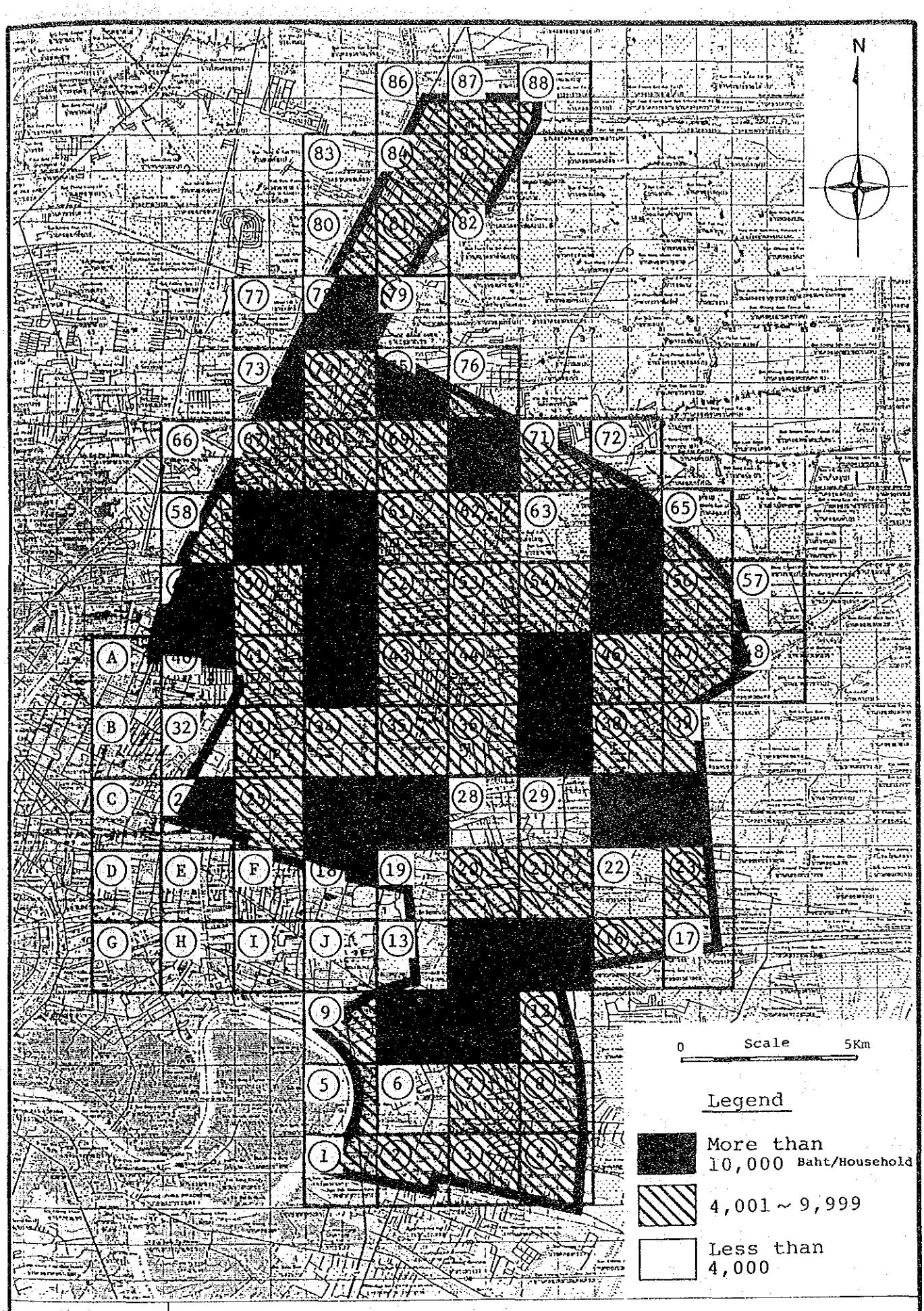


Fig. L.4 DENSITY OF INCOME IN 1984

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

