Chapter 5. WORKING OUT AND COMPARATIVE STUDY OF ALTERNATIVE PLANS FOR DETERMINING AN OPTIMUM DEVELOPMENT PLAN

5.1 Basic Conception

The Feasibility Study on the West Wharf Thermal Power Plant Project has been carried out under the following basic conception, which was mutually discussed and agreed upon between KESC and the JICA Feasibility Study Team during the site survey period beginning on 23rd Nov. and ending on 21st Dec. 1987.

(1) Modernization (the first unit) of the plant will be completed before the end of 1992.

(2) 220 kV transmission lines will be constructed and connected prior to completion of the new unit.

(3) Power supply for the West Wharf region will be continued during the construction period of the new unit.

(4) Basically, it is desirable to decommission and dismantle "BX" station before starting the modernization work. Note, however, that the Feasibility Study has been carried out in case of the "BX" station is under commissioning throughout the construction period of the first unit.

5.2 Selection of Capacity, Type and Number of Generating Units for New Power Plant

According to the KESC intention of the project, one (1) or two (2) of 200 MW class units are planned to be constructed in the existing West Wharf Power Plant area with the target commissioning date of the first unit set for 1991/1992 as described in the previous Chapter (Chapter 4. POWER DEVELOPMENT PLAN). The unit(s) should have a capacity as large as possible in view of the KESC electric supply system as this will improve system reliability and stability as well as respond to the increased power demand.

Considering the limitted area available at the site and other restricting factors such as the cooling water quantity, fuel availability, environmental impact, etc., two (2) sets of 200 MW oil fired thermal power generating units are the most preferable plan.

To verify this conclusion, a comparative study has been performed, considering firstly all possible limitations and secondly devising an economic comparison study using the Net Present Value method.

5.2.1 Limiting conditions

As for the limiting conditions, the following items are investigated and surveyed for several development plans.

Items:

- Existing land availability
- Cooling water availability
- Fuel transportation and storage
- Environmental restrictions

(1) Existing land availability

Since no alternative site other than the existing thermal power station site (approximate site area: 37,000 m2) is available, the new thermal power plant should be constructed within the existing power plant.

The site area has an almost rectangular configuration approximately 120 m in width and 310 m in length.

Preliminary study of layout arrangements for several alternative power generating facilities has been made and it is found, even though the available site area is confined, that two (2) sets of 200 MW thermal power units are feasible for construction in this area.

In case one (1) unit is constructed, a larger unit, for example, a 300 - 350 MW thermal power unit, might be more suitable for this area.

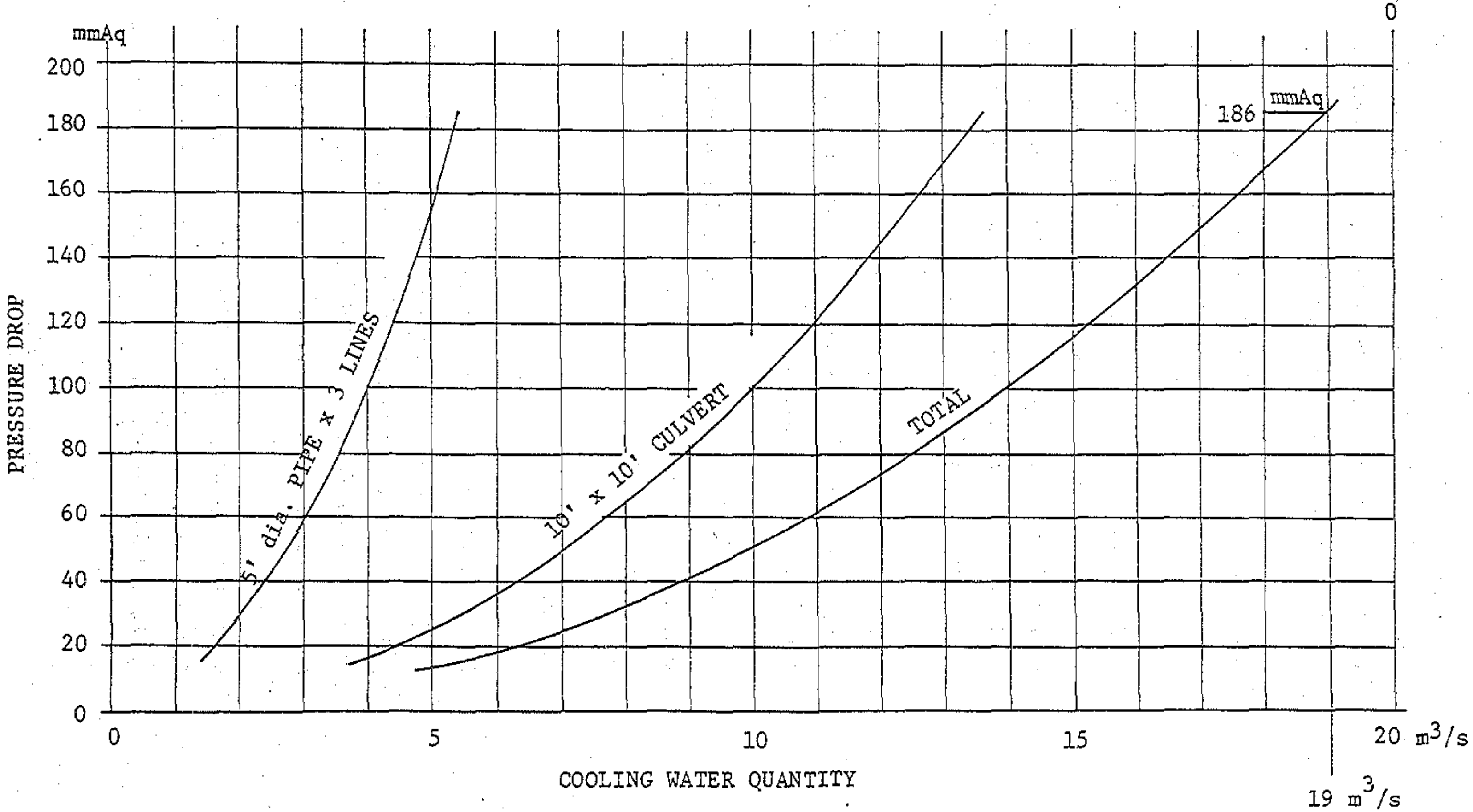
However, this plan is not recommended mainly because of the KESC system reliability and the results of the economic comparative study.

(2) Cooling water

The capacity of the cooling water intake tunnel will be studied on the assumption that the existing five (5) feet dia. x three (3) concrete pipelines are reused, together with ten (10) feet x ten (10) feet x one (1) concrete culvert already constructed but not yet used.

Estimated capacity chart (Fig. 5.2-1, "Existing Cooling Water Intake Lines Capacity") reveals that pressure drop through these intake water lines with enough cooling water quantity

Fig. 5.2-1 EXISTING COOLING WATER INTAKE LINES CAPACITY



(Note 1) for two (2) sets of 200 MW thermal power generating unit is within reasonable values and thereby allowing two (2) sets of 200 MW unit to be installed.

Note 1
In this calculation, sea water temperature rise of cooling water is assumed as 7° celsius for the upper limit but can be adjusted according to environmental requirements.

(3) Fuel transportation and storage

In the "CALTEX" area, adjacent to the West Wharf Power Plant, there exist one (1) 19,689 kl tank and one (1) 6,351 kl fuel oil tank available for KESC use. These facilities are sufficient for two (2) sets of 200 MW T/G unit. However, some modification and reinforcement of the facilities are necessary to serve as a reliable fuel oil supply source.

As for auxiliary fuel, the capacity of the existing natural gas, or auxiliary fuel supply facilities (for start up and low load unit operation), is 10 MMCFD (10 x $10^6 ft^3$/day). This capacity is sufficient for auxiliary fuel supply to a 200 MW class thermal power unit (up to about 40 MW load). However, the present capacity is not enough for a combined cycle unit of about 90 MW capacity or larger, without increasing the present quota of natural gas to the Power Plant.

At present, the total quota of natural gas for KESC is 74 MMCFD. If a larger amount than the present portion is required for W.W.P.P., rearrangement of the quota for KESC and within KESC would be necessary.

(4) Environmental impact

The environmental impact, supposing that a 200 - 400 MW oil-fired thermal power plants is installed in the West Wharf Power Plant, has been evaluated.

At present, no regulations governing environmental impact for Karachi City and vicinity have been issued or made available to us.

Nevertheless, major environmental impacts due to large thermal power plants comprise flue gas emission, waste water and thermal pollution of discharge water, etc., and these should be assessed.

In this project, as the sulphur content in the fuel oil is as high as 3.5%, air pollution due to SOx emission in the flue gas is foreseen.

Consequently, two (2) units of 200 MW oil fired thermal power plant, having a 140 m height of chimney, is evaluated to be sufficient for satisfying the on-ground concentration of 0.04 ppm of SO_2. This value is acceptable and is based on Japanese Environmental Regulations.

5.2.2 Economic Comparison of Alternative Plans

The economic comparative study of the respective alternative plans was carried out by calculating the net prevent values in contrast to the discount rate based on the net present value method. Then, the largest value of the present worth was selected. On the basis of the largest value, an optimum development plan has been selected taking into account the economic and technical factors.

As a result of executing economic comparative studies of the respective alternative plans, the following four plans have been selected by taking into account the results of studies on the major study items in the previous Clause 5.2.1 as follows:

Plan 1: Two (2) 200 MW oil-fired thermal power units

In view of the restriction in available site area, the maximum capacity power units which can be constructed at this site will be two (2) 200 MW class units. The Plan 1 for constructing two (2) 200 MW units has been adopted in consideration that construction of these two units will be low in construction cost and desirable in view of plant operation.

Plan 2: One (1) 300 MW oil-fired thermal power unit

This plan for constructing one (1) 300 MW unit has been adopted in consideration that it would be advantageous in view of cost performance (scale merit) to construct a large capacity unit.

Plan 3: One (1) 300 MW combined cycle unit

The combined cycle power unit is high in efficiency. In addition, a combination plan of 90 MW combined cycle unit and 200 MW oil-fired thermal power unit was proposed on the preliminary design stage of this project. The Plan 3 has been adopted as a representative plan among various combined cycle power unit plans.

Plan 4: One (1) 200 MW oil-fired thermal power unit

This plan has been adopted solely for economic comparison with the Plan 1.

As a result of economic comparative study of the above four alternative plans, the Plans 1 and 2 were evaluated to be advantageous.

Since only one large capacity unit will be constructed under the Plan 2, however, this plan is not desirable in view of system operation and cannot be recommended when shutdown for periodical inspection, emergency shutdown and other factors are taken into consideration.

Moreover, the Plan 3 has been determined not to be adopted in view of its economic drawbacks as well as the following reasons.

According to the prevailing policy of the Government of Pakistan, natural gas is allocated preferentially for civil and industrial uses and its use for thermal power plants will not be permitted by the government.

At present, the total amount of natural gas allocated to KESC is 74 MMCFD, out of which 10 MMCFD is allocated to the West Wharf Thermal Power Station.

This amount is insufficient for the combined cycle power unit proposed under this plan.

Moreover, a combination of combined cycle power unit and conventional thermal power unit is comprised of a mixture of gas turbine, waste heat recovery boiler, steam turbines with different capacity, and other miscellaneous equipment, thereby requiring sophisticated operation and maintenance. Consequently, this plan cannot be recommended.

As a result of the above economic comparative study, the Plan 1 for constructing two (2) 200 MW thermal power units has been selected as an optimum development plan.

REFERENCE: The results of this economic comparative study are as outlined below. Meanwhile, the calculation conditions for economic comparative study are presented in Table 5.2-1 and the results thereof in Table 5.2-2.

(1) In terms of the internal rate of return (IRR) of the respective plans (a discount rate where the net present value becomes 0), the Plan 2 is most advantageous followed successively by the Plans 1, 3 and 4. In terms of the discount rate level of roughly 12%, the Plan 1 is most beneficial followed by the Plans 2, 3 and 4. Therefore, the Plan 1 (two 200 MW thermal power unit plan) is most advantageous.

Note: As a result of discussions with KESC and the study team, the rate of capital investment cost in Pakistan was set to 11%.

(2) Even though the combined cycle power unit is high in efficiency (about 42% at generator end), it is not so economically advantageous.

This is due to the price of fuel (natural gas) set to a rather higher level.

Fig. 5.2-2 KESC
WEST WHARF THERMAL POWER PLANT PROJECT
ECONOMIC COMPARISON STUDY

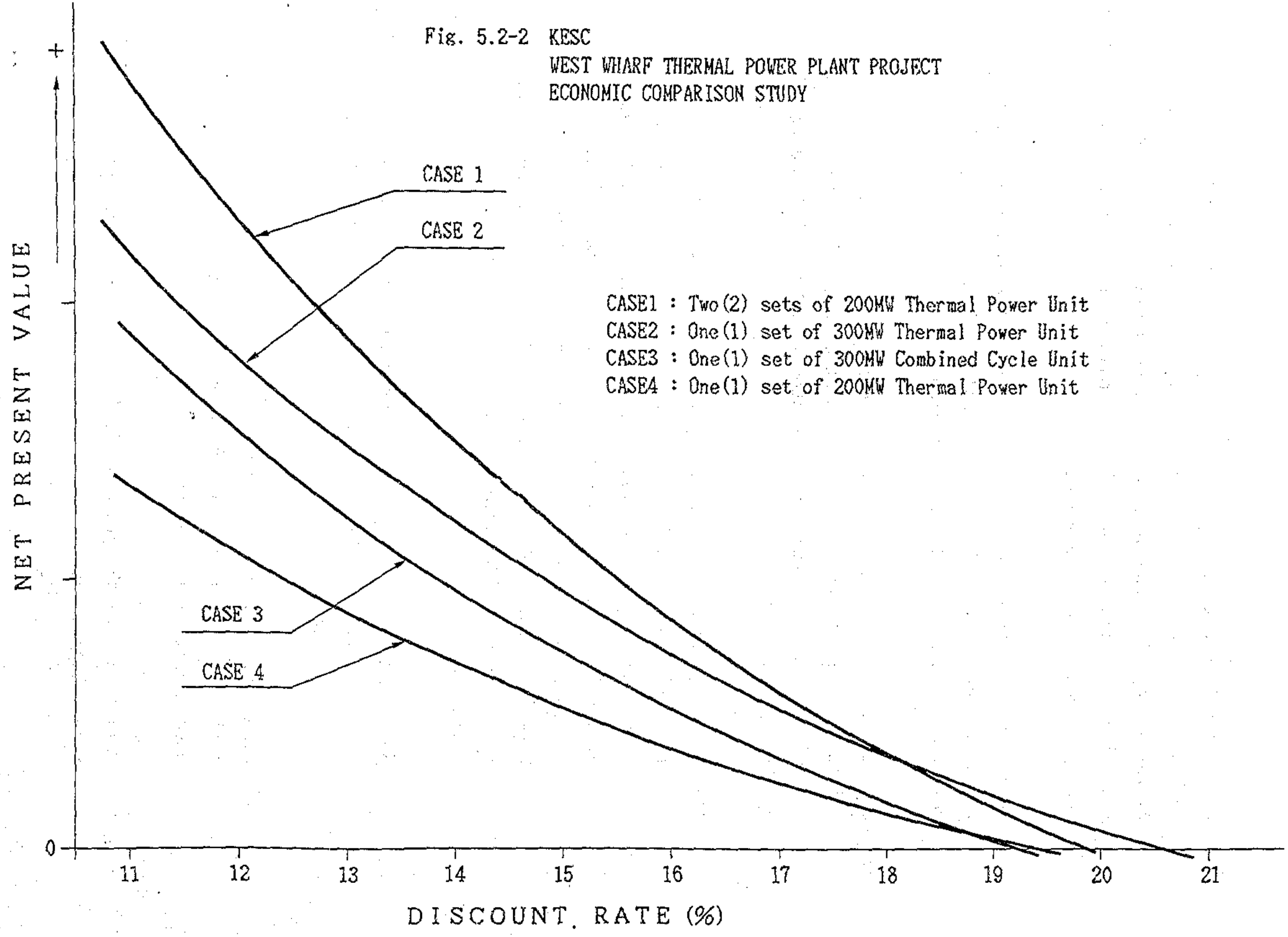


Table 5.2-1 ECONOMIC COMPARISON ASSUMPTION BASIS

	Case 1 200MW×2	Case 2 300MW×1	Case 3 300MW C/C	Case 4 200MW×1
1. Construction cost×10^6¥ Power plant equipments Civil & erection Total	 30,000 10,000 40,000	 21,000 7,500 27,500	 19,125 10,000 29,125	 15,000 5,000 20,000
2. Prime mover	Steam turbines	Gas turbines & steam turbines	Steam turbine	Steam turbine
3. Service life years	20	20	20	20
4. Annal plant factor	60	60	60	60
5. Auxiliary power consumption %	5	5	2.5	5
6. Transmission & distribution loss %	16	16	16	16
7. Thermal efficiency generator end %	38	38	42	38
8. Selling rate ¥/kwh	11.25	11.25	11.25	11.25
9. Type of fuel	Heavy oil	Heavy oil	Natural gas	Heavy oil
10. Fuel cost Rs/1000kcal	0.131	0.131	0.162	0.131
11. Annal fuel cost×10^6¥	4,673.6	3,505.2	3,922.8	2,336.8
12. Annal expenditure Operating & maintenance fee, etc.	3,482.36	2,709.23	3079.05	1,872.3
13. I R R %	19.79	20.45	19.18	19.37

5.3 Development Procedure

The development procedure that follow the basic conception comprise two possible major alternatives for the project, and are as described below.

These alternatives have been selected based upon the study cited in the previous sections (Sections 5.2.1 and 5.2.2).

The final conclusion has been made based on the study results of all influencing factors upon the project and by further carring out necessary studies and is derived from one of the following two plans.

Plan A:

One 200 MW (maximum), furnace oil fired thermal power generating unit will be installed while "BX" station continues operation during construction of the unit.

Construction work for the second unit having the same capacity will be started after decommissioning and dismantling of the "BX" station.

Main features of Plan A

(1) Construction of the first unit will be started without being influenced by any conditions affecting the operation of the "BX" station.

(2) Construction of the first unit should be carried out by giving carefull consideration to the "BX" station under commissioning and within a limited area.

(3) Cooling water discharge line(s) for the new unit(s) should be installed while using the existing discharge lines of the "BX" station, via a different route and with discharge openings other than the existing ones.

Plan B:

Two (2) sets of 200 MW oil fired thermal power generating units will be constructed after decommissioning and dismantling of the "BX" station. In order to realize this plan, 132 kV transmission line(s) will be connected to West Wharf Power Plant with sufficient power feeding so as to ensure continuous power supply for the district (11 kV lines) by the end of 1990.

Other modification plan(s) for strengthening transmission and distribution systems other than the above should be studied to ensure continuous power supply to the district.

The modernization work will be started for construction of two units of 200 MW (max.), with the completion date for the first unit set for the end of October 1992.

Main features of Plan B

(1) Decommissioning and dismantling of the "BX" station will be started after completion of power feeder lines (or power feeding countermeasures) from outside of West Wharf Power Plant.

5.3.1 Between the previously mentioned two alternative plans, Plan A has been selected as the optimum plan of the project.

The summarized reasons for this decision are as follows.

(1) In case of Plan B, early decommissioning and dismantling of the "BX" station by strengthening the transmission and distribution system and feeding sufficient power to W.W.P.P. seems to be impracticable under the present KESC situation.

5.4 Cooling Water Way

(1) Study of intake channel

The existing condenser cooling water intake facilities are comprised of 1.5 m dia. x 200 m length x 3 line concrete pipes and a 3 m square x 155 m x 1 line box culvert. The concrete pipes are used for the "BX" Station at present. The box culvert was constructed for use in about 1970. It has not been used, however, and blind covers have been placed on both ends until today.

Facing the Karachi Port, an international trade port, these intake facilities pass under the Customs Office site along different routes from two intake holes (inlets) provided alongside the quaywall of the Customs Office of the Karachi Port Authority located adjacent to the east side of the power station. This quaywall has a capacity of mooring 10,000 DWT class ocean-going vessels. The entire Customs Office site area comprises a cargo collection terminal where railway sidings are also provided.

Giving full consideration to the situation described above, in working out a plan for the condenser cooling water intake facilities for the new power units, it is most important to take into account effective utilization of the existing water intake facilities. Although it will be impossible to make effective use of the water intake facilities (pump room, intake channel/tunnel, etc.) within the station site due to substantial changes in the overall layout of the new power units, it may be possible to effectively use the portion of the intake facilities outside the station site as intake facilities for the new power units. This will depend on whether or not the following conditions are met:

(1) Such moves must be compatibile with optimum overall development,

(2) The facilities must have a sufficient water passing capacity,

(3) The water intake facilities should be free from substantial deterioration to allow continued use for a sufficiently long period in the future.

These conditions are discussed below.

a. Compatibility with an optimum overall development plan:

An optimum development plan under this project should include construction of Unit 1 (200 MW) on the south side of the "BX" Station while keeping the "BX" Station in operation, and subsequent construction of Unit 2 after decommissioning at "BX" Station. To ensure compatibility with the overall development plan, the following procedures for developing the intake facilities must be taken into consideration:

1. The 1.5 m diameter x 3 line concrete pipes will be used for water intake to the "BX" Station as at present. For Unit 1, only the new cooling water intake pump room and intake channel/tunnel next to the existing 3 m square 1 line box culvert will be constructed while independently using the existing box culvert.

2. Provided that the intake facilities up to the cooling water intake pump room for the existing "BX" Station will be effectively utilized as they are until development of Unit 2, the pump room and intake facilities for Unit 2 will be constructed after dismantling the pump room and intake facilities next

next to

to the pump room. Meanwhile, a connecting water channel/tunnel will be provided to make the flow rate uniform in the existing two water intake systems (concrete pipes and box culvert) that have different water passing sectional areas.

A site layout plan at the time of commissioning Unit 2 has been worked out as shown in Fig. A-1 to make the water intake facilities plan feasible in accordance with the optimum overall development plan and allow the most effective utilization of existing water intake facilities.

b. Study of water passing capacity

Presented below are the results of a study of the water passing capacity of the existing water intake facilities indicated in Table 5.4-1. According to this study, the mean flow velocity in the box culvert at the time of commissioning Unit 1 will be reduced to 1.2 m/sec., and the maximum mean velocity in the box culvert at the time of commissioning Unit 2 will be reduced to 1.7 m/sec. in contrast to the mean flow velocity of 2.1 m/sec. in the concrete pipes under the current conditions (during operation of only the "BX" Station).

In this way, both the mean and maximum mean flow velocities are to be reduced to those existing when only the existing "BX" Station is operated. The head loss is also to be reduced as a result.

The existing water intake facilities were evaluated and found to have a water passing capacity sufficient to meet requirements anticipated up until the development of Unit 2.

Table 5.4-1 Results of study on the water passing capacity of intake facilities

	Existing "BX" Station	Unit 1 (200 MW) development period	Unit 2 (200 MW) development period (400 MW in total)
Intake facilities	Existing concrete pipes 1.5 m dia. x 3 lines	Existing box culvert 3 m square x 1 line	Existing concrete pipes 1.5 m dia. x 3 lines Existing box culvert 3 m square x 1 line
Required amount of cooling water (m^3/sec.)	4.2 m^3/sec./unit x 2 units = 8.4 m^3/sec.	9.5 m^3/sec./unit x 1 unit = 9.5 m^3/sec.	9.5 m^3/sec./unit x 2 units = 19.0 m^3/sec.
Net water passing cross section (m^2) (10 cm of shell deposit allowance is given)	4.0 m^2	7.8 m^2	11.8 m^2
Mean flow velocity (m/sec.)	2.1 m/sec.	1.2 m/sec.	Concrete pipe: 1.4 m/sec. Box culvert : 1.7 m/sec.
Water head loss (m)	0.864 m	0.120 m	Concrete pipe: 0.186 m Box culvert : 0.185 m

c. Study of the soundness of existing water intake facilities

Under this study, visual inspection was carried out to determine the soundness of the existing concrete structures at the site, although it was impossible to directly clarify the soundness of the existing facilities since the majority of the facilities are underground and in operation. Other restrictions included concrete pipes, and blind covers applied on both ends of the box culvert. However, the external appearence of the concrete structure exposed on the ground level among the other structures and intake within the plant site indicated general soundness and almost no substantial deterioration.

Judging from the above soundness, the other existing intake facilities are also assumed to have an equivalent soundness and should be adequate to allow effective utilization as the water intake system for several decades. Considering that a period of two to three decades has elapsed since construction of the existing water intake facilities and that it was impossible to directly investigate the soundness of the facilities due to various restrictions, it will be necessary to allocate some extent of budget for cleaning and repair of the deteriorated portions of existing facilities.

d. Summary

The above study results indicate that it will be possible to effectively use the portion of the existing water intake facilities (concrete pipes and box culvert) outside the plant site for the new 200 MW x 2 units.

On the other hand, the alternative plan for constructing the portion of the intake facilities outside the plant site is disadvantageous economically as a plan for effective utilization of existing facilities. And construction of such facilities within the site of the Karachi Port could not be permitted because it would obstruct cargo handling by the port authority. Therefore, this plan cannot be said to be practicable. In other words, making effective use of the existing intake system as far as the portion of those outside the power plant is concerned is almost a prerequisite for this project.

