It can be said that the present situation of land use in the model area represents the future pattern of the urbanization in the Study Area.

Residential space in the model area which occupies a majority of the built up space belongs to a low density population area.

3) Klong

The two main drainage channels named Klong Kacha and Klong Gig lie in the middle of the model area in the East-West direction. Connected to these klongs, Klong Sakae, Klong Lao and Klong Chit run in the direction of South-North as lateral drainage channels in the model area. The total length of these Klongs is some 9.0 km and the discharge capacity of Klong kacha is estimated as some 4 cms as is indicated in Fig. G-4. Table G-2 shows typical dimensions of existing cross sections of the Klongs.

4) Existing Facilities for Flood Protection

Three pumping stations and seven cofferdams with gates, as shown in Figure G-1 and Table G-3, have been provided in the model area by DDS since 1981 and 1982. The operation period of the facilities corresponds with the high water period of the Chao Phraya River for about 5 months from September to January. During this period, all the cofferdam gates are almost fully closed and the pumping station is operated manually depending upon the inner water level.

3. Hydrological Observation in the Model Area

Hourly rainfall record at the Ramkhamhaeng University is the only source of rainfall data at present within the model area. Therefore, to grasp the relation between runoff and rainfall characteristics of the area and to obtain sufficient data for the analysis, the following observations were carried out in this stage.

1) Rainfall:

Rainfall was obtained by the automatic recording rainfall gauge installed at the Ramkhamhaeng University.

2) Water Level:

To analyze the relation between runoff and storage in the area, water levels were observed by two observation stations installed in Klong Kacha.

3) Pump Discharge:

To obtain the pump discharge, the pump operation was observed and recorded from hour to hour at the three pumping stations of K. Kacha, K. Gig and K. Chit.

Table G-4 and Fig. G-5 show the hydrological data which were observed in this stage.

In order to grasp the run-off percentage in the Model Area, the water balance that is an algebraic summation of the rainfall, water level and pump discharge is listed in table G-5 for the period of Aug. 22 to Sep. 10. In this period, the hydrological data were obtained simultaneously. The runoff percentage (f) indicated in the table G-5 is introduced with following equations:

$$f = \frac{\text{Total outflow}}{\text{Total inflow}} = \frac{\Sigma vp + \Sigma \Delta S}{\Sigma Vr}$$

Where,

Vr : Rainfall (m^3)

Vp : Pump discharge (m^3)

ΔS : Change of ponding volume (m^3)

The runoff percentage is to be less than 1.0, theoretically, being influenced with the factors of the evaporation, permeance, storage and so on. As is indicated in table G-5, however, the runoff percentages in this investigation introduced very high values which are about 2.0. It is considered, therefore, that there was much inflow from the outside area.

In general, for the execution of a hydrological observation analysis, in the model area, it is usually the lengthy trial and error method. Owing to the big value of the runoff percentage obtained by this Study, it is necessary to get more data. The further study will be made especially in cooperation with the DDS in the next stage in order to get reliable and adequate data and information.

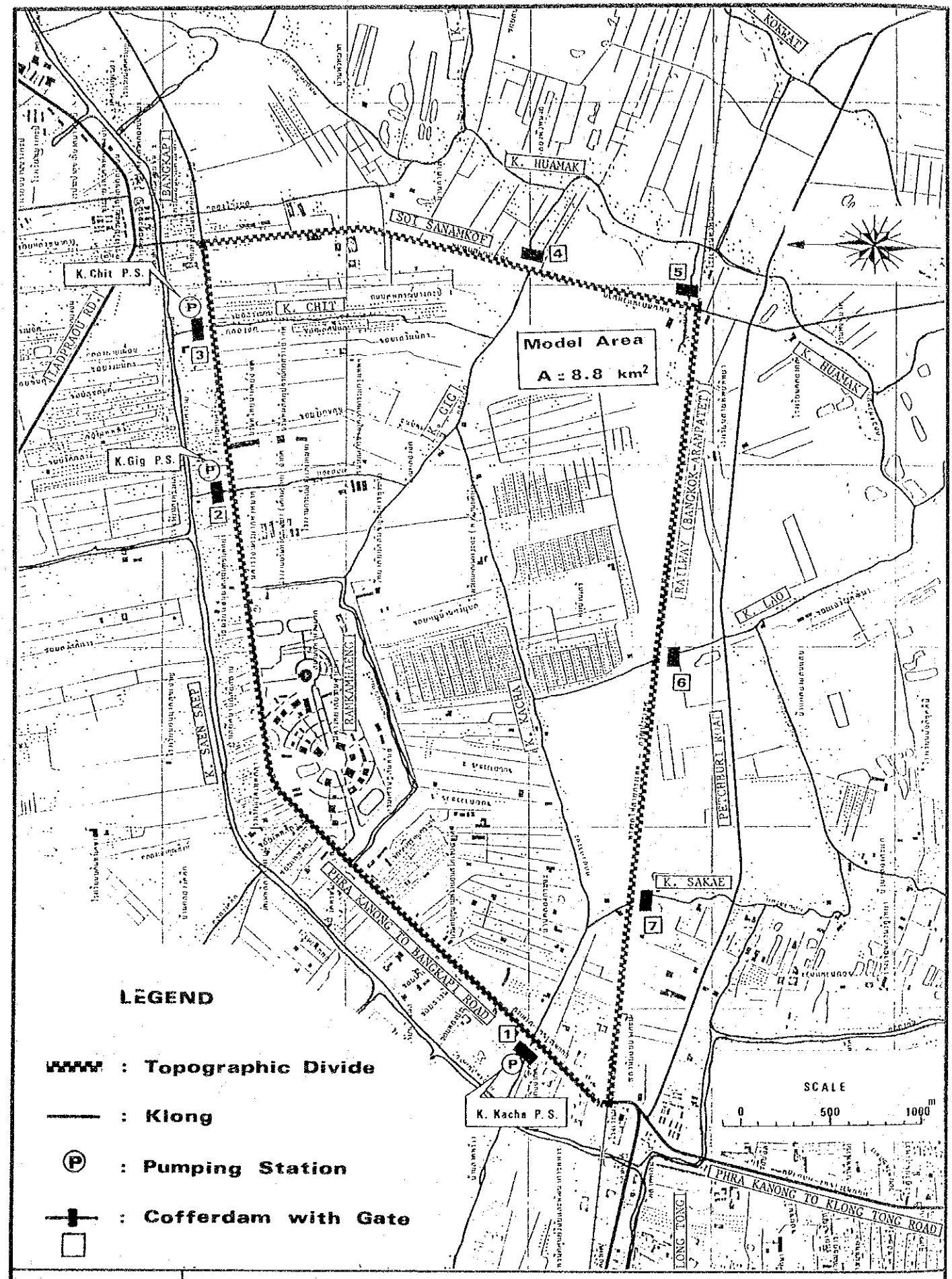
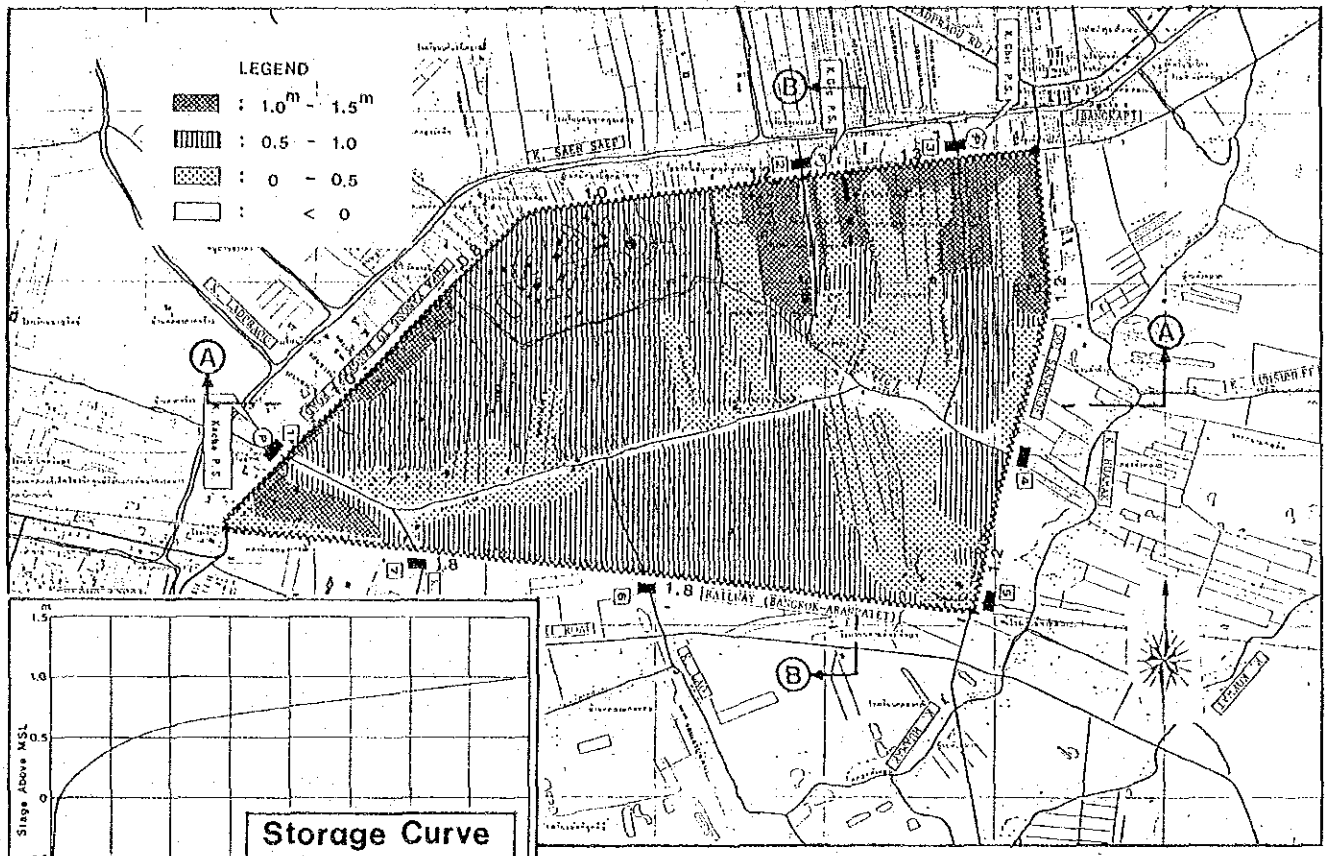
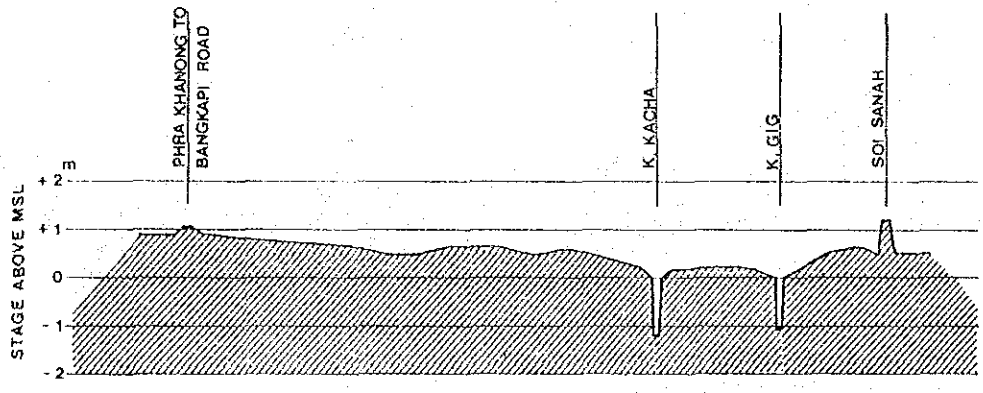


