APPENDIX

APPENDIX I

1-1 Organization of Study Team

Responsibility	Name	
Team Leader	Mr. Seiichi Kanai	Japan International Cooperation Agency
Pumping Station Planner	Mr. Tokushi Sato	Ministry of Agriculture, Forestry & Fisheries
Facilities Planner	Mr. Tetsuo Saka	Japan Engineering Consultants Co., Ltd.
Facilities Designer	Mr. Sumitada Okamoto	Japan Engineering Consultants Co., Ltd.
Civil Engineer	Mr. Masayuki Sunohara	Japan Engineering Consultants Co., Ltd.

1-2 Survey Schedule

Day number	Date	Day of the week	Distance covered	Survey content
1	July 5	Sunday	Tokyo to Bangkok	Journey
2	July 6	Monday		Meeting with Embassy of Japan, JICA, RID
3	July 7	Tuesday		Survey of Phra Khanong and Sam Rong pumping stations
4	July 8	Wednesday		Survey of Charoen Rat pumping station and inside area
5	July 9	Thursday		Meeting with RID
6	July 10	Friday		Survey team meeting, Study of content of minutes
7	July 11	Saturday		Preparation of manu-script of minutes
8	July 12	Sunday		Processing and study of collected data and information

Day number	Date	Day of the week	Distance covered	Survey content
9	July 13	Monday		Signing of minutes, Meeting with Japanese exparts
10	July 14	Tuesday	(Team members from Japanese government, Bangkok to Tokyo).	Team members from Japanese government return to Japan. Members of consultant team collect data.
11	July 15	Wednesday		Additional survey of Charoen Rat and Sam Rong pumping stations
12	July 16	Thursday		Additional survey of Phra Khanong pumping station
13	July 17	Friday		Collection of information at Weed Control & Research Branch of RID (Pakret)
14	July 18	Saturday		Processing and study of collected data
15	July 19	Sunday		Study of appropriateness and principles of plan
16	July 20	Monday		Arrangement for final meeting with RID
17	July 21	Tuesday		Preparation and distribution of memorandum
18	July 22	Wednesday		Meeting with RID, discussion of memorandum
19	July 23	Thursday		Memorandum signed, reports to Embassy of Japan and JICA
20	July 24	Friday	Bangkok to Tokyo	Journey

1-3 List of Persons Interviewed

(1) Embassy of Japan

Katsuyuki Nagayama	First Secretary of Embassy

(2) JICA Thailand office

Tsutomu Saito	Office Director
Toshiharu Kai	Office staff member

(3) Royal Irrigation Department (RID)

1) Members of working team

Mr. Chamroon Chindasa-Nguan	Senior Expert for O & M
Mr. Maitri Poolsup	Drainage Design Expert, Des. Div.
Mr. Sawin Kasuwan	Chief of Pump Equipment Branch, Mechanical Engineering Div.
Mr. Vidhaya Samaharn	Chief Hydraulic laboratory, Research & Laboratory Div.
Mr. Suthi Songvoravit	Chief of P.P.D Section 1, Project Planning Div.
Mr. Prakhong Pongprot	Khlong Dan Project Engineer
Mr. Vasan Boonkert	Chief of O & M Engineering O & M Div.

2) Japanese experts

Narumi Yamada	JICA Colombo Plan Expert (P.P.D.)
Yuzo Ozaki	JICA Colombo Plan Expert (O & M)
Kazushige Matsuo	JICA Colombo Plan Expert (IEC)
Masaru Sasaki	JICA Colombo Plan Expert (R.L.D)

3) Other persons interviewed

Mr. Prasit Tarugsa	Mechanical engineer, Mechanical Engineering Division
Mr. Mungkorn Viriyapanich	Same as above
Mr. Thanom Klaikayoi	Chief of Water Management Branch, O & M Div.
Mr. Wittawat Oranwat	Civil Engineer, Design Division 7
Miss Saowanee Thamasara	Weed Control and Research Branch
Mr. Amnuey Somsin	Chief of Data Processing Branch, Hydrology Division

(4) Department of Technical and Economic Cooperation (DTEC)

Mr. Vudhisit Viryasiri

(5) Bangkok Metropolitan Administration (BMA)

Shigeo Kanai	JICA Colombo Plan Expert

1-4 Conference Minutes

1-4-1 Minutes

MINUTES OF DISCUSSIONS

ON

THE PROJECT

FOR

IMPROVEMENT OF EXISTING PUMPING STATION

FOR

IRRIGATION AND DRAINAGE

IN

THE KINGDOM OF THAILAND

In response to the request of the Government of Thailand, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Existing Pumping Station for Irrigation and Drainage (hereinafter referred to as "the Project"), and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Thailand the Basic Design Study Team headed by Mr. Seiichi Kanai, Deputy Head, 1st Basic Design Study Division, Grant Aid Planning & Survey Department, JICA (hereinafter referred to as "the Team") from July 5 to 24, 1987.

The team had a series of discussions on the Project with the officials concerned of the Government of Thailand headed by Mr. Suha Thanomsingha, Director-General, Royal Irrigation Department, Ministry of Agriculture and Cooperatives, and conducted a field survey in the relevant areas to the Project.

As a result of the study, both parties agreed to recommend to their respective Governments that the major points of understanding reached between them, attached herewith, should be examined towards the realization of the Project.

Bangkok, July 13, 1987

Seiichi Kanai

Mr. Seiichi Kanai
Team Leader
Basic Design Study Team
Japan International Coopertion
Agency

C. Chindasa-Nguan

for Mr. Chamroon Chindasa-Nguan
Director-General
Royal Irrigation Department
Ministry of Agriculture
and Cooperatives

MAJOR POINT OF UNDERSTANDING

1. The objective of the Project is to install the automatic trash rake with belt conveyor system at the Phra Khanong, Charoen Rat and Sam Rong pumping stations to carry out the smooth pumping operation.

2. The Phra Khanong, Charoen Rat and Sam Rong pumping stations are located at the terminal points of the Phra Khanong, the Chai Thale and Sam Rong drainage canals respectively in Bangkok. (Site map is attached as Annex I.)

3. Royal Irrigation Department will execute the Project.

4. The Japanese Study Team will convey to the Government of Japan the desire of the Government of Thailand that the former takes necessary measures to cooperate by installing the facilities such as automatic trash rakes, screen, belt conveyors, control pannels and by constructing the necessary civil structures.

5. The Thai side has understood Japan's Grant Aid System explained by the Team which includes a principle of use of a Japanese consultant firm and other Japanese firm for the implementation of the Project.

