### 4.2.3 SECOND STAGE OF WORKS

(1) Mechanical Equipment

1) Installation of transmission & distribution pumps

(a) Transmission pump

Another pump for stand-by as expressed in 4.2.2-(1)-1) shall be installed in the second stage of works. Specification of the pump shall be:

17.5 $m^3$/min × 42.0 m × 3,000 V × 50 Hz × 180 kW

(b) Improvement and removal of existing distribution pumps

The Phum Prek treatment plant is equipped with four distribution pumps in the distribution pump house which was installed by Japan in 1959. One of the four pumps is completely defective, inoperative, and unrepairable. The rest of the three are in operation during the night when the water consumption is low. They are still operative but many parts have worn out excessively after 34 years of operation. In particular, their pump shaft rotates in an elliptic motion because of wear in the bearing of the shaft. Further, since the motor and motor starter are out of date, the starter can start up the motor only after the start-up operation is repeated to 10 times. The possibility of overhauling two relatively better units out of the three has initially been examined. The examination indicated that all of them are to be replaced with new pumps because of the following reasons.

- It is impossible to repair the bent shaft of the pump.
- It is impossible to remove the pump cover because of rusted mounting bolts.
- Since the design of the motor starter is old, it is no longer available.

Two sets of new distribution pumps (17.5 $m^3$/min × 42.0 m × 3,000 V × 50 Hz × 180 kW) shall be installed, one serving as a stand-by.
The plant has another four sets of distribution pumps installed by France (two are stand-by), but the priming system is defective on all four and electric devices are defective on one of them.

Because the priming system is defective, the pumps are operable only when the they are filled with water inside after the existing pump pit is filled with water, that is, after the existing clear water reservoir becomes full of water. And once the pumps have started operation, they must keep operating continuously. Two different priming systems have been considered for the improvement; a) vacuum pump method and b) method by mounting a foot valve on the suction pipe. By taking into consideration the technical level of the Water Supply Authority and ease of maintenance and operation, the foot valve method was adopted. Water shall be supplied to the pumps for filling them with water, utilizing the water head of the elevated tank by diverting the water from the transmission pipe located in the new pump house. To cope with an emergency situation, the water supply to the pumps through the distribution pipe shall also be made available.

The defective part of the electric equipment on the distribution pumps (made by France) will be improved in the electric equipment improvement scheduled in the second stage of the works.

When new transmission and distribution pumps are installed, the existing Japanese pumps will have finished their service as distribution pumps. Since the space taken up by these pumps will be utilized for storing mechanical and electric spare parts, they shall be removed at that time.

Because the transmission and distribution pumps are of the same specification, it is now possible to use common spare parts. In addition, the pipeline system shall be designed to allow each pump to operate as a transmission pump or a distribution pump by the isolating valve on the discharge of the pump.

(2) Electric Equipment

1) Improvement of existing electric equipment

Improvement of electric equipment in Phum Prek treatment plant must be accomplished without stopping the operation of the existing equipment, and therefore another electric room will be prepared in the treatment plant. Another electric room will be also constructed at the water intake site to improve the water intake function. The existing distribution pump house, which was constructed by Japan in 1959, shall be converted into an electric room for the treatment plant. The treatment plant electric room shall be equipped with incoming power equipment, extra-high tension power receiving/transforming equipment, high-tension power receiving/transforming/ distribution equipment, power equipment, and DC power supply; and the water intake site electric room shall be equipped with high-tension power receiving equipment and power equipment. Besides, an operation panel shall be installed with each equipment and a central supervisory/control panel shall be installed in the existing control center room.

At present, two lines of electric power are led into the treatment plant from No. 4 power station and No.1 power station. Since the line from No. 4 power station is not for the exclusive use for the treatment plant, it is used as a stand-by. Besides, the cables of the main line are very much worn out by time. In this project, the incoming line from No. 4 power station shall no longer be used and the line from the No. 1 power station be used as a stand-by, while the line from No. 5 power station will be used regularly. It is noted that the extra- high tension power cable from No. 5 power station to No. 8 substation will be laid out of rough the treatment plant yard, which is within the scope of the power supply facilities improvement project to be accomplished with grant aid from Japan.

(3) Buildings

1) Construction of new electric room at the water intake site

This room shall have the minimum necessary space for installing and inspecting the high-tension power receiving panel, the pump starter panel, the low-tension power

receiving panel, and the power control panel. The size shall be:

6.0 m wide × 11.0 m long × 3.4 m high = 66 $m^2$

2) Improvement of electric room (by converting the existing distribution pump house)

Inside the existing distribution pump house which was constructed by Japan in 1959, there are four distribution pumps and unusable electric equipment for these pumps. Part of the house is used as a storage space for spare parts.

In this project these four distribution pumps will become useless after two sets of new distribution pumps are installed in a newly built pump house. Every part of this pump house including doors, windows, and roof is considerably timeworn because it was built 34 years ago and has been in service without any maintenance or repair since then. However, from the structural view point it is alright and hence it can be used, as an electric room and a spare parts storage house.

(4) Civil works

1) Construction of a clear water reservoir

Supply capacity of the existing water treatment facilities is far lower than the demand. Construction of a clear water reservoir will make it possible to not only effectively utilize the existing facilities and increase their supply capacity but also to manage the treatment plant properly. The design considerations are described here.

Due to power shortage, Phum Prek water treatment plant can supply the treated water to its full capacity only for 13 hours in the daytime (5:00 AM to 6:00 PM), and during the night the supply is forced to decrease to about one-fourth the daytime supply. In the night, the reduced supply to the distribution pipeline is smaller than the raw water intake into the treatment plant by about 1,300 $m^3$/hour. This difference results from the difference in capacity between the raw water intake pump and the distribution pump. The aforementioned excess water of about 1,300 $m^3$/hour in the night is not used but discharged back into the river.

If the above unused raw water is treated and reserved during the night, the supply quantity from the plant will be increased by that reserved volume. In order to increase the daytime distribution as above, it is necessary to install a clear water reservoir in the treatment plant for storing the treated water. Required capacity of the reservoir will be 10,000 $m^3$.

Although the increase in the daytime distribution depends on the operation schedule of the pumps, it is expected to be about 500 $m^3$/hour. When the volume of 500 $m^3$/hour is distributed through the daytime operating hours, a total of 500 $m^3$/hour x 13 hours = 6, 500 $m^3$ is obtained. Adding to this the washing water volume of 3,500 $m^3$ for the filter basin of the plant, a total capacity of 10,000 $m^3$ is required the new clear water reservoir. Since the existing clear water reservoir of the plant has a capacity of about 11,000 $m^3$, adding a new reservoir of about 10,000 $m^3$ capacity makes the capacity of the clear water reservoirs 21,000 $m^3$ totally, which is equivalent to five hours distribution of the targeted 100,000 $m^3$/day.0,000 $m^3$/day.

2) Installation of the interconnection pipeline in the Phum Prek treatment plant

Distribution pipelines inside the Phum Prek water treatment plant consist of 800 mm diameter cast-iron pipeline which was installed by Japan in 1959, and 1,250 mm diameter steel pipeline and 600 mm, 700 mm, and 400 mm diameter cast-iron pipelines which were installed by France in 1966. These pipelines have the following problems.

- Since 400 mm to 800 mm cast-iron pipelines are not provided with mortar lining on their inside, excessive rust has been generated causing a pressure loss within the treatment plant.
- The layout of the pipelines is complicated. What is worse, is that two different types of isolating valves, Japanese and French, are used but they have different switching directions. Thus, it is difficult to switch them correctly.
- The 800 mm diameter pipeline installed by Japan is equipped with a flow meter but it is out of order and not functioning. Pipelines of other diameters are not equipped with flow meter, so it is impossible to measure the distribution flow from the treatment plant.

In order to improve the distribution of the treatment plant and resolve the above problems, complete distribution mains will be provided in the plant and flow meters will be installed for measuring the distribution flow. Design considerations for improving the functionality are as follows.

(a) Besides constructing another clear water reservoir, a 400 mm diameter ductile cast-iron pipeline (with mortar lining inside) and a 400 mm diameter flow meter will be laid as the distribution main for Toul Kork area. A flow meter having the same diameter as the distribution main will be installed because the distribution flow for the area is not certain. Differential pressure of the meter shall be 1,500 mm Aq.

(b) Distribution mains of 600 to 800 mm diameter pipes are in service for distribution from the treatment plant to the center of the city. In order to reduce the pressure loss within the plant and measure the distribution flow, the pipelines downstream of the branching point on the above 400 mm main will be rearranged. The design flow rate will be 125,000 $m^3$/day which is the maximum distribution of 100,000 $m^3$/day multiplied by the time factor of 1.2 to 1.3 (1.25 in average). Flow velocity in the distribution main shall be about 1.0 m/sec. Flow meter shall be installed at the differential pressure of 1,500 mm Aq, and its size be determined so that 50% of the full scale is equivalent to 125, 000 $m^3$/day.

3) Installation of the 250 mm diameter distribution pipeline

According to the simulation, the supply water head is lower than 2.5 m in the northern area of the city and the western area along the National Road Route 5 because of insufficient capacity of the distribution pipeline to those areas. The simulation model indicates that installing a 250 mm distribution pipeline will improve the water supply pressure.

4) Installation of 200 mm diameter distribution pipeline

In the south-eastern area of the elevated tank located in the center of the city, the supply

water head will not reach 2.5 m even by distributing the water directly from the elevated tank. The simulation model indicates that installing a 200 mm diameter distribution pipeline in the center of this area will improve the supply pressure.

5) Installation of isolating valves in the southern area of the elevated tank

After the elevated tank is put into service, the Water Supply Authority plans to proceed with repairing water supply equipment in the area at the beneficiary's cost. Isolating valves are necessary to shut off the distribution pipelines during the above repair, but only a few of the pipelines in this area are equipped with isolating valves. Thus, isolating valves will be installed to shut off the pipelines in the southern area which is included in the service area for distribution from the elevated tank.

The size of the valves shall be 80 to 300 mm diameter.

(5) Supply of Goods and Materials

1) Water meters

The improvement of the financial status of the Water Supply Authority is one of the issues for which the city of Phnom Penh must take an immediate action. Installation of water meters is essential for them to increase collection of water charges and improve their financial condition.

In this project, Water meters of 30 to 50 mm diameter will be furnished since it is necessary to plan high priority on collecting water charges from large users.

2) Cover joints for repairing pipes

Cover joints will be furnished for repairing broken sections on the distribution pipes. The Water Supply Authority shall make necessary repairs on broken sections using these cover joints. These repairs shall be made in the low pressure area where the water head is below 5 m, exclusive of the Don Penh area. It is presumed that most of the sections that require repair are the incomplete drilled holes in the pipes for connecting

service pipes. Since the sizes of the distribution pipes to which service pipes are to be connected are below 250 mm diameter, the target of repair will be pipes below this size. Required number of the cover joints shall be determined on the assumption that a broken section exists for every 500 m of length.

The sizes of the cover joints shall be 80 to 250 mm diameter.

## 4.3 BASIC PLAN

### 4.3.1 FIRST STAGE OF WORKS

(1) Mechanical Equipment

1) Installation of the transmission pump

The following shall be accomplished in the first stage of the works.

- Installation of a new pump
- Installation of suction pipes (350 mm diameter) and discharge pipes (200 mm and 350 mm diameter) for the pump
- Installation of header pipes (400 mm and 700 mm diameter) for the transmission and distribution pumps
- Installation of suction pipes (350 mm diameter) between foot valves and sluice valves and discharge pipes (350 mm diameter) between tees and header pipe, both for the transmission and distribution pumps to be installed in the second stage.

Outline of the transmission pump is as follows.

| | | |
|---|---|---|
| Type | : | Double-suction volute pump |
| Quantity | : | 1 unit |
| Flow rate | : | 17.5 $m^3$/min |
| Total head | : | 42.0 m |
| Size | : | 350 mm diameter suction, 200 mm diameter discharge |

| | | | |
|---|---|---|---|
| Motor specification | : | 3,000 V/50 Hz, 180 kW × 4 poles, Insulation class F (tropicalized), totally-enclosed fan-cooled squirrel-cage type | |
| Accessories | : | standard accessories, pressure gauge, compound gauge, priming detector, spare parts | |
| Incidental devices | : | Suction pipe | ; 350 mm diameter × 4 sets |
| | | Discharge pipe | ; 200 mm and 350 mm diameter × 1 set |
| | | Header pipe | ; 400 mm and 700 mm diameter × 1 set each |
| | | Foot valve | ; 350 mm diameter × 4 sets |
| | | Sluice valve | ; 350 mm diameter × 7 sets |
| | | Slow-close check valve | ; 350 mm diameter × 1 set |

(2) Electric Equipment

1) Installation of electric equipment

The basic design of the electric equipment is detailed below. The single wire diagram is shown in Figure 4-13.

(a) Power equipment

This includes the installation of the power cable for supplying power to the transmission pump motor from the secondary of the high-tension power panel in the existing distribution pump house by way of the high-tension main panel. Further included are the installation of the high-tension main panel, pump starter, and the local operation panels. The central supervisory/control equipment for this pump shall be installed in the second stage of the works.

| | |
|---|---|
| Supply voltage | : 3-phase, 3-wire, 3 kV, 50 Hz |
| Type of high-tension power panel | : indoor type enclosed switchboard |
| Type of local operation panel | : indoor stand type |

(b) Lighting

This includes the installation of the power cable for supplying power to the general illumination lights and plug sockets in the transmission and distribution pump house and installation of other devices.

| | |
|---|---|
| Supply voltage | : 3-phase, 4-wire, 380-220 V, 50 Hz |
| Type of distribution board | : indoor wall-mounted type |

(3) Building Facilities

1) Extension work of the transmission & distribution pump house (main distribution pump house)

(a) Pump suction pit

| | |
|---|---|
| Structure | : reinforced concrete construction, semi-underground |
| Number | : One |
| Dimension | : 3.5 m wide × 18.0 m long × 8.2 m high (effective depth: 5.2 m) |
| Capacity | : 328 $m^3$ |
| Detention time | : 9 minutes (when one each transmission and distribution pump are in service) |
| Incidental devices | : •Inlet pipe, 800 mm diameter × 2 sets<br>•Ventilator, 200 mm diameter × 2 sets |

(b) Pump house

Structure: •Columns, beams, floor, slab --- reinforced concrete construction
•Walls --- brick construction with mortar finish

| | |
|---|---|
| Number | : One |
| Dimension | : 8.0 m wide × 18.0 m long × 7.0 m high |
| Floor area | : 144 $m^2$ |

Incidental devices : Ceiling crane, 3-ton capacity × 1 unit

(4) Civil works

1) Installation of the interconnection pipeline in the Phum Prek treatment plant

From filtered water channel to newly constructed pump suction pit

| | | |
|---|---|---|
| Kind of pipe | : | Ductile cast-iron pipe, K-joint, mortar lining |
| Size | : | 700 mm and 800 mm diameter |

2) Installation of 500 mm diameter transmission pipeline

| | | |
|---|---|---|
| Kind of pipe | : | Ductile cast-iron pipe, T-joint and K-joint, mortar lining |
| Size | : | 500 mm diameter |
| Length | : | 2,410 m |
| Incidental devices | : | •Sluice valve, 500 mm diameter × 1 set<br>•Double-mouth air relief valve, 200 mm diameter × 2 places |
| Transmission flow meter | : | Venturi meter of 400 mm diameter, differential pressure of 1,500 mm Aq, measurement range: 150 to 1,500 $m^3$/hour |

3) Improvement of existing elevated tank

| | | |
|---|---|---|
| Waterproofing of top roof | : | 577.6 $m^2$ |
| Waterproofing of tank inside | : | 1,223.2 $m^2$ |
| Incidental devices | : | Lightning rod, water level detector × 1 set |

Incidental pipes : Inlet pipe, 500 mm diameter × 1 set
Outlet pipe, 600 mm diameter × 1 set
Overflow pipe, 500 mm diameter × 1 set
Drain pipe, 250 mm diameter × 1 set
Bypass pipe, 500 mm diameter × 1 set
Connection pipe to the existing pipeline, 250 to 600 mm diameter × 1 set

4) Installation of pressure control isolating valves for distribution networks

| | |
|---|---|
| 150 mm diameter | 10 points |
| 200 mm diameter | 10 |
| 250 mm diameter | 16 |
| 300 mm diameter | 10 |
| 350 mm diameter | 5 |
| 400 mm diameter | 1 |
| Total | 52 points |

### 4.3.2 SECOND STAGE OF WORKS

• Facilities from water intake to distribution

(1) Mechanical Equipment

1) Installation of new transmission and distribution pumps and removal of existing distribution pumps

(a) Installation of new transmission and distribution pumps

This work will install pumps of the specification given in 4.3.1 (1)-1) and their ancillary pipes between the sluice valve of the suction pipe and the Tee of the

discharge pipe both of which have been installed in the first stage of the works.

| | | |
|---|---|---|
| Type | : | Double-suction volute pump |
| No. of pumps | : | One transmission pump and two distribution pumps, 3 sets in total |
| Flow rate | : | 17.5 $m^3$/min |
| Total head | : | 42.0 m |
| Size | : | 350 mm diameter suction, 200 mm diameter discharge |
| Motor specification | : | 3,000 V/50 Hz, 180 kW × 4 poles, Insulation class F (tropicalized), totally-enclosed fan-cooled squirrel-cage type |
| Accessories | : | Standard accessories, pressure gauge, compound gauge, priming detector, spare parts |
| Incidental devices | : | Suction pipe ; 350 mm diameter × 3 sets |
| | | Discharge pipe ; 200 mm and 350 mm diameter × 3 sets |
| | | Slow-close check valve; 350 mm diameter × 2 sets |

(b) Removal of existing pumps

Four sets of the distribution pumps which were installed by Japan in 1959 are considerably timeworn and will no longer be used after the aforementioned distribution pumps are installed. In addition, the space taken up by these pumps is supposed to serve as space for storing spare parts. Therefore, the four existing pumps shall be moved to another place after the new transmission and distribution pumps are installed in the second stage of the works. Items to be moved are as follows.

Pump × 4 sets
Motor starter × 4 sets
350 mm diameter × 45° and 350 mm diameter × 90° bend × 12 sets
Sluice valve, 350 mm diameter × 4 sets
Valve operating head stock × 4 sets

(2) Electric Equipment

1) Improvement of existing electric equipment

The basic design for the improvement of the existing electric equipment is detailed below. The single wire diagram is shown in Figure 4-13.