FIG. G.1 Drainage Basin of Model Area

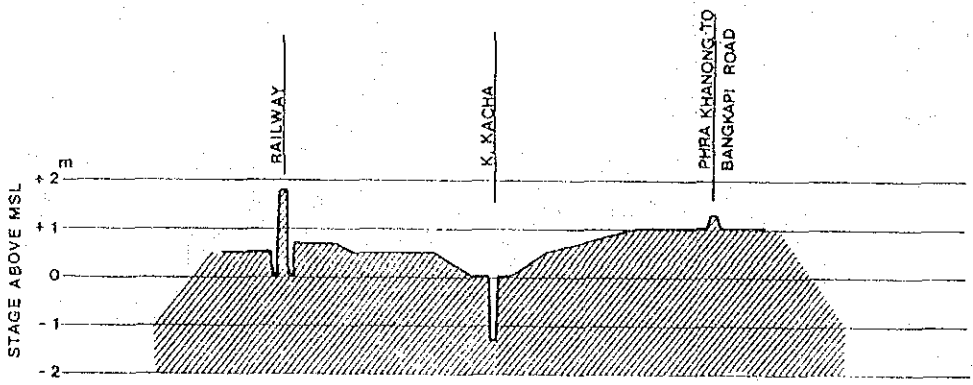
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Ground Elevation in Model Area



SECTION A-A (EAST - WEST)



SECTION A-A (SOUTH - NORTH)

FIG. G . 2 **Existing Topographic Condition**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

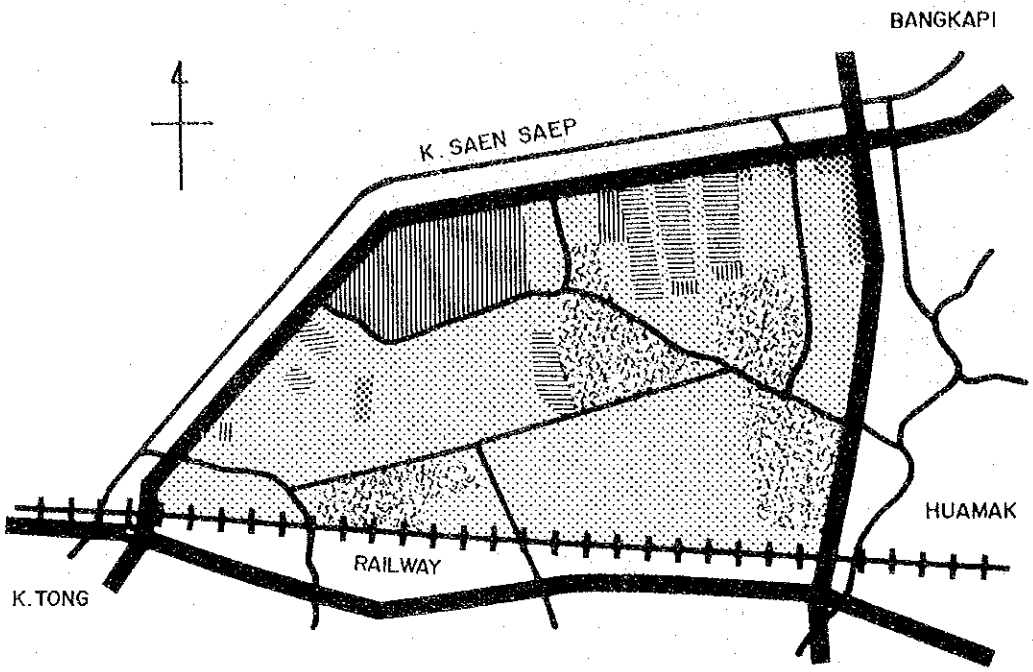


Fig. G-3 Existing Land Use of Model Area

Table G-1 Categolization of Existing Land Use

Land Use	Model Area		Study Area		Mark
	Area (ha)	Percent	Area (ha)	Percent	
Residential	583.0	66.2	11,100	22.2	
Commercial	17.6	2.0	650	1.3	
Industrial	41.6	4.7	300	0.6	
Institutional	87.8	10.0	2,250	4.5	
Park	0.0	0.0	550	1.1	
Agricultural & Open Space	151.0	17.1	35,250	70.3	
Total	881.0	100.0	50,100	100.0	

FIG. G.3 **Existing Land Use in Model Area**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Table G-2 Typical Dimensions of Existing Klongs

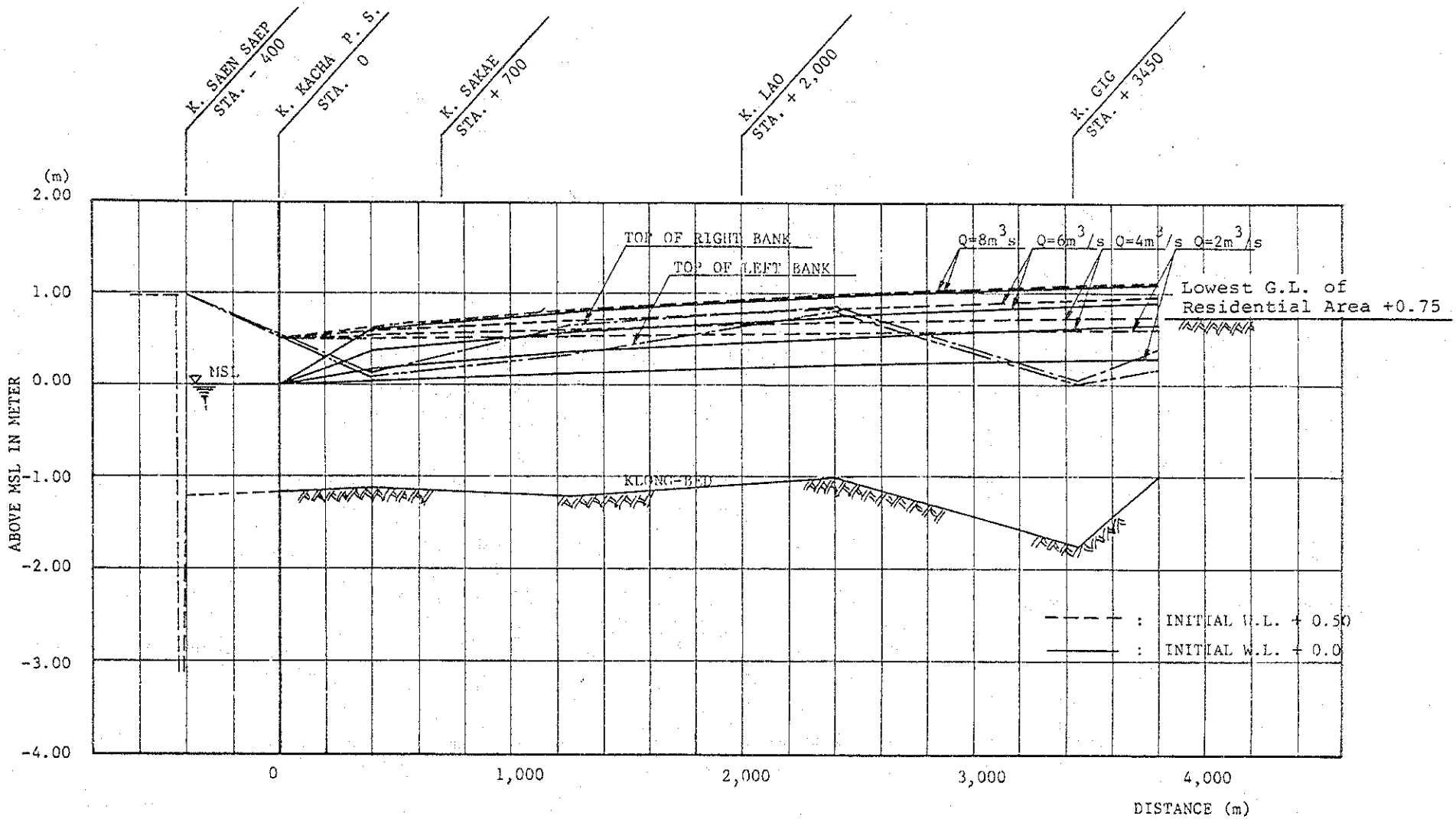
Dimension Name	Length	Typical Section			Remarks
		Width	Depth	Bottom Elev.	
Klong Kacha	3.5 Km	8.0 m	1.5 m	El.-1.2 m	
Kong Gig	2.0	11.0	1.8	El.-1.8	
Klong Sakae	0.3	5.5	2.3	El.-1.1	
Klong Lao	0.7	13.0	2.4	El.-1.5	
None Name	0.9	6.5	1.7	El.-1.2	
Klong Chit	1.6	-	-	-	
Total	9.0 Km	-	-	-	

Table G-3 Existing Facilities of Flood Protection for Model Area

Facilities	Place	Name of Klong	Size	Installed Month/Year	Operation	Remarks
Pump	1	K. KACHA	ϕ24" x 2 Unit ϕ20" x 1 ϕ14" x 2	1982	Manual	Submersible Sewerage Pump
	2	K. GIG	ϕ14" x 1 ϕ12" x 1	1982	Manual	"
	3	K. CHIT	ϕ12" x 1	1982	Manual	"
Gate	1	K. KACHA	H m W m leaf 2.50x2.00x2	1981	Manual	Wooden Gate Leaf
	2	K. GIG	H m W m 2.35x2.00	1981	Manual	"
	3	K. CHIT	H m W m 2.10x2.00	1981	Manual	"
	4	K. GIG	H m W m 2.50x2.00	1981	Manual	"
	5	NONE	H m W m 2.10x2.00	1981	Manual	"
	6	K. LAO	H m W m 2.30x2.00	1981	Manual	"
	7	K. SAKAE	H m W m 3.00x2.00	1981	Manual	"

Table G-4 The Collected Period of Hydrological Data

Item	Aug. 1983 10	Aug. 1983 20	Sept. 1983 10	Sept. 1983 20	Oct. 1983 10	Oct. 1983 20	Remarks
Rainfall	Installed			Out of Order			At Ramkamhaeng Univ.
Water Level (1)							At Upstream end of K. Kacha
Water Level (2)	Visual Observation						At K. Kacha
Pump Discharge		8/22					K. Kacha, K. Gia, K. Chit



Note : Two kinds of water level lines (----) and (——) show the results of non-uniform flow analysis which discharges are 8,6 4 and 2 cms. and initial water levels are MSL ± 0.00 and + 0.50 m respectively.