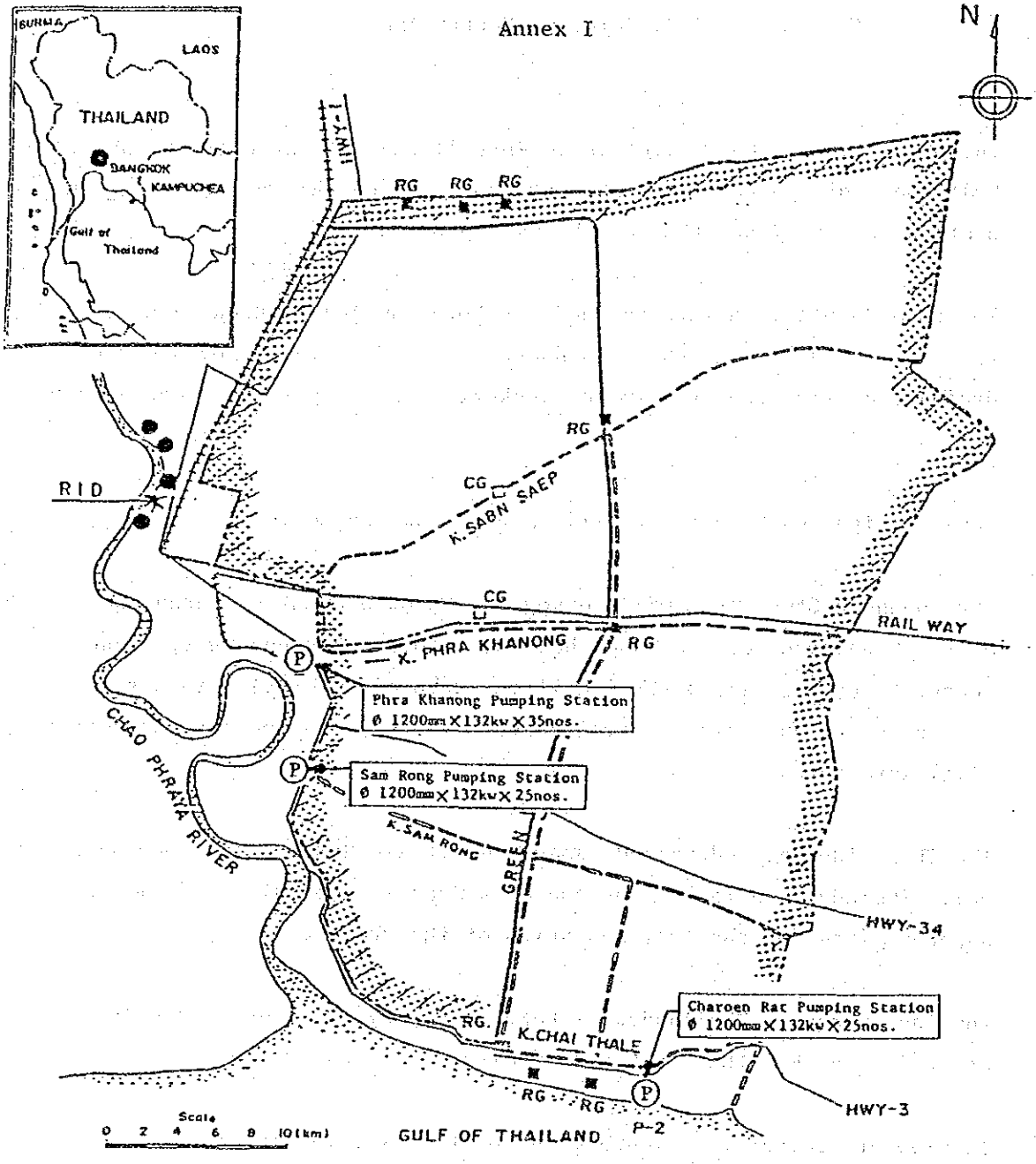
6. The Government of Thailand will take necessary measures listed in Annex II on condition that the Grant Aid is extended to the Project.

7. In view of necessity of improvement of the existing pumping stations, Thai side requested the team to study of the following items. The team agreed to examine in the Study.

   1) Modification of control system for existing pumps and automatic trash rakes to operate relatively.

   2) Modification of level control device.

   3) Supply electric cranes for the Phra Khanong and Sam Rong pumping stations.



BOUNDARY OF AREA
EXISTING CREEK
HIGH WAY
RAIL WAY
TO BE INSTALLATED AUTO-TRASH RAKE
EXISTING PUMPING STATION
REGULATOR OR CONTOL GATE
RG CG

IRRIGATION AND DRAINAGE AREA			
FARM	ha	113.000	81%
OTHERS	ha	27.000	19
TOTAL	ha	140.000	100

1. To arrange the sufficient power supply for the operation of the automatic trash rake.

2. To take the necessary measures to dispose the trash or garbage which are raked up by the automatic trash rake.

3. To secure work yard for construction of substructure which is installed the automatic trash rake.

4. To secure stockyard for the automatic trash rake which is transported to the site.

5. To provide the access way for construction of the substructure of the automatic trash rake.

6. To ensure unloading and customs clearance at the port of disembarkation in Bangkok.

   1) Marine transportation of the products from Japan to the port of disembarkation is to be borne by Japanese side.

   2) Tax exemption and customs clearance at the port of disembarkation is to be done by Thai side.

   3) Internal transportation from the port of disembarkation to the Project site is to be borne by Japanese side.

1-4-2 Memorandum

MEMORANDUM OF SITE SURVEY RESULTS

ON

THE PROJECT

FOR

IMPROVEMENT OF EXISTING PUMPING STATION

FOR

IRRIGATION AND DRAINAGE

IN

THE KINGDKOM OF THAILAND

After the conclusion of minutes of discussion, the team had a series of site survey and discussions continuously on the Project with the officials concerned of the Government of Thailand headed by Mr. Chamroon Chindasa-Nguan, Head of Working Team for Improvement of Existing Pumping Station, Royal Irrigation Department, Minsitry of Agriculture and Cooperatives.

As a result of the survey, both parties agreed to the major points of understanding reached between them herewith, should be examined towards the realization of the Project.

Bangkok, July 23, 1987

Maitri Poolsup

Mr. Maitri Poolsup
for Head of Working Team for
Improvement of Existing
Pumping Station
Royal Irrigation Department
Ministry of Agriculture and.
Cooperatives

T. Saka

Mr. Tetsuo Saka
Planner of Facility
Basic Design Study Team
Japan International Cooperation
Agency

Considering site survey results, collected data and information etc, following conclusions are obtained at this moment. Final conclusions shall be given during home office work in Japan by further examination of those data and information.

1. Location of Automatic Trash Rake to be Installed

Considering the principle of installation of trash rake which should be installed just in front of pump pit, the location of automatic trash rake will be planned as shown in Figure 1-1 to 1-3. For these plans, some remarkable points are indicated as follows:

(1) For the leftbank pump pit at Phra Khanong pumping station, installation of automatic trash rakes just in front of the pump pit prevents the water from flow down through the gate which is located close to the pump pit. Therefore, installation site should be shifted to the appropriate point of slight upstream as shown in Figure 1-1.

(2) For the No. 1 pump pit of the leftbank pump pits at Sam Rong pumping station, location of pump pit and gate is similar to the leftbank pump pit at Phra Khanong pumping station. However, installation of automatic trash rakes for the No. 1 pump pit hardly prevents the water from flow down. Because, the No.1 pump pit has some space, so that, the structure should not be extended so much for the installation.

(3) At Phra Khanong pumping station, alternative plan whcih installation point is shifted upstream is considered. For these plans mertis and demerits are pointed out as follows:

1) Alternative plan makes the scale of the automatic trash rake small.

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T. Sakai

2) Conversely, the velocity of throughflow of screen bar is faster than original plan and this causes larger drop down of water level at the rear side of screen.

3) Concrete structure to be installed the automatic trash rakes is constructed across the canal in this alternative plan. This causes long operation of the automatic trash rakes because trash has to be raked up even when the water is drained by gravity through the gate.

4) Removal of trash raked up is rather difficult for this alternative plan.

Considering these merits and demertis, original plan which makes less operation cost for both automatic trash rakes and pumps is regarded to be suitable for this site.

2. Type of Automatic Trash Rake

By the observation of trashes through the site survey of Chai Thale, Sam Rong, Phra Khanong canals and also by the information, the characteristic of trashes in front of the screen is roughly acknowledged as follows:

1) Kinds of trashes which flow to the pumping station are water hyacinth, trunk of tree, vinyl bag, empty plastic container, a piece of cloth, etc.

2) The trash which seriously affects the pump operation is water hyacinth.

3) When the pumps are operated at the flood season, a big amount of water hyacinth is gathered in front of screen. Considering the amount of water

hyacinth, the rake-up ability of automatic trash rake is bit less than the gathering trashes. Therefore, it is supposed that the water hyacinth will be compressed and become hard block in front of the screen due to the continuous flow.

4) However, water hyacinth does not flow under water. On the other hand, vinyl trash mingles into water by turbulent flow. So, vinyl trash coils to the screen bar under the water hyachinth and closes up the openings of screen.

Considering these situations, it seems that the following conditions are necessary for the automatic trash rake.

1) Trash removal ability shall be big.

2) For these trashes dip-up method is suitable.

3) A kind of trash to be raked up is not only the trash from agricultural area but the trash from urbanized area.

Therefore, rotary endless type automatic trash rake and screen seems to be adopted for this project at this moment. The general figure of this type is shown in Figure 2-1 and typical installation condition is shown in Figure 2-2.