(a) Incoming power equipment

At present, totally two lines of electric power are led into the plant, each from No. 1 power station and No.4 power station (one line serving as a stand-by). Power cable from No. 1 power station is exclusively for the treatment plant, so this power is regularly used by the plant. In the improvement work scheduled, the power from No. 4 power station will stop working and the line from the No. 1 power station will be used as a stand-by, and the power supplied by the No. 5 power station will be used on a regular basis. No. 5 power station is supposed to be build with grant aid from Japan. This modification will further improve stable power supply to the treatment plant.

| | |
|---|---|
| Incoming voltage | : 3-phase, 3-wire, 15 kV, 50 Hz |
| Length of underground portion | : 300 m |
| Type of incoming panel | : Indoor closed type |

Power to No.8 substation is supplied by way of this incoming panel.

(b) Extra-high tension power receiving/transforming equipment

Included in this work are the installation of the power cable from the secondary of the incoming power panel to the extra-high tension power receiving panel and installation of the extra-high tension power receiving panel and transformer.

| | |
|---|---|
| Primary voltage | : 3-phase, 3-wire, 15 kV, 50 Hz |
| Secondary voltage | : 3-phase, 3-wire, 3 kV, 50 Hz |

Transformer : 3,000 kVA × 1 set

Type of power receiving/distribution board : Indoor closed type

(c) High-tension power receiving/transforming/distribution equipment

This equipment serves to supply power to the high-tension equipment and appliances in the treatment plant and to the water intake site electric room. The low-tension power supplied to the existing treatment plant causes excessive voltage drop (-15% or below) because the power originally supplied by No. 4 power station comes into the plant by way of the No. 8 substation and the No. 119 sub-station. For this reason, a 3 kV/380-220 V transformer will be installed in this stage of the works in order to unify the power source and generate stable low-tension power of high quality.

Included in this work are the installation of power cables from the secondary of the 15 kV/3 kV transformer to the high-tension power receiving panel and from the high-tension switchboard to the primary of the 3 kV/380-220 V transformer and installation of the high-tension power receiving/distribution board and 3 kV/380-220 V transformer.

Primary voltage : 3-phase, 3-wire, 3 kV, 50 Hz

Secondary voltage : 3-phase, 4-wire, 380-220 V, 50 Hz

Transformer : 750 kVA × 1 set

Type of power receiving/distribution board: indoor closed type

(d) High-tension power receiving equipment at the water intake site

At present, there are three intake pumps installed in the water intake tower and the power (3 kV) to each of the equipment there is supplied from the treatment plant (3-kV cable × 3c × 3w). Since an electric room will be constructed in the water intake site this time, the water intake should improve.

Included in this work are the installation of the power cable and conduit from the high-tension switchboard at the treatment plant to the high-tension power

receiving panel at the water intake site, other wiring, and installation of the high-tension power receiving panel.

Receiving voltage : 3-phase, 3-wire, 3 kV, 50 Hz
Type of power receiving panel : Indoor closed type

(e) Power equipment

Included in this work are the installation of the power cable and conduit from the secondary of the 15 kV/3 kV transformer by way of the pump starter up to the high-tension power equipment and that from the secondary of the 3 kV/380-220 V transformer by way of the power control panel up to the low-tension power equipment and the installation of the pump starter, low-tension distribution board, and power control panel.

| | |
|---|---|
| Distribution voltage | : 3-phase, 3-wire, 3 kV, 50 Hz (high-tension equipment)<br>3-phase, 4-wire, 380 V, 50 Hz (low-tension equipment) |
| Type of pump starter | : Indoor closed type |
| Type of low-tension distribution board | : Indoor self-standing type |
| Type of power control panel | : Indoor self-standing type |

(f) Power equipment at the water intake site

Included in this work are the installation of the power cable and conduit from the secondary of the high-tension power receiving panel at the water intake site by way of the pump starter up to the high-tension power equipment and the installation of the pump starter.

At present, a low-tension power source (380-220 V) for the water intake site is supplied from a substation located in the city. In this project, the low-tension power source will be supplied from the treatment plant for increased stability of power supply and higher reliability of the equipment.

Included in this work are the installation of the power cable from the low-tension distribution board at the treatment plant to the low-tension power panel at the water intake site and that from the low-tension power panel to the low-tension equipment and installation of the low-tension power panel.

Distribution voltage : 3-phase, 4-wire, 380-220 V, 50 Hz
Type of low-tension distribution board : Indoor self-standing type
Type of power control panel : Indoor self-standing type

(g) Lighting

The installation of illumination lights and plug sockets for the water intake site electric room and the treatment plant electric room (to be improved in this project) and replacement of existing defective lighting fixtures, are included under this topic.

Also included are the installation of the power cable to the distribution board for illumination lights, plug-sockets and existing air-conditioning equipment, wiring and conducting for supplying power to the lights and plug-sockets, installation of the distribution board, and installation or replacement of lighting fixtures.

Distribution voltage : 3-phase, 4-wire, 380-220 V, 50 Hz
Type of distribution board : Indoor wall-mounted type

(h) Supervisory control equipment

The existing supervisory/control panel located in the central supervisory control room, which was installed by France in 1966, supervises and controls the high-tension power receiving/transforming equipment and high-tension equipment. The new central supervisory/control panel to be installed in the existing central supervisory room employs a system for supervising and controlling the extra-high tension power receiving/transforming equipment, high-tension power receiving/transforming equipment, and high-tension

equipment and for supervising the low-tension equipment. A local operation panel will also be installed beside each high-tension and low-tension equipment so that each equipment within the system can also be supervised and controlled locally. Control of the low-tension equipment is allowed only locally as the central supervisory/control panel is only meant to supervise.

The wiring between each panel necessary for supervisory and control and the installation of the central supervisory/control panel and local operation panels an included in this work.

| | |
|---|---|
| Type of central supervisory/control panel | : Indoor self-standing type |
| Type of local operation panel | : Indoor stand type, outdoor stand type, or outdoor self-standing type |

(i) DC power supply equipment

DC power supply will be used as the control power for the extra-high tension power receiving/transforming equipment and high-tension power receiving/transforming equipment and as the start-up power for the existing distribution pumps (installed by France).

The wiring and installation of the DC power supply are done as part of this work.

(3) Building Facilities

1) Construction of a new electric room at the water intake site

| | |
|---|---|
| Structure | : Columns, beams, floor, slab --- reinforced concrete construction<br>Walls --- brick construction with mortar finish |
| Number | : One |
| Dimension | : 6.0 m wide × 11.0 m long × 3.4 m high |
| Floor area | : 66 $m^2$ |

2) Improvement of electric room (improving the existing distribution pump house)

Structure : Columns, beams, roof truss --- steel structure
Floor --- reinforced concrete
Walls --- brick construction

Floor area : 558 $m^2$

Repairs : Rust removal and oil painting of steel structures, painting of internal and external walls, removal of the existing wooden window frames and doors, installation of new windows and doors, new roofing, installation of gutters and down pipes, etc. (installation of drain pipes, water service pipes, shower and stool) --- 1 lot
Concreting the existing floor and concrete foundation for electric equipment --- 1 lot

(4) Civil works

1) Construction of clear water reservoir

In the south-western part of the Phum Prek water treatment plant site, there is a place where the construction of a clear water reservoir was once started with financial aid from the ex-Soviet Union but the construction has been left unfinished since the dissolution of the Union. The construction was terminated just after a part of the base slab was completed. This base slab will be utilized as the foundation (plain concrete) for the clear water reservoir to be built newly. Whether the base slab was constructed to the original design is not known because no construction record is maintained. So, new test piles will be driven in at the space for constructing the new reservoir to verify the allowable load of the base slab before utilizing it.

Structure : Reinforced concrete construction, flat slab structure, semi-underground, covered with soil

Number of reservoirs : Two

Dimension per reservoir : 31.4 m wide × 31.4 m long × 5.7 m high (effective depth: 5.08 m)

Capacity : 5,000 $m^3$/reservoir × 2 = 10,000 $m^3$

Detention time : 2.4 hours at the maximum water supply of 100,000 $m^3$/day

| | | |
|---|---|---|
| Incidental devices | : | Inlet pipe, 500 mm diameter × 2 sets<br>Outlet pipe, 600 mm diameter × 2 sets<br>Overflow pipe, 600 mm diameter × 2 sets<br>Drain pipe, 300 mm diameter × 2 sets, 100 diameter × 1 sets, and 700 mm diameter × 2 sets<br>Connection pipe, 450 mm diameter × 4 sets<br>Ventilator, 200 mm diameter × 8 sets<br>Level gauge, common to both reservoirs × 1 set<br>Level gauging room, 3.35 m wide × 5.00 m long × 2.85 m high × 1 set |

The capacity required of the clear water reservoir is explained in 4.2.3(4)-1). The flat slab structure is applied to the reservoir for easy construction and best utilization of reserved water. From the point of view of convenient maintenance and operation, the reservoir will be divided into two parts by a partition wall, each being operative independently. The top and sides of the clear water reservoir shall be covered with the excavated soil in order to prevent temperature increase of the reserved clear water. Utilizing the surplus soil in this way incidentally helps to reduce the total volume of surplus soil used for disposal, resulting in reduced project cost.

2) Installation of interconnection pipeline in the Phum Prek treatment plant

(a) Piping

| | | |
|---|---|---|
| Kind of pipes | : | Ductile cast-iron pipes, K-joints, and mortar lining inside |
| Size | : | 400 mm diameter |
| Distribution flow meter | : | Venturi meter of 400 mm diameter, differential pressure of 1,500 mm Aq, measurement range of 150-1,500 $m^3$/hour |

(b) Improvement

| | |
|---|---|
| Kind of pipes | : Ductile cast-iron pipes, K-joints, and mortar lining inside |
| Size | : 500 to 1,350 mm diameter |
| Distribution flow meter | : Venturi meter of 1,100 mm diameter, differential pressure of 1,500 mm Aq, measurement range of 1,200-12,000 $m^3$/hour |

3) Installation of 250 mm diameter distribution pipeline

| | |
|---|---|
| Kind of pipes | : Ductile cast-iron pipes, T-joints and K-joints, and mortar lining inside |
| Size | : 250 mm diameter |
| Length | : 1,340 m |
| Incidental devices | : Single-mouth air relief valve 75 mm diameter × 25 mm diameter × 5 place |

4) Installation of 200 mm diameter distribution pipeline

| | |
|---|---|
| Kind of pipes | : Ductile cast-iron pipes, T-joints and K-joints, and mortar lining inside |
| Size | : 200 mm diameter |
| Length | : 1,310 m |
| Incidental devices | : Single-mouth air relief valve 75 mm diameter × 25 mm diameter × 5 place |

5) Installation of isolating valves in the southern area of the elevated tank

| | |
|---|---|
| 80 mm diameter | 23 places |
| 100 mm diameter | 61 places |
| 150 mm diameter | 10 places |
| 200 mm diameter | 9 places |
| 250 mm diameter | 10 places |
| 300 mm diameter | 1 place |
| Total | 114 places |

6) Supply of goods

(a) Water Meters

| | |
|---|---|
| 30 mm diameter | 1,500 sets |
| 40 mm diameter | 1,000 sets |
| 50 mm diameter | 500 sets |
| Total | 3,000 sets |

Each meter contains two sets of sockets and compound flanges (including rubber packing, bolts and nuts) for connecting steel pipes.

(b) Cover joints for repairing pipes

| Size | Total length of pipeline | Quanty |
|---|---|---|
| 80 mm diameter | 33,800 m | 70 sets |
| 100 mm diameter | 101,750 m | 200 sets |
| 125 mm diameter | 2,300 m | 5 sets |
| 150 mm diameter | 30,300 m | 60 sets |
| 200 mm diameter | 20,400 m | 40 sets |
| 250 mm diameter | 21,950 m | 45 sets |
| Total | | 420 sets |

### 4.3.3 BASIC DESIGN DRAWINGS

The following is a list of basic design drawings.

| Drawing No. | Title |
|---|---|
| 4-1 | LOCATION PLAN OF FACILITIES FOR URGENT REHABILITATION WORKS |
| 4-2 | GENERAL PLAN OF PHUM PREK TREATMENT PLANT |
| 4-3 | HYDRAULIC & FLOW DIAGRAM OF PHUM PREK TREATMENT PLANT SYSTEM |
| 4-4 | STRUCTURAL DRAWING OF THE MAIN DISTRIBUTION PUMP HOUSE |
| 4-5 | STRUCTURAL DRAWING OF 10,000 $m^3$ CLEAR WATER RESERVOIR (1) |
| 4-6 | STRUCTURAL DRAWING OF 10,000 $m^3$ CLEAR WATER RESERVOIR (2) |
| 4-7 | IMPROVEMENT DRAWING OF THE EXISTING ELEVATED TANK |
| 4-8 | PLAN OF 500 mm DIA. TRANSMISSION PIPELINE |
| 4-9 | PLAN OF 250 mm DIA. DISTRIBUTION PIPELINE |
| 4-10 | PLAN OF 200 mm DIA. DISTRIBUTION PIPELINE |
| 4-11 | INSTALLATION DRAWING OF SLUICE VALVES |
| 4-12 | INSTALLATION DRAWING OF THE PRESSURE CONTROL VALVES |
| 4-13 | SINGLE WIRE DIAGRAM OF THE PHUM PREK TREATMENT PLANT SYSTEM |
| 4-14 | PLAN OF THE ELECTRIC ROOM OF THE PHUM PREK TREATMENT PLANT SYSTEM |
| 4-15 | PLAN OF CABLING FOR RAW WATER INTAKE |
| 4-16 | STRUCTURAL DRAWING OF THE ELECTRIC ROOM FOR RAW WATER INTAKE |

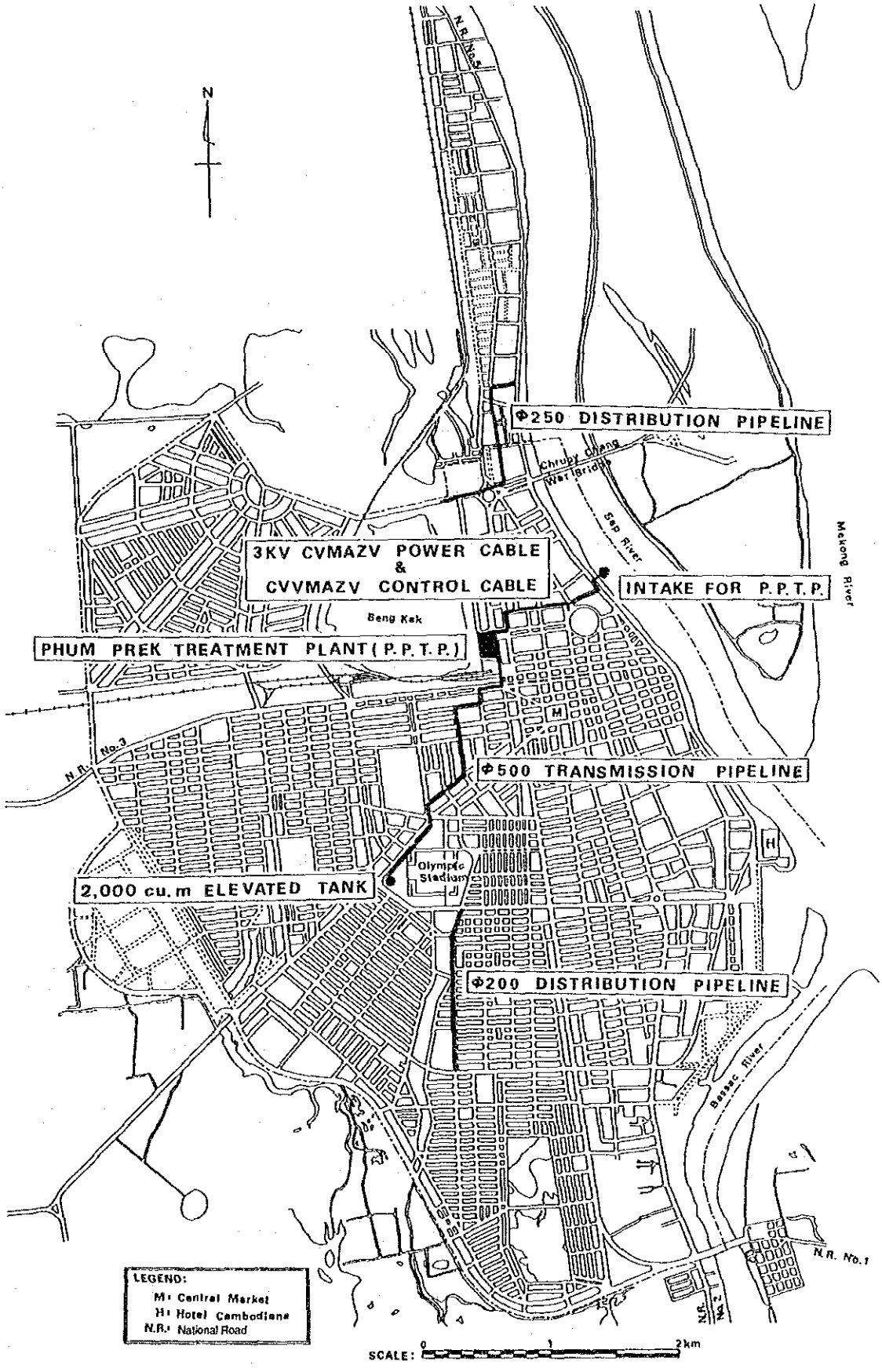
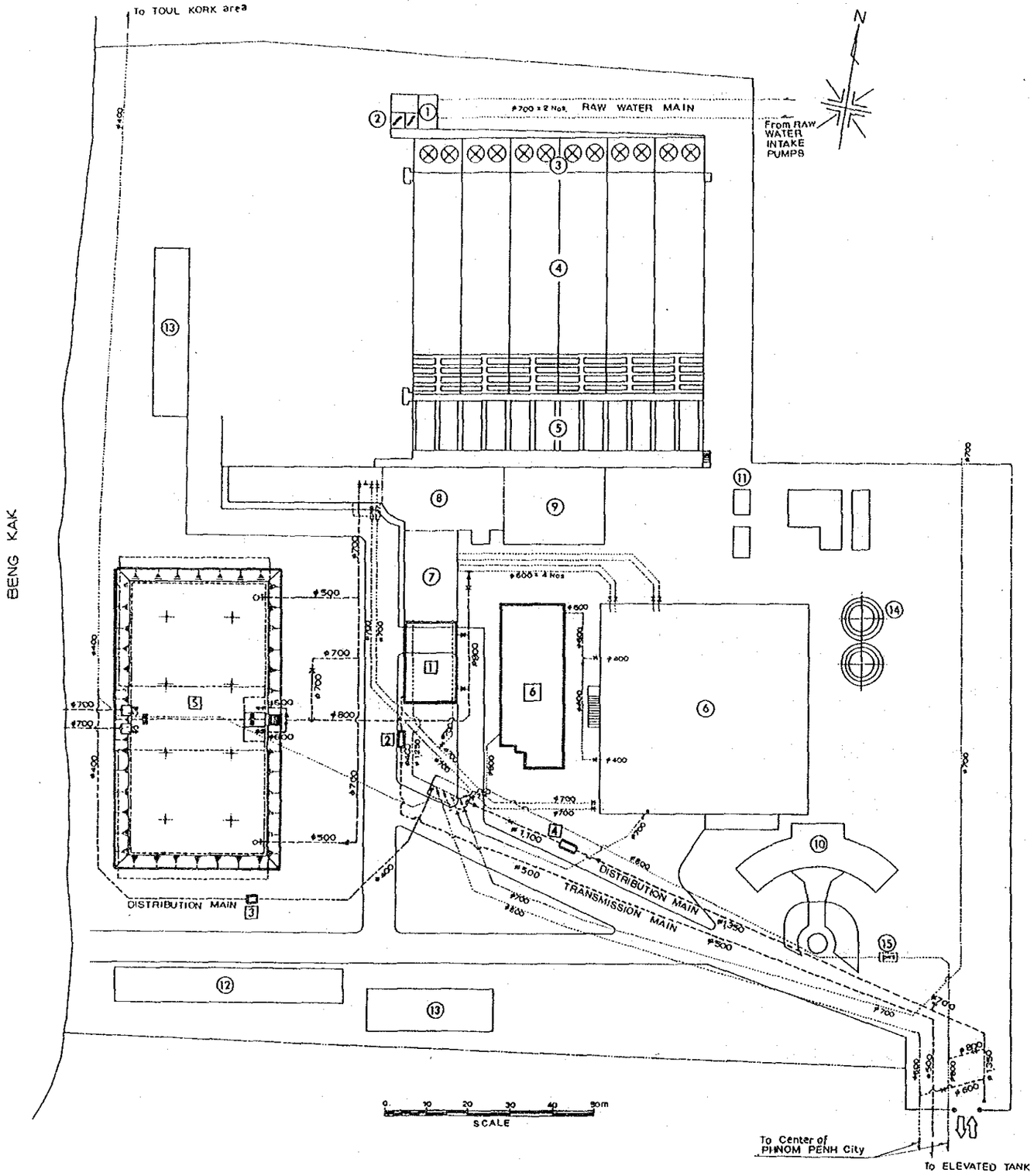



