CHAPTER 4 BASIC DESIGN

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4-1 Principles of Basic Design

In Thailand, the pump sites located in Phra Khanong, Sam Rong, and Charoen Rat are encountering difficulties with pump operation, that is, a large quantity of flowing trash adheres to the screens in the pump systems and not only interferes with the normal operation of the pumps but also has a great adverse effect on the pump itself. This project is designed to solve these problems through installation of an automatic trash rake that facilitates pump operation, thereby preventing flood in urban areas in Bangkok, and at the same time, promoting regional agriculture through proper water control in the farmland upstream. In order to achieve this goal, it is important to select an efficient automatic trash rake as well as to construct a stable structure suitable for installation.
Following are the principles of those basic designs.

(1) Automatic Trash Rake

The automatic trash rake to be installed shall be efficient enough to stir up and draw off the trash adherent to the screen. Therefore the variety, quantity, and flowing conditions of the trash that adheres to the screen and blocks the passage of water shall be investigated carefully. Based on the results of this investigation, a type of machine that can dispose of the trash most effectively will be selected.

The mechanism of the automatic trash rake shall be improved so that it can be installed completely above the water surface, taking into account the function and structure of the existing pumping stations. These pumping stations have no divider wall in the water tank and require operation of the pump at the time of the installation of an automatic trash rake, etc.

The trash conveying method depends on the variety and quantity of waste. In view of the actual local conditions and the trash disposal system, such a plan will be made as providing for the trash to be

quickly carried off without affecting the operating conditions of the automatic trash rake.

(2) Civil structures

Civil structures must be able to hold the selected automatic trash rake securely, and be constructed at a low cost. In order to design a stable structure, it is important to examine closely the drawings of the existing structures collected at the time of the field survey and information regarding these materials. In addition, it is also necessary to evaluate the stability of the structures based on construction examples in Japan, taking into consideration the difference in design standards between Thailand and Japan.

It is important to use construction materials which can be procured locally as much as possible, so construction costs will be low. In other words, it is necessary to keep this in mind at the planning stage so that the construction can be done with locally procured material. However, there should be no compromise in the stability and long-term durability of the structure because of efforts to reduce the construction cost.

4-2 Basic Design Conditions

4-2-1 Selection of equipment and material

Automatic Trash Rake

The necessary conditions to the automatic trash rake are given below.

- Adequate stirring capability depending on the size, variety, and quantity of the flowing trash.
- Ability to stir up the trush ceaselessly and entirely over the screen surface, thereby minimizing the loss of head on the screen.
- Ease of operation; no heavy labor involving many workers; capable of remote control.
- High operational reliability; no difficulty in maintenance and management.
- No difficulties caused in pump operation; capable of installation, maintenance, and management (because it is a machine to be established at existing pumping stations).

Considering the above conditions, a proper type of machine which is suitable for the project will be selected.

Conveying Facilities

The belt conveyor, which is one of the trash conveying facilities, shall be of optimum dimensions, taking into consideration the number of automatic trash rakes to be installed as well as the largest quantity of trash to be disposed of. To comply with the new request from the Government of the Kingdom of Thailand regarding the transportation of trash by water and by land, it is making to plan a practical conveying system from the viewpoint of its mechanism, maintenance, and management.

Conveying facilities such as barges and trucks, used for carrying off trash, will be provided by the Government of the Kingdom of Thailand. The number of barges and trucks to be procured for the project shall be determined on the basis of the distance of transportation, thereby contributing to the formulation of a maintenance and management program.

4-2-2 Design conditions of facilities

As stated above, the current project is intended to set up automatic trash rakes at the existing pumping stations. When no space is available in the existing structures, it will be necessary to build extensions to provide on the structure. The design conditions of these facilities are given below.

Structure

The structures of pumping stations that require some extension work shall be repaired through concrete placement, that is, the concrete edge of the existing structure shall be broken and then new concrete of necessary length shall be placed. In principle, materials of the same quality shall be used for concrete and reinforcement, although the existing structures go through an internal check.

The sectional dimensions of a structure shall be determined on the basis of the scale of existing structures. At the same time, the additional load of an automatic trash rake as well as the practical examples of similar structures built in Japan shall be taken into consideration. Yet there are some pump sites where no stoplog recess is established in the inlet of suction tank. These pump sites shall be equipped with stoplog recesses for the convenience of maintenance and management after installation of the automatic trash rake.

Pile Foundation

There are some pump sites whose structures require long extension. At these pump sites, a pile foundation is necessary to stabilize the structure. The pile foundation to be established under the extended structure shall be of the same scale as the existing foundation because an adverse

effect on the upper structure caused by differential settlement of piles must be prevented. After completion of the pile foundation, it is necessary to check the stability of the entire structure based on the bearing capacity of the piles.

At pump sites where an extension of suction water tanks is not scheduled, it is necessary to confirm the stability of the entire structure under the present scale of the pile foundation. In that case, the additional load created after installation of an automatic trash rake shall be taken into consideration. Also, the bearing capacity of piles must be checked by the method used by RID, provided that it depends on the scale of pile foundations established in the existing structure.

As for the new structure that will be built away from a particular pump site, it is necessary to make a comprehensive study of the pile foundations existing in the neighboring pump sites. It is also necessary to check the stability of the new structure when deciding on a pile foundation.

4-3 Basic Plan of Equipment and Material

4-3-1 Equipment and material plan

(1) Automatic trash rake

1) Types of waste

The upstream area along the Phra Khanong drainage canal (draining into the Phra Khanong pumping station) and Sam Rong drainage canal (draining into the Sam Rong pumping station) is paddy field where urbanization is now in progress. The downstream area along these drainage canal, is a densely built-up district of private houses.

As a result of the urbanization and dense population, a wide variety of rubbish and garbage flow into both pumping stations. The rubbish coming from the upstream paddy field includes water hyacinth (which grow thick in that area), banana trees and leaves, head-out weeds, and so on. The garbage coming from the downstream built-up area includes vinyl sacks, plastic containers, pieces of cloth, dregs of fruit, wood chips, used home appliances, and various other large and small objects.

Water hyacinth, among other things, comprises the greater part of rubbish flowing into the pumping station during the wet or high water season when pumps are operated extensively. Garbage from the downstream urban districts joins the water hyacinth and flows down together.

The Charoen Rat pumping station is located south of the above two pump sites. The Chai Thale drainage canal which drains into the Charoen Rat pumping station has a basin consisting mostly of paddy fields because it joins a canal that runs through a paddy field area. This paddy field area is outside (east-side) of a polder dike which was constructed to protect Bangkok from floods.

As evident from the above geographical features, the greater part of waste that concentrates at the pumping station when pumps are operated is water hyacinth. The waste includes a small quantity of garbage from cities because of private houses along the Chai Thale drainage canal which runs parallel to the coastline.

During the season when pumps are operated, the variety waste described above flows into those three pumping stations, and the waste will be captured by the screen in front of the pump. The captured waste blocks the opening of the screen, obstructing the flow of water. The mechanism of screen blockage is as follows:

[When the waste consists of water weeds and city garbage:]

(i) The waste flows down to the pump site.
(ii) Waterweeds reach the screen, floating on the water surface.
(iii) The water flows beneath the waterweeds, being sucked into the pump.
(iv) The water surface is covered with the waterweeds, causing the underwater stream to flow at higher speed.
(v) As a result, the urban garbage (vinyl sacks, in particular) that has been mingled with the waterweeds or deposited on the bottom gets mixed in the underwater stream and reaches the screen.
(vi) In the end at the screen, the water surface is covered with waterweeds and the underwater depths are choked with urban garbage.

[When the waste consists mostly of waterweeds:]

(i) Waterweeds flow down to the pumping station.
(ii) to (iv): The same as above case.
(v) As a result, the waterweeds with smaller buoyancy get sucked down into the underwater stream and reach the screen.
(vi) In the end, the screen is covered with waterweeds both on the water surface and in the underwater depth, thereby blocking the passage of water.

To overcome these conditions, an automatic trash rake must be able to stir up and draw off not only a great quantity of waterweeds floating on the water surface but also the rubbish that blocks up the underwater opening of the screen. Otherwise, the passage of water will be rough and the suction water level of a pump will be lowered, causing the pump to suck air or causing cavitation and pump malfunction.

2) The type of trash rakes

Generally speaking, the following automatic trash rakes are available for farm drainage, city drainage, and urban sewerage:

- Automatic trash rake
  - Chain-driven rotation system
    - Back-drop front stirring type
    - Front-drop front stirring type
    - Traveling screen type
  - Rake vertical reciprocating motion system
    - Rope type
    - Rack type
    - Hydraulic cylinder type

The automatic trash rakes mentioned above have the characteristics shown in Table 4-1.

Table 4-1 Comparison of Automatic Trash Rakes

Item \ Type	Rake vertical reciprocating motion system						Chain-driven rotation system					
	Rope type		Rack type		Hydraulic cylinder type		Back-drop front stirring type		Front-drop front stirring type		Traveling screen type	
1. Applicable uses	Primary screen for intake gate, drainage, and sewerage	Δ	Primary or secondary screen for sewerage plant, relay pump site, and drainage system	o	Screen for waste disposal plant	Δ	Screen for large-caliber pump facilities such as waste disposal plant and drainage system	o	Screen for medium-caliber pump facilities such as waste disposal plant and drainage system	o	Cooling water secondary screen for thermal power plant or screen for factory waste water disposal system	Δ
2. Allowable waste size	Rake opening width	Δ	Rake opening width	o	Hydraulic cylinder opening width	o	Twice larger than rake width	Δ	Medium size about rake width (because of mechanism)	Δ	Small-sized waste	x
3. Stirring capacity	Lower efficiency because of loss caused by reciprocating motion and long cycle affected by waste empty.	x	Medium efficiency because of long cycle due to reciprocating motion, though quicker than rope type, as the rake lowers under power.	Δ	Medium efficiency because of long cycle due to reciprocating motion, though quicker than rope type, as the rake lowers under power.	Δ	Higher efficiency because of continuous stirring performance.	o	Medium efficiency because of a little shorter rake width despite continuous stirring performance.	Δ	Low efficiency but enough to dispose of small waste adhering to the screen.	x
4. Operation method	Usually handled by operator at the machine.	Δ	Remote-controlled automatic operation.	o	Usually handled by operator at the machine.	Δ	Remote-controlled automatic operation.	o	Remote-controlled automatic operation.	o	Remote-controlled automatic operation.	o
5. Maintenance and management	Time and labor required for maintaining equipment that operates rake lifting and switching ropes.	Δ	Easy maintenance as the whole driving system is established on the water, but time and labor are required for maintenance because of intricate mechanism and problems caused by the vertical motion of rake switching motor cable.	Δ	Easy maintenance work as the whole driving system is established on the water, but adequate maintenance is needed for the flexible part affected by hydraulic cylinder as well as for rake and guide rollers.	Δ	Adjustment needed for chain expansion, only a little maintenance required for the underwater section.	o	Adjustment needed for chain expansion, only a little maintenance required for the underwater section.	o	Additional maintenance and management service because of the screen cleaning equipment; difficult maintenance work because of the underwater chain gear.	x
6. Maximum installation width	About 6 m	Δ	About 6 m	Δ	About 6 m	Δ	About 7.5 m	o	About 6 m	Δ	About 3 m	x
7. Other characteristics	This type is not suited for the waste deposited on the bottom of waterways.	o	The deeper the waterway, the longer the arm and the larger the mechanical equipment on the ground. This type is not suited for the waste deposited on the bottom of waterways.	o	The waste adhering to the guide roller causes the roller to derail and draw the screen and rake out of the gear, resulting in a decline of waste disposing efficiency.	x	The aboveground height of the machine can be reduced because the guide frame on the ground is inclined. A few parts must be fixed on the bottom of waterways.	o	The aboveground height of the machine can be reduced because the guide frame on the gorund is inclined. A few parts must be fixed on the bottom of waterways.	o	Some equipment that separates waste from cleaning water is necessary.	Δ
Aptness							◎					

o: Appropriate Δ: Somewhat appropriate x: Not appropriate

Considering the properties of these different trash rakes and the varieties of waste described in the previous section, it is decided that the back-drop front stirring type is the best for the current project for the following reasons:

(i) To handle a large quantity of floating waterweeds, it is better to draw up from under the water than to stir up from above the water.

(ii) The back-drop front stirring type is better suited for large floating rubbish.

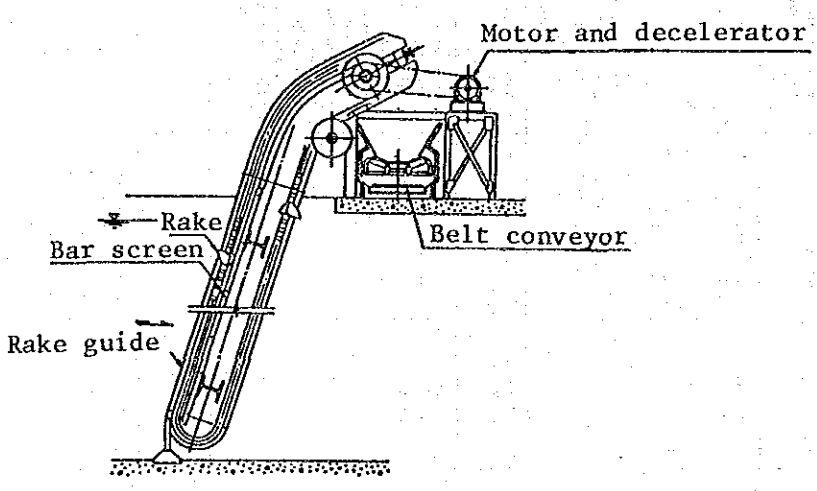
(iii) To improve pumping efficiency, the trash rake must be able to draw up of not only a lot of rubbish floating on the water near the screen but also the waste flowing under the water such as urban garbage and water plants which block the screen. The back-drop front stirring type is best suited for this.

(iv) This type can be installed without closing the front of a pump suction tank.

(v) This type is easy to handle and operate.

(vi) Maintenance, management, and inspection are simple.

The following figure shows the back-drop front stirring type of trash rake.



3) Automatic trash rake dimension

(a) Trash rake width

When an automatic trash rake is installed directly on the existing structures, such as the Phra Khanong and Sam Rong right-bank pumping stations, the width of the trash rake depends on the dimension of the existing structures. In these pumping stations, one trash rake is fixed to every two pumps. In principle, a trash rake should be fixed to every pump (one trash rake per pump), but installation of too many trash rakes is not economical if there are so many pumps established. This is why one trash rake should serve two or more pumps.

Considering the caliber (ϕ1200 mm) of pumps in these pumping stations, the width of a trash rake will have to be nearly 9 m if three pumps should be covered by one trash rake. This is not a mechanically proper width because it is beyond the maximum width (about 7.5 m) applicable to the current project. Therefore, there should be one trash rake for every two pumps.

Based on the dimensions of existing structures in these two pumping stations, the optimum width and number of trash rakes to installed are 5.5 m x 2, 5.4 m x 2, 5.3 m x 2, 5.0 m x 1 and 4.9 m x 2 in the Phra Khanong right-bank pumping station, 5.4 m x 7, and 2.4 m x 1 in the Sam Rong right-bank pumping station.

Applying this to the Charoen Rat pumping station where many pumps are established, the arrangement of trash rakes is 5.4 m x 12 and 2.6 m x 1.

In the Phra Khanong left-bank pumping station, trash rakes will be installed in a newly built structure, where the screen installation width is about 27 m considering both topographical conditions and the velocity of water passing

through the screen. Therefore, the width and number of trash rakes to be installed in Phra Khanong are 5.4 m x 5.

The left-bank pumping station No. 1 and No. 2 in Sam Rong have a relatively small number of pumps (five per station). If trash rakes are installed on the same scale as in the past, then there will be two wider trash rakes and one narrower trash rake, resulting in noticeable imbalance as a whole. In addition, trash rakes will not become very economical due to the smaller number installed. Therefore, the optimum ratio is one trash rake for each pump. As a result, five 2.4 meter wide trash rake will be installed in the Sam Rong left-bank pumping stations No. 1 and No. 2.

(b) Installation height of the trash rake

The installation height of an automatic trash rake is equal to the difference of levels between the upper floor slab and bottom slab of a suction water tank to which the trash rake is fixed. Based on this assumption, the installation height of trash rakes in each pumping station is shown as follows.

Pump site	Installation height
Phra Khanong right-bank	5.0 m
Phra Khanong left-bank	5.0 m
Sam Rong right-bank	5.3 m
Sam Rong left-bank No. 1	5.2 m
Sam Rong left-bank No. 2	5.2 m
Charoen Rat	4.8 m

4) Rake size

The rake width depends on the size of waste stirred up by the rake. As mentioned in Section 1), most of the waste flowing down to the three pumping stations is water hyacinth that grows thick in the drainage canals. Urban garbage coming from the densely

populated area also flow-down to these pumping stations and is mixed with the water hyacinth. Urban garbage varies significantly both in size and variety, but its quantity is insignificant when compared with that of water hyacinth.

Therefore, water hyacinth is considered as the criterion on which to determine the rake width. There is no problem in this criterion since the chosen automatic trash rake can easily stir up both water hyacinth and most urban garbage.

The data on the growth trends of water hyacinth, compiled by the Weed Control & Research Branch of RID, is available for this study to confirm the individual size of water hyacinth. This data is based on the observation and measurement conducted in each site of Region 7, which includes the area proposed under the current project.

The growth density of water hyacinth was measured in March, April, and June at 21 different points in Region 7. The result demonstrated that the density ranges from 70 to 100 plants/m^2 and remains almost unchanged in these three months. Actually, the density concentrates around 70 plants/m^2, that is, 0.014 m^2/plant, which equals a circle about 15 cm in diameter.

In the proposed area, April is the hottest month of the year, suggesting that water hyacinth grows thickest in April. It is assumed, therefore, that the above size per plant is the largest. However, in this field observation, it was found that the individual size of water hyacinth ranges from 25 to 30 cm because its fibers are intertwined with one another.

A roll size about two-thirds that of the largest piece of waste seems to be sufficient for constant stirring. The rake size in that case should be 20 cm, but 30 cm is adopted, which is the standard rake size of automatic trash rakes large enough to deal with both the great quantity of water hyacinth and large pieces of urban garbage.

(2) Waste conveying facilities

1) Method of waste conveyance

To remove the waste stirred up and drawn off by the automatic trash rake, two conveyance methods may be used depending on topographical conditions: (i) transportation by barge, and (ii) transportation by truck. Transportation by barge was planned by RID. This is described in the request letter, concerning the current project, sent from the Kingdom of Thailand to the Government of Japan.

However, water hyacinth comprises the greater part of waste flowing to the pumping stations when pumps are operating. To effectively use this water hyacinth as fertilizer, a new request was made to the study team during the field survey. It called for a plan to build facilities that can provide transportation by both water and land (using a truck). In response to this new request, the following basic plan was prepared considering factors such location peculiar to each pumping station, quantity of water hyacinth to be disposed of by trash rakes, and scale of the facilities used for waste conveyance.

a) Phra Khanong pumping station

In this pumping station, the pump in the right-bank station operates longer than in the left-bank station. Comparing the two pumping stations, based on past data, it is found that on the average the right-bank pumps operates twice as long as the left-bank pump. As mentioned before, the overall width of automatic trash rake is 55 m on the right and 30 m on the left, a ratio of nearly 2 to 1.

From this, it was found through simple calculation, that the right-bank pumping station remove four times as much waste as the left-bank pumping station (i.e., the waste disposal capacity on the right-bank is considerably greater than on the left). To utilize water hyacinth effectively, it would be

necessary to convey it from the right-bank pumping station to the land of the left-bank.

Therefore, to connect the belt conveyor of the right-bank with that of the left-bank is planned. The connection work will be facilitated by using the pier located in the main water gate of Phra Khanong. Where the left end of the left-bank belt conveyor contacts the land, these shall be connected to the inclined belt conveyor used for conveyance by truck.

For conveyance by barge, the left-bank belt conveyor shall be turned backward, while both right-bank and connecting belt conveyors shall be turned forward. This will concentrate the waste on the left-bank corner outside of the Phra Khanong main water gate. From this corner the waste can be transported by water using a barge. With this method, it is no longer necessary to shift the installation point of belt conveyors. To realize a two-way waste transportation system, only the belt conveyors rotating direction of need be changed.

Basic Design Drawing No. 04 shows the system described above.

b) Sam Rong pumping station

According to the recorded data, the average operation time per pump is almost the same for the right-bank and two left-bank pumping stations of this pump site. However, the installed width of automatic trash rakes is 1.5 times greater on the right-bank than on the left-bank. Likewise, the quantity of removed waste is 1.5 times greater.

To effectively use water hyacinth, the belt conveyor in the right-bank pumping station will be capable of backward rotation. The water hyacinth removed by the automatic trash rakes of the right-bank pumping station can thereby be carried out by truck. At its right-bank end, the right-bank belt conveyor will connect to the inclined belt conveyor which is designed for transportation by truck.

The water hyacinth disposed of in the left-bank pumping station will be carried out to the left-bank of the Sam Rong drainage canal. Due to topographical conditions, however, the belt conveyor will be segmented, raising some problems in waste conveyance, machine maintenance, safety, and so on. Considering these circumstances, the two left-bank pumping stations should have waste conveyance facilities transporting by water only (using a barge).

Basic Design Drawing No. 05 shows the system described above.

c) Charoen Rat pumping station

The waste disposed of in the Charoen Rat pumping station shall be carried out toward the right-bank because there is a control facility on the left-bank. This raises no problem because on the right-bank there is sufficient space to convey water hyacinth by truck.

To convey waste either by water (barge) or by land (truck) in this pumping station, the best and easiest way is to establish a belt conveyor of pivot type at the edge of the right-bank. Within the pumping station there are a concrete structure and a flat lot that allow a belt conveyor of pivot type to be readily installed and operated.

Basic Design Drawing No. 06 shows the system described above.