3. Method of Trash Removal

There are two ways of trash removal. One is by truck on the ground and the other is by barge on the water. By RID's request letter, raked-up trash is to be removed by barges. However, from view point of use of water hyacinth as a fertilizer, RID requested the team to consider to remove the trash also by truck. The team agreed to examine the possibility of two ways trash removal from mechanical and technical viewpoint.

Fig 1-1 PHRA KHANONG PUMPING STATION

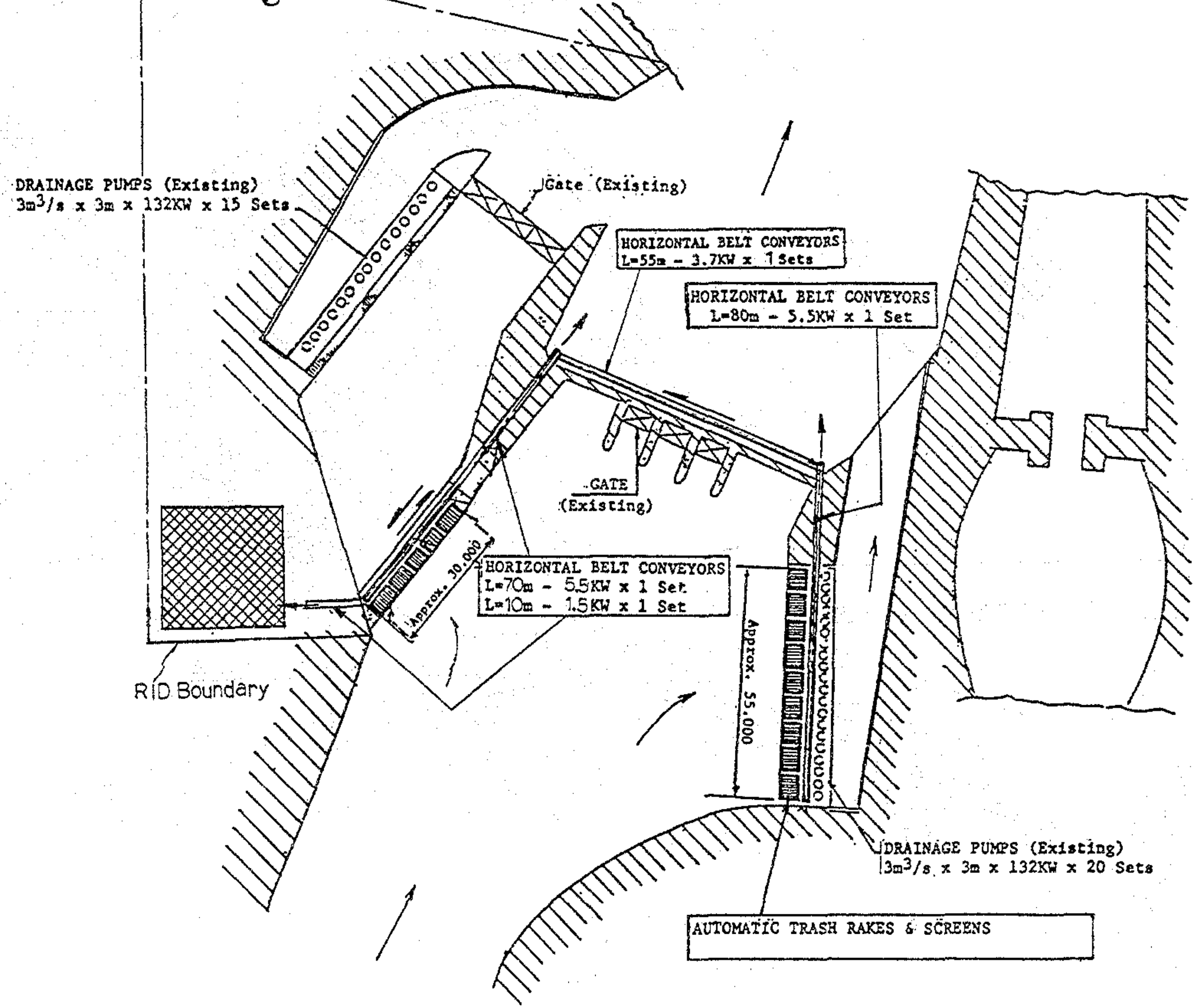


Fig 1-2 SAM RONG PUMPING STATION

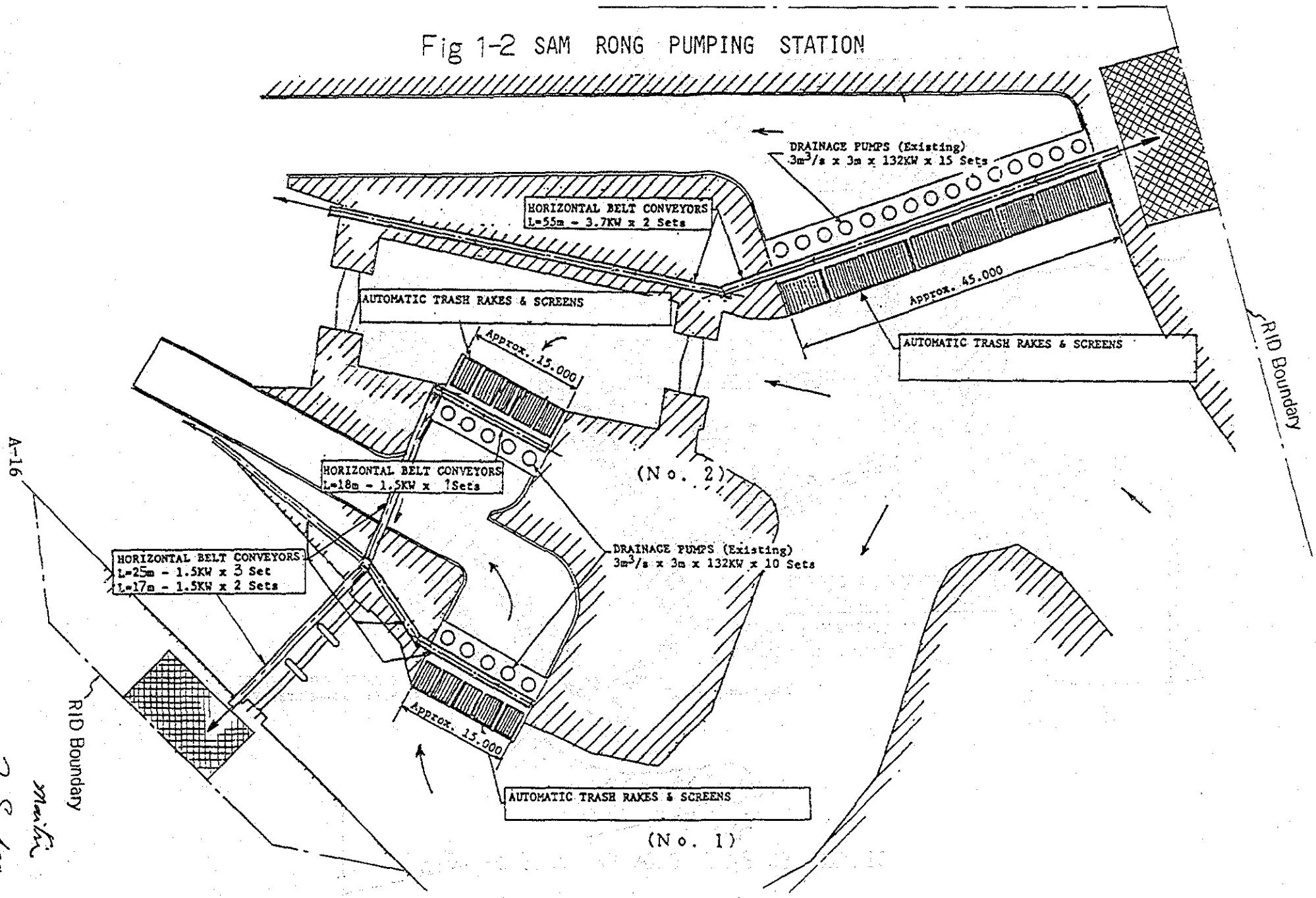


Fig. 1-3 CHAROEN RAT PUMPING STATION

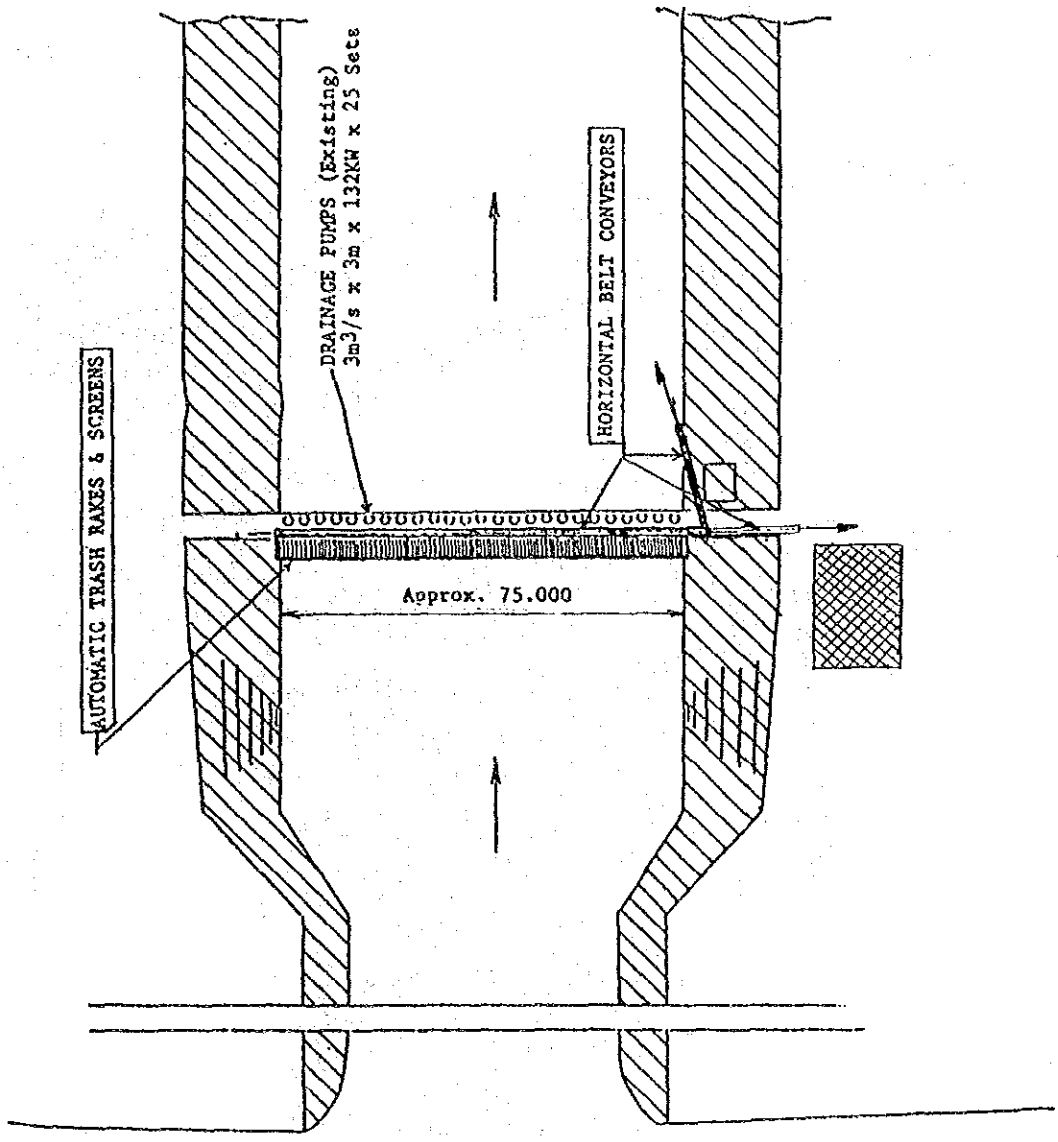


Fig 2-1 STRUCTURE OF AUTOMATIC SCREEN FACILITIES

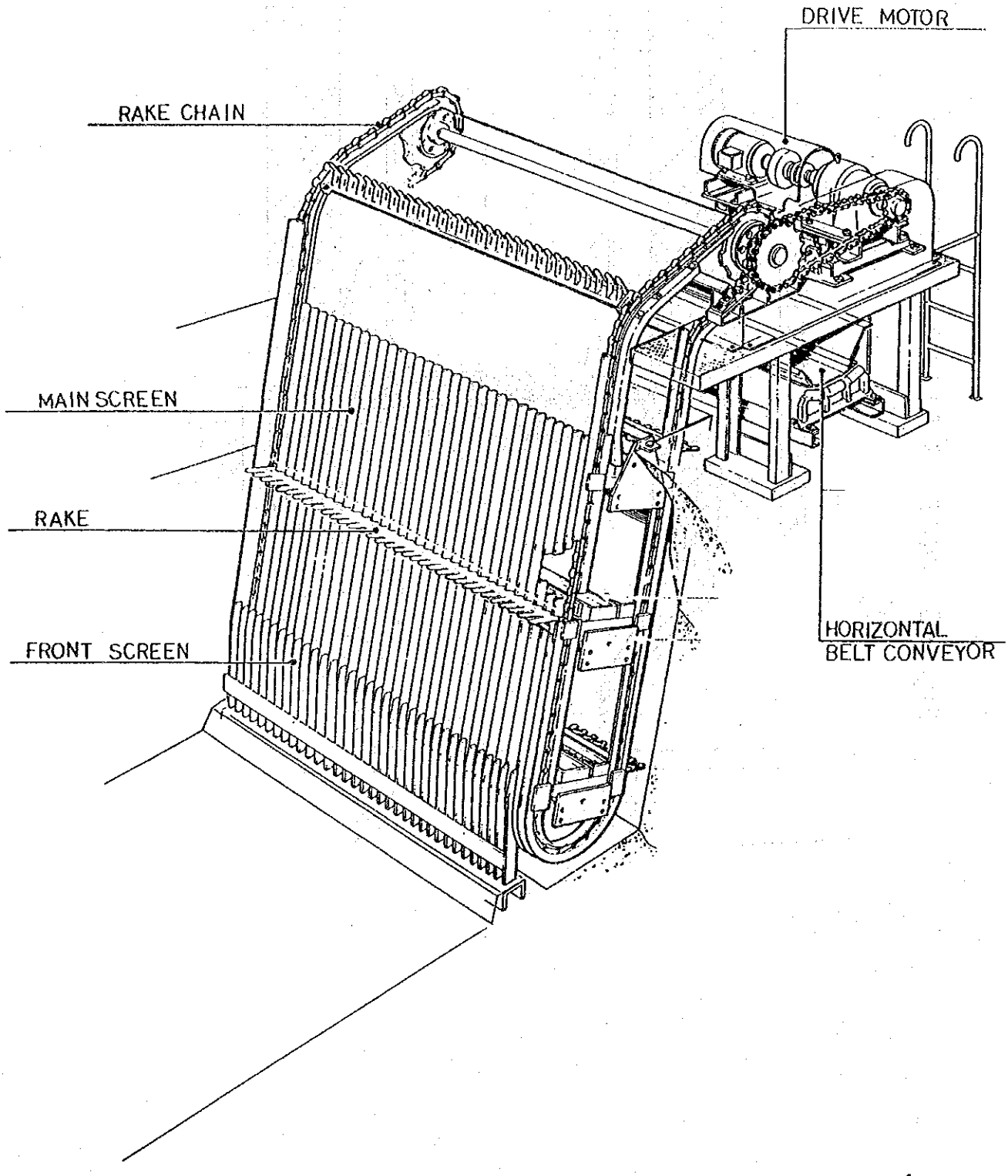
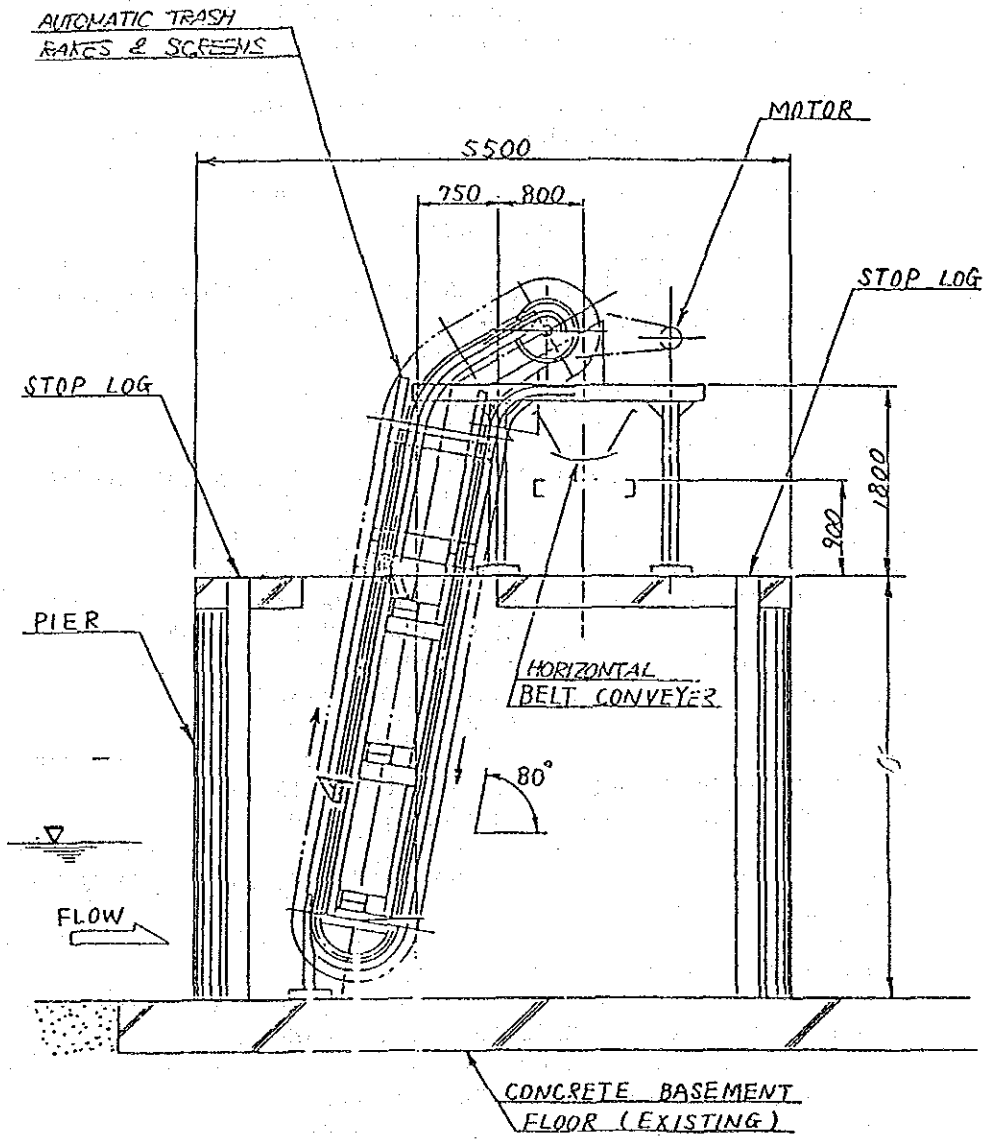