Fig.-4.1 LOCATION PLAN OF FACILITIES FOR URGENT REHABILITATION WORKS



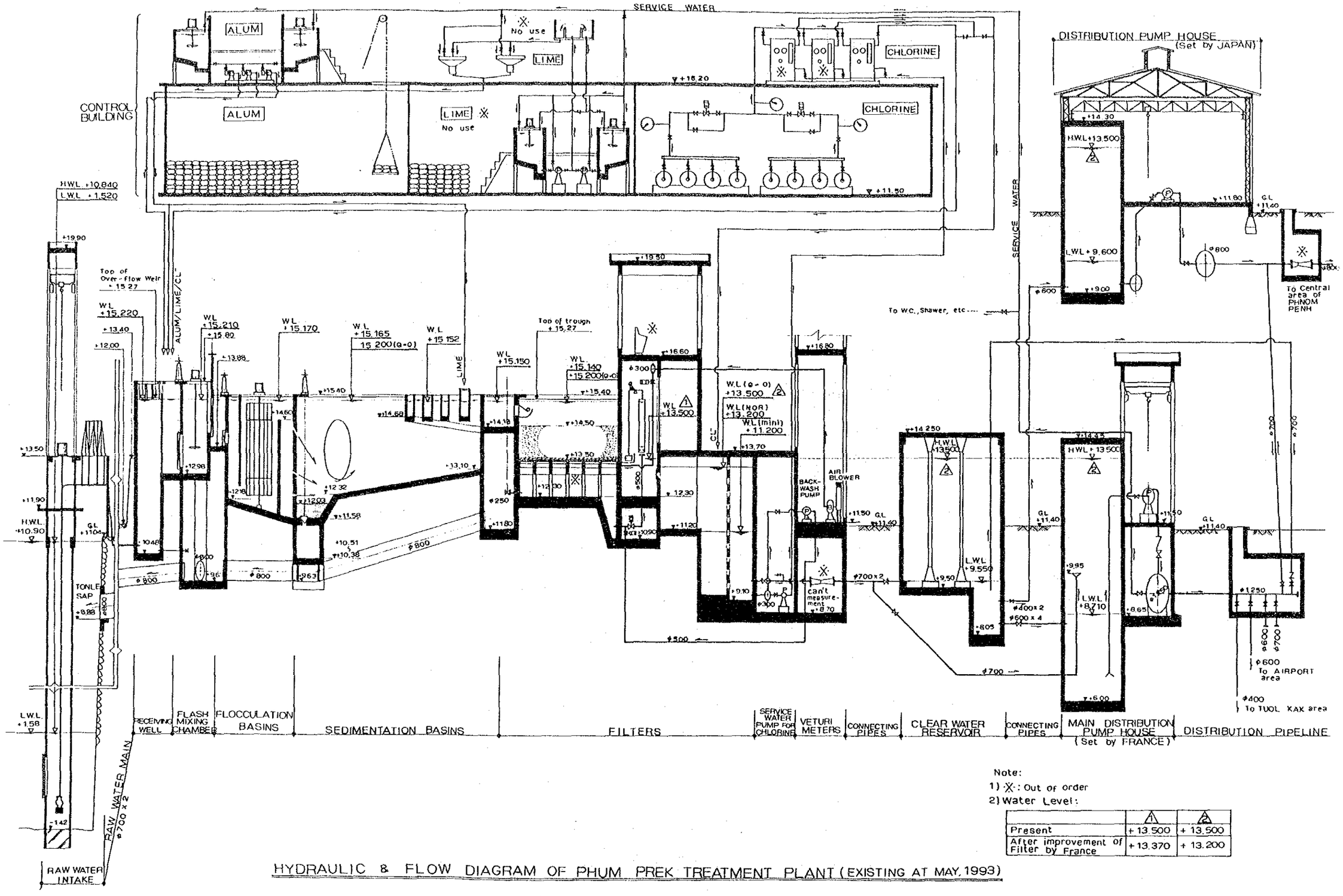

Exsiting facilities (Constructed by JAPAN or FRACE)

① RECEIVING WELL (FRANCE)
② MIXING CHAMBERS ( —·— )
③ FLOCCULATION BASINS ( —·— )
④ SEDIMENTATION BASINS ( —·— )
⑤ FILTERS ( —·— )
⑥ CLEAR WATER RESERVOIR (JAPAN)
⑦ MAIN DISTRIBUTION PUMP HOUSE (FRANCE)
⑧ CENTRAL CONTROL BUILDING ( —·— )
⑨ GENERATOR ROOM ( —·— )
⑩ ADMINISTRATIVE OFFICE ( —·— )
⑪ E.D.P. TRANSFORMER ROOM
⑫ OFFICE & WORKSHOP
⑬ STORAGES
⑭ FUEL TANKS (FRANCE).
⑮ FLOW METER (JAPAN)

Proposed facilities

[1] MAIN DISTRIBUTION PUMP HOUSE
[2] FLOW METER φ 400mm FOR TRANSMISSION PIPELINE
[3] FLOW METER φ 400mm FOR DISTRIBUTION PIPELINE TO TOUL KORK AREA
[4] FLOW METER φ 1,100mm FOR DISTRIBUTION PIPELINE TO CENTER OF PHNOM PENH CITY
[5] 10,000m³ CLEAR WATER RESERVOIR
[6] ELECTRIC ROOM (to be imoroved exsiting distribution pump house constructed by JAPAN)

Fig.-4.2 GENERAL PLAN OF PHUM PREK TREATMENT PLANT




Note:
1) ※: Out of order
2) Water Level:

| | ① | ② |
|---|---|---|
| Present | + 13.500 | + 13.500 |
| After improvement of Filter by France | + 13.370 | + 13.200 |

HYDRAULIC & FLOW DIAGRAM OF PHUM PREK TREATMENT PLANT (EXISTING AT MAY, 1993)

Fig.-4.3 HYDRAULIC & FLOW DIAGRAM OF PHUM PREK T. P. SYSTEM

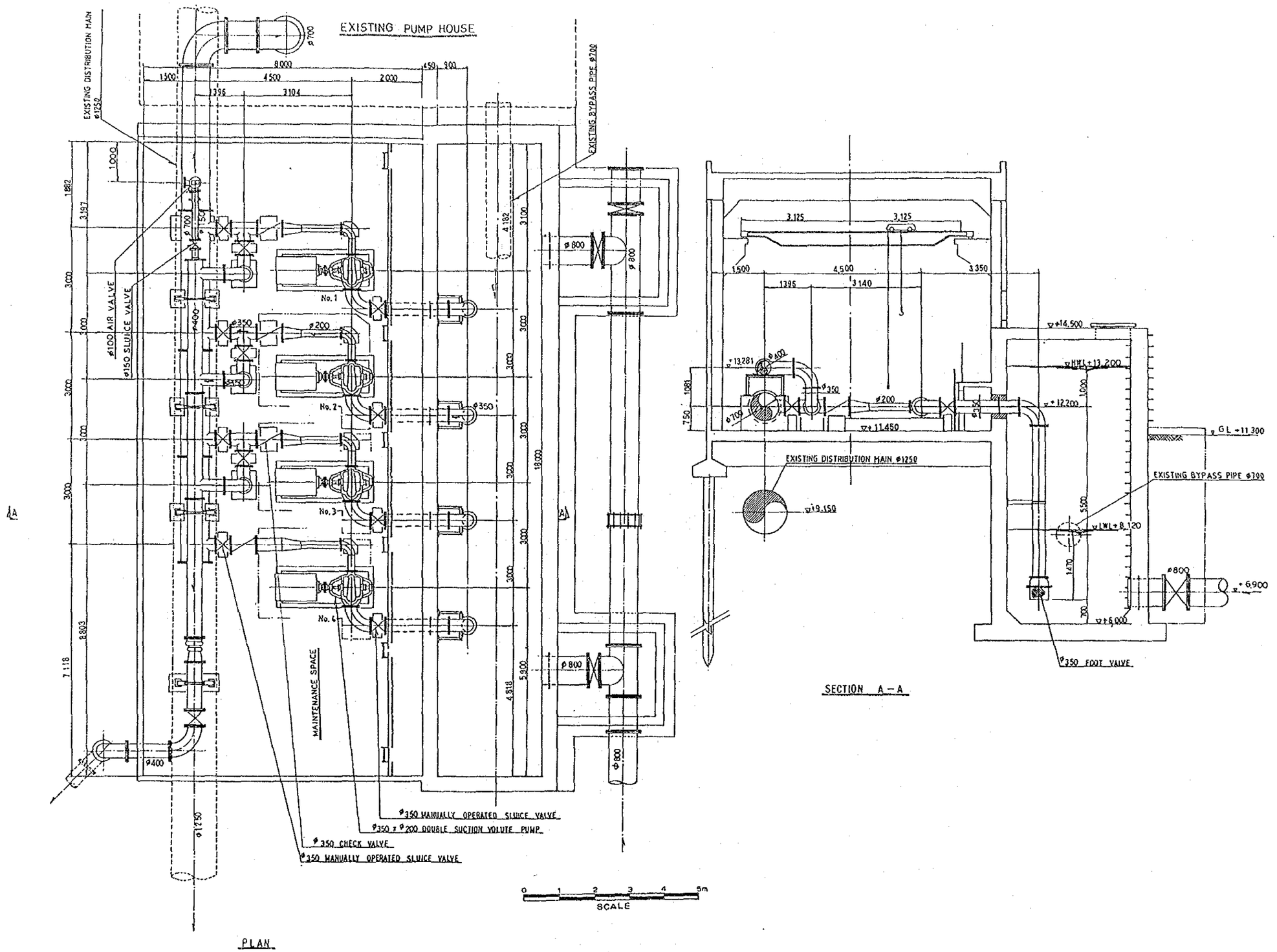
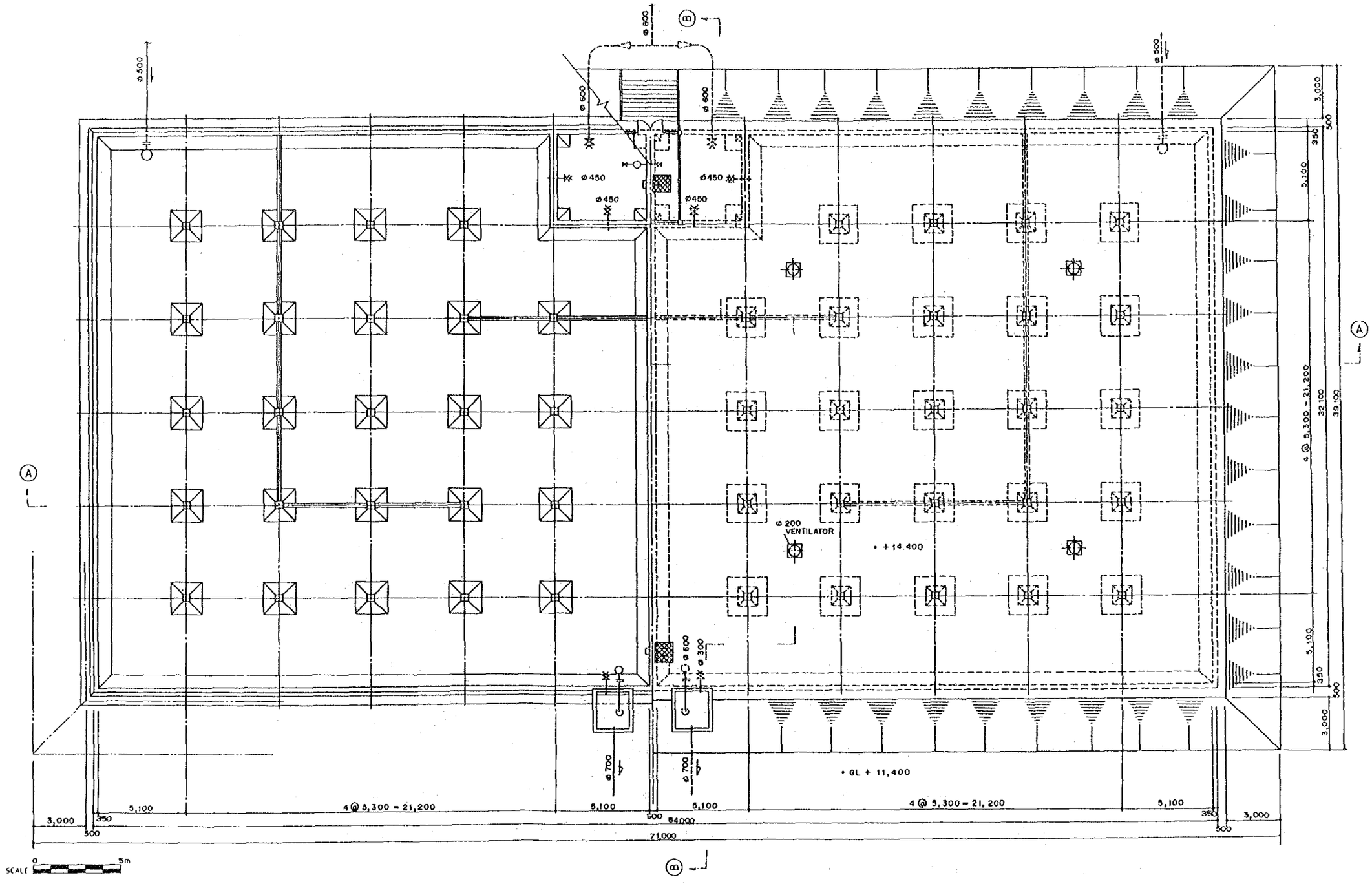
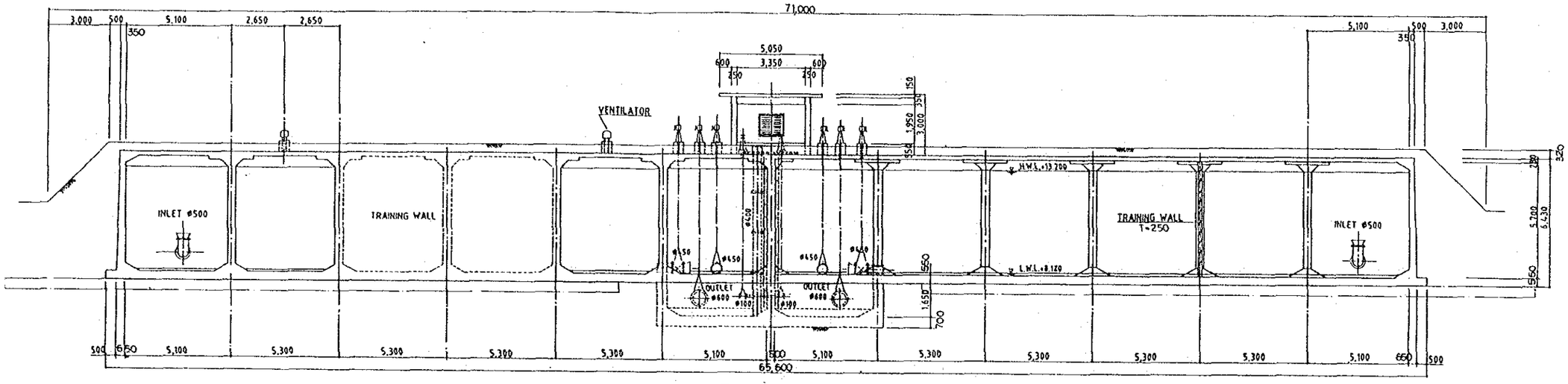



Fig.-4.4 STRUCTURAL DRAWING OF THE MAIN DISTRIBUTION PUMP HOUSE

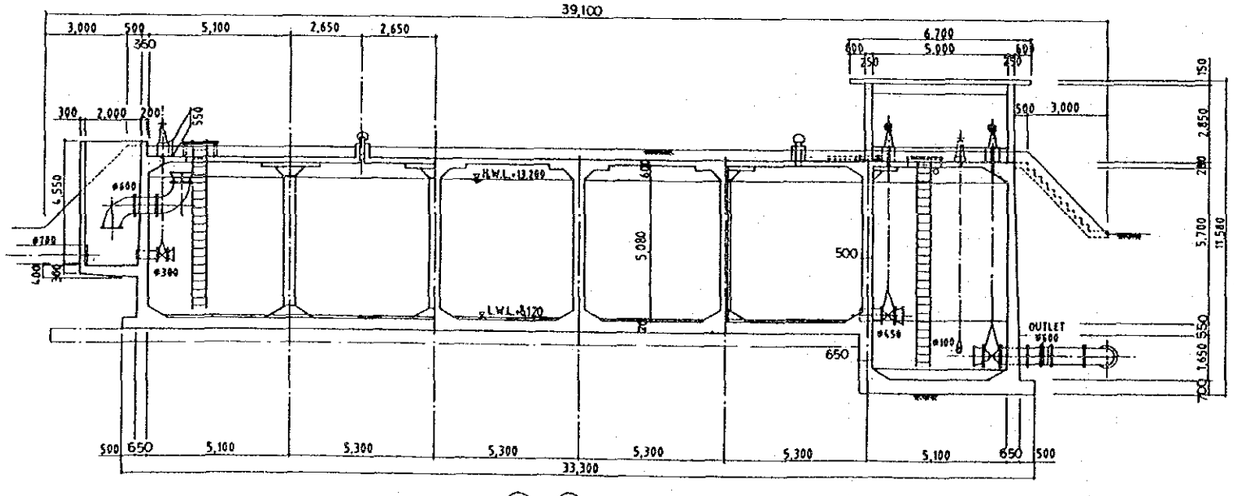



PLAN

Fig.-4.5 STRUCTURAL DRAWING OF 10,000m³ CLEAR WATER RESERVOIR (1)