2) Belt conveyor standards

The belt conveyor installed at each pumping stations shall have sufficient capacity to convey the largest volume of waste brought to that point. The scale of a belt conveyor depends on the number of trash rakes as well as the method of conveyance described in the previous sections. The dimensions of belt conveyors to be installed in each pumping station are given below.

a) Phra Khanong pumping station

o Right-bank pump system belt conveyor :	900 mm wide, 67 m long
o Left-bank pump system belt conveyor :	900 mm wide, 63 m long
o Connecting belt conveyor:	900 mm wide, 53 m long
o Inclined belt conveyor :	900 mm wide, 15 m long

b) Sam Rong pumping station

o Right-bank pump system belt conveyor :	900 mm wide, 55 m long
Barge loading belt conveyor :	900 mm wide, 55 m long
o Inclined belt conveyor :	900 mm wide, 15 m long
o Left-bank No. 1 pump system belt conveyor :	600 mm wide, 18 m long
Barge loading belt conveyor :	600 mm wide, 18 m long
o Left-bank No. 2 pump system belt conveyor :	600 mm wide, 18 m long
Barge loading belt conveyor :	600 mm wide, 18 m long
	600 mm wide, 23 m long

c) Charoen Rat pumping station

o Pump system belt conveyor :	900 mm wide, 82 m long
o Inclined belt conveyor :	900 mm wide, 18 m long (slope)
o Incined belt conveyor for pivot type	900 mm wide, 15 m long

The trough three-roller belt shall be used for horizontal belt conveyors and the trough two-roller finned belt shall be used for inclined belt conveyors.

(3) Waste hauling machinery

The waste hauling machinery is an appliance designed to carry off the waste (sent from the waste-conveying facilities) promptly to a designated disposal place. It is necessary to determine how many waste hauling machinery is adequate so that automatic trash rakes and waste conveying facilities may operate without a hitch. However, the necessary number of waste hauling machinery must be procured by the Government of the Kingdom of Thailand since these machinery are not on the list of free grants covered by the Japanese grant aid assistance project.

1) Number of trucks

The number of waste hauling trucks necessary shall be calculated on the following basis.

Distance of conveyance (to Soi Onnuch)

According to information from RID, the waste-hauling distance covered by the trucks includes 14 km from the Phra Khanong pumping station, 20 km from the Sam Rong pumping station, and 3 km from the Charoen Rat pumping station.

Speed of trucks

In view of the road conditions and traffic density around each pumping station, the speed of the trucks shall be estimated at 30 km/h around the Phra Khanong pumping station, 30 km/h around the Sam Rong pumping station, and 60 km/h around the Charoen Rat pumping station.

Cargo volume of trucks

In view of the conditions of approach to each pumping station, the cargo volume of each truck shall be estimated at 10 m^3.

Flow quantity of waste

With regard to the pump discharge capacity, the quantity of flowing waste accelerated by pump operation shall be empirically estimated according to the following equation.

$V = K \times Q$

V : Quantity of waste (m^3/h)
K : Coefficient
Q : Pump discharge capacity (m^3/s)

The value of K ranges from 0.20 to 0.25 in time of flood. For safety's sake, it shall be set at 0.45, considering the quality and quantity of locally produced waste.

Automatic trash rakes shall stir up and dispose of the following quantities of waste without delay.

Pump station	Pump discharge capacity	Waste disposal quantity
Phra Khanong right-bank	60 m^3/s	27 m^3/h
Phra Khanong left-bank	45	20
Sam Rong right-bank	45	20
Sam Rong left-bank No. 1	15	7
Sam Rong left-bank No. 2	15	7
Charoen Rat	75	34

Number of trucks required

Pumping station	Conveyance distance	Truck speed	Cycle time	Truck capacity	Conveyable volume per hour	Disposable volume per hour	Required number of trucks
	km	km/hr	hr	m^3	m^3	m^3	
Phra Khanong	14	30	1	10	10	47 */	5
Sam Rong	20	30	1.5	10	6.7	20 **/	3
Charoen Rat	3	60	0.1	10	100	34	1

Note: */ Total quantity of waste including both left and right-bank pumping stations.

**/ Only the waste in the right-bank pumping station is carried off by trucks.

2) Number of barges

The necessary number of waste-hauling barges shall be calculated on the following basis.

Distance of conveyance (to the Gulf of Thailand)

According to information from RID, the waste-hauling distance covered by barges includes 30 km from the Phra Khanong pumping station, 20 km from the Sam Rong pumping station, and 3 km from the Charoen Rat pumping station.

Speed of barges

The speed of barges on the hydrostatic water shall be estimated at 15 km/h (8 knots). Regarding the Sam Rong pumping station, however, it is necessary to consider the velocity of the water (about 3.5 km/h) flowing through the Sam Rong drainage canal when the pumps are in full operation.

Cargo volume of barges

Considering the width and depth of each drainage canal, the cargo volume of a barge shall be estimated at 10 m^3.

Quantity of waste disposed of

The quantity of waste disposed of as calculated in the previous section shall apply, with the Sam Rong left-bank pumping stations No. 1 and No. 2 being in full operation. Regarding other pumping stations, the quantity of waste carried off by barge shall be based on interrupted operation equivalent to 10% of the number of pumps, which are in regular operation.

Number of barges required

Pumping station	Conveyance distance	Barge speed	Cycle time	Barge capacity	Conveyable volume per hour	Disposable volume per hour	Number of barges required
Phra Khanong	30 km	15 km/hr	4 hr	10 m^3	2.5 m^3	2.7	1
Sam Rong (No. 1 and No. 2)	20	18.5 (down) 11.5 (up)	3	10	3.3	7 7	3 3
Charoen Rat	3	15	0.4	10	25.0	3.4	1

3) Total number of machines

Based on the data given above, it is determined as follows that the total number of waste-hauling machinery (trucks and barges) are necessary for each pumping station.

Pumping station	Trucks	Barges
Phra Khanong	5	1
Sam Rong	3	6
Charoen Rat	1	1
Total	9	8

(4) Maintenance and inspection crane

1) Purposes of installation

According to the principle of the Japanese grant aid assistance, the crane proposed in the current project shall be installed to maintain and inspect automatic trash rakes. If the crane can also be used for pumps, it will improve the maintenance and management of pumping stations as a whole.

2) Necessity of installation

The automatic trash rakes to be installed under the current project requires no maintenance and inspection of heavy objects that will have to be lifted by the crane after installation. Therefore, it is not necessary to install a crane for automatic trash rakes.

3) Crane used to maintain and inspect pumps

Except in the Charoen Rat pumping station, pumps have so far been maintained and inspected by means of a simple crane or tripod. The simple crane was moved horizontally utilizing the space between the pump and screen. This space has also been used to carry out pumps that needed repair.

During the current project, this space will be used for installing automatic trash rakes. After installation, there will be no space, causing difficulties in the maintaining, inspecting, and repairing pumps. The space could be reserved for use after installation of trash rakes through substantial extension of the existing structures, but this is not a good idea for the reasons given below.

- o Phra Khanong and Sam Rong right-bank pumping stations
  These pump stations have space for installing automatic trash rakes. In the past, improving civil structures has been regarded as unnecessary in both pumping stations. Now,

however, extension of structures is necessary to provide this space. As a result, it costs more than expected to cover the expenses of extension work and temporary construction work.

- o Sam Rong left-bank pumping station No. 1
  The Sam Rong drainage gate is downstream from this pumping station. Large extension of structures would disturb operation of this drainage gate.

- o Sam Rong left-bank pumping station No. 2
  This pumping station is in a navigation lock. Large extension of structures would disturb the passage of vessels.

In view these circumstances, a traveling crane should be installed in the pump sites except Charoen Rat.

In the Phra Khanong left-bank pumping station, the existing pump facilities will not be repaired because a new structure separate from the present pumping station will be constructed to install the automatic trash rakes. It is thus not necessary to install a crane since the installation of automatic trash rakes will no longer be affected by the availability of space.

If cranes are installed in other pumping stations, then the Phra Khanong left-bank pumping station alone of all pumping stations proposed under the current project will have no traveling crane. If pumps in Phra Khanong left-bank malfunction, it would take a long time to restore them. During this time, the automatic trash rakes would be ineffective.

These are the reasons why pump maintenance/inspection cranes must be installed for the pumping station where automatic trash rakes are to be installed under the Japanese grant aid assistance program.

The dimensions of cranes are given below.

o Phra Khanong pumping station
  . Left-bank pumping station: 3.0 m wide, 5.0 m high, 40 m long (rail)
  . Right-bank pumping station: 2.7 m wide, 5.0 m high, 55 m long (rail)

o Sam Rong pumping station
  . Left-bank pumping stations
    No. 1 and No. 2: 3.2 m wide, 5.0 m high, 15 m long (rail)
    Right-bank pumping station: 2.7 m wide, 5.0 m high, 45 m long (rail)

(5) Hopper

In the case of overland haulage, the refuse is carried by truck. To efficiently use trucks, it is desirable to introduce a method for storing refuse moved by belt conveyor into a hopper until it reaches a certain amount before it is loaded on to the truck.

[Type]
Using a elevated hopper to store refuse is convenient when unloading on to trucks.

[Capacity]
As is stated in the section dealing with the number of waste hauling trucks, the capacity of a hopper is estimated at 10 m^3, taking into consideration the quantity of waste stirred up and taken off the automatic trash rake, the cargo volume of trucks, and the number of trucks used in deliverly.

(6) Trash rake panel

Because the automatic trash rake, the hopper, and the crane are all electrically powered, a panel to control the supply of electricity for the manipulation of these machines is necessary. 3ϕ 4 W, 380 V, and 50 Hz, shall be supplied to each machine from a newly established

substation in the pump station. The manipulation of the trash rake and conveyor belt shall be handled through a panel connected to the power manipulation panel mentioned above. The hopper shall be manipulated independently by a control panel installed on the hopper.

(7) Water gauge

A minimum water level on the intake side has to be observed for optimal operation of the pump. Operation under that level will result in abnormal vibration and deterioration of the performance of the pump, which will eventually lead to the break down of the pump itself. In order to prevent this from happening, it is necessary to install a water gauge which will monitor the water level on the intake side and a control system which will stop the operation of the pump automatically when the water level drops below the required level.

A water gauge for this purpose has been installed at some of the existing pump stations. However, if the refuse accumulates at the bar screen, the water level in front of the bar screen becomes higher than the water level behind the bar screen. The water gauge, in all the pumps at the station, is installed on the upper of the bar screen, it cannot detect a dropping of the water level below normal in the suction water tank.

To intall the automatic trash rakes for this project, the water gauge has to be installed on the down stream side of the automatic trash rake. In additon, a water gauge has to be installed for each pump group in pump stations where pumps are grouped into several units and separated from one another by divider walls.

The water gauge shall be float-type, because of the severe contamination of the river water.

(8) Remodeling of the existing panel

The automatic trash rake, to serve its purpose, has to begin operation before the pump starts operation, and has to stop operation only after

the pump stops operation. For this reason, a control system in which the operation of the pump and automatic trash rake is linked in necessary. The existing system should be remodeled to integrate this system as well as the system to stop the pump operation when the water gauge detects any abnormality as was mentioned earlier.

4-3-2 List of equipment

Table 4-2 shows the equipment mentioned above which will be supplied.

Table 4-2 List of Equipment

Equipment \ Pumping station	Phra Khanong		Sam Rong		Charoen Rat
	Left-bank	Right-bank	Left-bank	Right-bank	
Automatic trash rake	m m kw units 5.4 x 5.0 x 5.5 x 5	m m kw units 5.5 x 5.0 x 5.5 x 2	m m kw units 2.4 x 5.2 x 3.7 x 10	m m kw units 5.4 x 5.3 x 5.5 x 7	m m kw units 5.4 x 4.8 x 5.5 x 12
	-	5.4 x 5.0 x 5.5 x 2	-	2.4 x " x 3.7 x 1	2.6 x " x 3.74 x 1
	-	5.3 x 5.0 x 5.5 x 2	-	-	-
	-	5.0 x 5.0 x 5.5 x 1	-	-	-
	-	4.9 x 5.0 x 5.5 x 2	-	-	-
Belt conveyor (horizontal)	m kw unit 63 x 5.5 x 1 (reversible type)	m kw unit 67 x 5.5 x 1 53 x 3.7 x 1	m kw units 18 x 1.5 x 4 23 x " x 1	m kw units 55 x 3.7 x 2 (1 unit is of the reversible type)	m kw unit 82 x 5.5 x 1
" (inclined)	25 x 7.5 x 1	-	-	15 x 5.5 x 1	18 x 3.7 x 1
	-	-	-	-	15 x 5.5 x 1 (pivot type)
	-	-	-	-	
Hopper	m^3 kw unit 10 x 0.75 x 2 x 1	-	-	m^3 kw unit 10 x 0.75 x 2 x 1	m^3 kw unit 10 x 0.75 x 2 x 1
Automatic trash rake panel	1 set	1 set	2 sets	1 set	1 set
	-	-	-	-	1 set of operation desk
Hopper operation panel	1 unit	-	-	1 unit	1 unit
Modification of existing pump panel	15 units	20 units	10 units	15 units	25 units
Water level gauge	1 set	1 set	2 sets	3 sets	25 sets
Crane (3-ton type)	1 unit	1 unit	2 units	1 unit	-

4-4 Basic Plan of Facilities

4-4-1 Distribution plan

The trash rake is integrally combined with the screen. Generally speaking, the screen is installed at the inlet of a suction water tank to protect the pumps against blockage or damage caused by the inflow of trash and impurities. In this project, too, the installation point of trash rakes, including screens, shall be basically set at the inlet of suction water tanks. Based on this principle, the installation points of automatic trash rakes in each pump site are described as follows.

(1) Phra Khanong pumping station

- o Left-bank pump system

  In the left-bank pump system, there is no space to install a trash rake on the suction water tank. Installation of a trash rake therefore necessitates a forward extension of the tank's concrete structure. Immediately downstream from this pump site, however, there are left-bank drainage gates, which pose a problem.

  If the tank extension work is executed, one of the drainage gates will become projected by about two-thirds of the gate width. This projection may disturb the drainage performed by the drainage gate. Therefore, extension of the suction water tank is not a good idea.

  As an alternative to this, the trash rake shall be installed at the division point of a diversion canal which runs from the Phra Khanong drainage canal to the left-bank pump system. The distance between this point and the left-bank pump system is about 50 m. Within this distance there are no private houses on either side of the diversion canal, and so there is no afraid of the inflow of garbage.

The left-bank facilities to be built by this project are situated in the RID precinct. The access from the nearby trunk roads is well prepared to facilitate the maintenance and management of existing pumps. For the convenience and facilitation of both construction work and trash conveyance work (after completion of construction), it is believed that this point is most suited for the installation of trash rakes.

o Right-bank pump system

The suction water tank in the right-bank pump system was originally built in anticipation of the installation of automatic trash rakes and therefore a broad space was reserved. The trash rake chosen for the current project presents no problem in terms of space and mechanism relevant to its installation. So it shall be installed at in the existing screen position.

The right-bank pump system is located in an island-like area which lies between the Phra Khanong drainage canal and a navigation lock that has been constructed by short-cutting the zigzag line of the Phra Khanong drainage canal. No civil work is necessary for this pump system, as mentioned above. Being located away from inland area, the site is better suited for transportation by water than by land, making it easier to carry and install the equipment and material used for installing automatic trash rakes.

(2) Sam Rong pumping station

o Left-bank pump system No. 1

The left-bank pump system No. 1 has no space that allows an automatic trash rake to be installed, and therefore it is necessary to extend the concrete structure of the suction water tank. There is a drainage gate downstream from this pump system. It is considered that tank extension will not disturb the drainage performed by the drainage gate because: small scale of extension work will suffice; there is a distance of about 10 m between the suction water tank and drainage gate. Therefore, the automatic trash rake shall be installed at the inlet of the suction water tank.

o Left-bank pump system No. 2

Pump system No.2 also lacks a space that allows a trash rake to be installed, necessitating extension work. This pump system is situated in a navigation lock and so tank extension on a large scale would disturb the passage of vessels. However, the extension work proposed in the current project will not be executed on a large scale, that is, the tank bottom slab would become projected in the forward direction by only about 1 m as a result of the extension work. Such a slight extension will not disturb the passage of vessels. Therefore, the trash rake shall also be installed at the inlet of the suction water tank in pump system No. 2.

Both pump systems No. 1 and No. 2 on the left-bank are located in an island-like area surrounded by a navigation lock constructed by short-cutting the zigzag line of the Sam Rong drainage canal. Access to the site of these pump systems must be procured for the purpose of transporting construction equipment and materials that are necessary for the tank extension work.

In view of the topographical conditions of this area, access may be provided by building a temporary bridge extending from the left-bank of the Sam Rong drainage canal. However, the road approaching this drainage canal (from existing roads) is not only narrow but cannot be widened because private houses are densely built on either side of the road, making it impossible to transport construction machinery and equipment by motor vehicle.

Therefore, a temporary approaching path built of steel shall be established from the right-bank of the Sam Rong drainage canal over the pump discharge channel and navigation lock of the existing pump site.

o Right-bank pump system

As in the case of the right-bank pump system of Phra Khanong, the suction water tank in this pump system was originally built in anticipation of the installation of automatic trash rake. The condition of structures existing on this site is checked with regard to the type of automatic trash rakes to be employed for the project. As a result, it is found that there is no problem in terms

of space and mechanism relevant to installation. Therefore, the automatic trash rake shall be installed on the existing screen position.

The right-bank pump system is in contact with the right-bank of the Sam Rong drainage canal. This location will make it easy to carry in trash rake installation machines by land. Another advantage of this location is that it allows the trash to be carried out both over water (using a barge) and overland (using a truck).

(3) Charoen Rat pumping station

The suction water tank in this pump site has no space reserved for the installation of an automatic trash rake, and therefore it is necessary to extend the tank's concrete structure. Tank extension raises no problem because there is a large stilling basin in front of the pump site. Therefore, the automatic trash rake shall be installed at the entrance to the suction water tank.

On both the left and right-banks of the pump site, there is plenty of reserved space available for the management of facilities. This is a topographical advantage that makes it easy to carry in or set up equipment and material as well as to carry off the trash after completion of the facilities.

4-4-2 Structural planning

Civil structures to be built to install automatic trash rakes should be planned considering workability, additional load, pump operation water level, existing structures, and so on. Items to be examined for this plan are given below.

- The shape, dimension, and structure of the facilities
- The type and size of the foundation
- Other appurtenant structure

The proposed structures are outlined below.

- Phra Khanong left-bank pumping station : A new independent structure shall be built in front of the suction water tank.

- Phra Khanong right-bank pumping station : Trash rakes shall be installed in existing pumping station structures.

- Sam Rong left-bank pumping station : A section installing the trash rake shall be constructed in front of the suction water tank as an integral part of the existing facilities.

- Sam Rong right-bank pumping station : Trash rakes shall be installed in the existing pumping station structures.

- Charoen Rat pumping station : A section installing the trash rake shall be constructed in front of the suction water tank as an integral part of the existing facilities.

(1) Phra Khanong left-bank pumping station

. Main Structure

There is no space available in front of the suction water tank, so the trash rake shall be installed ahead of the diversion canal. Two different approaches are possible. The trash rake can be installed either in parallel with the suction water tank or at a right angle to the bank-protecting sheet pile on the left-bank.

In the latter plan, the trash will most likely remain trapped because a dead water area may be produced when gravitational drainage occurs. Therefore, it is chosen to employ the arrangement parallel to the suction water tank. From the standpoint of hydraulics, the centers of the suction tank and trash rakes should coincide with each other. Therefore, the trash rake shall be installed a reasonable distance ahead of the pumping station.

The width of installed trash rakes shall be determined so that the velocity of the water passing through the screen remains at nearly 0.5 m/sec. It is considered that the optimum installation width is 27 m (5.4 m x 5 set) because the elevation of this diversion canal is fixed at -2.0 m and because there is a drainage gate on the downstream left-bank. When the width is 27 m, the water will pass

through the screen at a velocity of 0.69 m/s, with the proposed low water level being set at +0.4 m. In that case, the head-loss may increase a little, but that is no problem.

The level of the upper floor slab must be some 1.0 m higher than that of the surrounding ground because there will be a trash-conveying belt conveyor installed on it. The optimum level would be 3.0 m corresponding to the upper floor slab of the pumping station. In that case, the difference in height between the upper and lower floor slabs is 5.0 m.

Due to the trash rake, the lateral dimension must be 4.0 m for both divider wall and upper floor slab. In this pump facility, the trash rake does not form an integral part of the suction water tank, so stop-log recesses must be provided on the downstream side to install, maintain, and inspect trash rakes. For this reason, the divider wall shall be extended 1.0 m downstream. As a result, the overall lateral width becomes 9.0 m.

The thickness of RC members can be determined following the practical examples of similar structures built in Japan. Both divider wall and lower floor slab shall be 60 cm thick, and the upper floor slab shall be 40 cm thick.

. Appurtenant Structure

A section connecting to the present protective bank must be installed at the edge of the left-bank. Two different types of structure are possible, sheet piles to protect the bank or the revetment (retaining wall) of RC structure. For safety's sake, the revetment type is chosen because the soil around there consists of Bangkok clay which is very soft and because the section may constitute the structural weak point of this facility.

. Foundation

There is a deposit of soft clay (N = 0) forming a layer about 15 m

thick, so it is impossible to support a structure directly by this layer. Considering the load, however, the foundation composed of the existing piles seems to support the load safely. The results of current field survey have shown that the foundation of the existing pumping station consists of friction piles mixed up with bearing piles. A lot of friction piles (about 8 m long) are placed at a pitch of about 0.7 m, thereby preventing differential settlement.

In this current survey, it is found that the older pumping station has friction piles, while the newer pumping station has bearing piles. Therefore, it is planned to adopt bearing piles in this study. Bearing piles are likely to create a cavity between the foundation ground and the lower surface of the lower floor slab. Steel sheet piles 5.0 m long with some allowance, shall be installed to prevent this.