FIG. G. 4	Longitudinal Profile of K. Kacha
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK	

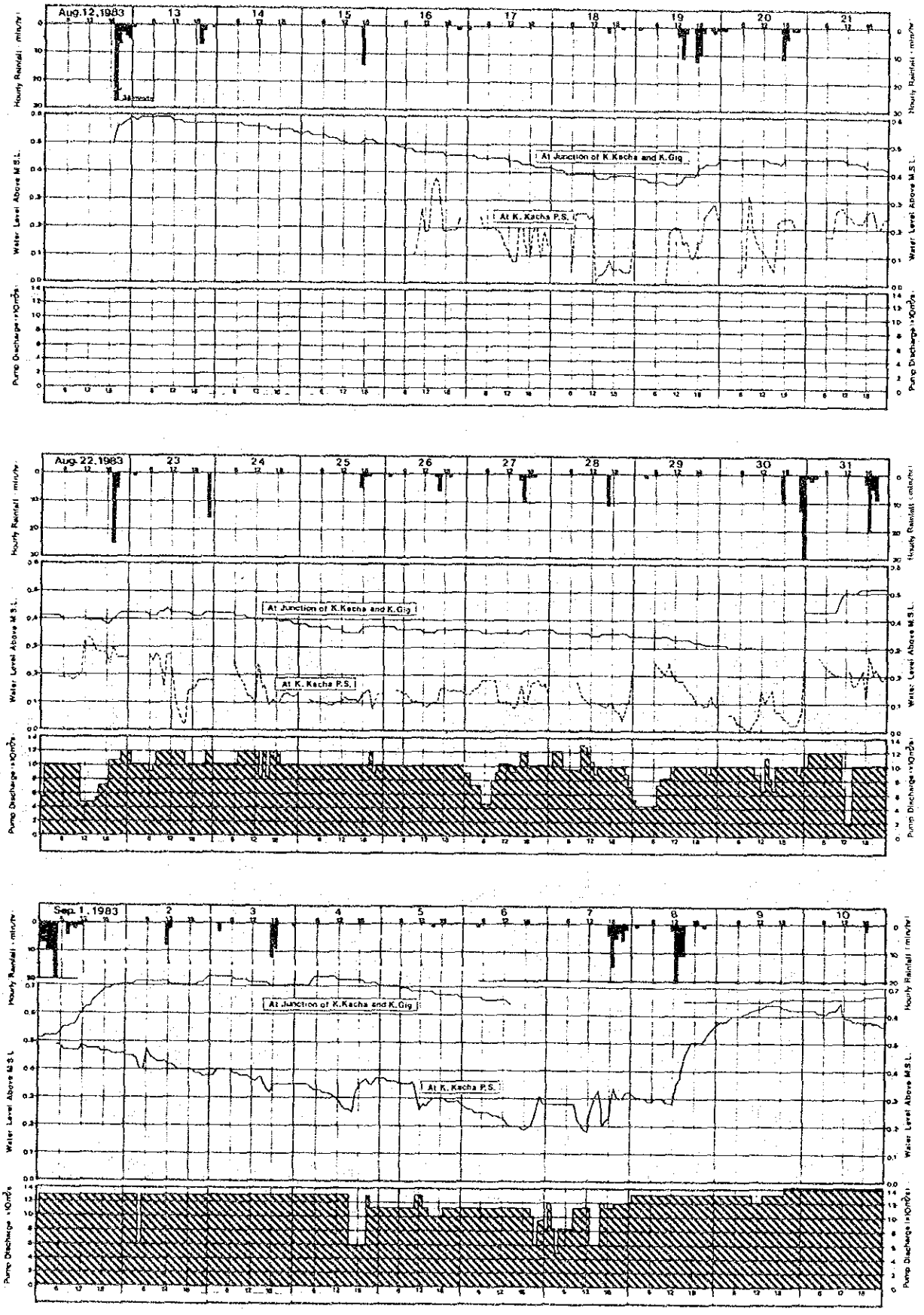


FIG. G. 5 **Collected Hydrological Data in Model Area**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Table G-5 Run-off Percentage

Date		Rainfall			Pump Discharge		Storage in the Area				Total Outflow	Runoff Percentage
		Height (mm)	Volume (m^3/Day)	Σ Vr (m^3)	Volume (m^3/Day)	Σ Vp (m^3)	Water Level (m)	Storage (m^3)	ΔS (m^3/Day)	Σ ΔS (m^3)	ΣVp + ΣΔS	$\frac{\Sigma Vp + \Sigma \Delta S}{\Sigma Vr}$
1	Aug. 21	-	-	-	-	-	0.41	540,000	-	-	-	-
2	22	30	264,300	264,300	209,800	209,800	0.42	560,000	+ 20,000	+ 20,000	229,800	0.87
3	23	17	149,770	414,070	261,600	471,400	0.42	560,000	0	0	471,400	1.14
4	24	0	0	414,070	255,900	727,300	0.38	490,000	- 7,000	- 50,000	677,300	1.64
5	25	7	61,670	475,740	245,100	972,400	0.37	475,000	- 15,000	- 65,000	907,400	1.91
6	26	9	79,290	555,030	244,500	1,216,900	0.36	455,000	- 20,000	- 85,000	1,131,900	2.04
7	27	15	132,150	687,180	226,200	1,443,100	0.36	455,000	0	- 85,000	1,358,100	1.98
8	28	11	96,910	784,090	241,200	1,684,300	0.34	425,000	- 30,000	- 115,000	1,569,300	2.00
9	29	1	8,810	792,900	201,100	1,885,400	0.31	380,000	- 45,000	- 160,000	1,725,400	2.18
10	30	53	466,930	1,259,830	230,100	2,115,500	0.43	580,000	+200,000	+ 40,000	2,155,500	1.71
11	31	41	361,210	1,621,040	255,500	2,371,000	0.51	765,000	+185,000	+ 225,000	2,596,000	1.60
12	Sep. 1	63	555,030	2,176,070	316,200	2,687,200	0.70	1,675,000	+910,000	+1,135,000	3,822,200	1.76
13	2	10	88,100	2,264,170	309,000	2,996,200	0.73	1,960,000	+285,000	+1,420,000	4,416,200	1.95
14	3	25	220,250	2,484,420	316,200	3,312,400	0.70	1,695,000	-285,000	+1,135,000	4,447,400	1.79
15	4	0	0	2,484,420	274,800	3,587,200	0.70	1,675,000	0	+1,135,000	4,722,200	1.90
16	5	1	8,810	2,493,230	271,900	3,859,100	0.66	1,400,000	-275,000	+ 860,000	4,719,100	1.89
17	6	1	8,810	2,502,040	259,800	4,118,900	lack	-				
18	7	35	308,350	2,810,390	246,700	4,365,600	lack	-				
19	8	47	414,070	3,224,460	316,200	4,681,800	0.65	1,350,000	- 50,000	+ 810,000	5,491,800	1.70
20	9	0	0	3,224,460	318,600	5,000,400	0.66	1,400,000	+ 50,000	+ 860,000	5,860,400	1.82
21	10	2	17,620	3,242,080	344,700	5,345,100	0.67	1,470,000	+ 70,000	+ 930,000	6,275,100	1.94
Total		368 mm	3,242,080 m^3	-	5,345,100 m^3	-						

APPENDIX H

Operation and Maintenance

Appendix H Operation and Maintenance

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Appendix H Operation and Maintenance

1. General

Flood protection and drainage system consist of the following facilities:

- .Embankment
- .Drain
- .Klong (Canal)
- .Gate
- .Pump

These facilities can function well provided that they are operated and maintained properly.

This chapter describes briefly how existing facilities are operated and maintained.

2. Existing operation and maintenance

The operation of pumps and gates in the city core area controlled by the DDS is carried out based on water levels measured hourly at about 30 locations. In case of other areas, the surface of some roads has been raised temporarily by means of sand bags.

Some of the existing gates are driven by motor, but most of them are manually operated. As many of the gates are of timber construction, operation may be hindered by warping of the gate due to the influence of the sun.

The two permanent main pumping stations, Rama IV and Padung Krung Kasem, are used for a much bigger area than originally planned. This is a heavy burden, especially when one or more pumps are out of order or in need of repairs. In special cases, for instance during September 1983, the pumping stations were even used to relieve the flood in the eastern suburban area suffering from high water levels in Klong Phra Kanong and Klong Tan.

Present maintenance is considered insufficient to keep the klong system and the adjacent structures in the required condition. Many problems are encountered, such as the poor accessibility to many klongs and illegal garbage dumping, especially in slum areas.

2.1 Drain

Drains can work with full capacity provided that slope and cross-sectional area are maintained as designed.

The discharge capacity of a drain is governed by cross-sectional area and velocity which is influenced by slope, roughness coefficient and hydraulic radius. Manning's formula, which is usually used for calculation of discharge capacity of drain, is expressed as follows:

$$Q = A.V$$
$$= A.\frac{1}{n}.\ R^{\frac{2}{3}}.\ I^{\frac{1}{2}}$$

Where,
- Q : Discharge Capacity (m^3/sec)
- A : Cross-Sectional Area of Drain (m^2)
- V : Velocity (m/sec)
- n : Mannings' Roughness Coefficient
- R : Hydraulic Radius of Drain (m)
- I : Slope

Cross-sectional area will be reduced and roughness coefficient will be increased if siltation occurs within drain. For example, the discharge capacity and velocity are lowered by about 10 percent when 10 percent of drain depth is blocked due to siltation. (Fig. H.1)

Drains have become gentle in slope and some have become adverse slope as is shown in Fig. H.2. due to unequal land settlement caused by excessive withdrawal of groundwater.