Judging from the above conditions, the new facilities inside the power plant site will have to be constructed under this development project, while those outside the power plant site can be effectively utilized.

(2) Study of discharge channel

Traversing the Dockyard Road on the west side of the power station from the main powerhouse building, the existing discharge channel crosses under the site of the Karachi Shipyard and reaches the discharge outlet provided at the mooring quaywall of the shipyard.

In other words, the cooling water intake and discharge systems of this power station are based in an ideal layout, taking advantage of topographical features. Conditions are also good for recirculation of warm waste water, with intake of cooling water from the east side of the West Wharf and discharge on the west side of the wharf.

The existing discharge facilities are comprised of 1.5 m diameter x 2 line and 1.2 m diameter x 2 line concrete pipes up to the weir chamber provided from inside the power plant site through the Karachi Shipyard site as well as 1.8 m diameter x 2 line concrete pipes up to the discharge outlet from the weir chamber. The mooring quaywall under which the discharge outlet is provided is of a steel sheet pile construction, and rails for 30-ton gantry cranes are laid on the discharge outlet. The discharge outlet is located adjacent to the inlet of the dry dock of Karachi Shipyard, and the sea area in front of the discharge outlet constitutes a mooring site for the Karachi Shipyard and a navigation route for ocean-going vessels.

In consideration of the above situation, a plan for a condenser cooling water discharge channel for the new units is studied below.

a. Feasibility of effectively utilizing existing discharge channel

i) Existing discharge channel:

To ensure utmost effective utilization of the existing discharge channel while satisfying coordination with the overall development plan, the following two alternative plans can be taken into consideration:

(1) A plan to connect the discharge channel for the new units by installing a weir chamber along the existing channel while keeping the existing discharge channel in service as it is during operation of the "BX" Station.

(2) A plan to install a new discharge channel up to the (existing) weir chamber within about five (5) months from shutdown and start of decommissioning of the "BX" Station to commissioning of the new units after power begins to be received from the 220 kV transmission line.

In the case of Plan 1, modification of the existing weir chamber provided inside the site of Karachi Shipyard will be unavoidable. However, it would be extremently difficult to modify the weir chamber while keeping the existing discharge channel in service. In addition, the area along the route up to the weir chamber is so narrow (about 17.4 m) and it is located between the block fences comprising a boundary between a factory building site inside the Karachi Shipyard and the site of Acetylene Gas Co. Therefore, it will be extremely difficult to construct a new discharge channel for new power units within the limited space without adversely affecting the existing discharge channel in service.

Consequently, Plan 1 is not a realistic one for use of the existing water system. Therefore, Plan 2, which calls for installing a weir chamber after shutdown of the "BX" Station, is studied below.

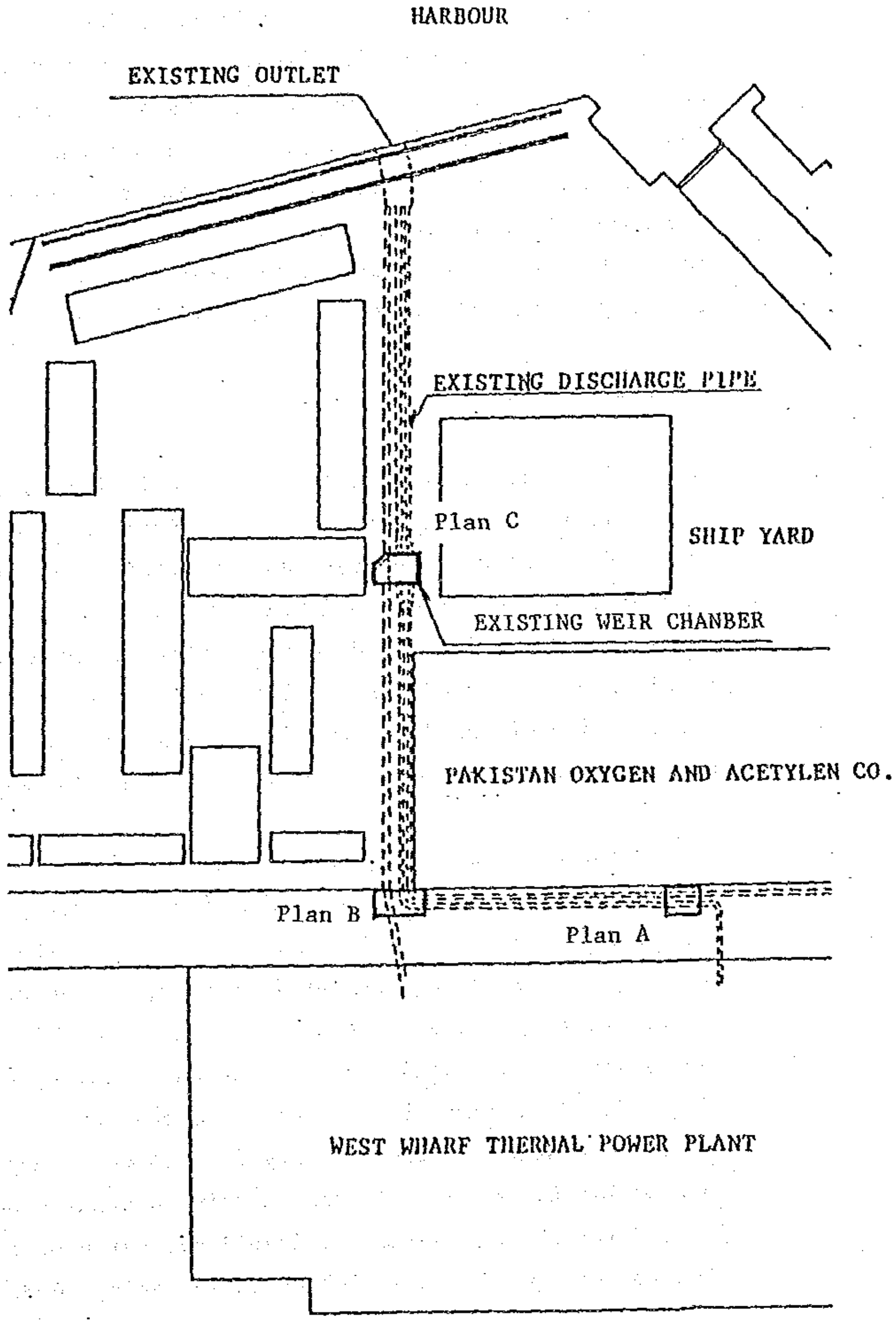
With regard to Plan 2, the three possible positions (A, B and C) are considered for installing the new weir chamber. The length available for the existing discharge channel varies in each case. The flow velocity in the existing discharge channel between the sections in each case have been calculated and are indicated in Table 5.4-2.

As the table shows, flow velocity in the discharge channel is substantially increased to more than 3.0 m/sec. wherever the weir chamber is installed at position A, B or C when cooling water is discharged entirely from new Units 1 and 2. Therefore, it would not be practical to use the existing discharge channel for new Units 1 and 2.

Table 5.4-2 Location of weir chambers and flow velocity in the existing discharge channels

Location on new weir chambers / Applicable units / Items		New development plan					
		PLAN A		PLAN B		PLAN C	
		Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
Channel to be used	New existing weir chambers	1.5 m dia. x 2 lines		1.5 m dia. x 2 lines 1.2 m dia. x 2 lines		———	
	Existing weir chamber channel	1.8 m dia. x 2 lines		1.8 m dia. x 2 lines		1.8 m dia. x 2 lines	
Net sectional area (m^2)	New existing weir chambers	3.53 m^2		5.80 m^2		———	
	Existing weir chamber channel	5.09 m^2		5.09 m^2		5.09 m	
Amount of water to be used (m^3/sec.)		9.5 m^3/sec.	19.0 m^3/sec.	9.5 m^3/sec.	19.0 m^3/sec.	9.5 m^3/sec.	19.0^{3}m /sec.
Flow velocity (m/sec.)	New weir Existing chambers	2.7 m/sec.	5.4 m/sec.	1.6 m/sec.	3.3 m/sec.	-	-
	Existing weir chamber Discharge channel	1.9 m/sec.	3.7 m/sec.	1.9 m/sec.	3.7 m/sec.	1.9 m/sec.	3.7 m/sec.

Fig. 5.4-1 LCOATION OF WEIR CHANBER



If the existing channel is used solely for either of the two new units, the flow velocity between the new and existing weir chambers will become excessively high, to as much as 2.7 m/sec. or more, when the weir chamber is installed in position A. When either positions B and C are used, however, the flow velocity in the existing discharge channel will be 2.0 m/sec. or less. In these latter two cases, it would be feasible to use the existing discharge channel in view of the flow velocity.

ii) Discharge outlet

In consideration of the fact that the existing discharge outlet is located adjacent to the dry dock of Karachi Shipyard in the sea area used as a mooring site and navigation route for ocean-going vessels, and that the quaywall under which the discharge outlet is provided is still frequently used for mooring, any further acceleration of the discharge flow could possibly cause adverse effects upon mooring operations and navigation.

In the light of the fact that the current surface discharge flow velocity measured during this study period was roughly 0.2 - 0.3 m/sec., and since the flow velocity at a discharge outlet is required to be 0.3 - 0.5 m/sec. at positions facing a mooring site and navigation route considered to cause an effect upon the navigation of ocean-going vessels in Japan, the allowable discharge flow velocity in this case should be made within 0.3 m/sec. If the existing discharge outlet is used for the new units, estimated discharge outlet flow velocity would be as indicated in Table 5.4-3.

Table 5.4-3 Discharge flow velocity at discharge outlet

	Unit 1	Unit 2
Quantity of water to be used (m^3/sec.)	9.5	19.0
Discharge outlet opening area (m^2)	16.38	
Discharge flow velocity (m/sec.)	0.6	1.2

Even if the cooling water from one of the two new units is discharged, the flow velocity will become 0.3 m/sec. or over at the discharge outlet. This, in turn, would necessitate modification of the outlet to decelerate the flow velocity.

Since the existing discharge outlet is provided under the foundation of gantry cranes, which are in service at the Karachi Shipyard, and since the mooring quaywall above the discharge outlet is also in frequent service for mooring, full-scale modification of this discharge outlet would greatly affect operation of Karachi Shipyard. In addition, the extremely sophisticated construction of the existing quay wall will make it extremely difficult to perform modification work such as a coffer dam, dismantling and other work. When the above situation is taken into consideration, one can see that modification of the discharge outlet would not be practical.

iii) Summary

As a result of above study, it was concluded that modification to expand the existing discharge outlet to meet the discharge requirements for cooling water from either one or both of the 200 MW units would not be realistic. Using even a part of the existing discharge channel up to the discharge outlet would be in significant because modification of the discharge outlet is difficult. It is, therefore, concluded that it would infeasible for effective utilization of the existing discharge facilities.

b. Construction of discharge channel

On the basis of the results of above study, the construction of a discharge channel for both Units 1 and 2 is planned along the route shown in Fig. 5.4-2. Use can be made of the vacant land adjacent to the border on the south side, inside the site of the Karachi Shipyard. This area is located away from the quaywall of the Karachi Shipyard. It is advantageous in that the construction work can be executed without interfering with operation of the shipyard.

Meanwhile, only the discharge channel for Unit 1 will, in principle, be constructed during the construction period of Unit 1. It will be designed to permit extension of the discharge channel for Unit 2 in the future. However, the discharge outlet for Unit 2 will be constructed in advance together with that for Unit 1 since extending the discharge outlet for Unit 2 later would be difficult due to the cofferdam work that will be necessary when the unit is extended.

(3) Study of recirculation of warm waste water

Generally, the standard target minimum distance on the water surface between intake hole and discharge outlet to ensure freedom from recirculation of warm waste water is calculated according to the following formula:

$$L = 20Q$$

where L: Minimum distance on water surface between intake inlet and discharge outlet (m)

Q: Amount of cooling water (m /sec.)

$Q = 9.5\ m^3/sec. \times 2 = 19.0\ m^3/sec.$

$L = 20 \times 19.0\ m^3/sec. = 380\ m$

Since the distance between the intake inlet and discharge outlet for the new power units of West Wharf Power Station is sufficiently distant by as much as about 1,500 m, there should be no possibility of recirculation of warm waste water.

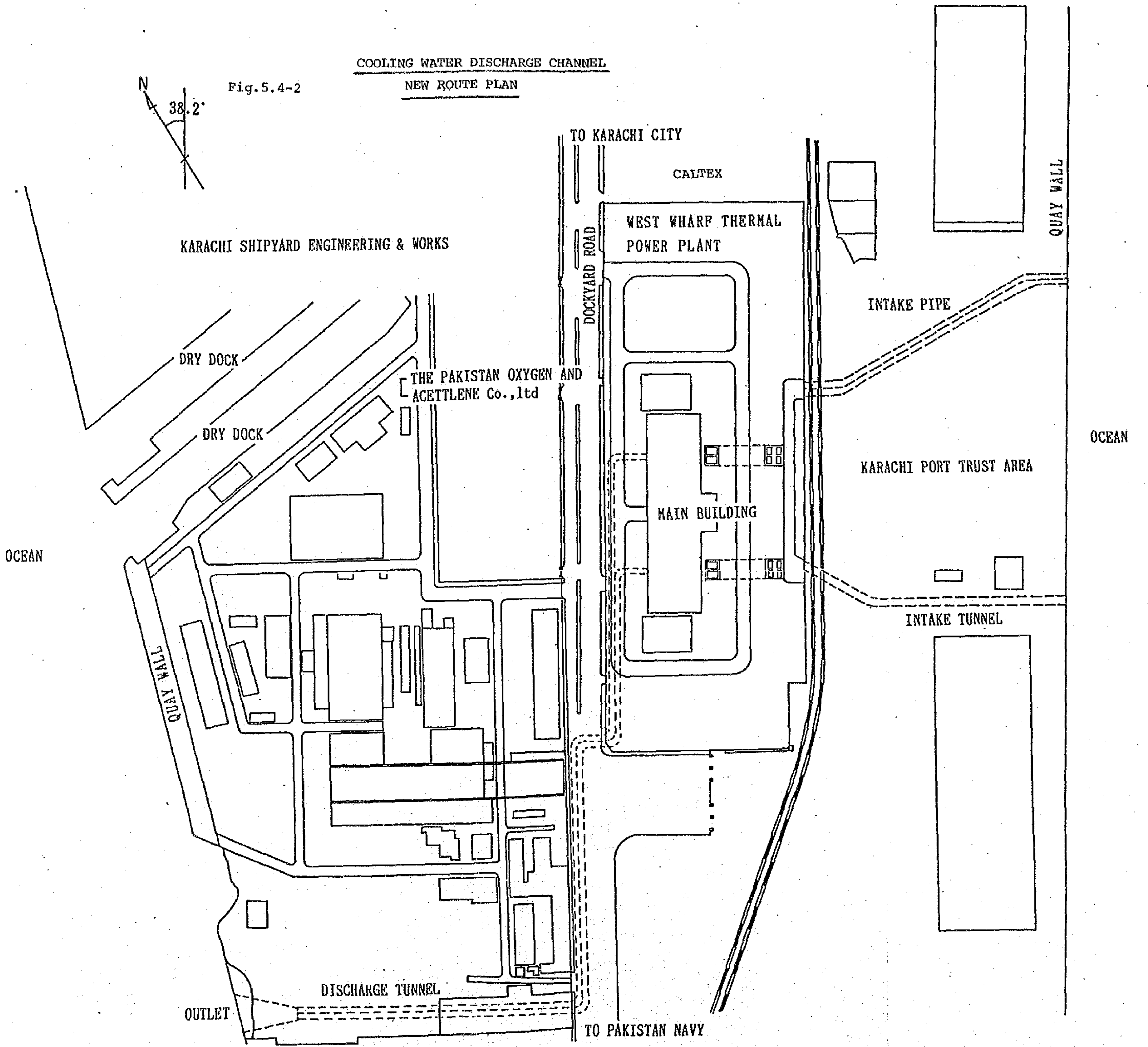


Fig.5.4-2 COOLING WATER DISCHARGE CHANNEL NEW ROUTE PLAN

5.5 Transmission and Substation Facilities

5.5.1 System configuration

(1) Present system configuration

The existing 220 kV power transmission line of KESC has been extended up to the Baldia G/S in the northwestern part of Karachi City surrounding the outskirts of the city, from the Bin Qasim Power Station. Located about 35 km east of Karachi, this station has 2 x 210 MW units in operation, with extension to four (4) units now under way and a fifth unit under the evaluating stage. The transmission line is connected to the 132 and 66 kV networks toward the city area through three 220/132 kV grid stations; Pipuri West, KDA-33 and Baldia. The Korangi Thermal Power Station, the Korangi and S.I.T.E Gas Turbine Power Stations are interconnected to the 132 kV power system, while, the West Wharf Power Plant is interconnected to the 66 kV power system. This total power is supplied to Karachi and surrounding areas.

In addition, this transmission line is interconnected to the power system to WAPDA, or the Water and Power Development Authority, through a 220 kV transmission line connecting KDA-33 and Jamshoro approximately 130 km distant therefrom.

In the case of this power system, major power sources are located one-sidedly in the eastern area, while power consumption areas are located around and in Karachi City on the west side. KESC has steadily been implementing modernization of the power system while drawing up future power system configuration.

(2) Study of system configuration

On the assumption that two (2) 200 MW units will be installed at the West Wharf Power Station under this project, a desirable configuration of power system in the future has been studied herein.

Under this study, the 220 kV system which has been constructed up to the Baldia G/S from the Bin Qasim P.P. is assumed to be extended to the West Wharf Power Plant, thereby enabling stable system operation and making it easy to take appropriate countermeasures for mutual intersection with the WAPDA system. This will form a configuration surrounding Karachi City.

In consideration that the city center of Karachi, where the load density is high, is located near the West Wharf Thermal Power Station, a system configuration has been worked out to transmit the power generated at the power plant to the 220 kV system and supply it to the city center through 132 kV tie transformers.

For supply of electric power to the city center, the following two alternative plans (Plan A and Plan B) have been worked out. As a result of comparative study on the economy, problematical points in view of operation, easiness of construction and other factors, it has been determined to adopt Plan A.

Plan A: By installing 220, 132 and 11 kV facilities at the West Wharf Thermal Power Station, the power generated at the power plant will be supplied to the demand area, including those existing in the city center, through a 132 kV system (Refer to Fig. 5.5-2).

Plan B: To avoid concentration of various voltage classes at the West Wharf Thermal Power Station, the 220/132 kV and 132/66 kV transformer banks will be installed at the Mauripur G/S, and the power from the West Wharf Power Plant will be supplied from Mauripur to the demand area in the city center (Refer to Fig. 5.5-3).

According to Plan B, the power facilities will be simplified at the West Wharf Thermal Power Station.

Although it will be possible to avoid concentration of 132 kV cables along the surrounding roads, Mauripur is too distant from the city center. Thus, it will be required to cross over the Layari River running halfway along the route. In addition, the substation facilities should be separated into two locations, thereby necessitating an increase in the number of disconnecting switches which, in turn, will result in an increase in the construction cost. Consequently, Plan B is less advantageous than Plan A in terms of construction costs and operation.

Furthermore, a method of connecting the West Wharf Thermal Power Plant directly to the 132 kV system, which is gradually being extended, has also been studied as a countermeasure for supply of electric power to the city center. However, the short circuit capacity in the 132 kV system is anticipated to exceed 5,000 MVA from place to place at the Queen's Road G/S, Korangi Power Station and so forth. Therefore, it will be necessary to take countermeasures against the insufficient short circuit capacity.

(3) Calculation of power flow

The power flow in the power system of KESC in 1992 and 1994, when West Wharf 200 MW Units 1 and 2 are assumed to be commissioned respectively, was calculated. As a result, it has been clarified to be important and desired to construct a 220 kV transmission line.

a. Power Flow Study Diagram in 1992

(a) Fig. 5.4-4

Conditions of power facilities

In case the West Wharf Power Station (1 x 200 MW) will be in operation and two circuit 220 kV transmission line (Baldia G/S - West Wharf Power Station) be in service.

Power flow

The balance of power flow will be attained.

(b) Fig. 5.5.5

Conditions of power facilities

In case the West Wharf Power Station (1 x 200 MW) will be in shutdown and two circuit 220 kV transmission line (Baldia G/S - West Wharf Power Station) be in service.

Power flow

The transmission line between Korangi GT G/S and Baluch Colony G/S will be subjected to overload of 151.4 MVA in contrast to the transmission capacity of 103 MVA.

(c) Fig. 5.5-6

Conditions of power facilities

The West Wharf Power Station (1 x 200 MW) will be in shutdown and there be no 220 kV transmission line between Baldia G/S and West Wharf Power Station.

Power flow

The following transmission lines will be subjected to overload with respect to the transmission capacity as listed below:

Transmission lines	Load (MVA)	Transmission capacity (MVA)
Korangi P/S - Queen's Road G/S	293.4	260
Korangi West G/S - Gizri G/S	114.7	103
Korangi G/S - Baluch Colony G/S	151.4	103

b. Power Flow Study Diagram in 1994

Fig. 5.5.7

Conditions of power facilities

In case the West Wharf Thermal Power Station (2 x 200 MW = 400 MW in total) will be in operation and the two circuit 220 kV transmission line (Baldia G/S - West Wharf Power Station) be in service.

Power flow

About 300 MW of power output from the West Wharf

Power Station will be transmitted to the city center of Karachi through 220/132 kV banks to be installed at the power station.

Since the transmission line between the Korangi Power Station and Korangi West G/S (one circuit) will be subjected to overload of 214 MVA in contrast to the transmission capacity of 165 MVA, moreover, it is considered necessary to work out countermeasures for extending the transmission line while carefully paying attention to the trend of the region-wise growth of load in the future.

For further detail regarding the case study of power system configuration in 1994, refer to "System Interconnection and Improvement of Reliability of the Power Transmission System of KESC" in APPENDIX A-1.

For preparation of the above-mentioned power flow study diagrams (Fig. 3.5-4 - Fig. 5.5-7), studies were carried out on the assumption that any 66 kV equipment would not be installed at the West Wharf Power Station in accordance with the final design for this project.