It is impossible to calculate the bearing capacity by the piles because no boring test has been conducted in this pumping station so far. However, a pile-driving test was performed when this facility was being constructed. With the safety factor being set at 2 (SF = 2), the bearing capacity was calculated as follows:

□ -35 x 35 cm	L = 19 m	Ra = 50 t/pile
□ -25 x 25 cm	L = 23 m	Ra = 35 t/pile

The bearing capacities calculated by the pile-driving test are unavoidably inaccurate since the test is affected by the factors such as the type of pile drivers, shape of the cushion, and quality of the material. In addition, it is too difficult to estimate the static bearing capacity based on the dynamic penetrating resistance. Therefore, designing the bearing capacity to the allowable maximum would raise some problem. For the current study, the criterion is set at 65% and thereby the number of piles to be installed is determined.

Calculating the number of piles (L = 19 m):

Load	Main structure (RC section)	740 t
	Trash rakes (5.4 m x 5 sets)	70 t
	Horizontal belt conveyor	10 t
	Weight of loaded earth	380 t
		ΣW = 1,200 t

Number of piles : $n = \Sigma W/(Ra \times 0.65) = 52$ (Pile size: 35 x 35 cm)

(2) Phra Khanong right-bank pumping station

In this pumping station, trash rakes shall be installed on the existing structures. With the proposed low water level of -0.6 m, lower floor slab elevation of -3.0 m, and suction water tank width of 5.3 m (9 tanks), the velocity of water passing through the screen is 0.52 m/s. This raises no problem from the standpoint of hydraulics.

An additional load will be created by the trash rakes. It is necessary to confirm whether or not the existing piles are safe enough to support the additional load.

Checking the bearing capacity provided by existing piles:

Load (every 5.5 m in depth)		
	Main structure (RC section)	WR = 185 t
	Trash rake (5.4 m)	W1 = 13 t
	Horizontal belt conveyor	W2 = 1 t
	Pump	WP = 8 t
		ΣW = 207 t

Percentage of the additional load : $P = (W1 + W2)/\Sigma W \times 100\% = 6.8\%$

Calculating the bearing capacity provided by existing piles:

□-35 x 35 cm L = 19 m Ra = 50 t/pile
Number of piles for every 5.5 m in depth n = 20
Allowable bearing capacity ΣRa = 50 t x 20 = 1,000 t
ΣW/ΣRa x 100% = 20.7%

The above figures verify that the existing piles are safe.

(3) Sam Rong left-bank pumping stations (No. 1 and No. 2)

. Main Structure

The existing structures in this pumping station have no space for trash rakes to be installed. It is therefore necessary to provide such space in front of the suction water tank. However, the forward projection should be minimized because a drainage gate or navigation rock is downstream from the pumping station. The minimum dimension should allow the trash rake to be projected 4.0 m forward from the existing upper floor slab. The lower floor slab will then project 1.0 m from the existing structures.

The divider wall of the existing structure is set at a pitch of about 2.7 m. Extending the divider wall in the forward direction, either a 2.7 m or a 5.4 m (two-span) trash rake may be installed. An installation width of 2.7 m is chosen (a detailed explanation is given in Section 4-3-1). It is thus reasonable to extend the existing structure in the forward direction.

The upper floor elevation slab shall be 2.8 m, which is the elevation of the existing pumping station. This will not create any problem in installing a belt conveyor. The level of the lower floor slab shall be identical with that of the drainage canal (EL = -2.8 m).

The same concept as for the Phra Khanong pumping station shall be applied to the dimensions of RC structure members (e.g., the divider wall shall be 60 cm thick and the upper floor slab shall be 40 cm thick. For stop-log installation, the divider wall thickness

should involve a 15 cm stop-log recess. To secure the effective member thickness (30 cm), any dimensions less than this are not acceptable. The lower floor slab shall be 65 cm thick, which equals the thickness of the existing structure. To prevent scour, the front edge of the lower floor slab shall be rooted in the ground at a depth of 1.5 m.

With the proposed low water level of -0.4 m, inlet bottom slab elevation of -2.4 m, and suction water tank width of 2.4 m (5 tanks), the water will pass through the screen at a velocity of 0.63 m/s. This raises no major functional problem.

. Foundation

In the existing foundation, piles ϕ200 mm diameter, 8.0 m long are placed at a pitch of 0.65 to 0.80 m. The number of length of these piles suggest that they are friction piles designed to protect structures against differential settlement. No boring test has been conducted at this pumping station. The bearing capacity of these piles, therefore, must be calculated based on the bearing capacity calculation diagram for friction piles used near Bangkok.

The load acting on the foundation shall be added to the load created by enlarging the existing structure to form the gross load. The gross load and allowable bearing capacity are compared below. These data indicate that the ratio of gross load to allowable bearing capacity is 58%, and so it is not necessary to place new piles.

In addition, the gravitational center of the load moves forward with the forward extension of the structure. It is likely, however, that the existing structure will become eccentric on the pump side. In the long run, the load center of gravity becomes almost identical to the center of the structure, demonstrating that the construction is stable.

Checking the bearing capacity of existing piles:

Load (every 3.0 m in depth)

Main structure (RC section)	WR = 135 t
Trash rakes (5.4 m x 5 sets)	W1 = 8 t
Horizontal belt conveyor	W2 = 0.5 t
Pump	WP = 2.7 t
	ΣW = 146 t

The bearing capacity of existing piles (refer to Appendix 2-1.):

φ200 mm	L = 8 m	Ra = 4.2 t/pile
Number of piles for every 3.0 m in depth		n = 60
Allowable bearing capacity		ΣRa = 4.2 t x 60 = 252 t
ΣW/ΣRa x 100% = 58.0%		

The above figures verify that the existing piles are safe.

(4) Sam Rong right-bank pumping station

In this pumping station, trash rakes shall be installed on existing structures. With the proposed low water level of -0.4 m, floor slab elevation of -2.5 m, and suction water tank width of 5.4 m (7 tanks) and 2.4 m (1 tank), the water will pass through the screen at a velocity of 0.53 m/s. There is no problem in these figures from the standpoint of hydraulics.

An additional load will be created by the trash rakes. As verified below, the existing piles can safely support the additional load. The foundation of this pumping station is composed of friction piles like that of the left-bank pumping station, so the same bearing capacity calculation diagram applies.

Checking the bearing capacity of existing piles:

Load (every 6.0 m in depth)

Main structure (RC section)	WR = 225 t
Trash rake (5.4 m)	W1 = 13 t
Horizontal belt conveyor	W2 = 1.2 t
Pump	WP = 5.4 t
	ΣW = 245 t

Percentage of the additional load: P = (W1+W2)/ΣW x 100% = 5.8%

The bearing capacity of existing piles (refer to Appendix 2-1):

□ -18 x 18 cm L = 8 m Ra = 4.6 t/pile

Number of piles for every 6.0 m in depth n = 80

Allowable bearing capacity ΣRa = 4.6t x 80 = 368 t

ΣW/ΣRa x 100% = 66%

The above figures verify that the existing piles are safe.

(5) Charoen Rat pumping station

. Main Structure

In the Charoen Rat pumping station, trash rakes shall be installed in front of the suction water tank. The existing structures do not have installation space for trash rake to be installed, so it is necessary to provide such space in front of the suction water tank.

The upper floor slab of the existing pump facility has crane rails, which shall be utilized after completion of repairs. Therefore, the new space for accommodating trash rakes and horizontal belt conveyors must be obtained. To secure the minimum space for installing automatic trash rakes, the upper floor slab shall be extended 4.0 m and the divider wall shall be projected 4.0 m.

The installation width of trash rakes depends on the numbers to be installed per pump, that is, one trash rake per pump or one trash rake for every two pumps. As explained in detail before, the type of one trash rake for every two pumps, resulting in a width of 5.4 m is employed. In addition, a trash rake 2.6 m wide shall be installed at the end.

The upper floor slab elevation shall equal to that of the existing pumping station (EL = 3.0 m). This raises no problem in the installation of belt conveyors. Regarding the lower floor slab, there is a difference of 0.8 m in elevation between the stilling basin (EL = -1.0 m) and suction water tank (EL = -1.8 m). Two different plans are possible by choosing either the height of the stilling basin or the floor level of the suction water tank. The latter plan was chosen and reasons are explained below.

The velocity of water passing through the screen is 0.46 m/s in the latter plan and 0.7 m/s in the former plan. To minimize the loss of head, the velocity should be as low as possible.

. Velocity

  Fitting elevation to the stilling basin:

  L.W.L. +0.6 m/Floor level -1.0 m/Water depth B = 1.6 m

  Flow width L = 5.4 m x 12 + 2.6 m x 1 = 67.4 m

  Velocity V = Q/A = 0.70 m/s

  Fitting elevation to the suction water tank:

  L.W.L. +0.6 m/Floor level -1.8 m/Water depth B = 2.4 m

  Flow width L = 5.4 m x 12 + 2.6 m x 1 = 67.4 m

  Velocity V = Q/A = 0.46 m/s

. In this pumping station, there is sufficient space to lower the floor slab for installation.

The same thickness of RC members as in other pumping stations shall be apply. The divider wall, upper floor slab, and lower floor slab shall be 60, 40, and 65 cm respectively.

- Appurtenant Structure

The section connecting new structures to the protective bank slope requires embankment height of 2.5 m to install belt conveyors for conveying trash. To build the embankment, two different plans are possible, constructing the sheathing wall with either in RC or sheet piles. There is an existing structure behind the wall in this pumping station, and the shoring sheet pile structure would be rapidly practicable if the structure is utilized as an anchor. It is believed that there is no problem in using sheet pile even though the foundation ground is soft.

- Foundation

A boring test was conducted in this pumping station. A standard penetration test revealed the presence of a soft clay (N = 0 to 2) layer about 18 m thick, beneath which there is a deposit of clay (N = 10 to 20) forming a layer 4 m thick. Further beneath the clay layer, there is a sand layer (N > 30) which can be used as the bearing layer. The existing piles are deeply placed in this sand layer, whose bearing capacity is expected enough to bear the load of 110 t/pile. It seems to be better, however, that the strength of locally available piles might be up to 80 t considering their stress (refer to Appendix 2-1).

In the existing section, 12 piles are placed every 6 m in depth, producing the gross bearing capacity of 960 t. Adding the new section, the load totals about 440 t, but then eccentricity occurs in the load because the structure becomes projected about 4 m on the lower floor slab. It is necessary therefore to balance the load by adding two piles in every 6 m of depth.

Checking the bearing capacity of existing piles:

Load (every 6 m in depth)

Main structure (RC section)	WR = 418.0 t
Trash rake (5.4 m)	W1 = 12.5 t
Horizontal belt conveyor	W2 = 0.5 t
Pump	WP = 5.5 t
	W = 436.5 t

Bearing capacity of existing piles: (refer to Appendix 2-1.):

ϕ450 mm L = 26 m $\sum$Ra = 80 t/pile

Number of piles for every 6.0 m in depth :

n = 14 (12 old plus 2 new)

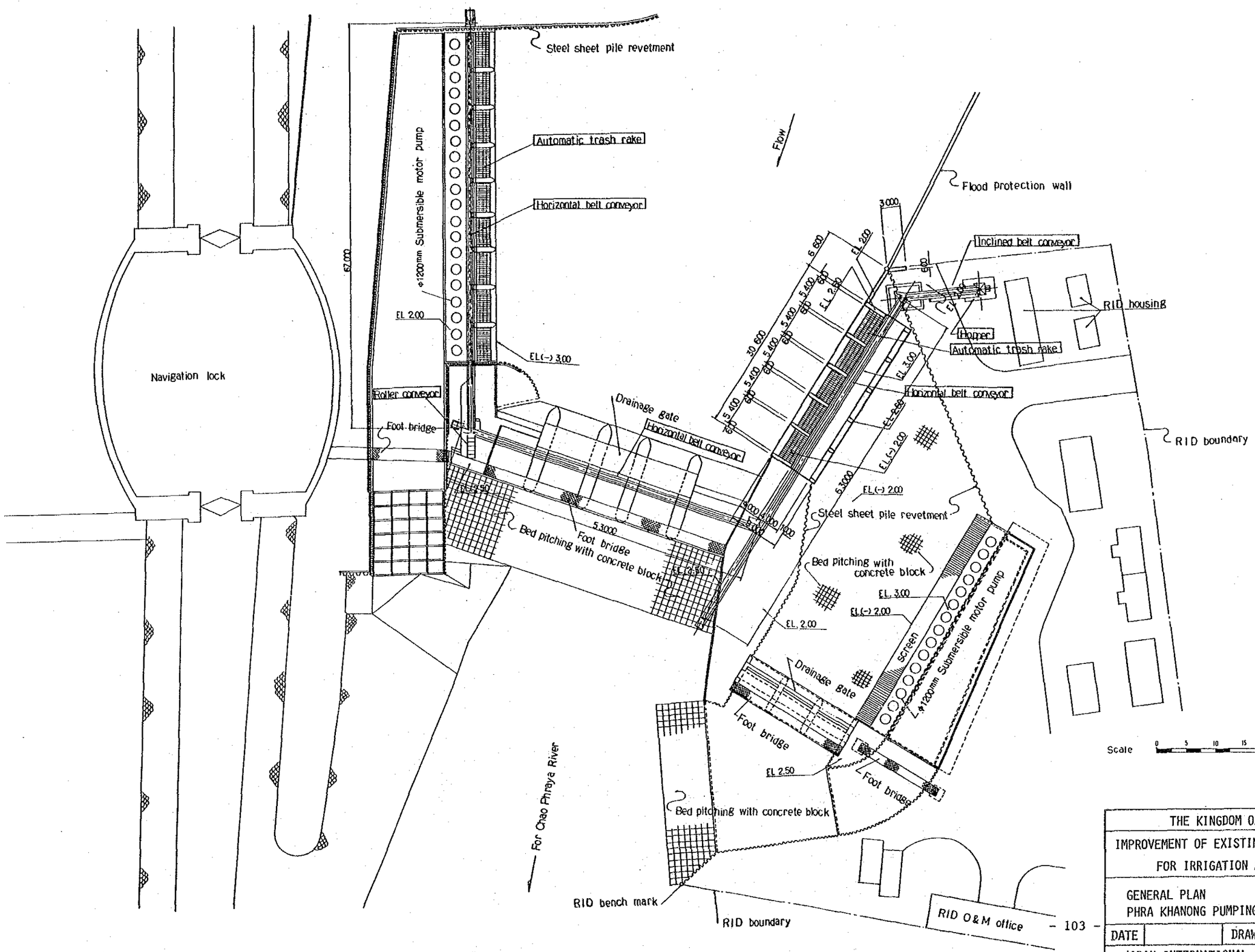
Allowable bearing capacity $\sum$Ra = 80 t x 14 = 1,120 t

$\Sigma W/\sum Ra \times 100\% = 39.0\%$

The above figures verify that the existing piles are safe.

4-4-3 Basic design drowings

DRAWING NO.	NAME OF DRAWING
01	General plan, Phra Khanong pumping station
02	General plan, Sam Rong pumping station
03	General plan, Charoen Rat pumping station
04	Installation plan of equipment, Phra Khanong pumping station
05	Installation plan of equipment, Sam Rong pumping station
06	Installation plan of equipment, Charoen Rat pumping station
07	Detail of new structure, Phra Khanong Left-Bank pumping station
08	Detail of improving structure, Sam Rong Left-Bank pumping station
09	Detail of improving structure, Charoen Rat pumping station
10	Detail of temporary facility, Phra Khanong Left-Bank pumping station
11	Detail of temporary facility, Sam Rong Left-Bank and Charoen Rat pumping stations



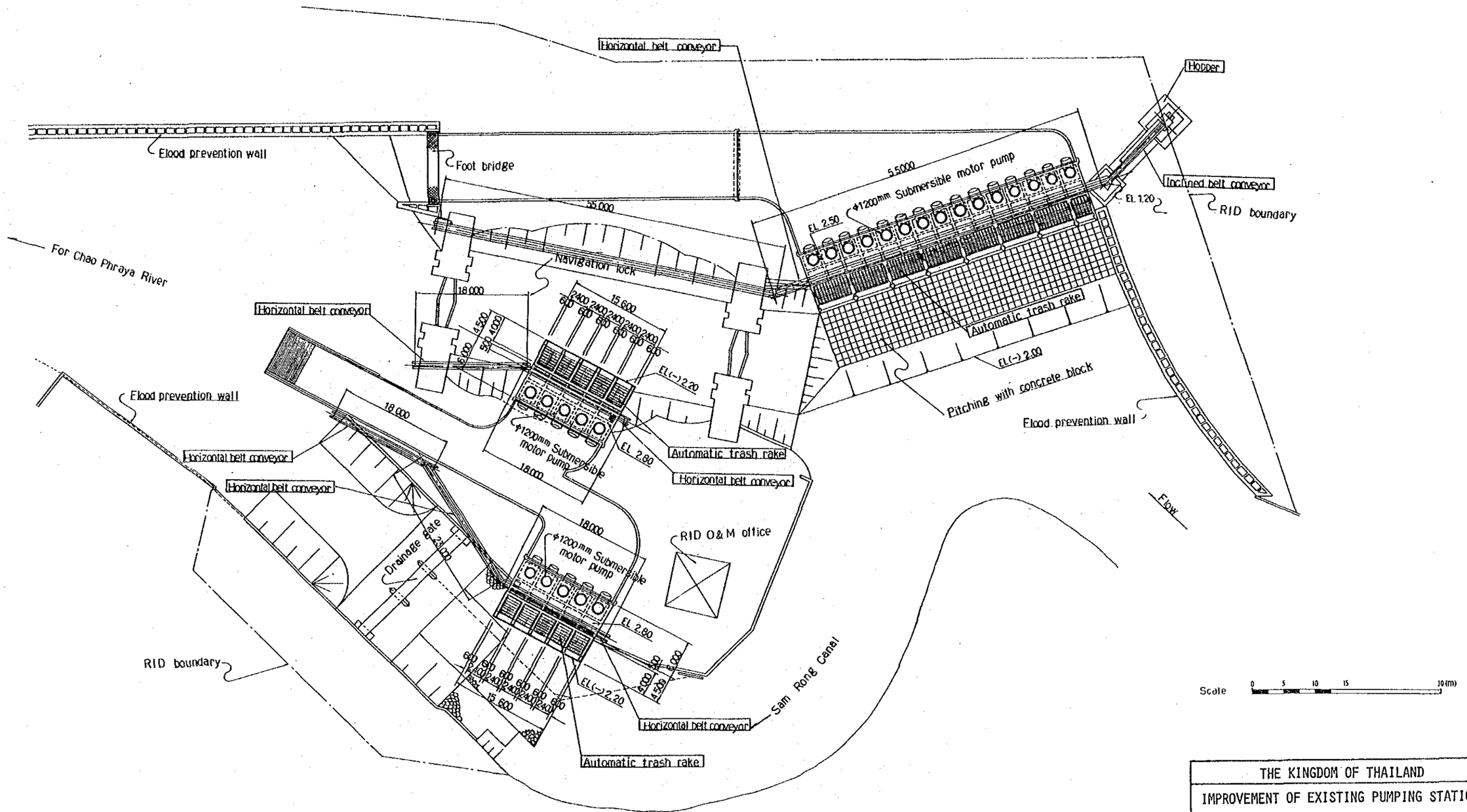
THE KINGDOM OF THAILAND

IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE

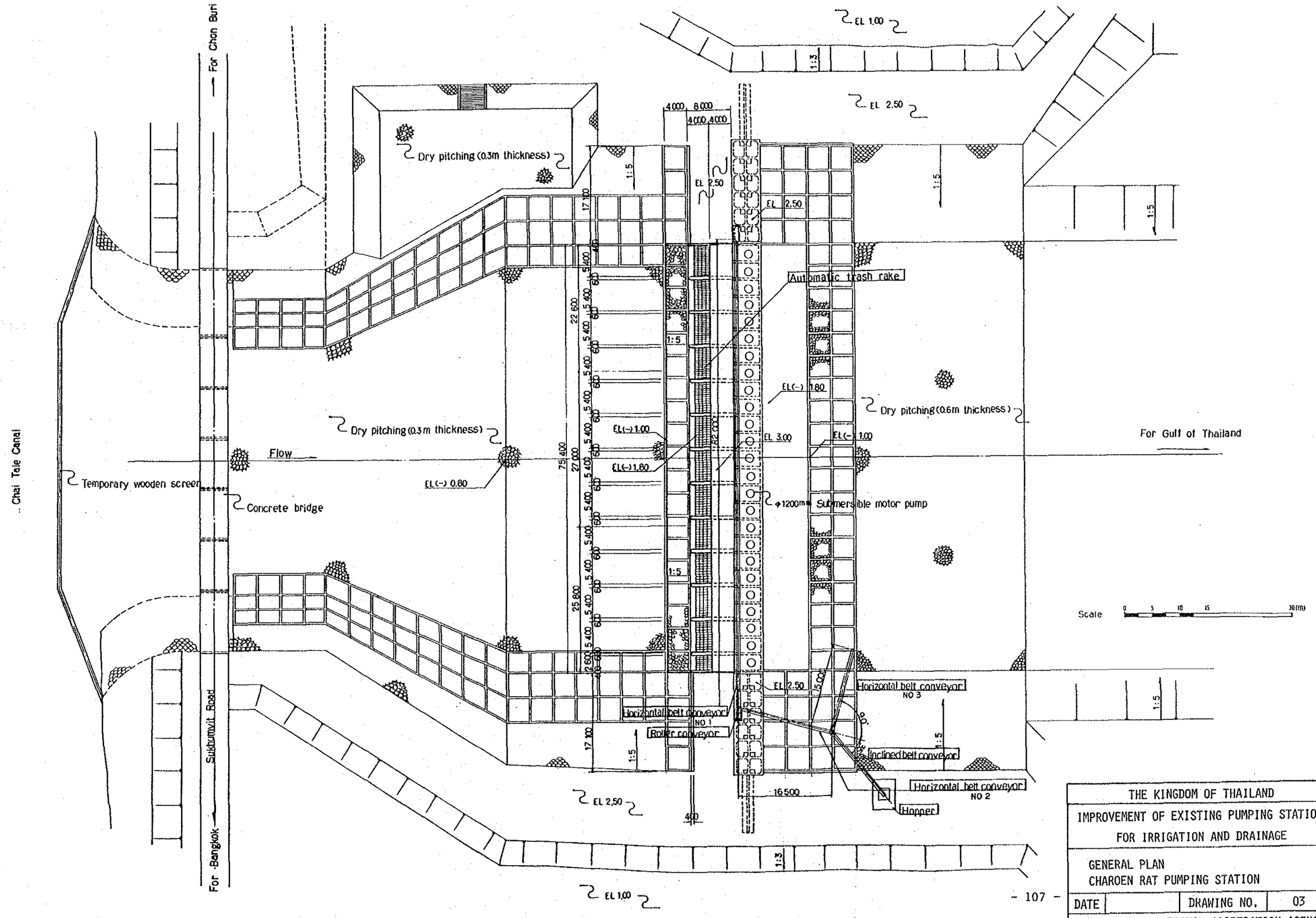
GENERAL PLAN
PHRA KHANONG PUMPING STATION