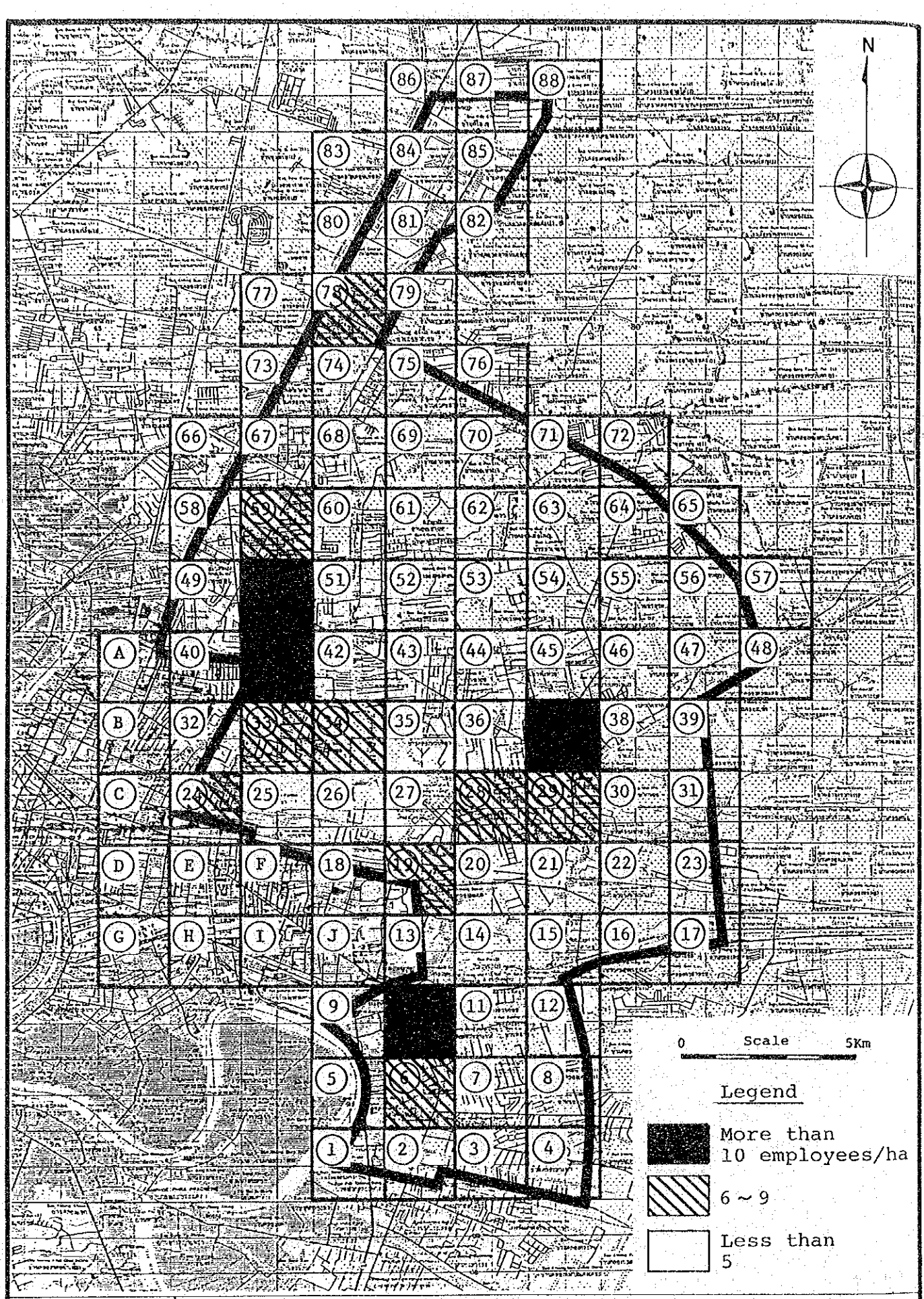


Fig. L.5 DENSITY OF COMMERCIAL EMPLOYEES IN 1984

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