Fig.5.5-1 Existing Transmission System around West Wharf Power Plant

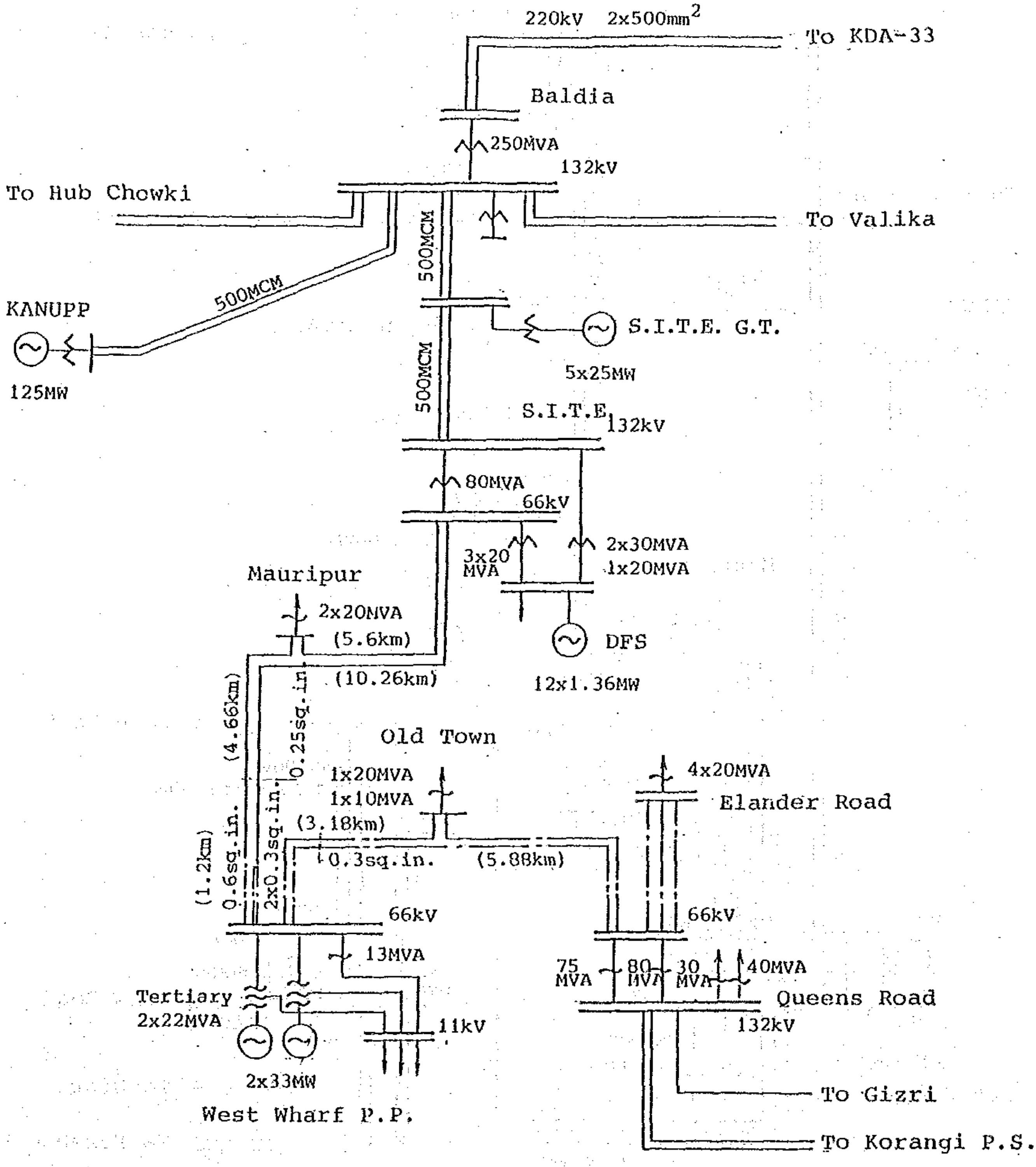


Fig.5.5-2 Transmission System Plan for West Wharf Power Plant

(Plan A)

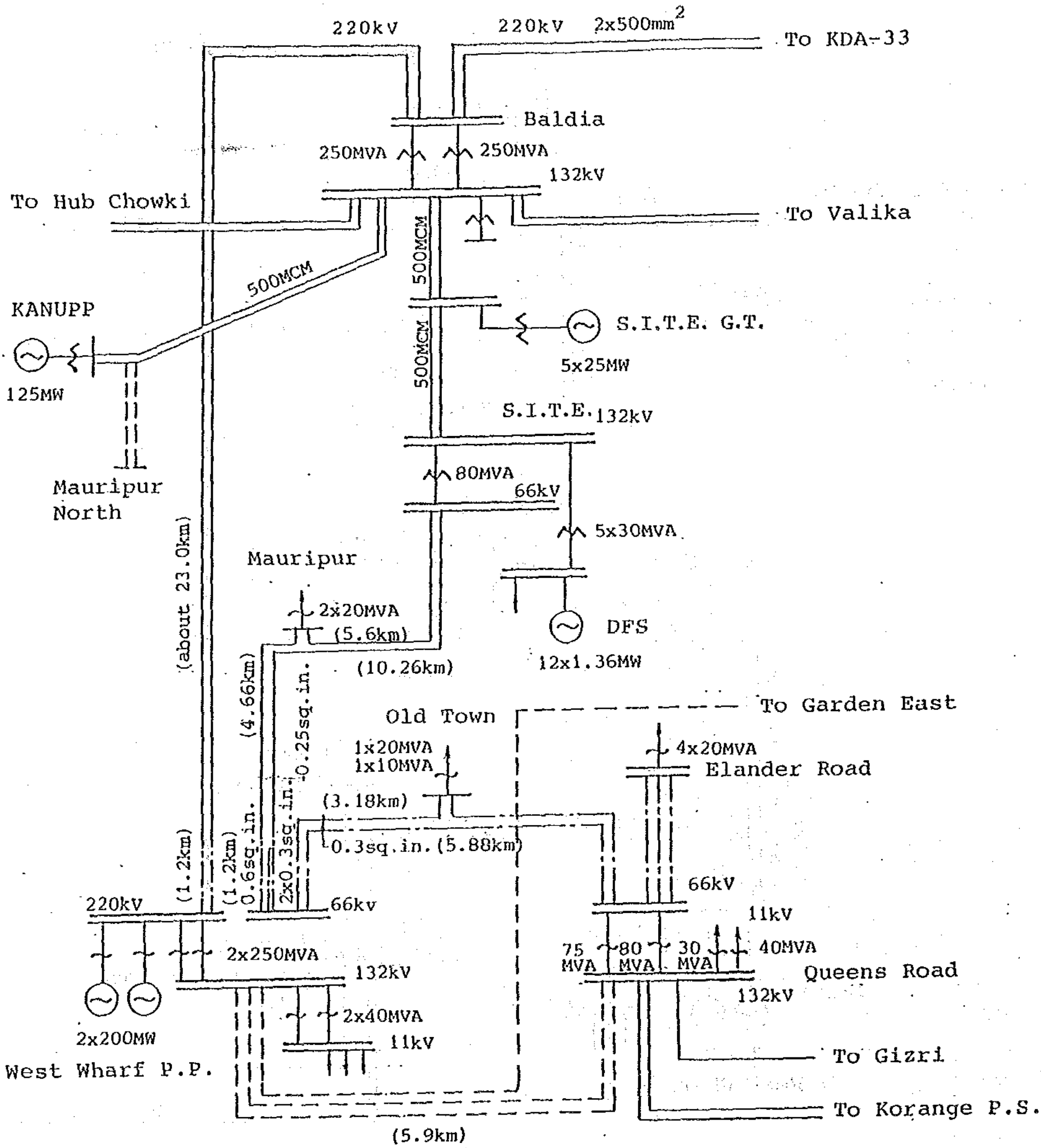


Fig.5.5-3 Transmission System Plan for West Wharf Power Plant (Plan B)

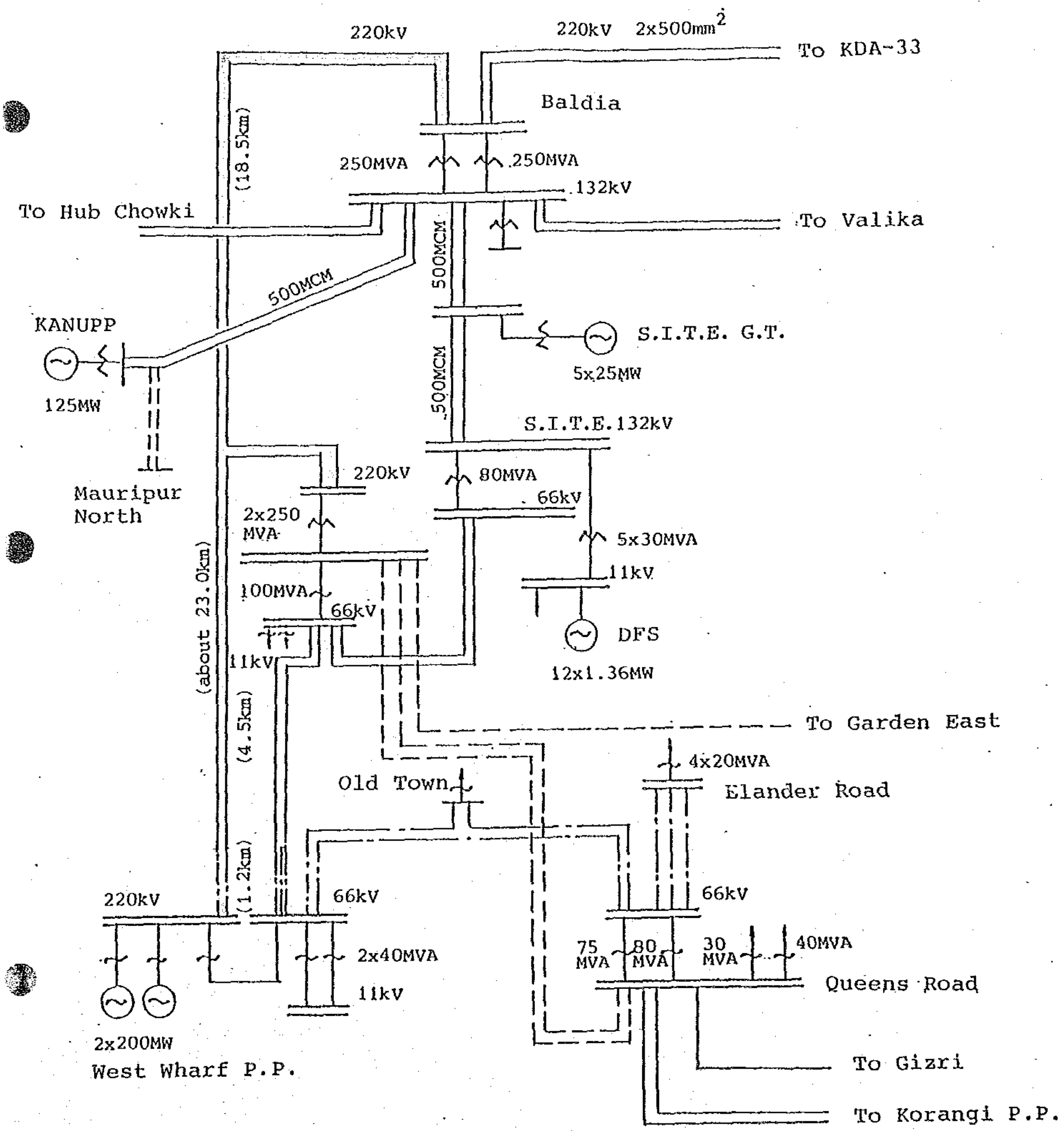
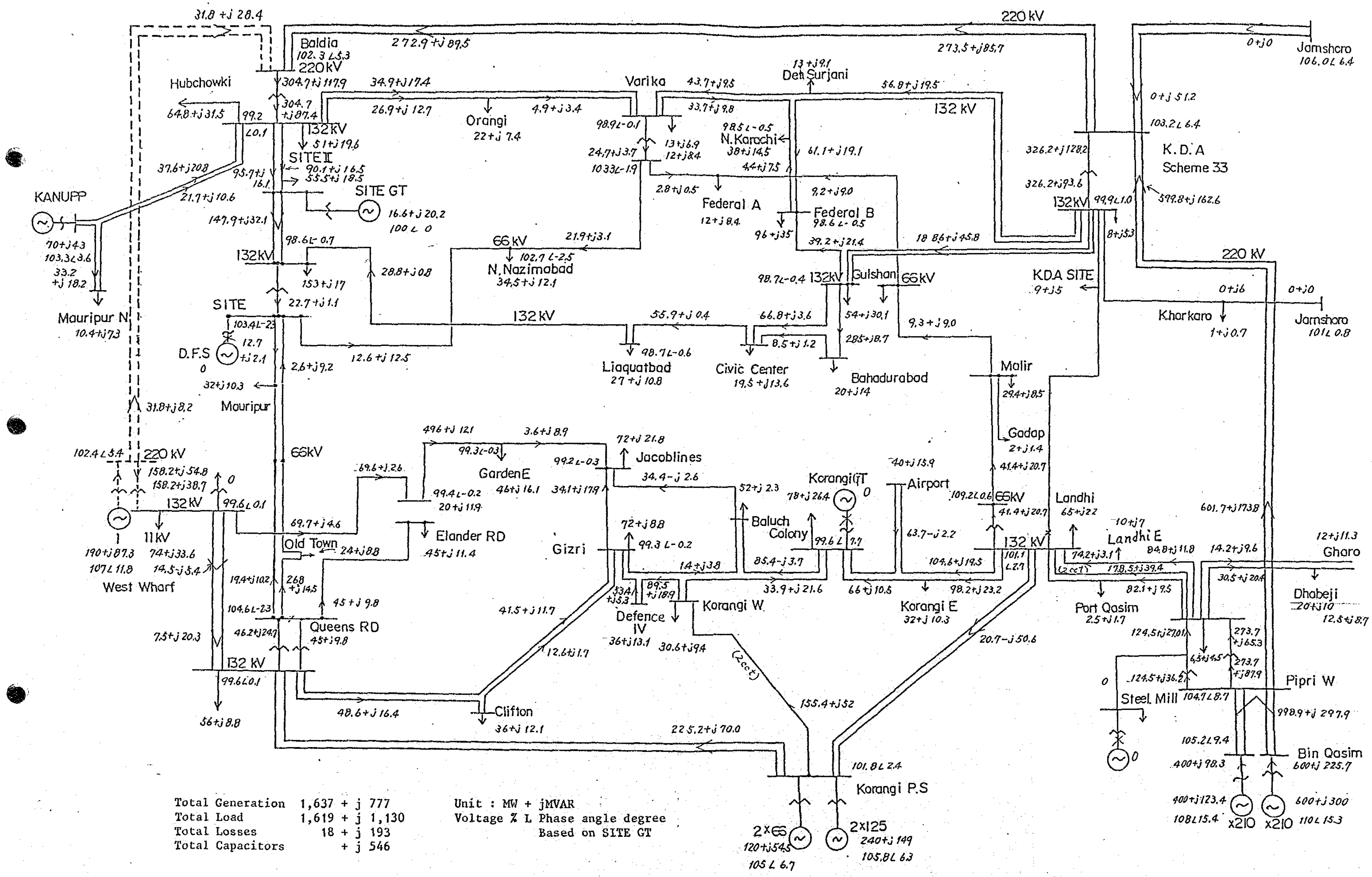


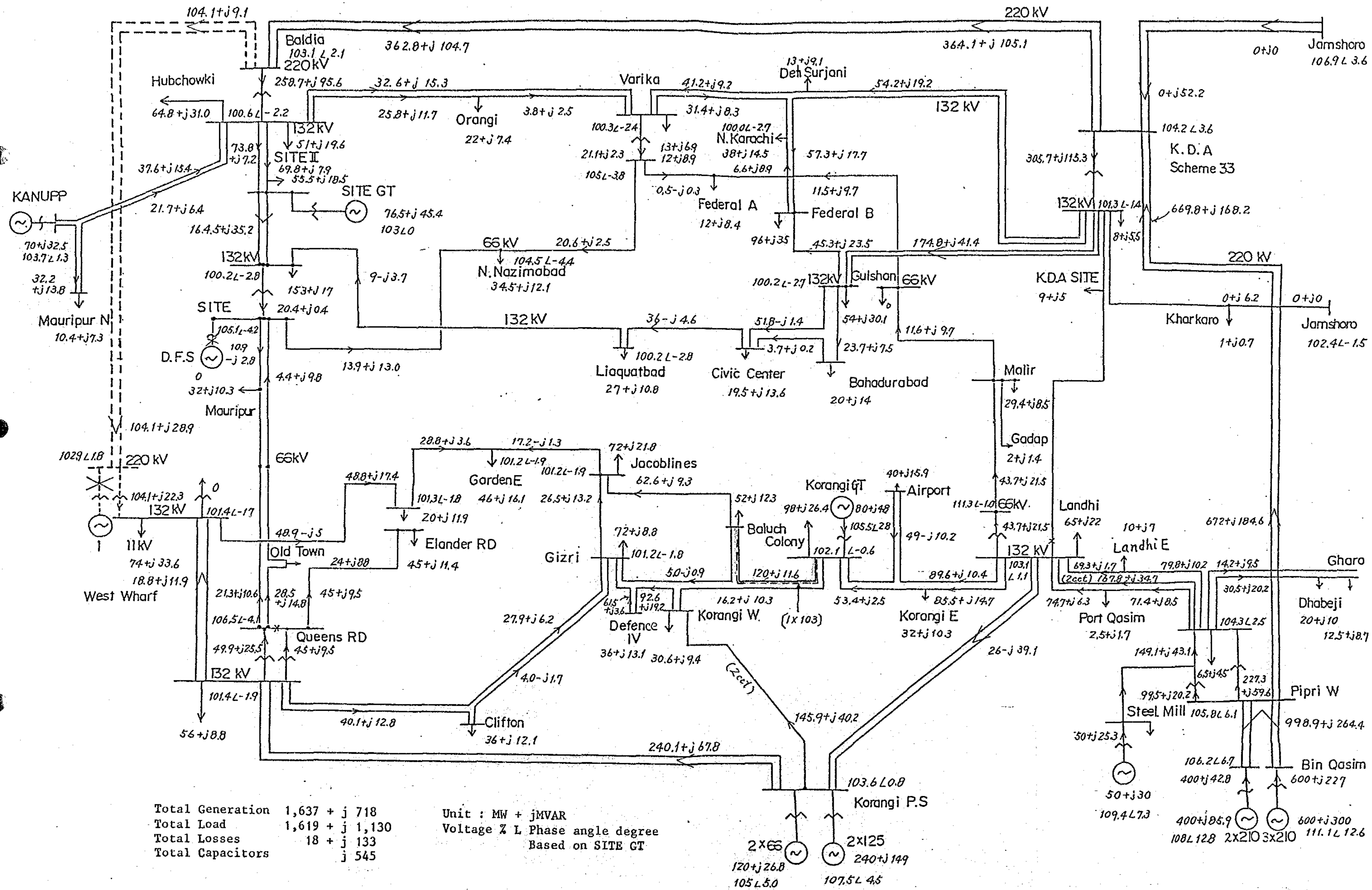
Fig. 5.5-4 Power Flow Study Diagram in 1992



Total Generation	1,637 + j 777	Unit : MW + jMVAR
Total Load	1,619 + j 1,130	Voltage % ∠ Phase angle degree
Total Losses	18 + j 193	Based on SITE GT
Total Capacitors	+ j 546	

Fig. 5.5-5 Power Flow Study Diagram in 1992

(Outage of generator at West Wharf P.P.)

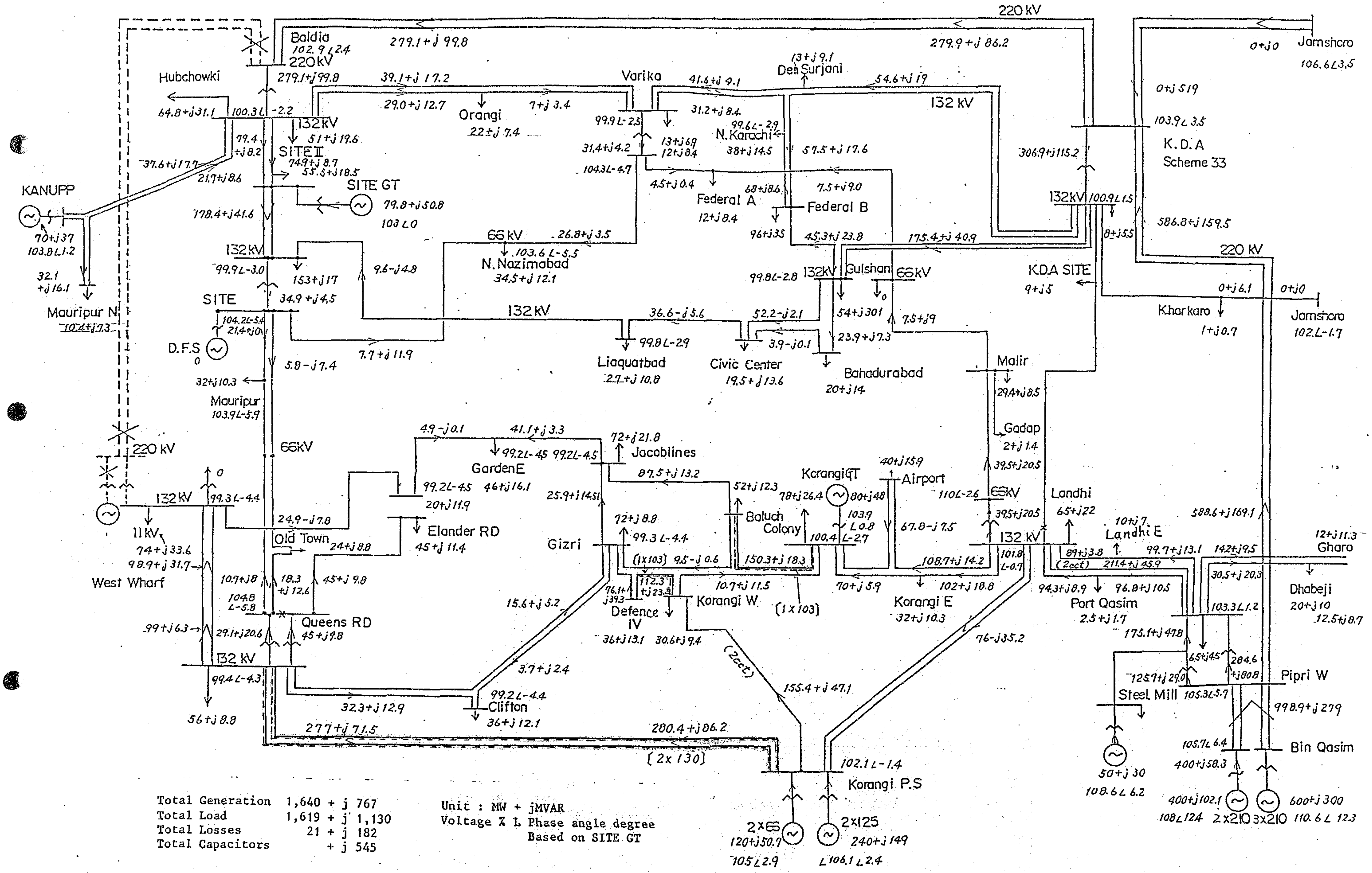


Total Generation 1,637 + j 718
Total Load 1,619 + j 1,130
Total Losses 18 + j 133
Total Capacitors j 545

Unit : MW + jMVAR
Voltage % ∠ Phase angle degree
Based on SITE GT

Fig. 5.5-6 Power Flow Study Diagram in 1992

(There is no 220 kV line between West Wharf-Baldia) (Outage of generator at West Wharf P.P.)

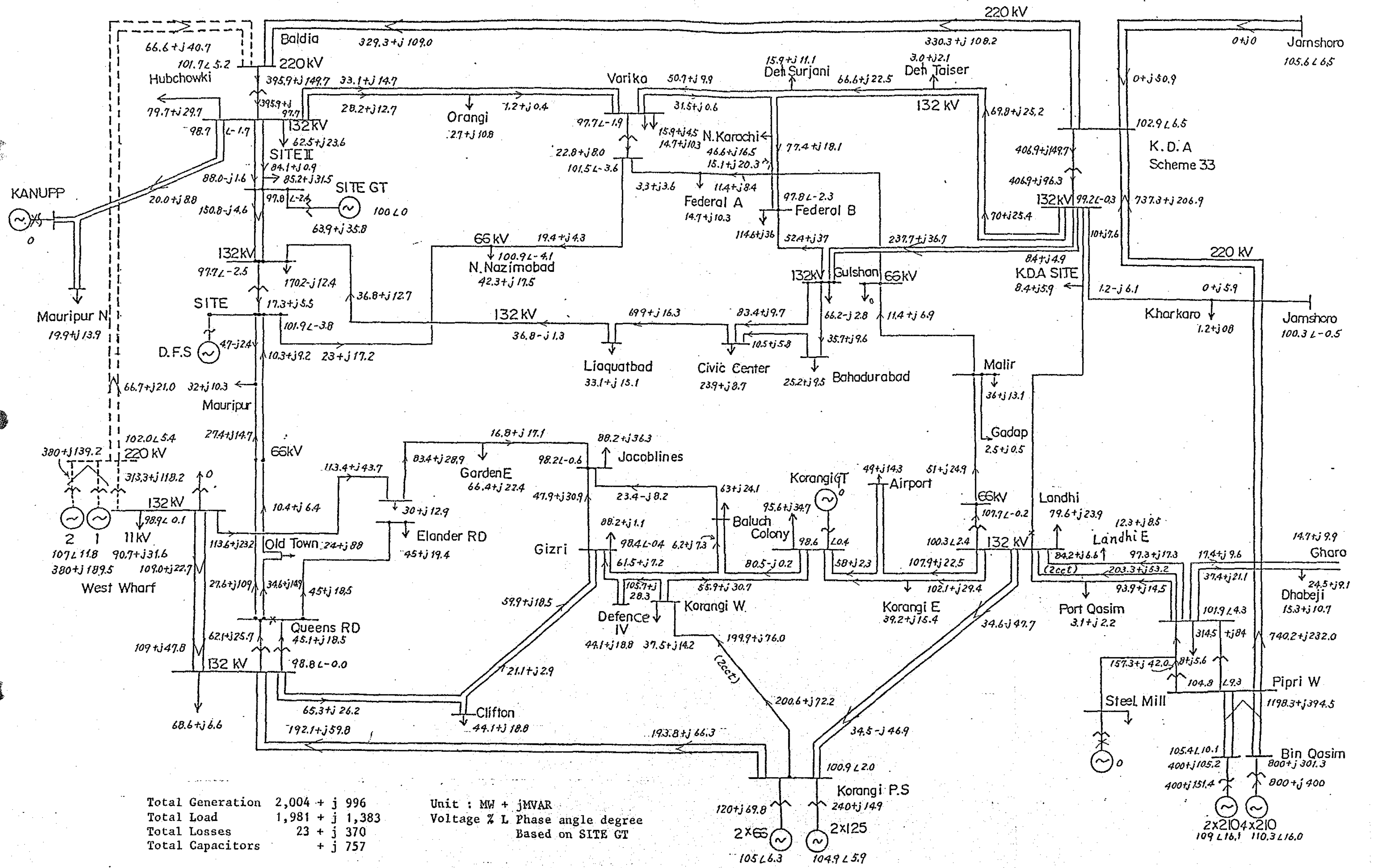


Total Generation 1,640 + j 767
Total Load 1,619 + j 1,130
Total Losses 21 + j 182
Total Capacitors + j 545

Unit : MW + jMVAR
Voltage % ∠ Phase angle degree
Based on SITE GT

Fig. 5.5-7 Power Flow Study Diagram in 1994

(There is no 132/66 kV bank at West Wharf P.P.)



Total Generation 2,004 + j 996
Total Load 1,981 + j 1,383
Total Losses 23 + j 370
Total Capacitors + j 757

Unit : MW + jMVAR
Voltage % ∠ Phase angle degree
Based on SITE GT

5.5.2 220 kV Transmission Line between Baldia Grid Station (G/S) and West Wharf Power Plant

(1) Route of transmission line

In accordance with the policy of the power system configuration aforementioned, a plan for constructing a 220 kV transmission line from Baldia G/S to West Wharf Power Plant has been worked out.

