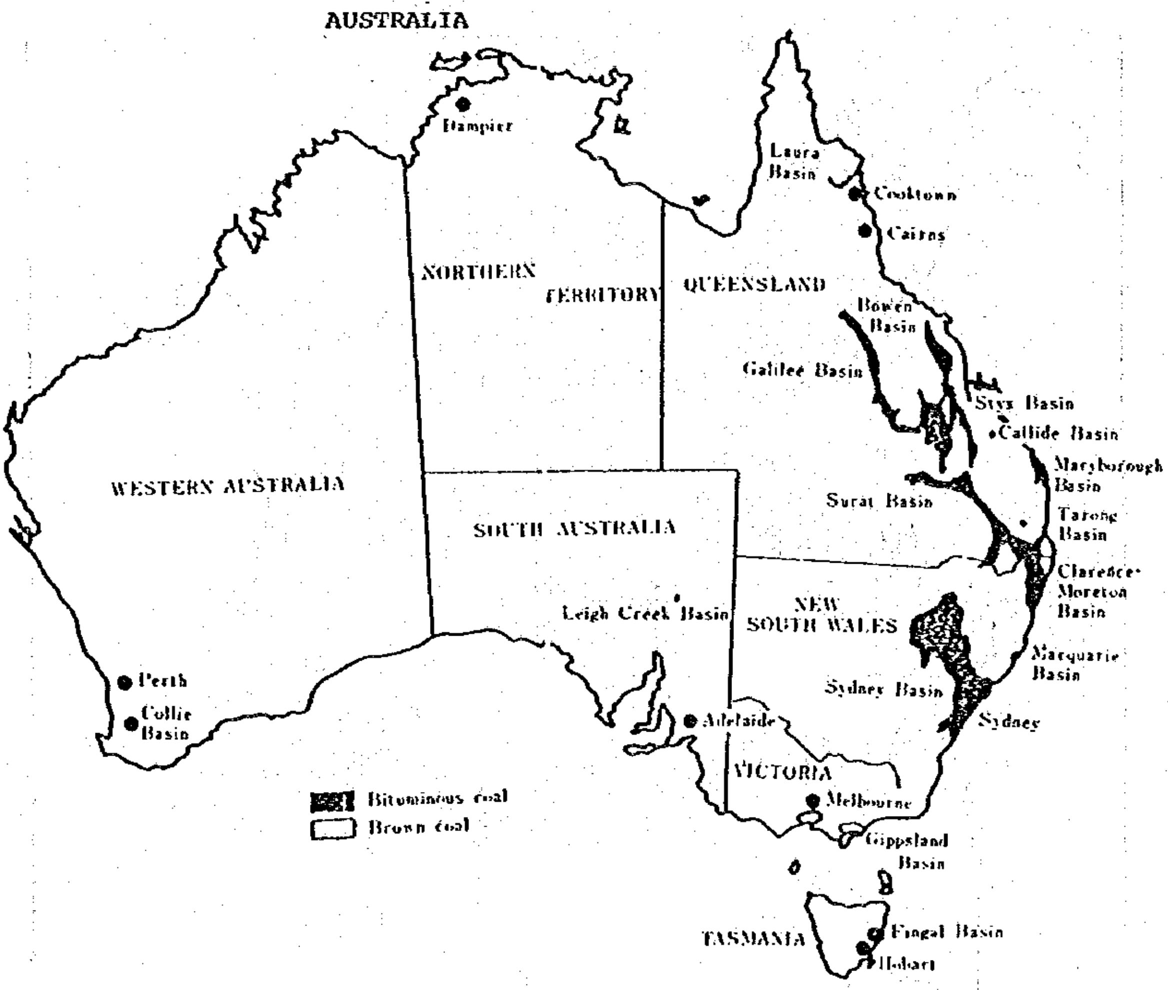


Fig. 4-7 Australia and South Africa



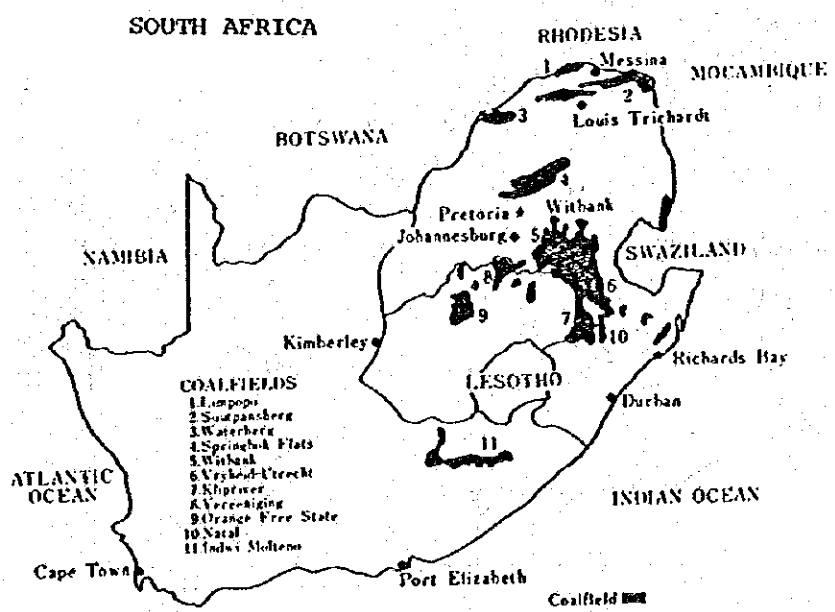
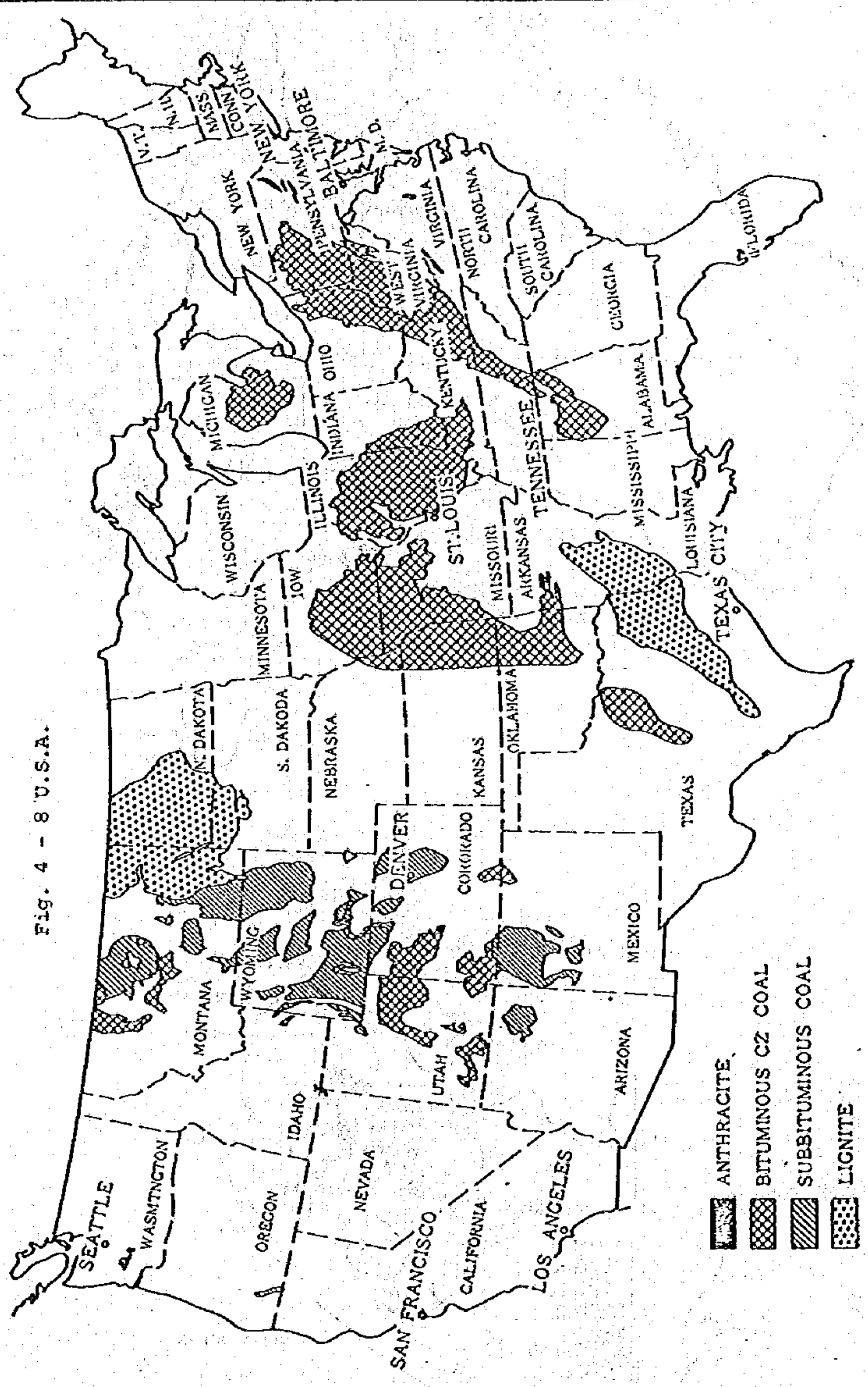


Fig. 4 - 8 U.S.A.


ANTHRACITE
BITUMINOUS CZ COAL
SUBBITUMINOUS COAL
LIGNITE
SEATTLE
SAN FRANCISCO
LOS ANGELES
DENVER
ST. LOUIS
TEXAS CITY
BALTIMORE
NEW YORK
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
MEXICO
COLORADO
N. DAKOTA
S. DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOW
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
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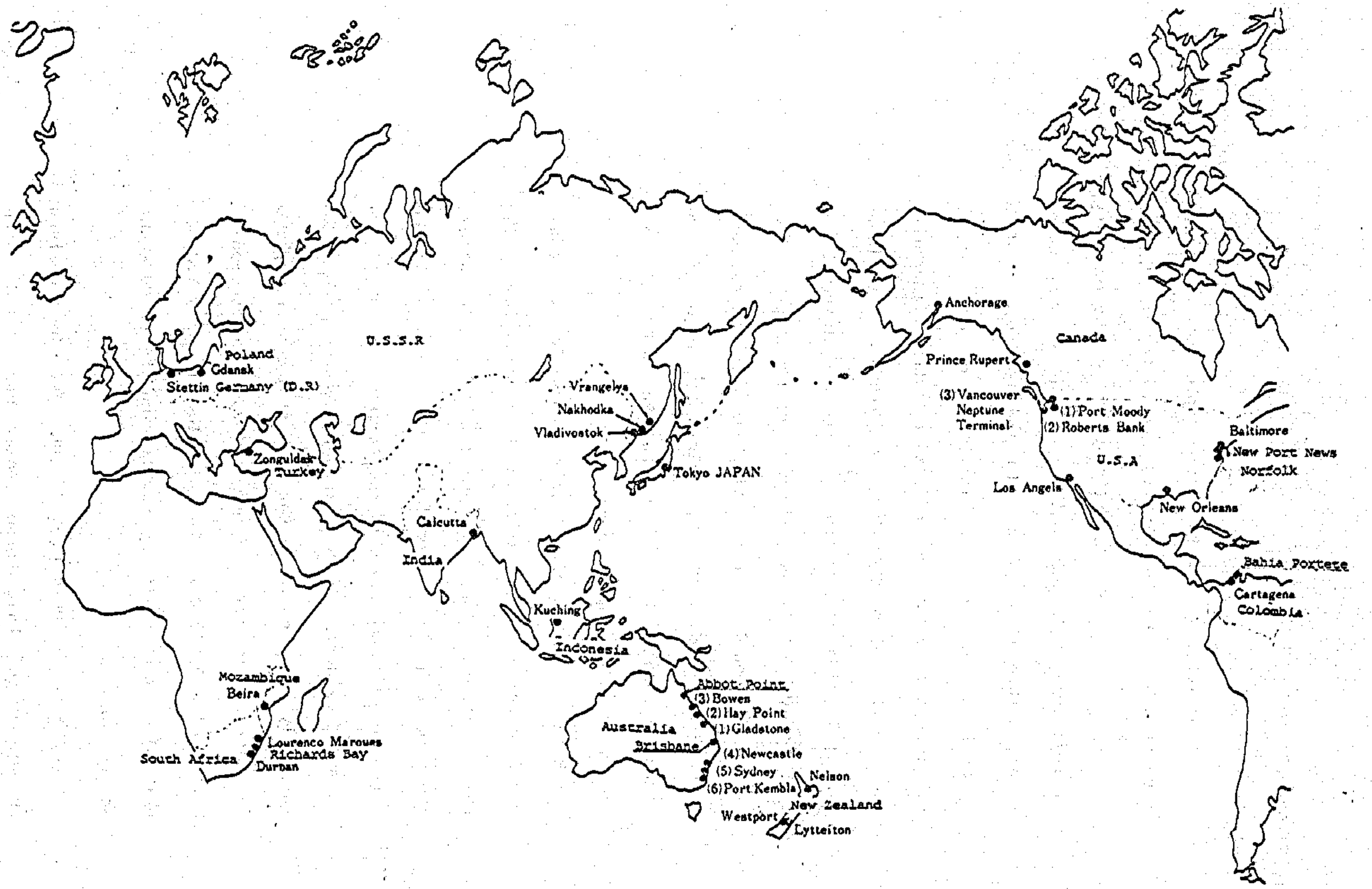


Fig. 4 — 9   Major Ports of Coal Exportation

c. Transportation

a) Coaler Size

As aforementioned, the conceivable coal exporting countries for the project are Australia, U.S.A. and South Africa. In order to transport a huge quantity of coal with a lowest cost from such far away countries, enlargement of a ship and employment of a special carrier for sea transportation of coal, a coaler are necessary and effective. Mass transportation by the enlarged coaler makes merits of rationalizing loading and unloading works and minimizing a transportation cost as a shipping charge per ton including personnel expenses and other relevant expenditures is lowered. However, coalers and cargo ships of tonnages ranging from 30,000 DWT to 70,000 DWT are widely used for coal transportation.

Because coalers of bigger tonnages than the above could enter only ports of a limited number. The number of ports with enough width and depth for accommodating such a larger coaler is very few and all the ports in the coal exporting countries have not always be able to accept such a larger tonnage coaler. So far, only three ports in the exporting countries, two in Australia and one in South Africa, could accomodate a ship of 120,000 DWT. Thus, employment of a 120,000 DWT coaler will result in restricting the procurement sources of coal.

Further, the number of 120,000 DWT class coalers is so limited that these coaler has already been secured by some carterers and timely chartering for the project may be very hard. As compared the investment to the harbor and unloading facilities at the power station, the investment for the 120,000 DWT coaler is three times higher than that for the 60,000 DWT coaler.

On the contrary, the 60,000 DWT coalers can enter almost all the coal exporting ports. Brands and grades of coal can be selected without any restriction. Thus, the ships of a maximum tonnage of 60,000 DWT will be applied for the transportation of imported coal for the project.

The comparative studies between the employment of 120,000 DWT and 60,000 DWT coalers are shown in the following tables.

Comparison of 120,000 DWT and 60,000 DWT coaler for coal transport

1. Dimensions of coaler and harber

(Case of standard coaler)

		120,000 DWT	60,000 DWT	Remarks
Dimmensions of coaler	Length (m)	290	233	
	Width (m)	43	35.2	
	Draft (m)	16.9	12.6	Fully loaded
Dimensions of harber	Length of berth (m)	360	300	
	Depth of berth (m)	20	16	
	Manevering area (m^2)	390 x 10^3	275 x 10^3	with tugboat

2. Difference of anchorage by ship type and anchorage days

	120,000 DWT		60,000 DWT	Remarks
Annual No. of Entary (A)	25 (1 boat/15 days)		49 (1 boat/7.5days)	
Stay days per NO. (B)	3	6	3	
Stay days per annual (A)x(B)=(C)	75	150	147	
Anchorage per day (D)	11,000	11,000	9,000	Unit: US$
Annual anchorage (C)x(D)	(E) 825,000	(F) 1,650,000	(G) 1,323,000	Unit: US$
Difference	(G) - (E) + 498,000	(G) - (F) -327,000	Base	+ shows profits - shows loss

3. Comparisons of transport cost

(1) Annual profit: Case where whole quantity of 2,934,000 t/y is imported from Australia and each 50% quantity is imported from Australia and U. S. A.

	Australia	Australia	U. S. A.	Remarks
Import quantity (T)	A 2,934 x 10^3	B 1,467 x 10^3	B 1.467 x 10^3	
60,000 DWT ($/T)	17.26	17.26	15.27	Refer to Fuel plan
120,000 DWT ($/T)	12.76	12.76	11.31	
Difference ($)	C 4.50	C 4.50	D 3.96	
Difference of transport ($)	A x C 13,203,000	B x C 6,601,500 B x C + B x D 12,410,820	B x D 5,809,320	

(2) Difference cost considering anchorage

	Whole quantity is import from Australia		Each 50% quantity is import from Australia and U.S.A.		Remarks
Anchorage day	3 days	6 days	3 days	6 daysp	
Deference of transport cost	13,203,000	13,203,000	12,410,820	12,410,820	
Annual anchorage	825,000	1,650,000	825,000	1,650,000	
Difference	12,378,000	11,553,000	11,585,820	10,760,820	

4. Construction cost of harbar and coal handling facilities

	120,000 DWT		60,000 DWT	Remarks
No. of unloading days	3 days	6 days	3 days	
Construction cost of harber	130,005		43,497	Civil date
Price of tugboat	8,696 (4 boats)		4,348 (4 boats)	
Coal handling facilities	67,735	45,022	45,022	
Total	206,436	183,723	92,867	

5. Annual expenses

		120,000 DWT		60,000 DWT	Remarks
		3 days	6 days	3 days	
Capital cost	Capital depreciation	18,337	16,319	8,249	Construction cost x 8.9%
Direct cost	Personal expenses	104			
	Maintenance expenses	5,360	4,770	2,412	Construction cost x 2.6%
	Overhead expenses	2,519	2,241	1,133	Construction cost x 1.22%
Indirect expenses		1,229	1,096	562	Direct cost x 15.4%
Annual expenses		A 27,549	B - C 25,530	12,460	Construction cost x 13.4%
Difference		A - C 15,089	B - C 13,070	Base	

6. Difference cost of transport profit and Annual expenses comparing with 60,000 DWT ship

	Whole quantity is imported from Australia		Each 50% quantity is imported from Australia and U. S. A.		Remarks
Ship type	120,000 DWT				
No. of unloading days	3 days	6 days	3 days	6 days	
Difference of Annual expenses	15,089	13,070	15,089	13,070	
Difference of transport profit	12,378	11,553	11,585.8	10,760.8	
Difference	2,711	1,517	3,503.2	2,309.2	

7. Result comparing with 60,000 DWT ship

(1) Whole quantity is import from Australia by 120,000 DWT ship.

a Unloading 3 days ..... loss 2,711 x 10^3 \$ in annual
b Unloading 6 days ..... loss 1,517 x 10^3 \$ in annual

(2) Each 50% quantity is import from Australia and U. S. A. by 120,000 DWT ship.

a Unloading 3 days ..... loss 3,503.2 x 10^3 \$ in annual

Cost Table of Coal Handling Equipment

Equipment	Cap.	Unit cost	Case of 600,000 DWT	Cap.	Unit cost	Case of 120,000 DWT
Unloader (2U)	1,300 T/H	$1,500 \times 10^6$ yen	$3,000 \times 10^6$ yen	2,600 T/H	$3,200 \times 10^6$ yen	$6,400 \times 10^6$ yen
Stacher-Reclaimer	3,200 T/ 1,200 T	900×10^6 yen	900×10^6 yen	6,200 T/ 1,200 T	$1,100 \times 10^6$ yen	$1,100 \times 10^6$ yen
Stacker (1U)	3,200 T	450×10^6 yen	450×10^6 yen	6,200 T	700×10^6 yen	700×10^6 yen
Reclaimer (2U)	1,200 T	550×10^6 yen	$1,100 \times 10^6$ yen	1,200 T	550×10^6 yen	$1,100 \times 10^6$ yen
Conveyor	10,800 IN	450×10^6 yen/m	$4,860 \times 10^6$ yen	9,540 m	630×10^3 yen/m	$6,010 \times 10^6$ yen
				1,260 m	450×10^3 yen/m	560×10^6 yen
Total/yen		—	$10,310 \times 10^6$]yen		—	$15,870 \times 10^6$ yen
US$		—	US¢$44,800 \times 10^3$		—	US$$69,000 \times 10^3$

Personnel Expenses

Trade	No.	Rank	Salary LE/month	Total Salary LE/month	For Barth (%)	Salary for Barth (LE/month)	Remarks
Excellent Operater	2	A	300	600	10	60	Salary for Barth is assumed
1st Operater	2	B	250	500	10	50	"
Coal Operater	2	C	200	400	10	40	"
Operater	42	D	180	7,560	12/42	2,160	3...Unloader 5...Bulldozer 4...Conveyor Total 12
Assistant Operater	42	E	150	6,300	12/42	1,800	"
Ship Work	24	F	100	2,400	100	2,400	
Total	114	-	-	17,760	-	6,510 x 1.1 = 7,161	10% allowance is added for semi night
Monthly Total in US$	—			—		8,701	
Annual Total in US$						104,412	

b) Procurement Plan

A procurement plan of coal should be made corresponding to the generating plan of the power plant. On executing the contract for procurement of the improted coal on annual or longer term basis, the full consideration will be made on terms and conditions such as brand, quality, quantity, and cost of coal including an escalation clause for long-term contract, delivery, method of acceptance including analysis of coal delivered, demurrage, etc.

c) Transportation Plan

i. Shipping Plan

The shipping plan will be formulated in accordance with the procurement plan. With the following conditions, the shipping plan is formulated.

i) The shipping plan has been formulated on the basis of use of Panamax type (60,000 DWT) and shipping from major ports in the prospective exporting countries, namely Australia and the U.S.A. (Eastern), to the unloading berth of the power plant.

ii) The ocean shipping takes long, more than one to two months and the sailing schedule is susceptible to the influence of the weather and ocean conditions. Therefore, one spare day is included in each sailing and another spare day in the unloading period.

iii) The coal loading capacity of each port is given in Table 4-5.

iv) Since the ships undergo the annual inspection requiring about 10 days, the actual working days a year of a coaler is 97%.

v) A set quantity of imported coal will be shipped by the so-called "piston sailing" of the annual charter liners between the exporting ports and the power plant, and the balance of requirements will be shipped by tramp coalers.

The following Table 4-6 shows the conditions of this shipping plan and Fig 4-7 and 4-8 show results of simulation of transision of coal storage quantity for first 5 years are shown on Tables 4-7 and 4-8 on the conditions described in the table.