DATE		DRAWING NO.	01

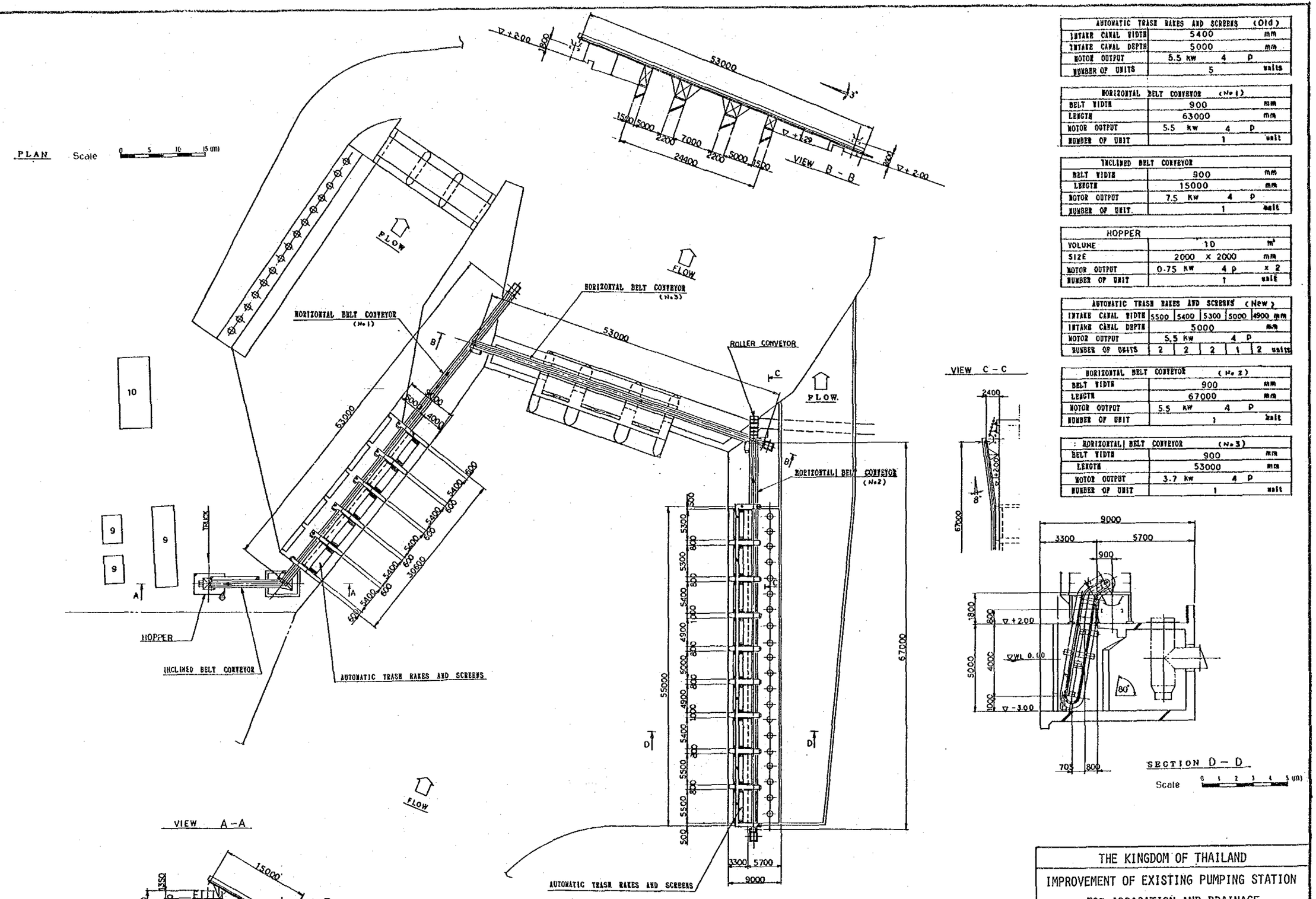
JAPAN INTERNATIONAL COOPERATION AGENCY



THE KINGDOM OF THAILAND			
IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE			
GENERAL PLAN SAM RONG PUMPING STATION			
DATE		DRAWING NO.	02
JAPAN INTERNATIONAL COOPERATION AGENCY			



THE KINGDOM OF THAILAND			
IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE			
GENERAL PLAN CHAROEN RAT PUMPING STATION			
DATE		DRAWING NO.	03
JAPAN INTERNATIONAL COOPERATION AGENCY			



AUTOMATIC TRASH RAKES AND SCREENS (Old)		
INTAKE CANAL WIDTH	5400	mm
INTAKE CANAL DEPTH	5000	mm
MOTOR OUTPUT	5.5 kw 4 p	
NUMBER OF UNITS	5	units

HORIZONTAL BELT CONVEYOR (No.1)		
BELT WIDTH	900	mm
LENGTH	63000	mm
MOTOR OUTPUT	5.5 kw 4 p	
NUMBER OF UNIT	1	unit

INCLINED BELT CONVEYOR		
BELT WIDTH	900	mm
LENGTH	15000	mm
MOTOR OUTPUT	7.5 kw 4 p	
NUMBER OF UNIT	1	unit

HOPPER		
VOLUME	10	m³
SIZE	2000 x 2000	mm
MOTOR OUTPUT	0.75 kw 4 p	x 2
NUMBER OF UNIT	1	unit

AUTOMATIC TRASH RAKES AND SCREENS (New)						
INTAKE CANAL WIDTH	5500	5400	5300	5000	4900	mm
INTAKE CANAL DEPTH	5000					mm
MOTOR OUTPUT	5.5 kw 4 p					
NUMBER OF UNITS	2	2	2	1	2	units

HORIZONTAL BELT CONVEYOR (No.2)		
BELT WIDTH	900	mm
LENGTH	67000	mm
MOTOR OUTPUT	5.5 kw 4 p	
NUMBER OF UNIT	1	unit

HORIZONTAL BELT CONVEYOR (No.3)		
BELT WIDTH	900	mm
LENGTH	53000	mm
MOTOR OUTPUT	3.7 kw 4 p	
NUMBER OF UNIT	1	unit

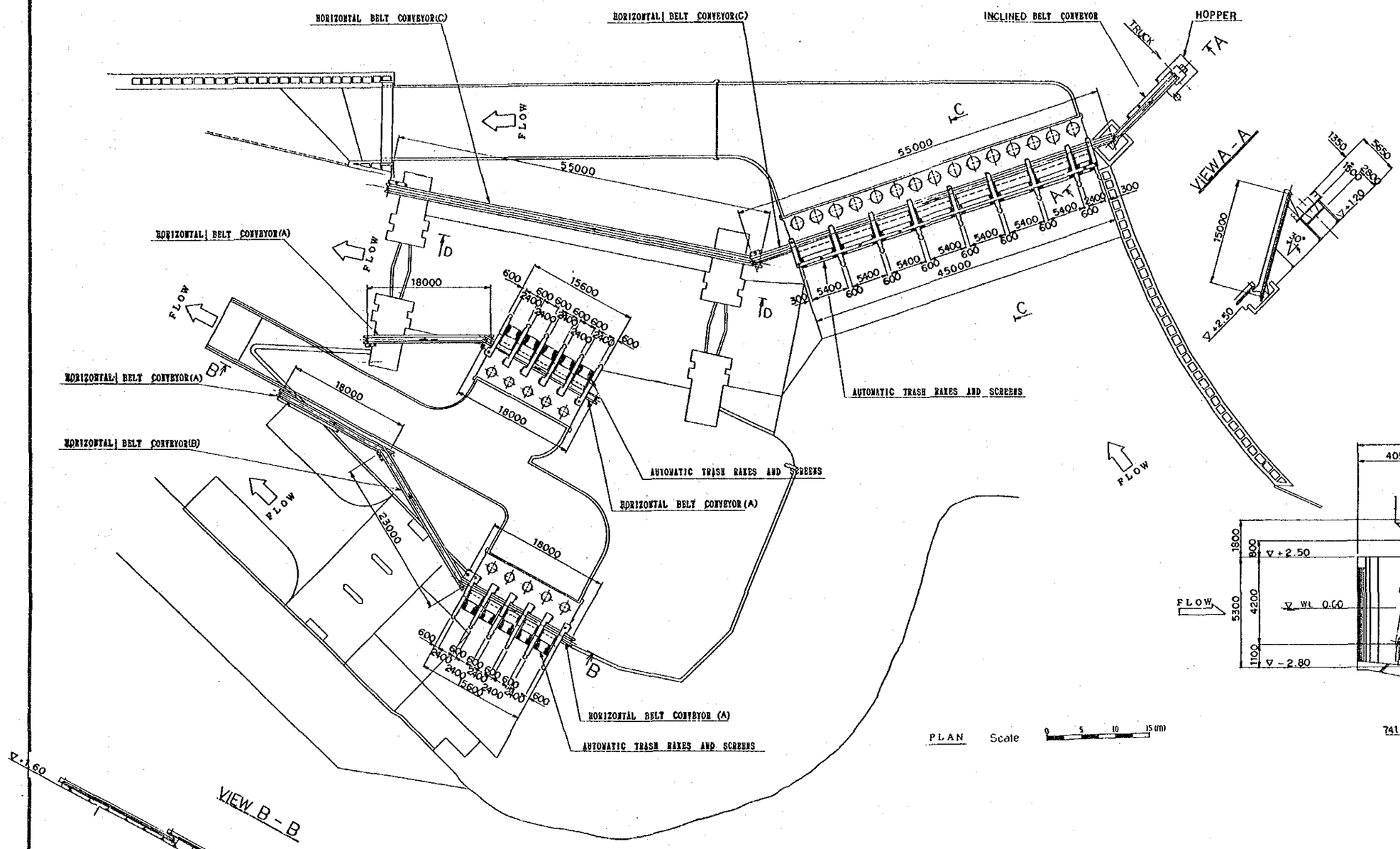
THE KINGDOM OF THAILAND

IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE

INSTALLATION PLAN OF EQUIPMENT
PHRA KHANONG PUMPING STATION

DATE		DRAWING NO.	04

JAPAN INTERNATIONAL COOPERATION AGENCY



AUTOMATIC TRASH RAKES AND SCREENS (Old)		
INTAKE CANAL WIDTH	2400	mm
INTAKE CANAL DEPTH	5200	mm
MOTOR OUTPUT	3.7 kw 4 P	
NUMBER OF UNITS	10	units

HORIZONTAL BELT CONVEYOR (A)		
BELT WIDTH	600	mm
LENGTH	18000	mm
MOTOR OUTPUT	1.5 kw 4 P	
NUMBER OF UNIT	4	units

HORIZONTAL BELT CONVEYOR (B)		
BELT WIDTH	600	mm
LENGTH	23000	mm
MOTOR OUTPUT	1.5 kw 4 P	
NUMBER OF UNIT	1	unit

AUTOMATIC TRASH RAKES AND SCREENS (New)			
INTAKE CANAL WIDTH	5400	2400	mm
INTAKE CANAL DEPTH	5300		mm
MOTOR OUTPUT	5.5KW 4 P	3.7KW 4 P	
NUMBER OF UNITS	7 units	1	unit

HORIZONTAL BELT CONVEYOR (C)		
BELT WIDTH	900	mm
LENGTH	55000	mm
MOTOR OUTPUT	3.7 kw 4 P	
NUMBER OF UNIT	2	units

INCLINED BELT CONVEYOR		
BELT WIDTH	900	mm
LENGTH	15000	mm
MOTOR OUTPUT	7.5 kw 4 P	
NUMBER OF UNIT	1	unit

HOPPER		
VOLUME	10	m³
SIZE	2000 X 2000	mm
MOTOR OUTPUT	0.75 kw 4 P X2	
NUMBER OF UNIT	1	unit

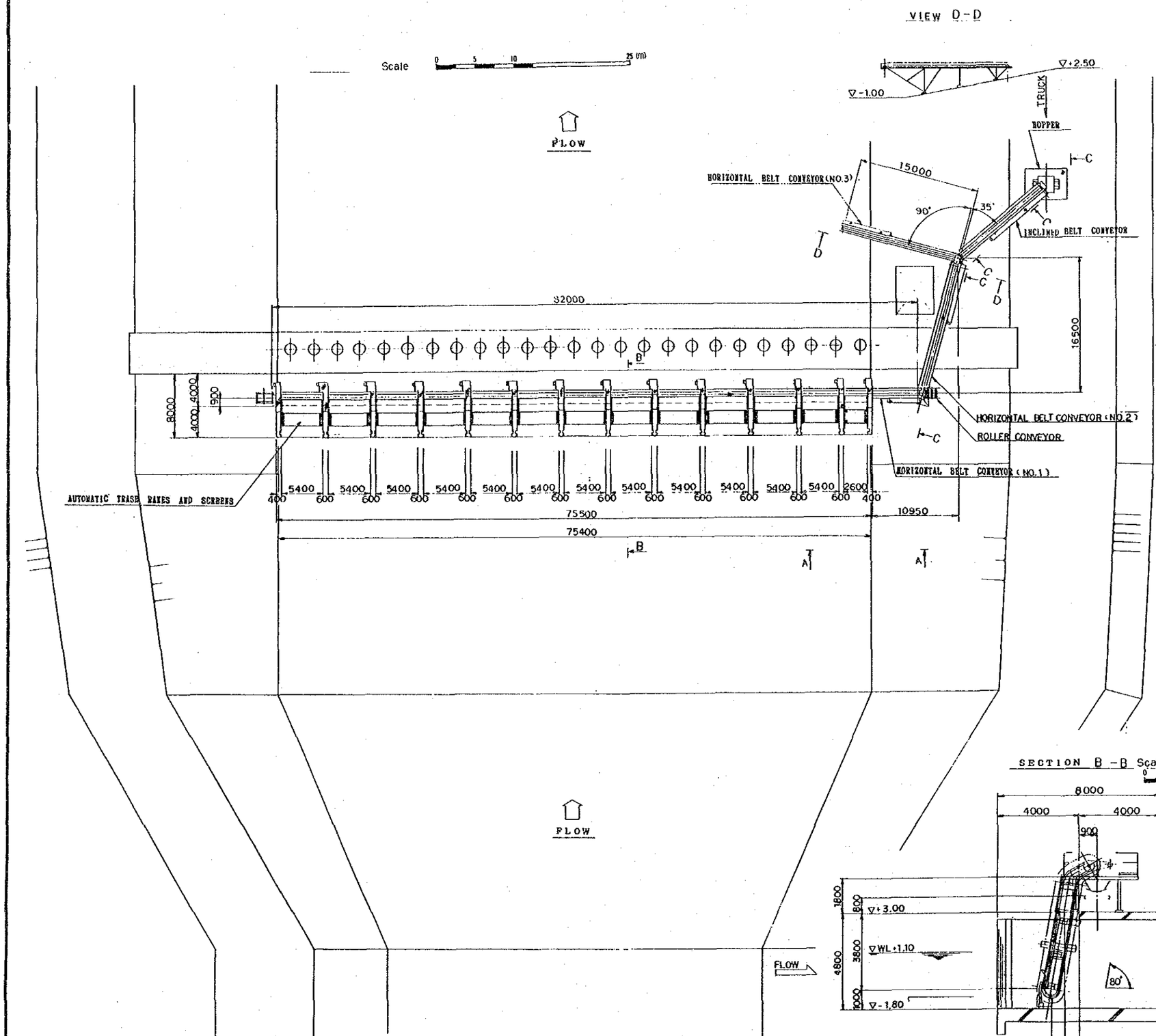
THE KINGDOM OF THAILAND

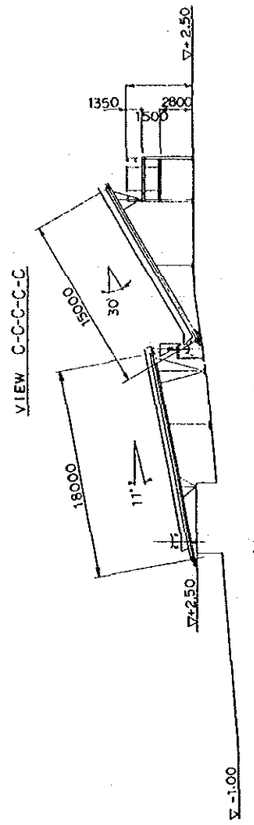
IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE

INSTALLATION PLAN OF EQUIPMENT
SAM RONG PUMPING STATION

DATE		DRAWING NO.	05

JAPAN INTERNATIONAL COOPERATION AGENCY





AUTOMATIC TRASH RAKES AND SCREENS				
INTAKE CANAL WIDTH	5400		2600	mm
INTAKE CANAL DEPTH	4800			mm
MOTOR OUTPUT	5.5kw	4 P	3.7kw	4 P
NUMBER OF UNITS	12	units	1	unit

HORIZONTAL BELT CONVEYOR (NO.1)		
BELT WIDTH	900	mm
LENGTH	82000	mm
MOTOR OUTPUT	5.5 kw 4 p	
NUMBER OF UNIT	1	unit

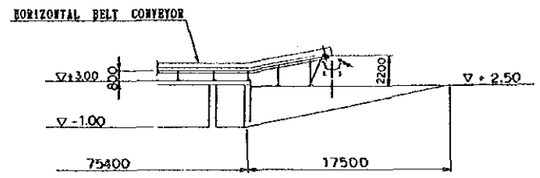
HORIZONTAL BELT CONVEYOR (NO.2)		
BELT WIDTH	900	mm
LENGTH	18000	mm
MOTOR OUTPUT	3.7 kw 4 p	
NUMBER OF UNIT	1	unit

INCLINED BELT CONVEYOR		
BELT WIDTH	900	mm
LENGTH	15000	mm
MOTOR OUTPUT	7.5 kw 4 p	
NUMBER OF UNIT	1	unit

HOPPER		
VOLUME	10	m³
SIZE	2000 × 2000	mm
MOTOR OUTPUT	0.75 kw 4 p × 2	
NUMBER OF UNIT	1	unit

HORIZONTAL BELT CONVEYOR (NO.3)		
BELT WIDTH	900	mm
LENGTH	15000	mm
MOTOR OUTPUT	2.2 kw 4 p	
NUMBER OF UNIT	1	unit

VIEW A-A

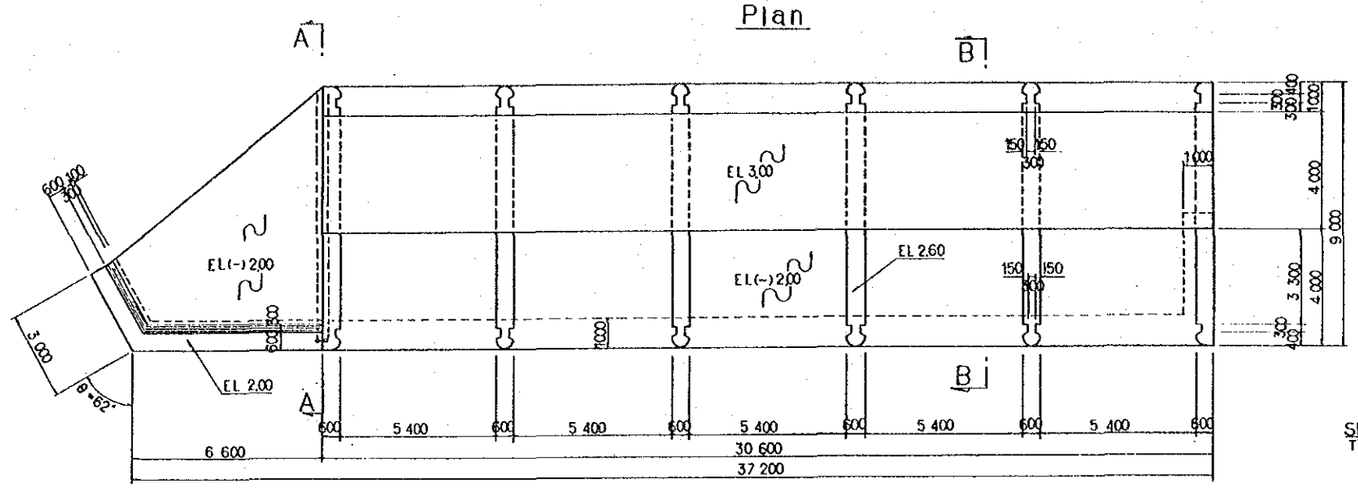


SECTION B-B Scale 0 1 2 3 4 5 (m)

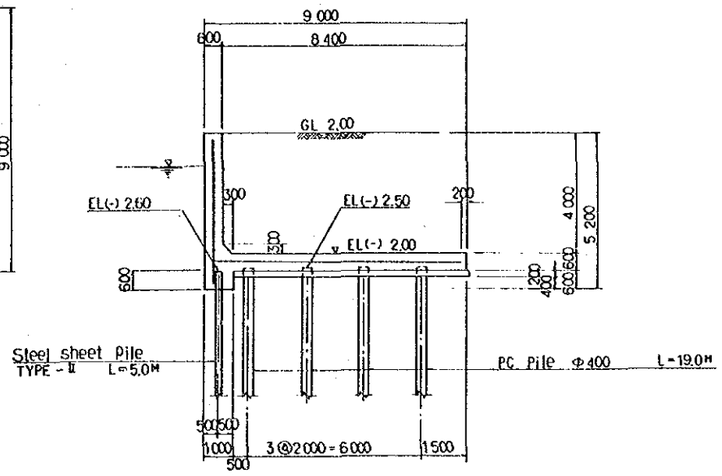
THE KINGDOM OF THAILAND			
IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE			
INSTALLATION PLAN OF EQUIPMENT CHAROEN RAT PUMPING STATION			
DATE		DRAWING NO.	06
JAPAN INTERNATIONAL COOPERATION AGENCY			