FIG 2-2 SECTIONAL DRAWING FOR INSTALLATION USE



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1-5 Data Collected

Number	Title of data
1	SOIL INVESTIGATION REPORT BANGPOO COUNTRY CLUB/BANGPOO SAMUT PRAKAN
2	DAILY MAXIMUM, MINIMUM AND MEAN GAGE HEIGHT Station: MEMORIAL BRIDGE 1983, April - 1987, March
3	DAILY MAXIMUM, MINIMUM AND MEAN GAGE HEIGHT Station: POM PHRACHUL 1983, April - 1987, March
4	MAP OF THAILAND (BANGKOK) S = 1 : 50000 Serial No. 5136 I - IV, 5036 I - II
5	FINAL REPORT FOR TECHNICAL ASSISTANCE ON URBAN DRAINAGE AND FLOOD PROTECTION IN BANGKOK APRIL 1986 JICA
6	INTERIM REPORT VOLUME I FLOOD CONTROL OF BANGKOK AND VICINITY
7	DIAGRAMS OF ELECTRICAL FACILITIES AND ELECTRICAL WIRING
8	LAND USE MAP S = 1 : 50000 Serial No. 62255
9	SYSTEM DIAGRAM FOR IRRIGATION AND DRAINAGE S = 1 : 100000 Serial No. 69385
10	SYSTEM DIAGRAM FOR IRRIGATION AND DRAINAGE S = 1 : 50000 Serial No. 62255
11	RESULTS OF MEASUREMENTS OF SALT CONCENTRATION (3 LOCATIONS; MAP OF LOCATIONS ATTACHED)
12	DIAGRAM OF FACILITIES FOR RECEIVING ELECTRICITY, DIAGRAM OF INCOMING LINES
13	BORING TEST DATA (CHAROEN RAT P/S)
14	BORING TEST DATA (KING'S DRAINAGE PROJECT)
15	PILE-BEARING-CAPACITY CALCULATION CHART AVERAGE COHESION VALUE, FOR BANGKOK AREA

Number	Title of data
16	STRUCTURAL DRAWINGS OF PRESENT STATE OF PHRA KHANONG P/S
	16.1 General Plan of Regulator Serial No. 70221
	16.2 General Plan Serial No. 72152
	16.3 Plan & Section Serial No. 72153
	16.4 Section Serial No. 72154
	16.5 Foundation Pile Serial No. 72155
	16.6 Detail Serial No. 72157
	16.7 Detail of Pump Pit Serial No. 74544
17	STRUCTURAL DRAWINGS OF PRESENT STATE OF SAM RONG P/S
	17.1 General Plan Serial No. 76102
	17.2 Plan & Section Serial No. 76103
	17.3 Plan & Section Serial No. 78528
	17.4 Plan of Pile Serial No. 76105
	17.5 Reinforcement Serial No. 78375
	17.6 Reinforcement Serial No. 78376
	17.7 Plan of Pile Serial No. 78531
	17.8 Basement of Panel Serial No. 80509
18	STRUCTURAL DRAWINGS OF PRESENT STATE OF CHAROEN RAT P/S
	18.1 General Plan Serial No. 80551
	18.2 Plan & Profile Serial No. 78373
	18.3 Detail Serial No. 78374
	18.4 Cross-Section of Pump Pit Serial No. 78377

Number	Title of data
19	PUMP OPERATION RECORDS
	19.1 Phra Khanong P/S
	19.2 Sam Rong P/S
	19.3 Charoen Rat P/S
	19.4 Chart of Totals
20	RECORDS OF INTERNAL AND EXTERNAL PUMPING STATION WATER LEVELS
	20.1 Phra Khanong P/S
	20.2 Sam Rong P/S
	20.3 Charoen Rat P/S
21	INSPECTION RECORD FOR PUMPS
22	REGULATION FOR OPERATION AND OTHERS
23	ORGANIZATION FOR O/M Record of Expenditure for O/M Record of Removing Trash
24	CLIMATOLOGICAL DATA FOR THE PERIOD 1952 - 1986
25	Daily Rainfall at RID Office Samsen (C-12) 1952 - 1957, 1973 - 1986
26	HOURLY WATER LEVELS OF THE CHAO PHRAYA RIVER April 1986 - May 1987, Station: Memorial Bridge
27	PREPARING FOR THE MODEL OF PHRA KHANONG UPSTREAM DRAINAGE SYSTEM AND PROPOSAL OF IMPROVEMENT PLAN JULY 1987
28	WATER HYACINTH SURVEY REPORT
29	MAINTENANCE CONTROL OF WATER HYACINTH Aquatics June 1981

APPENDIX 2-1 Bearing Capacity of Piles

(1) Study of pile foundation of Phra Khanong pumping station

1) Existing piles

i) Left-bank pumping station

ϕ200 mm, ℓ = 8.0 m Type : friction pile

ii) Right-bank pumping station

□-35 x 35 cm, ℓ = 19.0 m, suction tank.
Type : bearing pile

□-25 x 25 cm, ℓ = 23.0 m, discharge tank
Type : bearing pile

2) Calculation of bearing capacity of piles

Load testing was conducted when the pumping station on the right-bank of the Phra Khanong was constructed. The following are the figures on the bearing capacity of its piles.