The shipping plan together with the port entry and departure restrictions with respect to the weather conditions will be advised to the shipping company and with these information, the shipping company will arrange the coalers.

ii. Review of Shipping Plan

Every quarter of the year, the coal transportation plan will be reviewed considering the trends of storage quantity and programmed power generation. And the results will be informed to the mines and shipping companies so as to attain stabe fuel supply and keep appropriate stock quantity through the year without any loss by demurrage.

d) Coal Storage Quantity

The coal stock will be influenced by the following factors. And as a result of study, it is confirmed that the 60-day stock is sufficient for the continuous operation of the plant.

i) Factors of coal delivery concerned

°Normal Conditions:

Quantity of delivery, delivery cycle, and timing of coalers' entry

°Abnormal Conditions:

Strike at harbours and coal mines, accident, shipwreck and other force majour

°Failure of unloading equipment

ii) Factors of coal dispensary concerned

°Normal Conditions:

Quantity and cycle of dispensary

°Abnormal Conditions:

Failures of power generating facilities

°Others:

Fluctuation of power demand due to economic and seasonal trends

°Failure of coal dispensary equipments

e) Operating Range of Coal Storage

There is no specific range of coal stock as a standard operating quantity. The future stock is forecast considering current stock, ship arrangement, consumption, etc. so as to attain higher efficiency of the coal handling equipment. As the tonnage of coaler employed for the project will be 60,000 DWT, the operating range of coal storage can be set at 160 x 10^3 tons (for 44 days power plant operation) for maximum taking a shipping volume of a coler into account and 54 x 10^3 tons for minimum storage quantity for about 0.5 months which is adopted generally in Japan.

f) Rotation of Stockpile

In theoritical point of view on the figures, the higher rotation rate seemes to be resulted in better economically. However as coal is a solid substance, its handling (loading and unloading, transportation, dispensary, etc.) is less efficient than the handling of the liquid substance like heavy oil. Therefore, reasonable rotation of stockpile will be 6 times per year since the spontaneous combustion period of coal is about two months.

g) Transportation Plan at Abnormal Conditions

As an abnomral condition affection to the fuel supply, a general strike by workers at coal mines, loading and unloading ports and ship companies is liable to happen. A period of strike is usually projected to be settled in two months or so at the worst case, it is necessary to prepare the alternative procurment sources of supply and transportation plans.

For the project, the following conditions are set for projection:

- The works at some mines or harbor involving the project go into a general strike.
- Forecasting that the strike might continue about 60 days or so, the power plant side promptly took actions for hiring a tramper coalers.

The table 4-9 show the shipping plan, and changes of coal strage quantity and estimated period of oil firing.

Table 4-6 Major Factor for Transportation Plan

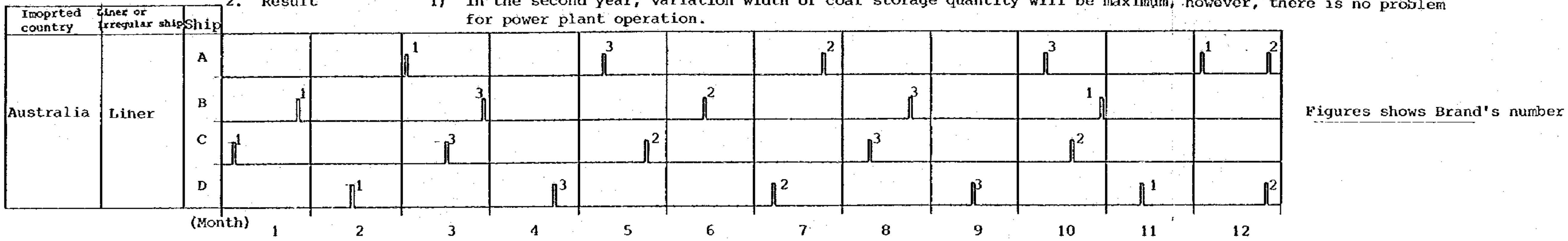
Items	Country and Port Australia New castle	 U.S.A Norfork	 S. Africa Richard Bay	Remarks
Type of ship		Panamax		
Transportation distance (N.M)	8,370	5,392	4,430	
Speed (NM/h)				
Loaded		13.0		
Empty		14.0		
Loading (days)	6.5	4.0	4.0	
Sailing days(days)				
Loaded	28	18	15	incl. 1 spare day
Empty	26	17	14	incl. 1 spare day
Waiting days for Suez Canal crossing		2		2 days each both ways
Unloading (days)	4.5	4.5	4.5	incl. 1 spare day
Total days required (days)	65	47.5	37.5	excl. annual inspection days
Annual working days (days)	354	354	354	
No. of times of sailing per year	5.44	7.45	9.44	
Coal transported per year per ship (1,000 tons/year)	326	447	566	

Table 4 - 7

Simulation Case 1   Transition of coal storage quantity in case of import 1,310 x 10^3 t/year (3 blands) from Australia by 60,000 DWT 4 ships

1. Input conditions
   1) Period: 5 years
   2) Periodical maintenance is assumed for 45 days (May 1 to June 14 for No. 1 Unit and Sept. 1 to Oct. 15 for No. 2 Unit).
   3) Equipment fault factor/year: Power plant; 2%, Unloader; 2%, Stacker; 1%, Reclaimer; 1%, Receiving conveyor; 1%, 1 %, dispensing conveyor; 1%.
   4) Initial coal storage volume is assumed at 5% (133,800 ton) of coal storage capacity.
   5) Working hour for coal unloading: 7:00 - 22:00, arrive and departure of ship: 7:00 - 18:00

2. Result
   1) In the second year, variation width of coal storage quantity will be maximum, however, there is no problem for power plant operation.



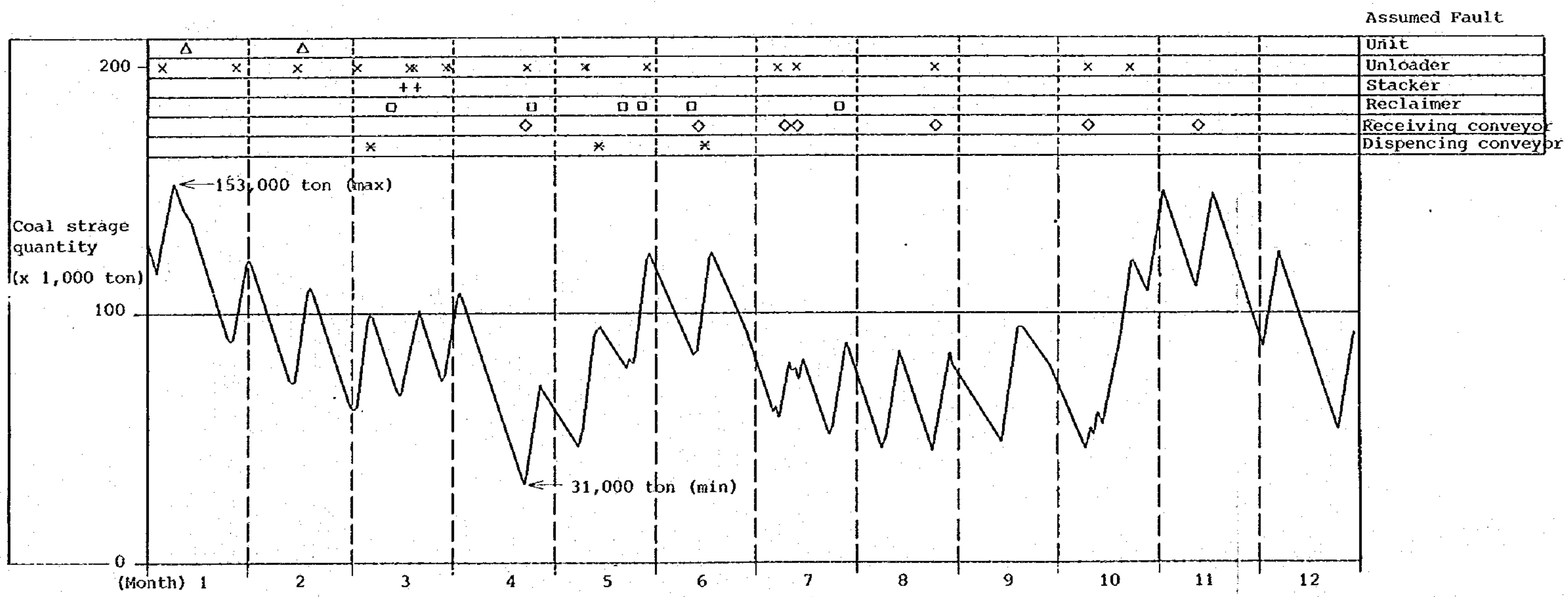
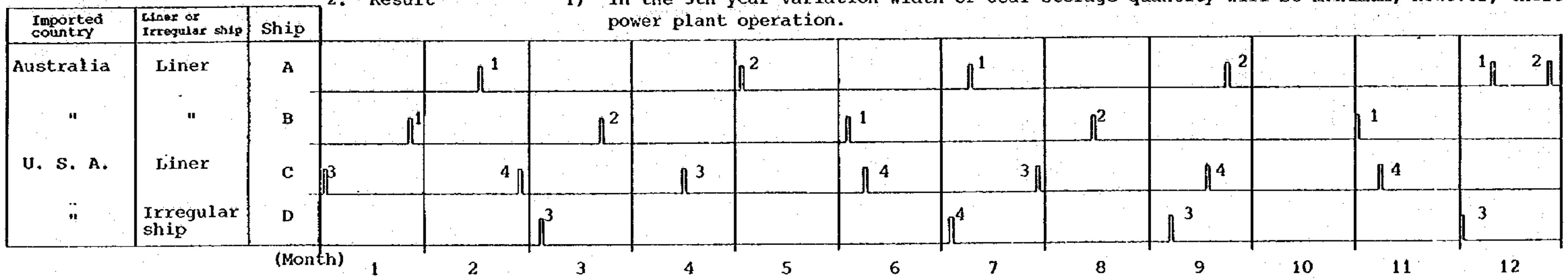


Table 4－8

Simulation case 2 　Transition of coal storage quantity in case of import 655,000 t/year (2 brands) or 50% from Australia by 60,000 DWT 2 ships and 655,000 t/year (2 brands) from Eastern America by a ship.

1. Input conditions
   1) Period: 5 years
   2) Peirodical maintenance is assumed for 45 days (May 1 to June 14 for No. 1 Unit and Sept. 1 to Oct. 15 for No. 2 Unit).
   3) Equipment fault factor/year: Power plant; 2%, Unloader; 2%, Stacker; 1%, Reclaimer; 1%, Receiving conveyor; 1%, dispensing conveyor; 1%
   4) Initial coal storage volume is assumed at 5% (133,800 ton) of coal storage capacity.
   5) Working hour for coal unloading: 7:00 - 22:00, Arrive and departure of ship: 7:00 - 18.00
2. Result
   1) In the 5th year variation width of coal storage quantity will be maximum, however, there is no problem power plant operation.



Figures show Brand's number

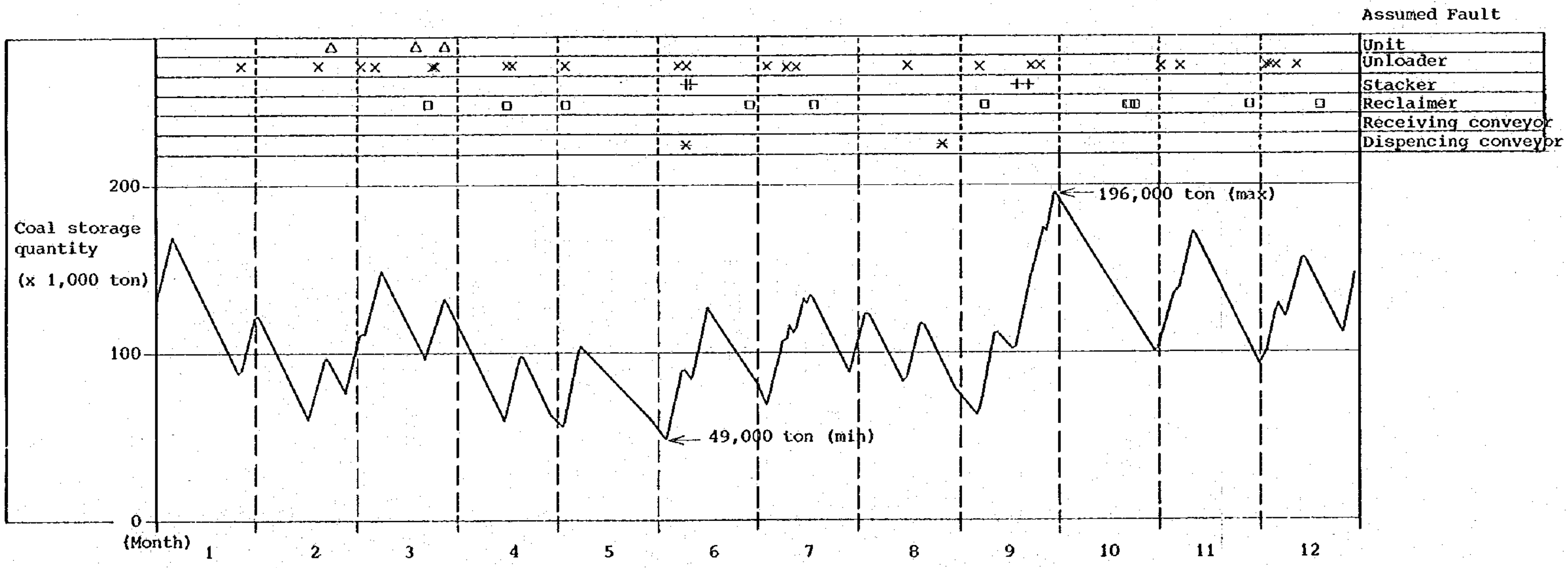
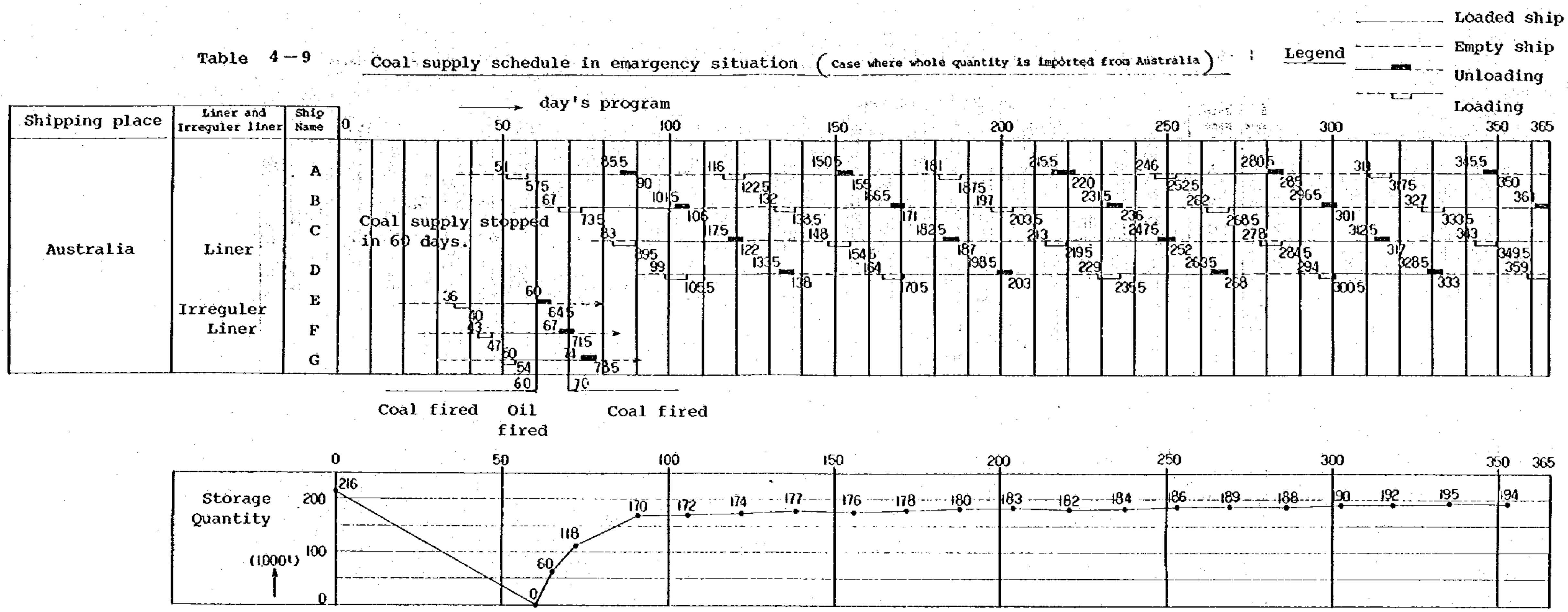
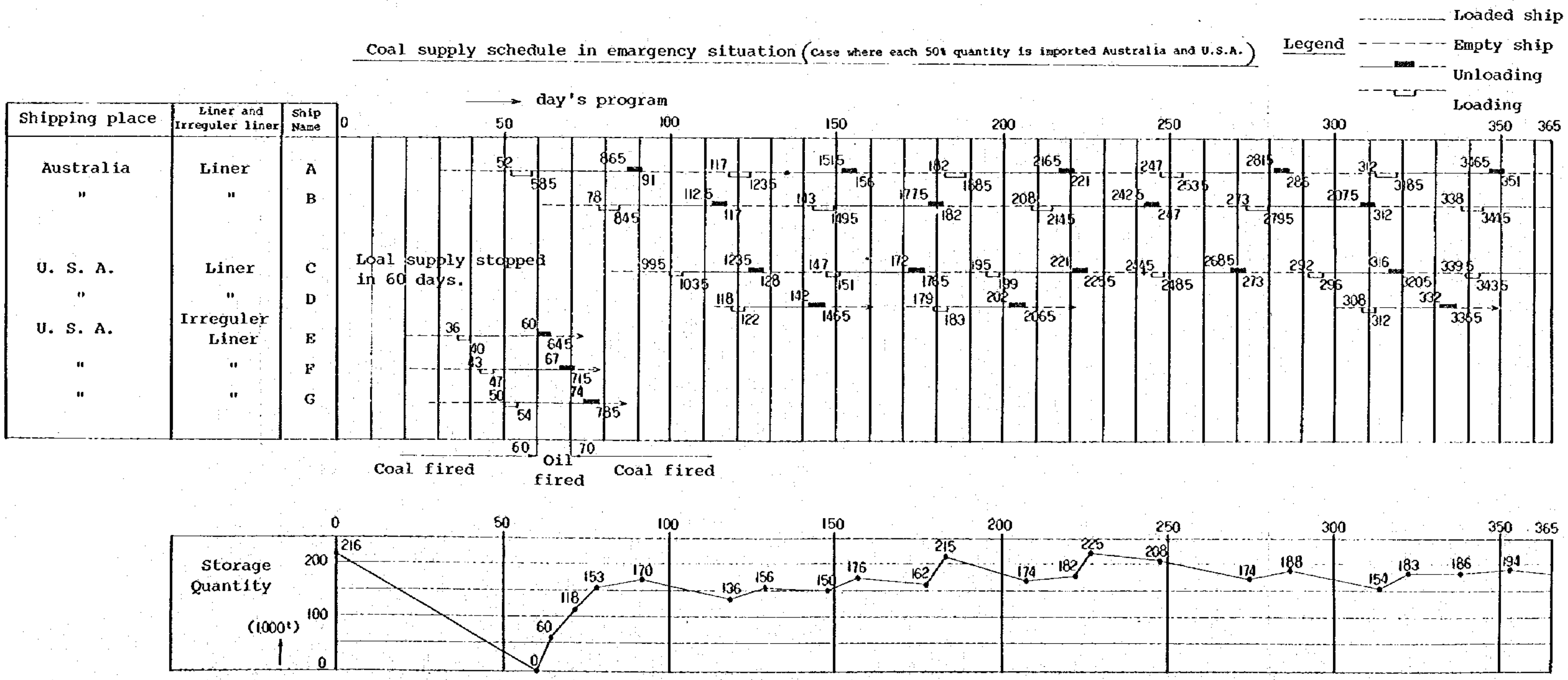


Table 4 - 9 Coal supply schedule in emargency situation (Case where whole quantity is imported from Australia)



Coal supply schedule in emargency situation (Case where each 50% quantity is imported Australia and U.S.A.)



d. Grade of Coal

The above-mentioned coal supplier countries produce a variety of grades and brands of coal, and the following points should be given full consideration in selecting the grades and brands.

Since the imported coal involves US$10-20/ton of ocean freight, the coal of as low ash content and as high calorific value as possible is desirable, and for stable supply, the brands of large yield and with interchangeability of sources of supply should be selected.

The distribution of brands exported or offered for export to Japan are shown on Fig. 4-10. It is seen that the calorific values of 6,500 - 6,700 kcal/kg are most common. The typical grade of these brands of coal is as follows.

Inherent moisture	3.0 - 3.5%
Ash	14 - 16%
Volatile matter	28 - 32%
Fixed carbon	49 - 52%
Calorific value	6,500 - 6,700 kcal/kg

e. Price

a) FOB Price

At present, the coal price is rather low due to stagnant demand and the prices on the spot market are also low. However, the coal prices may vary a great deal in the future by the influence of oil prices and demand for coal. Thus, it is very difficult to estimate the coal price into future.

When planning over a long period, it is dangerous to assume too low coal prices on the basis of the present low prices. Therefore, for this project, the coal prices as considered normal on a long range basis, were adopted.

The coal prices vary somewhat by the supplier countries, and the South African coal is the lowest in price and the price is higher in the order of Australia and the U.S.A. It is a matter of course that the coal price varies according to the calorific value.

In consideration of these conditions, the FOB price of 6,600 kcal/kg coal is assumed as follows.