Therefore, drains are cleared annually. According to the result of drain cleaning from 1980 to 1982 as is shown in Table H.1, 0.2 to 0.3 cubic meters per meter is cleaned annually. This volume equals to the cross-sectional area of 600 mm-diameter drain pipe. The cleaning cost was 100 to 180 Baht per m^3, and 30 to 50 Baht per meter.

Due consideration into construction methods, types of structure etc. will be emphasized to alleviate siltation, taking into account the big volume of siltation and its cost of removal.

Table H.1 TABLE OF DRAIN CLEANING

YEAR	ITEM	DDS	CONTRACTOR	REMARK
1980	LENGTHS (KM)	222	273	
	VOLUMES (M^3)	42,726	62,621	DISPOSAL □AT SITE □ELSEWHERE
	COST (฿)	5,912,298	11,288,275	
1981	LENGTHS (KM)	222	210	
	VOLUMES (M^3)	42,727	57,924	DISPOSAL □AT SITE □ELSEWHERE
	COST (฿)	7,766,726	10,000,000	
1982	LENGTHS (KM)	299	273	
	VOLUMES (M^3)	98,764	72,695	DISPOSAL □AT SITE □ELSEWHERE
	COST (฿)	8,944,620	10,005,000	

[Source : DDS]

2.2 Klong

Klongs have been used by Bangkokians for various purposes like irrigation, drainage, navigation etc. Canal maintenance division of the DDS has responsibility of keeping the klongs' facilities properly with the following personnel, equipment and facilities.

Personnel, Equipment and Facilities

About 680 employees work with the Canal Maintenance Division, subdivided as follows:

- engineers	18
- technicians	70
- secretaries and clerks	54
- labour	544

The equipment belonging to the Division can be subdivided as follows:

- trucks :	
. dump truck (4 m^3)	35
. crane truck	4
- excavators :	
. backhoe loader	2
. truck mounted hydraulic excavator	3
. track mounted hydraulic excavator	1
. truck mounted crane with drag	1
. pontoon mounted hydraulic excavator	4
- composite pontoons	3
- barges (various sizes)	7

(1) Garbage Collection

The day to day maintenance of the klongs includes also the collection of garbage and debris. The equipment used for this consists of fiber glass boats with outboard engines (5-10 hp). Three to five labourers are employed on each boat. Table H.2 show some cost and production figures on garbage collection from the klongs.

Table H.2 Production and cost figures on klong garbage collection

Klong	Costs	
	Monthly basis ฿/month	Average unit price for removed and deposited garbage ฿/m^3
Lord	45,400	378
Ong Ang and Bang Lum Phu	75,400	300
Padung Krung Kasem	115,100	193
Maha Nak	75,400	214
Saen Saep	71,200	35
Sam Sen	30,600	59
Bang Sue	22,800	95
Total/average	435,900	106

(2) Cleaning

Table H.3 presents the available data on the number of klongs which have been cleaned during the years from 1979 to 1983 inclusive; they refer only to maintenance work done by the Division using its own man-power and equipment.

The following working methods used for the klong cleaning:

- by manual labour, disposing the dredged material on the embankment, or, where possible in a dump truck.
- by truck mounted excavator, working from the bank and dumping the material in a dump truck
- by a pontoon mounted excavator, floating in the klong and dumping the spoil in a barge.

Table H.3 Figures on Klong Maintenance by Canal Maintenance Division

Year	Zone:	Number of Klongs	Excavator		Transport		Labout		Management	
			truck	pontoon	truck	barge	no:	monthly wages	no:	monthly wages
1979	Outer	1	-	1	-	-	2	2,500	1	3,000
1980	-	-	-	-	-	-	-	-	-	-
1981	Inner	2								
	Outer	2 (5)	5	3	9	3	23	2,500	6	3,500
	Central	1								
1982	Inner	1								
	Central	5 (6)	6	1	7	2	10	2,500	6	4,000
1983	Inner	2								
	Central	1 (3)	4	3	4	4	19	2,500	3	4,500

Note : This table is exclusive of maintenance on contract basis.

2.3 Gate

Most of the present gates are operated by hand. None of them work automatically, synchronized with the in-or outside water levels. Manual operation is not easy for proper operation, especially where additional pump capacity is lacking. In order to have an efficient operation, it is recommend to adopt automatic operation.

2.4 Pump

Many pumps are installed mainly in the city core area as shown in Fig. H.2. These pumps are classified into the following four types;

1) Major Pumping Station
2) Sub Pumping Station
3) Temporary Pumping Station (Pontoon)
4) Moveable Pump (Submerged)

Characteristics of operation and maintenance at some pumping stations (general views of which are shown in Figs. H.4 to H.7) are presented in Table H.5.

All pumping stations except Rama 4 pumping station (which is driven by diesel engine) are driven by electricity. More staff and higher running cost occur at Rama 4 pumping station than at Padung Krung Kasem pumping station whilst they are of almost the same capacity.

Much garbage is brought into these pumping stations through the open klongs except at Rama 4 pumping station which is equiped with a shield trunk main. 1.5 tons per day garbage is brought into Padung Krung Kasem pumping station.

According to the result of klong dredging from 1980 to 1982 as shown in Table H.4, dredging by mechanical cost about 300 Baht per meter and 70 Baht per m^3, while dredging by manual labour cost about 200 Baht per meter and 80 Baht per m^3 as of 1982.

Table H.4 Dredging

YEAR	METHOD	ITEM	CONTRACTORS
1980	Mechanical	Cost (฿)	3,038,300
		Lengths (m)	11,922
		Volumes (m^3)	58,344
	manual labour	Cost (฿)	2,531,140
		Lengths (m)	14,088
		Volumes (m^3)	(28,908)
1981	Mechanical	Cost (฿)	2,913,750
		Length (m)	1750
		Volumes (m^3)	(-)
	manual labour	Cost (฿)	1,664,560
		Lengths (m)	11,235
		Volumes (m^3)	(22,709)
1982	Mechanical	Cost (฿)	4,607,800
		Lengths (m)	14,586
		Volumes (m^3)	71,199
	manual labour	Cost (฿)	2,842,000
		Lengths (m)	15,482
		Volumes (m^3)	37,222

More effort is required to reduce the garbage volume, because it causes pump operations to be less efficient. For example, after the automatic rake was installed in the Padung Krung Kasem pumping station, head loss was considerable reduced, thus resulting in efficient operation of pump as shown in Fig. H.8. Efforts to reduce the garbage amount should be continued.

Table. H.5 Abstract of Operation and Maintenance at the Pump Stations

Pump Station	Type	Staff			Running Cost ฿/year			Collected Garbages t/year	Maintenance	
		Operator	Others	Total	Electric or Fuel Fee	Repairing	Total		Visually	Measures
Rama 4 Pump St.	1	16	13	29	2.800,000	1,900,000	4,700,000	30		0
Krung Kasem "	1	8	19	27	1,865,000	-	1,865,000	540	0	
Klong Tan "	2	3	-	3	544,000	5,000	549,000	48	0	
Linchee "	2	4	-	4	267,000	1,800	268,800	36	0	
Phra Khanong Gate	3	3	-	3	168,000	500	168,500	-	0	
Klong Sam Saen Pomp St.	3	5	-	5	515,000	2,500	517,500	72	0	
Klong Kra Cha	4	3	-	-	148,000	500	148,500	36	0	

[Source DDS]

Note :

Type 1. Major Pumping Station
2. Sub Pumping Station
3. Temporary Pumping Station
4. Movable Pump

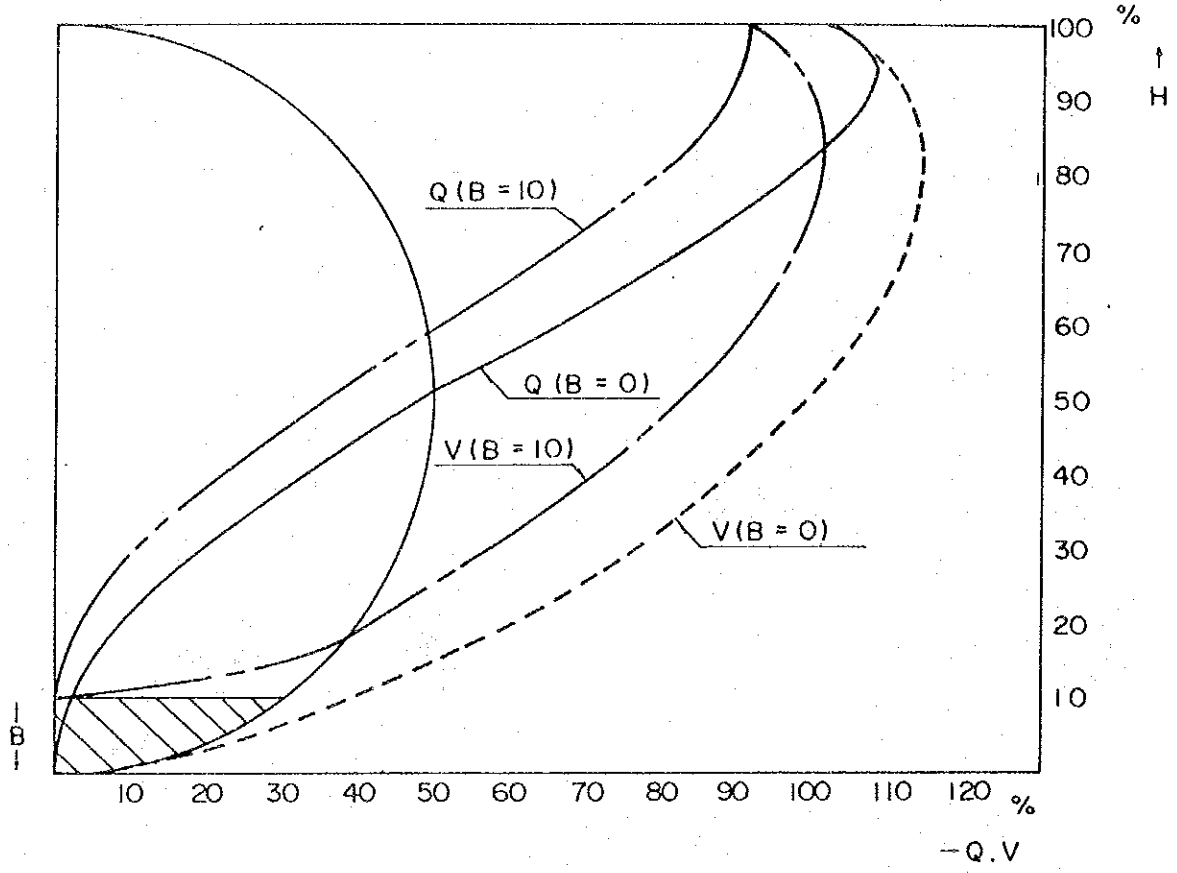

FIG. H.1 **Hydraulic Characteristics of Hume Pipe**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