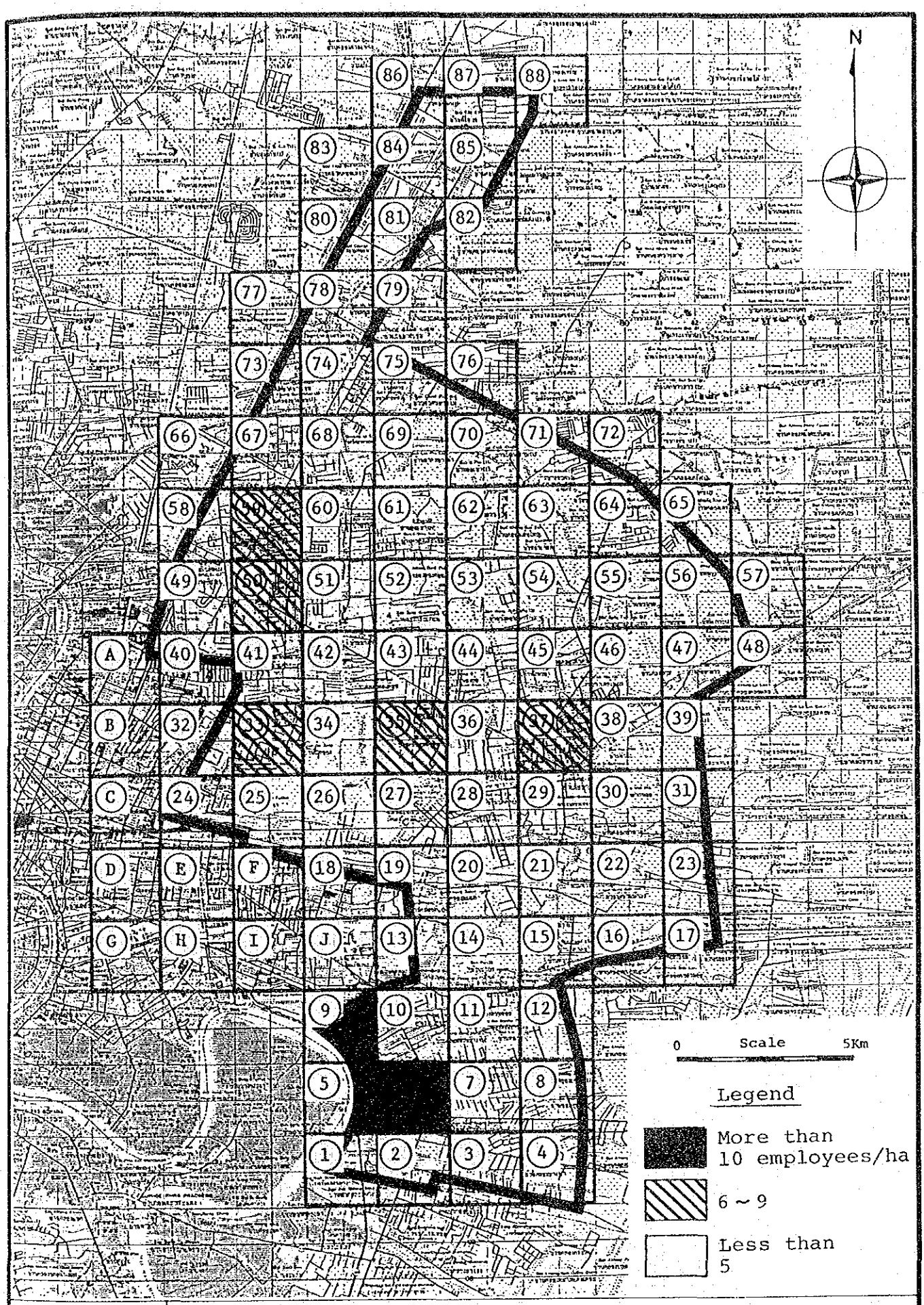


Fig. L.6 DENSITY OF INDUSTRIAL EMPLOYEES IN 1984 AND 2000

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