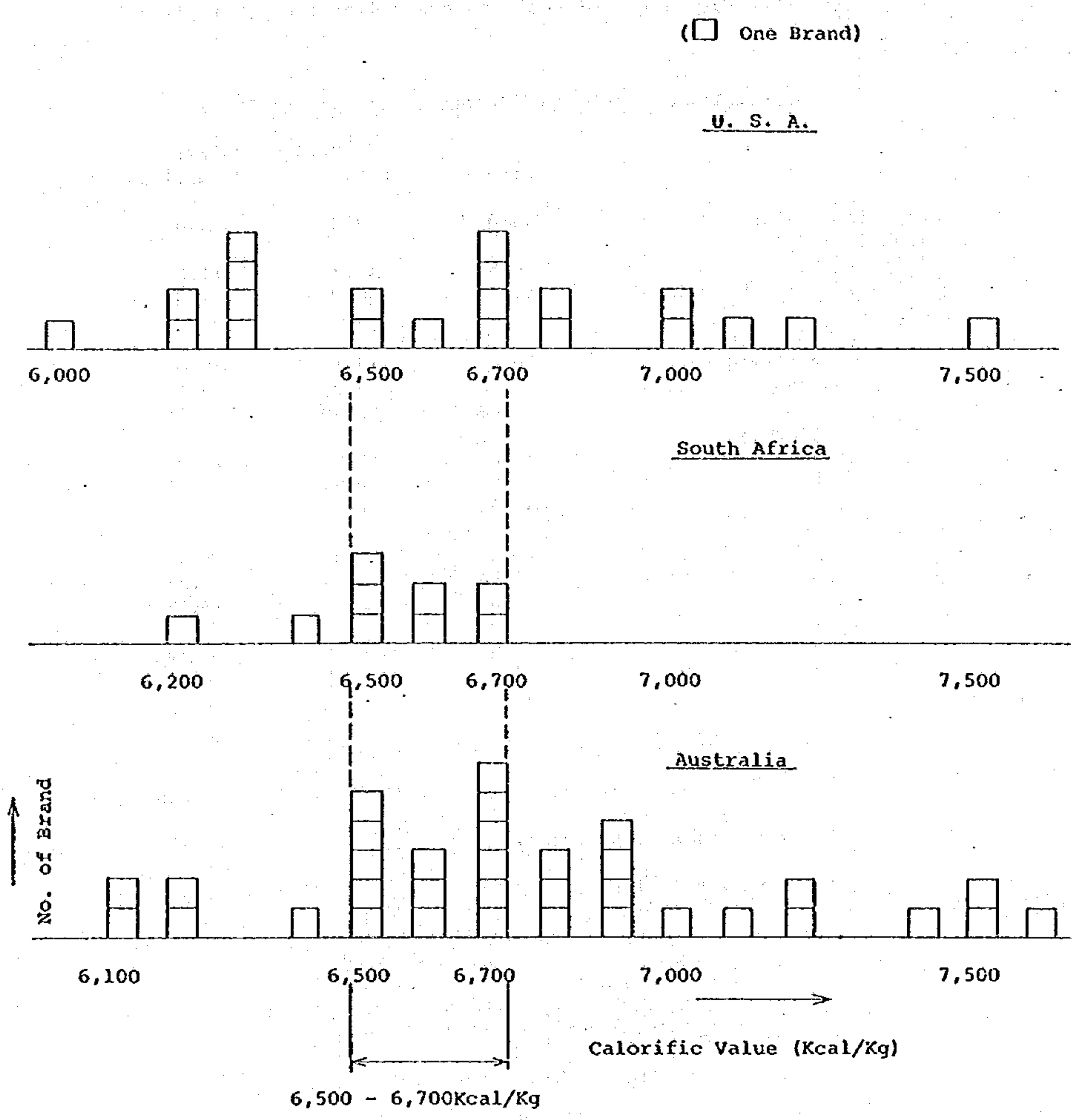
Table 4-10 FOB Price

(Unit: US$/t)

Country	Australia	U.S.A.	S. Africa
FOB Price	40.0	44.0	37.0

(as of 1983)

Fig. 4-10 Distribution of Coal for Export by Calorific Value and Brand



b) CIF Price

The CIF prices of coal as received at the power plant are as follows.

Table 4-11 CIF Prices of Imported Coal (as of 1983)

(Unit: US$/T)

	Australia	U.S.A.	S. Africa
Shipping Distance (nautical mile)	8,370	5,392	4,430
Shipping Days	26.8	17.3	14.2
FOB Price (6,600 kcal/kg)	40.0	44.0	37.0
CIF Price			
Type 35			
Ocean freight	20.5	17.5	17.0
Insurance & Others	2.28	2.29	2.25
CIF	62.78	63.79	56.25
Type Panamax			
Ocean freight	15.0	13.0	12.0
Insurance & Others	2.26	2.27	2.23
CIF	57.26	59.27	51.23
Type 100			
Ocean freight	11.4	10.22	8.9
Insurance & Others	2.24	2.27	2.22
CIF	53.64	56.49	48.12
Type 120			
Ocean freight	10.53	9.05	8.10
Insurance & Others	2.23	2.26	2.21
CIF	52.76	55.31	47.31

Notes: 1. The "Others" in the table is assumed to be US$2/t.

2. Insurance premium is assumed to be (FOB Price + Ocean freight) x 1.15 x 0.004.

*1 1 nautical mile = 1.852 km

*2 Panamax: Largest type of ship that can pass through Panama Canal

Width of ship : 32 m

Length of ship: 210 - 225 m

Depth of ship : 17.3 - 18.7 m

Draft : 12.09 - 13.42 m

DWT : 60,000 class

3) Plan of Coal for Ayun Musa Power Plant

From the overall consideration of coal reserve, properties, method of transportation, price, etc. and the fact that the poewr plant is located on the Gulf of Suez, Australia, the U.S.A. (Eastern) and South Africa are considered as the sources of imported coal for the Ayun Musa Project.

South Africa involves problems in the long stable supply which is the most important factor for the power plant, even though the distance of transportation is short and the cost is low, and therefore, two countries, the U.S.A. (Eastern) and Australia will be considered as the supplier countries.

Consequently, the basic plan for Ayun Musa Power Plant coal will be as follows.

a. Grade of Coal for Power Plant

When 300,000 t of coking coal and 300,000 t of fuel coal is produced from 600,000 t of raw coal, the grade of fuel coal is 6,140 kcal/kg, and the most common brands exported stably from supplier countries are 6,500 - 6,700 kcal/kg. If 1,220,000 t of shortage of domestic coal is made up with imported coal, the grade of blended coal would become as shown on Table 4-12.

Table 4-12 Grade of Coal for Power Plant

Cal. Value of Imported Coal		6,500 kcal/kg	6,600 kcal/kg	6,700 kcal/kg
Inherent moisture	%	3.4	3.4	3.4
Ash	%	16.6	15.9	15.0
Volatile matter	%	34.1	32.9	31.4
Fixed carbon	%	35.9	47.6	50.2
Calorific value of blended coal	Kcal/kg	6,430	6,510	6,590

And therefore, the average calorific value of coal for the power plant is planned to be 6,500 kcal/kg, and the analysis of the blended coal will have the following range, depending upon the properties of coals used in blending.

Inherent moisture	%	2.8 - 8.3
Ash	%	8.9 - 17.8
Volatile matter	%	28.1 - 35.1
Fixed carbon	%	36.8 - 53.4
Calorific value	kcal/kg	6,450 - 6,550 (6,500 ±50)

However, since there are many brands of coal and power plant will use not only coal with a certain range of calorific value but also blended coal of many brands, coal with calorific value ranging from 6,100 kcal/kg to 6,900 kcal/kg can be included in the coal purchase program.

b. Coal Price at Power Plant

The prices of domestic coal and imported coal as received at the power plant are as follows.

Domestic coal	53.5	US$/t	(44.0 LE/t) LE = US$1.215
Australia	57.26	"	
U.S.A.	59.27	"	In case of Type Panamax
S. Africa	51.23	"	

The prices of blended coal by different proportions of imported coal from Australia and the U.S.A. are computed as shown on Table 4-13.

Table 4-13 Coal Prices When Proportions of Imported Coal Are Varied

(In case of Type Panamax) (as of 1983)

Proportions of Imported Coal (%)		Price (US$/t)		
Australia	U.S.A.	Imported Coal(CIF)	Domestic Coal	Blended Coal at Power Plant
100	0	57.3	53.5	56.5
90	10	57.5	53.5	56.7
80	20	57.7	53.5	56.8
70	30	57.9	53.5	57.0
60	40	58.1	53.5	57.2
50	50	58.3	53.5	57.3

From the above table, the price of coal at the power plant would be at about 57.0 US$/t in case that 50% of coal required from Australia and another 50% is imported from U.S.A.

c. Coal Price at Power Plant in Future

The commissioning of the Project will be in 1988. It is extremely difficult to forecast the trend of the coal price into future, because the price is affected complicatedly by such factors as economic situation, demand and supply conditions, oil price, general political situation, etc.

As an example, the trend of coal price is computed on the assumption that the price will remain the same until 1985 and would increase by 2% per annum after 1985.

Table 4-14 Trend of Coal Price

(Unit: US$/t)

Year	1983	1984	1985	1986	1987	1988	1989
Coal Price	57.0	57.0	57.0	58.1	59.3	60.5	61.7

d. Properties of Coal

Properties of Maghara coal and imported coal by country are as shown on Table 4-15.

Table 4－15 Properties of Domestic Coal and Imported Coal

Properties of domestic coal (Maghara)

Country of Origin	Brand	Calorific Value kcal/kg	Surface Moisture %	Proximate Analysis: Inherent Moisture %	Proximate Analysis: Ash %	Proximate Analysis: Volatile Matter %	Proximate Analysis: Fixed Carbon %	Ultimate Analysis: Carbon %	Ultimate Analysis: Hydrogen %	Ultimate Analysis: Nitrogen %	Ultimate Analysis: Oxygen %	Ultimate Analysis: Sulphur %	Fuel ratio	HGI
Egypt literature	Maghara	7,270	—	4.90	6.50	50.70	37.90	70.66	5.67	1.04	8.26	2.97	0.75	—
in Japan	Maghara	7,140	—	5.14	3.96	50.51	40.39	73.74	5.83	1.22	12.21	2.83	0.8	51
For power station	Maghara	6,140	—	4.2	19.2	43.3	33.4	—	—	—	—	—	—	—

Country of Origin	Fusibility of Ash: Softening Point °C	Fusibility of Ash: Melting Point °C	Fusibility of Ash: Pour Point °C	Ultimate Analysis of Ash %: SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5
Egypt literature	1,220 -1,290	1,290 -1,340	1,320 -1,360	—	—	—	—	—	—	—	—	—	—
in Japan	1,290	1,430	1,440	65	3.3	4.0	4.4	0.4	6.2	0.4	Trace	Trace	Trace
For power station	—	—	—	—	—	—	—	—	—	—	—	—	—

$$\text{Fuel ratio} = \frac{\text{Fixed Carbon}}{\text{Volatile Matter}}$$

Properties of Imported Coal (South Africa)

Country of Origin	Brand	Calorific Value kcal/kg	Surface Maisture %	Proximate Analysis				Ultimate Analysis					Fuel ratio	HGI	Fasibility of Ash			Ultimate Analysis of Ash %									
				Inherent Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Carbon %	Hidrogen %	Nitrogen %	Oxygen %	Sulphur %			Softening Point °C	Melting Point °C	Pour Point °C	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5
South Africa	Wit Bank	6,530	7.0	3.0	14.6	24.7	57.5	70.3	4.0	1.54	8.1	0.68	2.23	50	1,260	1,410	1,460	42.8	31.3	5.9	7.2	1.3	4.2	0.3	0.4	1.5	2.0
		6,320	7.0	3.6	14.3	26.1	56.0	71.8	4.2	1.77	14.0	1.23	2.15	56	1,470	1,500 or more	1,500 or more	42.6	30.9	3.67	12.3	1.54	4.56	1.82	0.46	1.72	0.06
	Rietspruit	6,310	7.0	3.9	15.0	23.3	57.8	70.3	3.9	1.56	9.3	0.47	2.48	50	1,281	1,345	1,460	43.3	29.0	4.6	10.2	1.1	3.0	0.3	0.6	1.8	0.8
		6,010	7.0	2.3	16.7	26.5	54.5	81.0	4.6	1.7	12.3	0.4	2.06	58	—	1,340	1,350	34.6	28.0	10.9	13.8	2.72	5.5	0.79	0.44	0.54	2.72
	Natal	6,580	7.0	3.2	14.8	23.9	58.1	69.4	3.6	1.9	8.9	1.21	2.43	57	1,270	1,310	1,330	45.9	19.9	9.6	8.3	2.3	3.6	0.6	1.1	1.0	0.8
	Arther Taylor	6,687	9.0	3.0	12.0	26.5	59.0	71.9	3.9	1.6	7.2	0.6	2.23	54	1,380	>1,400	>1,400	43.3	32.54	4.63	8.73	2.14	4.87	0.50	0.35	1.84	1.10
	Ermelo	6,700	9.0	3.0	14.0	30.0	53.0	81.7	5.2	1.7	11.1	1.0	1.77	50	>1,300	>1,300	>1,300	44.7	30.3	6.2	8.5	3.3	3.61	0.42	0.69	—	—
	Middleburg	6,500	7.0	3.0	15.0	23.0	59.0	83.5	4.4	1.9	—	0.4	2.57	60	1,300	1,350	1,400	46.2	35.4	2.0	5.6	1.9	3.7	0.4	0.4	—	—
	Ungala	6,700	7.0	2.5	14.5	22.0	61.0	66.7	3.5	1.8	6.1	1.9	2.77	55 - 65	1,200	1,250	1,300	40.7	22.7	10.5	13.5	2.8	4.19	0.54	1.33	1.18	1.17
	Optimum	6,900	8.0	3.0	10.5	32.0	54.5	71.5	4.5	1.8	8.5	0.8	1.70	47	1,350	1,450	1,550	49.0	29.0	4.0	6.0	1.75	4.0	0.4	0.5	1.7	1.5
	Tavistock	6,690	7.0	3.7	11.9	25.7	58.7	74.4	4.0	1.7	7.2	0.5	2.28	53	1,370	>1,500	>1,500	42.8	37.9	1.8	7.1	2.0	2.8	0.6	0.5	20	1.3
	Wolgedacht	6,600	8.0	2.5	15-17	24-27	56.0	69.8	4.0	1.6	7.1	0.8-1.2	2.33-2.07	55	1,300	1,300	1,300	41.4	33.1	5.0	9.0	2.0	5.1	0.19	0.35	1.70	1.15

Properties of Imported Coal (Poland)

Country of Origin	Brand	Calorific Value kcal/kg	Surface Moisture %	Protimate Analysis					Ultimate Analysis				Fuel ratio	HGI	Fusibility of Ash	Ultimate Analysis of Ash %									
				Inherent Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Carbon %	Hydrogen %	Nitrogen %	Oxygen %	Sulphur %			Softening Point °C	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	NaO	K_2O	TiO_2	P_2O_5
Poland	Rydultowy, Wujek Polska, Brend of Gottwald	6,450	6-6.5	2-3.5	12-18	28-32	46.5-58	69-71	4.3-4.5	1.3-1.6	7.1-10.6	0.4-0.6	1.66 -1.81	48	1,100-1,150	40-50	14-23	10-20	5-8	3.0-5.5	—	0.4-1.0	1.5-2.6	0.7-0.9	—
	Rydultowy, Knurow Blend of Nowywirek	7,250	5.2-6.5	1.8-2.5	7-9	31-34	54.5 -60.2	77-80	4.7-5.1	1.2-1.6	6.1-7.6	0.5-0.7	1.76 -1.77	50	1,080-1,150	38-42	24-28	10-12	5-8	3.5-4.1	—	0.9-1.5	1.5-1.8	0.4-1.1	—

Properties of Imported Coal (Colombia)

Country of Origin	Brand	Calorific Value kcal/kg	Total Moisture %	Protimate Analysis					Ultimate Analysis				Fuel ratio	HGI	Fusibility of Ash			Ultimate Analysis of Ash %									
				Inherent Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Carbon %	Hydrogen %	Nitrogen %	Oxygen %	Sulphur %			Softening Point °C	Melting Point °C	Pour Point °C	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5
Colombia	Cerrejon	6,310	9.2	—	8.0	34.9	47.9	—	—	—	—	—	1.37	49	—	—	1,240										
	Cerrejon	6,940	9.2	—	6.3	34.5	50.0	71.4	4.5	13	6.35	0.89	1.45	48	1,299	1,399	1,443	66.18	13.42	9.7	1.96	2.36	1.09	1.51	1.49	0.76	0.13

Properties of Imported Coal (Canada)

Country of Origin	Brand	Calorific Value kcal/kg	Surface Moisture %	Proximate Analysis					Ultimate Analysis				Fuel ratio	HGI	Fusibility of Ash			Ultimate Analysis of Ash %									
				Inherent Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Carbon %	Hydrogen %	Nitrogen %	Oxygen %	Sulphur %			Softening Point °C	Melting Point °C	Pour Point °C	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5
Canada	Eastern	6,700	—	—	12-14	30-32	—	—	—	—	—	—	—	65-70	1,310	—	—	37.0	20.0	34.0	4.0	1.0	—	—	—	—	—

$$\text{Fuel ratio} = \frac{\text{Fixed Carbon}}{\text{Volatile matter}}$$

Properties of Imported Coal (U.S.A.)

Country of Origin	Brand	Calorific Value kcal/kg	Surface Moisture %	Proximate Analysis				Ultimate Analysis					Fuel ratio	HGI	Fusibility of Ash			Ultimate Analysis of Ash %									
				Inherent Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Carbon %	Hydrogen %	Nitrogen %	Oxygen %	Sulphur %			Softening Point °C	Melting Point °C	Pour Point °C	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5
U.S.A. (Eastern Part)	Kanawha	6,890	6.90	—	10.50	35.80	46.90	76.3	5.4	1.4	6.2	0.75	1.31	49	1.482	1,482	1,482	52.94	34.67	3.30	1.10	0.80	0.77	0.72	2.13	—	0.67
	Drummond	6,390	8.0	—	12.0	31.0	49.0	78.4	4.9	1.4	8.6	0.6	1.58	45	—	—	1,343	40.4	29.51	13.49	4.7	1.51	4.85	0.47	2.10	1.29	0.36
	Amherst 3A	7,110	4.97	—	9.70	33.63	56.67	76.9	5.2	1.6	5.8	0.80	1.69	50	1,582	1,632	1,654	56.91	31.86	3.80	0.62	0.82	0.71	0.93	2.59	1.33	0.15
	Elkhorn	7,555	5.50	—	8.50	37.00	49.00	—	—	—	—	0.85	1.32	—	—	1,538	—	—	—	—	—	—	—	—	—	—	—
	King	6,986	—	7.30	5.80	41.89	45.01	74.6	5.7	1.5	11.4	0.65	1.07	48:5	1,296	1,366	1.432	64.1	19.2	3.67	5.20	—	2.95	2.25	0.87	—	—
	Orchard Valley	6,300	—	13.08	3.96	35.48	45.48	79.8	5.6	1.9	12.3	0.35	1.28	45	—	1,430	—	45.46	30.82	3.36	8.24	2.28	3.26	0.39	0.46	—	—
	Pevler	6,800	6.6	—	7.8	35.0	50.6	—	—	—	—	0.7	1.45	60	—	1,540	—	—	—	—	—	—	—	—	—	—	—
U.S.A. (Western Part)	Braztah	7,020	—	4.0	7.94	41.45	46.61	71.56	6.04	1.51	12.10	0.52	1.12	50	—	—	—	47.3	17.9	5.5	12.8	3.3	—	1.5	0.5	1.2	—
	Mt. Gnison	6,560	—	5.5	10.18	36.86	47.46	69.45	5.33	1.64	12.23	0.57	1.29	51	—	—	—	47.6	25.0	10.3	5.6	1.5	—	2.4	0.9	0.9	—
	Eagle Mine	6,320	—	7.1	8.72	36.88	47.30	70.03	4.96	1.46	13.70	0.46	1.28	47	—	—	—	58.3	22.2	3.1	4.4	0.7	—	4.2	0.9	0.7	—
	Colo Wyo	6,510	—	7.8	4.93	36.44	50.83	73.22	4.97	1.6	14.38	0.47	1.39	50	1.295	1.326	1.344	43.4	23.3	5.4	9.4	1.6	—	3.1	0.6	1.0	—
	Mayden Gulch	6,070	—	9.6	6.91	36.91	47.58	71.10	4.9	1.7	14.5	0.52	1.29	50	1.274	1.290	1.298	39.8	25.3	5.0	11.8	3.0	—	2.8	1.0	0.7	—
	SUFCO	6,320	—	6.9	10.6	36.3	46.2	71.0	4.8	1.13	11.4	0.48	1.27	53	1.165	1.260	1.365	56.0	15.7	3.6	10.7	2.2	—	1.8	0.7	0.8	—
	Kaiparowits	6,780	—	4.0	7.87	40.94	47.19	71.73	5.18	1.14	13.18	0.57	1.15	46	—	—	—	52.9	17.6	4.5	10.9	2.4	—	0.8	0.6	0.9	—
	Seneca	6,210	—	4.1	12.96	36.50	46.44	66.63	4.64	1.37	12.91	0.93	1.27	38	—	—	—	60.8	24.7	2.4	4.1	1.1	—	0.9	1.2	0.7	—
	Emery	7,000	—	3.3	9.26	39.09	48.35	74.60	5.5	1.25	9.0	0.65	1.24	40	—	—	—	41.0	16.5	6.5	14.5	4.2	—	3.3	0.4	1.0	—
	Corral Canyen	6,230	—	5.3	10,43	37.06	47.19	68.13	4.84	1.37	14.6	0.03	1.27	53	—	—	—	58.1	23.0	5.0	5.0	1.7	—	0.4	0.7	1.0	—
	Plateau	6,700	—	5.5	9.45	41.48	43.57	67.20	4.66	1.29	16.09	0.76	1.05	45 - 50	1.282	1.357	1.421	62.2	17.6	3.5	4.8	1.2	—	0.7	0.9	1.0	—
	King Mine	6,850	—	5.0	11.43	41.28	42.29	71.87	5.45	0.98	9.15	0.52	1.02	43 - 46	—	—	—	62.5	18.3	4.3	4.6	0.9	—	1.6	1.4	1.0	—
	Solidier Creek	6,610	—	3.8	10.34	37.76	48.10	71.84	5.23	1.39	12.67	0.54	1.27	55	—	—	—	65.0	18.8	2.1	6.1	1.4	—	0.6	0.3	0.9	—

$$\text{Fuel ratio} = \frac{\text{Fixed Carbon}}{\text{Volatile Matter}}$$

Properties of Imported Coal (Australia)