(Blow count, SF = 3.0, serial No. 72155)

□-0.35 x 0.35 cm, ℓ = 19.0 m, Ra = 50 t/pile
□-0.25 x 0.25 cm, ℓ = 23.0 m, Ra = 35 t/pile

A boring test was not conducted, however.

(2) Study of pile foundation of Sam Rong pumping station

1) Existing piles

i) Left-bank pumping station

ϕ200 mm, ℓ= 8.0 m Type : friction pile

ii) Right-bank pumphouse

□-18 x 18 cm, ℓ= 8.0 m Type : friction pile

2) Calculation of bearing capacity of piles

No boring test has ever been conducted at the Sam Rong pumping station. Nor load testing has been carried out yet. RID's Design Division 7 calculates the estimated bearing capacity, using a simple calculation diagram. (See Appended Figure -1.)
The chart which follows shows the allowable bearing capacity, as calculated from this diagram.

i) Left-bank pumping station

Skin friction force on piling

$F = (1.19 + 2.18) \times 1/2 \times 8.0 \times (0.2 \times \pi) = 8.47$ t

Allowable bearing capacity

Rf = F x 1/2 = 4.2 t/pile (SF = 2)

ii) Right-bank pumping station

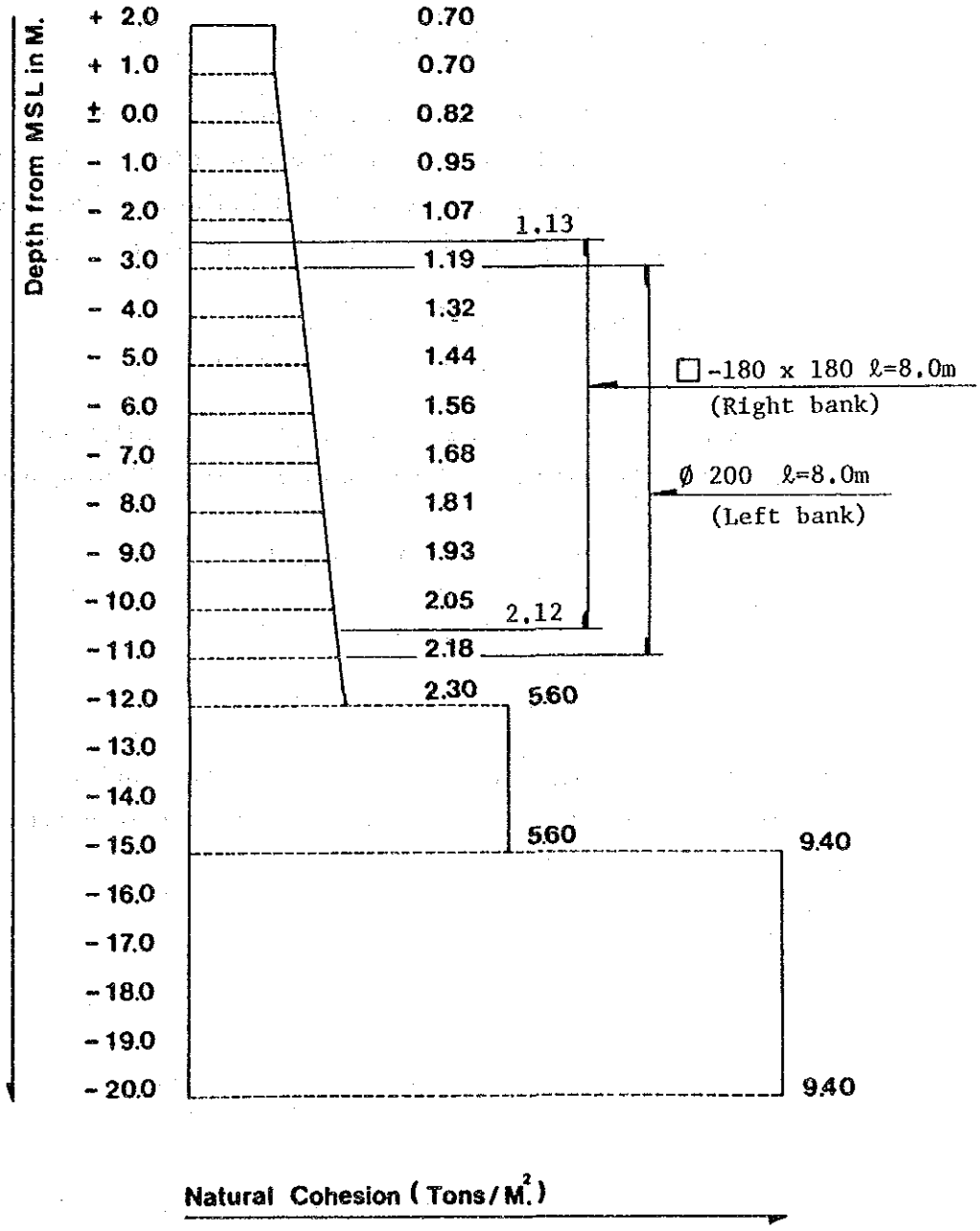
Skin friction force on piling

F = (1.13 + 2.12) x 1/2 x 8.0 (0.18 x 4) = 9.36 t

Allowable bearing capacity

Rf = F x 1/2 = 4.6 t/pile (SF = 2)

Appended Figure - 1 Average Cohesion Value for Bangkok Area



(3) Study of pile foundations Charoen Rat pumping station

1) Existing piles

The following shows the specifications of the existing suction tank piles.

□-0.40 x 0.40, ℓ = 26.0 m Type : bearing pile

2) Calculation of bearing capacity of piles

Bearing capacity will be calculated according to the "Specifications for Highway Bridges" established by the Japan Road Association, as a convenient method. Calculations for pilings are done under the assumption that the piling diameter is 450 mm.

$\because$ 0.40 x 0.40 m = 0.16 m^2 (□-40 x 40 cm)

$0.45^2 \times \pi/4 = 0.159\ m^2$ ϕ450 mm

The following shows only the results of the calculations. The calculations themselves will be shown on the following pages.