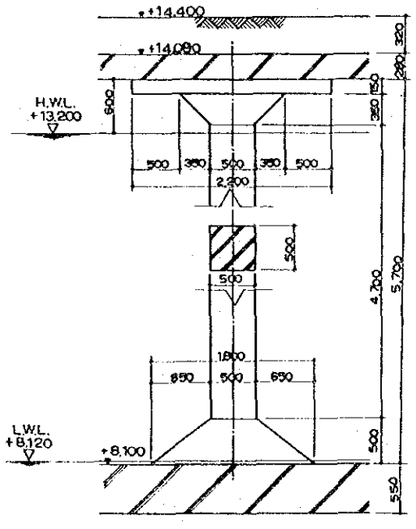



Ⓐ - Ⓐ SECTION




Ⓑ - Ⓑ SECTION

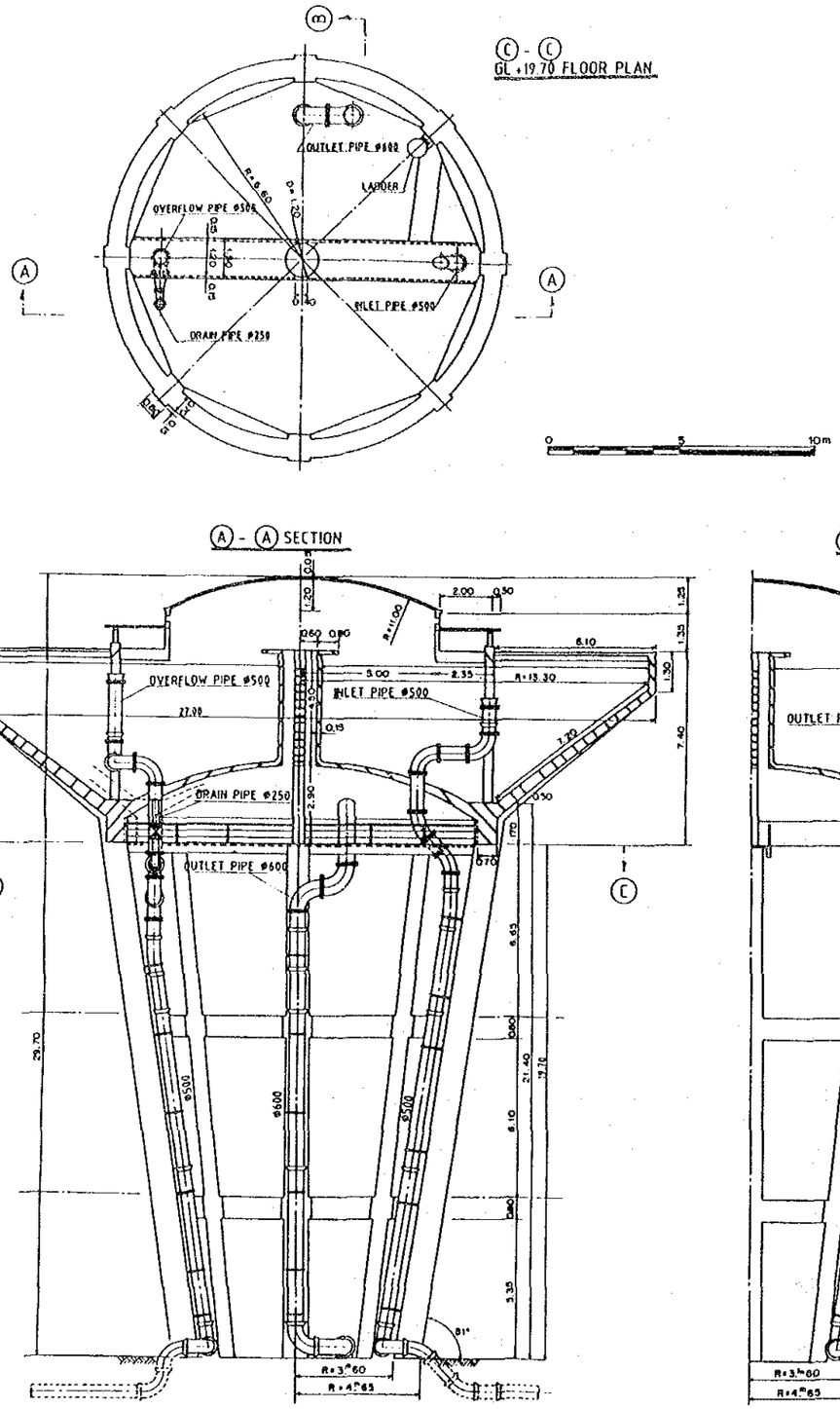
SCALE: 0 5.0m




DETAIL OF COLUMN

SCALE 0 1 2m

Fig.-4.6 STRUCTURAL DRAWING OF 10,000m³ CLEAR WATER RESERVOIR (2)



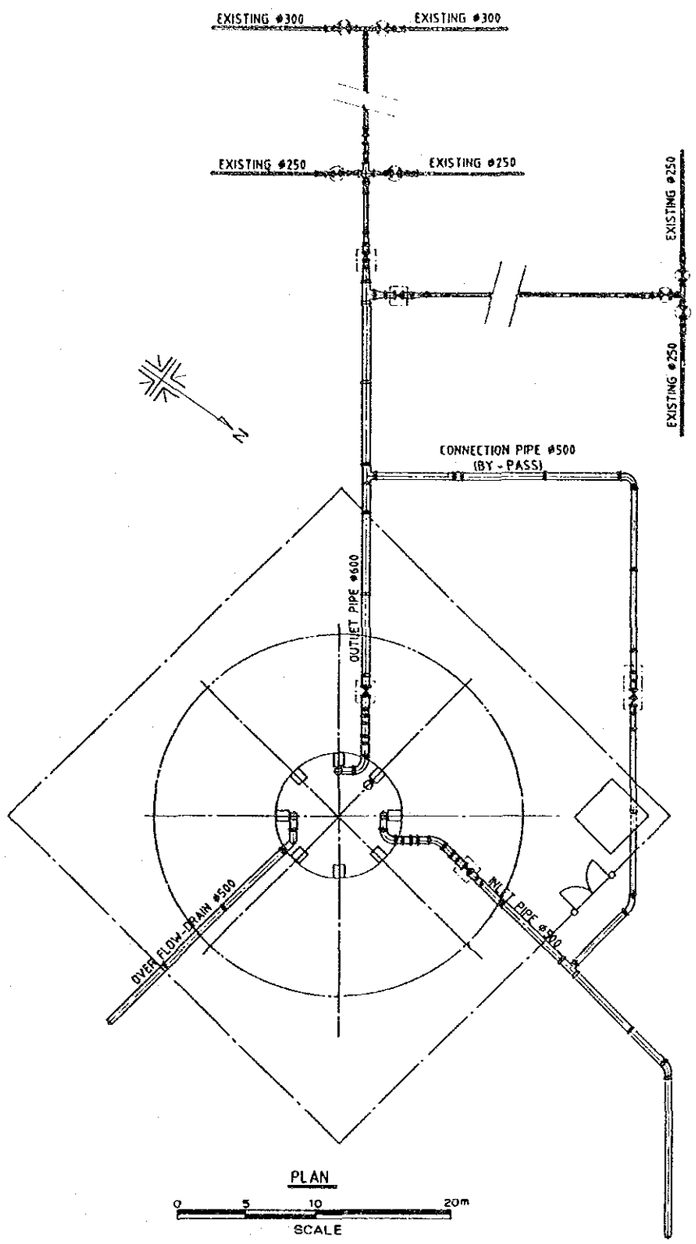




Fig.-4.7 IMPROVEMENT DRAWING OF THE EXISTING ELEVATED TANK

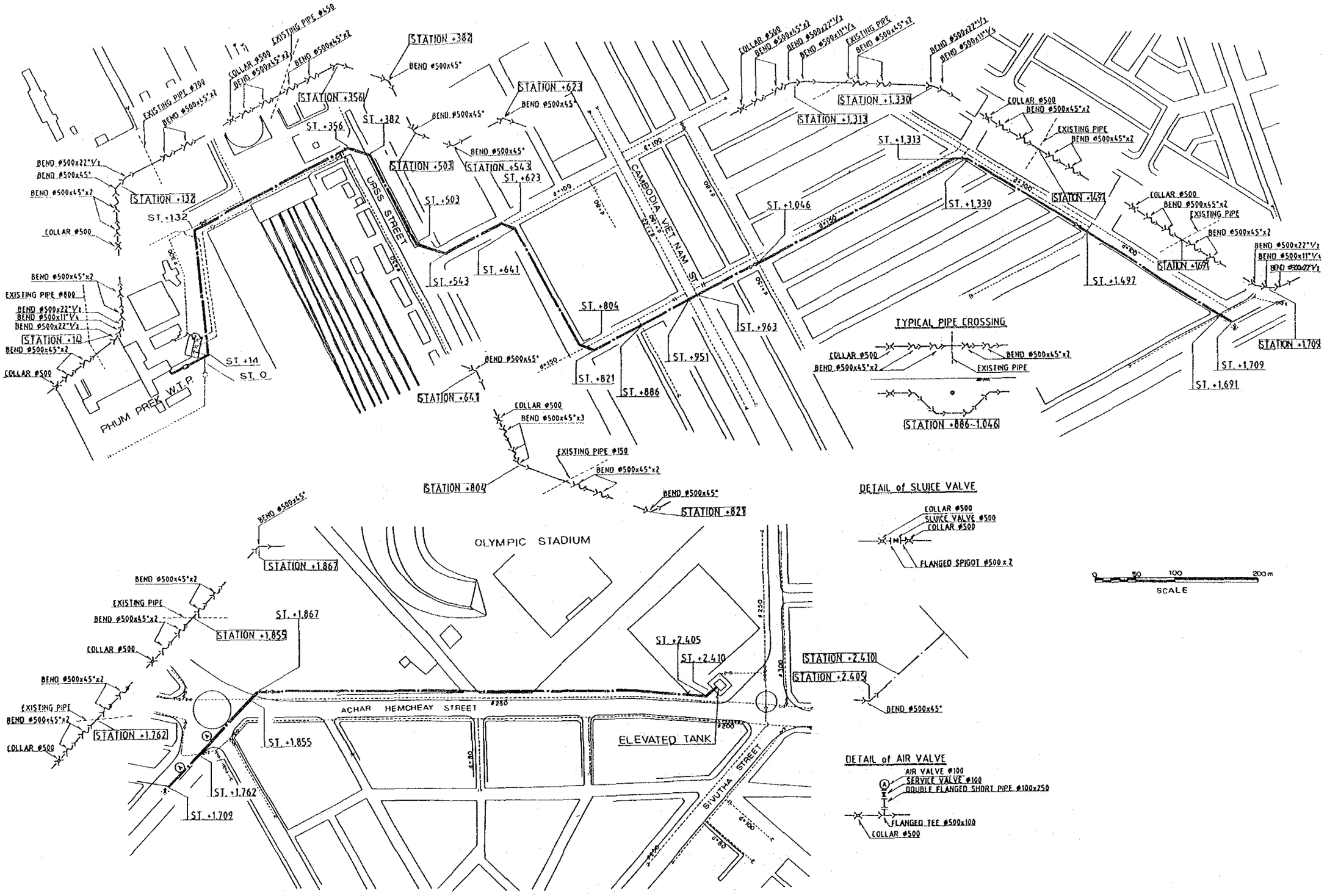



Fig.-4.8 PLAN OF $\phi$ 500mm TRANSMISSION PIPELINE

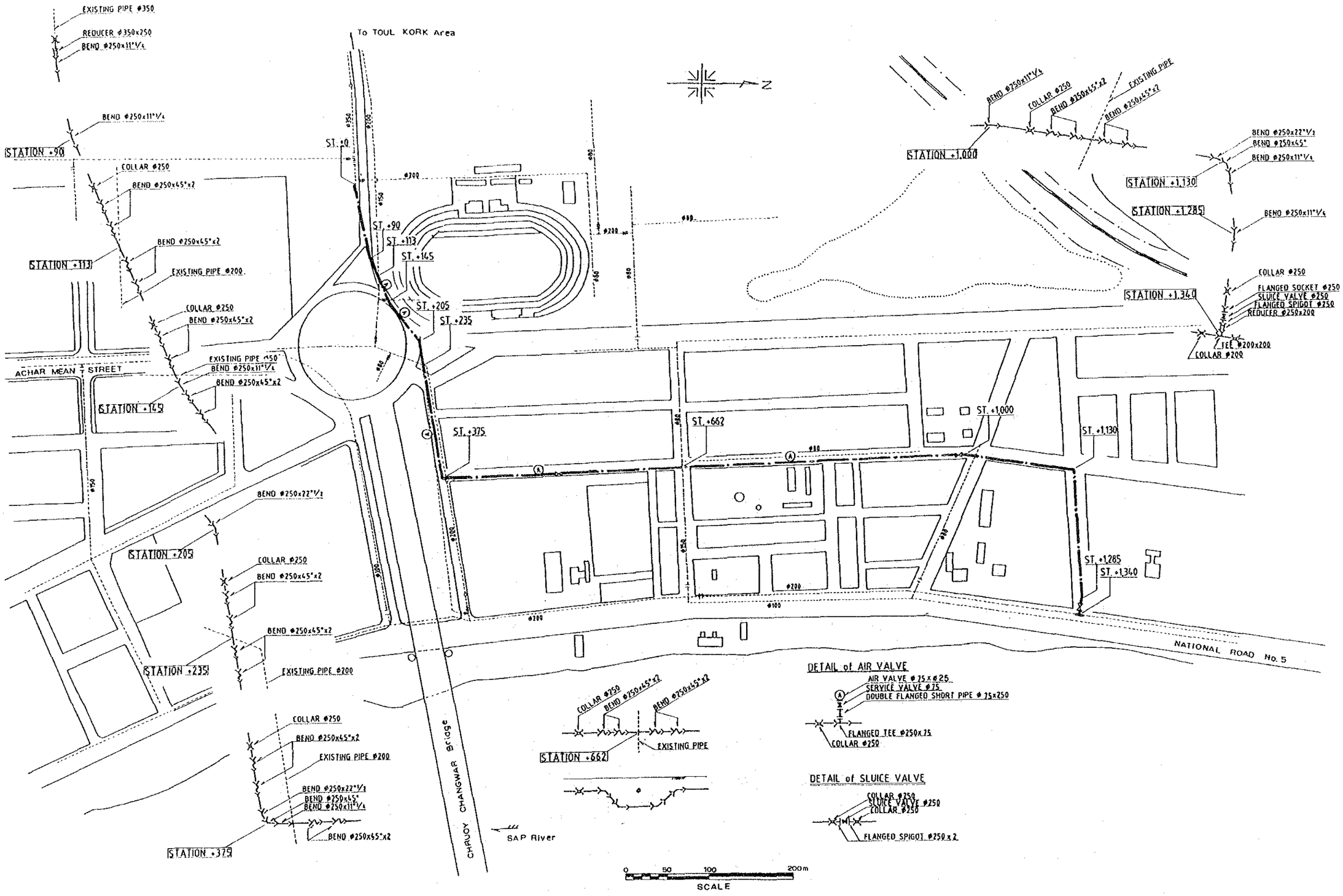



Fig.-4.9 PLAN OF $\phi$ 250mm DISTRIBUTION PIPELINE

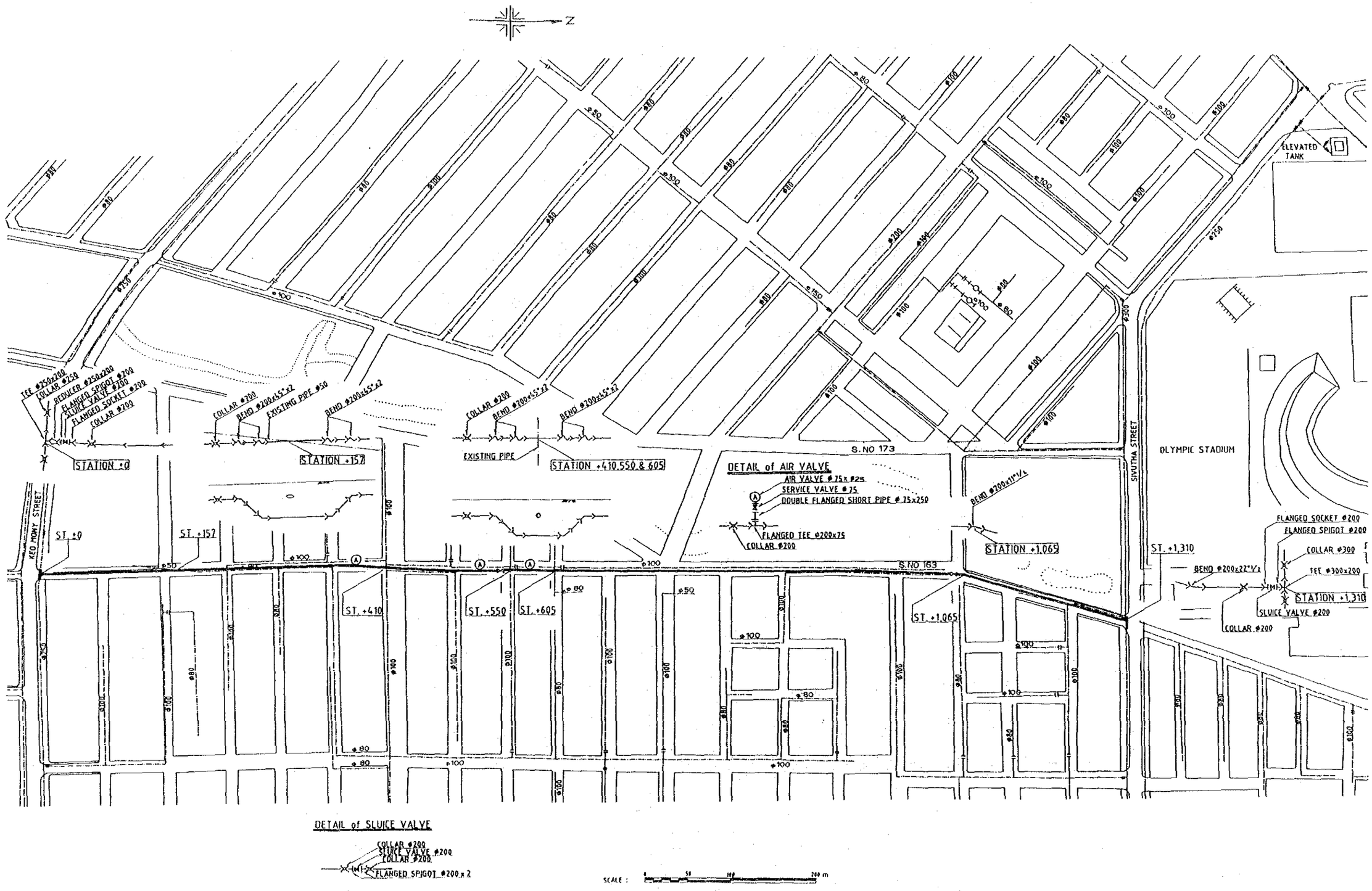
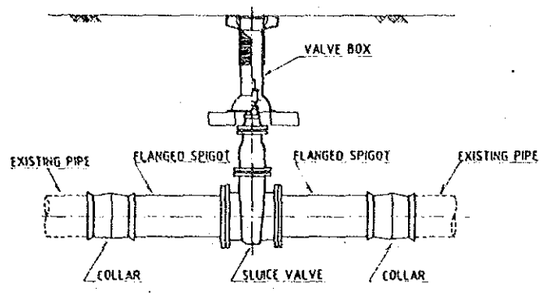