Country of Origin	Brand	Calorific Value kcal/kg	Surface Moisture %	Proximate Analysis				Ultimate Analysis					Fuel ratio	HGI	Fusibility of Ash			Ultimate Analysis of Ash %									
				Inherent Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Carbon %	Hydrogen %	Nitrogen %	Oxygen %	Sulphur %			Softening Point °C	Melting Point °C	Pour Point °C	SiO	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5
Australia	Lemington (A)	7,060	7.0	4.0	8.5	39.5	48.0	72.8	4.7	1.6	11.6	0.44	1.22	47	1,440	1,510	1,530	74.8	14.1	6.3	—	0.4	0.9	0.3	0.5	0.5	0.1
	(B)	6,860	7.0	2.3	9.0	34.0	54.0	80.3	5.0	1.7	12.4	0.59	1.59	48	1,260	1,300	1,325	51.7	22.6	9.55	5.70	1.60	3.50	1.90	1.42	1.03	0.91
	Work Worth	6,670	7.0	3.2	13.8	29.3	53.7	68.3	4.4	1.5	11.1	0.47	1.83	49	1,400	1,550	1,560	75.5	18.1	2.7	—	0.2	0.7	0.1	—	0.6	—
	Hunter Valley	6,800	9.0	3.5	13.5	34.0	49.0	82.2	5.1	1.8	10.5	0.6	1.44	55	1,500	1,570	>1,600	68.6	24.0	2.7	0.7	—	—	0.5	1.1	1.1	0.3
	Lithgow	6,400	7.0	3.2	17.4	29.2	50.2	67.5	4.2	1.5	8.2	0.59	1.72	39	1,500	1,500	1,500	60.7	30.6	0.6	—	0.2	1.3	0.1	3.0	0.5	0.1
	Invincible	6,720	8.0	2.5	16.5	30.0	51.0	83.3	5.4	1.9	8.6	0.7	1.70	48 - 55	>1,600	>1,600	>1,600	69.1	25.1	0.75	0.26	0.27	0.40	0.30	0.60	—	—
	Crose Valley	6,570	8.0	2.5	17.0	24.5	56.0	84.0	4.5	1.6	9.1	0.4	2.29	50 - 55	>1,600	>1,600	>1,600	66.2	32.0	0.71	0.09	0.22	0.93	0.30	0.60	—	—
	Ulan	7,070	7.6	3.3	10.8	33.4	52.5	74.1	4.3	1.6	8.3	0.5	1.57	48	1,500	1,500	1,500	80.42	13.87	2.81	0.64	0.15	0.98	0.06	0.28	0.64	0.11
	Wambow	6,700	9.0	3.0	14.0	32.0	51.0	82.9	5.5	1.6	9.5	0.5	1.59	47 - 51	1,280	1,400	1,460	67.8	18.6	5.37	1.72	2.23	1.66	0.63	1.07	—	—
	Blair Athol	6,540	16.0	7.5	8.2	27.6	56.7	82.2	4.6	1.9	10.9	0.3	2.05	70	1,490	1,560	1,600	62.4	31.7	2.0	1.1	0.3	0.4	0.2	0.2	—	—
	South Blackwater (A)	6,370	8.5	6.8	10.5	24.3	58.4	70.7	3.7	1.28	13.2	0.28	2.40	72	1,500	1,540	1,540	50.8	35.0	3.5	0.3	0.8	2.2	0.4	0.3	2.3	0.6
	(B)	5,960	7.0	6.2	13.1	27.4	53.3	76.7	4.2	1.4	17.4	0.33	1.95	80	1,480	1,500 or more	1,500 or more	54.1	32.6	5.91	1.50	0.48	0.05	1.74	0.51	2.08	0.91
	Baggabri	7,510	7.0	4.0	5.2	35.6	55.2	78.5	5.0	1.7	9.0	0.4	1.55	52	—	—	—	67.5	22.2	3.4	1.0	0.4	0.4	0.3	0.9	1.5	0.4
	Glendell	7,510	7.4	2.8	13.5	33.1	50.9	—	—	—	—	0.85	1.54	47 - 50	—	—	—	61.5	27.9	4.1	0.68	0.91	1.07	0.51	0.61	1.76	—
	Mt. Arther South	6,800	7.0	3.5	14.0	30.0	52.5	66.7	4.3	1.7	10.7	0.5	1.74	51 - 53	—	—	—	69.36	14.81	4.70	4.17	1.86	1.72	0.51	0.95	0.65	0.44
	Wallamaine	6,550	7.0	2.5	16.0	29.0	52.5	—	—	—	—	0.6	1.81	47	—	—	—	65 - 76	11 - 22	3 - 6	0.4 - 1.8	0.4 - 1.1	0.05 - 1.7	0.5 - 1.05	1.05 - 5.70	0.65 - 1.32	0.06 - 0.14
	Saxonbale	6,530	7.0	3.8	16.1	27.3	52.8	70.8	4.4	1.49	6.2	0.4	1.93	47	1,465	1,500 or more	1,500 or more	72.8	20.3	1.7	0.3	0.3	0.1	0.3	1.6	0.5	0.1
	BHP	6,690	7.0	3.0	15.6	30.9	50.5	70.1	4.7	1.72	7.0	0.4	1.63	52	1,355	1,500 or more	1,500 or more	64.2	23.1	4.1	3.9	0.7	0.3	0.8	1.2	0.9	0.7
	Black Hill	7,610	7.0	1.9	7.9	27.1	63.1	79.8	5.0	1.94	4.1	1.09	2.33	68	1,500 or more	1,500 or more	1,500 or more	58.1	28.8	6.15	0.90	0.42	0.43	0.17	0.47	1.79	0.85
	Newlands	6,800	8.0	2.7	14.0	25.8	57.5	84.4	5.0	1.7	8.4	0.51	2.23	54	1,550	—	>1,600	53.5	37.5	2.4	0.7	0.4	0.4	0.4	0.5	1.8	1.3
	Briglow	6,120	8.38	9.3	12.5	40.5	37.7	67.2	5.1	0.85	12.6	0.46	0.93	38	1,370	1,500	1,520	54.9	28.3	3.8	4.7	1.4	2.65	0.96	0.40	—	0.1
	Theodore	6,500	7.0	4.5	13.7	31.1	50.7	69.5	4.6	1.7	9.1	0.8	1.63	56	—	—	—	55.52	25.44	8.49	3.84	1.3	1.3	0.72	1.63	0.63	0.53
	Wandcan	6,260	7.06	7.9	10.6	40.5	40.9	77.2	6.1	0.94	15.5	0.34	1.01	31	—	—	—	52.05	29.0	3.22	5.2	1.93	—	2.14	0.56	1.32	0.13
	Winchester South	7,280	7.0	2.3	12.0	23.0	62.7	77.1	4.1	1.36	5.1	0.44	2.73	75-80	1,230	1,400	1,400	—	—	—	—	—	—	—	—	—	—
	Westfalen	5,700	9.4	2.9	20.9	28.9	44.8	64.4	4.4	1.15	8.3	0.21	1.55	52	1,370	1,600	—	55.6	30.7	3.29	2.64	1.61	1.49	0.14	0.41	2.13	0.40

$$\text{Fuel ratio} = \frac{\text{Fixed Carbon}}{\text{Volatile matter}}$$

4-1-2 Heavy Oil and Gas

1) Heavy Oil

Petroleum is one of major mineral products in Egypt. Production has increased year by year and considerable quantity is exported.

There is the refinery in Suez city, and supply of fuel oil is sufficient.

Production of oil is as shown in Table 4-16.

Table 4-16 Oil Production

	1976	1977	1978	1979	1980
Crude oil (10^3 tons)	19,000	20,800	24,300	26,300	29,400
Mazout oil (10^3 tons)	5,056	5,254	5,437	5,536	6,413
Light oil (10^3 tons)	1,717	1,961	2,190	2,280	2,519

Data source: Statistical year Book of Egypt, July 1981

Domestic heavy oil will be stored as the standby fuel, as stated before, against such unforeseeable situation as the stoppage of coal supply, and the dual type power plant will continue operation on heavy oil. Heavy oil is used also for stabilization of flame at low load of the boiler, namely, heavy oil will be used at unit start-up time until coal is fired at about 25% load. In case coal of low calorific value is fired, heavy oil would be used supplementarily to help maintain flame.

a. Properties of heavy oil

	Analysis Value	Standard Value
Flash point	200 F° (93.3°C)	Min 150 °F (65.6°C)
Viscosity	170 cst at 50°C	RI at 100 °F (37.8°C) Max 2,000 sec
Pour point	35 °C	Max 100 °F (37.8°C)
Carbon residue	11.0 wt%	Max 11 wt %
Moisture(water content)	0.2 vol %	Max 1 %
Ash	0.1 wt	Max 0.1 %
Sulphur	2.3 wt %	Max 2.5 %
Specific gravity	Aver. 0.94 15/4°C	Max 0.99 15/4 °C
Calorific value	10,500 kcal/kg	Min 10,000 kcal/kg (low calorific value)

b. Heavy oil consumption

$1,000 \times 10^3$ kl per year in case of exclusive heavy oil firing.

c. Transportation of heavy oil

Heavy oil is transported from the refinery in Suez by 5,000 k*l* tankers or barges to the unloading pier of the power plant, where the oil is received through the pipe line.

2) Gas

Natural gas is produced at Abu Garadic in the Western Desert on Mainland Egypt and there is the pipeline to Helwan near Cairo. However, the distance from Helwan to the power plant site is 120 km, and there are mountains, desert and Suez Canal to be crossed, and the use of this natural gas as fuel for this power plant can not be without trouble.

Another source of gas supply is the petroleum gas at Ain Sukhna, but again the distance is about 80 km and the pipeline route must pass through Suez City, Suez Canal and the steep mountain area, making the construction works difficult.

Thus, use of natural gas as the standby fuel for Ayun Musa is not considered in this Project.

The properties of the natural gas are shown in the following table, for reference.

Properties of Natural Gas (for reference)

		Abu Garadic (Western Desert)	Ataka P.S
Carbonic acid gas (vol %)	(CO_2)	3.68	0.688
Nitrogen (vol %)	(N_2)	0.45	0.385
Hydrogen Sulfide (vol %)	(H_2S)	-	
Methane (vol %)	(CH_4)	85.09	92.776
Ethane (vol %)	(C_2H_6)	8.44	4.117
Propane (vol %)	(C_3H_8)	2.17	1.211
Butane (Vol %)	(C_4H_{10})	0.16	0.529
Pentane (vol %)	(C_5H_{12})	0.01	0.165
Hexane (vol %)	(C_6H_{14})	-	0.138
Specific Gravity		0.6556	0.607 at 60 °F
Calorific Value (kcal/Nm³)		9,506	9,545 kcal/m³ at 60 °F

4-1-3 Light oil

Light oil is used at the unit start-up from the boiler light-off until the generator is synchronized, and also light oil is used in the emergency gas turbine generator.

Light oil of different grade is used for the bulldozers for coal handling.

1) Properties of light oil

		Gas Oil	Diesel Oil	Light Oil
Specific Gravity (15/4°t)		Min. 0.82	Min. 0.840	Min. 0.85
		Max. 0.87	-	-
Color ASTM		Max. 4.5	-	-
Flash Point P.M Closed (°C)		Min. 55	Min. 65	Min. 65
Viscosity Red I(d) 100 (°F)		Min. 30	-	-
	(37.8°C)	Max. 45	Max. 60	-
Pour Point (°C)	Winter (2)	Max. 4.5	Max. 13	Max. 4.5
	Summer (2)	Max. 10	Max. 16	Max. 12.5
Sediment (% wt)		Max. 0.01	Max. 0.1	-
Water Content (% vol.)		Max. 0.15	Max. 0.25	-
Ash Content (% wt)		Max. 0.01	Max. 0.03	-
Conradson Carbon (% wt)		Max. 0.1 (1)	Max. 2.0	Max. 0.08
Total Sulphur Content (% wt)		Max. 1.5	Max. 2	Max. 1.0
Calorific Value (Gross)		10,550 kcal/kg	10,250 kcal/kg	10,900 kcal/kg

Note: (1) On 10% residue from distillation

(2) Winter: From 1st of November to end of March

Summer: From 1st of April to end of October

2) Light oil consumption

For 10 starts and stops from cold state per year: 700 kl

For 7 days operation of emergency gas turbine generator per year: 1,100 kl

Total: 1,800 kl

For bulldozer operation per year: approx. 50 kl

3) Transportation of light oil

Light oil is received from the refinery in Suez by tank lorries.

Pipe line transportation of heavy oil and light oil from the refinery to the power plant is not considered because of such problems as the route through Suez City and crossing of the Suez Canal.

4-1-4 Decision of Standby Fuel

As shown in Table 4-16, heavy oil production is increasing year by year and is exported. The oil refinery is situated in Suez City, approximately 10 km by sea from the power plant site. However, since there are problems in pipeline route through the City and across the Suez Canal, the installation cost of the pipeline will be high.

Stable oil supply will be maintained by transportation with oil tankers or berges.

As for the gas as a stadnby fuel, there are problems in gas transportation pipeline route, construction cost, etc. as described in subsection 4-1-2, 2) and in addition, the construction cost for the pipeline will be high, ¥200,000/m equivalent to US$870/m (1 US$=¥230). Therefore, heavy oil is selected for the standby fuel.

4-2 POWER PLANT AND HARBOR SITE, TRANSMISSION LINE ROUTE AND SUBSTATION SITES

4-2-1 Selection of Power Plant and Harbor Site

1) Conditions of Site Selection

For selection of the project site, the following conditions are considered.

a. Sufficient water for condenser cooling is available.

b. Industrial water is abundant and easily obtained. In case that the industrial water is unavailable, a desalination plant to secure fresh water for power plant operations will be established.

c. The site including areas for coal storage and ash disposal can be acquired and the configuration and area is adequate for expansion and for reasonable layout of the plant equipment, but not susceptible to natural disasters such as flood, high tide, salt damages, storm, etc.

d. Convenient for transportation of fuel. In case of transportation by sea, the coast conditions at the site such as moorage space, water depth, wave, etc., are favorable and suitable for construction of fuel unloading facilities. In case of transportation by freight car, access to the site is easy.

e. The power plant major equipment will be located on the foundation with an optimum soil/rock conditions to avoid damage due to non-uniform settlement of the foundations.

f. Substation will be located at site where arrangement for incoming/outgoing transmission lines is easy and construction works are simpler.

g. The length of interconnecting transmission line to the existing trunk line will be short and the construction cost will be low.

h. Transportation by sea and land is convenient for delivery of the equipment and the construction equipment and materials.

i. Countermeasures for environmental impacts by dust, smoke, vibration, noise, etc. will be considered.

j. Workers for construction works are readily available.

2) Selection of North Ayun Musa Site

Four sites were proposed for the power plant site, that is, North Ayun Musa, South Ayun Musa and Abu Zenima, on Sinai Peninsula, and El Galala and Zafarana on the Egypt Mainland, and El Arish at Mediterranean Sea side on Sinai Peninsula, El Dekhela and Damietta at Mediterranean Sea side on the Egypt Mainland as well as the above four sites were proposed for the sites of harbor facilities, but it was decided finally that the proposed sites would be limited within the Gulf of Suez.

Now the power plant and the imported coal unloading harbor will be in the Gulf of Suez and the transmission lines from the power plant will be interconnected with the existing 220 kV x 2 circuit trunk line to Cairo via Suez City. And thus, the power plant site was selected on these conditions.

As it is not economical to select the sites for power plant and harbor facilities at separate places, the basic idea that the power plant and harbor facilities should be located on the same site is adopted.

As a result of site survey and careful studies on oceanology, geographical and geological features, transmission line route, Suez Canal crossing point of transmission line and location of substation, North Ayun Musa was selected for this Project.

The features of North Ayun Musa Site is summarized the following.

a. Geographical and geological conditions

a) Power Plant Site and Transmission Line Route

The power plant site is located on the plain land with an area of 500 m x 1,200 m along the national road 66, approximately 1,700 m south-west from the survey point No. 10 to No. 17. The elevation of the site is approximately 2 m above sea level, and about 2-meter of banking for El+4.00 m of power plant ground elevation will be needed, and cutting off will be needed on the side of national road.

Construction of temporary facilities for construction and use of construction equipment will be very easy.

About one meter top soil of fine sand will have to be removed, but the soil deeper than 3 meters is suitable for foundation of power plant equipment and buildings. (cf. Figs. 4-11 and 4-12)

Bearing capacity of the soil deeper than 10 meters is expected to be sufficient for equipment foundation, but for safety, 20-meter piling will be made for foundation of major power plant equipment.

As for transmission line, the site is almost flat and setting of supports and stringing works of overhead transmission line will be easy. Suez Canal crossing points are on almost the same elevation, and geological conditions are same as at the power plant site, and so 20-meter piling will be sufficient for the foundations. The span of transmission line for canal crossing point will be approximately 1,000 meters, with the possible future widening of the canal taken into consideration.

b) Site for Harbor Facilities

The sea coast is a shoal beach from the power plant site to 2.7 km offshore at a depth of 6 meters, and therefore, the location of fuel unloading berth will be 2.7 km offshore, and causeway for transport of coal is necessary. Geological conditions of the bottom of the sea are almost the same as those of the power plant site, formed mainly of sand, sandy silt, clay, etc.

Therefore, dredging works of approximately 3,900,000 m^3 from the approach channel to Suez Canal to the unloading port will be relatively easy.

The soil produced by the dredging works will be used for banking of the causeway for fuel transportation up to power plant, and thus the construction cost will be minimized and the problem of disposal of the dredged soil will be solved.

As seen in the above, it was confirmed that North Ayun Musa Site was the best on the overall, and after consultation with EEA, it was decided to proceed with the Sinai Coal-fired Thermal Power Project to be located at North Ayun Musa.

The comparison of the proposed sites on the basis of the field survey is given on the following tables.

Table 4-17 (1) Summarized Data for Site Selection

	North Ayun Musa	South Ayun Musa	Abu-Zenima	Zafarana	Remarks
1. Location	Gulf of Suez coast on Sinai Peninsula	Gulf of Zuez coast on Sinai Peninsula	Gulf of Suez coast on Sinai Peninsula	Gulf of Zuez coast on Mainland Egypt	
Straight line distance from Zuez City	Approx. 6 km	Approx. 18 km	Approx. 120 km	Approx. 100 km	Distance from base town for construction works and point of interconnection of transmission lines.
Sea route distance from Suez Port	Approx. 3.5 miles (5.6 km)	Approx. 7.5 miles (12.1 km)	Approx. 65 miles (104.7 km)	Approx. 52 miles (83.7 km)	Distance from point of custom clearance of imported equipment and fuel.
Distance from Maghara Coal Mine	Approx. 230 km (by land)	Approx. 240 km (by land)	Approx. 320 km (by land)	Approx. 260 km (by land) 35 km (by ship)	Stable supply of fuel and transportation cost.
Route length of Interconnecting T/L	Approx. 42 km (across Suez Canal)	Approx. 54 km (across Suez Canal)	Approx. 167 km (across Suez Canal)	Approx. 130 km (along national highway on mainland)	Construction cost and maintenance of T/L.
Rank	(1)	(2)	(3)	(4)	
2. Site conditions 1) Power Plant	- Land of 1,200m x 500m for 1,200 MW Power plant can be secured. - Ash disposal area can be obtained. - No special working method necessary.	Same as left	Same as left	Same as left	Problems relative of plan, design, construction cost and execution of work.
	- Land slopes down gently over approx. 2,000m from National Highway. (El. approx. 11 m) - Favorable for access road, construction works and operation of plant after completion.	- El. approx 40 m near National Highway, El. 30 - 40 m at power plant site, steeply sloped coast line. - Land formation is relatively expensive. - Access road approx. 5,000 m. - No particular problem in construction works and operation after completion.	- Convenient location along National Highway. - El. approx. 20 m, gently sloped to coast. - No particular problem in land formation, access road and operation after completion. - Many sedimental rocks, and land formation and foundation works are rather expensive.	- Convenient location along National Highway on Mainland. - Plateau of El. approx. 30 m, and coast line is rather steep. - Many sedimental rocks, and land formation and foundation works are rather expensive.	

Table 4-17 (2)

	North Ayun Musa	South Ayun Musa	Abu-Zemina	Zafarana	Remarks
2) Harbor	- The shore is shallow and it is 2,700 m from the shore line to depth of 6.00 m. - 4,700 m to approach channel to Suez Canal. - There are no waiting area or dredged sand dump nearby. - 1.00 - 5.00 m of surface of sea bottom is covered mainly with sand sandy silt, and little developed coral. Lower layer is of mudstone and partially linestome. - Length of jetty; 2,700 m and dredging volume: 3,900,000 m^3 for 60,000 DWT coalers.	- Not so shallow as at North Ayun Musa, and about 500 - 1,000 m to a depth of 5.00 m. Coral has developed in widths of 300 - 500 m along the shore line. - Waiting area for ships passing the canal is located nearby. Also there is the dump area for dredged sand in the approach channel to the canal. - Geology is similar to that at North Ayun Musa, but coral has developed and there is fairly large quantity of limestons, and dredging and foundation works for the coal unloading berth would be costly. - Length of jetty: 1,000 m and dredging volume: 4,500,000 m^3 for 60,000 DWT coalers.	- Good location in the bay is already occupied by the petroleum port. - There is a railway along the shore line and shore is shallow with coral on the south side, and this side is not suitable for the site. On the north side of the petroleum port, 10.00 m depth is reached in 500 m from shore line. - Coral has developed and no waiting area nor dredging sand dump nearby. Proteciotn system for intake is necessary due to contamination from petroleum port - Max. wave height of 4.00 m should be considered in design. - Length of jetty: 300 m and dredging volume: 500,000 m^3 for 60,000 DWT coalers.	- Mountains of sandstone, limestone and mudstone draw near the shore, and the sea is shallow to some distance with sedimental rocks of the Mesozonic and Paleozonic Eras. - The depths are 10.00 m at 2,500 m from the shore line and 20.00 m at 3,500 m. - There is a military jotty adjacent to proposed site. - Sand and sandy silt deprosit thin on the bottom, and there are limestones underneath. Dredging may be difficult. - There is no waiting area nearby. - Max. wave height of 4.00 m should be considered. - Length of jetty: 2,500 m and dredging volume: 1,500,000 m^3 for 60,000 DWT coalers.	