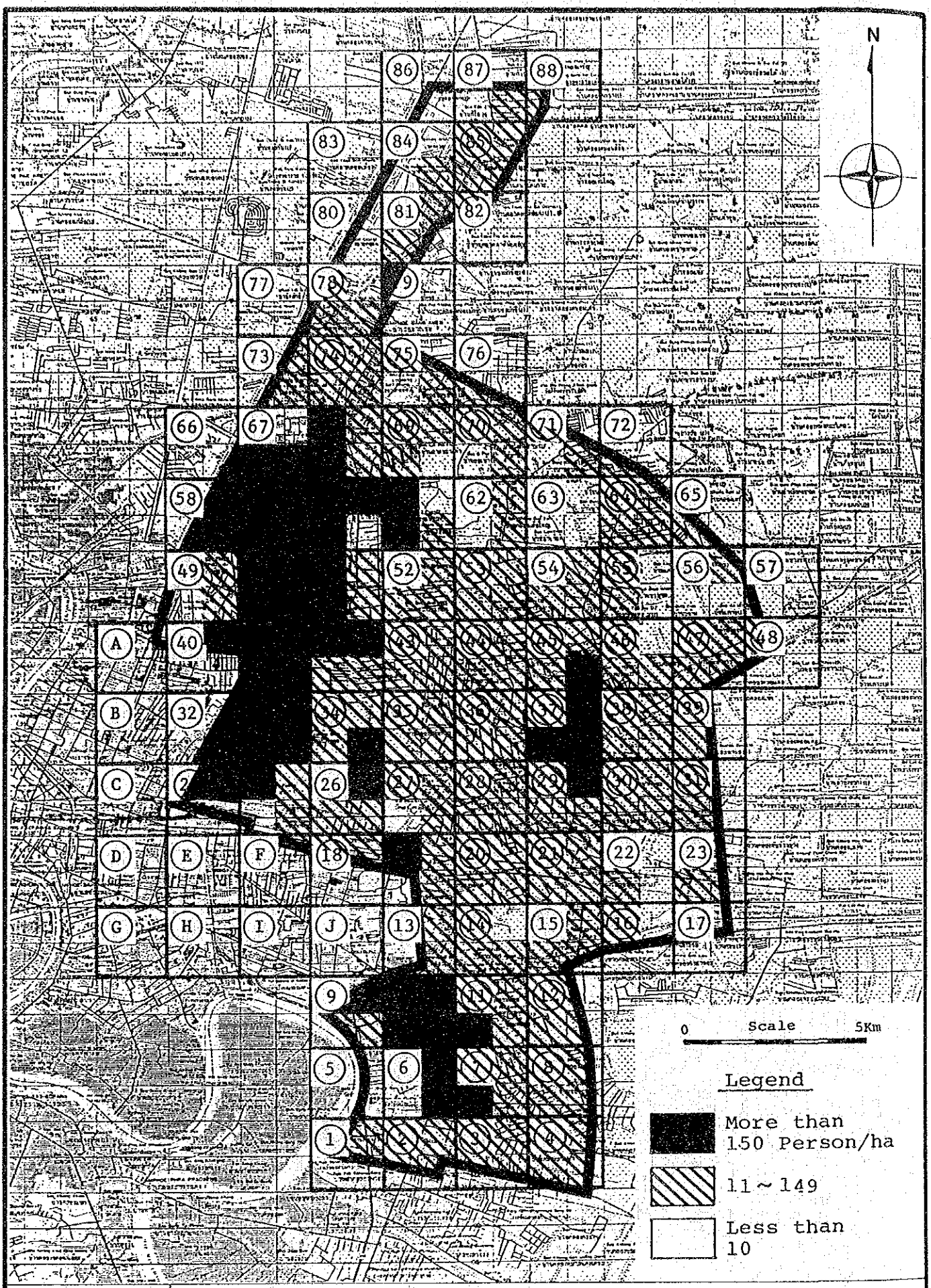


Fig. L.7 POPULATION DISTRIBUTION IN 2000

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