Fig.-4.10 PLAN OF $\phi$ 200mm DISTRIBUTION PIPELINE




TYPICAL DETAIL of VALVE BOX




Fig.-4.11 INSTALLATION DRAWING OF SLUICE VALVES

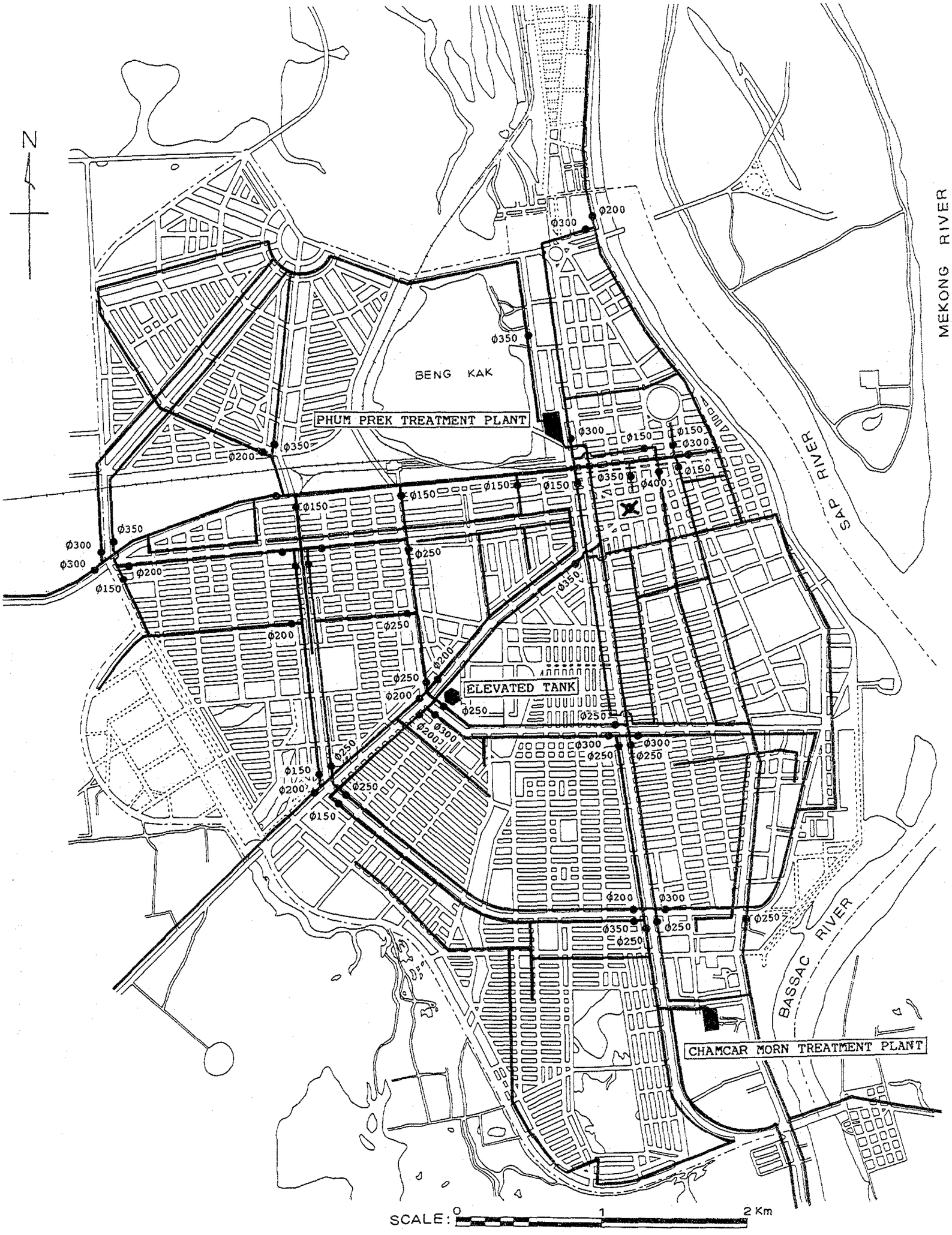



Fig.-4.12 INSTALLATION DRAWING OF THE PRESSURE CONTROL VALVES

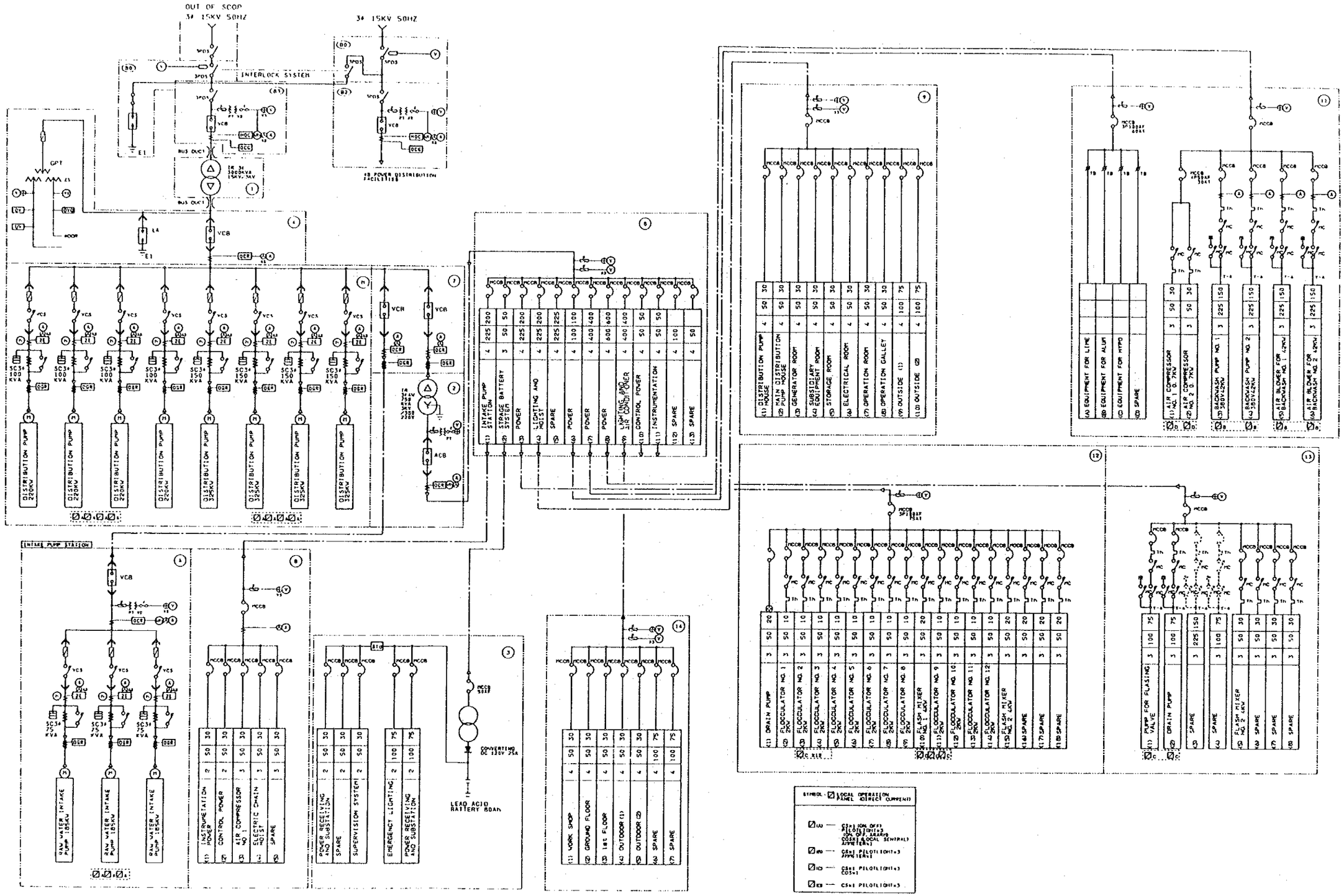
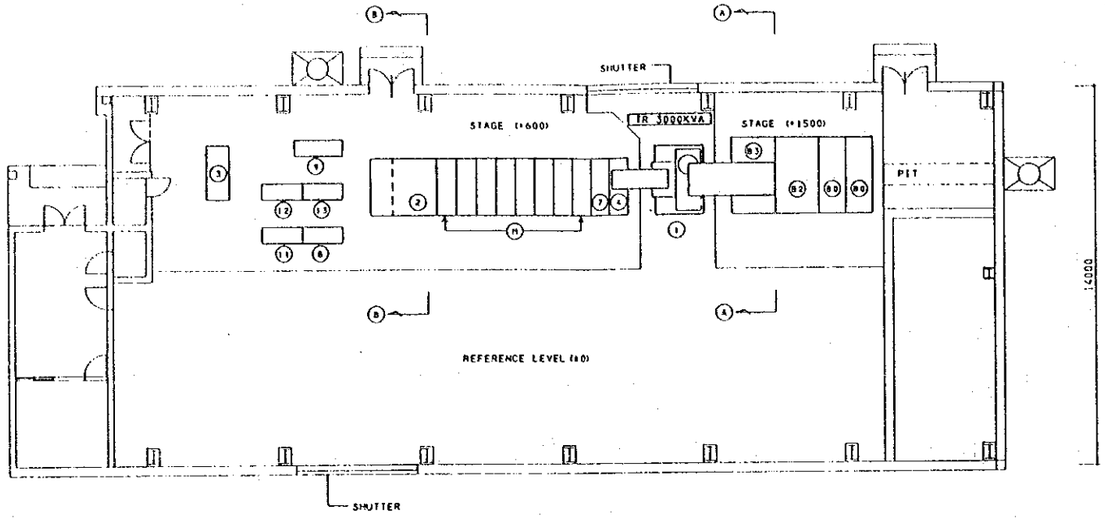
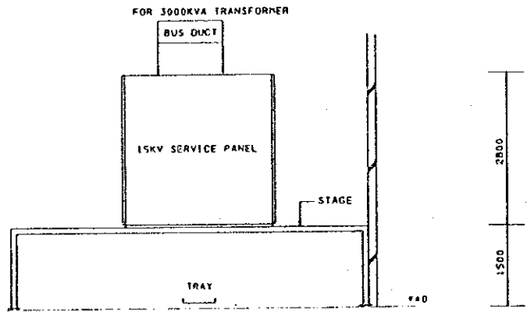


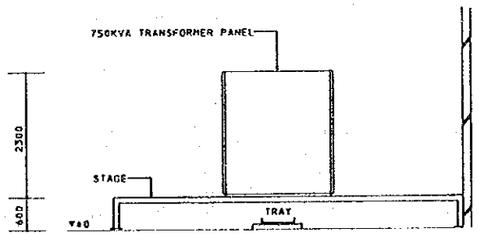

Fig.-4.13 SINGLE WIRE DIAGRAM OF THE PHUM PREK T. P. SYSTEM




| NO | NAME |
|---|---|
| 1 | TRANSFORMER 3000KVA |
| 2 | 750KVA TRANSFORMER PANEL |
| | (380, 220V SERVICE PANEL) |
| 3 | STRAGE BATTERY SYSTEM |
| 4 | 3KV SERVICE PANEL (3000KVA) |
| 7 | 3KV SWITCH PANEL (TWO-STAGE) |
| M | MOTOR STARTER PANEL |
| 8 | DISTRIBUTION PANEL (380, 220V) |
| 9 | DISTRIBUTION PANEL (380, 220V) |
| 10 | |
| 11 | MOTOR CONTROL PANEL |
| 12 | MOTOR CONTROL PANEL |
| 13 | MOTOR CONTROL PANEL |
| 14 | |
| | |
| | |
| 80 | 15KV INCOMING PANEL |
| 82 | 15KV SWITCH PANEL |
| 83 | 15KV SERVICE PANEL |
| | |




Ⓐ—Ⓐ SECTION




Ⓑ—Ⓑ SECTION

Fig.-4.14 PLAN OF THE ELECTRIC ROOM OF THE PHUM PREK T. P. SYSTEM

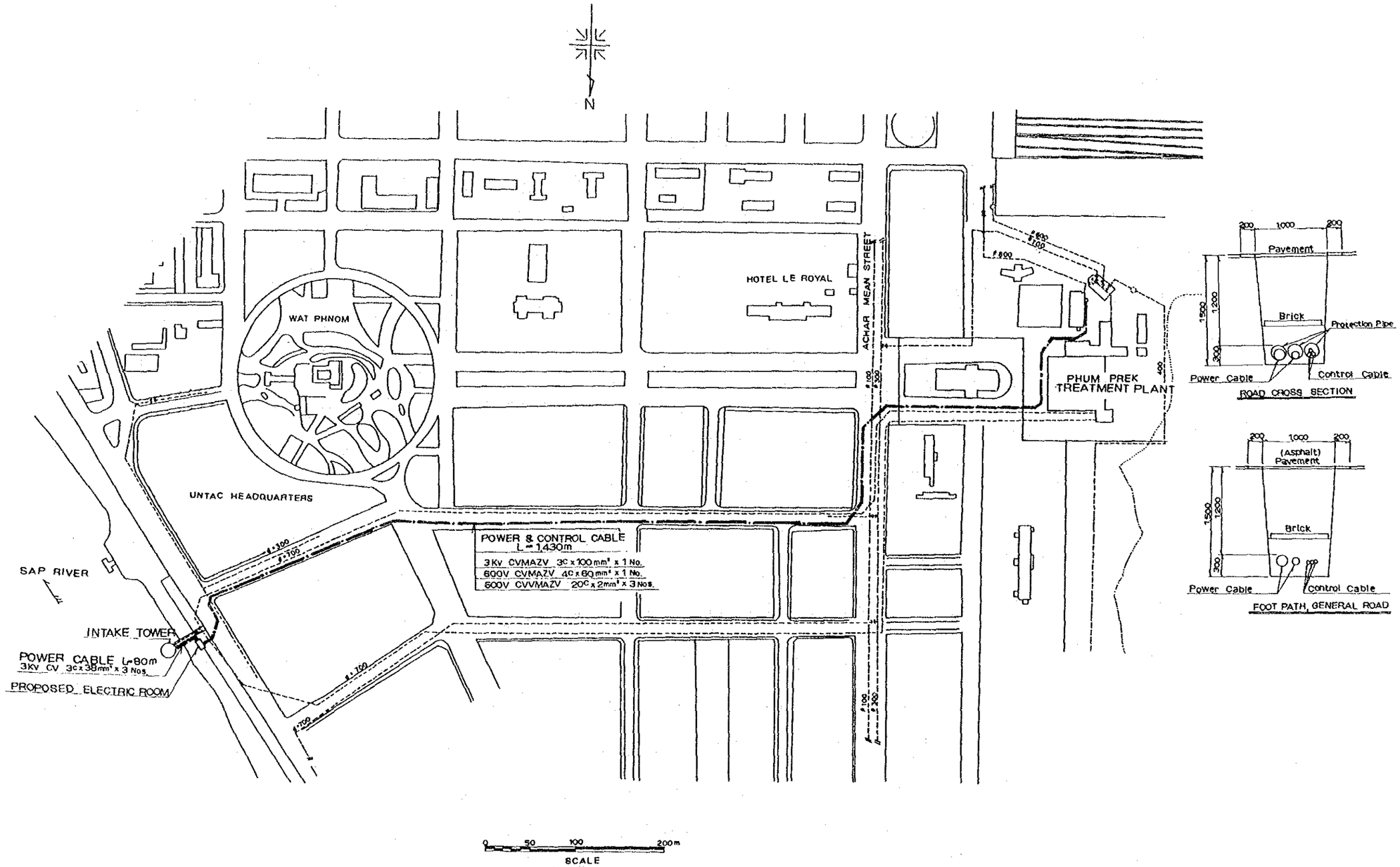
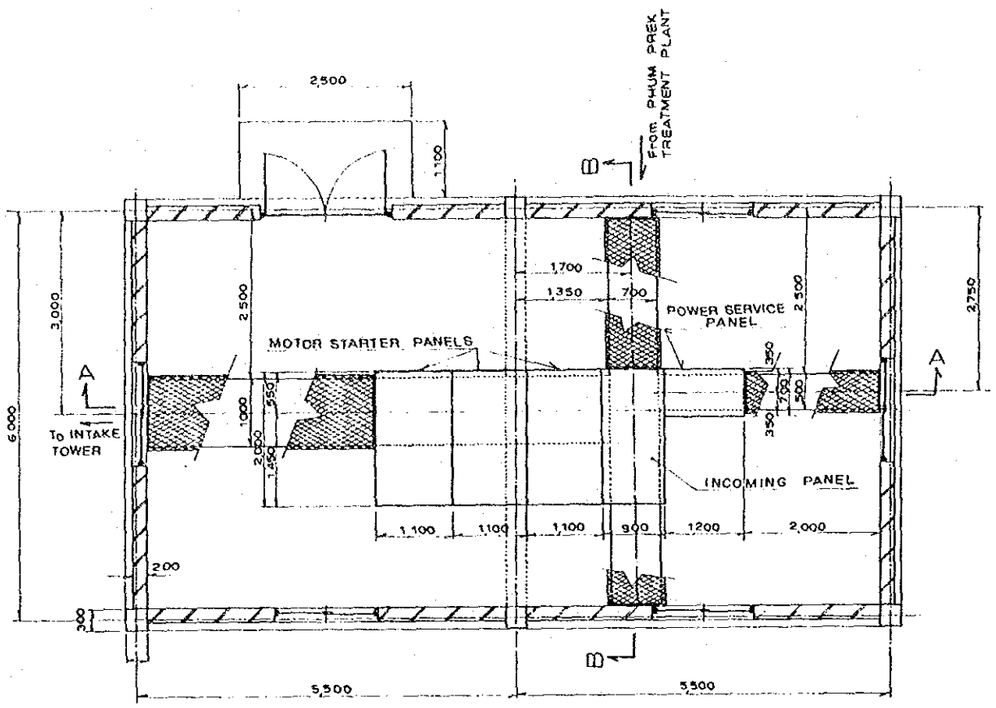
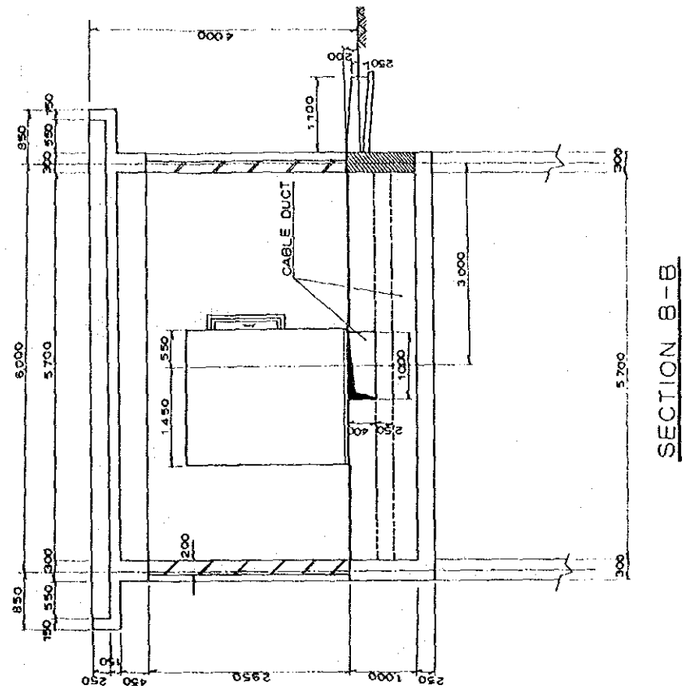