Table 4-17 (3)

	North Ayun Musa		South Ayun Musa		Abu-Zemina		Zafarana		Remarks
3. Comparison of Construction costs									
1) Equipment	(393.4×10^6 US$) 1.00 - Base Rank (3)	0.67	0.98 (2)	Mainly, belt conveyer 1,700m shorter	0.95 (1)	Mainly, belt conveyer 2,500m shorter	1.00 (3)		See Chapter 7 for construction costs in ( ).
2) Civil & Architectural	(95.7×10^6 US$) 1.00 - Base Rank (2)	0.16	1.03 (3)	Mainly, land reclamation cost higher	0.98 (1)	Mainly, intake and discharge length shorter	1.00 (2)		
3) Harbor Facilities	(43.6×10^6 US$) 1.00 - Base Rank (3)	0.07	1.30 (4)	Mainly, dredging volume 600,000m^3 bigger	0.60 (1)	Mainly, jetty length 2,200m shorter	0.90 (2)	Mainly, dredging volume 2,400,000m^3 smaller	
4) Transmission & Substations	(56.1×10^6 US$) 1.00 - Base Rank (1)	0.10	1.11 (2)	T/L length 12km longer	2.14 (4)	T/L length 125km longer	1.46 (3)	T/L length 88km Longer	
	(588.8×10^6 US$)	1.00							

Table 4 - 17 (4) Rank Table

	North Ayun Musa	South Ayun Musa	Abu Zenima	Zafarana
Rank Location	(1)	(2)	(3)	(4)
Construction Cost				
Equipment	0.67	0.66	0.64	0.67
Civil & Architecture	0.16	0.16	0.16	0.16
Harbor	0.07	0.09	0.04	0.06
T/L & S/S	0.10	0.11	0.21	0.15
Total	1.00	1.02	1.05	1.04
Rank	(1)	(2)	(3)	(4)
Overall Rank	(1)	(2)	(3)	(4)

Table 4—17 (5)

Logic Diagram

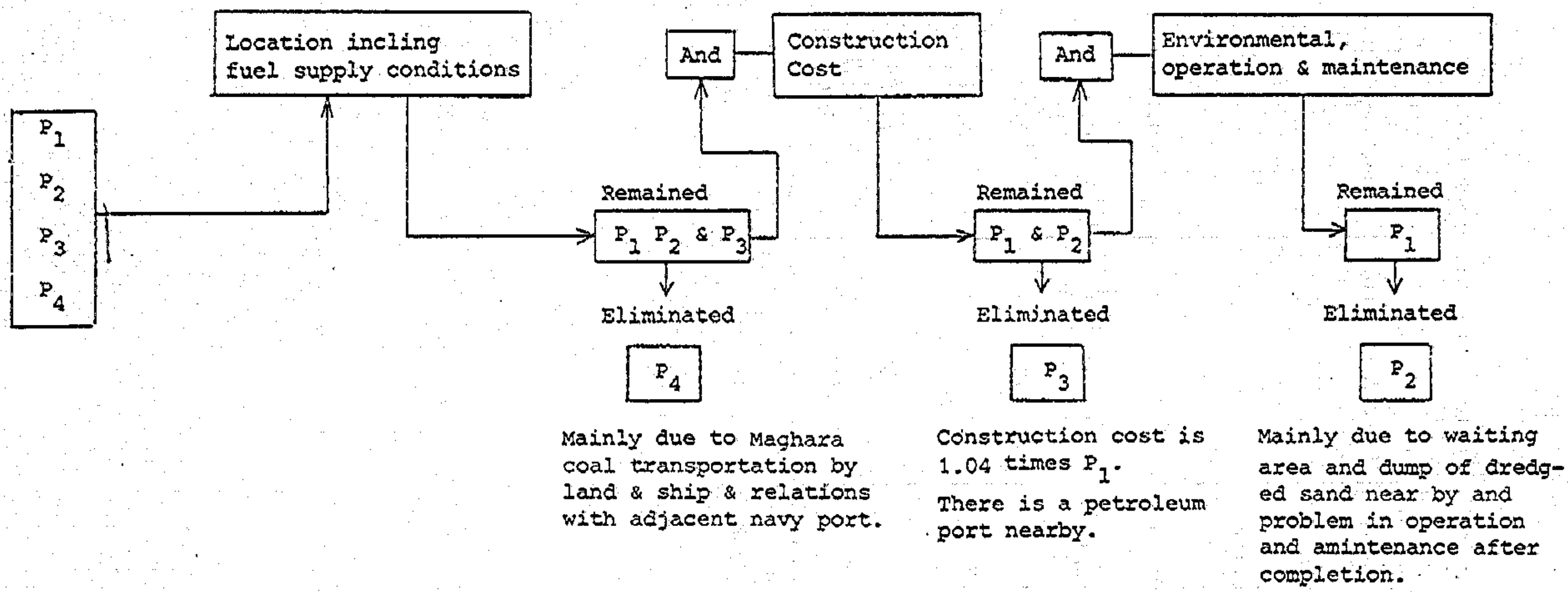
for decision of the site

North Ayun Musa P_1

South Ayun Musa P_2

Abu Zenima P_3

Zafarana P_4



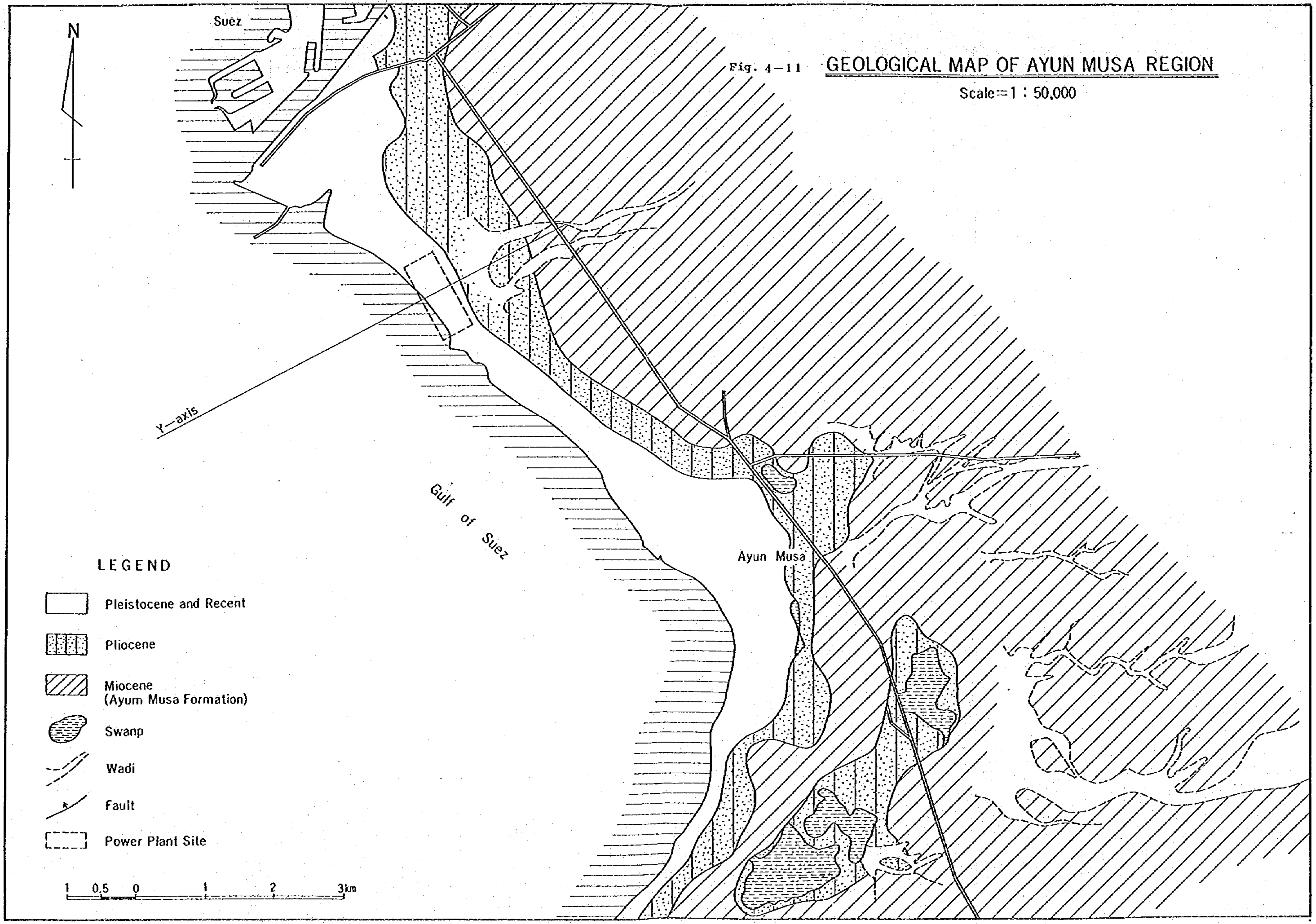


Fig. 4-11 GEOLOGICAL MAP OF AYUN MUSA REGION
Scale=1 : 50,000
N
Suez
Y-axis
Gulf of Suez
Ayun Musa
LEGEND
Pleistocene and Recent
Pliocene
Miocene
(Ayum Musa Formation)
Swanp
Wadi
Fault
Power Plant Site
1 0.5 0 1 2 3km

Fig. 4-12 Schematic Cross Section of Y-Axis

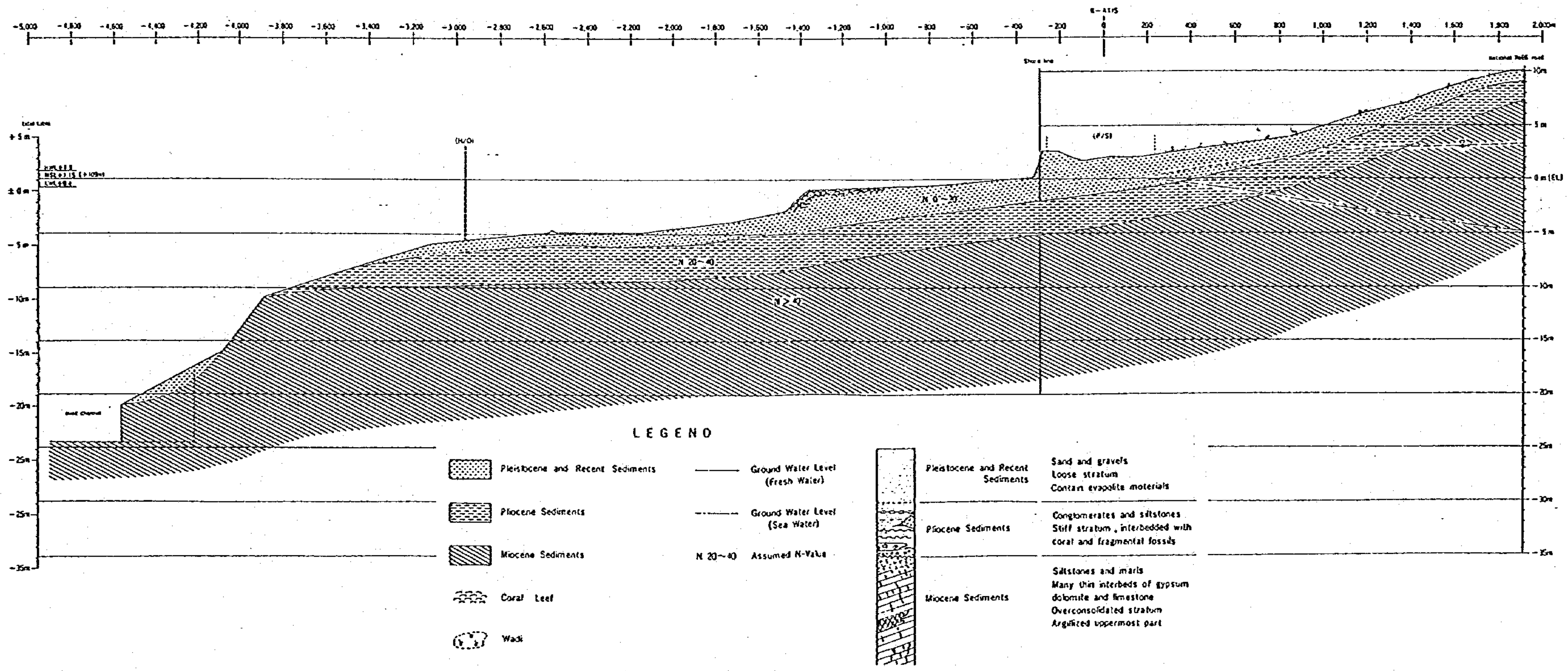
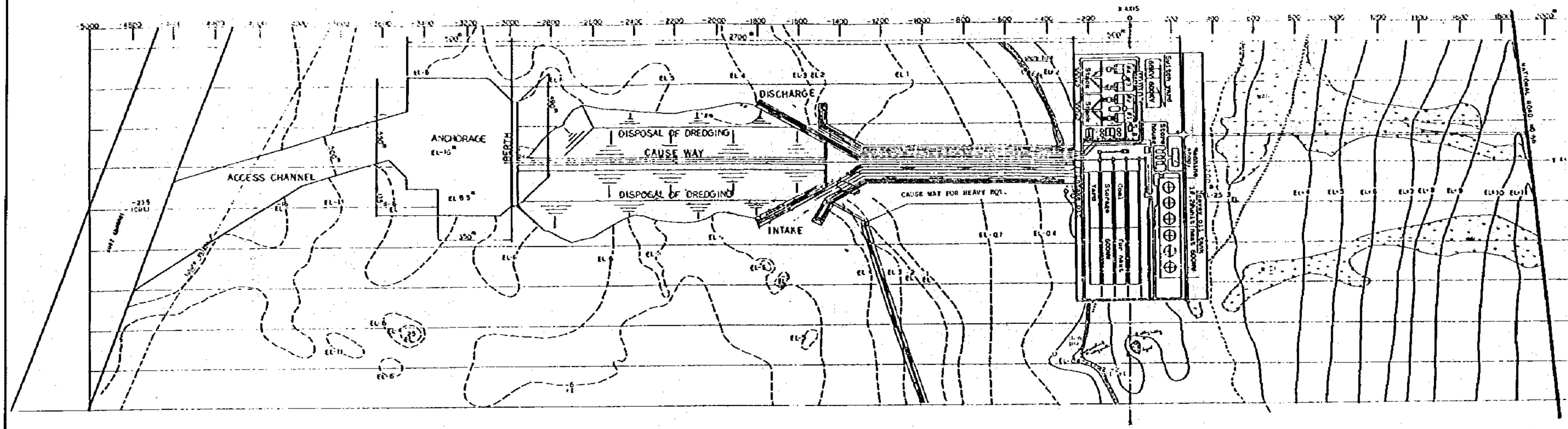
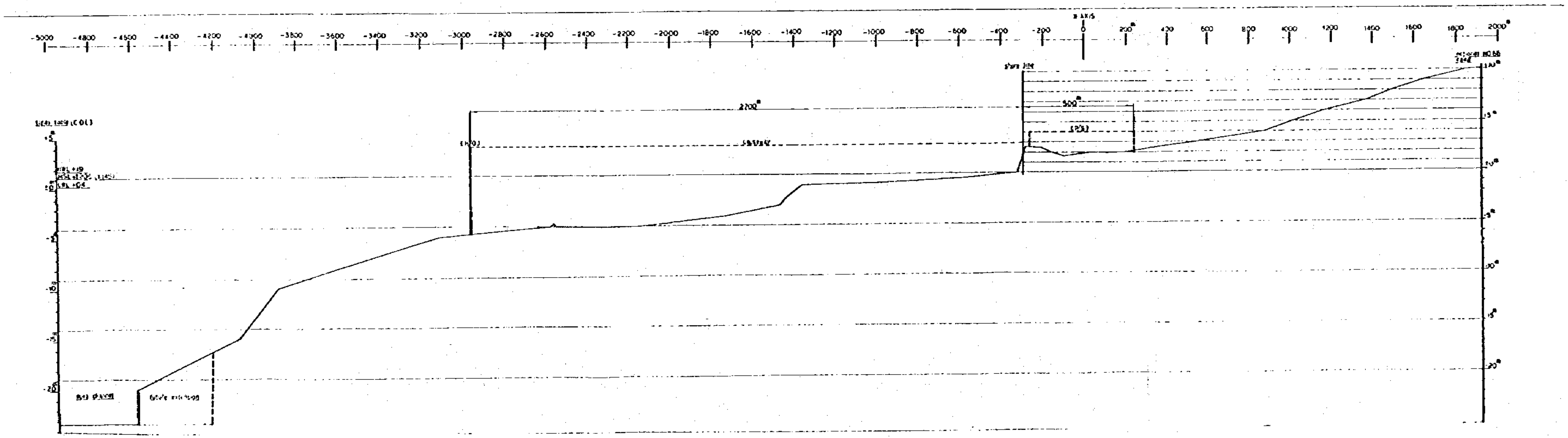


Fig. 4－13 General Layout of 1,200 MW Coal-Fired Thermal Power Plant





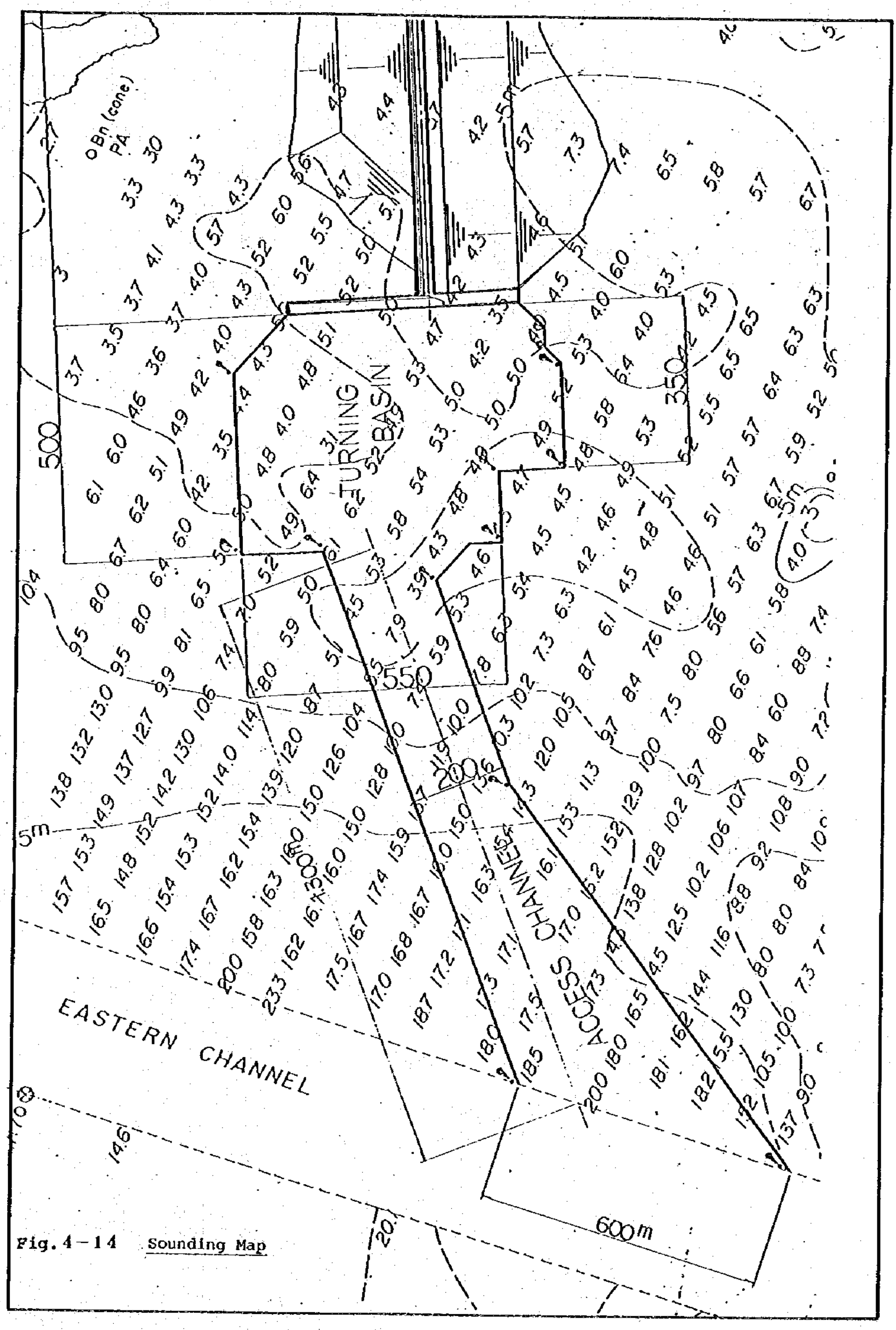
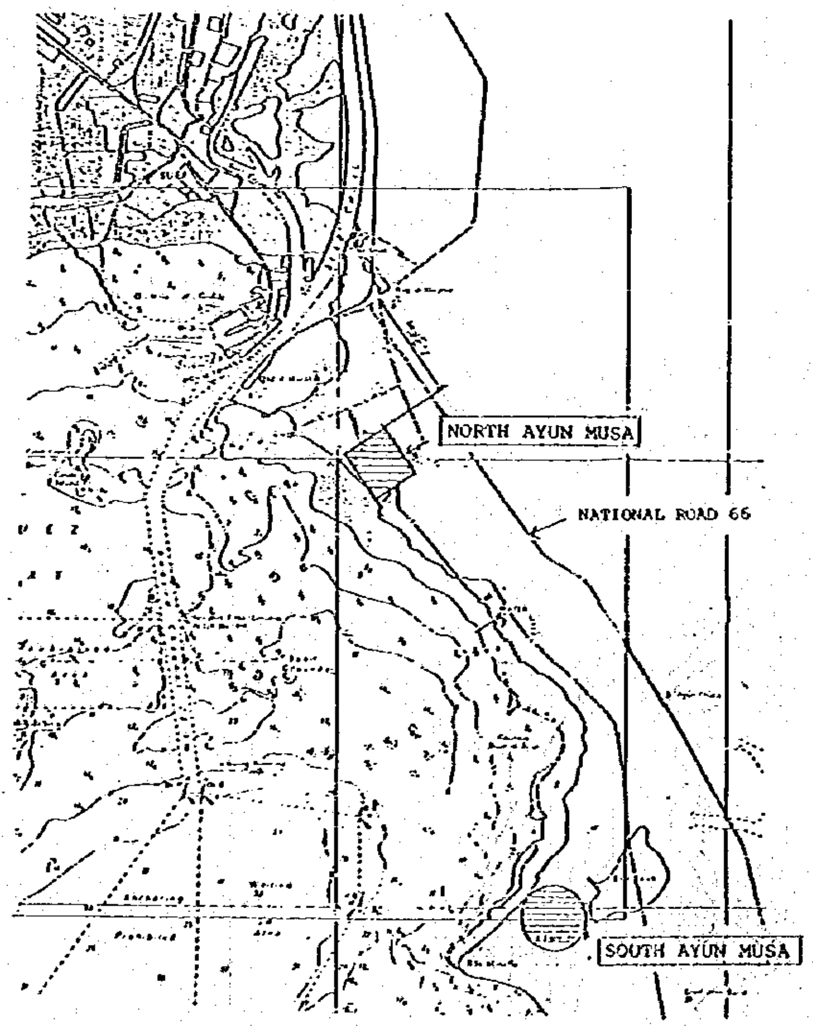