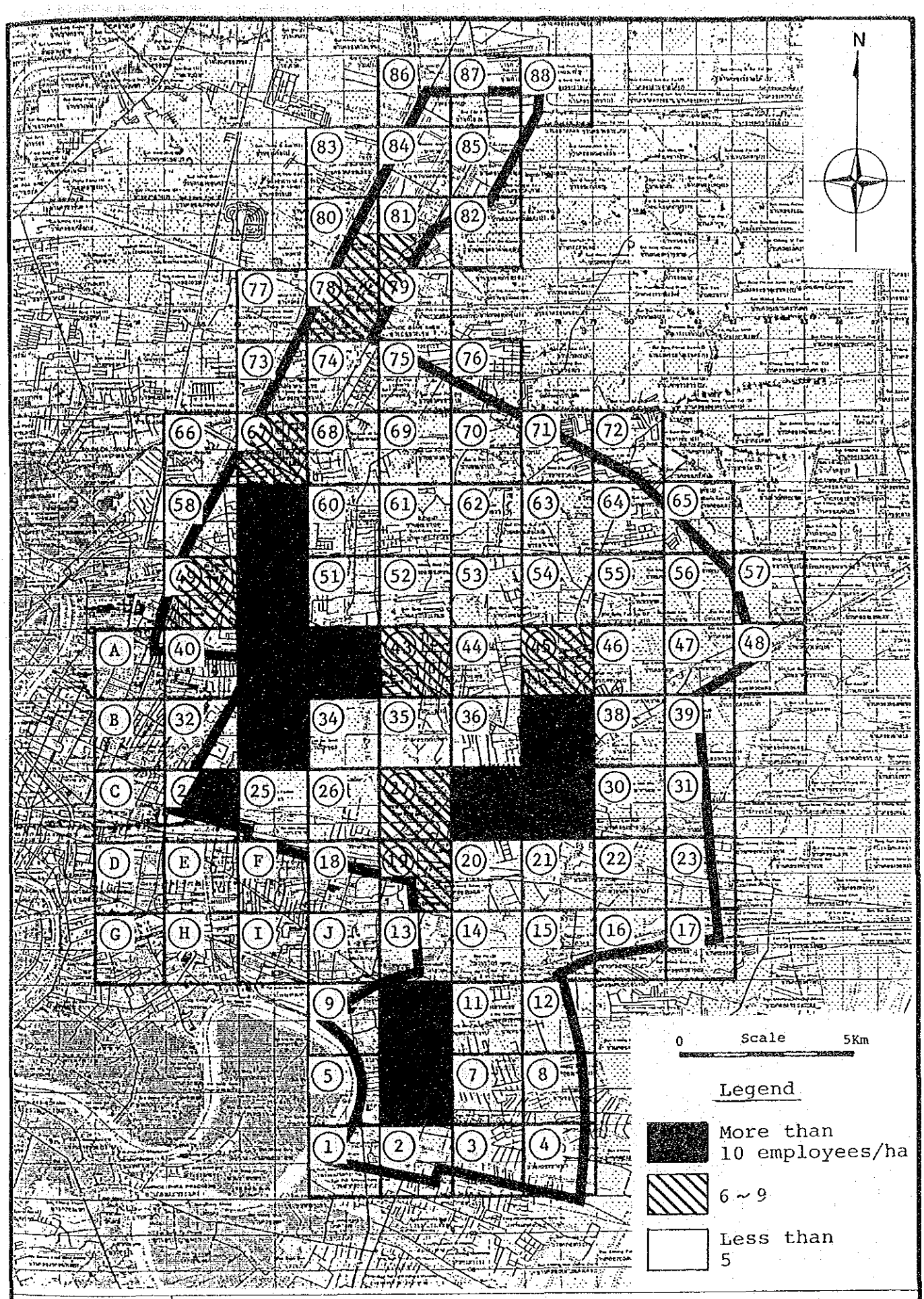


Fig. L.8 DENSITY OF COMMERCIAL EMPLOYEES IN 2000

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