ϕ450 mm (□-40 x 40 cm), ℓ = 26.0 m

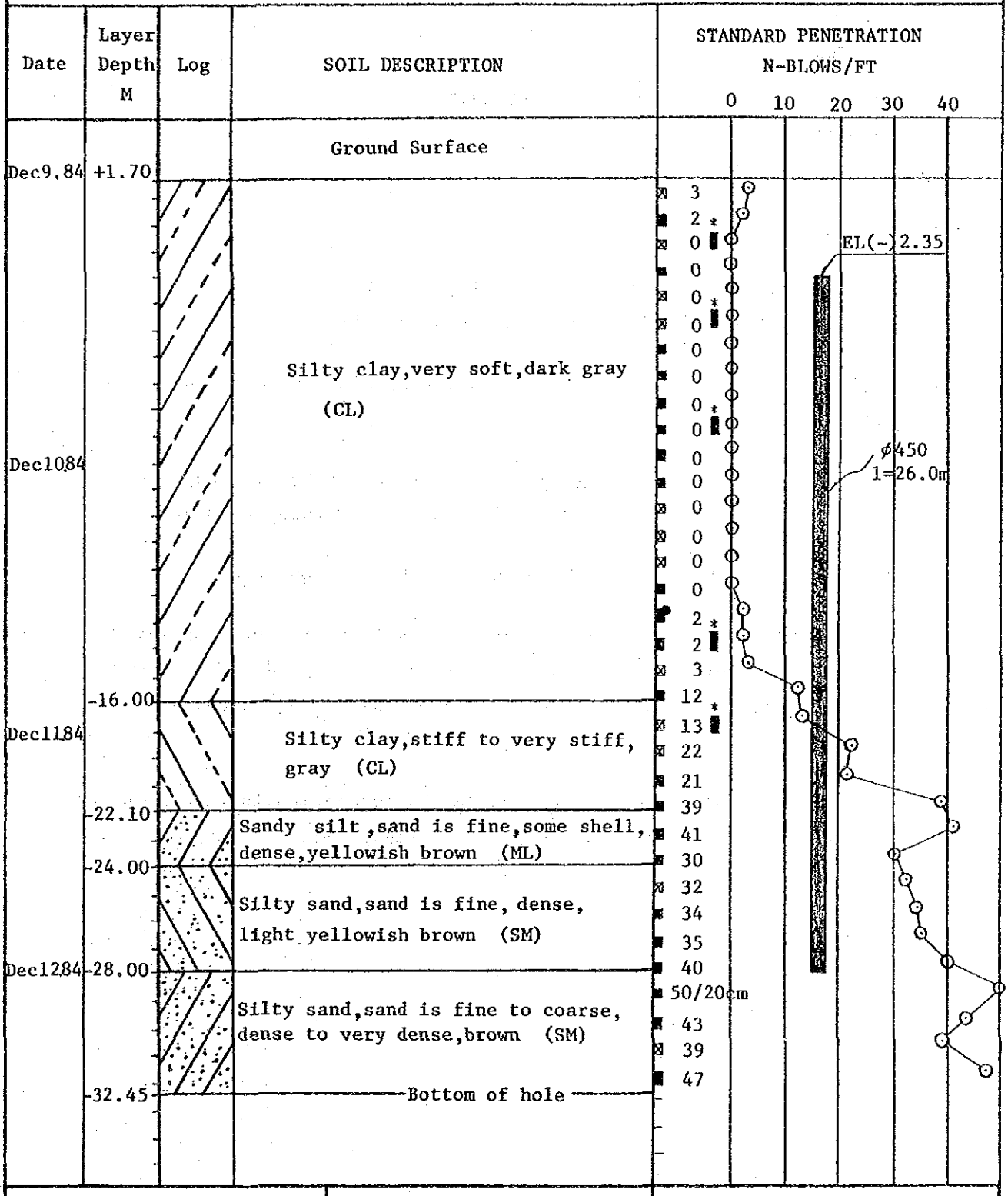
Allowable bearing capacity (SF = 3)

R_a' = 110 t/pile (from ground surface)

Safe load for piling body seems to be max. 80 t/pile.
The allowable bearing capacity per pile is therefore determined to be 80 t.

Appended Figure - 2 Boring Log

PROJECT Chareanraj Pumping Chv.Samut Prakan
HOLE NO. SPT.1
DEPTH 34.15 M
LOCATION Center of Pumping House
WORK Foundation of Pumping House
SURFACE ELV. + 1.70
TECHNICIAN Narong
WATER TABLE _____ DATE _____



Traced Prapaisri
Checked _____
Sheet _____

Remarks ■ Recovery sample ☒ Non-recovery sample
* Undisturb sample

VERTICAL SCALE 1:200
(1CM.=2M.)

[Allowable Bearing Capacity]

(1) Allowable axial bearing capacity : R_a

$$R_a = \frac{1}{n} R_u$$

In this equation, n is the safety factor

Normally : n = 3

During an earthquake : n = 2

$$R_u = q_d A + U \Sigma l_i f_i$$

$q_d A$: Ultimate point bearing capacity of pile

$U \Sigma l_i f_i$: Ultimate skin friction stress of pile

(2) Estimate of the degree of ultimate point bearing capacity, qd, of the pile

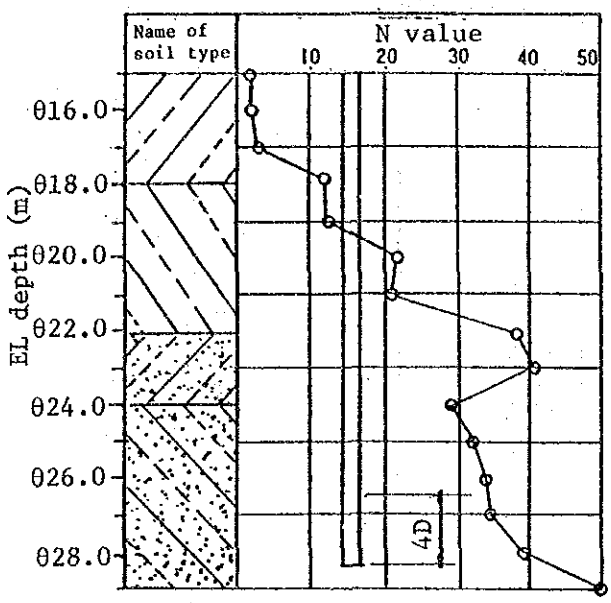
The estimate of qd, the degree of ultimate point bearing capacity of the pile, is based on the "Specifications for Highway Bridges".

1) Depth of embedding of the pile into the bearing layer

A layer deeper than 24 m is determined to be the bearing layer, from the soil columnar section boring log (Appended Figure -2). Therefore, the length of embedding of the piling is calculated at 4.3 m.

$\overline{N}$, the N value used for designing the foundation for the point of the pile, is obtained from Appended Figure -3.

Appended Figure -3 Depth - N value



$$\overline{N} = \frac{N_1 + \overline{N}_2}{2} \leqq 40$$

$$\overline{N}_2 = \frac{40 + 35 + 34}{3} = 36$$

$$\overline{N} = \frac{36 + 40}{2} = 38$$

N_1 : N value for bottom pile point

$\overline{N}_2$: Mean value of N, in the 4D range, from the bottom pile point upward

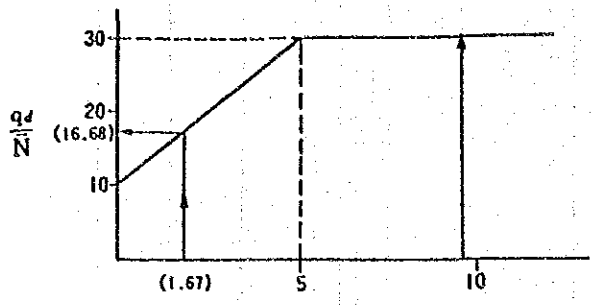
2) Estimate of qd, the degree of ultimate point bearing capacity of the pile

When the depth of embedding of the pile into the bearing layer is assumed to be 4.3 m.

$$\frac{\text{Depth of embedding converted into bearing layer}}{\text{Diameter of pile}} = \frac{4.3}{0.45} = 9.5$$

$q/\overline{N} = 30$, from Appended Figure -4

Appended Figure -4 Calculation of Ad, Ultimate Point Bearing Capacity of Foundation



$$\left(\frac{\text{Depth of embedding converted into bearing layer}}{\text{Diameter pile}}\right)$$

$$\frac{q_d}{\bar{N}} = 30 \qquad \therefore q_d = 30 \times \bar{N} = 30 \times 38 = 1140 \text{ t/m}^2$$

(3) Ultimate point bearing capacity : qdA

$q_dA = 1140 \times 0.45^2 \times \pi/4 = 181.3$ t

(4) Estimate of maximum skin friction force of pile

The estimate of the maximum skin friction force of the piling point will be based on the "Specifications for Highway Bridges".

Calculation of U $\Sigma l_i f_i$ will be done using Appended Table -1.