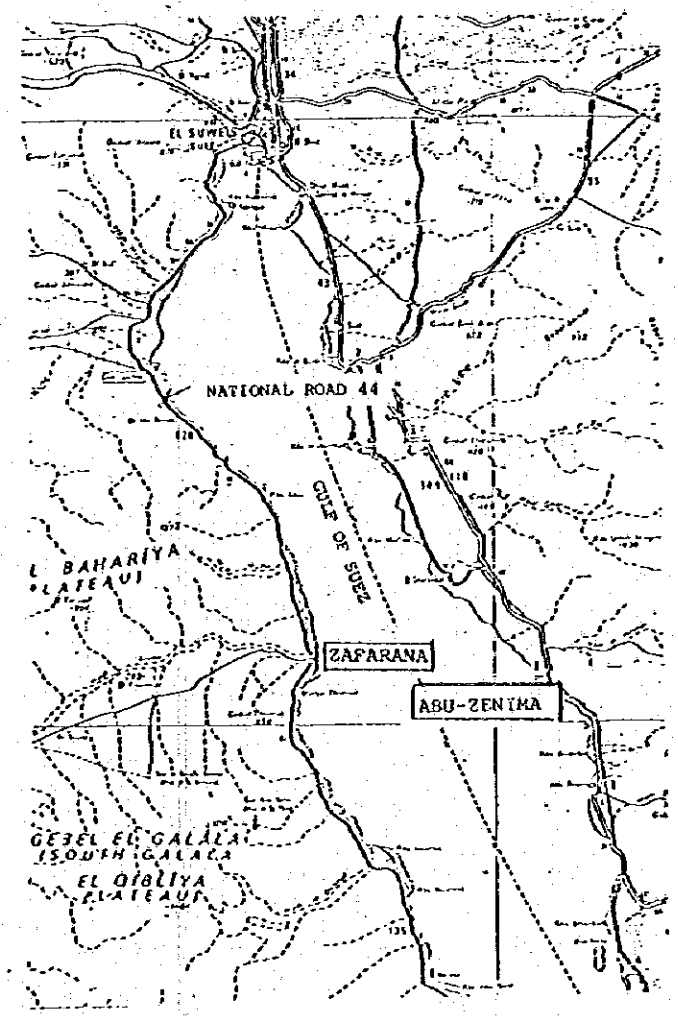
Fig.4-14 Sounding Map

Surveyed Data for Proposed Site

Table 4-18 Comparison Table of Power Plant and Harbor Sites

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
1. Location	- Approx. 8 km (straight-line distance) south-east of Suez City. Approx. 3.5 n.m by sea route from Suez Port Approx. 6 n.m. by sea route from Adabiya Port Approx. 21 n.m. by sea route from El Galala	- Approx. 18 km (straight-line distance) south-east of Suez City. Approx. 7.5 n.m. by sea route from Suez Port Approx. 9 n.m. by sea route from Adabiya Port Approx. 18 n.m. by sea route from El Galala	- Approx. 120 km (straight-line distance) south-east of Suez City, and approx. 170 km from Suez City by National Highway 66. Approx. 65 n.m. by sea route from Suez Port Approx. 65 n.m. by sea route from Adabiya Port Approx. 53 n.m. by sea route from El Galala	- Approx. 100 km (straight-line distance) south of Suez City and approx. 135 km from Suez City by National Highway 44. Approx. 52 n.m. by sea route from Suez Port Approx. 53 n.m. by sea route from Adabiya Port Approx. 38 n.m. by sea route from El Galala





	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
2. Conditions around Proposed Site	- Located between National Highway 66 and Gulf of Suez and is surrounded by the desert. There are military camps on the other side of the highway.	- Located near Ras Misalla on the Gulf of Suez side of National Highway 66, and is in the desert. There is no house nearby.	- Abu-Zenima is a small town of 200 - 300 houses, and there is a small berth nearby for shipping of manganese ore. - There are sea-bottom oil pumping rigs off Abu-Rudeis at about 20 km south of Abu-Zenima. - Apartment housing is under construction in Abu-Zenima, and coastline of 20 - 30 m depth (by sounding map) is already occupied. The north side of the proposed site faces shallow sea.	- Located between National Highway 44 and Gulf of Suez and on the opposite shore across the Gulf from Abu-Zenima. - There are practically no houses nearby. There is a military berth (400 m L x 8 m W x approx. 5 m deep) at about 1 km south of the proposed site, guarded constantly by the army.
3. Land				
(1) Availability of necessary area	- Necessary area for the power plant of approx. 1.2 km x 500 m for ultimate capacity of 1,200 MW can be acquisitioned. - Ash disposal area can be obtained in the sea in front.	- Necessary power plant area can be obtained. - Ash disposal area can be obtained in the front sea.	- Necessary power plant area can be obtained. - Ash disposal area can be obtained in the front sea, but influence of waves must be considered.	- Necessary power plant area can be obtained. - Ash disposal area can be obtained in the front sea, but influence of waves must be considered.
(2) Topography	- The land slopes down gently from the Highway (El +8 - 11) towards the sea.	- The elevation is about 20 m higher than North Ayun Musa Site. The land is highly undulated and grading will be expensive.	- The land is flat.	- The land is flat, but the ground level is low, and some filling may be necessary in consideration of waves.
(3) Geographical features and geological conditions	- Two or three raised terraces of different levels at less than 40 m in elevation are formed. - Edges of terraces make steep cliffs. - Geology is Miocene sediments, pliocene sediments and Pleistocene-Recent sediments. - Favorable conditions for power plant foundation.	- Same conditions as at North Ayun Musa.	- Platform of less than 30 m in elevation. - Geology is Miocene sediments, and Pleistocene-Recent sediments. - Favorable conditions for power plant foundation.	- Platform of less than 30 m in elevation. - Geology is mainly Miocene sediments - Hard Miocene sediments crop out. - Hard Miocene sediments may be difficult to excavate.

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
4. Meteorology	The meteorology of all the 4 proposed sites is similar to each other. North wind predominates, and NW and NE wind is the second dominant wind. According to the data collected, the NW, N and NE winds are 72 - 77% of the winds and south wind is very rare. The strong wind direction has the same tendency, but wind velocity of more than 3 m/s is very rare. The maximum gust of wind is in the north-westerly direction and approximately 29 m/s. The entering and leaving of port by ships and loading and unloading would be affected very little by the wind. Temperature, rainfall and humidity conditions are omitted.			
5. Conditions of Sea Coast	Gently sloped shore continues into the sea at a slope of less than 10°, and the sea bottom is sloped still more gently. There is a rather steep slope at 600 - 1,000 m from the shore, over which the slope is gentle again towards Suez Channel. The depth reaches 5 m at 1,200 - 1,700 m off shore. At low tide, 400 - 500m distance from the shore is dried, showing hardened asphalt at places, sometimes including small gravels.	The conditions of the sea coast are similar to those at North Ayun Musa.	The shore within the bay is composed of small gravels and sand, and slopes sharply down into the sea. The shore of the proposed site is composed of sand, and the sea is shallow for some distance from the shore. The marine chart shows distribution of coral reef.	The shore is composed of fine sand and the sea is shallow for some distance from the shore. There are sand banks. There is a 500 m long jetty with the tip bent in the south, which was built by the army and used for unloading. The base of the jetty is buried in the sand.

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
6. Conditions of Sea and Soil Conditions at Sea Bottom	Suez Channel runs at 2.5 - 4.0 km off the coast line and there are 2 wrecked ships at the middle of the distance. According to the chart there is a relatively deep inlet of -5 - -10 m depth in front of the site, but it was confirmed in the field survey that this inlet had been buried with dredged sand at the time of repair of the Channel, and there is no inlet any more. If a pier for 60,000 DWT vessels is to be built, a large quantity of dredging would be necessary, or the pier has to be built fairly off the coast line, requiring a long coal hauling distance. If it is 120,000 DWT vessels, the dredging quantity would be still greater, and the plan might be affected by the Suez Channel expansion plan.	North side of the front sea area is made a dumping area. The area 2 - 3 km off the coast is a waiting area for ships passing the Suez Channel. The marine chart indicates that the slope of the sea bottom is fairly steep. In the northern part where coral reef has developed, the depth increases suddenly at the edge of the reef. Thus the north side is not suited for construction of port facilities for large vessels. Rather, the south side is suitable for the port for large vessels. If 120,000 DWT class vessels are to be considered, it would be extremely difficult to establish the route unless it is planned on the south side.	The sea area within the gently curved bay are already occupied by vested rights and parallel piers, jetties, and other port facilities have been built. Only the unoccupied area mentioned before can be considered as the site. The sea bottom is sloped very gently until 1.0 - 1.5 km off the coast and becomes abruptly deep, showing the characteristic features of coral sea.	There are no obstructions in the front sea area. The sea abounds in coral reef according to the marine chart, and is relatively shallow as far as 1.5 - 2.0 km off the shore, where it gets suddenly deep. The conditions are supposed to be similar to those at Abu-Zenima. Here, too, the coal handling distance would become long if port facilities are to be built, and break water facilities would be needed, with increased construction cost.

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
Soil conditions at sea bottom	According to data related with the dredging of Suez Channel, the sea bottom is composed of soil containing sand, mudstone and some coral, and dredging can be made with 5,000 PS - 9,000 PS pump boats. However, as there are limestones at some parts, such limestone areas should be avoided when planning the shipping lane and mooring area. In formulating the construction program, boring test, test piling, loading test, etc., should be performed.	The conditions are supposed to be more or less similar to North Ayun Musa. The north side has wide=spread coral reef, but it was learned that the coral reef in Suez Bay is generally thin in the layer and would cause practically no obstacle to the construction of port facilities. The same tests as for North Ayun Musa should be performed in formulating the construction plan.	The soil is considered to be composed of sand and coral, but as stated before, the coral reef in Suez Bay and Suez Gulf is generally thin in layer and the hardness is not too high. It would be possible to dredge in this area with the dredger for hard soil layers. The same tests as for North Ayun Musa should be performed here, too.	The conditions and countermeasures are practically same as Abu-Zenima.

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
7. Marine Climate 7.1 Waves	Suez Bay is surrounded by land on the north, east and west, and waves enter the bay only from the south. The sea is calm with occasional waves of 0.5 - 1.25 m wave height. Very seldom, the maximum wave height of 2.5 m seems to occur, but the significant wave height is a matter of 1.5 m, and liable to occur in summer most frequently, and next in winter, and very rarely in spring. Since the wave height is small and frequency is also small, the port facilities and unloading works would not be affected by the waves .	The sea on the north is the same as North Ayun Musa. The south side has open sea to the south-east and the wave height is a little larger than at North Ayun Musa, but the frequency seems to be as small as at North Ayun Musa. There would be practically no influence on large vessels, but with medium and small vessels, mooring and other facilities plan may need some consideration to be given to the waves.	The site is located on the western part of Sinai Peninsula, and the sea opens on NW, W and SW, and therefore, the influence of waves is much larger than at North and South Ayun Musa. The maximum wave height of approx-imately 2.5 m has been observed, and the frequency is larger than at Ayun Musa. Judging from the records of wind the frequency of SW and W waves is small, but the frequency of NW waves would be fairly high. It is estimated that the significant wave height may be 1.4 - 2.4 m. Some countermeasures against waves would be necessary for medium and small vessels.	The site is located at the eastern part of Mainland Egypt on Gulf of Suez, and the sea opens on the NE, E and SW. Therefore, the influence of waves is large as at Abu-Zenima. The wave height would be similar to Abu Zenima. The maximum wave height of 2.5 m or so is observed and the frequency is fairly high. It was learned in the field survey that waves of 4 m order occurred in March - April season. Since the sea faces the Red Sea on SE, the entrance of swell from the Red Sea is conceivable and some countermeasures of wave breaking would be needed for medium and small vessels. Even large ships may be affected by the swell in loading and unloading with resulting decrease in the availability factor, limitations in entering and leaving the port and staying might occur. The team was told that waves of 4 m would occur in March-April.

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
7.2 Current	There seems to be no comprehensive record of current observation, and according to observations by ships sailing the channel, the current is 1.5 knots at the spring tide and 0.5 knots at neap tide. The direction of current is towards north when flowing and towards south when ebbing. Judging from the drift of the sounding boat (about 32 GT), the current of the afore-mentioned order was felt by the team. The current would not affect the operation of boats.	Same as at North Ayun Musa.	It is supposed that there would not be much difference from North Ayun Musa.	It is supposed that there would not be much difference from Ayun Musa.
7.3 Littoral Drift	As far as the natural coast line was observed, no noticeable littoral drift was seen. However a considerable deposit of sand was seen on the north base of the jetty which had allegedly been used by the British Forces. As there was entirely no data on littoral drift, no clear judgement could be made. There is no source of littoral drift, such as rivers, on the land. On the other hand, it is said that there was no phenomenon of burying according to the comparison of sounding results before and after the maintenance dredging of Suez Port. According to the observation in the Gulf of Suez, there seems to be some littoral drift but not very conspicuous. After construction of harbor facilities, the littoral drift may be somewhat accelerated due to the change of sea bottom, but the details must be verified by model test. The waves that constitute the energy source of the littoral drift phenomenon are relatively small and not frequent, and the current is also small, and consequently, no large change in a short period is expected.		Some littoral drift is conceivable, because the waves are higher than at North and South Ayun Musa. There is no river supplying sand for littoral drift, but flying sand and collapse of sand banks are considered to be sources of littoral drift.	The conditions are generally similar to Abu-Zenima, but considerable littoral drift due to swelling is observed. Especially in front of the site, the sand bar extends far into the sea. The base of the pier constructed by the army is buried in littoral drift. Careful consideration needs to be given to the littoral drift at the time of construction of the harbor facilities.

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
8. Availability of Water				
(1) Condenser circulating water	- Water can be taken from the Gulf of Suez in front of the power plant. - Recirculation of warm discharged water can be prevented by locating the coal receiving berth in between the water intake and discharge.	- Water can be taken from the Gulf of Suez in front of the power plant. - Excavation in the coral reef would be necessary for the water intake.	- Water can be taken from Gulf of Suez in front of the power plant.	- Water can be taken from Gulf of Suez in front of the power plant. - Because of the littoral drift in the front sea area, special care must be exercised in the selection of condenser tube materials and others.
(2) Industrial water	- Approx. 2,000 tons/day of fresh water is not available, and installation of a desalination plant would be necessary.	- Same as left		- Same as left.
	(Sinai Development Authority has a plan to supply water from the Nile to Ayun Musa and Abu-Zenima via Suez (25,000 t/d initially and 50,000 t/d secondary), but as it is still in the planning stage, EEA intends to built its own desalination plant for this Project.			
9. Fuel Transportation				
(1) Coal	- It is planned that the domestic coal from Maghara will be transported by truck. The transporting distance is approx. 200 km.	- The transporting distance of Maghara coal by truck is approx. 212 km.	- The transporting distance of Maghara coal is approx. 320 km, and the road near the entrance to Abu-Zenima needs improvement (unpaved at present).	- The transporting distance of Maghara coal by truck is approx. 340 km. About 75 km of the road from Ain Sukhna to Zafarana is narrow and unpaved and needs improvement.

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
(2) Heavy oil	- Transportation by tanker or Barge from the refinery in Suez City is considered. - The distance from Suez City is 45 km by land and 3.5 n.m. by sea.	- Transportation by tanker or Barge from the refinery in Suez City is considered. - The distance from Suez City is 57 km by land and 7.5 n.m. by sea.	- Though there are oil wells in the sea off Abu-Zenima, there is no refinery. Therefore, it is necessary to transport oil from Suez City. - The distance from Suez City is approx. 170 km by land and 65 n.m. by sea.	- Transportation by tanker or Barge Suez City is considered. - The distance from Suez City is approx. 135 km by land and 52 n.m. by sea.
10. Transportation of Equipment and Materials				
(1) Unloading port	- If the equipment and materials are unloaded at Suez Port or Adabiya Port, they have to be transported on land through Ahmad Hamdi Tunnel, and in this case large equipment such as the generator and boiler drum cannot pass the tunnel. Therefore, custom clearance only will be made at Suez or Adabiya Port and the cargo would have to be transshipped by LST directly to the site.	- Same as left	- Same as left	- Because of very poor conditions of National Highway 44 for inland transportation of equipment and materials from Suez Port or Adabiya Port, transportation by LST directly to the site after custom clearance at Suez Port or Adabiya Port would be necessary.
(2) Inland transportation of locally procured equipment and materials	- The road from Suez City to Mohamad Hamdi tunnel is narrow (about 4 m) and has hair-pin curves, but a new road is under construction. - The road in Sinai Peninsula to Ayun Musa is wide and presents no problem.	- Same as left	- The road along Highway 66 is good upto El Garandal, but about 30 km from there to entrance of Abu-Zenima is unpaved and bad. Especially, the road at G. Hammam Faraum pass near the entrance to Abu-Zanima is steep and conditions are bad with gushing water.	- The road conditions are good over 55 km from Suez City to Ain Sukhna, but about 75 km from there to Zafarana is not paved and abounds in hair-pin curves, and some improvement is necessary for transportation of equipment. - The route from Cairo along the Nile and across the desert from El Wasta has good road conditions with enough width.

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
11. Environmental Impact	- The site is approx. 6 km in straight line distance apart from Suez City, and there would be no direct influence of the flue gas discharged from the stack.	- The straight line distance from the site to Suez City is 18 km, while the maximum concentration reaching the ground surface of the flue gas from the stack is 18 km on the lee. Thus some countermeasure must be taken against the influence.	- As the power plant will be located adjacent to the town area, countermeasures against flying dust and noises from the coal yard should be considered rather than the influence of the flue gas.	- As there are no dwelling houses nearby, no special environmental countermeasure needs to be considered.
Summary (Power Plant)	- The conditions are the most favorable among the 4 proposed sites, and there is no critical problem as the power plant site.	- Additional cost would be required for the environmental countermeasures and grading of the site.	- A large scale improvement of National Highway 66 would be necessary for transport of the equipment and materials and the domestic coal. - As the site is near the town area, the cost of environmental countermeasures against flying dust and noises from the coal yard would be high.	- A large scale improvement of National Highway 44 would be necessary for transport of equipment and materials and the domestic coal. - Countermeasures against littoral drift due to waves would be necessary and special material for condenser tubes such as titanium might be needed, resulting in cost increase. - Land filling will be necessary because the existing ground level is low.

	NORTH AYUN MUSA	SOUTH AYUN MUSA	ABU-ZENIMA	ZAFARANA
Summary (Harbor Facilities)	- From the view point of harbor planning, the oceanographic conditions are best among the 4 sites, but the sea area conditions are rather less favorable. Namely, the necessary dredging quantity would be larger and the sea transport distance of coal would be longer.	The north side is not suitable for the harbor, because there are already the dumping area, waiting area and other vested interests in the front sea area. The south side is a little inferior oceanographically to North Ayun Musa, but superior to the other two sites. The required dredging quantity is less than at North Ayun Musa and coal transportation route is shorter than for North Ayun Musa.	As the oceanographic conditions are not favorable, wave breaking measures and countermeasures against littoral drift would be necessary.	The oceanographic conditions are not favorable; probably less favorable than Abu-Zenima. The construction cost of harbor facilities would run considerably high, and the rate of operation may be lower than at the other sites.

Table 4-19 Comparative Table for Coal Center

ITEM	ADABIYA	EL GALALA
Location	Approx. 16 km from Suez City by land, approx. 5.7 n.m. from Suez Port by sea. Approx. 6 n.m. to North Ayun Musa by sea Approx. 9 n.m. to South Ayun Musa by sea Approx. 6.5 n.m. to Abu-Zenima by sea Approx. 5.3 n.m. to Za Farana by sea	Approx. 55 km from Suez City by land, approx. 21 n.m. from Suez Port by sea. Approx. 21 n.m. to North Ayun Musa by sea Approx. 18 n.m. to South Ayun Musa by sea Approx. 53 n.m. to Abu-Zenima by sea Approx. 38 n.m. to Za Farana by sea
Topography	This site is a nearly flat plateau facing Suez Bay on the east. There are mountains of 200 - 300 m height at several km to the west, and there are quarry sites of Suez Canal Authority at the foot of these mountains. The site is nearly flat, and slopes down gently to the seashore. The land for coal yard can be secured.	The site faces Gulf of Suez on the east, continues on the flat desert to the west and there stand steep mountains of 300 - 500 m close on the south. The land is nearly flat and slopes gently down to the seashore. Securing of necessary land for the coal yard would be easy.
Conditions of the Seashore	The seashore consists of coral mingled with gravels and the shore is contaminated with heavy oil. The land from the shore-line has deposit of fine sand. The slope of the sea-bottom is rather steep. The coal hauling route would become rather long, because of the existing jetty for cement and fishing port.	As approach to the site was prohibited, it was impossible to examine the conditions of the seashore. And judging by the marine chart, the sea in front of the site is formed of sand and coral reef, and shallow into a distance from the shore. Where the mountains on the south closes on the seashore and the highway runs close to the shore, the shore is formed of limestone gravels and the slope of the bottom is steep. The coal hauling route will be considerably long.
Conditions of the Sea	On the south, there is Adabiya Port beyond the cement jetty and on the north there is Ataka fishing port. The offing on the north side and the south side is a berth area for ships entering Suez Port and passing the Suez Channel. It is a matter of 1.1 km from the coastline to the -15 m depth line and the site seems to be rather favorable for less 50,000 - 60,000 DWT ships in Suez Bay. This area is planned for a recreation area in the future plan of Suez City.	At 2 places in the offing of several km from the coast, there are oil rigs and the oil is sent to the land by submerged pipes. Consequently, the south side of the site is already occupied by the petroleum facilities and closed to the public. And there are scattered military areas around the proposed site. Judging from the conditions of the seashore and the oceanographic conditions, the construction of harbor facilities would prove expensive here.

ITEM	ADABIYA	EL GALALA
Soil Conditions at Sea Bottom	According to the information regarding the dredging at Ataka Port, the bottom seems to be sand, coral and partly limestone. It is said that dredging with 6,000 - 9,000 P.S. dredging boats would be possible.	The soil near the surface of the sea-bottom is formed of sand and coral, and the deep soil may include limestone judging from the mountains on land, but dredging would be possible by the use of dredgers for hard soil.
Meteorology	Nearly same as at Ayun Musa.	Same as Ayun Musa.
Oceanographic Conditions		
Waves	Located within Suez Bay, the conditions are similar to those at Ayun Musa. Rather, as this site is better than Ayun Musa topographically, there would be no concern about waves. The rate of working on the sea is expected to be very high.	Similar to Za Farana, the influence of waves would be fairly large. Swell might come from the Red Sea, even though not frequently, and 1.7 - 2.8 m waves are conceivable. Also, waves of N and N.E. directions may occur frequently with high winds. Roughly estimated, waves of 1.7 - 3.5 m would have to be expected and refuge facilities and breakwaters would be necessary. The cost of construction of port facilities would be high and the rate of working rather low.
Current	No record of current observations was available, but it is estimated that the current would be a matter of 1.5 knots to the north at flowing tide and 0.5 knot at the south at ebbing tide.	It is estimated that the current would be similar to that at Adabiya.