Fig.-4.15 CABLING PLAN FOR RAW WATER INTAKE

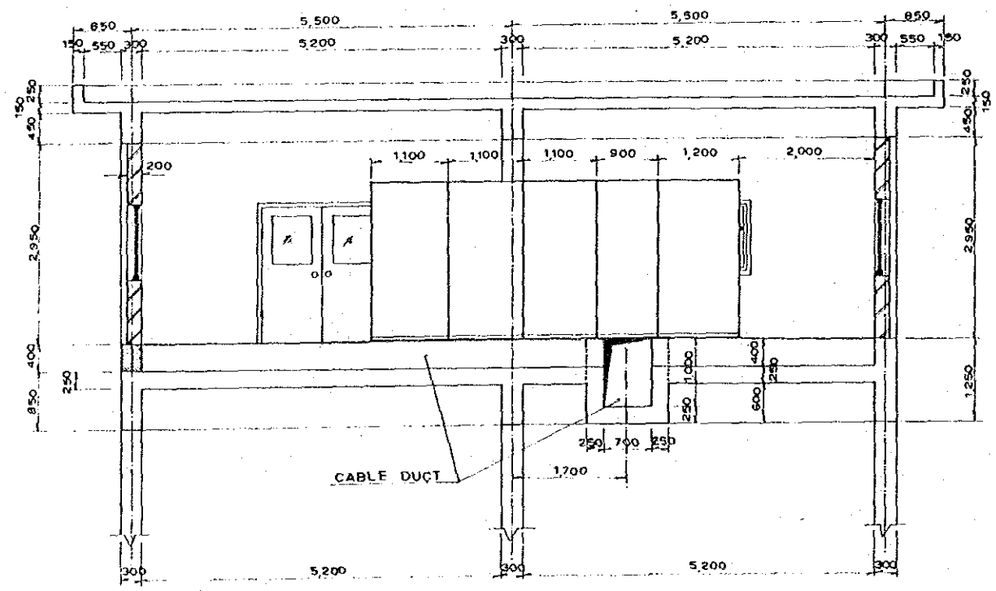



PLAN




SECTION B-B

SCALE 0 1 2 3m




SECTION A-A

Fig.-4.16 STRUCTURAL DRAWING OF THE ELECTRIC ROOM FOR RAW WATER INTAKE

## 4.4 IMPLEMENTATION PLAN

### 4.4.1 CONSTRUCTION CONDITION

In the execution of the rehabilitation works, the policy is to minimize the suspension period of water supply associated with the construction, while progressing with the work efficiently and also to enable the facilities and equipment to produce the intended effect immediately after completion. Here, the key to success is how to carry out each of the works.

The distribution mains in the Phum Prek treatment plant, which are the most critical lines supplying water to the city, branch into four directions. In installing connection pipes as a part of the improvement work on the main, it is necessary to take special precautions to carry out an efficient and safe construction and complete a changeover operation to those pipes within a short time during a specific period in the night when the water consumption is low. An appropriate installation procedure must be considered so that the supply to the city becomes available immediately after completion. In addition, installation of the distribution pipelines in the central area and a part of the northern area of the city and installation of flow meters and pressure control valves on the distribution pipelines around the elevated tank must progress in parallel with other work so that the supply service to all areas can be started immediately after the completion of the work.

Improvement work of the existing electric equipment shall be carried out in the following steps: While operation of the treatment plant is maintained using the existing electric equipment, the distribution pump house constructed in 1959 under Japan's reparation program will be converted to an electric room and the power transforming equipment, distribution equipment, and operation and control equipment which can handle the existing pumps as well as the new pumps will be installed in the new electric room. After completing all these installations, a switchover operation to the new electric equipment will be done within the shortest possible period of time.

Since routine maintenance and inspection of pipes, valves, and mechanical and electric equipment in the Phnom Penh water supply system are handled by plumbers, mechanics and electricians of the Water Supply Authority, skillful mechanical/electrical contractors do not exist in Cambodia. Under these circumstances, it seems better not to leave the work to local

contractors because of possible problems during or after the execution. The main duty of the technical employees of the Water Supply Authority is maintenance and operation of the existing facilities, and hence it is difficult for their current staff to execute a large scale project like this one within a limited period.

1) Organization for the implementation of the project

Phnom Penh Water Supply Authority (PPWSA) is the agency for implementing this project on the Cambodian side.

Figure 4.17 shows the entire organization for the implementation.

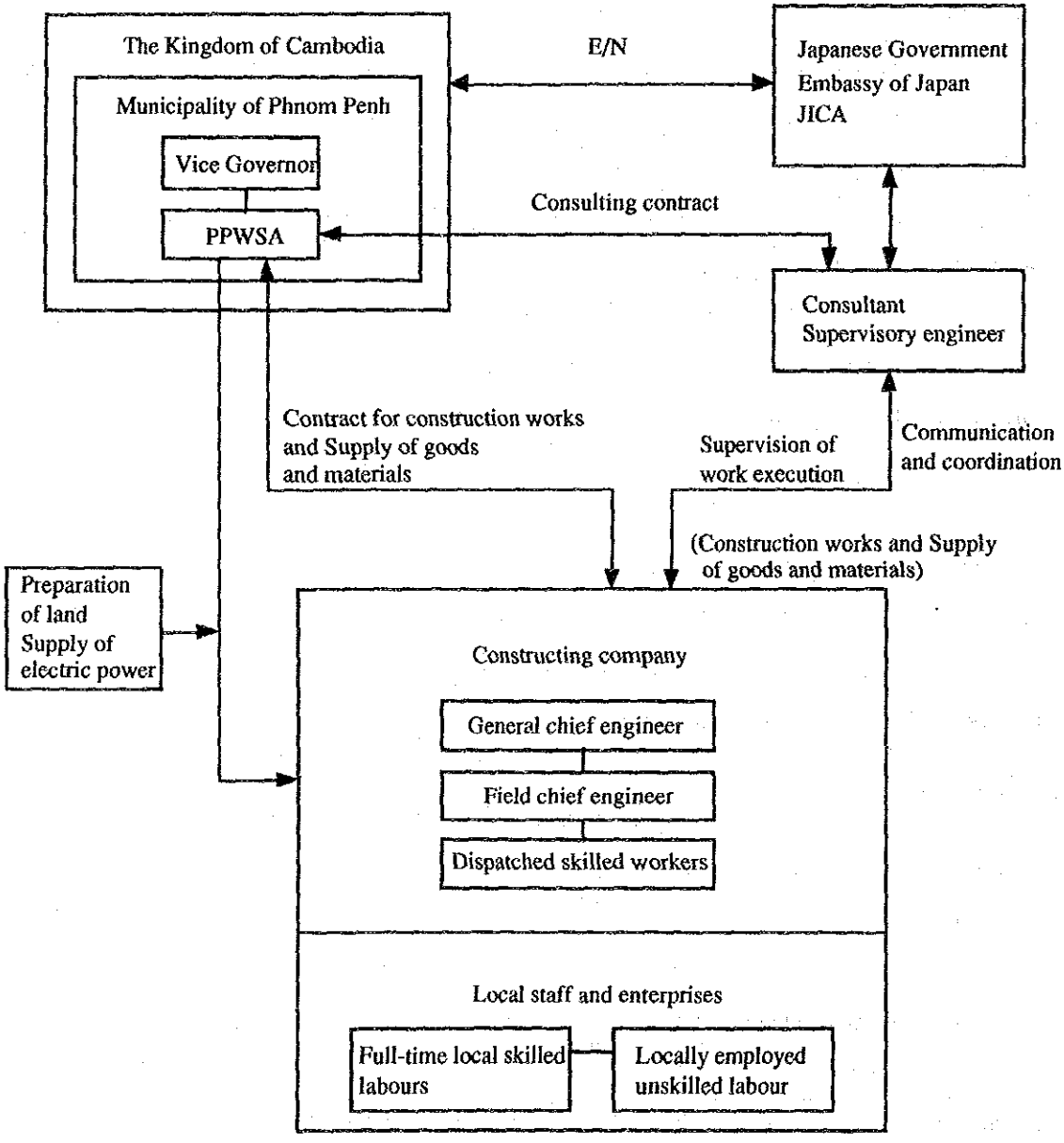



**Figure 4.17 Organization for project implementation**

2) Scope of the project

During the implementation, Japanese consultants shall be engaged in assisting the Water Supply Authority about the detailed design, tender procedure, and contract of the construction works and also in supervising the execution of the project.

Table 4.1 shows what materials and equipment are supposed to be supplied or installed by Japan or Cambodia in this project.

**Table 4.1 Scope of Work**

| Item | Construction Work | |
|---|---|---|
| | by Japanese side | by Cambodian side |
| 1. Water Intake Facilities | - Construction of electric room for water intake (W6m × L11m = 66m$^2$)<br>- Installation of lightning rod on the water intake tower<br>- Installation of high-tension power cable and control cable between treatment plant and water intake L = 1,430m<br>- Installation of incoming panel, high-tension starter panels, Low-tension panel and Local operation panels | - Demolition of existing caretaker's room (Approx. 24m$^2$)<br>- Renewal of cover wooden plate over the access bridge for the water intake tower (Approx. 168m$^2$) |
| 2. Treatment plant, Transmission and Distribution Facilities | - Construction of main distribution pump house for transmission pumps and distribution pumps, including pump suction pit. (W8.0m+3.5m) × L18.0m)<br>- Construction of clear water reservoir, capacity : 10,000m$^3$<br>- Improvement of electric room by existing distribution pump house constructed by Japan in 1959.<br>- Installation of transmission pumps and distribution pumps, including piping and electric equipment (Q17.5m /min × H42m × 3kv× 180kw× 4sets)<br>- Improvement of existing electric equipment including transformers | - Land leveling of inside treatment plant<br>- Fencing work in the elevated tank yard L = 160.m |

| Item | Construction Work | |
|---|---|---|
| | by Japanese side | by Cambodian side |
| | -Installation of interconnection pipeline in the phum Prek treatment plant including flow meters, valves (400mm dia. to 1,350mm dia, venturi meter : 400mm dia. & 1,100mm dia. )<br><br>- Improvement of existing distribution pumps installed by France<br><br>- Installation of 500mm dia. transmission pipeline. L = 2,410m<br><br>- Improvement of elevated tank including pipes & valves (250mm dia. to 600mm dia.)<br><br>- Installation of 250mm dia. & 200mm dia. distribution pipeline (250mm dia. : L = 1,340m) (200mm dia. : L = 1,310m)<br><br>- Installation of isolating valves 80mm dia. : 23 Nos. 100mm dia. : 61 Nos. 150mm dia. : 20 Nos. 200mm dia. : 19 Nos. 250mm dia. : 26 Nos. 300mm dia. : 11 Nos. 350mm dia. : 5 Nos. 400mm dia. : 1 No. | |
| 3. Supply of Goods and Materials | - Supply of water Meters including connection accessaries 30mm dia. : 1,500 sets 40mm dia. : 1,000 sets 50mm dia. : 500 sets | - Installation of water meters & piping, including supply of necessary piping materials such as pipes, fiftings, valve, saddle band. |
| | - Supply of Cover Joints for repairing pipes 80mm dia. : 70 sets 100mm dia. : 200 sets 125mm dia. : 5 sets 150mm dia. : 60 sets 200mm dia. : 40 sets 250mm dia. : 45 sets | - Installation of cover joints |

Estimated cost for the portion implemented by Cambodian side is as follows. (Refer to Appendix -4)

| | | |
|---|---|---|
| 1) | Demolition of existing caretaker's room | : US$3,000 |
| 2) | Renewal of cover wooden plate over the access bridge for the water intake tower | : US$5,000 |
| 3) | Fencing work in the elevated tank yard | : US$20,000 |
| 4) | Installation of water meters (Installation cost shall be paid by beneficiaries) | : US$787,500 |
| 5) | Installation of cover joints | : US$73,000 |
| | Total | : US$888,500 |

As shown in the table, it is Cambodia's job to install the water meters and cover joints (bands) for repairing broken pipes, which are to be supplied by Japan. The current leakage ratio assumed in this project is 50%. It is understood that most leakage results from the distribution pipeline and from the service pipes these upstream of the water meters. Although local workers are not familiar with installation of this cover joints (band), reducing the leakage to a minimum level can be done through necessary instructions in the field by Japanese engineers. It is also expected to be able to increase the collection of water rates by installing the water meters (to be supplied by Japan) and also installing the service pipes (to be provided by Cambodia) between the distribution pipeline and the water meters at large users' cost by the beneficiaries-pay principle.

It is also Cambodia's job to demolish the existing caretaker's room in the water intake site, and the Water Supply Authority shall complete the demolition in one month before the start of construction by Japan. Cover plate over the access bridge for the intake tower shall be installed immediately after the completion of Japan's portion of the work.

Due to the important nature of this project, the construction work shall be contracted on a package basis and a competent contractor having sufficient experience in waterwork construction shall be selected through an open tender. Criterion for selecting a successful contractor shall be determined upon consultation with the Water Supply Authority at the time of preparation of the tender.

### 4.4.2 IMPLEMENTATION METHOD

There are several private construction companies of a small size but none is competent enough to manage the entire work of this project. Cambodia suffers from a shortage of skilled workers because many capable people including engineers and skilled experts were lost during the civil war and none have been produced since then as there has been no remarkable construction work in Cambodia.

Their technical level is not sufficient, particularly in placing reinforcing bars, framing formworks and waterproofing, all of which are necessary for constructing complicated and water proof structures for this project. A large part of the durability and hydraulic characteristic of the structures depends upon the technical level of accomplishing these tasks. Due to the fact that technicians to complete the work proposed by the basic design are not available, there could be a delay in completing the work within a limited time schedule. In particular, it is essential to have skilled machine operators, form workers, and reinforcing-bar workers. Further, skilled workers for waterproofing are also important since this requires special techniques.

The necessary heavy construction machine operators should be dispatched from Japan and they will supervise and direct the execution of the work. Accordingly, it has been decided to dispatch technicians from Japan for the aforementioned tasks and for labor intensive tasks. The following workers are included.

1) Heavy construction machine operators
2) Concrete form workers
3) Reinforcing-bar workers
4) Waterproofing workers

Since it is impossible to employ engineers locally, it was also decided to dispatch the engineers required from Japan including those for construction, civil, electric and plumbing engineering.

When any public road or sidewalk is excavated in Cambodia, there is a regulation that all expenses incurred in restoring the excavated road or sidewalk must be borne by the

contractor of the work. Prior to start of the work, the contractor must submit a drawing of the area to be excavated and a request for traffic control stating the area and time to the Road Authority through the Water Supply Authority, and obtain their authorization for the excavation.

As per the result of local investigation, Cambodia also suffers from a shortage of construction machines. Even if some are available locally, it is very difficult to obtain the necessary spare parts. It is reported that procurement or leasing of necessary machines is impossible. Thus, this basic design is done on the assumption that construction machines of bringing in principle construction will be brought in from Japan.

### 4.4.3 CONSTRUCTION AND SUPERVISORY PLAN

1) Detail design

The signing and exchange of a note (E/N) according to the schedule, will seal the contract with Cambodia. Upon verification of the contract by the Japanese government, the consultant will proceed with the detail design. All detail designs and tender documents prepared by the consultant shall be subject to approval by the Phnom Penh Water Supply Authority. After this consultant will start preparation for the tender.

2) Tender

All tender documents shall be subject to approval by the Phnom Penh Water Supply Authority. As soon as they are approved, the consultants will hold a tender. The consultant shall act as a representative of the Water Supply Authority in distributing and receiving tender application documents, and upon receipt of the applications will review them without delay. The consultant shall then recommend the lowest bidder as the contractor for this project and help the bidder conclude a construction contract with the Phnom Penh Water Supply Authority.

3) Supervision of the Project Execution

The main construction sites are the Phum Prek water treatment plant, the transmission

pipeline zones and the elevated tank yard in the first stage of the works and the Phum Prek water treatment plant and distribution pipeline zones for the second stage. For supervising the implementation, the consultant will provide a project office within the Phum Prek water treatment plant where a large part of the work is to be done.

The consultant shall review the documents including the fabrication drawings and the execution drawings submitted by the authorized contractor, and approve them as a representative of Phnom Penh Water Supply Authority. In addition, the consultant shall witness pre-shipment inspections of production materials and components at factory and grant an official acceptance. The consultant shall attend a meeting between Phnom Penh Water Supply Authority and the contractor before the construction commences giving necessary advice. For supervising the erection, installation, final inspection and trial run at the job site, the consultant shall have a supervisory engineer stationed permanently for necessary instruction and supervision to ensure that the work can be completed within a specified period of time.