As a result of site survey, there is no surplus land available for constructing an overhead incoming line between a section of about 1.2 km adjacent to the West Wharf Power Plant. Therefore, an underground line must be laid through this section. Although there are some problematical points regarding construction work in that there is a section of about 1 km requiring common stringing of the line with the existing 66 kV line, and the fact that the line will cross over a marsh zone located at the river mouth, it has been evaluated to be feasible to construct the transmission line. That is, it has been judged to be possible to acquire a transmission line route along the coastal area by detouring around the Air Force Base from around Mauripur through to Baldia and passing through a desert zone thereafter. Regarding the results of route survey, refer to Annex A2.

However, it is required to perform investigation regarding the strength of ground soil for tower foundations, acquisition of land along the line route, etc. Further study will be needed at the detailed design stage.

Also, as for the actual 220 kV cable route, this should be planned carefully by considering other cable routes such as 132 kV lines around the West Wharf Power Plant which are now under study by KESC for future construction.

(2) Selection of conductor size

In consideration that the majority of generated output will flow into the city areas through 132 kV lines, it is required to consider in advance that the West Wharf Power Plant will be operated at full capacity even during the time of low load, as the units will be of high efficiency.

Consequently, the size of the conductors for the transmission line adjacent to the West Wharf Power Plant should be determined based on the capability that at least one circuit will be sufficient to transmit the output generated from one unit.

In addition, it is necessary to make possible the capacity and scale of the existing transmission line from around Mauripur through to Baldia to permit expansion of the KESC 220 kV system in response to future demand changes.

On the basis of this concept, the conductor size has been selected as listed below.

o Near West Wharf Power Station, underground cable section
  220 kV O/F cable, 1,000 mm2 single core x two cct x approx. 1.2 km (Transmission capacity: approx. 237 MVA/cct)

o From cable rising point to around Mauripur
  220 kV overhead ACSR/AW or AS 240 mm2 double core conductor x 2 cct x approx. 4.5 km (Transmission capacity: approx. 413 MVA/cct)
  Common stringing with the 66 kV overhead line should be adopted over a distance of about 1 km from among the total length.

o Between around Mauripur and Baldia G/S

220 kV overhead ACSR/AW or AS 510 mm2 double conductor x 2 cct x approx. 18.5 km)

(Transmission capacity: approx. 630 MVA/cct)

Thus, it has been considered possible under this study to secure the transmission capacity of one power unit through one circuit line as mentioned above. (Refer to Fig. 5.4-8).

Aluminum clad steel wire which is resistance to corrosion should be adopted for the overhead line. (Refer to Annex A3)

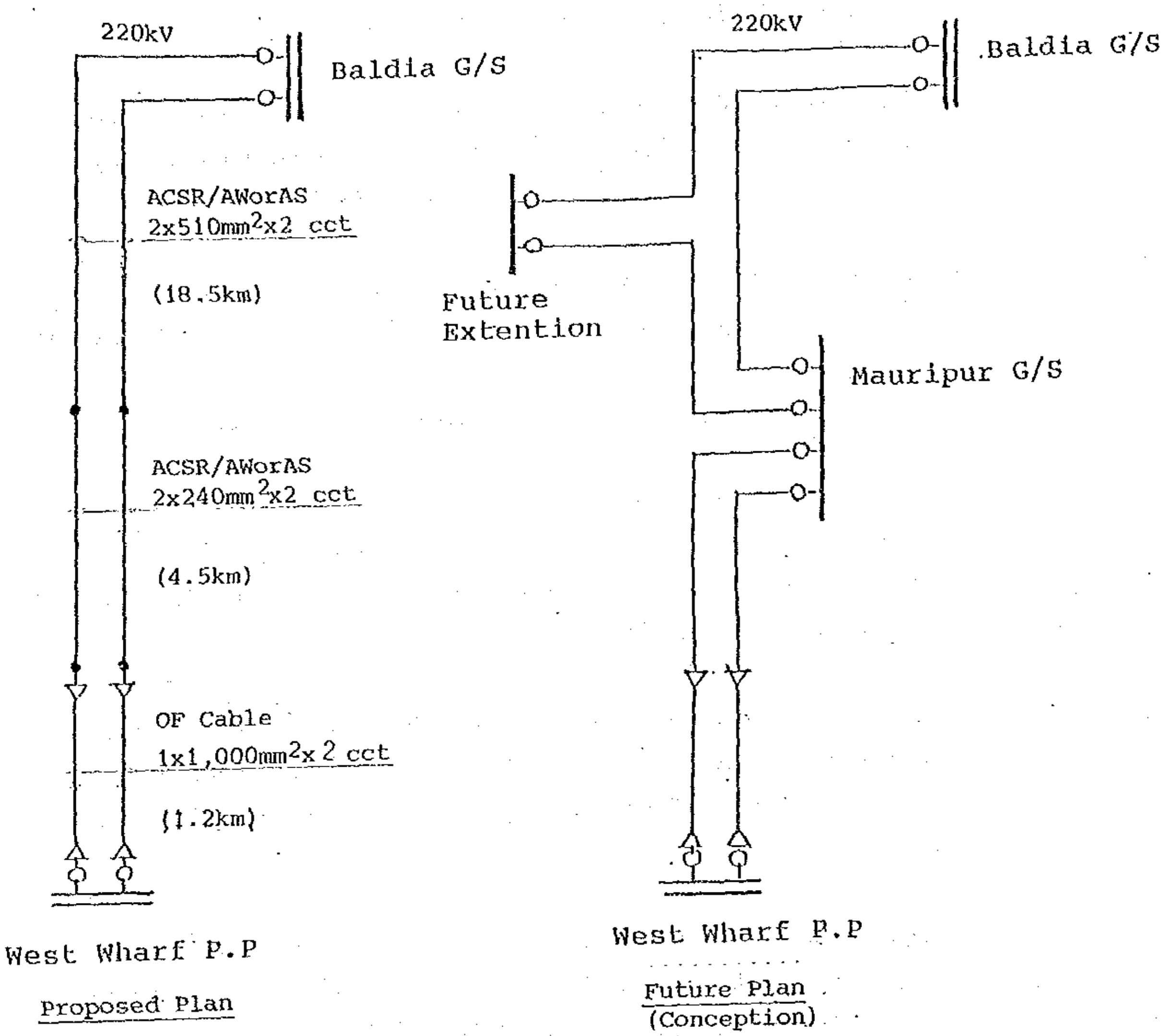
(3) Extension of incoming line to Baldia Grid Station

The construction cost for this project has been estimated on the assumption that the construction cost of the incoming section of the 220 kV transmission line to the Baldia G/S is included in the estimated cost.

The equipment to be adopted should be compatible with the existing 220 kV gas insulated (GIS) equipment; namely, rating current 1,250A, rating rupturing current 40 kA and GCB x 2 sets.

The equipment between the Baldia G/S and West Wharf Power Plant should be provided with a transmission line protection system by power line carrier (PLC) similarly as in the case of the existing system.

Fig.5.5-8 Size of 220kV Transmission Line.



LEGEND

- ACSR/AWorAS : Aluminum Conductor, Steel Reinforced, using aluminum clad steel wire
- OF Cable : Oil Filled Cable

5.5.3 Interconnection of power system and its reliability for supplying generated output to the transmission system of KESC

Development program of transmission and distribution systems of 132 kV voltage and lower is now under study and will be executed by KESC in 6th and 7th five year programs.

Neverthless, related transmission and distribution systems to the West Wharf Power Plant have been studied as one of the objecties of this study.

The study results are presented in the attached document "Annex A1" at the end of this report.

5.6 Electrical Equipment and Auxiliary Power Source

5.6.1 Basic plan of electrical facilities

According to the study results of the West Wharf Power Plant Project, the basic plan of the electrical facilities of the new power plant will be as described below.

1. Generated power of the 2 sets of 200 MW T/G units will be stepped up to 220 kV and transmitted to the Baldia Grid Station through 2 lines of 220 kV transmission lines.

2. In the power plant, 220 kV lines and 132 kV lines will be installed and these voltage systems will be connected through 2 sets of tie transformers.

3. 11 kV grid station in the West Wharf Power Plant will be fed by 132 kV system through tie transformers (2 sets) after connection of 220 kV line(s) to the W.W.P.P.

   Until that time, power will be supplied by the output of Units No. 8 and No. 9 of the "BX" station together with 66 kV switchyard by 11 kV output through the tertiary windings of the existing main transformers.

4. Location of the new 220 kV and 132 kV switchyards will be installed where the present 66 kV switchyard exists.

5. The 11 kV grid station will not be removed until the time it will be preferable to replace it in the future.

6. Electrical interconnections between the 66 kV system and both the 220 kV and 132 kV systems will not be considered.

7. After completion of the 220 kV and 132 kV facilities,

necessary works, such as circuit change of the existing 66 kV, etc., will be worked out.

5.6.2 Electrical Circuit

Generated power of 2 sets of 200 MW T/G units will be stepped up to 220 kV and transmitted by 2 circuits of 220 kV transmission lines through 220 kV switchyard buses.

A 132 kV switchyard will be installed to supply power to four (4) circuits transmission lines, 11 kV grid station and a starting transformer of the new plant to ensure high reliability and ease of operation and maintenance.

Optimum circuit arrangements

1. Switchyard circuit

   The switchyard will comprise 220 kV and 132 kV circuits having 2 sets of tie transformers. Both circuits will be double bus systems.

2. Generator main circuit

   Generator main circuit will be of a unit system, connected to a main transformer with isolated phase bus (IPB), and branched to an auxiliary transformer, excitation transformer, and PT, SA. Synchronizing circuit breaker will be connected to high tension side 220 kV circuit of the main transformer.

3. Auxiliary circuit

   As the auxiliary circuit for the power plant, a unit system will be adopted to ensure high reliability.

In this system, at the time of starting, power will be received from the starting transformer connected to the 132 kV switchyard bus.

After the generator is synchronized, power will be supplied from the auxiliary transformer connected to the generator circuit.

The auxiliary power voltage for the W.W.P.P. will be as follows:

High tension circuit : 6.6 kV
Low tension circuit : 400 V, 220 V, 110 V and DC 110 V

The short circuit capacity of the auxiliary circuit will be decided upon after the detail design stage, and will be based on the impedance of the unit auxiliary and starting transformer and the motor contribution by taking into account transformer voltage fluctuation.

The auxiliary circuit system to be determined after the detail design stage will be based on the capacity of the auxiliary load.

4. Emergency circuit

Emergency electric power source facilities will be installed to safely maintain the power source at the time of shut down of the turbine-generator due to tripping, etc.

The facilities will also be used for emergency auxiliary motor, lighting, communication system and control.

An installed-type storage battery will be used to supply DC electric power.

A diesel engine driven generator will be provided for emergency power for Units 1 and 2 so as to enable safe shutdown. This generator will supply the minimum required power in case of blackout, namely, all power source failures from units and transmission lines.

5. Uninterrupting circuit

The CVCF equipment (Constant Voltage and Constant Frequency) equipment will be provided as the power source equipment for the computer, automatic burner system, automatic boiler control system EHC, and other essential control systems.

The CVCF equipment having two (2) lines of power source (AC and DC) will be designed so that AC power will be stably supplied through an inverter at constant voltage and constant frequency.

5.6.3 Switchyard

1. The existing switchyard comprises 66 kV outdoor and indoor facilities, with a connecting bus bar of the conventional type.

The new switchyards will be 220 kV and 132 kV. Large capacity power will be transmitted through 220 kV transmission lines via the newly installed 220 kV switchyard.

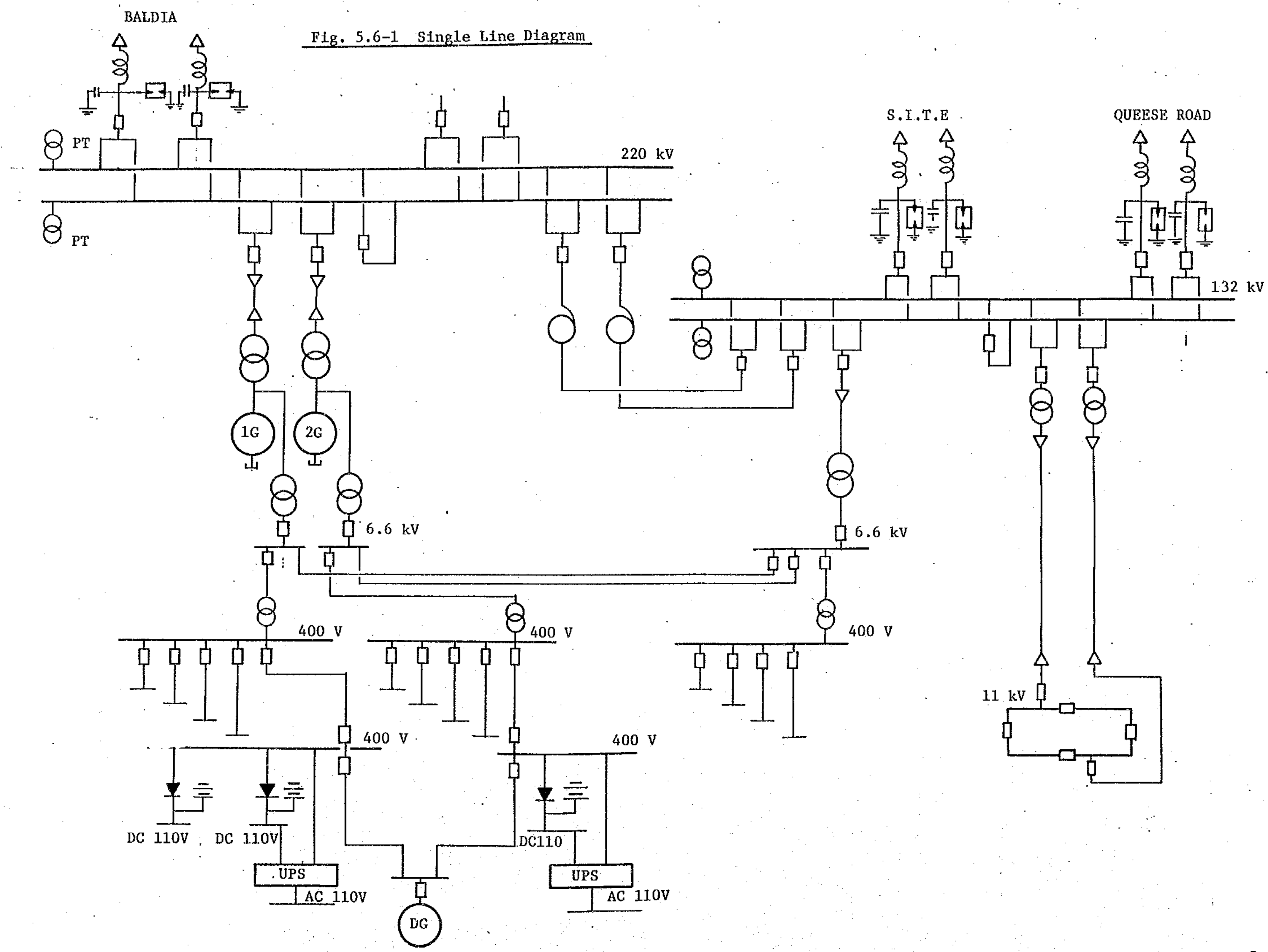
The 132 kV switchyard will be connected to the starting transformer of the new units and the 11 kV grid substation transformers.

For these new switchyards, a SF6 gas insulation switchgear (GIS) type indoor installation will be considered.

This type of switchgear requires less space than conventional type, and realizes higher reliability, easy operation and maintenance, improved safety, simple construction and a shorter construction period.

Location and arrangement of the new switchyards has been carefully studied and planned by considering outgoing transmission lines and location of transformers. Emphasis will be placed on physical and economical advantages, keeping in mind reliable and continuous power supply to the West Wharf area.

Fig. 5.6-1 Single Line Diagram



2. Location and arrangement of switchyards

The new switchyards are planned to be located in the existing 66 kV switchyard area which has an occupied area of approximately 2,250 m2 (90m x 25m).

The approximate dimensions of the new switchyards will be as follows:

(1)	220 kV switchyard	37.6 m x 12 m
(2)	132 kV switchyard	21.0 m x 8.4 m
(3)	Tie transformer	10.0 m x 8.0 m

The new switchyards should be completed by the time power is received from the 220 kV transmission line connected to the new power plant.

Therefore, the construction work of these switchyards should be executed with the "BX" station and the existing 66 kV switchyard still in operation.

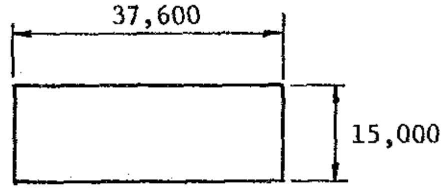
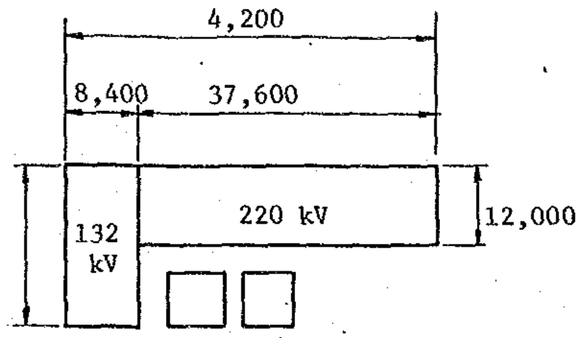
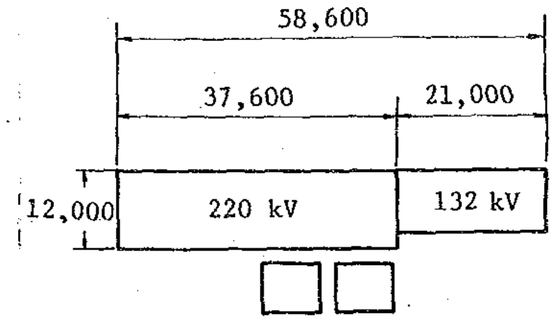
Accordingly, the existing 66 kV switchyard should be kept in its present state without any removal or rearrangement, if possible. However, rearrangement of the outdoor 66 kV switchyard should be considered to make the space for the 220 kV and 132 kV switchyard.

The existing 66 kV switchyard comprises 4 transmission lines, 2 generator outputs (No. 8 and No. 9) and feeder lines to the 11 kV distribution system.

Therefore, the switchyard should be kept in operation, with changing work of the circuits executed one by one.

The details of the changeover work is as described in Clause 5.6.5, "Modification Work of Existing 66 kV Switchyard."

Fig. 5.6-2 Switchyard Arrangement Plan

		PLAN A	PLAN B	PLAN C
Necessary space of switchyard excluding tie transformer		 2 storied building 220 kV : Ground floor 132 kV : 1st floor		
Existing 66 kV switchyard	Outdoor	To be dismantled	To be dismantled	To be dismantled
	Indoor	Remained	Remained	To be dismantled
Existing 66 kV switchyard modification work due to outdoor switchyard to be dismantled.		1. 66 kV switchyard [Line bay x 2] to be newly installed	1. 66 kV switchyard [Line bay x 2] to be newly installed	1. 66 kV switchyard [Line bay x 2] to be newly installed

5.6.4 Power supply system of 11 kV grid station

How to ensure power supply to the existing 11 kV grid station and where to move the facilities are the main points of the Feasibility Study.

Located in the West Wharf area are important facilities, such as the Naval Base, Karachi Shipyard, Karachi Port Trust, and Caltex, etc., all requiring highly reliable electric supply.

Electricity for this area is supplied through the 11 kV grid station, to which the No. 8 and No. 9 generators in the "BX" station are feeding power by 66 kV lines and through tertially winding of (22 kVA) transformers.

In addition, 66 kV transmission lines are connected to Queens Road and S.I.T.E. by two lines (each), balancing the load in this area.

66 kV of the Queens Road line is also branched to the Old Town Substation, with that of S.I.T.E. connected to the Mauripur Substation by one line.

In order to discontinue operation of the "BX" station in the future, the above 11 kV grid station in the W.W.P.P. should be connected by more than two feeder lines to enable more reliable power supply.

In the Feasibility Study, the following 4-cases have been studied to ensure reliable power supply to the 11 kV distribution system.

Case-1. Power feeding through existing 66 kV lines with strengthening nearby grid stations.
Case-2. New installation of 220 kV facilities.
Case-3. New installation of 132 kV facilities.

Case-4. Installation of gas turbine generators. (two (2) sets)

Case-1

Feeding power via 11 kV lines to the West Wharf area, by strengthening power supply facilities in the nearby grid station(s).

Note, however, that this should be carried out in time for commissioning of Bin Qasin Unit 3.

Case-2

Leading a 220 kV transmission line to the West Wharf P.P., installing a 220 kV switchyard and tie transformer in the West Wharf P.P., and feeding to existing 66 kV transmission lines.

Case-3

Installing a 132 kV switchyard, connecting 132 kV lines to the West Wharf P.P. and feeding power to the existing 66 kV transmission lines through 132/66 tie transformers.

Case-4

Ensuring power supply to 11 kV lines by installing two (2) sets of gas turbine generators, having the same capacity as "BX" Unit 8 and 9, will be installed.

Among the above 4 cases, as case-2, (New installation of 220 kV facilities) seems to be the most practical, this method is selected as the optimum plan for ensuring 11 kV line power supply.

However, other methods (Case-1 and 3) are also possible for consideration, if they are implemented at an early stage of the project so as to enable early decommissioning of the "BX" station.

Note:

Case-4 has been omitted for the reasons described in Section 5.2.

5.6.5 Modification work of the existing 66 kV switchyard

The West Wharf Thermal Power Plant Development Program should be executed by considering how to maintain power supply to the district for which purpose the "BX" station is now serving, through decomissioning and dismantling of the "BX" station and constructing the new plant.

Therefore, the modification work of the existing 66 kV switchyard should be planned carefully.

The final arrangements of the 66 kV system in and around the W.W.P.P. envisage elimination of the 66 kV facilities in the W.W.P.P. and simplifying the facilities inside the power plant.

Changeover of the power supply will be executed after receiving power from the 220 kV transmission line which will be constructed between the Baldia G/S and the W.W.P.P.

Also, power supply to the existing 11 kV grid station is ensured by change over of power supply from the "BX" station to the newly installed 220/132 kV switchyard.

Therefore the new 220/132 kV switchyard should be completed by the Power Receiving time from outside.

In order to construct the 220 kV and 132 kV switchyards prior to completion of the new power plant, the existing 66 kV outdoor switchyard should be removed by rearranging the existing 66 kV outdoor and indoor switchyards, so as to acquire necessary space for the new facilities.

Other necessary precautions

(1) Protection relay panels with respective relays

Existing protection relay panels for the transmission lines are located in the administration building of the plant.

Because this protection system is a power line carrier type, modification work should be carried out with full investigation of the present system. Items to be studied are wiring diagrams, back connections, specification of relays, outline drawings and besement setting drawings, etc.

(2) OF (Oil Fill) cable

Concerning modification of the existing OF cables, the following items should be confirmed by the manufactures, etc., these include detailed specifications, layout inside the plant, spare length of the cables, etc.

5.6.6 Final arrangement of 66 kV transmission line around the West Wharf Power Plant

According to the optimum plan, the existing 66 kV transmission lines related to the West Wharf Power Plant are planned to be modified as follows, while at the final stage the existing 66 kV switchyard and associated equipment will be dismantled from the W.W.P.P.

Modification of 66 kV transmission line.

	Existing	Final arrangement
(1)	W.W. ∿ Mauripur G/S	S.I.T.E ∿ Mauripur G/S
(2)	W.W. ∿ S.I.T.E G/S	Ditto
(3)	W.W. ∿ Old Town G/S	Queens Road ∿ Old Town G/S
(4)	W.W. ∿ Queens Road G/S	Ditto

The reason for the above modification is that the existing four (4) 66 kV transmission lines will remain connected via W.W.P.P., temporarily. Later, changeover of power supply to the 11 kV distribution system in the area from the "BX" station to the newly installed 220/132 kV switchyard facilities will be carried out. This simplication of the system is preferable.*

* Note:
If the existing 66 kV switchyard facilities are to remain, even after the above modification, the control and protection system of the switchyard should be left as it is in W.W.P.P. Also, additional building to contain these facilities should be built in the area, but this is not advantageous for KESC.

At present, the following facilities are being installed in the W.W.P.P.