Phra Khanong (left bank)

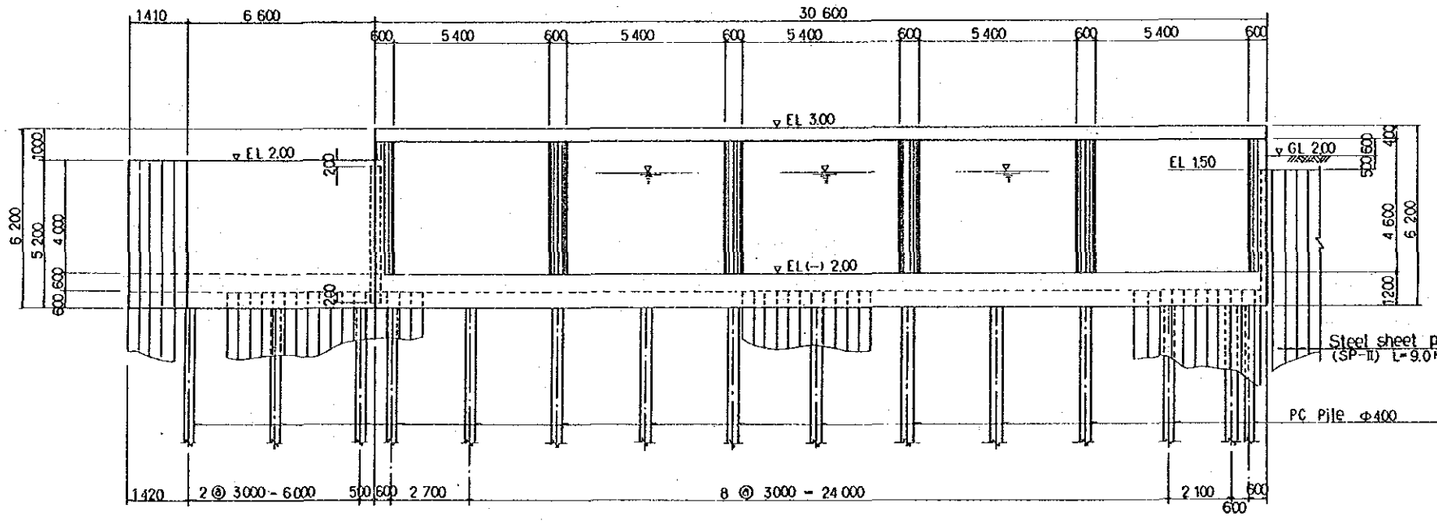
Plan



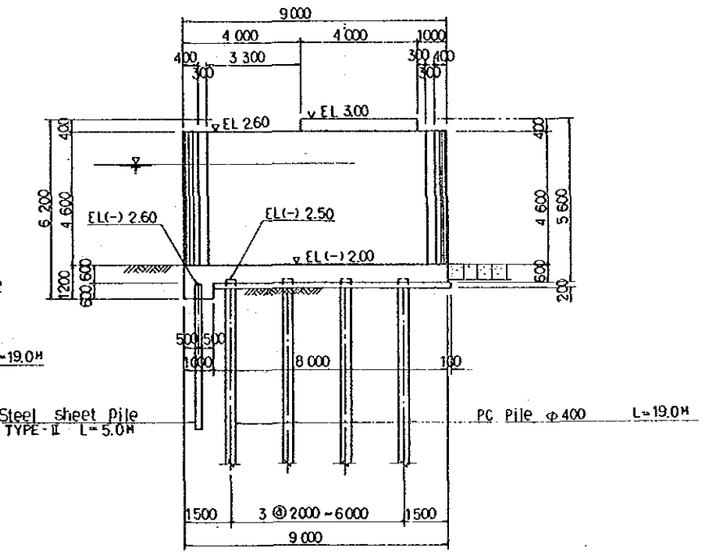
Section A — A



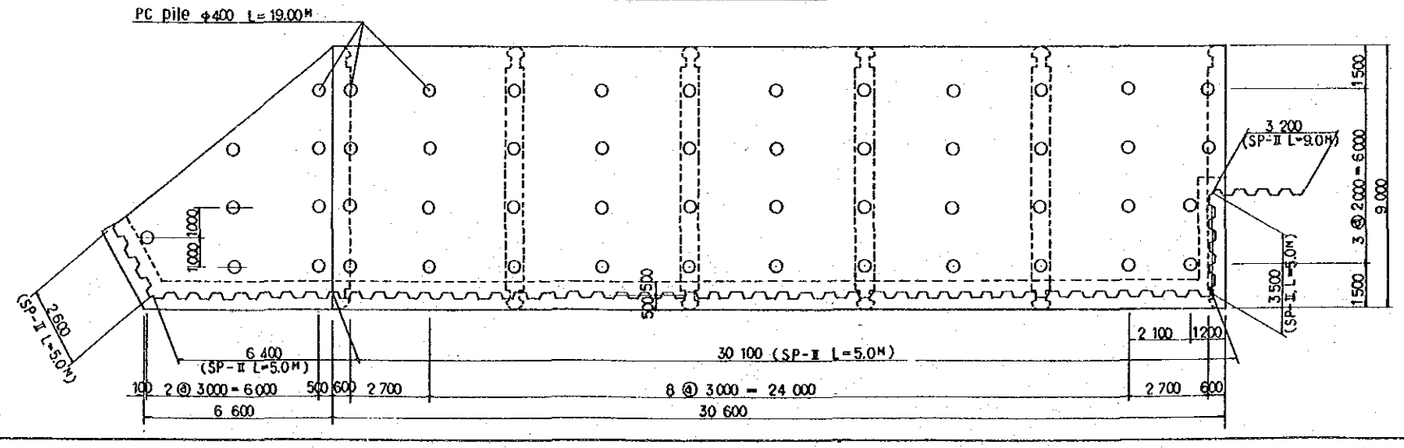
Front Elevation



Section B — B



Plan of Base Slab

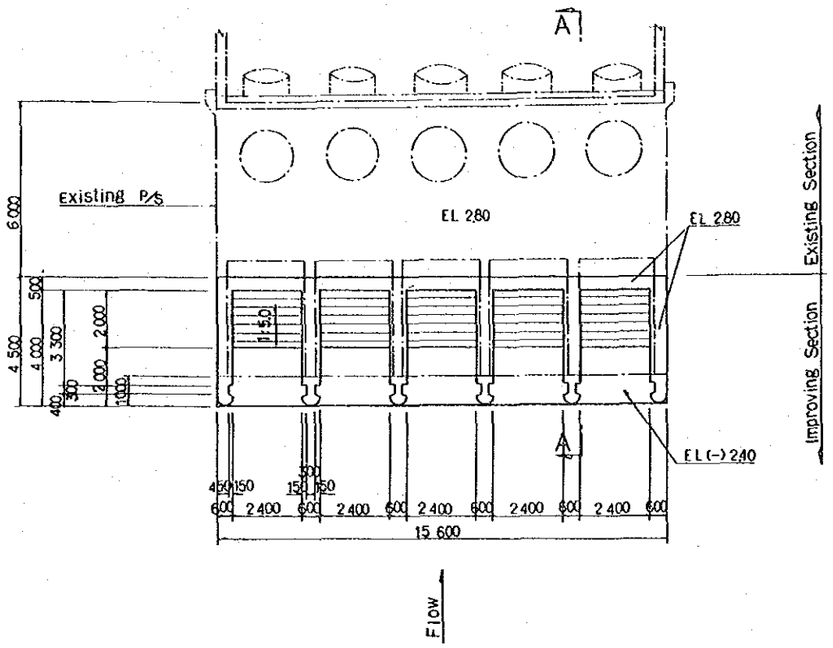


Scale 0 1 2 3 4 5 10 (m)

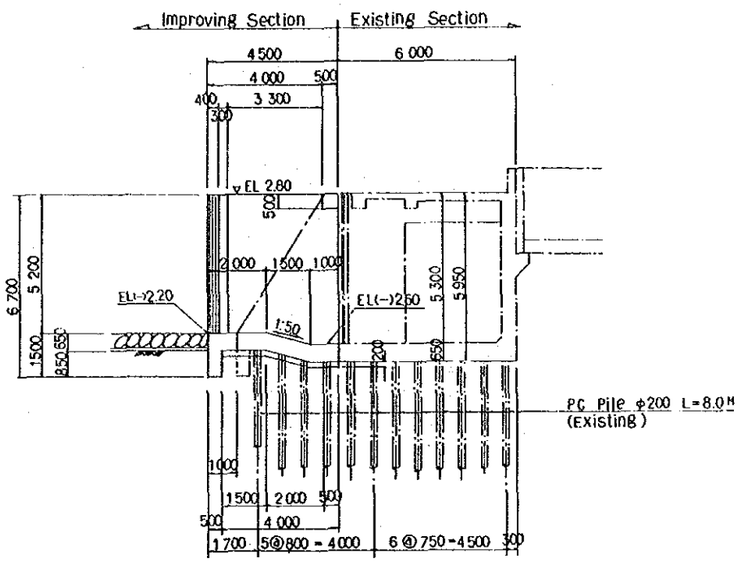
THE KINGDOM OF THAILAND	
IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE	
DETAIL OF NEW STRUCTURE PHRA KHANONG LEFT-BANK PUMPING STATION	
DATE	DRAWING NO. 07
JAPAN INTERNATIONAL COOPERATION AGENCY	

Sam Rong (bank)
(NO 1)
(NO 2)

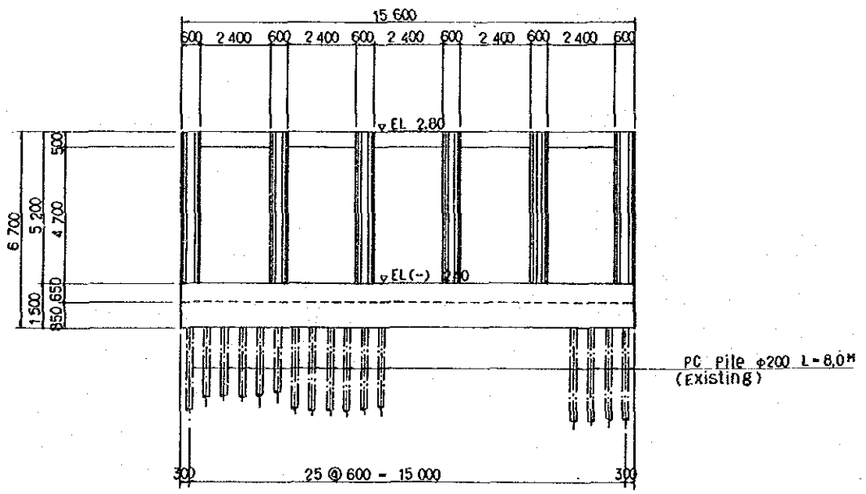
Plan



Section A – A



Front Elevation



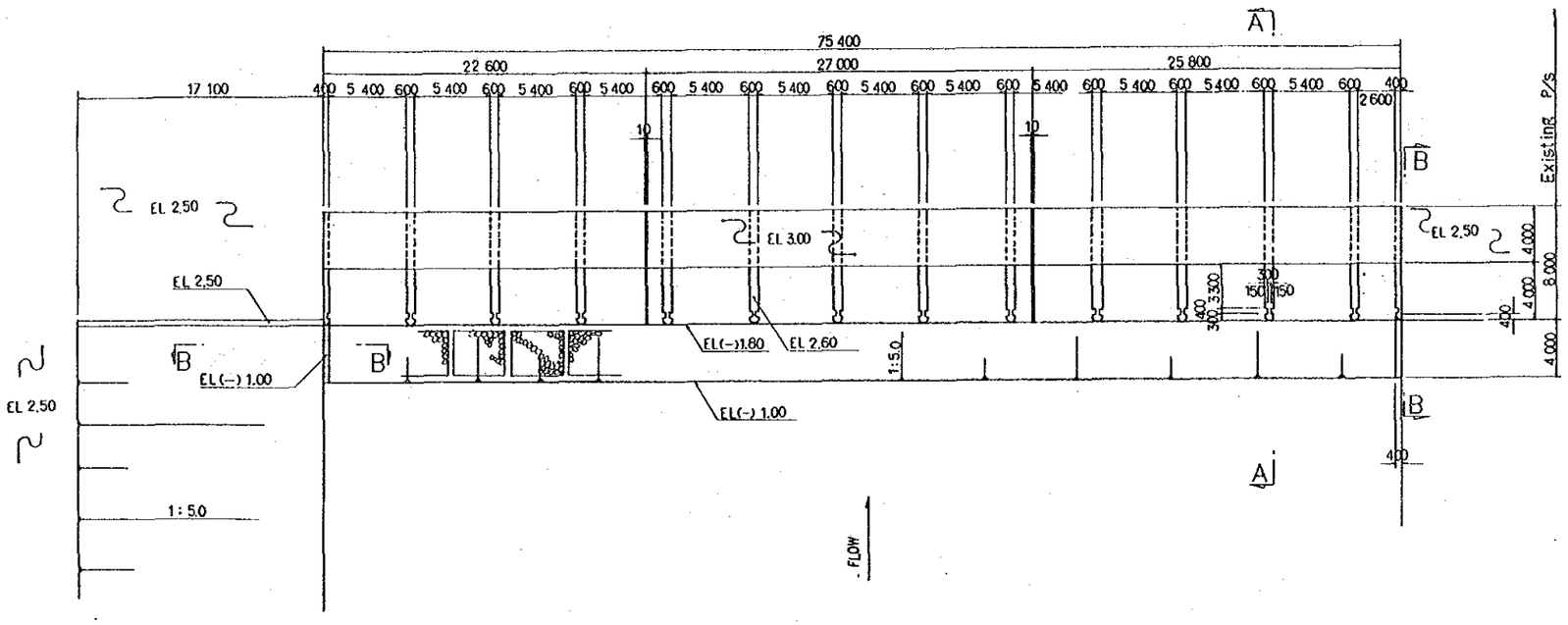
Scale 0 1 2 3 4 5 10 (m)

THE KINGDOM OF THAILAND			
IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE			
DETAIL OF IMPROVING STRUCTURE SAM RONG LEFT-BANK PUMPING STRUCTURE			
DATE		DRAWING NO.	08
JAPAN INTERNATIONAL COOPERATION AGENCY			

Charoen Rat

Plan

Scale 0 2 4 6 8 10 20 (m)



Section A — A

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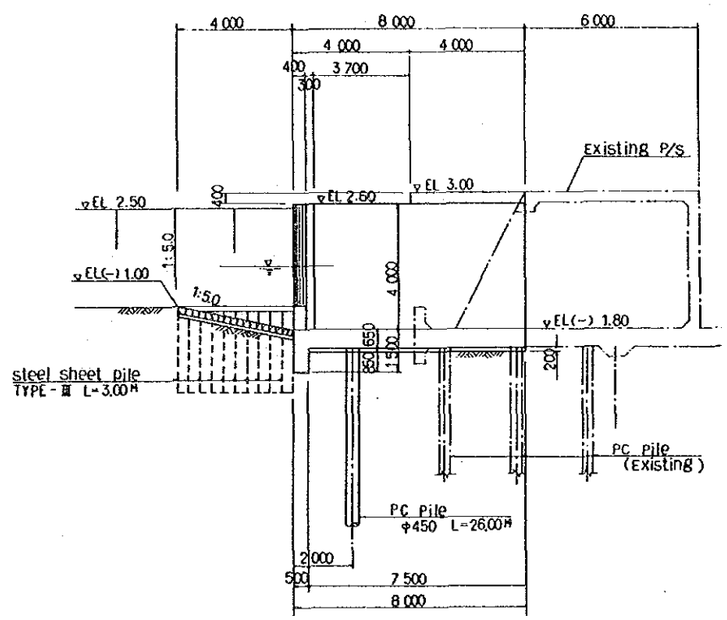
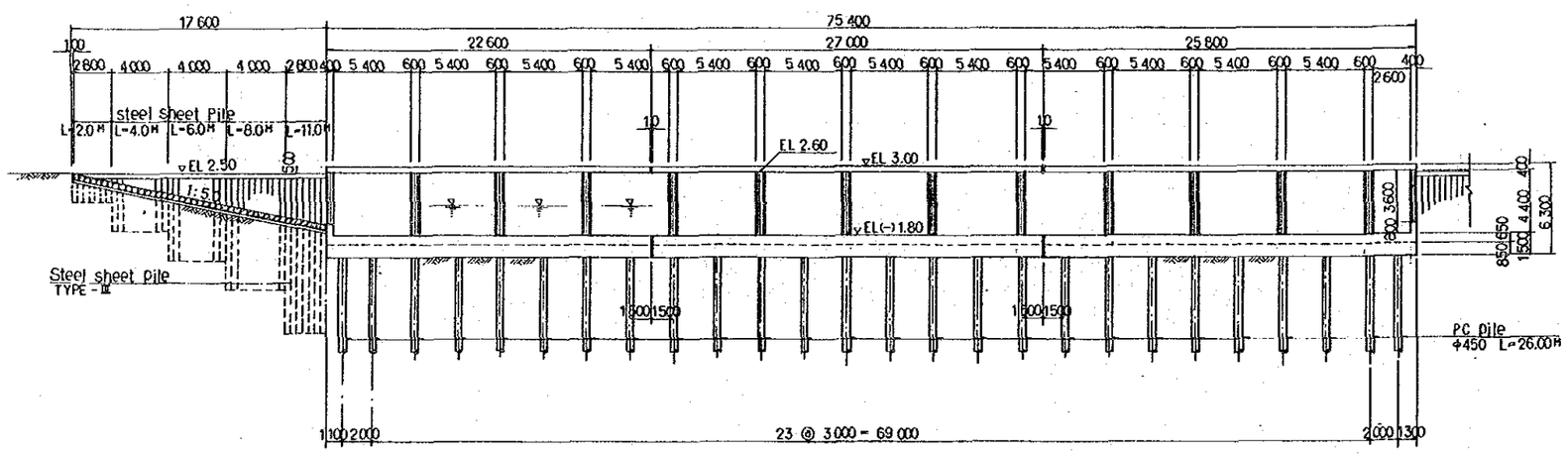


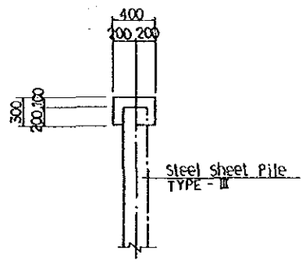
Flont Elevation

Scale 0 2 4 6 8 10 20 (m)



Section B — B

Scale 0 5 10 15 (m)

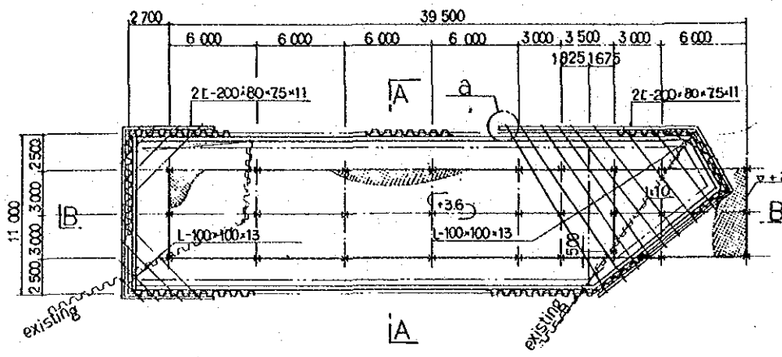


THE KINGDOM OF THAILAND			
IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE			
DETAIL OF IMPROVING STRUCTURE CHAROEN RAT PUMPING STATION			
DATE		DRAWING NO.	09
JAPAN INTERNATIONAL COOPERATION AGENCY			

Phara Khanong

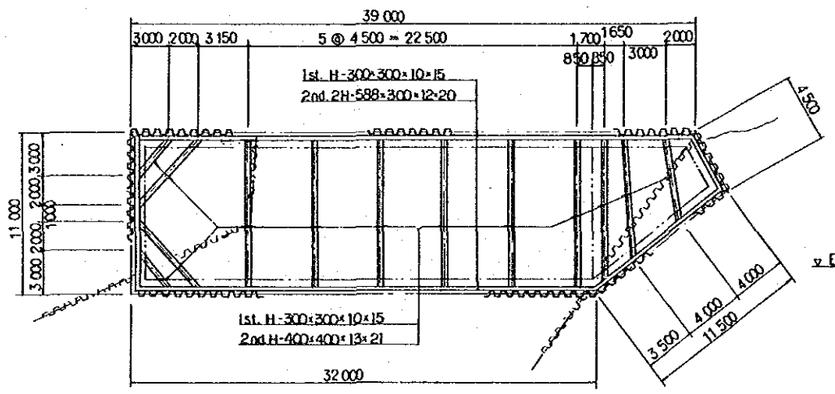
Temporary Decking Plan

Scale 0 2 4 6 8 10 (m)



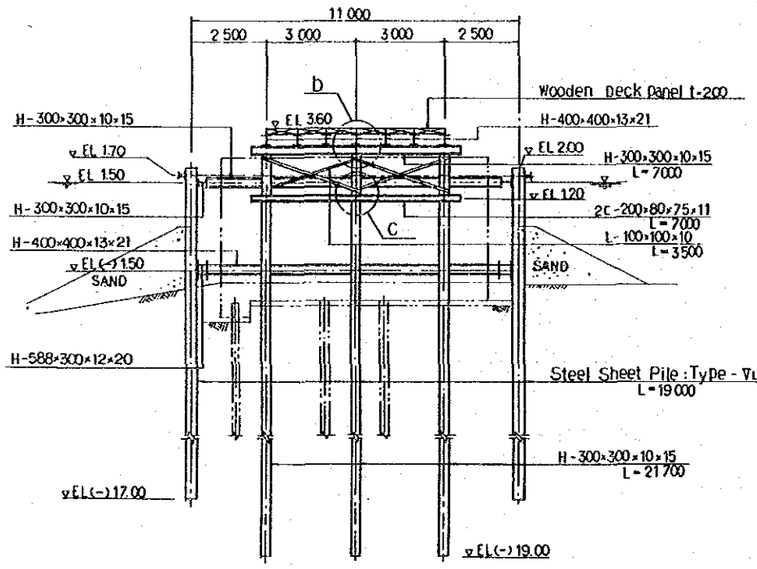
Strutting Plan

Scale 0 2 4 6 8 10 (m)