The supervisory engineer is required to have sufficient knowledge in civil and waterwork engineering as well as comprehensive management ability. As the construction work proceeds, the consultant will dispatch electrical and mechanical engineers to supervise the work in this area i.e. the construction of electrical and mechanical facilities.

4) Training upon delivery

Upon delivery of the project, the consultant will provide training for two months. It is not a typical supplier-oriented training but aims to transfer necessary technology for maintenance and operation of the supplied facilities and equipment in harmony with water treatment technology. Necessary operation manuals are provided during the training.

### 4.4.4 PROCUREMENT PLAN

Table 4.2 shows the material and device procurement schedule.

**Table 4.2**

| Name of Material and Device | From Japan | In Cambodia | From the Third Country |
|---|---|---|---|
| Aggregates for concrete | | ○ | |
| Cement | | | ○ |
| Reinforcing bars | | | ○ |
| Plywoods for formwork | ○ | | |
| Wooden | | ○ | |
| Steel materials | ○ (Large) | ○ (Small) | |
| Bricks,concrete blocks | | ○ | |
| Tiles | | ○ | |
| Galvanized corrugated roofing Sheets | | ○ | |
| Asbestos corrugated roofing Sheets | | ○ | |
| Windows, doors, glass | | ○ | |
| Paints | | ○ | |
| Fuel | | ○ | |
| Lubricant | ○ (Special) | ○ (Standard) | |
| Asphalt | | ○ | |
| Pipes (Ductile cast iron) | ○ | | |
| Pipes (steel) | ○ | | |
| Pipes (PVC drain pipes) | | ○ | |
| Valves | ○ | | |
| Pumps | ○ | | |
| Motors | ○ | | |
| Instruments | ○ | | |
| Wiring and lighting materials | ○ | | |
| Electric components including transformers and panels | ○ | | |
| Water meters | | | ○ |
| Cover joints (bands) for repairing pipes | ○ | | |

We investigated which construction materials are available locally and usable, and found that sands, gravels (crushed stones), small size section steels (angle steels, channel steels), wood materials, Galvanized corrugated steel sheets (0.2 mm thick), bricks, window/door materials, glass, asbestos roofing sheets, PVC drain pipes, reinforced concrete pipes, and fuel for automobiles can be procured locally and used as construction material. Materials other than these must be imported.

a) Cement

According to the information the study team obtained at the site, Thai cement (Elephant brand), Chinese cement (#525 brand) and Vietnamese cement (no brand) are imported into Cambodia. The Thai cement is superior both in strength and quality, and the study team see no problem in using it in this project. The Chinese and Vietnamese cement have a high lime content, their strength is questionable and cracks may be caused in the structure. Thus, the study team came to the conclusion that these cement are not applicable to water-tight structures.

Although it is true that construction work is booming in Thailand and consequently the Thai cement is not available in abundance, the study team decided to procure this cement for this project because it is strong and of high quality.

b) Reinforcing bars

Small size Chinese and Vietnamese reinforcing bars can be procured locally. However, when the study team conducted a bending test during the investigation there, the strength is of these bars was found to be insufficient. Hence the study team decided they could not be used. A Thai product is also availabe and does not lack in quality. However, there is a big demand for these bars inside the Thailand and thus they cannot be exported. Although the Singaporean product faces a similar situation, there is a possibility of export. So, the study team have decided to procure it from Singapore.

c) Plywood for framework

Locally available plywood is only 3 mm thick. Since plywood of 10 mm or 12 mm is used

for formwork, one as thin as 3 mm cannot be used. Since inferior adhesive is used in the products made by other countries, bonded plies frequently peel off when the plywood soaks up moisture. Since it is necessary to use the formwork two or more times in the project, the study team have decided to procure the Japanese product which is superior in quality.

d) Pipes and valves

PVC pipes shall be used for drain pipes (down pipes) and will be procured locally. Considering the current circumstances such as the existence of stolen water from the distribution pipeline, required pipe size, and installation requirement for a place with high ground water level, underground pipes shall be ductile cast-iron pipes and sourced from Japan. Pipes around the pumps shall be steel pipes and sourced from Japan. Valves shall also be sourced from Japan because the specification must conform to that of the ductile cast-iron pipes and pumps.

e) Others

In principle, Japanese products shall be supplied for the pumps, motors, electrical and mechanical equipment from the point of view the reliability required of each equipment and the availability of spare parts after delivery.

Transportation from Japan or the third countries (Singapore and Thailand) shall be routed as shown Figure 4.18.

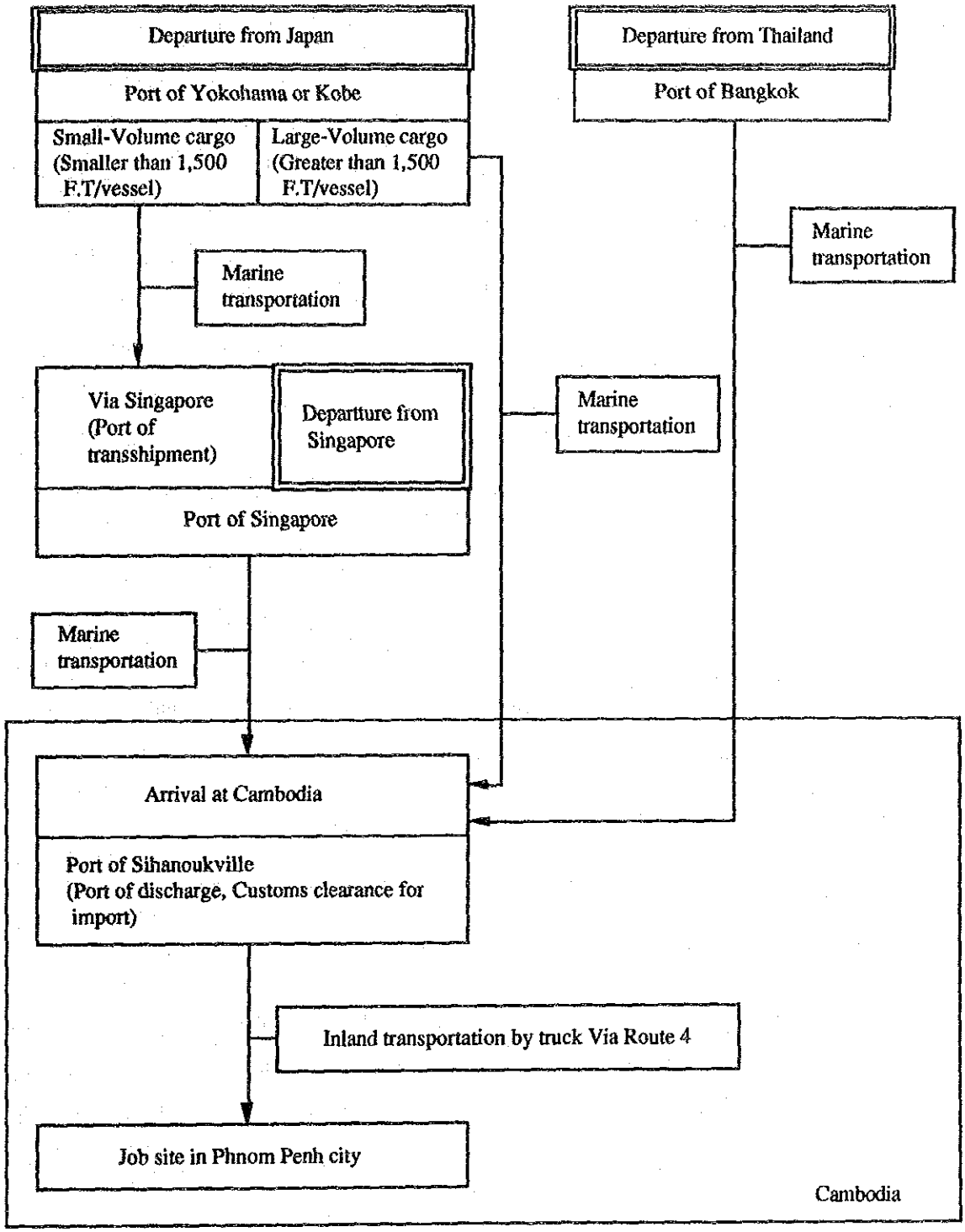



**Figure 4.18 Transportation Route of Imported Materials and Devices**

Note:

Another possible marine route of entering Cambodia is to sail up via Mekong River directly to the port of Phnom Penh, without entering Sihanoukville port, and unload the ship there. However, this is not considered in this project because the port facilities at Phnom Penh port are limited and a cargo heavier than 10 tons cannot be unloaded. This route is also risky because a sailing route from the mouth of Mekong River up to the port of Phnom Penh goes across a part of the Vietnamese territory and, as in the past, it is possible that the vessel is not permitted to pass through this territory once the border is closed for some reason. Taking into consideration the limited time schedule of this project, the aforementioned routing was decided.

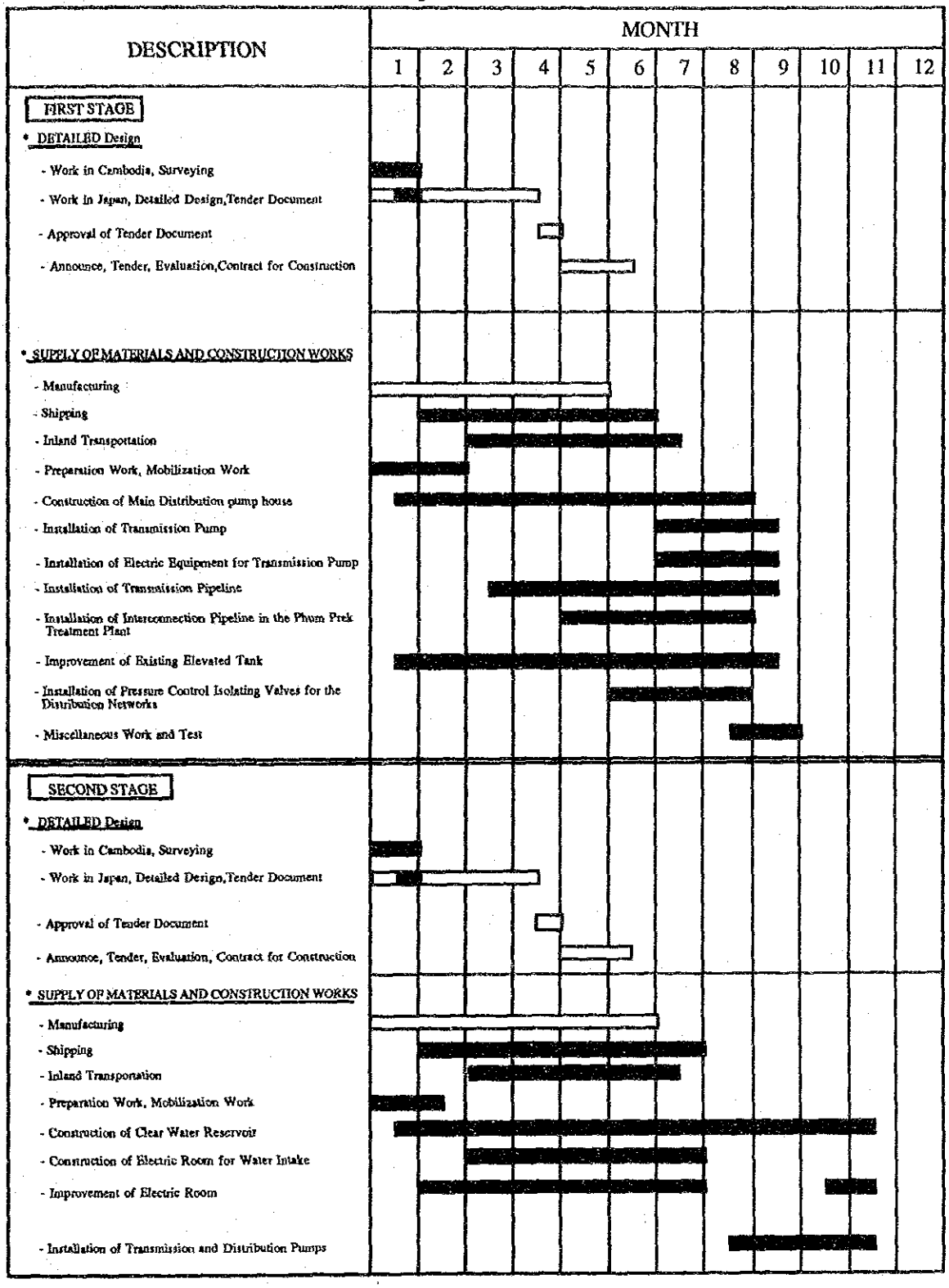
### 4.4.5 IMPLEMENTATION SCHEDULE

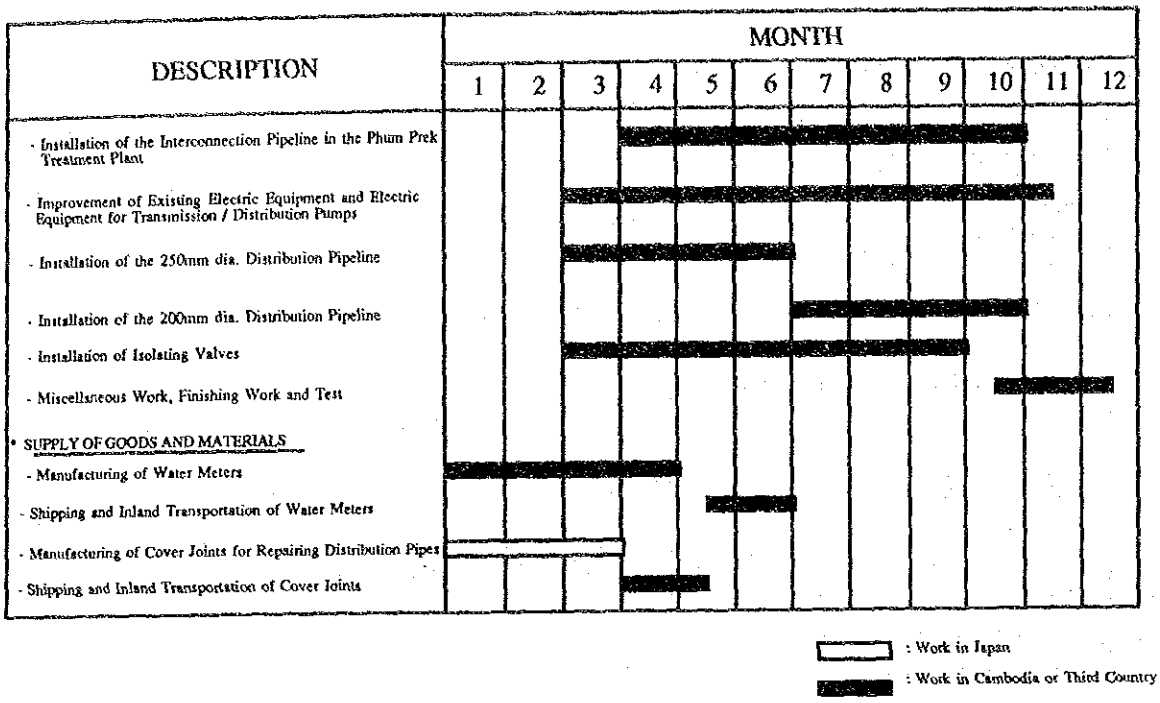
The detailed design work for the first stage begins is days after the E/N is concluded. The Topographic survey of the treatment plant and the transmission and distribution pipelines shall be conducted in parallel with the detailed design work. The survey shall be completed within the first stage from the point of view of economy, efficiency and hydraulic correlation. The time required for the survey will be one month.

The detail design work shall be completed in Japan to increase the efficiency and reduce the required time.

As expressed in 4.4.1, the works in this project must be carried out efficiently and functionally. The works are divided into two stages from the point of view of the schedule and the construction period required for each facility and equipment. The first stage will take 9 months and the second stage 11.5 months. Table 4.3 shows the detailed schedules of each stage.

## Table 4.3 Implementation Schedule




DESCRIPTION
MONTH
1
2
3
4
5
6
7
8
9
10
11
12
- Installation of the Interconnection Pipeline in the Phum Prek Treatment Plant
- Improvement of Existing Electric Equipment and Electric Equipment for Transmission / Distribution Pumps
- Installation of the 250mm dia. Distribution Pipeline
- Installation of the 200mm dia. Distribution Pipeline
- Installation of Isolating Valves
- Miscellaneous Work, Finishing Work and Test
• SUPPLY OF GOODS AND MATERIALS
- Manufacturing of Water Meters
- Shipping and Inland Transportation of Water Meters
- Manufactering of Cover Joints for Repairing Distribution Pipes
- Shipping and Inland Transportation of Cover Joints
: Work in Japan
: Work in Cambodia or Third Country

# CHAPTER 5

## EFFECTS OF THE PROJECT AND CONCLUSION

# CHAPTER 5 PROJECT EVALUATION AND CONCLUSION

## 5.1 PROJECT EVALUATION

The current basic design deals with improving the Phum Prek treatment plant and transmission and distribution facilities in the city of Phnom Penh and also supplying water meters and cover joints (bands) for repairing pipes. On the other hand, the scope of a project sponsored by French government covers the rehabilitation of the filter basin in the Phum Prek treatment plant, the rehabilitation and extension of the Chamcar Morn treatment plant and the supply distribution pipelines, service pipes and water meters in Don Penh area. The scope of that project and ours are designed so as not to overlap with each other. An improved volume of water as a result of rehabilitation of the treatment plant will be supplied to the users through transmission and distribution facilities. The following describes possible effects resulting from this project.

1) Effect on the Phum Prek treatment plant

The plant is operating only for 13 hours now, but 24-hours operation will be feasible because the electric power will be restored. As a result, the volume of treated water will increase by about 80% from 56,000 $m^3$/day to 100,000 $m^3$/day. In addition, more stable supply can be expected because the timeworn facilities will be replaced with new ones.

2) Effect on the transmission, distribution and service facilities

The water pressure will increase as a result of rehabilitation of the above facilities. This will make it no longer necessary for the users to receive the service water in the pit first, as is necessary at present, and will enable them to receive water through taps inside their houses. The water quality is contaminated in the rainy season because sewerage enters the service pipe by way of this pit or through openings in the distribution pipe. This will be eliminated and clean water will be supplied.

Leakage will be reduced by using the supplied cover joints (bands) for repairing pipes and installing isolating valves in the distribution system, allowing effective use of the water supplied.

3) Effect on waterworks management

Increase in the volume of treated and distributed water and decrease in the volume of leakage water will add to the volume of water supplied for effective use. Besides, installing water meters will make it possible to collect water charges properly depending upon the consumption. Thus, increase in income from the water charges can be expected.