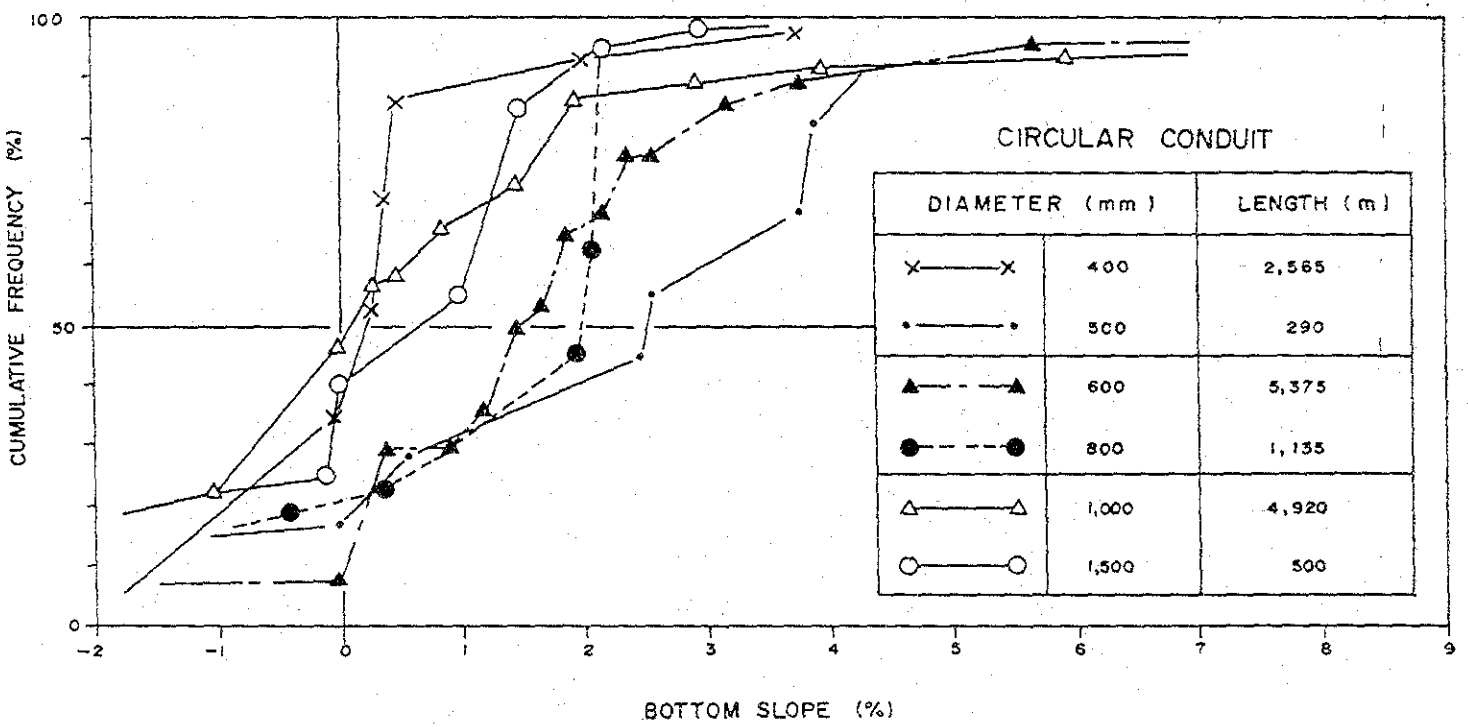

FIG. H.2 **Distribution of Existing Circular Conduit Slope**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

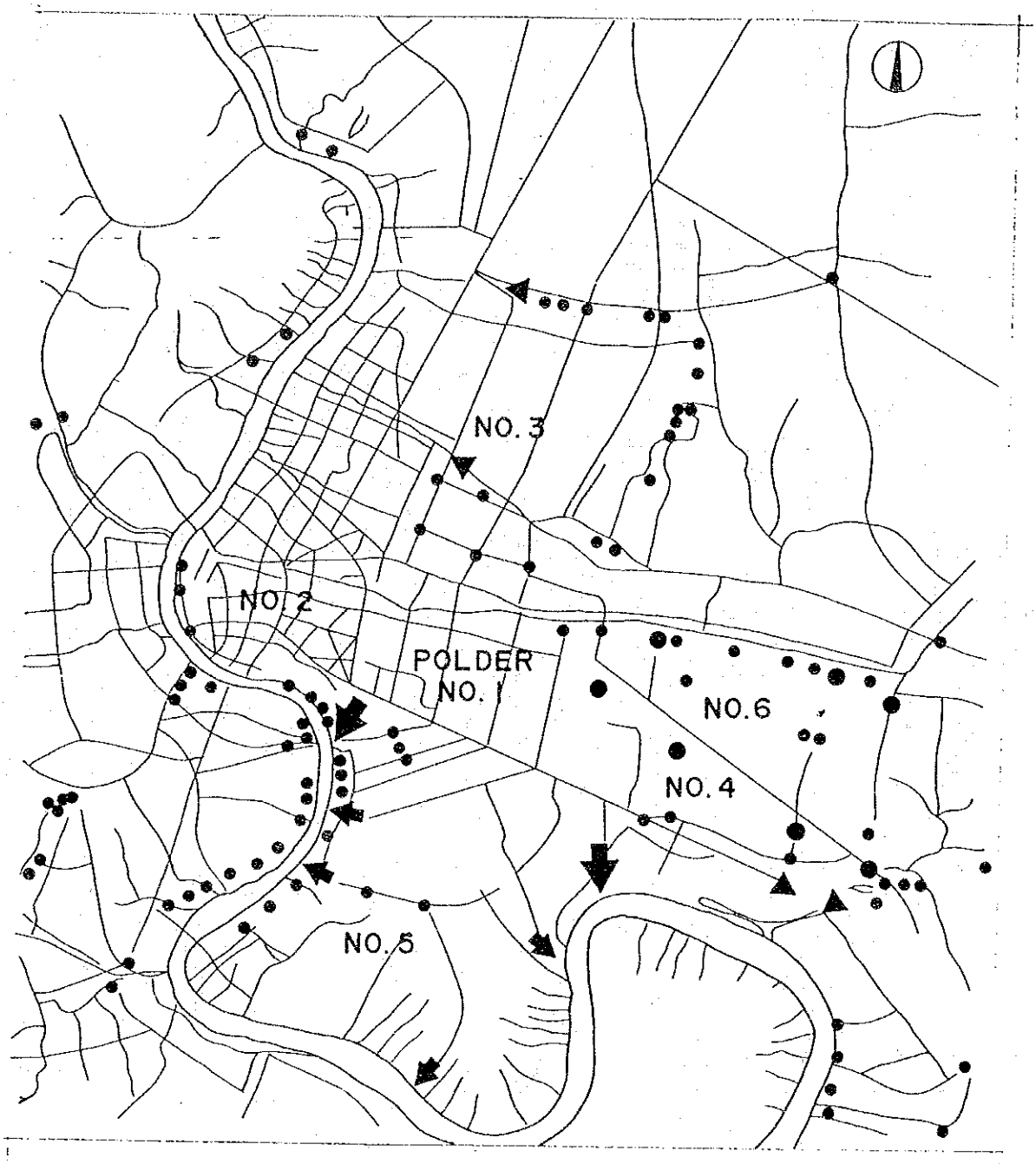

FIG. H.3 **Location of Pumping Station**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

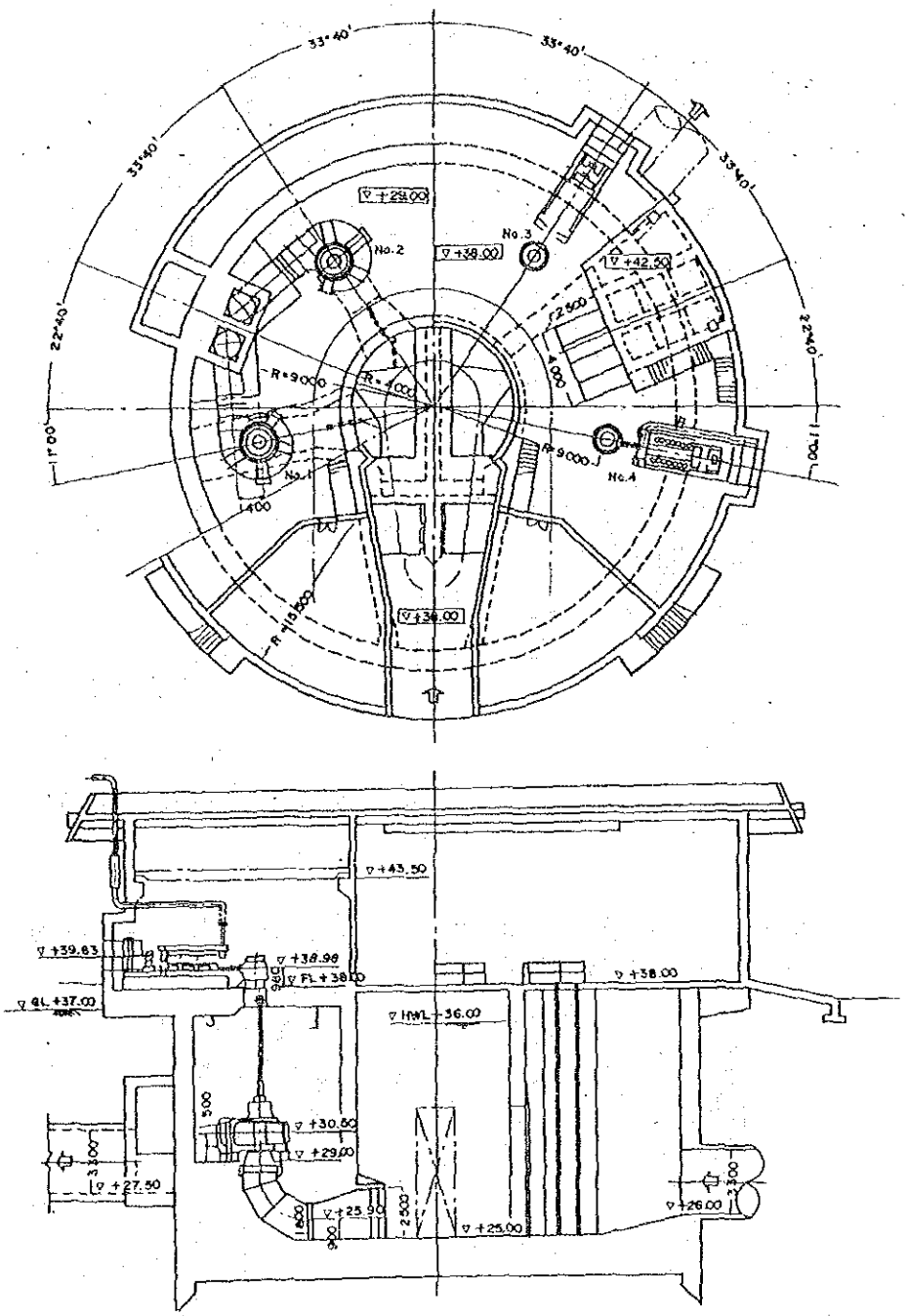

FIG. **H.4** | **General View of Rama IV Pumping Station**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