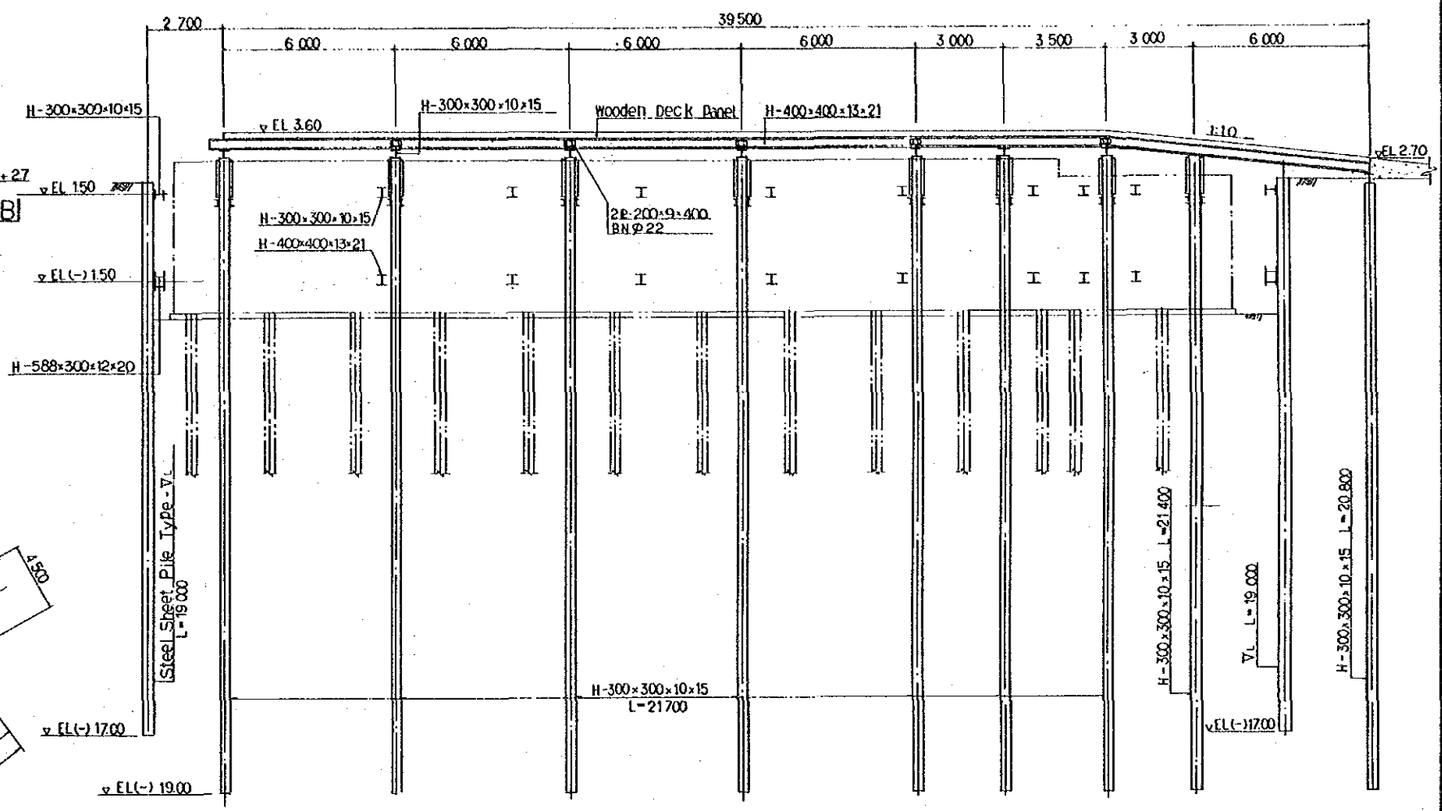
A — A

Scale 0 1 2 3 4 5 (m)



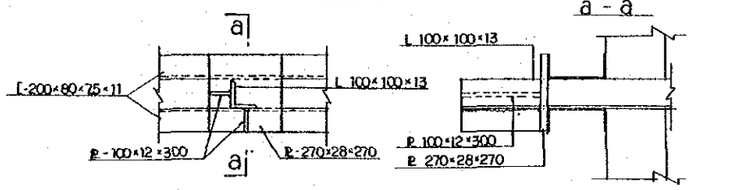
B — B

Scale 0 1 2 3 4 5 10 (m)



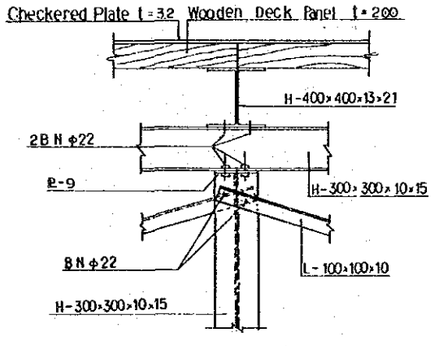
Detail 'a'

Scale 0 0.5 (m)



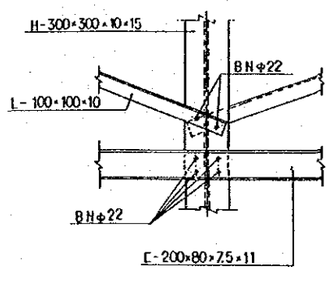
Detail 'b'

Scale 0 1 (m)



Detail 'c'

Scale 0 1 (m)

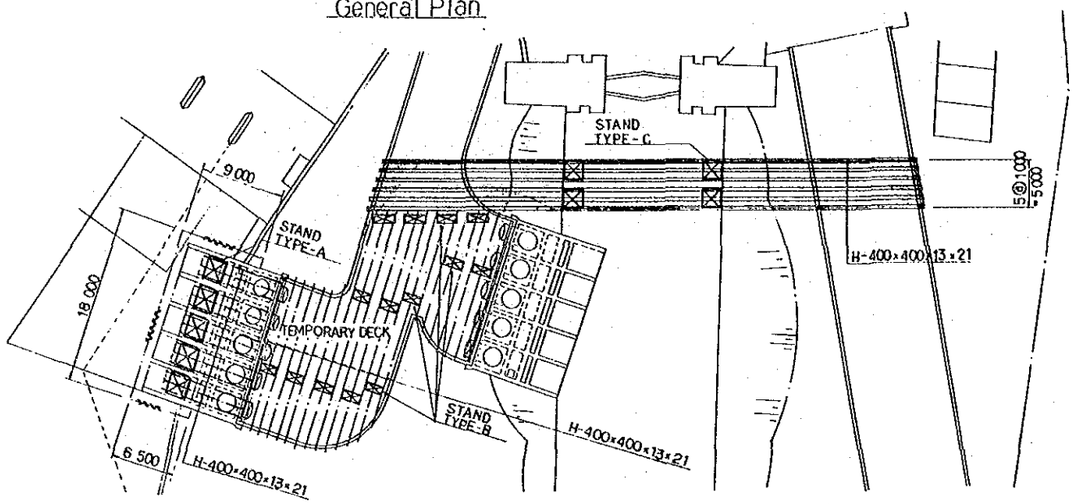


THE KINGDOM OF THAILAND			
IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE			
DETAIL OF TEMPORARY FACILITY PHRA KHANONG LEFT-BANK PUMPING STATION			
DATE		DRAWING NO.	10
JAPAN INTERNATIONAL COOPERATION AGENCY			

Sam Rong

General Plan

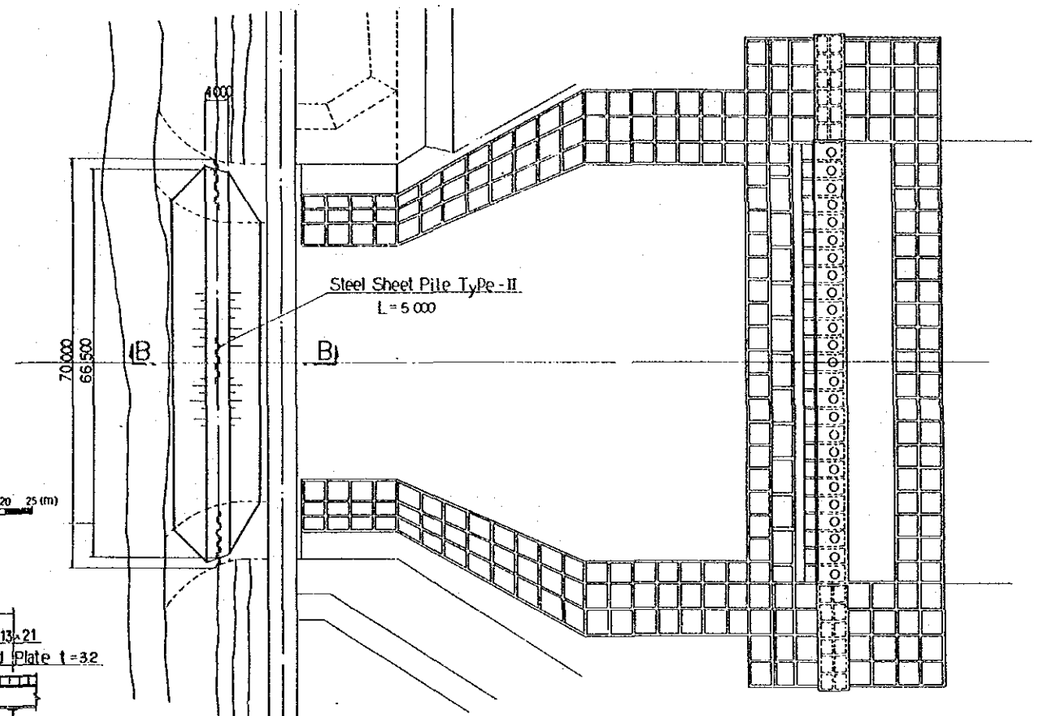
Scale 0 5 10 15 30 (m)



Charoen Rat

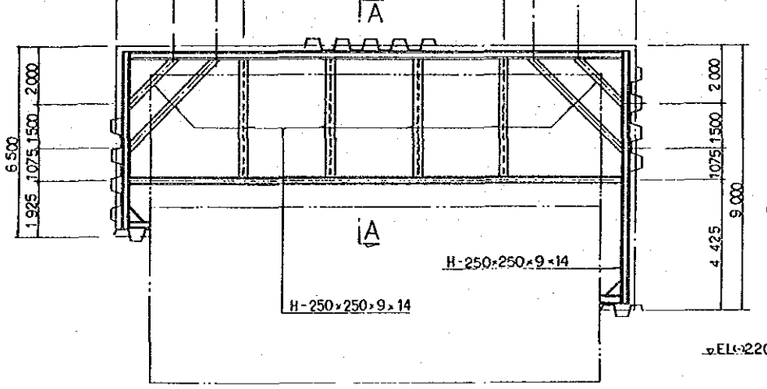
Plan

Scale 0 5 10 15 20 25 50 (m)



Strutting Plan

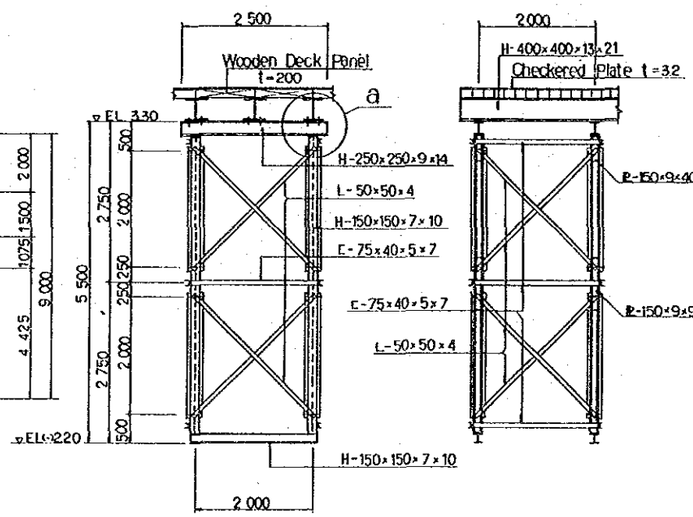
Scale 0 2 4 6 8 10 (m)



Decking Details

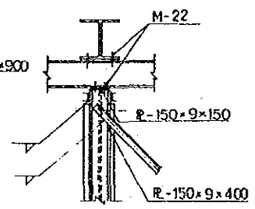
Scale 0 5 10 15 20 25 (m)

TYPE – A



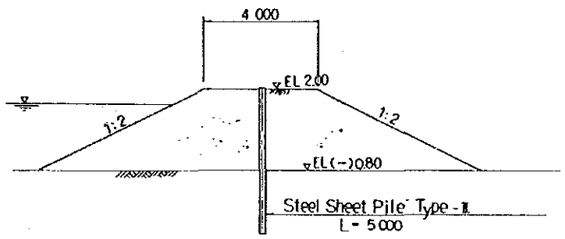
Detail "a"

Scale 0 5 10 15 (m)



B — B

Scale 0 2 4 6 8 10 (m)



A — A

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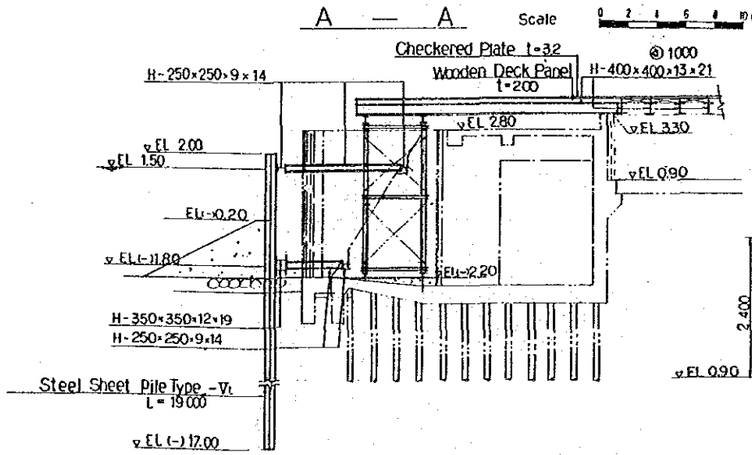
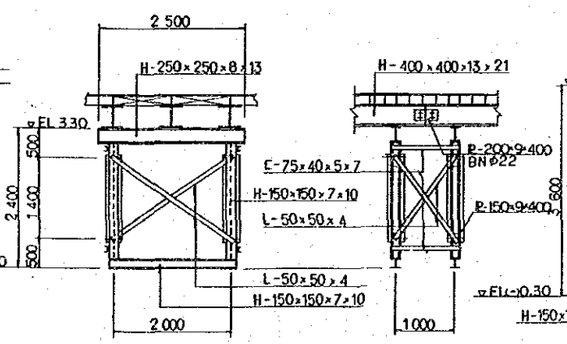
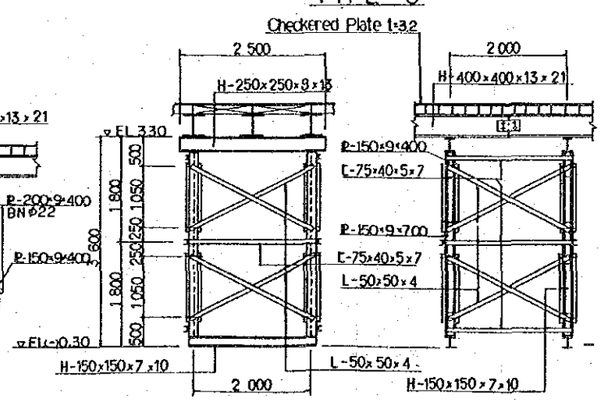


TYPE-B



TYPE-C



THE KINGDOM OF THAILAND	
IMPROVEMENT OF EXISTING PUMPING STATION FOR IRRIGATION AND DRAINAGE	
DETAIL OF TEMPORARY FACILITY SAM RONG LEFT-BANK AND CHAROEN RAT PUMPING STATIONS	
DATE	DRAWING NO. 11
JAPAN INTERNATIONAL COOPERATION AGENCY	

CHAPTER 5 PROJECT IMPLEMENTATION PLAN

CHAPTER 5 PROJECT IMPLEMENTATION PLAN

5-1 Project Implementation System

(1) Project Implementing Agency

The implementing agency of this project lies in RID, which is in charge of land irrigation and drainage services in the Kingdom of Thailand. This plan is designed to install automatic trash rakes in the existing drainage pumping facilities. The Operation and Maintenance Division of RID is responsible for the operation, maintenance, and management of these facilities. It is most desirable, therefore, that the Division oversees the installation and the subsequent operation and maintenance of the automatic trash rakes along with the pumps.

However, it is necessary that other departments of RID, such as the Water Management Division, Research and Laboratory Division, Design Division, and Mechanical Engineering Division, participate in or cooperate with the Operation and Maintenance Division in the implementation of this project, thereby giving full play to RID's function as a whole. This is both because all the pump sites proposed under the current project have vast farmland (paddy fields) behind them and because the installation of automatic trash rakes is the very first attempt of its kind ever made in the Kingdom of Thailand.

RID is a thoroughly experienced implementing agency that has received and accepted Japanese grant aid assistance many times in the past. Therefore, RID clearly possesses the institutional and administrative capacity for executing the project.

(2) Consultant

To support the Government of the Kingdom of Thailand for procurement of automatic trash rakes as well as the design of equipment and material, manufacturing management service, supervision of construction work and other jobs pertaining to the construction of civil

structures needed to install automatic trash rakes shall all be executed by a consultant of Japanese nationality.

After closing Exchange of Notes concerning the grant aid assistance, the Government of the Kingdom of Thailand shall enter into a contract with the Japanese consultant in respect of the Japanese consultant undertaking the following.

1) Making a detailed design of equipment, material, and civil structures that conforms to the basic design report.

2) Preparing tender documents pertaining to the procurement of equipment and material and to the construction of civil structures (including the preparation of technical specifications).

3) Executing tender procedures in the capacity of an agency as well as analyzing and evaluating tender documents.

4) Giving advice and recommendation through negotiations between the Government of the Kingdom of Thailand and successful bidders.

5) Acting as an inspector of equipment and material when these are manufactured and delivered.

6) Implementing and supervising the installation of equipment and material as well as the construction of civil structures.

7) Attending in the delivery of all facilities.

Strict process control will be required under this project when executing the foregoing undertakings in accordance with the Japanese grant aid assistance. As mentioned before, RID is thoroughly experienced in dealing with grant aid projects, and so it is necessary that the consultant should have experience, knowledge, and organization competent enough to perform its job promptly.

(3) Contractor

Construction of civil structures as well as delivery of equipment and material shall be executed by a contractor of Japanese nationality. While the consultant performs tender procedures and services, the Government of the Kingdom of Thailand shall conduct a tender and make a contract with the contractor. The contractor's job and duties can be roughly divided into the following two categories.

1) Manufacture, delivery, and installation of equipment and material

The contractor shall execute on-the-spot installation of equipment and material not later than the date prescribed in the contract. The services to be performed by the contractor include explanation, instruction, and manual preparation regarding the assembly, installation, trial run, maintenance, inspection, and daily management of the equipment and material.

2) Construction of civil structures

The contractor shall construct civil structures under adequate process control so that the on-the-spot installation of equipment and material is completed by the prescribed date.

The above-mentioned jobs and duties ought to be done under strict process control in a place where there are existing pumping facilities. It is essential, therefore, that the contractor be thoroughly experienced in the installation of similar equipment and material in Thailand.

5-2 Construction Work Allotment

In case this project should be carried out under grant aid assistance, the allotment of construction work based on the grant aid system as well as the division of the entire project between Thailand and Japan, according to the results of discussion between the study team and the Government of the Kingdom of Thailand, shall be determined as follows.

(1) Work allotted to Japan

1) Grant and installation of automatic trash rakes and waste conveying facilities

2) Construction of civil structures necessary for the installation of granted trash rakes

3) Improvement of electric apparatus for linking operation of the existing pumps and trash rakes

4) Improvement of water gauges to facilitate the maintenance of existing pumps

5) Installation of cranes to facilitate the maintenance and inspection of existing pumps

6) Transporting the granted equipment and material to the pump sites both by water and by land

7) Consulting service regarding the procurement of equipment and material as well as construction of civil structures

(2) Work allotted to Thailand

1) Procurement of space (prior to construction work) necessary to construct civil structures

2) Procurement of an approach road necessary for the construction of facilities and for the conveyance of equipment and material

3) Exempting the granted equipment and material from Thai customs duties and other taxes

4) Preparation of hauling machinery (trucks, barges) necessary to quickly dispose of the trash removed by automatic trash rakes

5) Establishment of an organization responsible for the maintenance and management of all the facilities after completion

6) Taking other measures and procedures necessary to facilitate the execution of this project

5-3 Construction Work Schedule

5-3-1 Principles of construction work

This is a project to install the automatic trash rake in the existing pump stations in order to prevent flooding in the Bangkok metropolitan area. Some of the existing pumping stations require improving of the suction water tanks, while some require construction a new structure in the vicinity. The civil work, therefore, ought to be completed by the end of the low water period so that the work does not interfer with the draining job performed by the existing pumps and drainage gates, which otherwise might give rise to flooding. For this purpose, the period, method of civil work, the procurement of construction machinery shall be adequately studied and carefully planned.

In addition, the temporary work plan requires a thorough examination, because of the complicated distribution of existing facilities and the extreme instability of the ground. Therefore, it is important that civil engineers who have experience in construction work under these conditions supervise the construction work. For this purpose, sending of qualified engineers to the construction site should also be given due consideration.