ITEM	ADABIYA	EL GALALA
Littoral Drift	The conditions seem to be similar to those at Ayun Musa. There is no particular source of supply of drift sand, and the energy sources for littoral drift, such as waves, current, etc., are very weak, and the phenomenon of littoral drift is practically inconceivable. There is no sign of littoral drift observed on the seashore nearby.	Similar to Za Farana, the influence of waves is large, and flying sand, desert sand and fine sand from the shore make the supply sources for the littoral drift. The conditions of the sea bottom and seashore would change if the harbor facilities are built, and the phenomenon of the littoral drift may be accelerated. It would be necessary to study the littoral drift by model test before planning the construction.
Others		
Road Conditions	There is an asphalt-paved road of 8 m or so from Suez City and the road conditions are good. There is also a road connecting to the main highway between Suez City and Cairo City.	There is an asphalt-paved road of 8 m or so from Suez City to El Galala via Adabiya, and the road conditions are good.
Working Area	The acquisition of areas for working, batcher plant, materials storage, etc., is possible.	The acquisition of areas for working batcher plant, materials storage, etc., would be easy.
Summary (Harbor Facilities)	The oceanographic conditions are very favorable and the marine conditions are good, and this site is considered to be quite suited for the port facilities for ships of up to 60,000 DWT.	As both the oceanographic and marine conditions are not favorable, breakwater facilities and countermeasures against littoral drift would be necessary, and consequently, the construction cost of the harbor facilities would run high and the rate of operation would be low as compared with Adabiya.

4-2-2 Transmission Line Route and Substation Site

The site of the power station in the Project is determined considering the following conditions that Ayun Musa site is most preferable one.

i) Transportation condition from Maghara Coal Mine

ii) Construction of coal handling harbor for imported coal

iii) Construction of transmission system to the unified power system

Transmission lines route and substation site selected for the Project are as follows.

1) Transmission Line Route

a. Sinai Peninsula Side

A flat desert land is located between Ayun Musa power plant site and the canal crossing point, east side of the bank. The transmission line should go around the outside of the Suez city's expansion plan, as the governorate desired. So the canal crossing point should be located near the Ahmed Hamdi tunnel. The distance between power station and canal crossing point is 22.5 km. There is a wadi, width about 1 km, in the center of the route. But it looks no problem for the construction of 220 kV transmission line.

The east side bank of the Canal at crossing point is not so high. But around the bank, about 1 km width and 10m depth, the deposit sand of dredging form the canal is laid on. The transmission line route will be sellected along the road as near as possible considering construction works and maintenance.

There are four over crossing points of highway in the route. But to keep the height over the road is no problem.

Planned route of transmission line runs toward the north along teh canal from Ayun Musa to 142.8 km point of Suez Canal near the tunnel and then, turning to the east, crosses the canal, after that the line extends towards the southwest and terminates at the eastern slope of Gebel Ataka.

Since the zone along transmission line forms platform less than 40 meters in altitude, topographical figure is good condition for foundation of transmission tower. Geologically, Miocene sediments which are distributed at tower point is a favorable for foundation and construction.

As described the bove, there exists no difficulty in the execution of the Project. However, the following items should be investigated.

i) Thickness of unconsolidate stratum

ii) Heterogeneity of stratum

iii) Presence of limestone

b. The canal crossing point

The plan of overhead transmission line crossing over the canal is rejected by the Canal Authority with the reason that it is not desirable for the safety of navigation of ships through the canal.

Then the method of crossing canal should use cables through the duct which locates under the drive way of tunnel. The length of cable is 2 km including drau-out duct at both ends of tunnel. The crosssection figure at west side entrance and topographical layouts of both entrances of tunnel are shown on Fig. 4-15, 4-16 and 4-17.

c. From the west side bank of canal to New Suez substation

A cable system through Ahmed Hamdi tunnel is used for the crossing canal from Sinai peninsula to west side main land. Cable terminal station at west side locates near the managing office of the tunnel. The transmission lines run directly western direction from the terminal station and turns left to south after crossing Suez-Ismailia high way upto New Suez substation. The length of the line is 16.5 km.

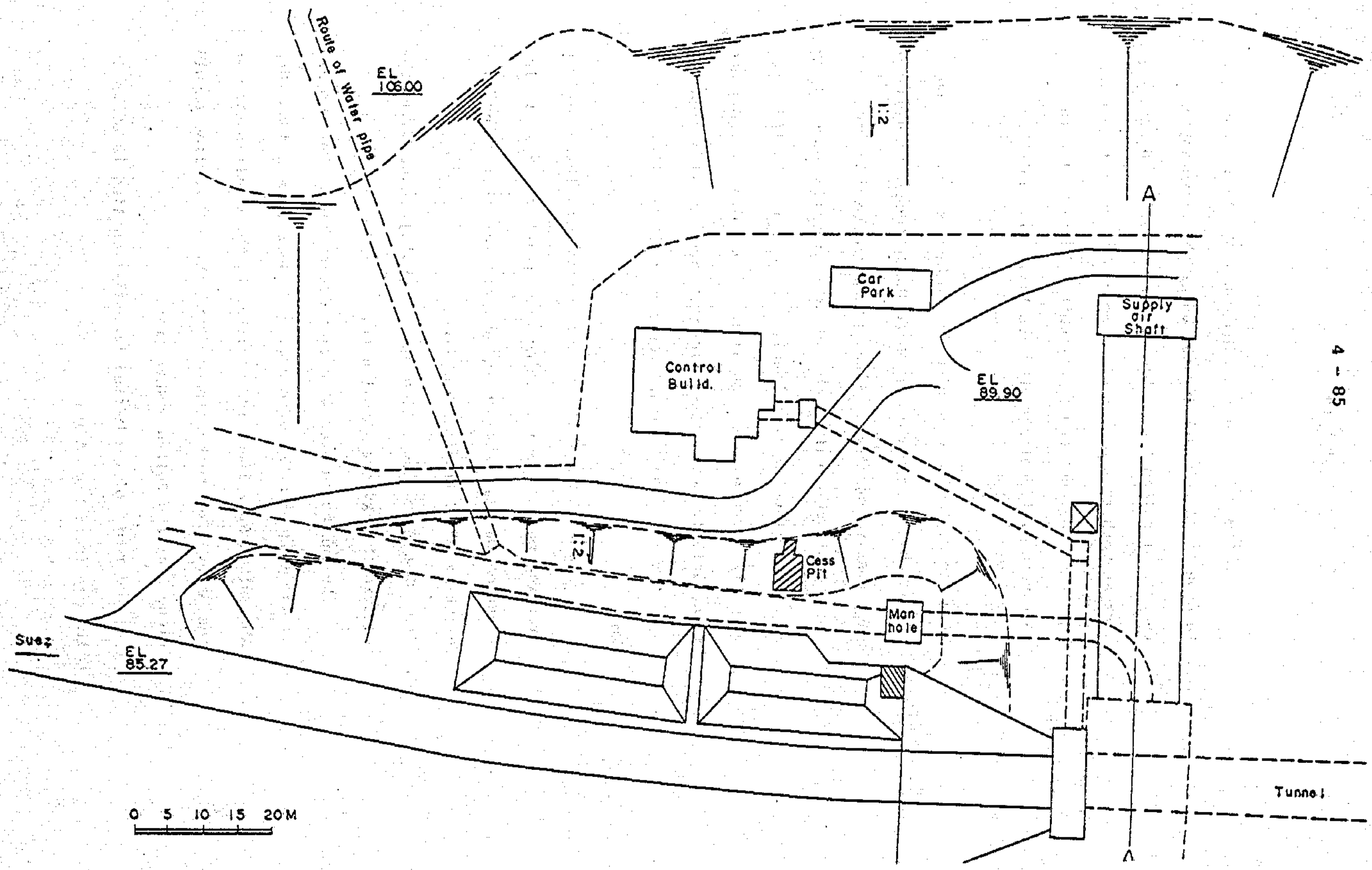
There are tow railway crossing points, three highway crossing points, one crossing over point for a small irrigation canal, width 10 m, and one crossing point over existing 60 kV transmission line.

d. From New Suez Substation to a tapping point from the existing 220 kV transmission line

The subjected area is a flat desert land. But two 220 kV transmission lines, one Sakr - Suez line and another Abu Sultan-Suez line, run parallel in the southern side of the area. So, to be tapped from Sakr - Suez line should cross over Abu Sultan - Suez line.

The route of candidated transmission line is shown in the map (see: Fig. 4-18)

Fig. 4—15 WEST SIDE ENTRANCE



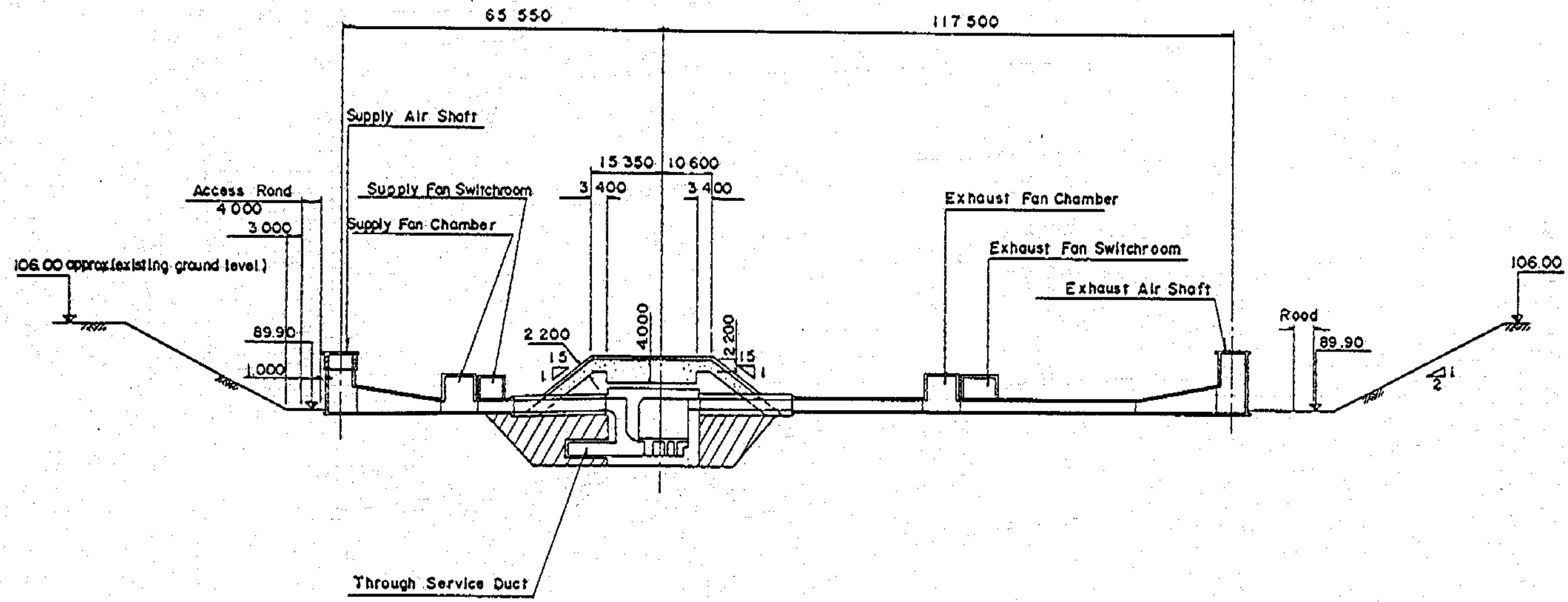


Fig.4-16 WEST END A-A SECTION

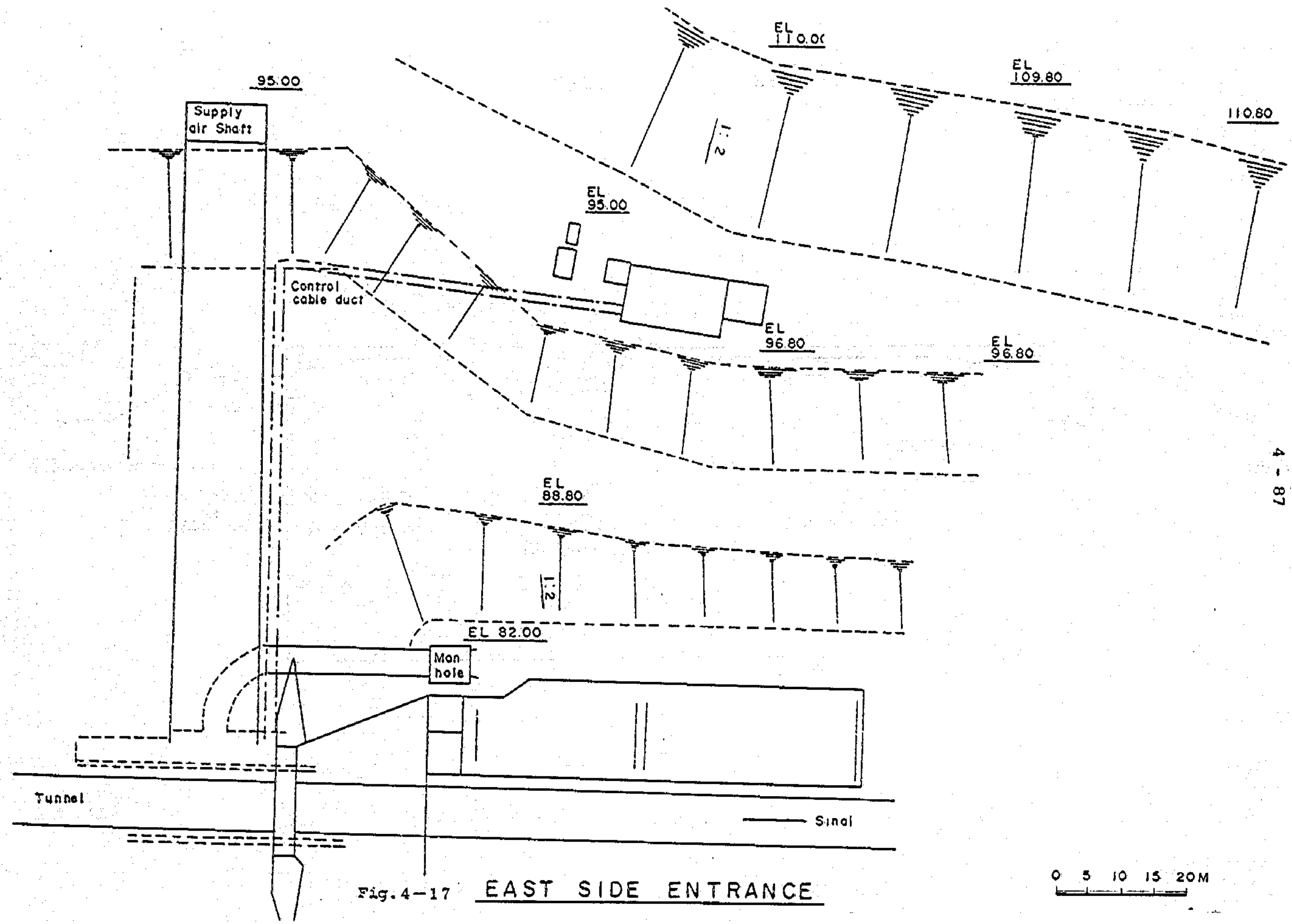


Fig.4—17 EAST SIDE ENTRANCE

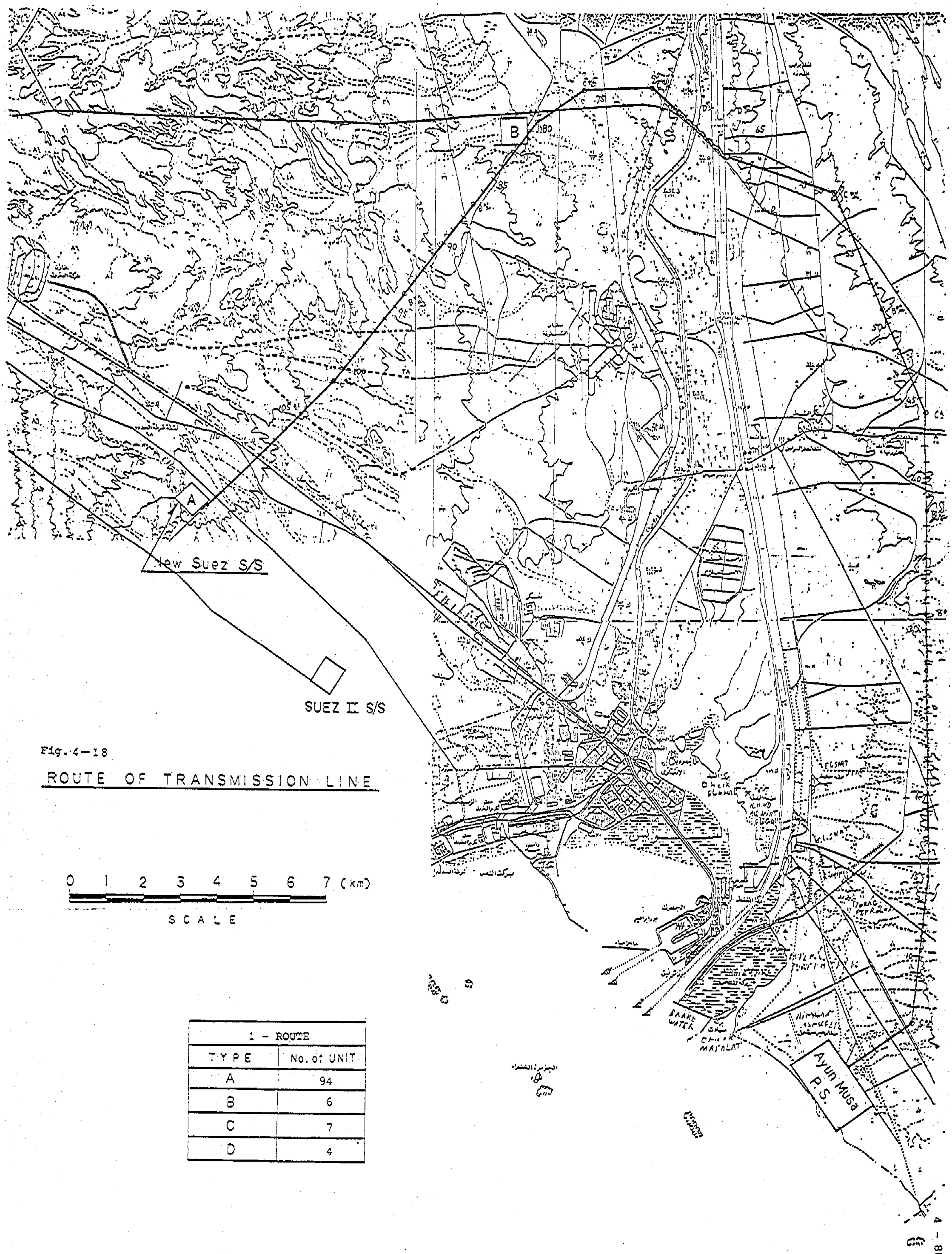


Fig. 4—18

ROUTE OF TRANSMISSION LINE

0 1 2 3 4 5 6 7 (km)

SCALE

1 - ROUTE	
TYPE	No. of UNIT
A	94
B	6
C	7
D	4

2) The Selection of Site for New Suez Substation

220 kV 2 circuits, 2 lines between Ayun Musa Power Station and the substation draw out from the station, and 220 kV 2 circuits each for Sakr Substation and for Suez Substation draw out, also. That is the substation is the interconnecting station between Ayun Musa and power station and the Unified power system on the 1st stage of the Project. (The capacity of ayun Musa Power Station is 600 MW.)

When Ayun Musa Power Station has an additional 600 MW unit, 500/220 kV transformers will be installed in the sub-station.

a. Location of the candidated sites

There are two candidated sites for the substation, one is A site and another B site, as shown in Fig 4-18.

A site is located along Cairo-Suez high way and B site along the branch way for Mohamed Hamdi tunnel. It will be easy for the transportation of construction materials and equipment at both sites. Topographic maps for each site are shown in Figs 4-19, 4-20. Both sites are located in a flat desert land and easy for their land reclamation. The area of each site is considered 600 x 600 sq. meter con-sidering future 500 kV yard extension and many 220 kV transmission lines' drawing outs.

b. Characteristics of A and B sites

a) Tie line for Ayun Musa power plant

The length of line is 40.5 km for A site and 30.5 km for B site. B site is shorter than A site.

b) The line from existing 220 kV line

The length of line is 1.5 km from A site and 7.5 km from B site. A site is shorter than B site.

c) 500 kV future tie line for Katamia substation

The length of tie line is almost same length for both site.

d) The characteristics for Microwave channel

There is no problem for both sites for the channel route to Sakr substation.

Considering the route of for Ayun Musa power plant, A site will be necessary for its route because many industrial factories are located between power station and substation.