	Existing facilities	Location
(1)	Control panel	Administration building
(2)	Protection relay panel	ditto
(3)	Battery and battery changer	"BX" building
(4)	Power sources for compressor	ditto
(5)	Control cable	Switchyard ∿ Administration building Switchyard ∿ "BX" building

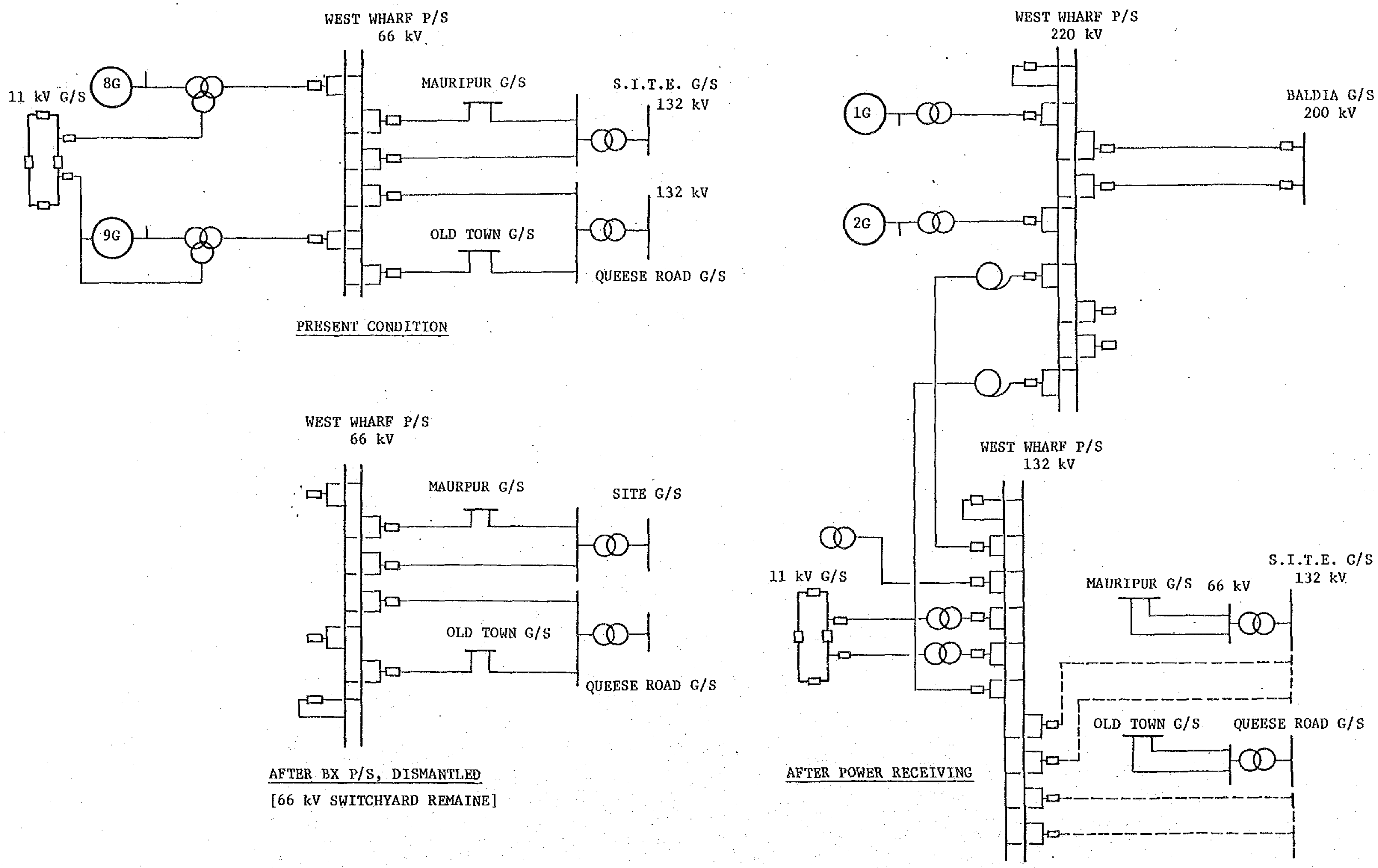


Fig. 5.6-3 Single Line Diagram of 66 kV Circuit before and after Modification

5.7 Site Survey Report

The site survey was carried out to determine the methods of dismantling the existing facilities, to establish a preliminary plot plan of the new power plant, preliminary design of foundation structures, and for measurements of sea depths (sounding test) around the inlet and outlet opennings of the cooling water way, etc.

Among these surveys, the JICA Study Team had prepared specifications, including special precautions for the work procedures, for geological survey (soil investigation), topographic survey and sounding test, with KESC undertaking the survey work. The survey items are described as follows and the Worked Schedule are shown in the attach Table 5.7-1.

1. Geological survey (soil investigation)
   Core boring and penetration test
2. Topographic survey
   (including survey of existing pile foundations)
3. Sounding test
4. Structural survey
5. Concrete strength test
6. Noise measurement

Soil investigation and topographic survey results are attached for reference at the end of this report. However, for the sounding test, no official detail report was obtained due to the test being carried out under controls of the Pakistan Navy.

A brief description of the site survey results are as shown below.

5.7.1 Geological survey (soil investigation)

1. Core boring and penetration test (including existing pile survey)

   5 core boring tests (1 of 30 m and 4 of 20 m in depth, as pilot boring) were conducted.

   The positions of these boring tests are as shown in Fig. 5.7-1.

   These positions were determined based upon layout of the existing structures and the existing buried pipes, cables, etc. Following the boring tests, standard penetration tests were carried out and related data concerning soil strength and deformation characteristic were gathered.

   Section drawings indicating the survey results are as presented in Fig. 5.7-2 (A-Section) and Fig. 5.7-3 (B-Section), together with the location drawing of the borings showing the location of these sections.

2. Soil profile

   The site, except for the center portion, is covered with reclaimed soil of 1 to 4 meters in thickness.

   Below this exists a gravel layer about 20 m thick.

   Composition of the sand layer is not homogeneous.

   Almost all sand silt with uneven grain sizes ranging from granular to large grains.

   Besides this sandy silt layer, there exists a sand layer in the north part of the "B" station as well as a sand gravel layer in the south part of the "A" station.

A hard clay layer exists under these sand layers.

This hard clay layer is slighty inclined from south to north, spreading throughout the site and seems stable in strength.

The thickness of this layer is estimated as approximately 8 meters and suitable for a common support layer for the new power plant.

Furthermore, under the hard clay layer spreads another sand layer. As for the support layer for bearing piles of the new power plant, this clay layer seems most suitable. However, further detailed soil investigation should be carried out at the detail design stage.

As the underground water level is approximately 1 meter below the surface of the soil, for excavation work, sufficient consideration should be given to drainage and retaining wall work.

3. Laboratory test

A summary of the laboratory soil test results is as presented in Table 5.7-2.

Because sand layers are prominent in this site, excavation work should be executed with care for drainage and retaining wall work.

Judging from the grain size of the soil, permeability of the soil is estimated as approximately 20 x 10-3 cm/s, indicating that the water quantity required for drainage will not be large.

As gravel content is a low 3.6%, piling work should cause no trouble.

As for the hard clay layer, the compressive strength is 4 ton/ft2 and over as seen from the results of the axial compression test, making it sufficient for the supporting layer.

The angle of internal friction of the sand layer is less than 30 degrees and generally loose. Thus, piling work of the sheet piles should be executed carefully.

5.7.2 Topographic survey (including survey of the existing pile foundations)

Topographic survey was executed mainly to measure level heights inside the site area and layout locations of the existing power station structures.

The results are as presented in Fig. 5.7-4.

In this project, it is necessary to dismantle the existing power stations. However, due to a lack of related drawings, the JICA Study Team also executed a survey related to the existing pile foundations.

The results of this survey are as presented in Fig. 5.7-5.

The survey of the pile foundations was executed around the No. 7 boiler foundation of the "A" station. These results are as shown in Fig. 5.7-5.

When the JICA Study Team proceeded to check under the boiler foundation by removing the concrete floor and excavating the soil and sand, it found a concrete mat slab under the boiler foundations.

To remove this mat slab, a dismantling machine had to be necessary. As none was available at that time, the survey was ended at this stage and the team could not confirm the existance of other parts of this mat slab.

However, there is a possibility that this mat slab exists over a wide area and is a direct foundation for the boiler without piles.

5.7.3 Measurement of sea water depth

A sounding test was executed for the purpose of gathering necessary data of the water depth around the intake and discharge area of the cooling water for the new power plant which will have an approximate 400 MW capacity.

These areas are located outside the KESC area, and it was necessary to obtain permission from KPT, KSY and the Navy.

Consequently, for the inlet side, the data from the survey results excuted by the Navy were adopted; for the outlet side, the survey was executed by the Navy according to KESC requirements.

The survey results are as shown in Fig. 5.7-6. According to these results, the sea depth around the inlet and outlet of the cooling water way is deep enough to obtain the required quantity of cooling water for the new power plant.

Also, note that a list of the tidal levels is attached for reference at the end of the report (attachment Table A-1).

5.7.4 Structural survey

To gather necessary data for dismantling the existing facilities, the size, number and types of facilities were surveyed.

This survey was executed as there exist no drawings related to the existing facilities. Also, the survey of the existing foundations was not practical at this stage and could not be executed. However, the number and quantity of the mat foundations and piles, which should be removed during the dismantling work, are as estimated according to the site investigation result and listed in the Table 5.7-3, together with the layout of the existing facilities as shown in Fig. 5.7-7.

5.7.5 Concrete strength test

Compressive tests of the existing concrete were executed by using a Schmidt hammer.

The tests was executed at the boiler foundations and turbine foundations of the "A" station, and the results are as presented in Table 5.7-4.

This non-destructive test was performed by applying impact force on the concrete surface to be tested using the Schmidt hammer and measuring the Rebound Value. Compressive strength of the concrete was estimated from the Rebound Value (R).

The measurements were executed selecting one place at one foundation and performed 20 times at this same place.

Determination of compressive strengths was obtained based on Equation 5.7-1 below.

$$F = 13R - 184 \quad \text{-------------} \quad \text{Eq. 5.7-1}$$

where, F: Estimated compressive strength of the concrete
R: Rebound Value

From these data, the concrete strength of the existing foundations are estimated to be about 200 kg/cm2 for the boiler foundations, and about 400 kg/cm2 for the turbine foundations.

Therefore, chipping work during dismantling of the existing facilities will no doubt be difficult, and the work should be executed by use of chipping machine(s).

5.7.6 Noise measurement

The present noise level in the West Wharf Power Plant area was measured at 4 points in the premises and the measurements were carried out two times each day, at 11 a.m. and 3 p.m.

The measurement locations are as shown in Fig. 5.7-8, and the results as listed in Table 5.7-5.

There are no significant differences, at any one point, among the data measured in different days of the week.

However, noise levels in the afternoon are, in general, higher than those obtained in the morning.

The noise levels at points No. 1 and No. 3 are higher than those of at Nos. 2 and No. 4. This fact seems to be due to the reason that these points are near the "BX" station which is in operation.

Table 5.7-1 ACTUAL SCHEDULE OF SURVEY AND INVESTIGATION FOR WEST WHARF POWER PLANT PROJECT

ITEM	1987 DEC 19–25	26–1	1988 JAN 2–8	9–15	16–22	23–29	REMARKS
1. SOIL SURVEY	19				22		F & W Management Group
2. TOPOGRAPHIC SURVEY	23					25	G.R.Mirza & Co.
(PILE SURVEY)				9	21		
3. SEA WATER DEPTH				9	17		Pakistan Navy
4. STRUCTURE SURVEY	19	30					JICA Study Team
5. CONCRETE STRENGTH	23—24						JICA Study Team
6. NOISE SURVEY	23	30					JICA Study Team

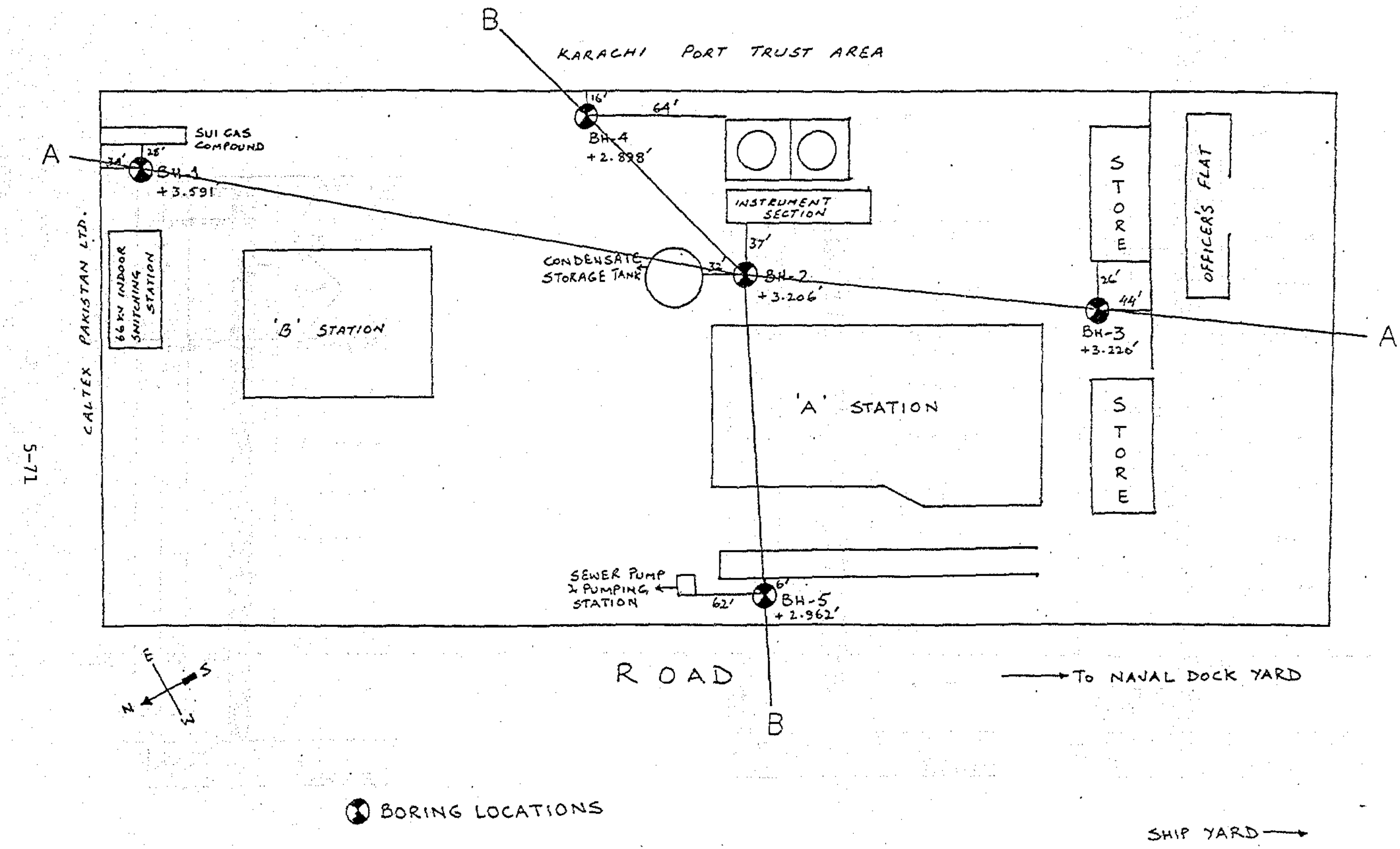


Fig. 5.7-1 LOCATION OF BORING

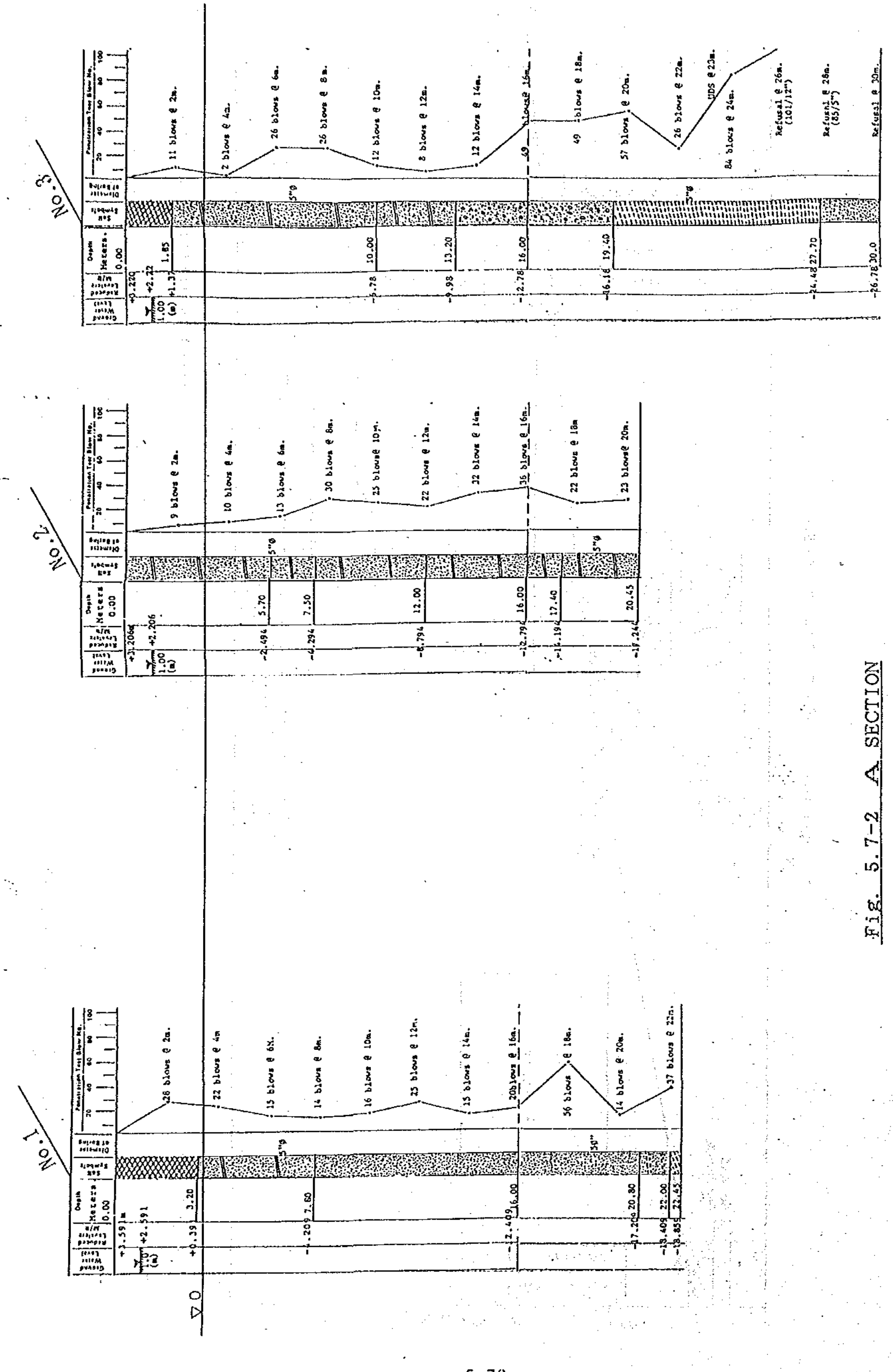


Fig. 5.7-2 A SECTION

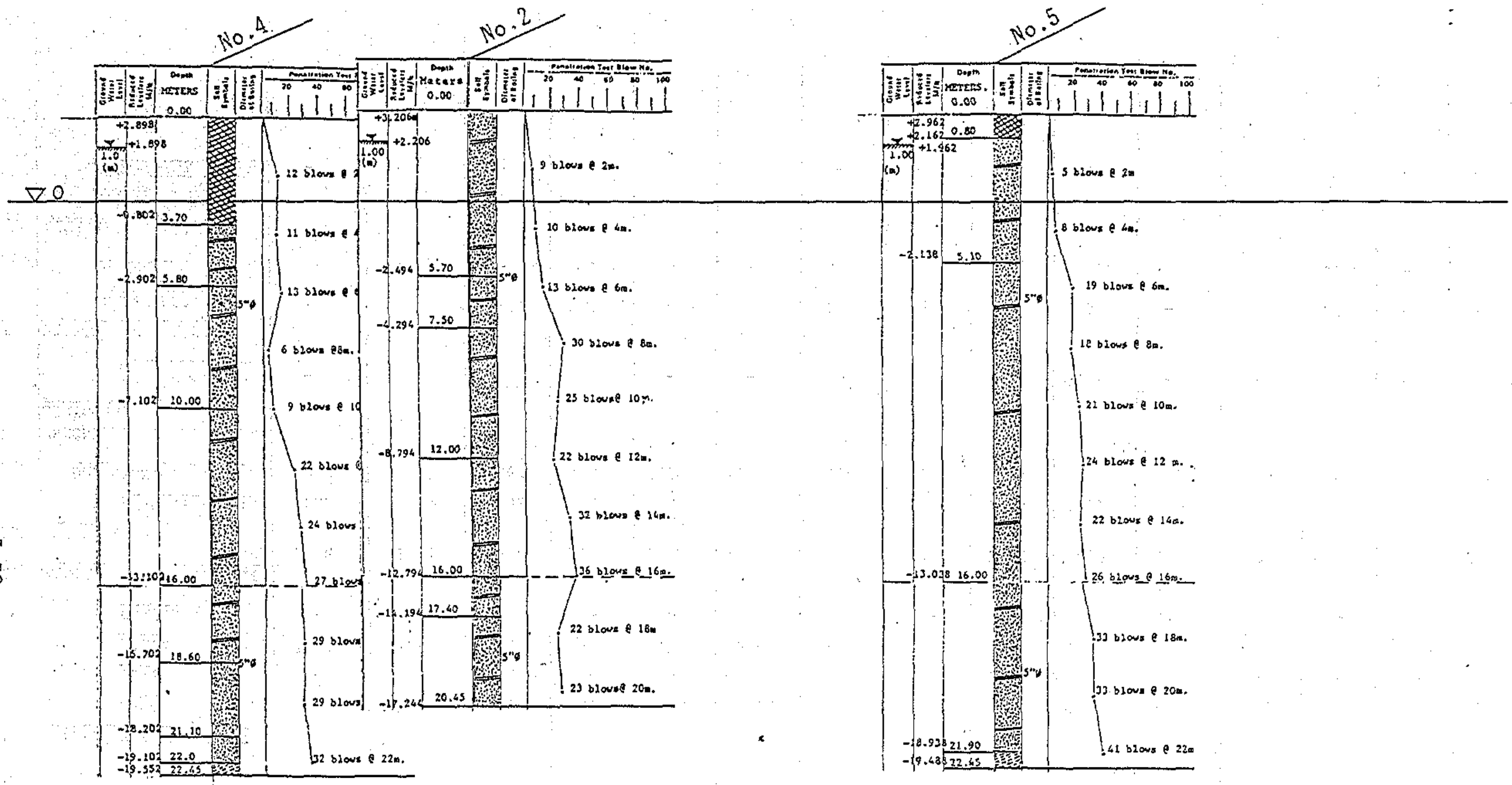


Fig. 5.7-3 B SECTION

Table 5.7-2 ABSTRACT OF LABORATORY TESTS

S.NO	SOIL TEST	BH - 1			BH - 2			BH - 3				BH - 4			BH - 5		
		DS 4.00 m.	DS 12.00m.	DS 22.00m.	DS 4.00 m.	DS 12.00 m	DS 20.00m.	DS 4.00m.	DS 6.00m.	DS 20.00m.	UDS 23.00m.	DS 6.00.	DS 14.00m.	DS 20.00m	DS 4.00m.	DS 16.00.	SS 22.0
1.	PARTICLE SIZE ANALYSIS																
	SAND%	67.7	95.3	6.9	80.7	95.3	91.6	-	88.2	3.4	3.2	86.8	95.1	97.6	88.0	93.8	7.0
	CLAY%	-	-	54.0	-	-	-	-	-	55.4	58.0	-	-	-	-	-	51.9
	SILT%	32.3	4.7	39.1	19.3	4.7	8.4	-	11.8	41.2	38.8	9.6	4.9	2.4	12.0	6.2	41.1
	GRAVELS%	-	-	-	-	-	-	-	-	-	-	3.6	-	-	-	-	-
2.	NATURAL MOISTURE CONTENT (%)	17.8	21.3	24.4	23.9	20.3	22.2	28.0	28.9	22.4	24.9	6.7	9.8	6.7	10.3	22.8	26.8
3.	DENSITY																
	BULK DENSITY gm/cc.	2.03	2.04	1.98	1.85	1.80	1.88	1.92	1.86	1.88	1.91	2.00	1.60	1.68	1.90	1.82	1.98
	DRY DENSITY gm/cc.	1.72	1.68	1.60	1.49	1.50	1.54	1.50	1.44	1.54	1.53	1.87	1.45	1.58	1.72	1.48	1.48
4.	UNCONFINED COMPRESSIVE STRENGTH:																
	q_u tons/ft^2.	-	-	-	-	-	-	-	-	2.85	4.18	-	-	-	-	-	-
5.	DIRECT SHEAR TEST																
	Ø DEGREES	-	24	-	28	-	-	26	-	-	15	-	-	27	-	-	16
	C kg/m^2	-	0.12	-	0.15	-	-	0.11	-	-	0.32	-	-	0.10	-	-	0.31
6.	ATTERBERG LIMITS																
	LIQUID LIMIT %	-	-	-	-	-	-	-	-	48.6	48.9	-	-	NP	-	-	-
	PLASTICITY INDEX	-	-	-	-	-	-	-	-	23.7	24.3	-	-	NP	-	-	-