As considerable difficulties are expected with regard to the construction period and other conditions, it is important to secure skilled local staff and workers as well as qualified Japanese engineers and office workers. Many people in Thailand are adequately trained in industrial fields, so there should not be a problem in securing a work force. Nevertheless, securing proper personnel should be given a higher priority in these project.

In the pumping stations where no structural extention is necessary, on the other hand, it is advisable that automatic trash rakes be installed immediately after their production and delivery. It is probable, however, that the delivery of equipment may carry over into the high water period because of the schedule of production. In anticipation of this, it is recommended that an installation method that allows automatic trash rake to be installed while the existing pumps are ready to run be employed.

5-3-2 Suggestions on construction work

The following points call for particular attention when improving civil structures or installing automatic trash rakes in existing pumping stations.

(1) Civil work

1) The soil in and around Bangkok has a layer of very soft Bangkok clay ($N < 10$) about 20 to 25 m underground. As a result, temporary structures such as piles and coffer dams tend to be larger and the steel materials being used tend to be of larger size of specific type. Some of these are not readily available locally, and so the procurement of equipment and material must be carefully examined.

2) All three construction sites are in contact with a drainage canal and therefore coffer dam is necessary. Solid and stable temporary equipment needs to be established so that no delay occurs in construction work because of deficient temporary equipment.

3) At the Phra Khanong and Sam Rong pumping stations, a lot of drainage facilities are intricately arranged in a small area. Therefore, temporary equipment needs to be carefully checked and planned so that machinery and material can be easily carried in or out and so that construction work can go on without a hitch.

4) The Phra Khanong and Sam Rong drainage canals are badly contaminated and their water is extremely deteriorated in quality because of rubbish and garbage discharged by the community inhabitants. Attention must be paid to the health of the workers engaged in construction work by taking necessary measures such as installation of sanitary equipment.

(2) Installation of automatic trash rakes

1) The Phra Khanong right-bank and Sam Rong right-bank pumping stations have no civil structures that require improving work. In the Charoen Rat pumping station, any repair work on civil structures will be completed before the high water season when the pumps are in full operation. Consequently, the installation of automatic trash rakes in these three pumping stations shall be executed during pump operation. When the pumps are in operation, water hyacinths tend to flow in large quantities down to the pumping station. It is necessary, therefore, to take some preventive or protective measures so that the progress of the installation work will not be affected by such rubbish.

2) In the Phra Khanong right-bank pumping station, which is situated away from the land, automatic trash rakes shall be installed through transportation over water by barge. The installation work will be done during the period of pump operation when the stream or the surface of waters tends to be disturbed. Attention must be paid so that the progress of the installation work and the safety of the workers is not affected by such disturbances.

3) As described above, the installation work on automatic trash rakes is supposed to be performed under pretty difficult conditions. It therefore requires to send skilled workers from Japan and secure excellent local staff beforehand. In addition, it is hoped that officials (as many as possible) from the Operation and Maintenance Division of RID will participate in this job, considering the future necessity of personnel who shall be responsible for maintenance and management after completion of the installation work.

5-3-3 Construction and supervision program

(1) Construction

The form of construction work

Contractors who undertake to execute this program shall collectively perform all their jobs including: construction of civil structures needed to install automatic trash rakes; installation, trial run, and delivery of automatic trash rakes subsequently. Yet, jobs in different categories, that is, production and installation of machinery and construction of civil structures, are included in contractor's duties.

Since the production and installation of machinery account for a large percentage of project expenses in this program, it is hoped that machinery producers will be appointed as contractors. However, a pretty difficult temporary job and construction work administration job are involved in the civil work. To realize the completion of reliable facilities as a whole, it is advisable that, under contractor's responsibility, the civil work should be assigned to reliable Japanese contractors who specialize in civil engineering.

Start of the civil work

Without closing rivers, it is impossible to carry out any civil work. The coffer dam must be removed by August, when full operation of the pumps begins. In the Phra Khanong left-bank and Sam Rong left-bank pump stations, a considerable quantity of steel materials needs to be used for temporary work and it takes quite a long time to procure it.

According to the proposed work schedule, this might make it impossible to remove the coffer dam before the rainy season, although this depends on when the Japanese grant aid assistance program starts. In these two pumping stations, therefore, it is necessary to set about the construction of coffer dam in November, when pump operation is almost stopped, or at least reduced by half.

At the Charoen Rat pumping station, the coffer dam is done by embankment and therefore the civil work can be completed within 3.5 months if it proceeds day and night without uninterruption. Depending on the time when the Japanese grant aid assistance program starts, it may be possible to complete the civil work and remove the coffer dam by the time full-scale pump operation begins. If that is possible, automatic trash rakes can be installed while the pumps are in operation, making it possible to shift them during the period when full-scale pump operation is under way.

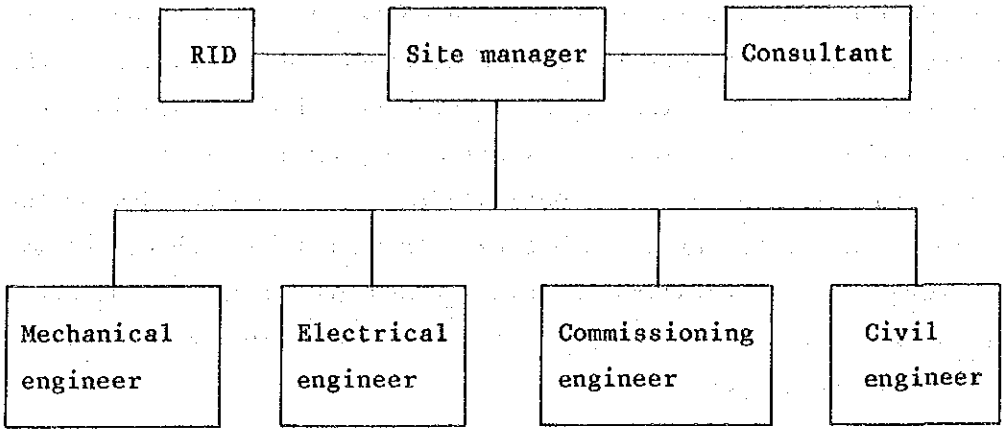
Construction work system

All the civil work can be divided into two periods, starting work before the wet season and starting work after the wet season. The work ceases for about 3 months between these periods, but local procurement of steel materials used for temporary works shall not be discontinued.

After reviewing the construction work schedule, it was found that the work ought to be completed within a limited period of time whether it starts before or after the wet season. It is necessary, therefore, to establish a work scheme based on two day-and-night shifts.

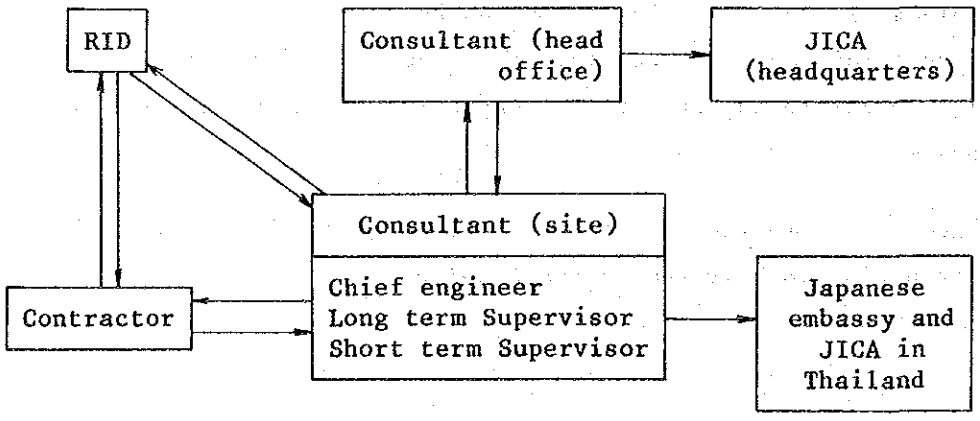
The machinery installation work is divided into two stages: installation at pumping stations where civil structures need not to be improved; installation work begun after completion of civil work at pumping stations where the work starts after the end of the rainy season. Machinery installed early enough can be operated during the rainy season. This makes it possible to conduct a trial run for RID personnel, a possible opportunity for operation training and maintenance/management instruction.

Based on the findings and considerations given above, an outline of the construction work system is shown below.



(2) Construction supervision system

The construction work supervision shall be performed by the engineer in charge of civil engineering, who will be stationed as a supervisor on the site throughout the project period because the engineering work is expected to take a long time. The machinery installation work shall be supervised by mechanical and electrical engineers. One of a succession of chief engineers, who administer the entire project, shall act as a supervisor at the start of work, at the midpoint of work, at final delivery, and at fabrication of the machinery in Japan. As necessary, all these engineers shall be responsible for communication, reporting, instruction, issuance of certificates, and so on.



5-3-4 Equipment and material procurement plan

(1) Civil work

As much of the equipment and material used in the construction work shall be procured locally as possible. Among the various steel materials used for coffer dam, large-sized pieces must be used for the main steel material because the foundation is composed of very soft soil. It is considered that the main steel had better be procured from foreign country, because this kind of material is not available on the local market. Due to the character of the Japanese grant aid assistance project, it is considered that the Japanese market is the most stable source of supply in order to complete the construction work within a limited period of time.

The equipment and material necessary for the construction work shall be procured either in Thailand or in Japan, as itemized below.

Procurement in Thailand	Procurement in Japan	Reason
. Steel sheet pile (Type II and III)	. Steel sheet pile (Type V)	Specific material
. Lightweight shaped steel beam	. H-300 x 300	Too long
. Ready mixed concrete	. Tie rod	Too large in diameter
. Reinforcing bar		
. Wooden material		
. PC pile		
. Stone material		
. Construction machinery		

(2) Trash rake installation work

To ensure that automatic trash rakes should be established firmly, tools needed for their installation shall be brought from Japan, except for installation machinery. The distinction between procurements in Thailand and in Japan is shown below.

Procurement in Thailand	Procurement in Japan	Reason
. Installation machinery	. Automatic trash removing equipment	Specific equipment
. Installation vessel	. Installation tool	"
. Expendable supplies	. Installation-testing instrument	"

5-3-5 Construction works to be taken by the Government of the Kingdom of Thailand

The primary purposes of this project is the installation of automatic trash rakes at existing pumping stations. Improving work on the existing structures to prepare for the installation is important but secondary. Partly because this project is intended to deal with the existing facilities under the Japanese grant aid assistance and partly because the major infrastructures have already been prepared, little construction work is to be executed at the expense of Thailand. The jobs and work to be done by the Government of the Kingdom of Thailand are described next.

(1) Phra Khanong pumping station

Automatic trash rakes will be established in a place upstream from the Phra Khanong left-bank pumping station. A new structure is needed for the purpose of installing trash rakes, and some additional space is needed in the neighborhood of the new structure for its construction.

In this place there is a house for RID personnel at the present time. There is also a shrine at the boundary with the adjacent private land. It is necessary that RID remove these buildings by the time the preparatory construction work on this project starts. This is essential to the smooth progress of construction work, which will have to be done under severe, difficult conditions.

(2) Sam Rong pumping station

In order to approach the Sam Rong right-bank pumping station from nearby trunk roads, it is unavoidable to go through a path where tent shops stand roof by roof. When installing trash rakes in the right-bank pumping station as well as when conducting structure improve and trash rake installation work at the left-bank pumping station, it is expected that a good many incoming and outgoing motor vehicles will carry equipment and material over this path.

It is necessary that RID remove these shops by the time the project work starts. It is essential that the removal will be accomplished beforehand in light of the work schedule.

Over the temporarily route approaching the left-bank pumping station, there are power transmission lines stretched around to the adjacent private houses. It is necessary that RID move these lines to another route or raise them up to a height free from trouble. It is essential that such measures be accomplished prior to construction of an approach road to the left-bank pumping station.

5-3-6 Project implementation schedule

This project will be inaugurated after conclusion of the Exchange Notes between both Governments of the Kingdom of Thailand and Japan. After conclusion of the Exchange Notes, RID shall enter into a contract with the Japanese consultant regarding the supervision work for the procurement and installation of equipment and material as well as the construction work on the civil structures.

After conclusion of the contract, the consultant shall work out a detailed design, draw up detailed design drawings, write out specifications, and prepare tender documents. After these papers are approved by both Governments, the consultant shall invite the Japanese equipment and material manufacturers to offer a bid, and then observe the conclusion of a contract between the successful bidder and the Government of the Kingdom of Thailand. It will take about three months to go through these procedures from the conclusion of the Exchange Notes to the successful bidder's contract.

The contractor shall be responsible for the fabrication and procurement of the necessary equipment and material as well as for the construction of civil structures.

In the three pumping stations (Phra Khanong right-bank, Sam Rong right-bank, and Charoen Rat), either no civil work is necessary or only short-term civil work will suffice. For the convenience of these three pumping stations, the fabrication of equipment and material shall be started immediately after conclusion of the above-mentioned contract. It will take about three and a half months to complete the fabrication. Adding one month for the subsequent transportation by sea, it will take about four and a half months altogether for the equipment and material to reach Thailand.

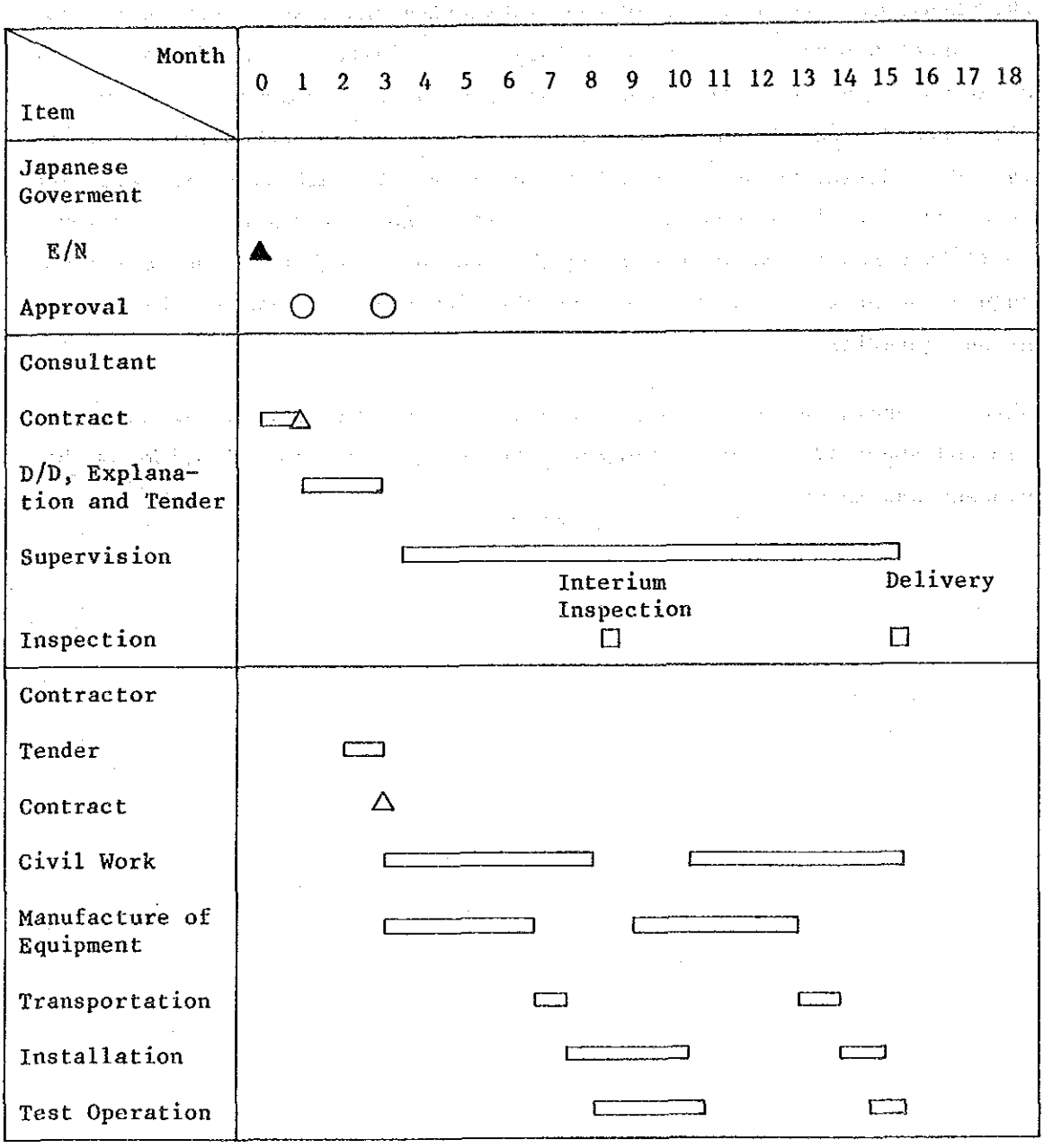
About the same time that the fabrication of the equipment and material starts, the improving work in the Charoen Rat pumping station begins. This improving work takes about four months, but it shall be completed in time for the arrival of the equipment and material. The installation work and trial run in the three pumping stations will take about two months to finish. Therefore, it will take about six and a half months altogether to go through the stages from fabrication of equipment and material to on-the-spot installation and trial run.

In the two pumping stations (Phra Khanong left-bank and Sam Rong left-bank), on the other hand, the temporary work will be conducted on a large scale, requiring a lot of time to procure the steel materials used for temporary work. The procurement of these steel materials must be started at the same time as the conclusion of the contract so that it should be completed in time for the construction work starting after the end of the rainy season.

The construction work takes about four months, including the temporary work. Equipment and material must be fabricated and transported in a relatively short period of time so that they can be installed immediately after completion of the construction work. The amount of equipment to be installed has decreased and the frequency of pump operation has fallen extremely. Considering these factors that facilitate the job, both installation work and the trial run must be finished within about one month. Therefore, it will take about five months altogether to go through the processes from inauguration of the civil work to installation and trial run of the equipment and material.

Figure 5-1 shows the entire work schedule as described above. It will be estimated about 12.5 months altogether to complete the installation of the equipment and material.

Fig. 5-1 Implementation Schedule



5-4 Project Cost

In implementing this project, the Government of the Kingdom of Thailand shall also bear a part of the construction cost. The cost to be borne by the Government of the Kingdom of Thailand is as follows.

(1) Transfer cost of RID's staff houses

It is necessary that RID transfer the RID's staff houses to get construction yard for the construction of civil structure to install the automatic trash rakes in the Phra Khanong left-bank pumping station. The cost of this will be estimated as follows.

- Area of houses 100 m^2

  (14.5 m long, 4.0 m wide, 1 unit
  5.0 m long, 4.0 m wide, 2 units)

- Transfer cost 100 m^2 x 3,000 baht/m^2 = 300,000 baht

(2) Transfer cost of shops

It is necessary that RID temporarily transfer the shops on the route which will be used as a construction road in the Sam Rong pumping station. The cost of this will be estimated as follows.

- Area of shops 1,000 m^2 (200 m long, 5 m wide)
- Transfer cost 1,000 m^2 x 600 baht/m^2 = 600,000 baht

(3) Total cost

The cost to be borne by the Government of the Kingdom of Thailand will be estimated approximately 900,000 baht.

(4) Preparation of trash hauling machines

So far as the trucks and barges to convey the trush are concerned, those owned by RID are available. Therefore, the cost for these machines is not included in the total cost estimate.

CHAPTER 6 OPERATION AND MAINTENANCE PLAN

CHAPTER 6 OPERATION AND MAINTENANCE PLAN

6-1 Operation and Maintenance System

This is a project for the installation of automatic trash rakes in the existing drainage pumping stations. The operation and maintenance systems for existing pumps have already been established. However, it is necessary to establish operation and maintenance routines, based on the installation of automatic trash rakes so that maximum performance of all functions of pumping facilities can be realized.

Periodic inspection and maintenance are important to the smooth operation of automatic trash rakes. The types of periodic maintenance and inspection can be classified as shown below.

(1) Inspection when operation has ceased

Periodic inspections shall be conducted when operations cease after the flood season.

(2) Annual inspection

Annual inspection shall be carried out prior to the flood season, and all facility functions, including comprehensive test operations, shall be confirmed.

(3) Regular inspection

After annual inspection has been done, regular inspections shall be carried out periodically, in order to maintain facilities in operating condition. This is done in preparation for operation.

(4) Inspection at the time of operation

1) Inspection prior to operation

The presence of any irregularities will be noted prior to the starting and operating the facility.

2) Inspection during operation

Surveillance and inspection shall be carried out during operation, for the purposes of efficient operation and early discovery of mechanical problems.

3) Inspection after operation

The presence of any irregularity will be noted after operation has finished.

Classification (4), Inspection at the time of operation, must be done by the operator of the pump to achieve quick operation of the pump. Also, the automatic trash rakes to be installed by this project are planned for linkage with pump operation. Therefore, both the pump and the automatic trash rake should be inspected by the same person. Also, where the inspections listed in (1) - (3) above are done satisfactorily, this should reduce the duties of inspection at the time of operation of the automatic trash rakes, and should simplify them. Therefore, the pump operator shall control both items of equipment simultaneously at the time of operation.