Fig. 4-19

TOPOGRAPHICAL SURVEYING
A SITE (ALONG THE SUEZ-CAIRO NATIONAL HIGH WAY)

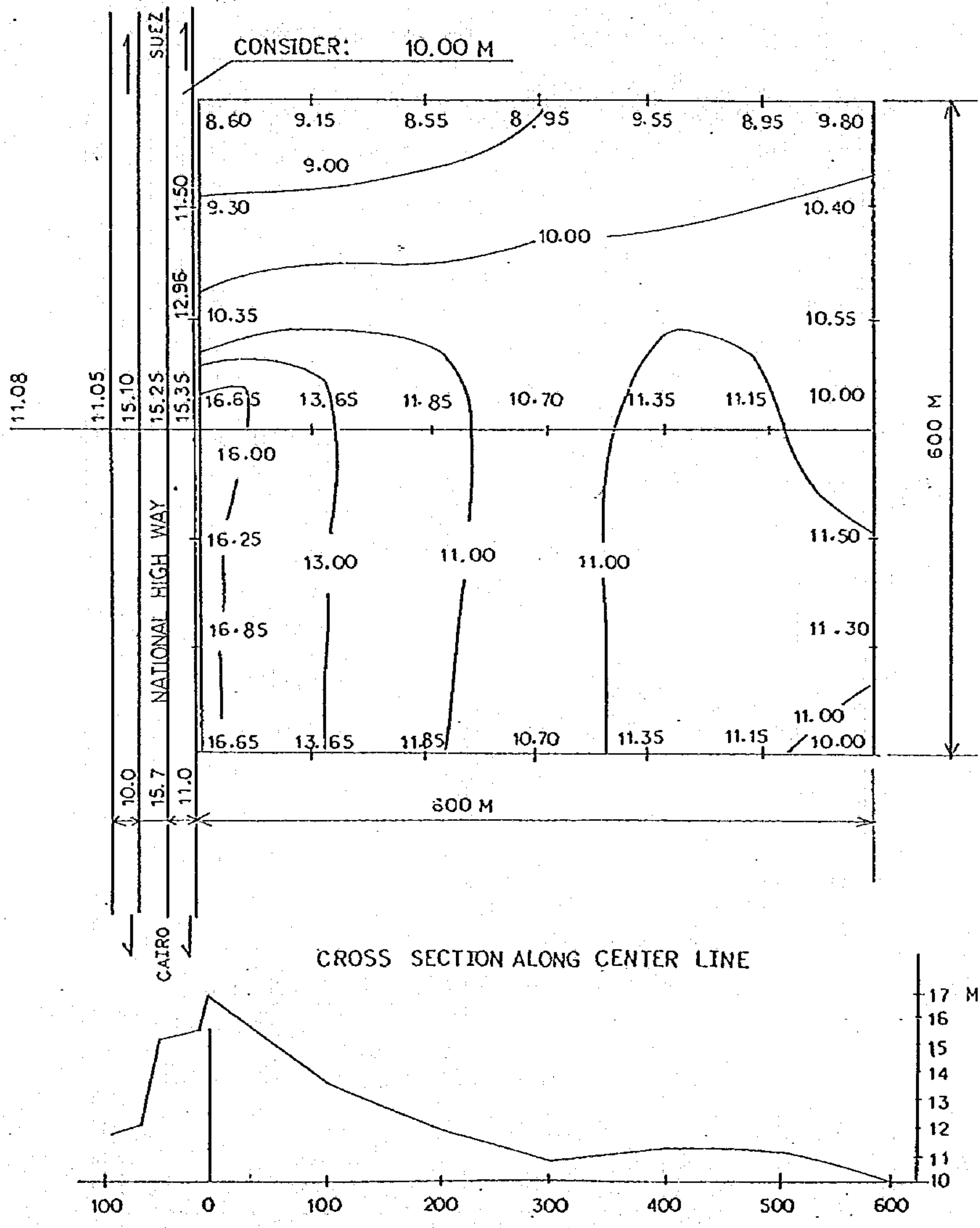
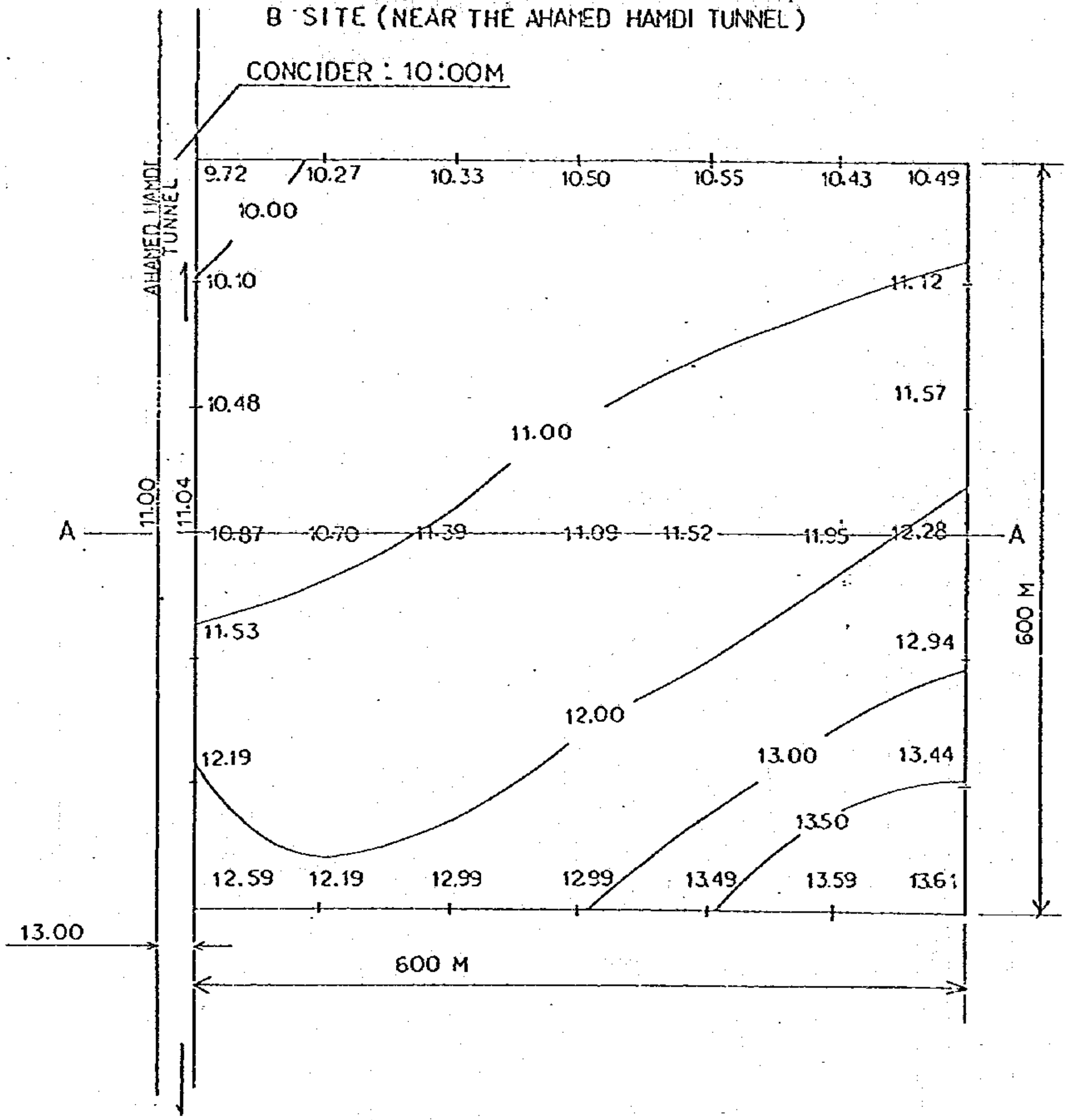
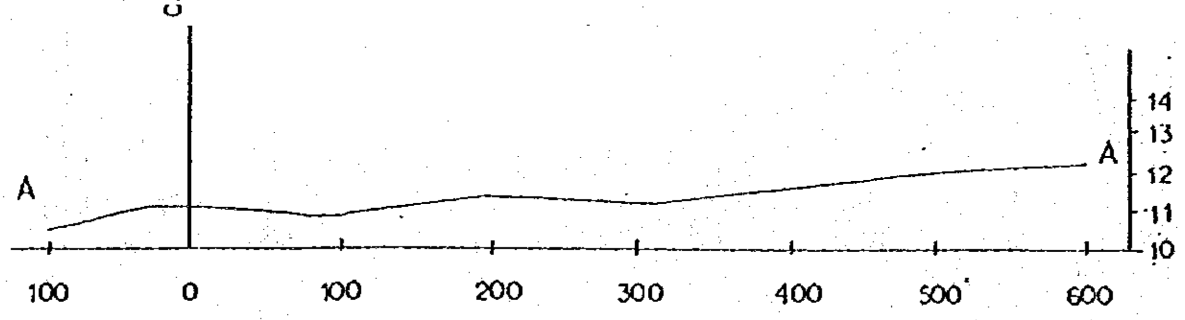


Fig. 4-20

TOPOGRAPHICAL SURVEYING
B SITE (NEAR THE AHAMED HAMDI TUNNEL)



CROSS SECTION ALONG CENTER LINE



e) Operation of substation

The location of A site is same side to Suez city that of Suez tr substation. B site is located northern corner of Suez city. In future distribution of power for Suez city, B site has some flexibilities more than A site.

c. Comparison of construction cost

The construction costs of both sites are shown in Table 4-20.

a) 2 route tapped system

A site is cheaper about 628 million yen than B site.

b) 1 route branch and 1 route drawing in system

A site is cheaper about 268 million yen than B site.

c) 1 route tapped system

B site is cheaper about 91 million yen than A site.

d. Conclusion

In future stage, the output of Ayun Musa power plant will become 1,200 MW. EEA is scheduled to construct one 500 kV line from New Suez substation to Katamia substation. It is enough to interconnect to existing 220 kV lines with "one route tapped and one route drawing in system" from the load flow study.

The construction cost for the system is cheaper than "two route tapped system.

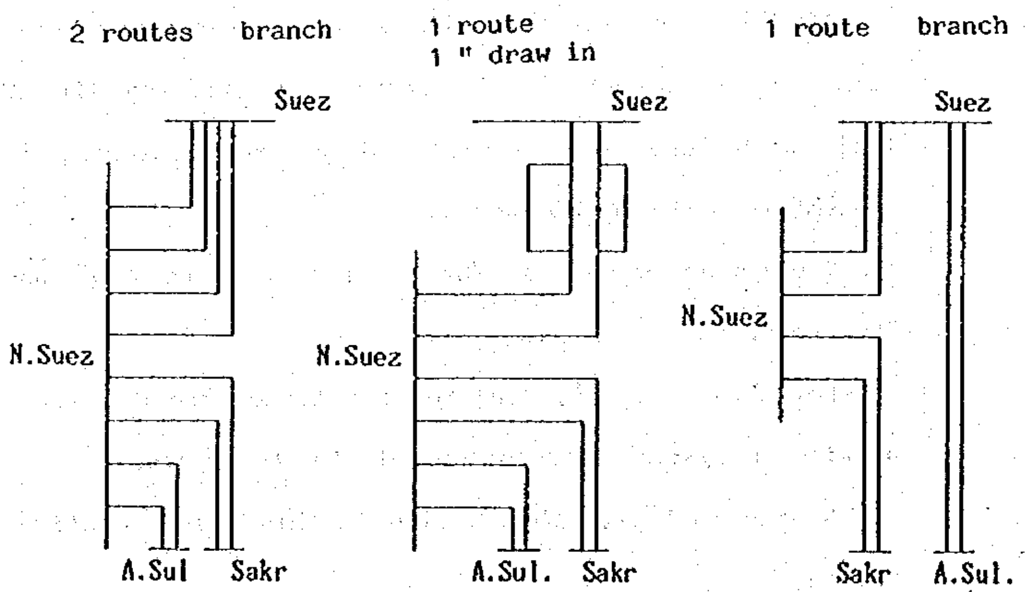
For these reasons, "one route t tapped and One route drawing in system" is recommendable for the system.

A site is better than B site in this system configuration.

Table 4-20 Comparison of Construction Cost Unit: million Yen

ITEM	A Site			B Site		
	2 routes branch	1 route 1 draw in	1 route branch	2 routes branch	1 route 1 draw in	1 route branch
Ayun Musa PS-New Suez ss 400 mm^2 x 2; 4 circuits	3,246.5	3,246.5	3,246.5	2,434.9	2,434.9	2,434.9
Suez Canal crossing O.H.L.	543.8	543.8	543.8	543.8	543.8	543.8
220 kV branch L.	288	216	144	1,728	1,296	864
C.B.;D.S.	408	306	204	408	306	204
Relay system (for branch)	1,168	876	584	1,168	876	584
P.L.C.	340	300	170	340	300	170
TOTAL	5,994.3	5,488.3	4,892.3	6,622.7	5,756.7	4,800.7

NOTE:



4-3 SELECTION OF UNIT CAPACITY OF 1ST STAGE (600 MW) OF SINAI COAL-FIRED THERMAL POWER PLANT

1) Reserve Capacity

As stated in Section 3-4, it is desired from the electric demand-supply balance that 600 MW will be installed in 1988-1989 and another 600 MW in 1990 under this Project. Two alternative unit capacities of 300 MW x 2 and 600 MW x 1 were compared for the first 600 MW from the view point of supply reliability in Egypt.

a. Power Sources Development Program

Case 1 represents the development program described in Section 3-4 in which the unit capacity of 300 MW is adopted for output requirements of over 300 MW in the 1988-1990 period, and Case 2 represents the case where the unit capacity of 600 MW is adopted for 1988-1990.

	Case 1	Case 2
up to 1982	4,077 MW	4,077 MW
1983 - 1987	300 MW x 5 110 MW x 2 150 MW x 10	300 MW x 5 110 MW x 2 150 MW x 10
1988 - 1990	300 MW x 8	600 MW x 4
Output in 1990	10,118 MW	10,118 MW

b. Peak Load

The peak load in 1990 is assumed to be 9,000 MW.

c. Supply Reliability

The number of allowed supply shortage days is set at 0.6 day/month/year (basic shortage probability: 0.02), and it is assumed that the supply reliability will be maintained by securing the stand-by capacity to make up this shortage.

Note: Standard scheduled shutdown rate for the whole facilities: 20%

The basic shortage probability of 0.02 corresponds to the unit shutdowns excepting the scheduled shutdowns, and does not include the standard scheduled shutdown rate.

d. Outage Rate

The outage rate of the thermal power plant is assumed to be as follows, from the past records(refer to APPENDIX-E).

Unit Capacity	Outage Rate
100 MW class	0.018
150 MW class	0.015
300 MW class	0.020
600 MW class	0.020

Under the above conditions and with the demand variations of ± 100 MW taken into account, the probabilities of troubles for the whole facilities become as shown in the following table.

Table 4-21 Probabilities of Troubles for Combination of Facilities

Peak Load	9,000 MW	
Case	Case 1	Case 2
Generators	110 MW x 2, 150 MW x 10	110 MW x 2, 150 MW x 10
Developed from 1983 to 1990	300 MW x 13	300 MW x 5, 600 MW x 4
Failed Power	Probability	Probability
1,000 MW	0.0000944	0.0001818
950	0.0047774	0.0091403
900	0.0122162	0.0205377
850	0.0151526	0.0232334
800	0.0152712	0.0233874
750	0.0168380	0.0267912
700	0.0187882	0.0310201
650	0.0195325	0.0325802
600	0.0352494	0.0638913
550	0.0511699	0.0952956
500	0.0519031	0.0961426
450	0.0606694	0.1004326
400	0.0715627	0.1057054
350	0.0757355	0.1076604
300	0.1635396	0.1467252
250	0.2524822	0.1871678
200	0.2936792	0.1906100
150	0.3426700	0.2438754
100	0.4115256	0.3100379

As seen in the table, with Case 1 for 0.02 of basic shortage probability (0.6 day/month/year), the probability is about 0.0352 for 600 MW of power failure and 0.0195 for 650 MW. In other words, the probability figure is larger than the basic shortage probability for 600 MW, showing that 600 MW is not sufficient to cover the power shortage. Consequently, with Case 1 the reserve capacity should be 650 MW or larger so that the probability may be less than 0.02.

With Case 2, as against 0.02 of the basic shortage probability, the probability of failure is 0.0205 for 900 MW and 0.00914 for 950 MW, and 900 MW is somewhat short as the reserve capacity. Therefore, 950 MW or larger reserve capacity would be needed.

From the above the necessary reserve capacity would be 650 MW or over for Case 1 (the case where 300 MW unit capacity is adopted for all 300 MW or larger units required in 1983 - 1987), and 950 MW or over for Case 2 (the case where 600 MW unit capacity is adopted for all 600 MW or larger units required in 1988 - 1990), and as long as the reserve capacity is concerned, Case 2 requires an extra installation of 300 MW (or about 223 x 10^6 LE of construction cost of an equivalent thermal power plant).

Thus, both Case 1 and Case 2 are technically possible for a stable power supply with possible reserve capacities. And therefore, for Sinai Power Plant to be commissioned in 1988/89, Case 1 or 300 MW x 2 units, requiring smaller reserve capacity, should be adopted from the economic point of view.

2) Economic Comparison between 300 MW x 2 Units and 600 MW x 1 Unit

In determining the unit capacity for the present project, an economic comparison of Case 1 and Case 2 was made by the generating cost (millimes/kWh).

The results are shown in Table 4-22.

The generating cost at P/S transformer end is 8.23 millimes/kWh with Case 1 and 8.30 millimes/kWh with Case 2, and Case 1 of 300 MW x 2 is more economical than Case 2.

Case 1 is more advantageous than Case 2 in the comparison of the annual operable hours of 300 MW x 2 and 600 MW x 1.

The salable energy at consumer end is 3,700.2 GWh with Case 1 and 3,467.4 GWh with Case 2, and the annual revenue is 56.7 million LE with Case 1 and 52.9 million LE with Case 2, and Case 1 is more advantageous, in this point too.

Table 4-22 Generating Cost Comparison between 300 MW x 2 and 600 MW x 1

Item	Unit	Formula	Case 1	Case 2
A. Unit Capacity	MW		320 x 2	638 x 1
B. Maintenance Period	days		42	52
C. Forced Outage	days		29(8%)	36(10%)
D. Availability	%	100x(365-B-C)/365	80	75
E. Annual Gross kWh	$\times 10^6$ kWh	A x 8.760 x D/100	4,485.1	4,191.7
F. Station Service Loss	%		6.25	6.0
G. Annual Available Energy at P/S Tr. End	$\times 10^6$ kWh	E x (1 - F/100)	4,204.8	3,940.2
H. Plant Efficiency	%		39	39
I. Construction Cost excluding T/L	$\times 10^6$ LE		464.2	441.0
J. Fuel Calorific Value	kcal/kg		6,500	6,500
K. Fuel Consumption	$\times 10^3$ ton	$\frac{860 \times E}{H \times J} \times 100$	1,521.6	1,422.0
L. Unit Price of Fuel	LE/ton		4.9	4.9
M. Fuel Cost	$\times 10^6$ LE	$K \times L \times 10^{-3}$	7.5	7.0
N. Operation & Maintenance Cost	$\times 10^6$ LE	I x 0.02	9.3	8.8
O. Administration Cost	$\times 10^6$ LE	I x 0.005	2.3	2.2
P. Depreciation	$\times 10^6$ LE	I/30	15.5	14.7
Q. Annual Cost	$\times 10^6$ LE	M + N + O + P	34.6	32.7
R. Generating Cost at P/S Tr. End	Millimes/kWh	$Q/G \times 10^3$	8.23	8.30
S. T/L and D/L Loss	%		12	12
T. Salable Energy at Consumer End	$\times 10^6$ kWh	G x (1 - S/100)	3,700.2	3,467.4
U. Salable Unit Price	Millimes/kWh		23.55	23.55
V. Revenue/kWh	Millimes/kWh	S-R	15.32	15.25
W. Annual Revenue	$\times 10^6$ LE	$V \times T \times 10^{-3}$	56.7	52.9

3) Conclusion

i. With respect to (1) reserve capacity, Case 1 can realize the same supply reliability as Case 2, with about 300 MW smaller reserve capacity.

ii. In the economic comparison in (2), although the construction cost of Case 2 is 5% lower than Case 1, the generating cost of Case 1 of 8.23 millimes/kWh is more advantageous than Case 2 of 8.30 millimes/kWh. And, the annual salable energy is 3,700.2 GWh with Case 1 and 3,467.4 GWh with Case 2, and the annual revenue is 56.7 million LE and 52.9 million LE, respectively, and Case 1 is more advantageous.

iii. Thus, with Case 1 of 300 MW x 2 units, more flexible operation and maintenance are possible than with Case 2, and the supply reliability is higher.

iv. In conclusion, even though both the cases are not much different economically, it is recommendable to adopt 300 MW x 2 units for this Project from the view points of less reserve capacity required, lower generating cost and more flexible operation in the total Egypt system.

4-4 THE SCOPE OF THE PROJECT

This Project covers the coal-fired thermal power plant of 300 MW x 2 units, the harbor for imported coal, the transmission lines from the power plant to the interconnecting point in the existing grid and other appurtenant facilities.

That is to say, the following facilities will be included in this Project.

Access road, land reclamation, embankment, intake and discharge facilities of condenser cooling water system, seawater desalination plant, boiler, turbine-generator and auxiliaries, coal unloading and transportation facilities, ash disposal facilities, drainage water treatment facilities, fuel oil facilities, coal storage yard, ash disposal pond, service building, machineshop, warehouses, transmission lines and substation facilities, communication facilities, fire fighting facilities, all safety measures, etc.

The minimum required facilities for future extension of 600 MW plant, namely, land reclamation, coal unloading and transport facilities, and intake and discharge facilities will be included in the scope.

4-5 ENVIRONMENTAL MEASURES

4-5-1 Basic Conception of Environmental Matters

In consideration of environmental impact of the construction of the thermal power plant, the environment of the construction site, living conditions, reliability of technology of pollution control, construction cost, etc. will be judged overall, and the most effective and economical pollution prevention measures will be taken.

In connection with this Project, the present situation regarding environmental problems in Egypt are taken into account, and countermeasures against atmospheric pollution, hot water discharge, waste water treatment including oil leakage, noise, and ash disposal waste water are considered.

4-5-2 Air Pollution Countermeasures

The greatest problems of air pollution with a coal-fired thermal power plant are dust and soot (SO_x) problems.

The countermeasures are described in the following.

1) Dust Countermeasures

Generally speaking, with pulverized coal-firing boilers, ashes may be divided into bottom ash falling into clinker hoppers of boilers, and fly ash caught at air preheaters and dust collectors, the ratios of the ashes being roughly 15 to 25% for bottom ash and 75 to 85% for fly ash. Therefore, in this Project, dust collecting apparatus will be installed to catch fly ash and prevent ash from scattering from the stack. There are mechanical dust collectors and electrostatic dust collectors, and for this Project, the electrostatic precipitators will be adopted in consideration of these high collecting capacity.

Dust Collector Type	Size of Dust Particles Collected
Electrostatic	Larger than 0.05
Mechanical	Larger than 10

2) Soot Countermeasures

Regarding soot problems, the influence on the environment of sulfur oxides (SO_x) due to combustion of the sulfur content in coal was studied on the basis of criteria in Japan.

Generally, the influence on the environment of sulfur oxides in exhaust gas can be judged from the relation between maximum ground concentration of SO_x and the environmental quality standard value for SO_x. The maximum ground concentration of SO_x in this Project, when calculated by the Sutton-Bosanquet formula is 5.4×10^{-2} ppm that the environmental quality standards of Egypt and USA EPA are amply satisfied.

4-5-3 Warm Water Discharge Countermeasures

The temperature of the condenser cooling water will rise 7°C through the condenser. This warm water will be cooled down to the temperature of the surrounding seawater by mixing and heat dissipation to the atmosphere. Relatively high discharge velocity will be adopted in an effort to increase the mixing dilution effect and to limit the affected area by the warm discharged water.

4-5-4 Treatment of Waste Water Containing Oil

In general, problems in waste water treatment at a thermal power station are with water from stacks, air preheaters and boilers during periodic inspections, discharge of regeneration water from the water treatment plant, and waste water from around the light oil equipment containing oil. The countermeasures for these are described below.

1) Countermeasures for Stack, air preheater and boiler wash water

These wash water discharges are of fairly high pH values at the early stages of washing. The wash water is led to a neutralization tank and neutralized to about pH 7.0 through injection of caustic soda (NaOH), after which it is discharged to the discharge tunnel.

2) Countermeasures for Regeneration Water Discharge from Water Treatment Plant

Of the water discharged daily, the greatest volume is made up of the regeneration water from the water treatment plant. This effluent water is produced at the time of regeneration of ion-exchange resins, and is alkaline.

The effluent is led to the neutralization tank, neutralized through injection of sulfuric acid (H_2SO_4) or caustic soda (NaOH), and discharged to the discharge tunnel.