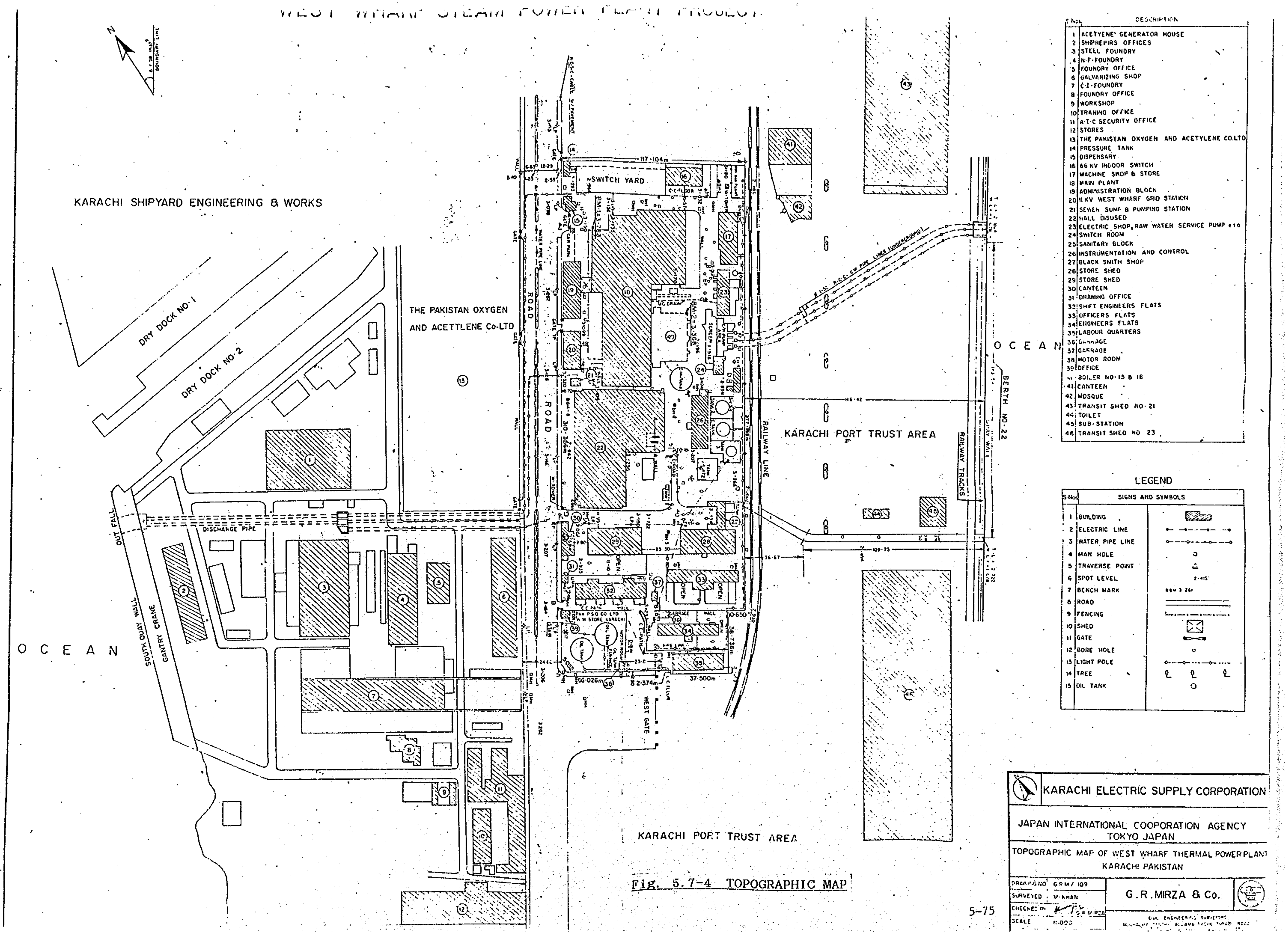
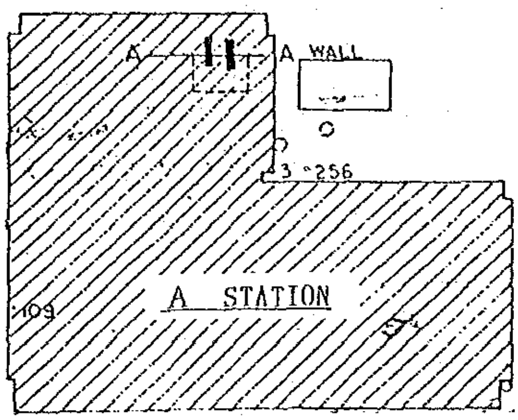


Fig. 5.7-4 TOPOGRAPHIC MAP



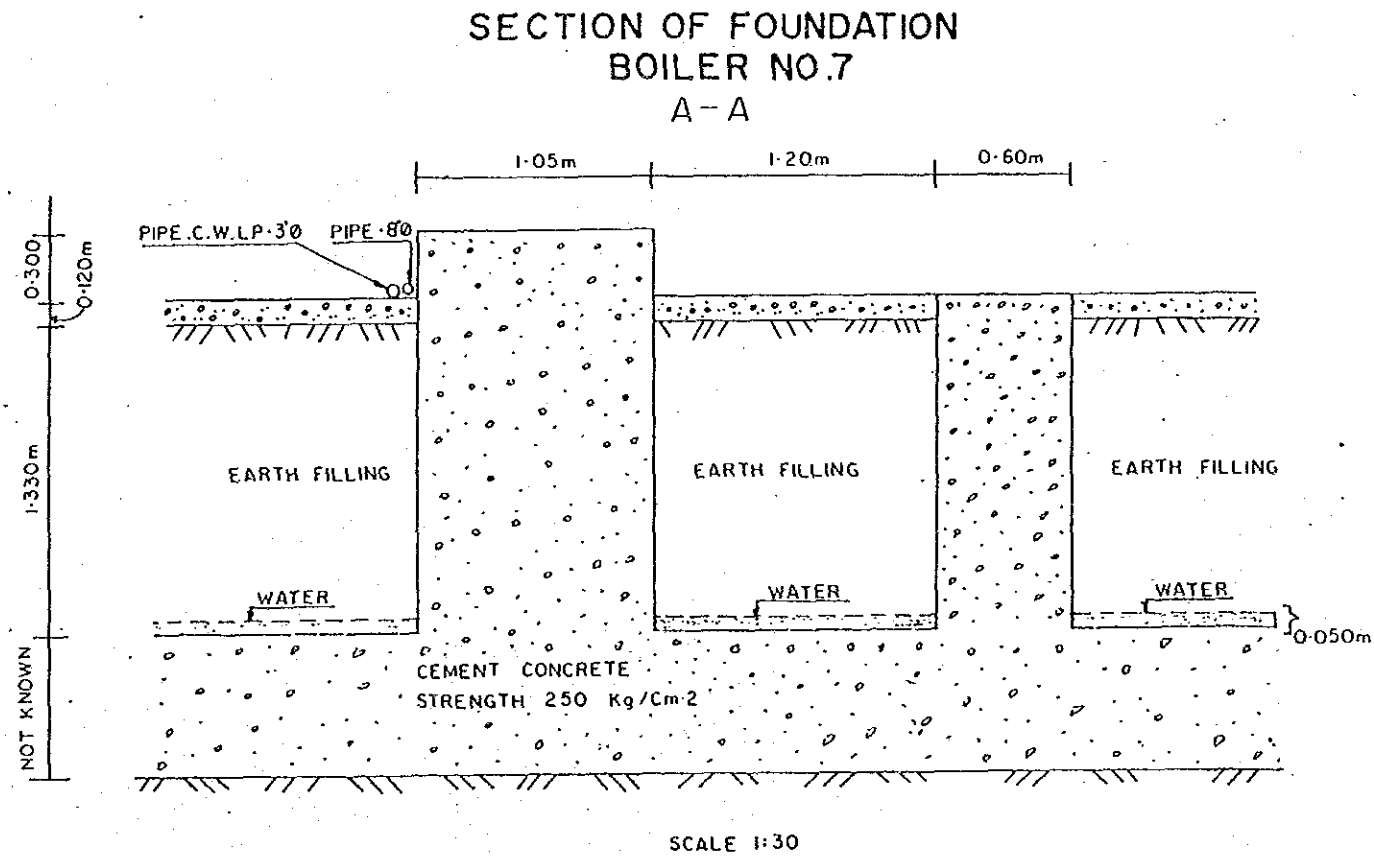


Fig. 5.7-5 SECTION OF FOUNDATION

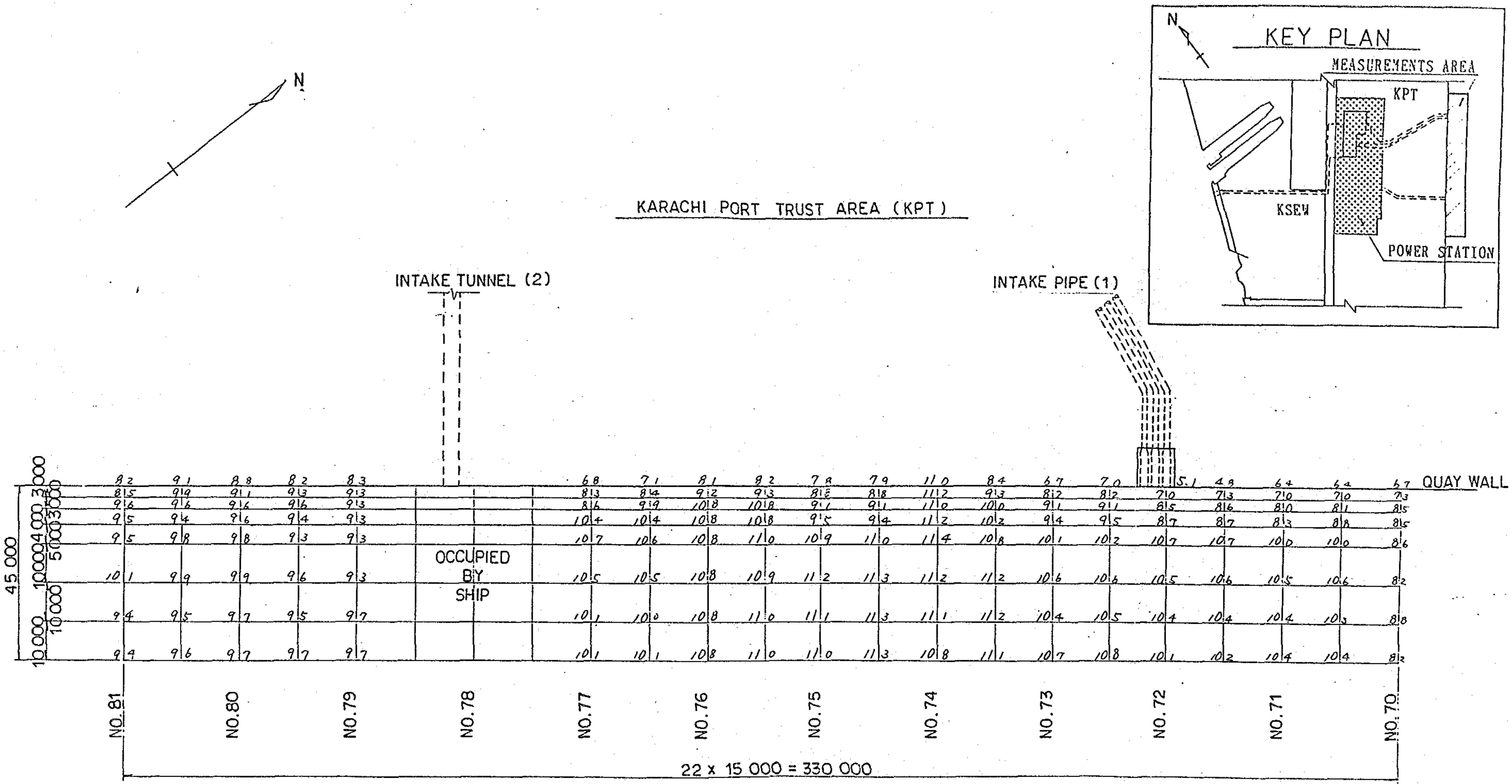


Fig. 5.7-6 (a) SEA WATER DEPTH (1/2)

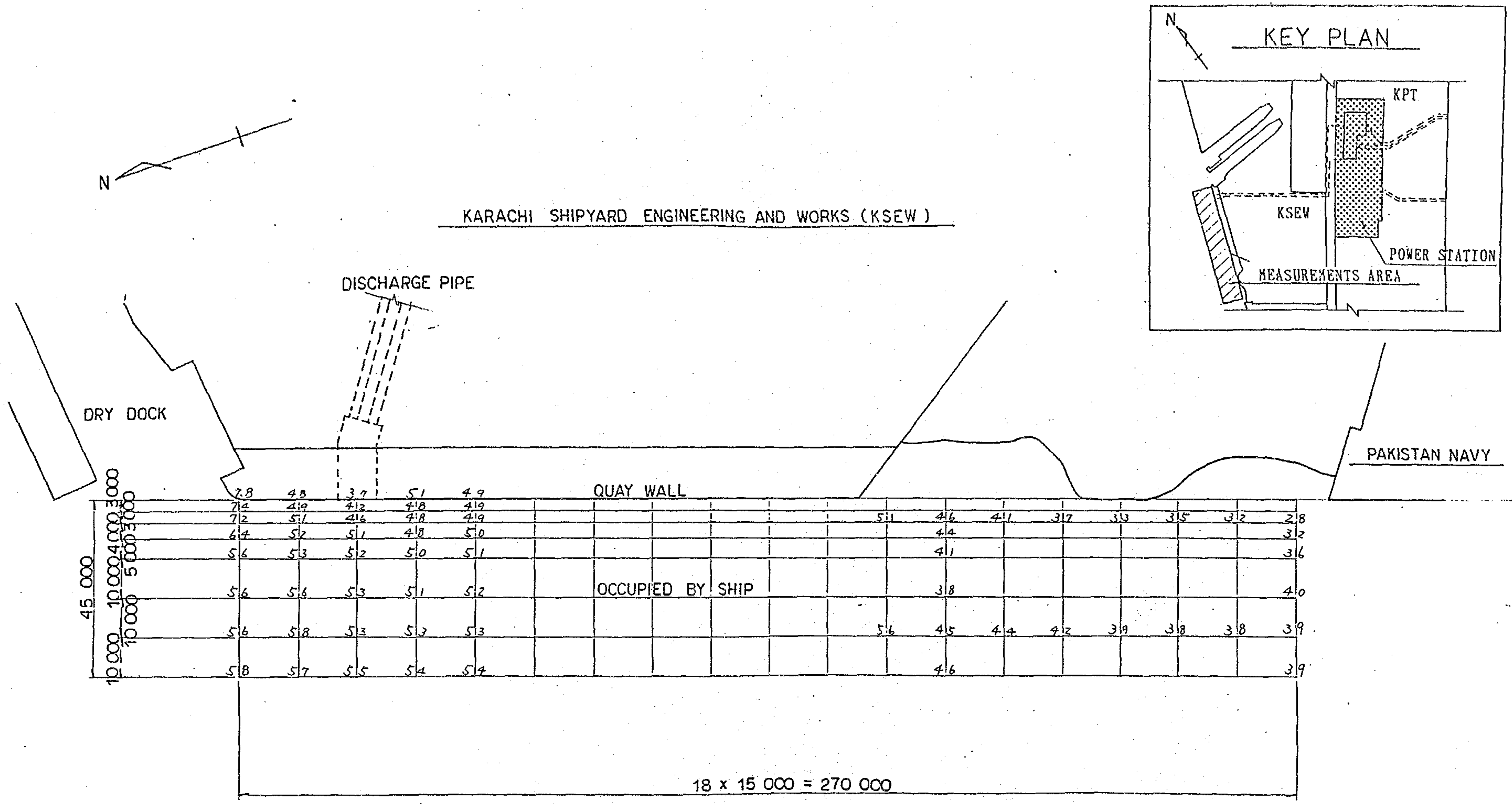


Fig. 5.7-6 (b) SEA WATER DEPTH (2/2)

Table 5.7-3 (a) INVESTIGATION OF FACILITIES

No.	NAME OF STRUCTURE	CLASSIFIC. OF STRUCT.	NUMBER OF STORIES	DIMENSION OF STRUCTURE B(m) × D(m)	H(m)
1	A STATION	STL. CONC.	2 STORIES	35.6 × 88.2	15.0
2	B STATION	STL. CONC.	2 STORIES	60.0 × 51.6	22.0
3	BX STATION	STL. CONC.	2 STORIES	31.0 × 56.0	22.0
4	ADMIN. BLDG.	CONC.	3 STORIES	10.0 × 35.0	15.0
5	No.15 BOILER	STEEL	-	13.6 × 7.2	22.0
6	No.16 BOILER	STEEL	-	13.6 × 7.2	22.0
7	CHIMNEY OF B ST.	CONC.	-	DIA. 3.4	38.6
8	CHIMNEY OF BX ST.	STEEL	-	DIA. 3.4	40.0
9	11KV SWITCHGEAR	CONC.	1 STORY	11.0 × 23.5	5.2
10	66KV SWITCH ST.	CONC.	1 STORY	23.3 × 11.0	8.0
11	66KV SWITCH ST.	CONC.	-	56.6 × 19.7	1.0
12	INLET PIPE	CONC.	-	DIA. 1.5	L=200.0
13	INTAKE CULVERT	CONC.	-	DIA. 3.0	L=155.0
14	PUMP HOUSE No.2	CONC.	2 STORIES	25.0 × 50.0	5.0
15	INTAKE PIPE A	STEEL	-	DIA. 0.6	L=100.0
16	INTAKE PIPE B	STEEL	-	DIA. 1.3	L=130.0
17	INTAKE PIPE BX	STEEL	-	DIA. 2- 1.3	L= 30.0
18	DISCHARGE PIPE A	CONC.	-	DIA. 1.2	L=150.0
19	DISCHARGE PIPE B	CONC.	-	DIA. 1.5	L=433.0
20	DISCHARGE PIPEBX	CONC.	-	DIA. 1.5	L=327.0

Table 5.7-3' (b) INVESTIGATION OF FACILITIES

No.	NAME OF STRUCTURE	CLASSIFIC. OF STRUCT.	NUMBER OF STORIES	DIMENSION OF STRUCTURE B(m) × D(m)	H(m)
21	OUTFALL	STL. CONC.	-	19.0 × 9.4	8.8
22	SUI GAS COMPOUND	CONC.	-	8.9 × 20.3	2.0
23	MACHINE SHOP	CONC.	1 STORY	11.9 × 22.5	4.5
24	FUEL OIL PUMP	CONC.	1 STORY	10.5 × 9.6	6.0
25	RAW WATER PUMP	STEEL	1 STORY	9.0 × 28.0	6.0
26	SWITCH ROOM	CONC.	1 STORY	7.8 × 35.7	5.0
27	SANITARY BLOCK	CONC.	1 STORY	4.3 × 8.5	4.0
28	SEWAGE PUMP	CONC.	1 STORY	3.8 × 2.9	3.0
29	STORAGE TANK	CONC.	-	DIA. 9.5	5.0
30	OIL TANK No.1	STEEL	-	DIA. 7.5	8.0
31	OIL TANK No.2	STEEL	-	DIA. 7.5	8.0
32	OIL TANK No.3	STEEL	-	DIA. 7.5	8.0
33	OIL DIKE	CONC.	-	1.0 ×146.6	1.0
34	INSTRUMENT SEC.	CONC.	1 STORY	10.4 × 33.0	4.0
35	GROUND RESERVOIR	CONC.	-	13.9 × 13.9	2.0
36	PUMP HOUSE No.1	CONC.	2 STORIES	4.8 × 21.0	5.0
37	UNDERGROUND TANK	CONC.	-	4.1 × 8.0	2.0
38	STORE No.1	CONC. STL.	1 STORY	34.1 × 15.8	11.2
39	STORE No.2	CONC. STL.	1 STORY	34.1 × 15.8	11.2
40	OFFICER'S FLAT	CONC.	2 STORIES	55.0 × 11.2	10.0

Table 5.7-3 (c) INVESTIGATION OF FACILITIES

No.	NAME OF STRUCTURE	CLASSIFIC. OF STRUCT.	NUMBER OF STORIES	DIMENSION OF STRUCTURE B(m) × D(m)	H(m)
41	SHIFT ENG. FLAT	CONC.	3 STORIES	45.0 × 14.0	15.0
42	ENGINEER'S FLAT	CONC.	2 STORIES	40.0 × 7.0	10.0
43	DRAWING OFFICE	CONC.	2 STORIES	8.5 × 17.7	8.0
44	GARAGE FOR ENG.	CONC.	-	3.5 × 5.6	2.5
45	CHOWKIDOR ROOM	CONC.	1 STORY	3.0 × 3.0	3.0
46	DISPENSARY	CONC.	1 STORY	6.0 × 5.1	4.0
47	PRESSURE TANK	CONC.	-	4.4 × 8.7	3.0
48	ROAD & ENTRANCE	CONC.	-	7,500m^2	t= 200mm
49					
50					

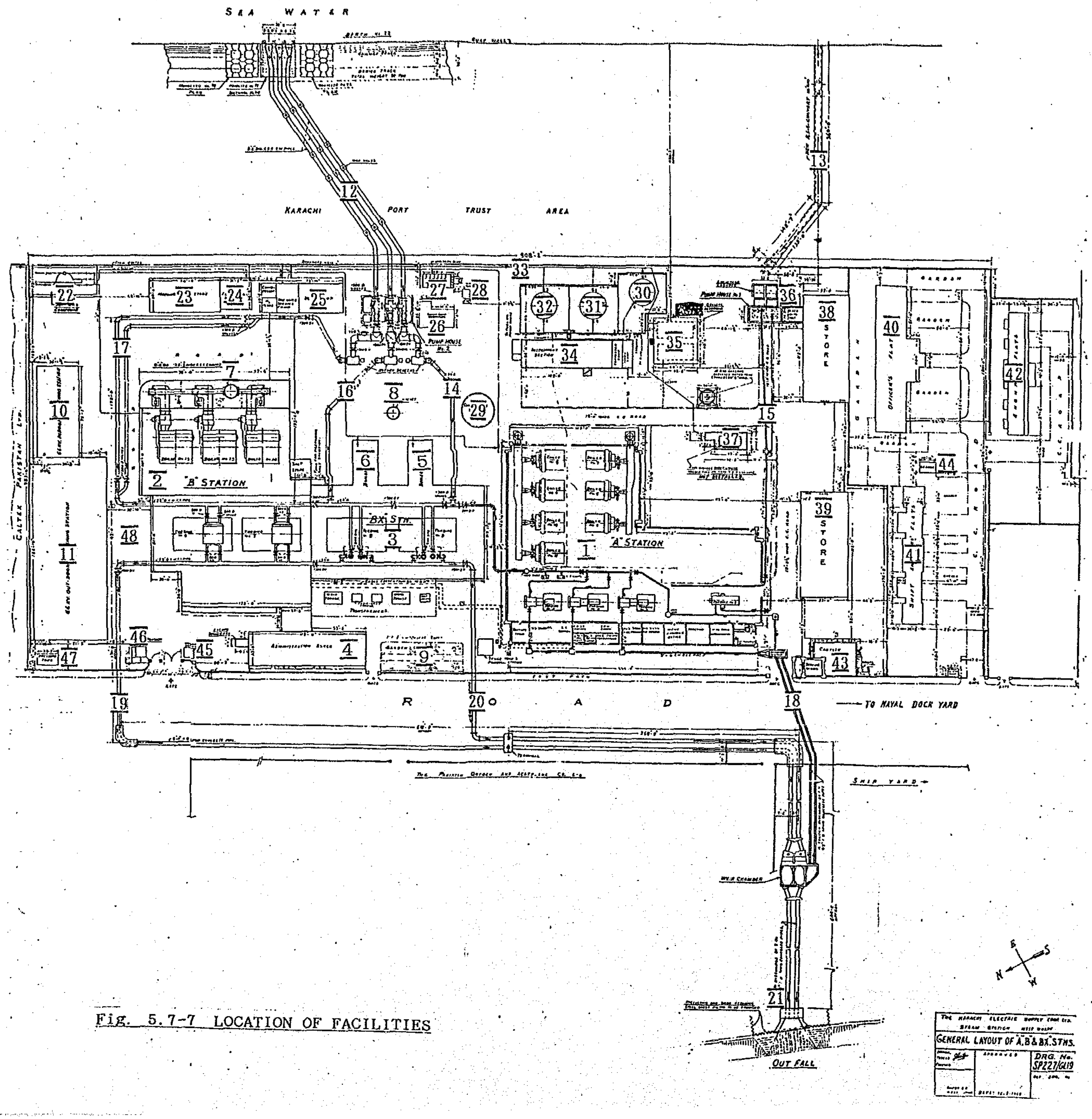


Fig. 5.7-7 LOCATION OF FACILITIES

Table 5.7-4 COMPRESSIVE STRENGTH OF CONCRETE

NAME OF FOUNDATION	A STATION No.7 BOILER	A STATION No.1 TURBINE
REBOUND VALUE (R)	29	46
	24	49
	24	53
	27	43
	27	49
	25	44
	25	52
	26	41
	24	48
	28	36
	32	53
	30	49
	29	48
	26	48
	32	50
	36	50
	37	42
	35	50
	33	46
	45	43
AVERAGE (R)	29.7	47.0
ATANDARD DEV.	5.3	4.3
COMPRESSIVE STRENGTH	202 (kg/cm^2)	427 (kg/cm^2)

Table 5.7-5 NOISE INVESTIGATION (UNIT:dB)

TIME	DATE	No.1	No.2	No.3	No.4
11:00	DEC. 23	64	50	70	54
	DEC. 24	64	48	70	54
	DEC. 26	64	50	68	54
	DEC. 28	63	50	68	52
	DEC. 29	64	46	69	52
	DEC. 30	61	48	67	58
	AVERAGE	63.3	48.7	68.7	54.0
15:00	DEC. 23	66	48	70	54
	DEC. 24	64	48	70	54
	DEC. 26	65	50	70	54
	DEC. 28	66	52	66	53
	DEC. 29	65	50	70	53
	DEC. 30	64	54	68	57
	AVERAGE	65.0	50.3	69.0	54.2

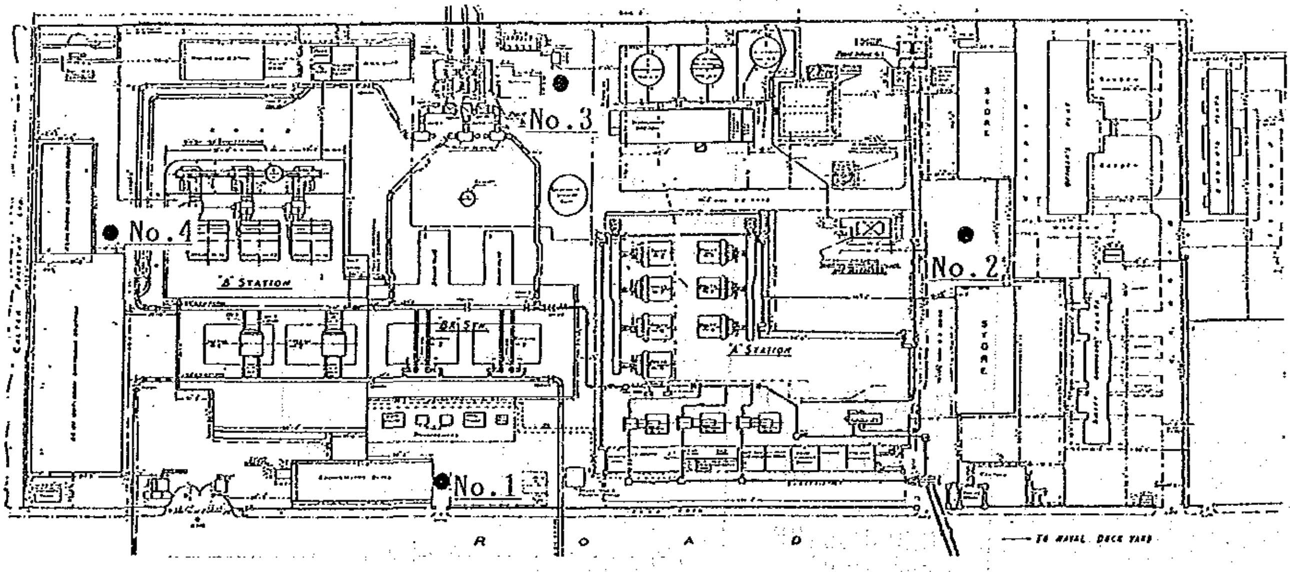


Fig. 5.7-8 LOCATION OF NOISE INVESTIGATION POINTS

Chapter 6. FEASIBILITY DESIGN BASED ON THE OPTIMUM DEVELOPMENT PLAN

6.1 Basic Plan of Power Plant

The scope of the project for Units 1 and 2 in West Wharf Thermal Power Plant to be implemented by KESC, consists of:

(1) Two sets of oil-fired, thermal power generating units of 200 MW capacity and their related accessories to be constructed at the West Wharf Power Plant Site.