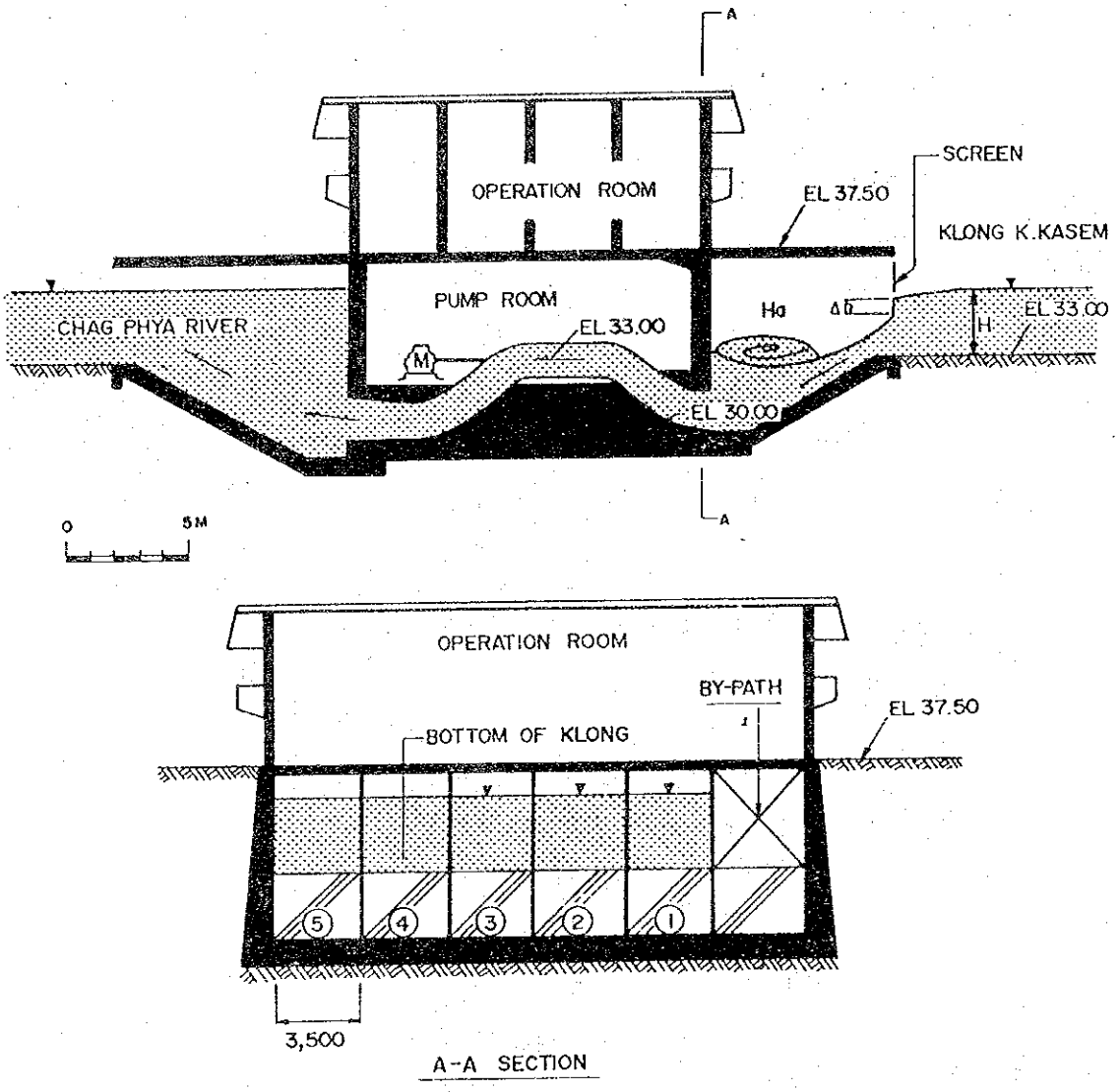

FIG. H . 5 General View of Padung Krung Kasem Pumping Station

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

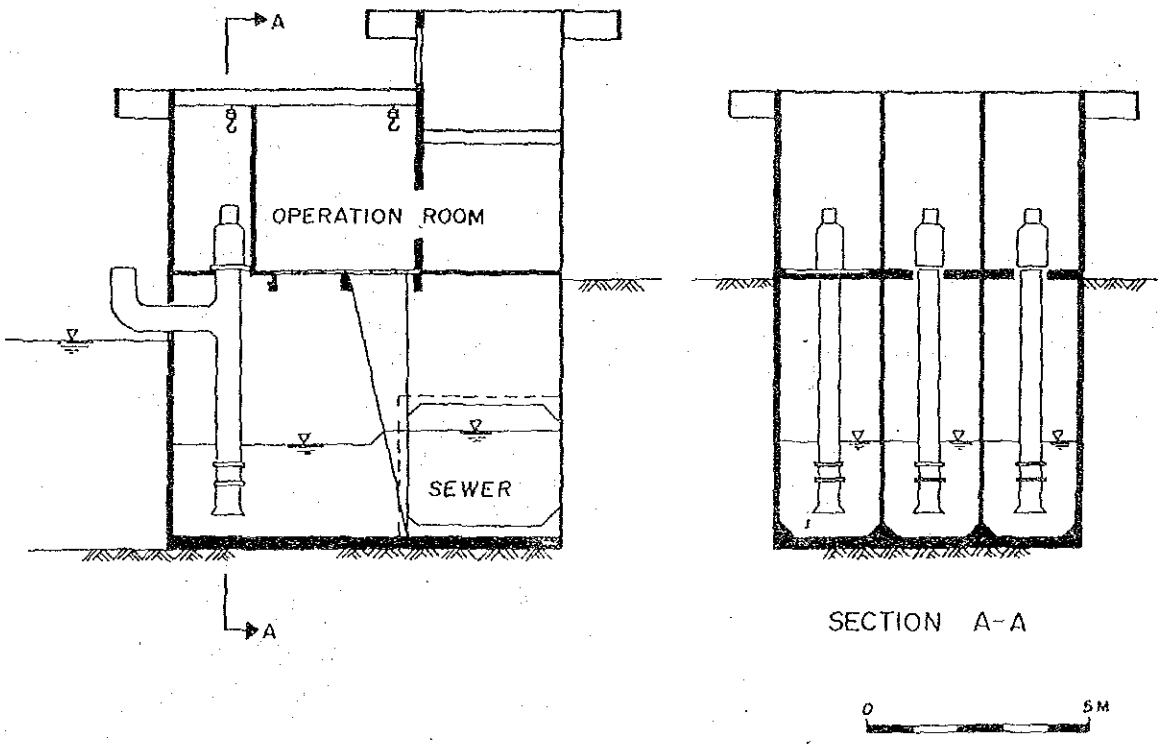

FIG. H.6 General View of Nang Lingee Pumping Station

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

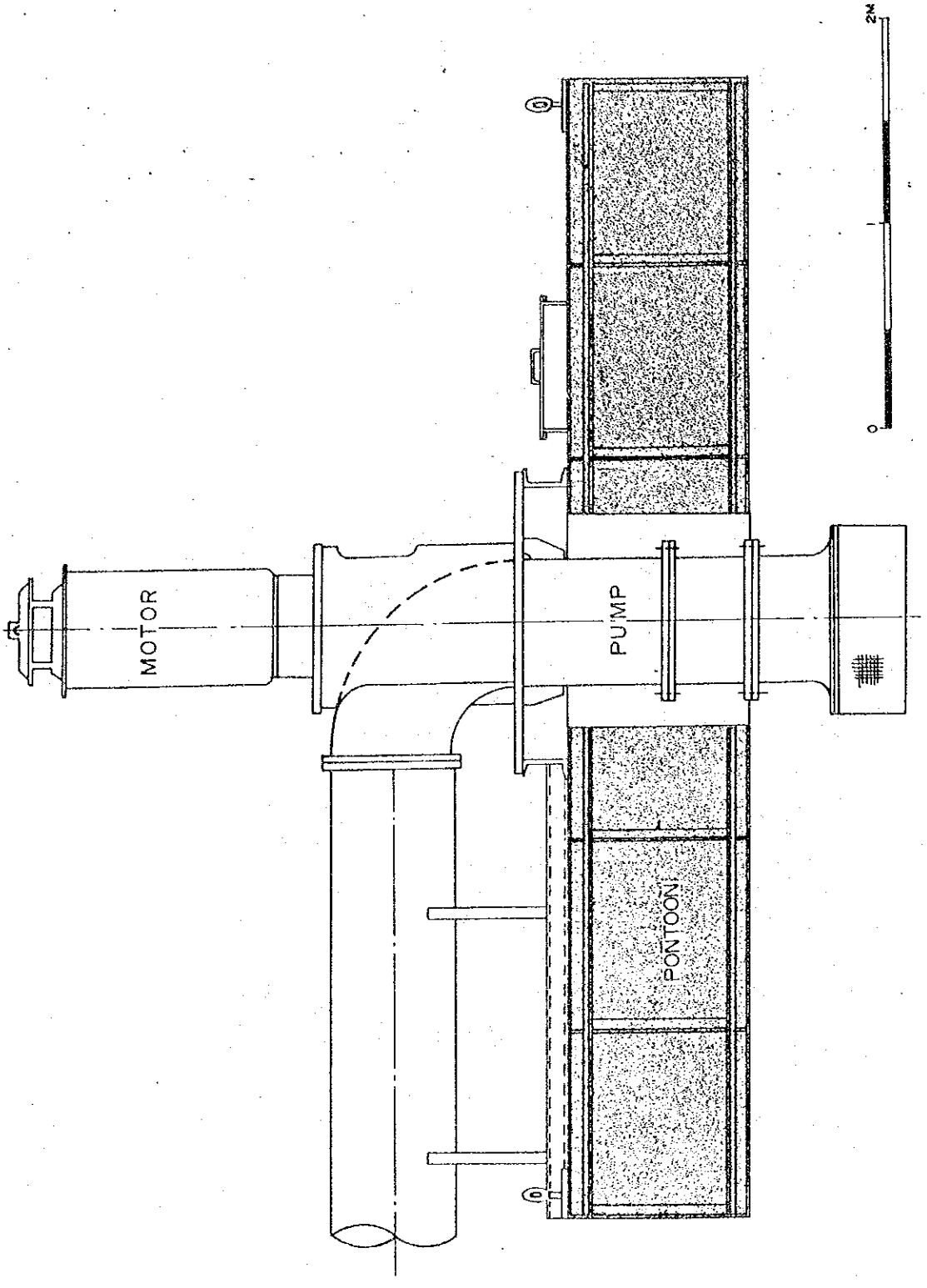

FIG. H . 7 **Sectional View of Pontoon-mounting Pump**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