Inspections and maintenance listed in (1) - (3) should be done thoroughly and carefully, when the automatic trash rake is not in use. It is therefore appropriate that a technician, who has thorough knowledge of the mechanism of the automatic trash rake, should inspect it while receiving a detailed report from the pump operator on the situation during operation of the facilities. It is desirable that this technician not only have a knowledge of machinery, but also have electrical knowledge. At present, 4 groups, each consisting of 6 members chosen and organized from among the workers in charge of pumping operation region 5 of RID, carry out maintenance and control of the pumping stations involved in this project. The

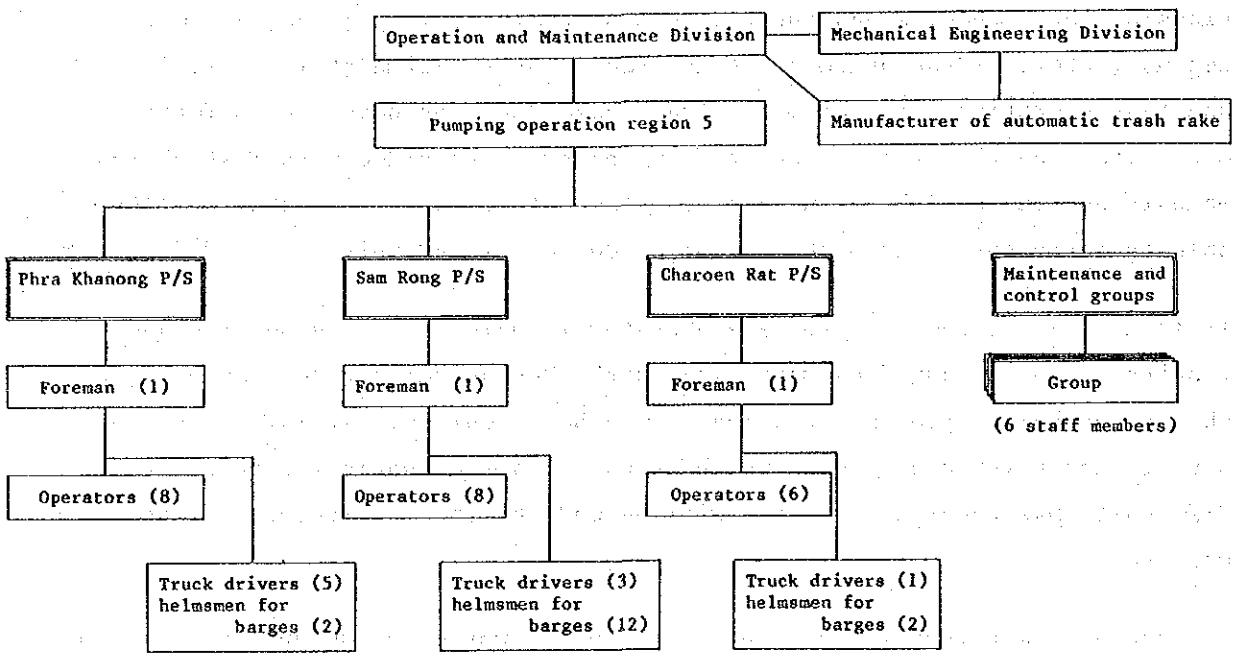
staff members in these groups are technicians who have mechanical and electrical knowledge of pumps, and they shall therefore be appointed to carry out the duties of inspection and maintenance of the automatic trash rakes. The manufacturer of the automatic trash rakes will provide explanations of the mechanism and instructions on the use, inspection, and maintenance, etc., of the automatic trash rakes, at the time of installation and test operation. An automatic trash rake does not have a complicated mechanism, and therefore, when staff members are provided with instruction manuals and on-the-job training at the time of installation, they will be able to carry out their machine control duties effectively.

It is necessary, however, to have a system in which quick inspection and repairs can be arranged by reporting to the Mechanical Engineering Division when a mechanical problem or irregularity has occurred. It is also necessary to establish a system in which, when a major mechanical problem or difficulty has occurred, repairs will be made by the manufacturer of the machine.

The scale of machines for hauling the refuse removed by the automatic trash rakes to the designated locations is described in 4-3-1 (3). Operation and control will be done by the individual drivers. However, the foreman of each pumping station shall carry out the duties of comprehensive control and command, for the machines and materials belonging to the pumping station.

The following diagram shows the organization for operation, maintenance, and control of automatic trash removal facilities, which has been prepared in consideration of the previously mentioned content and the existing operation and control system.

Fig. 6-1 Organization for the Operation and Maintenance of Automatic Trash Removal Facilities



Total 74 persons

6-2 Inspection and Maintenance Plan

The following are the major items which constitute the automatic trash removing facilities.

(1) Main body of automatic trash rake
(2) Horizontal belt conveyor
(3) Inclined belt conveyor
(4) Hopper
(5) Trucks and barges

The series of equipment from the automatic trash rake to the hopper must be operated smoothly. If it is not, the result will have a direct bearing on any operation of the pumps. Therefore, periodic inspection and maintenance are needed to maintain smooth operation of these facilities. The content of periodic inspection and maintenance is classified into 4 stages, as stated in the previous section 6-1. Table 6-1 to 6-4 show the items for inspection and maintenance for each stage.

Table 6-1 (1) Regular Inspections, Annual Inspections, and Instections when Operation of Trash Rake is Interrupted

Level of importance			Item	Content	Method	Method and standards for judgment of quality	Method of improvement, or treatment of irregularity
Stopping	Annual	Regular					
A		A	General	State of cleanliness	Visual checking	There should be no dirt adhering.	Cleaning
A	A		Total operation	Condition of each function	Visual checking of operation	Rake movement should be smooth, and should not make any irregular noises.	
	A	A	Motor	Amperage	Visual check	Should be within rated current value	Investigation of cause of overload
A	A	A	Decelerator	Lubricant	Visual check (oil gauge)	The specified quality and the quantity of oil designated, must be used. Oil should not be discolored or muddy.	Adjustment of lubricant quality and quantity
	A		Transmission chain	Elongation	Instrumentation	Any elongation of the chain should be less than about 4% of the distance between the shafts.	Adjustment of chain tension conditions
	A	A	Main body bearing	Generation of noise and heat	Hearing and touching	No irregular noise or heat should be generated.	Greasing. Burned or damaged bearings shall be replaced.
	A		Hydraulic coupling	Oil leak	Visual checking	There should be no leakage of oil.	Tighten the coupling further, or replace the oil seal.
	A		Rake chain	Elongation	Visual checking	The chain, on the side below the sprockets, becomes too loose.	Chain tension should be adjusted by screw take-up, or the chain should be replaced, when the elongation becomes too great for adjustment.
	A	A	Rake	Deformation	Visual checking	The chain and roller should not be off the guide rail, nor should the interlock between the rake and the screen be disturbed.	The rake strain should be relieved, or the rake should be replaced by a new one. The manufacturer of the rake must be notified, for rake correction.
B	B		Frame, rail, and screen	Rust, corrosion, and deformation	Visual checking	Rust, corrosion, and deformation must not be present.	Removal of rust, repainting, and fixing of the strained part

Table 6-1 (2) Inspection when Trash Rake is Operated

Level of importance			Item	Content	Method	Methods and standards for judment of quality	Method of improvement, or treatment of irregularity
Before operation	During operation	After operation					
A		A	General	State of cleanliness	Visual checking	No dirt should adhere.	Cleaning.
	A		Entire operation	Conditions for each function	Visual checking of operation	Must remove refuse satisfactorily, and the functions of the rake and other parts must be smooth and noiseless.	See each of the columns below.
	A		Motor	Amperage	Visual checking (ammeter)	Should be within the rated current value.	Investigation of cause of overload
A	A		Decelerator	Lubricant	Visual checking (oil gauge)	The specified quality and quantity of oil must be used. Oil should not be discolored or muddy.	Adjustment of quality and quantity of oil.
A			Transmission chain	Oiling	Visual checking	There should not be any friction. Lubrication should be done.	If chain is dry, oil must be applied.
	A		Bearing, on main body	Noise and generation of heat	By listening, and by touching with a finger	There should be no irregular noise, and no irregular exothermic reaction (Temperature of bearing should be lower than the surrounding temperature plus 40°C.)	Greasing. Burned or damaged bearings must be replaced by new bearings.
A		A	Hydraulic coupling	Leakage of oil	Visual checking	Should not have any leakage of oil	Additional tightening, or replacement of oil seal
	B	A	Rake chain	Bending and damage	Visual checking	Sprocket fitting must be smooth, and should not squeak. There should be no areas where it does not bend easily. There should be no bends in the link plates, etc.	When corrosion is discovered, or parts which do not bend easily, or which have bends in the link plate, the defective parts should be replaced.
A	B	A	Rake	Deformation	Visual checking	Should not have any deformation.	Rake strain should be corrected, or the rake should be replaced by a new one. The rake manufacturer must be notified, regarding the correction of rake strain.

Table 6-2 (1) Inspection when Operation is Stopped, Annual Inspection, and Regular Inspection of Horizontal Conveyor

Level of importance			Item	Content	Method	Methods and standards for judgment of quality	Method of improvement, or treatment of irregularity
Stopping	Annual	Regular					
A		A	General	State of cleanliness	Visual checking	No dirt should adhere.	Cleaning.
	A		Entire operation	Condition of each function	Visual checking of operation	The belt should not be off-center, and should function smoothly.	See the individual columns below.
	A	A	Gear motor	Amperage	Visual checking (ammeter)	Should be within the rated current value.	Investigation of cause of overload
A	A	A	Transmission chain	Oiling	Visual checking	There should be no friction. The chain should be oiled, and the transmission should operate quietly.	If the chain is found to be dry, apply oil.
	A	A	Bearing	Noise and generation of heat	By listening, and touching with the finger.	There should be no irregular noise, and no irregular exothermic reaction. (The bearing temperature should be no higher than 40°C above the ambient temperature.)	Oiling. A burned or damaged bearing must be replaced with a new bearing.
	A	A	Belt	Abrasion, damage	Visual checking	The belt must not be worn so badly as to have cracks, peeling off of layers of the belt, exposure of canvas by cuts or abrasions, etc.	A belt which has worn badly or which has many cuts or abrasions, shall be replaced with a new belt.
	A	A		Slackness	Visual checking	Slack between carrier rollers should be 2% or less of the distance between carrier pitches.	When the belt is too slack, it should be tightened to increase tension, by using the screw take-up.

Table 6-2 (2) Inspection of Horizontal Conveyor during Operation

Level of importance			Item	Content	Method	Methods and standards for judgment of quality	Method of improvement, or treatment of irregularity
Before operation	During operation	After operation					
A		A	General	Condition of cleanliness	Visual checking	No dirt should adhere.	Cleaning.
	A		Entire operation	Condition of individual functions	Visual checking of operation	The belt should not be off-center, and should function smoothly.	See individual column below.
	A		Gear motor	Amperage	Visual checking (ammeter)	Should be within the rated current value	Investigation of cause of overload
A			Transmission chain oiling	Oiling	Visual checking	There should be no friction. The chain should be oiled.	If the chain is found to be dry, apply oil.

Table 6-3 (1) Inspection when Operation is Stopped, Annual Inspection, and Regular Inspection of Inclined Conveyor

Level of importance			Item	Content	Method	Methods and standards for judgment of quality	Method of improvement, or treatment of irregularity
Stopping	Annual	Regular					
A		A	General	State of cleanliness	Visual checking	No dirt should adhere.	Cleaning.
	A		Entire operation	Condition of each function	Visual checking of operation	The belt should not be off-center, and should function smoothly.	See the individual columns below.
	A	A	Cyclone motor pulley	Amperage	Visual checking (ammeter)	Should be within the rated current value.	Investigation of cause of overload
	A	A	Bearing	Noise and generation of heat	By listening, and by touching with the finger	There should be no irregular noise, and no irregular exothermic reaction. (The bearing temperature should be no higher than 40°C above the ambient temperature.)	Greasing. A burned or damaged bearing must be replaced with a new bearing.
	A	A	Belt	Abrasion and other damage	Visual checking	The belt must not be worn so badly as to have cracks, peeling off of layers of the belt, exposure of canvas by cuts or abrasion, etc.	A belt which has worn badly, or which has many cuts or abrasions, must be replaced with a new belt.
	A	A		Slackness	Visual checking	Slackness between carrier rollers should be about 2 % of the distance between the carrier pitch.	When the belt is too slack, it should be tightened to increase tension, by using the screw take-up.

Table 6-3 (2) Inspection during Operation of Inclined Conveyor

Level of importance			Item	Content	Method	Methods and standards for judgment of quality	Method of improvement, or treatment of irregularity
Before operation	During operation	After operation					
A		A	General	Condition of cleanliness	Visual checking	No dirt should adhere.	Cleaning.
	A		Entire operation	Condition of individual functions	Visual checking of operation	The belt position should not be off-center, and the belt should move smoothly.	See individual column below.
	A		Cyclone motor pulley	Amperage	Visual checking (ammeter)	Should be within the rated current value.	Investigation of cause of overload
	A		Bearing	Noise and generation of heat	By listening, and by touching with the finger	There should be no irregular noise, and no irregular exothermic reaction. (Bearing temperature should not exceed the ambient temperature by more than 40°C.)	Greasing. A burned or damaged bearing must be replaced with a new one.
A				Grease	Visual checking	The specified quality and quantity of grease should be used.	Greasing.
	A		Belt	Damage	Visual checking	The belt must not be worn so badly as to have cracks, peeling off of layers of the belt, exposure of canvas by cuts or abrasion, etc.	A belt which has too many flaws must be replaced with a new belt.

Table 6-4 (1) Inspection when Operation is Stopped, Annual Inspection, and Regular Inspection of Hopper

Level of importance			Item	Content	Method	Methods and standards for judgment of quality	Method of improvement, or treatment of irregularity
Stopping	Annual	Regular					
A		A	General	Cleanliness	Visual checking	No dirt should adhere.	Cleaning
	A		Overall operation	Condition of each function	Visual checking of operation	The function of each part should be satisfactory. Gates should not stop, or make any noise, during operation.	See the individual columns below.
A	A	A	Power cylinder	Amperage	Visual checking (ammeter)	Amperage should be within the rated current value.	Investigation of cause of overload Measures for coping with foreign matter caught or entangled, and with seizure caused by sand or soil.
	A		Cut gate	Deformation	Visual checking	Should have no deformations	Repair
		A		Condition of opening and closing of gate	Visual checking and auditory checking	Gate should not seize up or make any noise during operation.	

Table 6-4 (2) Inspection of Hopper during Operation

Level of importance			Item	Content	Method	Methods and standards for judgment of quality	Method of improvement, or treatment of irregularity
Before operation	During operation	After operation					
A		A	General	Cleanliness	Visual checking	No dirt should adhere.	Cleaning.
	A		Overall operation	Condition of each function	Visual checking of operation	The function of each part should be satisfactory. Gates should not seize up or make any noise during operation.	See the individual columns below.
	A		Power cylinder	Amperage	Visual checking (ammeter)	Amperage should be within the rated current value.	Investigation of cause of overloading.
	B		Cut gate	Deformation	Visual checking	Should have no deformations.	Repair
	A			Condition of opening and closing of gate	Visual checking, and auditory checking	Gate should not seize up or make any noise during operation.	

6-3 Expenditures for Operation and Maintenance

The following chart shows the expenditures for operation and maintenance, which accompany the installation of an automatic trash rake and trash conveying facilities, and the distribution of trash-hauling machinery (see Appendix 2-2 for details.)

Unit : 1,000 baht

	At present	Planned
(1) Pump Operation		
(a) Amount of savings on operating costs	-	(-)1,086
(b) Operating costs (personnel expenses)	616	616
(c) Expenditures for maintenance	2,805	2,805
(2) Automatic trash rakes		
(d) Cost of electricity	-	777
(e) Operating costs (personnel expenses)	-	-
(f) Expenditures for maintenance	-	600
(3) Hauling machinery		
(g) Fuel costs	-	1,206
(h) Operating costs (personnel expenses)	-	750
(i) Expenditures for maintenance	-	130
(4) Extraordinary expenditures for trash removal		
(j) Labor costs	1,668	-
(k) Mechanical costs	1,750	-
(l) Total	6,839	5,798

The savings on expenditures for operation and maintenance are estimated at about one million baht annually. Therefore, there is no problem whatsoever with expenditures for operation and maintenance.

CHAPTER 7 PROJECT EVALUATION

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7-1 Effects of Project

The current project is designed to eliminate the problems caused by refuse flowing into the three pumping stations located at Phra Khanong, Sam Rong, and Chareon Rat, which serve the Bangkok metropolitan area and surrounding farmland. For this purpose, automatic trash rakes shall be installed to secure smooth operation of the pumping stations, and to protect the Bangkok metropolitan area from floods. The following effects can be expected after this project has been carried out.

(1) Direct effects

The following are the direct effects of this project.

① Decreased flood damage in the Bangkok urban area:

With recovery of pump drainage capacity, protection against floods becomes possible in the urban area. This is an urgent matter from both the humanitarian and the national viewpoint.

② Promotion of agriculture on the farmland of the Bangkok metropolitan area:

Flood water remaining in the area surrounding Bangkok can be removed in the same way as flood water in Bangkok itself, and the control of drainage canal water levels will be easier. Therefore, improvement can be expected in the agricultural productivity of this area.

③ Savings on the cost of excess pumping caused by refuse:

Savings can be expected on the operating expenses which have now increased because of the higher pumphead which is a result of refuse accumulation; on expenses for the manual removal of refuse at pumping stations; and on expenses for removal of refuse upstream using heavy equipment.

④ Beautification of the river environment around drainage and pumping stations:

When refuse is completely removed from the drainage canals by automatic trash removing facilities, the downstream environment along the drainage canals can be beautified. This is also related to beautification of the areas of the city around the canals.

(2) Indirect effects

The following are the indirect effects of this project.

① Stabilization of the local standard of living by protection of the Bangkok urban area from floods.

② Relieving workers of the dangerous operation of manual removal of refuse at pumping stations:

It is urgent from a humanitarian viewpoint that the labor be free from the dangerous job of manually removing refuse at the screen sections while pumps are being operated. This is a necessary task which secures pump operation during the flood season.

7-2 Practicality of the Project

The practicality of the installation of large-scale automatic trash rakes, for the first time in the Kingdom of Thailand, is demonstrated below.

(1) Technical practicality

The type of automatic trash rake to be installed by this project has previously been installed in only two locations in the City of Bangkok. This equipment is small and limited in number. Therefore, considering the scale of the automatic trash rakes to be installed by this project, this is essentially the first time that such large trash rakes have been installed in the Kingdom of Thailand. The pumping

stations where the automatic trash rakes are to be installed are, at present, operated and maintained in a satisfactory manner by RID, and the mechanism of the trash rakes to be installed is not complicated. So operation and maintenance are relatively easy. After a comprehensive evaluation of the present technical capabilities of RID, it is considered sufficient to carry out operation and maintenance of the new facilities.

(2) Financial practicality

As stated in the section on operation and maintenance costs, estimation of the expenses following the installation of automatic trash rakes when compared with the necessary expenses at present for the operation and maintenance of pumping stations shows a potential savings of about one million baht. Even if unexpected expenditures should be required after the installation of automatic trash rakes, expenditures are still considered to be approximately the same in scale as present expenditures. This creates no financial problems in light of the RID budget.

In light of the above, the installation of automatic trash rakes with Japanese grant aid assistance is practicable for the three pumping stations included in this project.

CHAPTER 8 CONCLUSION AND RECOMMENDATION

CHAPTER 8 CONCLUSION AND RECOMMENDATION

8-1 Conclusion

The pumping stations in the three locations, i.e. Phra Khanong, Sam Rong, and Charoen Rat, which are the subjects of this project, greatly influence the drainage of the entire Bangkok metropolitan area. These three pumping stations have broad expanses of farmland in their drainage basins, and accordingly the inflow and accumulation of water hyacinths at these pumping stations are extremely critical. Furthermore, since the areas around these pumping stations are urbanized, disposal of city-type refuse into the drainage canals is a frequent practice. Such refuse forms a complex mixture, which flows down to the pumping stations, blocks the screens and thus blocks the smooth operation of the pumps. Thus the downflow and the accumulation of the refuse which obstructs pump operation are particularly critical problems at these pumping stations.

The Government of the Kingdom of Thailand is improving its traffic and transport, flood protection, water supply, and housing departments, as an investment in basic public services for the urban area. The stabilization of the living infrastructure of farmers in suburban farm areas is also an indispensable factor in the development of the entire metropolitan area.

Therefore, the problem of refuse treatment which has become a cause of flooding at the three pumping stations must be quickly solved, if the development of the Bangkok metropolitan area and the stabilization of the local standard of living are to be achieved. Refuse is now manually removed from pumping station screens and the refuse in areas upstream of the drainage canals is removed using heavy equipment. These are temporary solutions to this problem. These methods, however, are not only inefficient but also present safety problems. It is therefore urgent that the situation be improved.

As previously stated, it is desirable that automatic trash rakes be installed at the above pumping stations at an early date, both from a humanitarian point of view and from the viewpoint of national development. In light of these aspects, the project to be carried out with Japanese grant aid assistance is extremely significant and pertinent.

8-2 Recommendations

The following recommendations are made to the Government of the Kingdom of Thailand, with the expectation that this project will be completed successfully and that the installed equipment will function satisfactorily for an extended period of time, thus contributing to the orderly growth and development of the Bangkok metropolitan area which is the heart of the Kingdom of Thailand.

(1) Objectives to be taken at by the Government of the Kingdom of Thailand

It is desirable that the objectives to be taken by the Government of the Kingdom of Thailand, be achieved in a suitable and timely manner in order to permit execution of the project by the Government of Japan. In particular, the removal of existing structures and the securing of access roads at the work sites will exert major influence on the progress of the work. Accordingly, it is desirable that this work in particular be performed quickly.

(2) Temporary budgetary measures for refuse control

According to the information obtained by the study team during its field survey, temporary refuse-removal expenses have not been allocated in the RID budget for the 1988 fiscal year (October, 1987 through September, 1988). It is believed that this is based on the assumption that automatic trash rakes will be installed. In practice, however, judging from the implementation schedule, there is a strong possibility that the automatic trash rakes will not be installed by the first half of the period when full-scale operation of pumps is required. It is therefore felt that temporary refuse removal should be performed as usual in this period while the pumps are operating.

(3) Preparation of trash hauling machinery

Even when the automatic trash rake and trash conveying equipment are completed, use of the completed automatic trash rakes cannot continue unless trash hauling machinery is prepared. The stoppage of trash

rakes will interfere with the smooth operation of the pumps and the significance of the facilities installed in this project will be greatly reduced. Therefore, preparation of trash hauling machinery by the Government of the Kingdom of Thailand with the simultaneous completion of the installation of the automatic trash rakes is definitely necessary.

(4) Operation and maintenance of facilities

Not only the facilities to be installed with Japanese grant aid assistance but also the existing pumps and trash hauling machinery, etc., must be properly operated and maintained in order to contribute continuously to the long-term development of the Bangkok metropolitan area.