(2) Double circuit 220 kV transmission lines and their related accessories to be constructed between the West Wharf Thermal Power Plant and the Baldia Town G/S including the switchgears.

(3) Dismantling of existing units which are the "B" an "BX" stations after power receiving is established in the West Wharf Thermal Power Plant.

The completion date of the project is tentatively scheduled for the end of 1992 for the first unit and two (2) years after for the second unit.

6.2 Design Features

The JICA Study Team studied the optimum development plant by taking into consideration past through present data used in Japan as well as the situation of KESC.

6.2.1 Type of main equipment

(1) Type of boiler

Among boilers to be used for steam power plants, there are the drum type (natural circulation or forced circulation boiler) and the once through type. Both boiler types are manufactured for a wide range of steam generation capacities.

For large a capacity unit of 400 MW or over, once-through type supercritical pressure boilers are adopted in many cases to meet higher steam conditions in view of thermal efficiency.

However, strict water quality control is required to maintain the high efficiency and to prevent the generation of scale and acceleration of corrosion.

On the other hand, drum type natural or forced circulation boilers are adopted mostly for 200 MW class units in Japan and at KESC thermal power plants.

As such, adoption of a drum type boiler is not difficult to maintain plant conditions during operation and maintenance conducted by KESC engineers.

(2) Type of turbine

A TCDF (Tandem compound double flow) type turbine is usually adopted for 200 MW class steam power plants similar to the Bin Quasim and Korangi Steam Power Plants of KESC. This turbine is manufactured by several reliable makers and excels operation and maintenance characteristics.

The JICA Study Team considered adoption of the TCDF turbine for the KESC West Wharf Thermal Power Plant Units 1 and 2.

(3) Type of generator and excitation system

The generator to be installed will be directly coupled with the steam turbine.

It should be a horizontal, 3 phase synchronous machine of totally enclosed type. By adopting water cooling for stator and H2 gas cooling for rotor, the cooling effect of the generator will be enhanced, while the dimensions and weight of the generator can be reduced.

Its cost will also be substantially reduced. The revolution speed of the generator should be 3,000 r.p.m, and its frequency 50 Hz. The rated capacity should be made 210 MW (248 MVA, 0.85 PF) based on the results of load forecasts, the power factor of 0.85 should take into account the voltage and VAR control of the electric power system line in the Karachi area. The rated voltage may differ depending upon the manufacturer.

The excitation system will be of a static excitation type using the power potential transformer connected to the generator bus as the power source.

The excitation system will consist of an automatic voltage regulator, a detector, an amplifier, field voltage control, etc.

In this system, such equipment as under excitation limiter, over-excitation limiter, reactive power regulator, power system stabilizer, and so on will be built in so that static and dynamic stability are improved.

6.2.2 Plants Service Water System

6.2.2.1 As a stable supply of water is very important for a steam power plant, the plant water system should be designed based upon the following conditions.

(1) Maximum consumption of water during trial operation and/or periodical inspection.

(2) Minimum consumption of water during normal operation

The maximum consumption of water in item (1) constitues one of the most important factors in view of stable operation of a steam power plant. Therefore, sufficient attention should be paid to this factor.

6.2.2.2 Basic concept

The plant service water system has been planned on the assumption that the system for Units 1 and 2 will be constructed at the same time. The reasons are as follows.

(1) Construction work

If the plant service water system for only Unit 1 is constructed at time of Unit 1 construction, it will be difficult to carry out construction work in view of the limited area, material yard and coordination with Unit 2.

(2) Reliable supply of service water

If the plant service water system for only Unit 1 is constructed at the time of Unit 1 construction, it will be difficult to ensure sufficient supply of required water for the trial operation of Unit 2.

(3) Economy

If the plant service water system for both Units 1 and 2 is constructed at the same time, it will be possible to reduce construction costs.

6.2.3 Plant Operation and Control System

The West Wharf Thermal Power Plant will play an important role in meeting the base load of the power system in the Karachi area.

Therefore, not only the power plant equipment but also the control system is required to be high reliability and should not be easily shut down at the time of system trouble.

In view of this, the JICA Study Team is considering the following items to maintain optimum operation in the plant control system.

a. The control system should be simple in design and excel in controllability, maintenance, operation and economy.

b. The boiler and turbine main control system should be of an electronic type so as to enable easy input of information into the computer system.

c. By introducing a computer system, it will be possible to ensure stable operation by monitoring plant operation and communicating with operators.

6.2.4 Environmental Protection

Along with the growth of industries in many countries, environmental protection becomes a subject of major concern.

It is, therefore, essential to work out an environmental protection plan for the specified industrial area based on long term industrial development programs.

To minimize air pollution in the West Wharf area, the JICA Study Team has studied the equipment which should be adopted for the plant facilities.

(1) SOx

The height of the stack was decided upon based on the maximum on-ground concentration of SOx of less than 0.1 ppm per one (1) hour as specified in the Japanese Environmental Standards.

As a result of recalculation, the 140 m height of stack for Units 1 and 2 is justifiable.

(2) NOx

a. The JICA Study Team considers the maximum discharge amount of NOx from the boiler to be 180 ppm.

b. In order to maintain the NOx value of 180 ppm discharged from the boiler for Unit 1 and 2, it is necessary to give boiler design consideration at the detail design stage against NOx discharge.
Namely, optimum furnace dimensions enabling adoption of low NOx type burners, overfire-air ports, gas injection fans and other effective provisions.

(3) Particle density

Sufficient space should be given to the layout and arrangement of Units 1 and 2 so as to enable installation of electrostatic precipitators between the boiler and stack at the time when regulation becomes stringent.

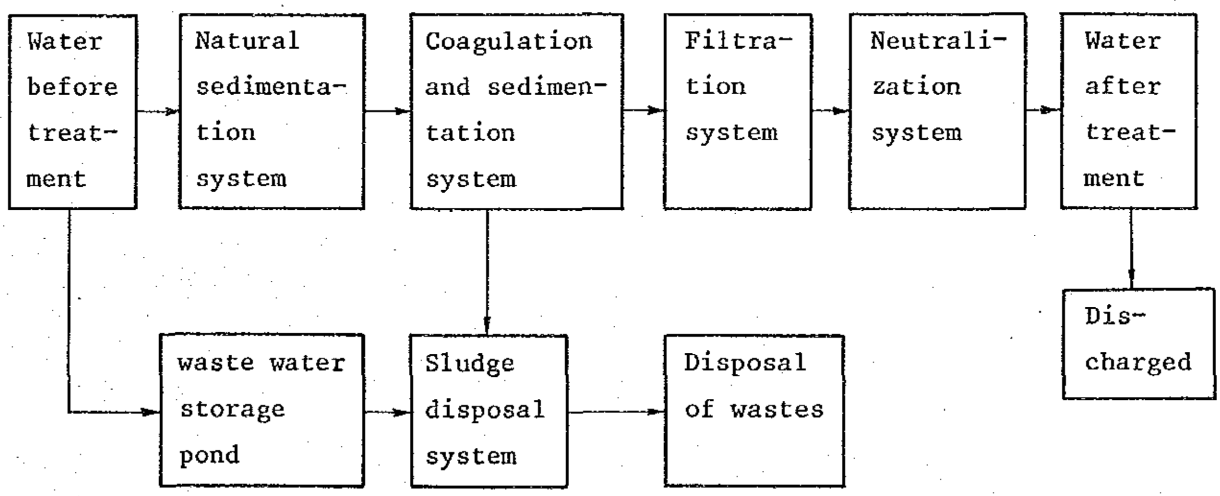
6.2.4.1 Water Pollution

In thermal power plants, there are many pollutant sources such as regenerative waste water discharged from the water treatment system, high suspended waste water from air preheater cleaning, boiler furnace washing and chemical cleaning water.

These waste waters, if discharged directly into the sea, will have a harmful effect on the entire surrounding sea area.

To effectively remove these pollutants contained in the waste water and prevent pollution of sea water, the coagulation-sedimentation, filteration and neutralization waste water treatment systems should be furnished for Units 1 and 2.

Waste water treatment process



6.2.5 Chlorination equipment

Measures for preventing attachment of marine growth on the inner surfaces of intake equipment, piping, heat exchangers, etc., of the cooling water system is very important in case sea water is used at steam power plant. The most effective method for preventing this is the chlorination method, which is classified into the following three processes:

a. Chlorine gas injection process.
b. Sodium hypochloride injection process.
c. Direct sea water electrolysis process.

In order to select the optimum chlorination process for the West Wharf Thermal Power Plant, the direct sea water electrolysis process which features good economy, ease of operation, effective operation and safety, should be considered as the chlorination equipment for Units 1 and 2.

6.2.6 Site Plot Plan and Layout

In making the site plot plan and layout of Units 1 and 2, design unification and coordination with the surrounding area will be taken into account in order to facilitate proper operating conditions.

6.2.7 Application of Computer System

To assist in the operation of the units a computer system will be considered so as to ensure stable power supply.

Its function will be to simplify unit operation and prevent unit malfunction.

The computer system will also serve energy saving purposes by monitoring operation conditions and maintaining conditions best suited for high efficiency unit operation.

6.2.8 Improvement of Heat Efficiency

In order to minimize fuel consumption, high steam temperature and steam pressure as well as a lower heat rate cycle plant will be adopted; also, ease of unit operation, maintenance, proven design and successful operation in lower heat cycle shall be considered.

6.2.9 Environmental Protection

The design is carried out in conformity with World Bank Recommendations, Japanese environmental regulations and Regulations governing environmental protection.

6.3 Outline of the Power Plant

6.3.1 Site layout

The site layout (Plot Plan) is as shown in the attached drawing Fig. A-1.

(1) Wharf

For delivery of the construction materials and equipment, the West Wharf, which is maintained and controlled by KPT (Karachi Port Trast), will be used.

(2) Condenser Cooling Water Way

Sea water will be used for condenser cooling. Two (2) existing intake ways will be used as cooling water intakes for the new power plants by restructuring of both existing intake ways within the site of the West Wharf Thermal Power Plant.

Circulating water pumps with necessary equipment to prevent any damage on entrance of foreign matter will be set at the intake channel, and water will be sent to the condenser by way of a box culvert.

The cooling water discharge way will be constructed newly passing through the KSY (Karachi Ship yard) area alongside the road and will be designed in consideration of future extension.

(3) Fuel Oil Tank

Two (2) oil tanks having a capacity of 20,000 kl and 6,000 kl respectively are used as fuel storage tanks located in the "CALTEX" area.

New fuel oil storage tanks will be constructed in the "CALTEX" area to ensure sufficient storage capacity, with modification of the fuel oil receiving and delivery facilities newly constructed.

6.3.2 Plant specifications

The plant specifications are as follows.

a. Power plant output:
   210 MW (at generator end)
b. Fuel:
   Oil and natural gas (auxiliary fuel)
c. Power plant utilization factor:
   75%
d. Power plant auxiliary power:
   Approx. 5%
e. Power plant thermal efficiency:
   Approx. 38.0% (at generator end)

6.3.3 Main equipment specifications

(1) Steam generator

Type	Outdoor type, reheat, pressurized Oil/gas fired, top supported boiler

(2) Steam turbine

Type	Reheat condensing tandem-compound double flow turbine
Rated output	200 MW (at 65 mmHg.abs. 0% make-up)

(3) Generator

Type	Horizontal type, totally enclosed synchronous machine
Cooling method	
Stator	Water cooled
Rotor	H_2 gas cooled
Rated output	248 MVA
Power factor	0.85
Frequency	50 Hz
Speed	3,000 rpm

(4) Transformers

a. Main transformer

Type	Outdoor, three phase three wire, oil forced and air forced (OFAF)

b. Auxiliary transformer

Type	Outdoor, three phase three wire, oil natural and air natural (ONAN)

c. Starting transformer

Type	Outdoor, three phase three wire three winding (ONAN)

(5) 220 kV and 132 kV Switchyard

Bus component	Double bus system indoor use, SF_6 gas insulation switchgear (GIS)

6.3.4 Building and civil works

(1) Main building

(2) Land filling for fuel oil tank

(3) Condenser cooling water way

(4) Stack

One combined concrete stack will be constructed.

6.4 Outline of Other Major Items

6.4.1 Transmission line

a. Route

Between the West Wharf Thermal Power Plant and Baldia G/S. Double circuit conductor strings and insulators will be provided about 24 km in length.

220 kV transmission line of 23 km length will be installed using overhead wires, and an approximate 1 km long line near the West Wharf Thermal Power Plant will be installed using underground cables.

6.4.2 Site area

The West Wharf Thermal Power Station was constructed on the West Wharf Peninsula of Karachi Bay. Within the total site area of about 37,000 m2, the power plant is comprised of stations "A", "B" and "BX". However, station "A" had been decommissioned and almost all equipment and machinary dismantled.

The first unit of 200 MW will be constructed in the existing "A" station area after complete dismantling of some vacant buildings and existing buried piles.

6.4.3 Ground level

The highest high water level of the Karachi Port Trust is 3.2 m. Taking the margin of 1.6 m for this, the land level will be 4.8 m. 4.8 m is the same ground level of the existing power station.

6.4.4 Space for construction

Material storage space and working space are required during construction. Particularly for a project of this size, a great amount of equipment and materials will be brought to the site during a limited period.

Sufficient space to store and handle these materials and equipment, as well as those in and around the storage areas, is essential.

For the construction of Units 1 and 2, an area must be secured adjacent to the construction site.

6.4.5 Road

(1) A main road for the construction works will be constructed to facilitate delivery access.

(2) Around the main power house, a road to facilitate construction and maintenance will be constructed. Other roads for construction works which may be needed for construction purposes, will be constructed.

6.4.6 Landscaping and site finishing

Landscaping and site finishing works including planning, designing and construction, will be carried out.

6.5 Equipment Specifications for Power Plant

Note: Numbers indicated in this section are for one (1) unit, unless otherwise specified.

6.5.1 Steam generator and auxiliary equipment

(1) Boiler and accessories

Type and accessories	Outdoor, drum type preheat, pressurized furnace dual firing natural gas and furnace oil, top support, natural or forced circulating
Number	One (1)
Capacity	700 ton/H (tentative)
Outlet steam condition	174 kg/cm2g, 541/541°C (Tentative)

(2) Forced draft fan

Type	Motor driven, double suction air foil type, inlet vane control
Number	Two (2)
Capacity	50% each

(3) Gas recirculation fan

Type	Motor driven, double suction air foil type, inlet vane control
Number	Two (2)
Capacity	50% each

(4) Air preheater

Type	Rotary regenerating type, electric motor and air motor driven
Number	Two (2)

Capacity	50% each

(5) Steam air preheater

Type	Tube type
Number	Two (2)
Capacity	50% each

(6) Seal air booster fan

Type	Motor driven, turbo vane type
Number	One (1)
Capacity	100%

(7) Soot blower

Type	Motor driven, steam blowing type, automatic remote control
Number	To be decided by manufacturer

(8) Fuel oil burner

Type	Steam atomizing
Number	To be decided by manufacturer
Kind of oil	Furnace oil
Operation	Automatic control system

(9) Warm up burner

Type	Air atomizing
Number	To be decided by manufacture
Kind of fuel	Natural gas
Operation	Remote/manual

(10) Fuel oil heater

Type	Horizontal, U tube type
Number	Two (2) (one (1) for stand-by)
Capacity	100% each

(11) Fuel oil pump

Type	Motor driven, screw or centrifugal type
Number	Two (2), (one (1) for stand-by)
Capacity	100% each

(12) Oil service tank

Type	Steel cone roof type
Number	One (1)
Capacity	To be decided later

(13) Instrument air compressor

Type	Motor driven, reciprocating type, oilless
Number	Two (2), (one (1) for stand-by)
Capacity	100% each

(14) Instrument air dryer

Type	Refrigerative type
Number	One (1)
Capacity	200% of actual air consumption

(15) Service air compressor

Type	Motor driven, reciprocating type, lubricated type
Number	Two (2)
Capacity	100% each

(16) Chemical feed equipment

a. Diluted hydrazine tank

Type	Vertical cylindrical type
Number	One (1)
Capacity	100%

b. Concentrated hydrazine tank

Type	Vertical cylindrical type
Number	One (1)
Capacity	100% (Three (3) times start-up)

c. Hydrazine pump

Type	Motor driven, metric pump
Number	Two (2) (one (1) for stand-by)
Capacity	100% each (for normal operation consumption)

d. Ammonia solution tank with automatic dissolving equipment

Type	Vertical cylindrical type
Number	One (1)
Capacity	100%

e. Ammonia pump

Type	Motor driven, metric pump
Number	Two (2) (one (1) for stand-by)
Capacity	100% each

f. Phosphate tank with agitator

Type	Vertical cylindrical type
Number	One (1)
Capacity	100%

g. Phosphate pump

Type	Vertical cylindrical type
Number	Two (2) (one (1) for stand-by)
Capacity	100% each

(17) Flame detector and flame viewing television cooling air fan

Type	Motor driven, centrifugal fan

	Number	Two (2) one (1) AC motor driven, the other, DC motor driven
	Capacity	100% each
(18)	Boiler control system	
	Type	Electronic, automatic boiler control system
	Number	One (1) set
(19)	Instrumentation	
	Type	Electronic
	Number	One (1) set
(20)	Local control system	
	Type	Electronic or pneumatic
	Number	One (1) set
(21)	Burner control system	
	Type	Electronic, automatic control system
	Number	One (1) set
(22)	Flame viewing television system	
	Type	Color
	Number	One (1) set
(23)	Sampling rack	
	Type	Open, self-supporting steel frame type, one side mounting
	Number	One (1) set
(24)	Thermo-probe	
	Type	Retractable type
	Number	One (1) set

6.5.2 Steam turbine and auxiliary equipment

(1) Steam turbine

Type	Reheat-condensing tandem compound double flow turbine (TCDF)
Number	One (1) set
Rated output	200 MW (at 65 mmHg.abs. 0% make up)
Steam condition	169 kg/cm2g, 538/538°C (at turbine inlet)
Exhaust pressure	Normal 65 mmHg.abs. Maximum 90 mmHg.abs.
Speed	3,000 ppm
Governing system	Low pressure type EHC
Extraction	Eight (8) stages

(2) Hydraulic and lubrication oil equipment

a. Turbine oil storage tank

Type	Steel plate tank (Separated for clean and dirty oils)
Number	One (1)

b. Turbine oil transfer pump

Type	Motor driven, rotary gear pump
Number	Two (2)

c. Main oil tank

Type	Steel plate, box type
Number	One (1)

d. Oil cooler

Type	Vertical, surface cooling type
Number	Two (2) (one (1) for stand-by)
Capacity	100% each

e. Main oil pump

Type	Turbine shaft driven centrifugal pump
Number	One (1)

f. Auxiliary oil pump

Type	Motor driven, vertical centrifugal pump
Number	Two (2) (one (1) for stand-by)

g. Turning gear oil pump

Type	Motor driven, vertical centrifugal pump
Number	One (1)

h. Emergency oil pump

Type	DC motor driven, vertical centrifugal pump
Number	One (1)

i. Oil conditioner

Number	One (1)

j. Oil filter circulating pump

Type	Motor driven, rotary gear pump
Number	One (1)

(3) Condenser

Type	Horizontal surface cooling, divided water boxes
Number	One (1)
Design pressure	65 mmHg.abs. (Cooling water temp. at 30°C)
Cathodic protection	Electrical anti-corrosion device
Tube cleaning equipment	Ball cleaning

Sea water leakage detecting equipment	One (1) set

(4) Unit make up water tank

Type	Steel cone roof, inner floating type
Number	One (1)
Capacity	To be decided by manufacturer

(5) Make up pump

Type	Motor driven, horizontal, centrifugal
Number	One (1)

(6) Air ejector

a. Steam jet air ejector

Type	Twin elements, two stage steam jet air ejector
Number	One (1)
Condenser	Condensate water cooling

b. Starting air ejector

Type	Single stage, steam jet type
Number	One (1)

(7) Gland steam condenser

a. Condenser

Type	Horizontal, surface cooling type
Number	One (1)

b. Exhaust blower

Type	Motor driven, centrifugal blower type

Number	Two (2) (one (1) for stand-by)
Capacity	50% each

(8) Circulating water pump

Type	Motor driven, vertical mixed flow-type
Number	One (1)

(9) Priming vacuum pump

Type	Motor driven, rotary, water sealed, positive displacement type
Number	One (1)

(10) Condensate pump

Type	Motor driven, vertical multi-stage turbine pump
Number	Two (2) (one (1) for stand-by)
Capacity	100% each

(11) Feed water

a. LP - 1 heater

Type	Closed U-tube, horizontal, surface cooling type (with condenser neck)
Number	One (1)

b. LP - 2 heater

Type	Closed U-tube, horizontal, surface cooling type
Number	One (1)

c. LP - 3 heater

Type	Closed U-tube, horizontal, surface cooling type
Number	One (1)

d. LP - 4 heater

Type	Closed U-tube, horizontal, surface cooling type
Number	One (1)

e. Deaerator

Type	Horizontal, cylindrical, direct contact tray type
Number	One (1)
Storage tank	Horizontal type

f. HP - 6 heater

Type	Closed U-tube, horizontal, surface cooling type
Number	One (1)

g. HP - 7 heater

Type	Closed U-tube, horizontal, surface cooling type
Number	One (1)

h. HP - 8 heater

Type	Closed U-tube, horizontal, surface cooling type
Number	One (1)

i. LP heater drain pump

Type	Motor driven, horizontal, centrifugal type
Number	One (1)

(12) Boiler feed pump

Type	Motor driven, horizontal multi-stage, centrifugal, barrel type injection seal
Number	Three (3) (one (1) for stand-by)
Capacity	50% each
Speed	6,000 rpm (with step-up gear)

(13) Booster pump

Type	Horizontal, single suction volute type
Number	Three (3)
Capacity	50% each

(14) Cooling water equipment

a. Cooling water heat exchanger

Type	Horizontal, shell and tube type
Number	Two (2) (one (1) for stand-by)
Capacity	100% each

b. Cooling water pump

Type	Motor driven, horizontal, centrifugal pump
Number	Two (2) (one (1) for stand-by)
Capacity	100% each

c. Cooling water stand pipe

Type	Steel plate, vertical type
Number	One (1)
Capacity	Appropriate size

d. Chemical injection

Type	Solution injection
Number	One (1) for units III & IV

Pump	Motor driven, horizontal, variable capacity plunger pump
Pump number	Two (2) for units III & IV
Capacity	100% each
Tank	Vertical type One (1) set

(15) Instrumentation system

Type	Electronic type
Number	One (1) set

(16) Local control system

Type	Pneumatic type
Number	One (1) set

(17) Computer system

Type	Digital type (32 bit), main memory; IC memory, auxiliary memory; magnetic disk Auto restart system
Number	One (1) set
CPU memory	128 KB (Tentative)
Bulk memory	2 MB (Tentative)
Peripheral device	One (1) set

(18) EHC panel

Type	Vertical self-standing type
Number	One (1) set

(19) Sump pump

Type	Motor driven, vertical, centrifugal pump
Number	Four (4) sets

(20) Turbine supervisory instrument cabinet

Type	Vertical, self-standing type

Number	One (1) set

(21) Ferrous ion injection system

Type	Sodium sulfate ($FeSO4$) injection system

6.5.3 Common Auxiliary Equipment

(1) Turbine room overhead crane

Type	Overhead travelling crane
Number	One (1) for Units 1 and 2
Capacity	Capacity to be decided at detail design stage.