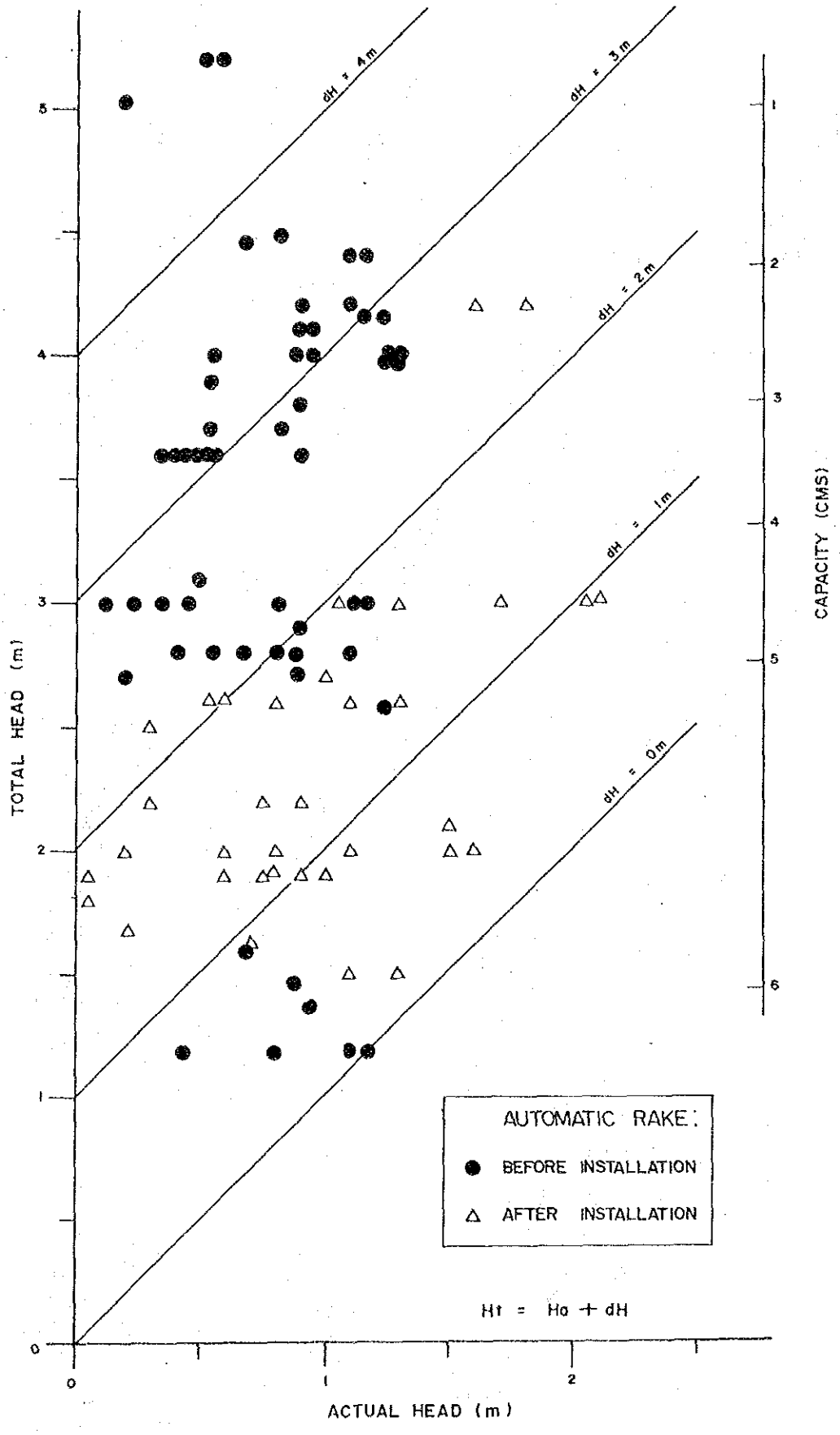

FIG. H.8 **Effect of Automatic Rake in Padung Krung Kasem Pumping Station**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

APPENDIX I

Scope of Work

Appendix I Scope of Work

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SCOPE OF WORK

FOR

PRELIMINARY AND MASTER PLAN
ON

FLOOD PROTECTION/DRAINAGE PROJECT
IN

THE EASTERN SUBURBAN-BANGKOK IN THE KINGDOM OF THAILAND

AGREED UPON BETWEEN

THE BANGKOK METROPOLITAN ADMINISTRATION
AND
JAPAN INTERNATION COOPERATION AGENCY

T. Fukui

Tsunekazu Fukui

Leader,
JICA Proliminary Study Team

Amphan Punnakant

Amphan Punnakant

Deputy Govenor
of the Bangkok Metropolitan
Administration
(for the governor of BMA)

1. Introduction

In response to the request of the Government of Thailand, the Government of Japan has decided to conduct the Preliminary and Master Plan Study on the Flood Protection/Drainage Project in Suburban Bangkok (hereinafter referred to as the Study), within the general framework of technical cooperation between Japan and Thailand which is set forth in the Agreement on Technical Cooperation between the Government of Japan and the Government of the Kingdom of Thailand signed on 5 November 1981. The Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programme of the Government of Japan, will accordingly undertake the study in accordance with the relevant laws and regulations in force in Japan, in close cooperation with the Department of Drainage and Sewerage, Bangkok Metropolitan Administration (DDS BMA) and other Thai authorities concerned.

2. Objective of the Study

The objective of the study is to carry out a preliminaly study on the Flood-Protection/Drainage Project in Suburban Bangkok, and to conduct a master plan study on the high priority area to be identified and based on the result of the preliminary study.

3. Study area

1. The study area of preliminary study coveres the eastern suburbs of approximately 600 sq.Km located between the Viphavadee Ransit Highway and the Green Belt Zone.
2. The study area of the master plan will be selected from the result of the preliminary study.

(5) Previous flood and damages

a. Rainfall, runoff and flood damages (b)

b. The hydrological regime of the river (b)

c. Frequency (b)

d. Flooding areas, recession time and damages (b)

e. The operation of pumps and gates of the BMA. (b)

(6) Institution and finance

a. Organisation and management of the BMA and other authorities relating to the flood and drainage (a)

b. Annual budget, financial planning of the BMA (a)

c. Tax revenue and property (a)

(7) Related maps and drawings

a. Topographical map of the Study Area (a)

b. Aerial photograph of the Study Area (a)

(8) Miscellaneous items

a. Existing water supply project and future plan (a)

b. Ground water usage and level (a)

c. Green-belt project (b)

d. Lower Chaopraya Basin Management project (b)

1-2 Review of Previous Study

(1) Review of previou study carried out in 1968 by C.D.M.

1-3 Development of the criteria to formulate the drainage zone

1-4 Development of the creteria to set the priority of the drainage zone

1-5 Analysis for selecting master plan area

1-6 Definition of survey area for master plan

1-7 Rough study of flood protection and drainage method

1-8 Studies of organisation, operation and management plan

JJ

4. Scope of Study

4. I. Preliminary Study

1-1 Data collection and analysis related to the study are of two groups as follow:

(a) Those data and materials to be provided by the BMA.

(b) Those data and materials to be provided by the BMA with the assistant of JICA

(1) Land use	
a. Existing land use map	(a)
b. Existing road net work (in map)	(a)
c. Existing open drain network (in map)	(a)
d. Existing main building (office, school, hotel etc.)	(b)
(2) Population	
a. Population and its annual change (in Bangkok)	(a)
b. Population density of the Study Area and each zone	(a)
c. Day-time and night-time population of the study area and each zone	(b)
(3) City planning	
a. Future population	(b)
b. Future demand of land by use	(a)
c. Land use plan	(a)
d. Network of road and railway	(a)
e. Network of open drains	(b)
f. Future development plan	(a)
- new housing area	
- new industrial area	
- others	
(4) Natural condition	
a. Meteorological data	(a)
b. Hydrological data	(a)
c. Geographical data such as klongs, configuration, elevation, land subsidence etc.	(b)

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4.II Master Plan Study

2-1 Supplemental data collection and analysis.

2-2 Establishment of the target year for planning.

2-3 Study of flood protection and drainage system.

2-4 Study of facilities.

2-5 Study of construction method and materials.

2-6 Study of available construction materials and man-power for construction, operation and maintainance.

2-7 Study of construction programme.

2-8 Rough estimation of costs for construction, operation and maintainance.

2-9 Rough estimation of benefits.

2-10 Study of finance.

2-11 Studies of organisation, operation and management plans.

2-12 Study of the priority of the project.

2-13 Proposing the area for the feasibility study.

5. Study schedule

The whole study will be conducted in accordance withe attached schedule.

6. Reports

JICA will prepare and submit the following reports to the DDS in the course of the preliminary and master plan study:

1. Inception report
   20 copies
   at the beginning of the field survey.
2. Progress report
   20 copies
   at the end of the field survey.
   The DDS will submit to JICA its comment within one month after the receipt of the report.

3. Interim report

20 copies at the end of the field survey.

The DDS will submit to JICA its comments within one month after receivin the report.

4. Draft final report

20 copies within 3 months after the receipt of comments on the progress report.

Another 20 copies within 4 months after the receipt of comments on the interim report.

The DDS will provide JICA with its comments within one month after the receipt of the D/F

5. Final report For the Preliminary study report, 40 copies and Master plan, 200 copies within 2 months after the receipt of the comments on the D/F.

7. Undertaking of the Government of Thailand

In accordance with the Agreement on Technical Cooperation between the Government of Japan and the Government of the Kingdom of Thailand, the Government of Thailand shall accord privileges, immunities and other benefits to the japanese team and , through the authorities concerned, take necessary measures to facilitate smooth conduct of the study.