4) Benefits

The aforementioned effects will bring about the following benefits.

- Extension of supplied area and an increase in the population supplied

  At present, no water service is provided in the area of 5.45 $km^2$ (about 60,000 population to be supplied) within Phnom Penh and 49.05 $km^2$ (about 130,000 of the same) in the suburbs of the city. As a result of the increased volume of the water treatment and distribution and increase of water pressure, it becomes possible to supply water to a part of the suburbs.

- Increased water supply per person

  People are obliged to refrain from using sufficient service water and often need to buy from a merchant or bring it into the house from another source because they cannot receive water from taps inside the house. Restoration of the water supply allows them to use as much water as they require.

- Stable water quality

  In the areas where the pressure is lower than the ground level (804 ha, about 84,500 population) people receive water in a pit, and sewerage enters the water supply through the pit. Increased water pressure will prevent sewerage from entiring the water supply.

- Extension of service hours

  As the capacity of the treatment plant is improved, operating hours of the plant are extended from 13 hours to 24 hours a day.

## 5.2 CONCLUSION AND RECOMMENDATION

When this project is complete, the condition of the water supply in Phnom Penh city will improve considerably and consequently the financial condition of the Water Supply Authority will also improve. The rehabilitation of Phum Prek treatment plant planned in this project is only to improve the function of the plant. No special technique is required for maintenance and operation, and hence there will be no need to increase the staff of the plant except for meter installation and leakage prevention.

Since this project not only brings remarkable effects like the above but contributes to the improvement in the life of Phnom Penh citizens, it is justifiable to execute this project under Japan's Grand Aid program. We will be able to expect better project management in the joint effort with other on-going collaboration programs like the one by UNDP. We are sure that this project can be executed much more smoothly and effectively if the following recommendations are put into practice.

(1) The Cambodian side should devote their best to this project so that they can maintain financial self-sustenance of the water supply system by collecting water charges consistently and further development of their system can be promoted in the future.

(2) The Cambodian side needs to increase the water tariff within the payable limit of beneficiaries after efforts are made to improve the collection of water charges and to prevent leakage. This is so that both ends on the balance sheet of the Water Supply Authority can be met by the income from the water charges.

(3) In order to ensure water charge collection, the Cambodian side should organize a special term for the installation of water meters, and complete the necessary installation of house connections within the construction period of the projects.

(4) In view of improving the balance sheet, it is also essential to collect water charges from faucets installed for the public. For this purpose, the Cambodian side should determine the concrete tariff and the method of collection.

(5) It is very likely that water leakage will occur when the distribution water pressure is restored after the completion of this project. Therefore, the Cambodian side should formulate a special repair term consisting of well-trained skilled workers so that they can be ready to cope with the leakage problem by controlling the pressure using the isolating valves and repair the breakage.

(6) This project is planned as a first step for the increasing water demand. The Cambodian side should prepare the extension project as specified in the master plan.

(7) To prevent contamination of water resources from the waste water, the Cambodian side also needs to plan out and implement a sewerage disposal program.

(8) It is advisable to dispatch specialists from Japan and enter a technical collaboration with them for the purpose of efficient and effective operation, maintenance and control of the facilities as well as maintaining a sound water supply system after the completion of this project.

(9) The water tariff should be increased for maintaining a sound financial condition, and the increase should be sufficient enough to be able to clear the accumulated nonpayment of the power rates.

(10) In order to solve the problem of non payment of water charges by governmental organizations, the Authority should take decisive action against them. This should include shutting off the water supply for organizations water charges have accumulated above a certain amount.

(11) They must employ a depreciative accounting of the facilities so that they can manage to raise a fund for renewing the facilities. Accordingly, it is necessary for them to increase the water charges to a level which allows them to depreciate the facilities and yet make both ends meet on the balance sheet.

(12) In order to effectively utilize the insufficient water supply, the tariff should rise in proportion to the increase in consumption so that the system may give users an incentive to save water.

(13) In order to keep close contact and promote efficient cooperation between the relevant supporting organizations including UNDP, France and Japan, the Cambodian side should organize a periodic meeting at least once a month of the persons in charge.

# APPENDIX

## Appendix 1 Country Data

| | | |
|---|---|---|
| Area of the country | 180,035 km$^2$ | |
| Population (1992) | | |
| Nation | 9,170,000 | |
| Phnom Penh city | 600,000 - 1,000,000 | |
| Density of population | 50/km$^2$ | |
| Urban population | 12.0% | |
| The increase in ratio of population | | |
| Nation | 2.8% | |
| Urban area | 4.0% | |
| Country area | 2.5% | |
| Gross National Product (1992) | | |
| Nominal price | US$1,350 million | |
| Real growth rate | 9.0% | |
| Real GDP per person | US$150 | |
| Main constituents of GDP (1992) | | |
| Agriculture | 47% | |
| Industry | 16% | |
| Service industry | 37% | |
| Main products (1992) | | |
| Rice | 2,221,000 ton | |
| Rubber products | 28,000 ton | |
| Wood | 117,000 km$^3$ | |
| Foreign trade (1992) | | |
| Export | US$70 million | |
| Import | US$360 million | |
| National economy | 1992 | 1993 |
| Income | 153 billion Riel | 283 billion Riel |
| Expenditure | 263 billion Riel | 467 billion Riel |
| Official foreign debt (as of the end of 1989) | US$279 million (from liberalistic countries) | |
| Rate of inflation | 70%(1989), 157%(1990), 121%(1991), 200% above(1992) | |
| Exchange rate (at the end of each year) | US$1 = 345 riels (1989) | |

| | |
|---|---|
| | US$1 = 600 riels (1990) |
| | US$1 = 1,000 riels (1991) |
| | US$1 = 2,300 riels (1992) |
| Social indices | |
| Average life span | 48 |
| Infant mortality rate | 120 per 1000 |
| Literacy rate of adult | 70% |
| Population per doctor | 12,700 |
| Hospital bed per 1,000 population | 1.9 |

Source: Social Economy Report of 1992, 1993 National Plan, National Statistics, World Bank Report, etc.

## Appendix 2 List of Persons Met

| | |
|---|---|
| Phnom Penh Municipality | |
| Vice-President | MR. RATH SARIN |
| Phnom Penh Water Supply Authority | |
| Director | MR. NOP SADUM |
| Technical Division | MR. KONG GONTARA |
| | MR. LONG NARO |
| Control Division | MR. SOEUNG SOTHER |
| Accounting Division | MR. ROS KIM LEANG |
| Ministry of Foreign Affairs | |
| Vice-Minister | MR. SEK SETHA |
| Director of Economic & Cultural Cooperation Bureau | MRS. YOU AY |
| | MR. HEM HENG |
| UNDP | |
| Program Officer | MR. ROELAND KORTAS |
| Program Officer | MR. DAVID G.HUNTER |
| World Bank | |
| Senior Engineer | MR. EDOUARD MOTTE |
| French consultant | |
| SAFEGE | MR. CLAUDE NICOLAS |
| Embassy of France | |
| | MR. MARTIN FRECHET |
| | MR. DOMINIQUE CAUSSE |
| Embassy of Japan | |
| Ambassador | MR. YUKIO IMAGAWA |
| First Secretary | MR. TORU IMAMURA |
| First Secretary | MRS. NORIKO ABE |
| JICA Planning Examiner | MR. SHUHEI KIKUCHI |

## Appendix 3 Breakdown of Operation and Maintenance Cost after Completion of the Project

(1) Chemicals

1) Condition

(a) Treated water volume:

Phum Prek treatment plant : 105,600 m³/day

Chamcar Morn treatment plant : 11,000 m³/day

(b) Chemical dosing ratio:

| Item | Maximum(ppm) | Minimum(ppm) | Average(ppm) |
|---|---|---|---|
| Aluminium Sulphate | 60.0 | 20.0 | 40.0 |
| Lime | 15.0 | 5.0 | 10.0 |
| Chlorine Gas | | | |
| Pre-chlorination | 3.0 | 2.0 | 2.5 |
| Post-chlorination | 2.0 | 1.0 | 1.5 |
| Total | 5.0 | 3.0 | 4.0 |

(c) Unit price of chemicals and country of origin

- Aluminum Sulphate : 219 US$/ton, Made in Vietnam
- Lime : 140 US$/ton, Made in Cambodia
- Chlorine Gas : 572 US$/ton, Made in Vietnam

2) Consumption of chemicals

(ton / year)

| Item | Phum Prek | Chamcar Morn | Total |
|---|---|---|---|
| Aluminium Sulphate | 1,544. | 161. | 1,705 |
| Lime | 387. | 41. | 428 |
| Chlorine Gas | 157 | 19 | 176 |

3) Chemical cost

(US$ / year)

| Item | Phum Prek | Chamcar Morn | Total |
|---|---|---|---|
| Aluminium Sulphate | 338,136 | 35,259 | 373,395 |
| Lime | 54,180 | 5,740 | 59,920 |
| Chlorine | 89,804 | 10,868 | 100,672 |
| Total | 482,120 | 51,867 | 533,987 |

(2) Electric power cost

1) Condition

(a) Load of equipment, operating hours, and power consumption per day:
(See Load List.)

(b) Power rate : 170 Riel/kwH

(c) Power factor and efficiency : 80%

2) Power consumption

Phum Prek : 32,200 kwH/day × 356 days = 11,753,000 kwH/year

Chamcar Morn : 3,760 kwH/day × 356 days = 1,372,400 kwH/year

Total 13,125,400 kwH/year

3) Annual power cost

$$\text{Phum Prek} : \frac{11{,}753{,}000 \text{ kwH/year}}{0.8} \times 170 \text{ Riel/kwH} \quad 2{,}498 \text{ million Riel/year}$$

$$\text{Chamcar Morn:} \frac{1{,}372{,}400 \text{ kwH/year}}{0.8} \times 170 \text{ Riel/kwH} \quad 234 \text{ million Riel/year}$$

Total 2,732 million Riel/year

(3) Employees cost

According to the profit & loss calculation, the actual cost of employees paid in 1992 was about 122 million Riel for 300 employees. This means that an average monthly pay per person is equivalent to about 33,900 Riel.

Since the future salary system of the Water Supply Authority is unknown, an average monthly pay of 35,000 Riel per person shall be used in calculating the salaries in and after 1996 when the project is complete.

In our plan, the number of employees of Phnom Penh Water Supply Authority in and after 1996 is supposed to be 344. Required annual cost for these employees will be as follows.

344 persons × 35,000 Riel/man.month × 12 months = 144,480,000 Riel/year
= about 144 million Riel/year

(4) Maintenance and inspection cost

After completion of the urgent rehabilitation project in Phum Prek water treatment plant, the Water Supply Authority is responsible for conducting general external inspection (once every half a year) and periodic patrol inspection (once a year). However, the periodic patrol inspection for the first year shall be subcontracted with outside firm.

Precise inspection (once every five years) shall be subcontracted with outside outside firm, but an engineer (of manufacturer) shall be dispatched from Japan. Actual inspection shall be conducted by the subcontracted local firm.

Inspection in Chamcar Morn treatment plant shall be conducted by the Water Supply Authority.

| Item | Phum Prek | Chamcar Morn |
|---|---|---|
| Periodic patrol inspection (once a year) | US$2,000 | US$500 |
| Precise inspection | US$18,000 | ——— |
| Average | US$4,000/year | US$500/year |

## Load List

(Phum Prek)

| Load Name | Quantity | | Capacity (kw) | Total (kw) | Operating Hours | Power Consumption (kwH/day) |
|---|---|---|---|---|---|---|
| | Amount | Common Use | | | | |
| Raw Water Intake Pump | 3 | 2 | 185 | 370 | 48 hr/day | 8,880 |
| Distribution Pump(France) | 4 | 2 | 325 | 650 | 48 hr/day | 15,600 |
| Distribution Transmission | 4 | 2 | 180 | 360 | 30 hr/day | 5,400 |
| | | | | | | |
| Total | | | | 1,380 | | 29,880 |
| | | | | | | |
| Air Compressor (Intake Tower) | 1 | 1 | 4 | 4 | 2 hr/day | 8 |
| Crane (Intake Tower) | 1 | 1 | (4) | 4 | 1 hr/month | 0.2 |
| Flash Mixer | 2 | 2 | 4 | 8 | 2×24 hr/day | 192 |
| Flocculator | 12 | 12 | 1.3/2 | 24 | 2×24 hr/day | 576 |
| Service Water Pump | 1 | 1 | 22 | 22 | 6 hr/day | 132 |
| Crane (Gene. Room) | 1 | 1 | 7.5 | 7.5 | — | — |
| Pump for Flashing Valves | 1 | 1 | 17.6 | 17.6 | 2 hr/day | 35.2 |
| Backwash Pump | 2 | 1 | 42 | 42 | 4 hr/day | 168 |
| Air Blower for Backwash | 1 | 1 | 47.8 | 47.8 | 1 hr/day | 47.8 |
| Air Blower for Backwash | 1 | 1 | 45 | 45 | — | — |
| Air Comp. for Pheumatic | | | | | | |
| Operation System | 2 | 1 | 1.5 | 1.5 | 4 hr/day | 6 |
| Crane (Main Distribution) | | | | | | |
| Pump House | 1 | 1 | 7.32 | 7.3 | 1 hr/month | 0.3 |
| Drain Pump | 1 | 1 | 14 | 14 | 1 hr/month | 0.5 |
| Vacuum Pump | 2 | 1 | 1.5 | 1.5 | 1 hr/day | 1.5 |

## Load List

(Phum Prek)

| Load Name | Quantity | | Capacity (kw) | Total (kw) | Operating Hours | Power Consumption (kwH/day) |
|---|---|---|---|---|---|---|
| | Amount | Common Use | | | | |
| Oil Pump for Diesel | 2 | 1 | 1 | 1 | — | — |
| Ventilator (Gene. Room ) | 4 | 4 | 11 | 44 | — | — |
| Air Comp. for Respirator | 1 | 1 | 4 | 4 | — | — |
| Compressor for Diesel Eng. | 2 | 1 | 5 | 5 | — | — |
| Crane for Chemicals | 2 | 2 | 2.7 | 5.4 | 1 hr/day | 2.7 |
| Agitator for Alum. | 4 | 4 | 2.2 | 8.8 | 24 hr/day | 52.8 |
| | | | | | | |
| Total | | | | 314.4 | | 1,223 |
| | | | | | | |
| DC & Control Power, | | | | | | |
| Lighting,Air Conditioner | | | | 180KVA | | 900 |
| | | | | | SUB TOTAL | kwH/day 32,003 |
| | | | | | | |
| | Transformer loss ≒ 200 kw/day | | | | | |
| | 32,003 + 200 = 32,203 kwH/day = 32,200 kwH/day | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## Load List

(Chamcar Morn)

| Load Name | Quantity | | Capacity (kw) | Total (kw) | Operating Hours | Power Consumption (kwH/day) |
|---|---|---|---|---|---|---|
| | Amount | Common Use | | | | |
| Raw Water Pump | 3 | 2 | 37.0 | 74.0 | 48 hr/day | 1,776 |
| Air Blower for Backwash | 3 | 2 | 4.0 | 8.0 | 1 hr/day | 4 |
| Backwash Pump | 2 | 1 | 15.0 | 15.0 | 3 hr/day | 45 |
| Distribution Pump | 3 | 2 | 370 | 74.0 | 48 hr/day | 1,776 |
| Alum. Doser | 2 | 1 | 3.0 | 3.0 | 24 hr/day | 72 |
| Lime Doser | 2 | 1 | 1.1 | 1.1 | 24 hr/day | 26.4 |
| Service Water Pump | 1 | 1 | 5.5 | 5.5 | 4 hr/day | 22 |
| | | | | | | |
| Total | | | | 180.6 | | 3,732.4 |
| | | | | | | |
| Lighting | | | | 10KVA | | 25 |
| | | | | | | |
| Total | | | | | | 3,757.4 |
| | | | | | | ≒ 3,760 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## Appendix 4 Breakdown of Expenses Borne by Cambodia

(1) Demolition cost of existing caretaker's room

4 m wide × 6 m long × (3 m + 5 m) high = 192 $m^3$ space

Unskilled workers: 16 person/10 $m^3$ = 1.6 person/$m^3$

192 $m^3$ space × 1.6 person/$m^3$ space × 10 US$/person = US$3,072 = US$3,000

(2) Renewal cost of cover plate over the access bridge for the water intake tower

Width: 4 m, Length: 42 m, Thickness of cover plate: 60 mm

| | | |
|---|---|---|
| Plate material (wood) | : 4 m × 42 m × 0.06 m | = 10.08 $m^3$ |
| Support material (wood) | : (0.06 m × 0.10 m × 4 m) × 43 | = 1.03 $m^3$ |
| | Total | 11.11 $m^3$ |

① Labor cost

| | | |
|---|---|---|
| Coordinator | : 11.11 $m^3$ × 1.0/$m^3$ × 20 US$/person | = US$222.2 |
| Unskilled worker | : 11.11 $m^3$ × 6.0/$m^3$ × 10 US$/person | = US$666.6 |
| | Sub-total | US$888.8 |

② Material cost

| | | |
|---|---|---|
| Wood | : 11.11 $m^3$ × 360 US$/$m^3$ | = US$3,999.6 |
| Miscellaneous (nails, etc.) | : about 3% of material cost | = US$111.6 |
| | Sub-total | US$4,111.2 |
| | Total | US$5,000.0 |

(3) Construction cost of fence fencing work in the elevated tank yard

L = 160 m, H = 2.0 m

160 × 125 US$/m = US$20,000

(4) Installation cost of water meters

Installation cost shall be paid by beneficiaries.

1) Unit price of water meter installation

(US$ / place)

| Item | 30mm dia. | 40mm dia. | 50mm dia. |
|---|---|---|---|
| Materials | 145 | 205 | 295 |
| Works | 60 | 75 | 105 |
| Total | 205 | 280 | 400 |

(Estimated by Phnom Penh Water Supply Authority)

2) Installation cost of water meters

30 mm dia.: 1,500 places × 205 US$/place = US$307,500

40 mm dia.: 1,000 places × 280 US$/place = US$280,000

50 mm dia.: 500 places × 400 US$/place = US$200,000

Total US$787,500

(5) Installation cost of cover joints for repairing pipes.

Cover joints are to be supplied by Japan.

80 mm dia. : 70 places × 168.05 US$/place = US$11,763.50

100 mm dia. : 200 places × 168.60 US$/place = US$33,720.00

125 mm dia. : 5 places × 170.28 US$/place = US$ 850.900

150 mm dia. : 60 places × 171.28 US$/place = US$ 10,276.80

200 mm dia. : 40 places × 181.79 US$/place = US$ 7,271.60

250 mm dia. : 45 places × 184.95 US$/place = US$ 8,322.75

Total US$72,205.55

= US$72,200