Appended Table -1 Maximum Skin Friction Force (When N > 2)

Depth (m)	li (m)	Name of soil type	N	fi (t/m^2)	li fi (t/m)
- 18.0 - - 22.1	4.1	Silty clay	17	15	61.5
- 22.1 - - 24.0	1.9	Sandy silt	40	15	28.5
- 24.0 - - 28.3	4.3	Silt mixed sand	34	6.8	29.2
Σ					119.2

$$U \Sigma l_i f_i = 0.45 \times \pi \times 119.2$$
$$= 168.5 \text{ t}$$

(5) Ultimate bearing capacity : Ru

$$R_u = q_d A + U \Sigma l_i f_i = 181.3 \text{ t} + 168.5 \text{ t} + 349.8 \text{ t}$$

(6) Axial bearing capacity of pile : Ra

$$R_a = \frac{1}{n} R_u$$

Normally: $R_d = \frac{1}{3} \times 349.8 \text{ t} = 116.6 \text{ t} \longrightarrow 110 \text{ t/pile}$

During an earthquake: $R_a = \frac{1}{2} \times 349.8 \text{ t} = 174.9 \text{ t} \rightarrow 170 \text{ t/pile}$

APPENDIX 2-2 Calculation of Expenditures for Maintenance and Control

(1) Operating costs (1) - Cost of electricity and fuel

The following chart shows the operating costs for the automatic trash rakes, trash-conveying facilities (belt conveyors), and trash-hauling machinery (trucks and barges).

1) Automatic trash rakes and belt conveyors

The estimate of the operation time of the automatic trash rakes and trash-conveying facilities, is based on the estimate of pump operation time. The operation time for a single pump will be figured from total pump operation time and the number of pump units.

	Phra Khanong		Sam Rong		Charoen Rat
	Left-bank	Right-bank	Left-bank	Right-bank	
o Annual hours of operation	31,000	68,000	7,000	12,800	16,900
o Number of pumps	15	20	10	15	25
o Annual average hours of operation per pump	2,070	3,400	700	860	680
o Hours of operation of trash rakes	3,100	5,100	1,000	1,300	1,100
o Motor power (kW)					
Trash rake	5.5x5 =22.0	5.5x9 =49.5	3.7x10 =37.0	5.5x7+3.7x1 =42.2	5.5x12+3.7x1 =69.7
Belt conveyor	-	7.5x1+5.5x2 +3.7x1 =22.2	1.5x5 =7.5	3.7x1 +5.5x1 =9.2	5.5x1+3.7x1 +5.5x1 =14.7
Total	22.0	71.7	44.5	51.4	84.4
o Consumption of electric power (x 1,000 kWh)	69	366	49	67	93
o Electricity rates (x 1000 baht) (1.2¢/kWh = agricultural use rate)	83	439	59	84	112
	522		143		
Total (x1,000 baht)			777		

2) Trash-hauling machinery

a) Trucks

It is expected that, when full-scale pump operation begins, water hyacinths to be hauled away by truck will be collected at the pumping stations. The number of operating hours for automatic trash rakes at this time is determined, and the amount of water hyacinths to be raked up during this period, are calculated in accordance with the contents of 4-3-1 (3) in the report.

The total running distance for trucks is figured from the transport distance and the amount of water hyacinths to be transported per truck per round trip, which in turn is figured from the total amount of water hyacinths to be raked up, as stated above.

And from the total truck running distance, the total amount of fuel consumed is figured, on the assumption that fuel consumption per truck is 5 km/ℓ. Estimating the unit price of gasoline at 6.5 baht/ℓ, total fuel costs are then calculated.

	Phra Khanong		Sam Rong		Charoen Rat
	Left-bank	Right-bank	Left-bank	Right-bank	
Period during which trucks are used	Jul.-Dec.	Aug.-Oct.	Sep.-Oct.	Sep.-Oct.	Aug.-Oct.
Hours of pump operation	22,900	39,500	5,800	8,800	15,700
Ratio to annual hours of operation	0.74	0.58	-	0.69	0.93
Hours of operation of trash rake (hrs)	2,300	3,000	-	900	1,000
Amount of trash rake (m^3)	62,000	62,100	-	18,000	34,000
	12,210		-	1,800	3,400

	Phra Khanong		Sam Rong		Charoen Rat
	Left-bank	Right-bank	Left-bank	Right-bank	
Total running distance (km)	342,000		-	72,000	21,000
Fuel consumption(ℓ)	68,400		-	14,400	4,200
Fuel cost (x 1,000 baht)	445		-	94	27
Total (x 1,000 baht)			566		

b) Barges

The trash hauled away by barge is mostly urban trash, (i.e., materials other than plant tissue). The amount of this trash raked per hour is estimated at approximately 10% of all trash, during full-scale operation of the pumps. Barge operation hours are calculated taking into consideration the distance for transporting the trash, and the amount of trash carried per round trip per barge, for the above-stated amount of trash. Barge engines are assumed to be roughly 50 PS, and fuel consumption is determined using a consumption value of 0.25 /PS/hour.

	Phra Khanong		Sam Rong		Charoen Rat
	Left-bank	Right-bank	Left-bank	Right-bank	
Hours of operation of trash rakes(hr)	800	2,100	1,100	400	100
Amount of trash raked (m^3)	1,600	5,700	15,400	800	400
Barge operation hours (hr)	2,920		4,670	250	20
Fuel consumption (ℓ)	36,500		58,400	3,100	300
Fuel cost (x 1,000 baht)	237		380	21	2
Total (x 1,000 baht)				640	

(2) Operation costs (2) - Wages for operation staff

The only increase in operation staff accompanying the installation of automatic trash rakes, will be the addition of truck drivers and barge handlers. The automatic trash rakes will be linked with pump operation, so the distribution of other additional staff members will not be required in this project.

Each truck will require one driver, and each barge will require 2 handlers. Staff will be distributed according to the number of trucks and barges needed, as stated in the report. If the annual wage for a truck driver or barge handler, averages 30,000 baht, the operating cost (2) will be as follows.

Expenditures for :
Truck drivers : 9 persons x 30,000 baht = 270,000 baht
Barge handlers: 8 vessels x 2 persons x 30,000 baht
= 480,000 baht
Total = 750,000 baht

(3) Expenditures for maintenance

Expenditures for maintenance, for the facilities newly installed for this project, and for the machinery attached to those new facilities, are estimated as shown below, as part of the over-all estimate of equipment cost, operating expenses, etc.

Automatic trash rakes	600,000 baht
Trucks	60,000 baht
Barges	70,000 baht
Total	730,000 baht

(4) Savings on pump operation costs

With the installation of automatic trash rakes, the trash in front of screen can be removed quickly. The difference in water levels of approximately 1 m, which has been seen at the screen sections, will be

reduced to about 0.3 m. This will, in turn, cut down on the consumption of electrical power by the motors, with a consequent cost savings. The estimated amount is shown here.

[Present situation]

The present difference between the average external water level and the average internal water level is about 1 m, according to the water level observation data during full-scale operation of the pumps both upstream and downstream of the pumping stations.

Taking into consideration the difference in water levels caused by the trash at the screen section, the total pumping head is assumed to be 2 m. Pumping capacity at this time is 3.4 m^3/sec (204 m^3/min.), according to the pump performance curve. Pump efficiency at present is about 70%. The above conditions are substituted into the following equation, to obtain the amount of motor power needed.

$$Pm = \frac{0.163 \times H \times Q \times (1 + \alpha)}{\eta p \times \eta}$$

Pm : Motor power (kW)
H : Total pump head (m)
Q : Pumping capacity (m^3/min)
α : Margin ratio (=0.2)
ηp : Efficiency of pump
η : Efficiency of transmission (in this case, direct drive: 1.0)

$\therefore$ Pmp = 114 kW

[Plan]

The difference in water levels at the screen section is assumed to be around 0.3 m, and total pump head is assumed to be 1.3 m. Thus, the pumping capacity at this time will be approximately 3.5 m^3/sec. (222 m^3/min), and pumping efficiency is about 60%. The motor power needed is shown below.

ΔPmf = 94 kW

From the above results, it is evident that approximately 20 kW of power can be saved during full-scale operation of the pumps. However, operations are carried out throughout the year, even in seasons when the pump head is lower. Therefore the annual power saving is assumed to be 1/3 of this.

ΔPm = 20 (kW) x 135,000 (hours) x 1/3 x 1.2 (baht/kWH)
= 1,085,600 baht ≒ 1,086,000 baht