The BMA shall make the necessary arrangement with proper agencies concerned as follow:

(1) Coordination of the study will be provided through the BMA.

(2) To provide the counterparts fund for the execution of the study.

(3) To secure all available relevant studies and data for the use of the study team.

(4) To provide the study team with the followings:

a. Appropriate number of personnels as counterparts.

b. Office space, equipment and supplies for the study team.

c. Vehicles with drivers for the study team.

d. Credentials of indentification (ID) cards to the members of the study team who shall be working in Thailand for the execution of the study.

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8. Undertaking of the Government of Japan

(1) To transfer knowledge to the Thai counterpart personnel during the study.

(2) To give technical advices for the flood protection/drainage project being carried out by the DDS during the stay of the study team in Thailand.

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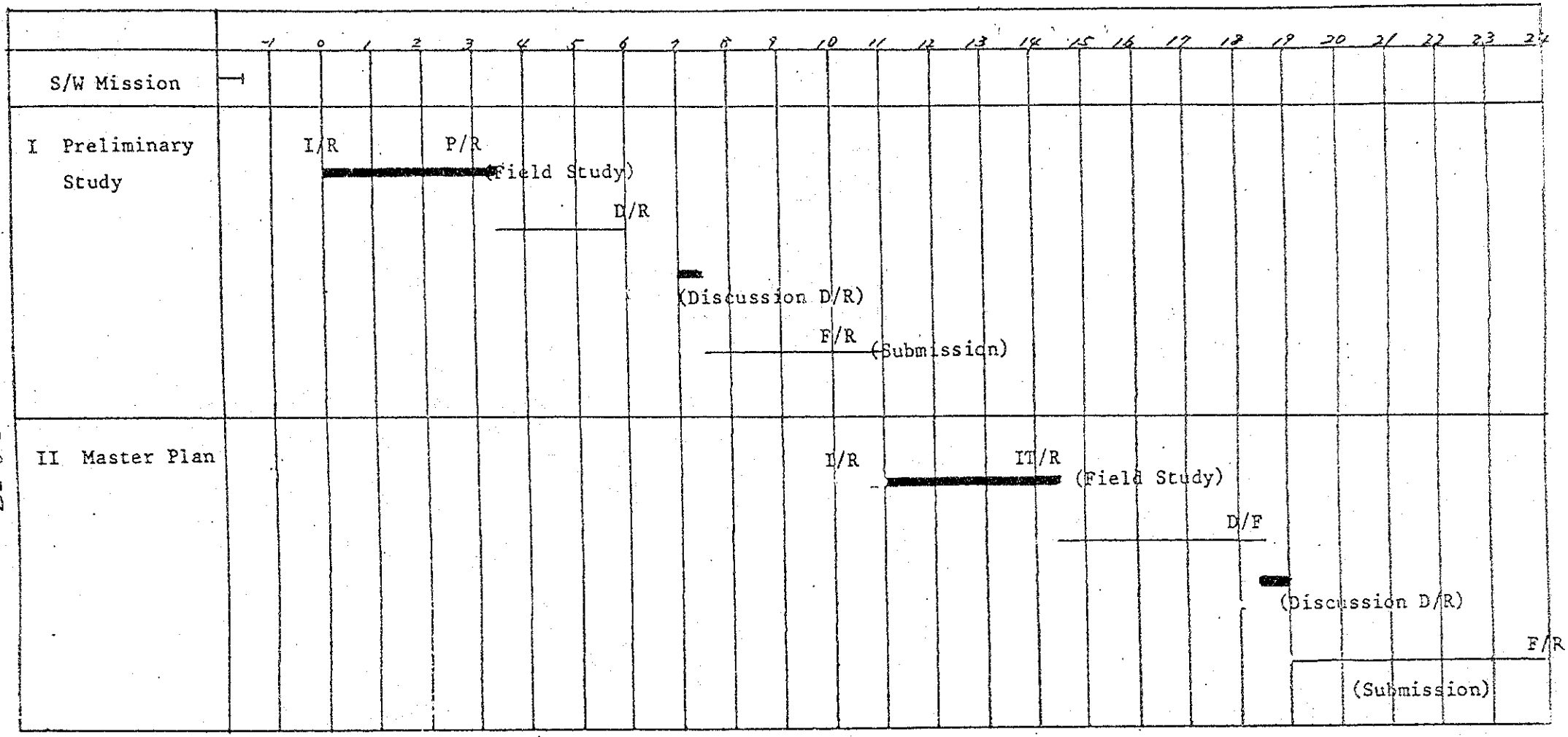
Study Schedule



I/R Inception Report
P/R Progress Report
IT/R Interim Report
D/R Draft Final Report
F/R Final Report

Thailand
Japan

T-8-74

Appendix J

List of Reference Data

Appendix J List of Reference Data

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Appendix J List of Reference Data

1. Authorities Visited in Connection with the Study

The authorities listed below were visited to collect data, discuss the study or to ask for advice and guidance. Their assistance is gratefully acknowledged.

- Department of Drainage and Sewerage (DDS), Bangkok.
- Asian Institute of Technology (AIT), Bangkok.
- Meteorological Department, Bangkok.
- Royal Irrigation Department (RID).
- Hydrographical Department, Royal Thai Navy.
- Marine Survey Division, Port Authority of Thailand.
- Department of Town and Country Planning (DTCP)
- City Planning Division, Bangkok.
- National Statistical Office (NSO).
- Mineral Resources Department (MRD).
- National Housing Authority (NHA).
- Highways Department.
- Public Works Division (PWD), Bangkok.
- Metropolitan Water Works Authority (MWWA).
- State Railway of Thailand (SRT).
- Office of the National Economic and Social Development Board (NESDB).
- Office of the National Environmental Board (NEB).
- Royal Thai Army.
- Royal Thai Air Force.
- Thailand Institute of Scientific and Technological Research.

2. Inventories of Available Data

The data listed in the following paragraphs were collected.

2.1 Topographical Data and Aerial Photographs

- Topographical maps:
  - Scale 1:20,000;

. Scale 1:50,000;

. BMA, existing benchmarks, dated August 1979.

- Aerial photographs:

. Scale 1:10,000 dated 1982.

- Existing land use map, dated 1980.
- Klong Network map
- Highway network map
- Road height
- Cross Sections of Klongs

2.2 Hydrological Data

The basic hydrological data required for flood control and drainage planning consist of river levels, klong levels, tide levels, rainfall and other meteorological data.

- Rainfall data:

. Location of rainfall stations and gauge particulars in Bangkok

. Daily rainfall data at:

Bangkok Metropolis	1951-1983
Bang Na	1966-1983
Bang Khen	1967-1983
Tungsertee Village	1977-1982
Banbuaman School	1979-1982
Bang Kapi	1956-1983
Min Buri	1956-1983
Bang Phli	1959-1983
Lat Krabang	1957-1983
43 stations	1978, 1980, 1982

. Hourly rainfall data

Station : Bangkok Metropolis 1965-1980

. The biggest rainfalls for 5, 10, 15 and 30 minutes and 1, 2, 6, 12 and 24 hours;

Bangkok Metropolis 1957-1968

. Monthly maximum rainfall for 15 and 30 minutes and 1, 2, 3, 6, 12 and 24 hours;

Bangkok Metropolis 1976-1979

- Water levels:

  . Location Map of water stage station of Lower Chao Phraya River.

  . Hourly water levels months August - November at:

Bangkok Bar	1970, 1975.-1980
O.B. Station (Bangkok Harbour)	1970, 1975, 1978-1981
Sathu Pradit	1978, 1980
BT Station	1970, 1975, 1978, 1980
Phra Pra Daeng	1970, 1975, 1978, 1980
Fort Phrachul	1970, 1975, 1978, 1980
Paknam	1970, 1975, 1978, 1980

  . Monthly Highest High Water Level (H.H.W.L.), High Water Level (H.W.L.) and Lowest Low Water Level (L.L.W.L.) of Chao Phraya River:

Bangkok Bar	1940-1982
O.B. Station (Bangkok Harbour)	1940-1982
Sathu Pradit	1976-1982
Phra Pra Daeng	1940-1982
Fort Phrachul	1940-1982
Paknam	1940-1982
Bang Sai	1940-1982

  . Monthly Highest High Water Level (H.H.W.L.) and Lowest Low Water Level (L.L.W.L.)

Hydrographic Department	1940-1982
Memorial Bridge	1940-1982

2.3 Other Reports and Data

- Master Plan for Sewerage, Drainage and Flood Protection Systems in Bangkok and Thonburi, Camp, Dresser and Mckee, (February 1968)

- Investigation of land subsidence caused by deep well pumping in the Bangkok area, Phase IV, Final Report, 1982.
- Investigation of land subsidence caused by deep well pumping in the Bangkok area, Comprehensive Report 1978-1971, 1981;
- Groundwater Resources in Bangkok Area, Development and Management Study, Comprehensive Report 1978-1982, 1982;
- Groundwater Resources in Bangkok Area, Development and Management Study, Phase II, Final Report, 1980;
- Rainfall and Evaporation Analyses of Thailand, 1980;
- The Fifth National Economic and Social Development Plan (1982-1986);
- The Greater Chao Phraya Project, 1957;
- Chao Phraya-Meklong Basin Study, Phase I, 1979;
- DDS year book, 1982; DDS, BMA
- Development Plan of drainage and Flood Protection under second BMA Development Plan (in Thai);
- Flood plain modelling of the Chao Phraya River, 1981.
- Study Project for Determination of Flood Solution in Samut Prakan Province (in Thai), 1983
- General Study Report (Draft) on Bangkok Flood Control and Drainage Project (City Core), 1983
- Quarterly Bulletin of Statistics, Vol. 29, Jan.-Dec. 1981, National Statistical Office (NSO)
- Draft of Budget Fiscal Year 1984, BMA (in Thai)
- Draft of Revenue Estimation and Expenditure Budget Regulation of Fiscal Year 1984, BMA (in Thai)

- Socio-Economic Survey, 1975-76, Greater Bangkok Area, NSO
- The Survey of Migration in Bangkok Metropolis, 1982, NSO
- Quarterly Bulletin, Bank of Thailand, March 1983
- Report of the 1978 Industrial Census, Whole Kingdom, NSO
- Report of Bangkok Metropolis, Nonthaburi, Pathum Thani, and Samut Prakan, NSO
- Statistical Year Book, Thailand, Number 32, 1976-1980
- Taxation in Thailand, Ministry of Finance, Thamasat University Press 1982
- Budget for Fiscal Year 1983, Tokyo Metropolis (in Japanese)