(2) Raw water tank

Type	Steel cone, roof type
Number	Two (2) for Units 1 and 2
	1,500 m3 each (Tentative).

(3) Water treatment system

Type	Two bed three tower with mixed bed polisher type
Number	Two (2) sets for Units 1 and 2
Capacity	Capacity to be decided at detail design stage.

(4) Make up water tank

Type	Steel cone roof air seal type
Number	Two (2) for Units 1 and 2
Capacity	Capacity to be decided at detail design stage.

(5) Oil storage tank

Type	Steel cone roof type
Number	One (1)
Capacity	Capacity to be decided at detail design stage.

(6) Oil suction heater

Type	Horizontal tube type

(7) Oil transfer pump

Type	Motor driven, screw or gear type
Number	Two (2) (one (1) for stand-by)
Capacity	100% each

(8) Waste water treatment system with necessary equipment

Type	Coagulation-sedimentation, neutralization type
Capacity	Capacity to be decided at detail design stage.

(9) Screen

a. Bar screen

Type	Inclined bar with motor driven rake
Number	Two (2)

b. Travelling screen

Type	Vertical, front spray type
Number	Two (2)

c. Wash pump

Type	Vertical, centrifugal pump
Number	Two (2) (one (1) for stand-by) for Units 1 and 2

(10) Chlorination equipment (including sea water feed pumps)

Type	Sea water electrolysis type
Number	Three (3) (one (1) for stand-by) for Units 1 and 2
Capacity	Capacity to be decided at detail design stage.

(11) Fire protection system

a. Oil tank area

Type	Air foam, pressure proportional type (with sea water spray for furnace oil service tank)

b. For turbine lubricating oil and burner

Type	Dry chemical
Number	One (1) set

c. For main building and boiler

Type	Fresh water hydrant
Number	One (1) set

e. Fire protection panel

Type	Vertical, self-standing type
Number	One (1) set (the panel will be installed in the central control room)

(12) Laboratory equipment (including instrument laboratory)

6.5.4 Generator and Electrical Equipment with Accessories

(1) Generator (1 set)

Type	Horizontal type, totally enclosed synchronous machine
Cooling method	Stator: Water cooled Rotor : H2 gas cooled
H2 gas pressure	Decided by manufacturer
Rated capacity	248 MVA
Power factor	0.85
Rated voltage	Decided by manufacturer
Frequency	50 Hz
Speed	3,000 rpm
Excitation system	Static excitation

Short circuit ratio	Not less than 0.5 at rated condition
Insulation class	B

(2) Excitation cubicle (1 set)

Type	Indoor self standing static excitation system with AVR equipment

(3) H2 gas generating plant

(4) PT and SA cubicle (1 set)

Type	Indoor used in self standing panel with PT and SA

(5) NGR cubicle and resistance (1 set)

Type	Indoor, self standing panel with grounding transformer

(6) Excitation transformer (1 set)

Type	Indoor self standing
Rated voltage	( )
Capacity	( ) kVA Capacity to be decided later

(7) Isolated phase bus duct (1 set)

Location	Gen. - main, aux. transf., PT & SA and Ex. transf.
Type	Natural air cooled
Rated voltage	Generator rated voltage

6.5.5 Transformers

Note; (   ): decided later

(1) Main transformer (1 set)

Type	Outdoor, three phase three wire, OFAF (Oil forced and air forced)
Rated capacity	( ) MVA
Low tension voltage	Generator voltage
High tension voltage	220 kV

(2) Auxiliary transformer (1 set)

Type	Outdoor, three phase three wire
Rated capacity	( ) MVA
High tension voltage	Generator voltage
Low tension voltage	6.6 kV

(3) Starting transformer (1 set for Units 1 & 2)

Type	Outdoor, three phase three wire three winding, ONAN, ONAF
Rated capacity	( ) MVA
High tension voltage	132 kV
Low tension voltage	6.6 kV

(4) Tie transformer (2 sets)

Type	Outdoor, three phase three wire, OFAF (Oil forced and air forced), Auto transformer
Rated capacity	( ) MVA
Low tension voltage	132 kV
High tension voltage	220 kV

(5) Grid station transformer (2 sets)

Type	Outdoor, three phase three wire
Rated capacity	( ) MVA
High tension voltage	132 kV
Low tension voltage	11 kV

6.5.6 Other electrical equipment and facilities

(1) Metal clad switch gear (MCSG)

a. Unit MCSG (1 set)

Type	Indoor, self standing
Rated voltage	6.6 kV

b. Common MCSG (1 set for Units 1 & 2)

Type	Indoor, self standing
Rated voltage	6.6 kV

(2) Power center

a. Unit power center (1 set)

Type	Indoor, self standing with transformer
Rated voltage	400 V

b. Common power center

Type	Indoor, self standing
Rated voltage	400 V

(3) Control center

Number	( )

(4) Panel and board

a. BTG board

Type	( )
Number	One (1) set

b. Bus and line control panel — For 220 kV and 132 kV switchyard

Number	To be decided after detail design

c. Bus and line relay panel — For 220 kV and 132 switchyard

Number — To be decided after detail design

d. Auxiliary control panel

Number — One (1) set

e. Auxiliary relay panel

Number — One (1) set

f. Distribution panel

Number — To be decided after detail design

(5) UPS (2 sets)

(6) Emergency diesel engine generator (1 set for Units 1 & 2)

(7) Battery and charger

Number	One (1) set	for unit
	One (1) set	switchyard

(8) Communication system

a. Paging system
b. Telephone system
c. Clock system

(9) Lighting system

(10) Erection materials

6.5.7 220 kV switchyard equipment

6.5.8 Switchyard equipment

(1) 220 kV switchyard

Type	Indoor, SF6 gas insulation switchgear (GIS)
Bus system	Double bus

(2) 132 kV switchyard

Type	Indoor, SF6 gas insulation switchgear (GIS)
Bus system	Double bus

6.6 Civil Works

6.6.1 Cooling water way

(1) Intake water way (Pipeline and culvert)

The amount of water intake per unit is Q = 9.5 m3/sec., and the existing intake water ways are as follows:

Intake water way 1 (concrete pipeline):
1,500 mm dia. x 3 lines
Intake water way 2 (box culvert)
□ 3,000 x 3,000 mm x 1 line

Since the intake water ways should be designed of a graviational flow system, the allowance for shell, sand and other foreign matter deposits equivalent to 10 cm has been taken into account.

In order to ensure the balance between the water ways of different intake capacities, a water intake open pit will be installed within the power plant site for connecting the two water ways.

As a result of hydraulic study of the intake water ways, the mean flow velocity of the intake water way 1 and that of the intake water way 2 are estimated to be V = 1.4 m/sec. and 1.7 m/sec., respectively.

(2) Balancing water way

The open intake water way has been designed so that the mean flow velocity becomes V = 1.0 m/sec. with the width of water way being 3 m to ensure the balance between the existing intake water ways.

For the open water way, a cofferdam will be provided for extending Unit 2.

(3) Circulating pump room

The circulating pump room shall be of reinforced concrete construction with two of 4.5 m span pits per one unit. For the circulating pump room and other heavy-weight structures, 600 mm diameter steel pipe piles will be used to support such structures on hard clay soil stratum.

As screen equipment, bar screen, travelling screen and so forth will be provided. The flow velocity of water approaching the screens shall be less than v = 0.35 m/sec. The circulating pump room shall have such a sectional form as to prevent suction of air due to eddy current, etc. and equipped with voltex flow preventive devices.

(4) Discharge water way

Generally, the types of discharge water ways available today are box culvert type, open water way type and pipeline type. An optimum sectional form is determined according to the relationship between the construction cost and motor power cost of circulating water pumps based upon the layout of the power station, number and capacity of units. The determination method is as follows: Namely, the motor power cost of circulating water pumps is calculated based upon the construction cost and head loss by assuming the sectional area of the water way, and an annual expense Y is obtained according to the following formula, and a section size and type at which the yearly expense becomes minimum is selected:

$$Y = Ar + L$$

where Y: Annual expenses

A: Construction cost of discharge water way + Circulating water pumping equipment cost

r: Ratio of annual capital cost

L: Annual cost of electric power loss

For example, the □ 2.2 m x 2.2 box culvert has been concluded to be economically optimum as shown in Fig. 6.6-1. Similarly, optimum sections of open way and pipeline are studied and as the results of comparative study are indicated in Table 6.6-1.

According to the above-mentioned comparative study, the box culvert type (□2.2 x 2.2 m) is lowest in the construction cost and yearly expenses. Therefore, this type has been concluded to be economically optimum.

Meanwhile, since the discharge water ways will be constructed outside the power station site, excavation methods are studied hereunder. An open cut and a retaining wall excavation methods have been considered as the excavation methods. Since the ground is comprised of silty sand stratum roughly up to GL -22 m and the ground water level is high, there are some problematical points in securing the stability/safety of the work on the excavation slope and shoulder section of the slope. In addition, a wider area is required for structures and work execution and various difficulties are anticipated to encounter during the excavation work. Therefore, the retaining wall excavation method will be adopted although this method requires a slightly higher cost than the open excavation method.

(5) Discharge water way outlet

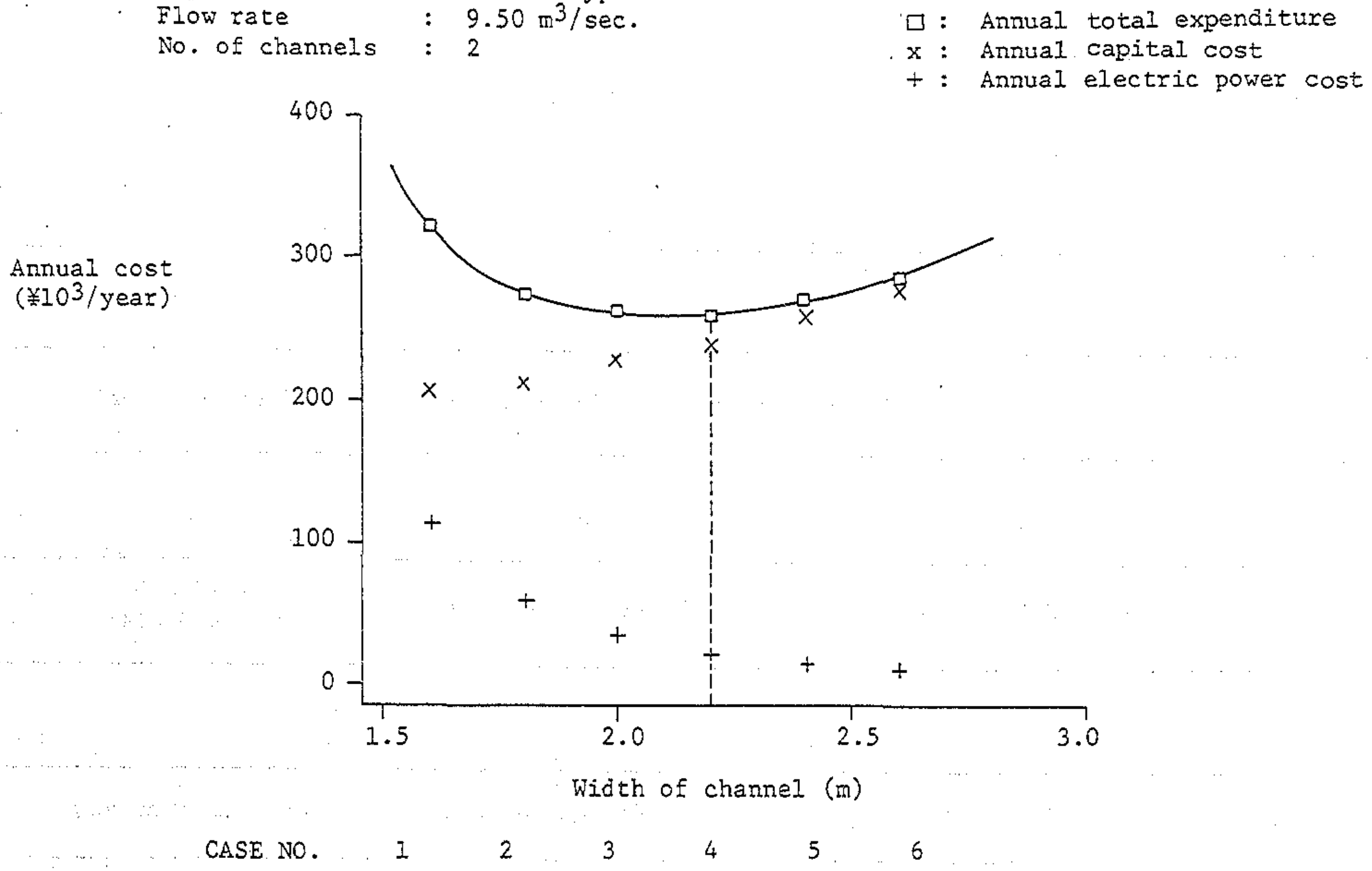
Since the sea area in front of the discharge water outlet is

Table 6.1 Comparative study according to the types of discharge channel

Type / Items	Box culvert type	Open channel type	Pipeline type
Flow rate (m^3/sec.)	19.0	19.0	19.0
Optimum internal dimensions	-2.2 x 2.2 m x 2 lines	w = 2.2 m x 2 lines	2.2 m dia. x 2 lines
Flow velocity (m/sec.)	2.0	3.9	2.5
Allowance for shell deposits	Not any allowance is not taken into account respectively.		
Ratio of total expenditure	92	103	133

Fig. 6.6-1 Comparison of Annual Cost/Expenses for Discharge Channel/Tunnel

Type of channel : Tunnel (Closed channel)
Type of foundation: Direct type
Flow rate : 9.50 m^3/sec.
No. of channels : 2



located within a bay where there are navigation routes and mooring sites, the discharge flow velocity shall be V = 0.5 m/sec. or less in consideration of the effects of the discharge water flow upon navigation of ocean-going vessels.

Effective/Net width of discharge outlet W;

$$W = \frac{19.3\ m^3/sec.}{2.2\ m \times 0.5/sec.} = 17.3\ m$$

To lower the discharge flow velocity less than 0.5 m/sec., the width of the discharge water way should be expanded gradually, and a partition wall be provided as required. Under this design study, the discharge flow velocity is estimated to be V = 0.49 m/sec.

6.6.2 Foundation of fuel facilities

The fuel facilities include fuel storage tanks, oil dike and fuel transfer pump facilities. As for types of foundation supporting outdoor storage tanks, the fill-up foundation, pile foundation and other types can generally be considered. To determine the optimum type and a method of constructing foundation, detailed study should be carried out with regard to the bearing capacity of ground, amount of settlement, etc. based upon the design conditions. Judging from the results of geological survey, the ground around the power station site is comprised of sandy soil, and since the N value is 15 or more from the standard penetration test, the ground is considered to be sufficiently solid. Consequently, the fill-up foundation type will, in principle, be adopted, and partially soft ground be improved by a reclamation method, etc. For the fill-up foundation, berms, etc. will be provided as required for the safety and inspection of storage tanks.

The oil dike is classified into a reinforced concrete and a fill-up construction. Since the power station site is narrow, a sufficient dike capacity must be obtained within a limited site area. Therefore, the oil dike shall be of a reinforced concrete construction.

The foundation of the fuel transfer pump facilities will be provided to support the fuel transper pump piping and other equipment. As for the construction or types of foundation for these facilities, a sleeper type of reinforced concrete construction, rack and other types can be taken into account. Although the foundation shall be of a direct foundation type, a part of the ground with insufficient bearing capacity shall be reinforced by driving foundation piles.

6.6.3 Foundation of water treatment equipment

The foundations will be provided for such water treatment equipment as fresh water storage tank, demineralized water storage tank, demineralizing plant and so forth in addition to water tank. Although the water tank is classified into an above-ground and an underground types, the above-ground type should be adopted taking into account the cost, execution of work and required work period. The foundation shall be of a fill-up foundation type similarly as in the case of those of the fuel storage tanks.

6.6.4 Waste water treatment equipment

The kinds of waste water discharged from power station is categorized into equipment washing waste water and sanitary drain, waste water containing oil and other foreign matter, rain water drain, etc.

The waste water treatment equipment is mainly comprised of waste water pond, coagulation - sedimentation tank, neutralizing tank, PH oxidation pit, enrichment tank, oil separator, other miscellaneous tanks and ponds, filters, dehydration equipment and so forth. All of these facilities will be installed on foundations.

At a power station, any waste water shall be discharged into an outside system after treating it to a specified level. Since the time period of discharge, quantity, quality, etc. of waste water vary depending upon the source of origins, an effective and economically optimum method of constructing the respective foundations shall be determined after comprehensive study regarding the construction/type and scale of waste water treatment equipment, amount of treatment chemicals consumed, etc.

6.6.5 Road and drainage system within the power station site

The road within the power station site will be constructed for the purpose of transportation of equipment and materials, passage of persons, patrol, inspection and fire extinguishing activities. For these purposes, the road shall have two 3.0 m car lanes x 2 lanes and a 2.0 m parking zone.

Rain water on the surface will be poured into side ditches along the road and surrounding drain holes, and lead into collecting pits. Then, such drain shall be discharged into the discharge water way, sea area, etc. by natural gravitation through drainage conduits.

6.6.6 Electrical equipment

As associated electrical facilities for power station, cable tunnels and conduit lines are used for accommodating power and control cables which connect various electrical systems between major transformers at power station, switchyard, central control room, electrical equipment room and other miscellaneous equipment.

In many cases where the cables laid are large in number, a tunnel system is generally economical. In case the electrical system is expected to be extended according to a future plan or in view of the importance for maintenance, a duct line system should be adopted.

6.7 Design and Construction of Structures

The site area of the West Wharf Thermal Power Plant is a limited space to construct two units of 200 MW power facilities. The three existing power stations "A", "B" and "BX" should be dismantled before the construction start of the new units. Furthermore, the first unit should be constructed while keeping the "BX" station in operation. As such, execution of this project will encounter very severe restrictions. To construct two units of 200 MW under these conditions, it is highly important to give sufficient study and consideration to design and construction work of the units. The basic concept pertaining to design and construction is presented herein with regard to the optimum construction method envisaging the two units of 200 MW power facilities and their commissioning in accordance with the construction schedule.

6.7.1 Basic concept of design

The design condition which must be taken into account is that the site area is small. Namely, one 200 MW unit should be constructed while the "BX" station is in operation, and should be constructed in an area comprising only half of the site space..

In other words, effective utilization of site space should be realized by increasing the height of the buildings as a first step. Should there be a substantial time interval between the construction schedule of Unit 1 and that of Unit 2, a final plan design and temporary plan design must be taken into consideration. Therefore, a temporary administration building should be built followed by a permanent structure after starting construction of Unit 2.

(1) Main powerhouse building

The small site area also makes it impossible to obtain space for constructing an auxiliary equipment building.

As a counter measure, the central control room and other rooms for control and other auxiliary equipment are designed to be located in the middle of the turbine building, that is in between No. 1 and No. 2 turbine buildings, with a portion of this intermediate building made higher and slightly longer in longitudinal span and width to accommodate all these facilities. (refre to Fig.6.7-1 a,b,c)

All structures should be of a steel-framed construction. Although the cost will be slightly higher in the case of this construction, it will be possible to substantially reduce the construction period.

To reduce costs, the possibility of fabrication at the Karachi Shipyard as well as other countermeasures should be studied.

For the exterior wall up to the operating floor, field-fabricated PC board should be adopted, and for the other sections, steel exterior wall materials. To confine structural vibration characteristics due to roof vibration caused by crane operation, the steel roofing materials should have a high degree of rigidity. As for flooring, adaption of deck plates permitting elimination of concrete forming work is most effective in view at the construction schedule.

(2) Administration building

In light of the requirement to obtain as wide a floor area as possible within the limited building area as seen from the base of the main powerhouse building, the administration building will be designed on the basis of four (4) stories. (refer to Fig.6.7-2)

However, the temporary administration building will be designed on the basis of two (2) stories and, after completion of the permanent administration building, the temporary building will be used as a warehouse or a workshop in the future. This building shall be of a reinforced concrete construction. Further detailed study will be executed at the execution design stage.

(3) Chimney (Stack)

The 140 meter high chimney should have two steel fabricated inner tubes with the outer casing surrounding the inner tubes made of concrete. These tubes should be erected by the slip form method. There are two methods to construct the outer casing of the stack. One is jump up method and the other is slip form method. Adoption of the slip form method will be preferable, because the stack can be constructed with three (3) m/day progress rate, compared with one (1) m/day by the jump up method. It can reduce the construction period of the stack.
If steel tower support, which requires a big foundation, will be applied, construction cost become higher than the concrete outer casing support. Refer to Fig. 6.7-3, Table 7.6-1.

(4) Water and waste water treatment rooms

The water and waste water treatment from room building will be two-storied to ensure effective utilization of the site area, and the building should be of reinforced concrete construction.

(5) Other buildings

Other miscellaneous buildings should be of one-story reinforced concrete construction. Intervals between respective buildings should not be made greater than required, with concentration of such buildings carried out wherever possible. Adoption of two-storied buildings should, if the situation warrants, be considered.

6.7.2 Problematical points in work execution and countermeasures

At this power station, it is required to dismantle and dispose of the existing structures prior to constructing the new power unit. As a result of geological survey, it has been clarified that the ground at this site is comprised of sandy soil layers, with the ground water level so high that sufficient consideration should be given in executing excavation and retaining work. Furthermore, the site area is too small to install a concrete batcher plant, and there is no space available for assembly of steel structures prior to erection. Other problems include securing sufficient work space and temporary storage of building materials, construction equipment and materials adjacent to the construction site. The problematical points and methods of countermeasures are proposed briefly as follows according to the categories of the respective works.

(1) Dismantling work

Under this project, dismantling work of superstructures should be executed under the conditions whereby the "BX" station is kept in operation. Although the dismantling will be started from the "A" station side, dismantling of foundation concrete and piles will pose a problem. According to strength test results of foundation concrete, the strength was clarified to be 400 kg/cm2, and powerful heavy-duty machines will be required for chipping work. Not only the dismantling work but also other common construction work will require heavy-duty machines which are in short supply in Pakistan. Thereby, it may be necessary to procure such machines from another country, although this will raise the construction cost but shorten the construction period.

Removal of piles is another major problem. Note that it was impossible to execute chipping work during pile survey work under this survey, but whether piles were used or not was not clarified. Judging from examples of construction work in Pakistan in the past, it would seem safe to say that concrete piles were used for these foundations.
It is found that concrete piles were applied in the "BX" station area, according to the drawings received from KESC. Consequently, it should be better to remove the piles prior to execution of the work. Here, too, the availability of heavy-duty mahcines constitutes a problem. The pulling-out and dismantling of piles is difficult work even in Japan, and varies depending upon the condition of the piling materials. In case the tensile strength of the piles is small, it would probably be impossible to pull the piles out. Accordingly, to pull out those concrete piles, the surrounding soil and edges are cut off by using casings, and water is ejected from the pile tips by water jet to pull out the piles. Consequently, the heavy-duty machines brought in from an outside country will be required.

(2) Retaining excavation work

In the case of foundations for the main powerhouse building, boiler, stack, pumps and other deep foundations for water discharge channels, the bearing capacity, or stability, of the ground associated with the excavation work will present a problem. Besides this ground being comprised of sandy soil, the overburden thereon consists of reclaimed soil. Thus, it is impossible to secure the work space in case an open excavation system is adopted within such a confined site area. Consequently, the excavation work should be