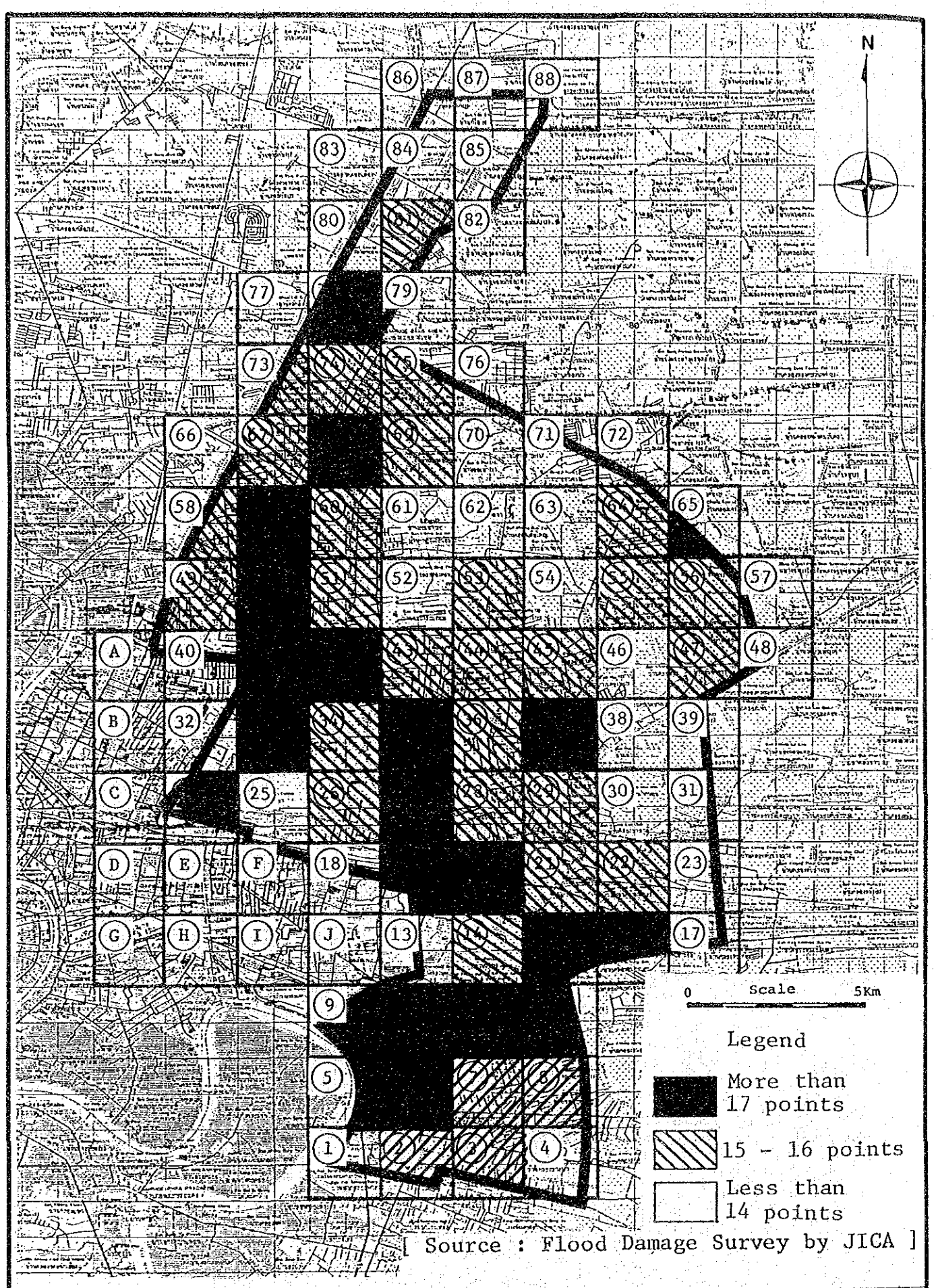


Fig. L.9 PRIORITY MESH FOR DRAINAGE SYSTEM BY RATING METHOD

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

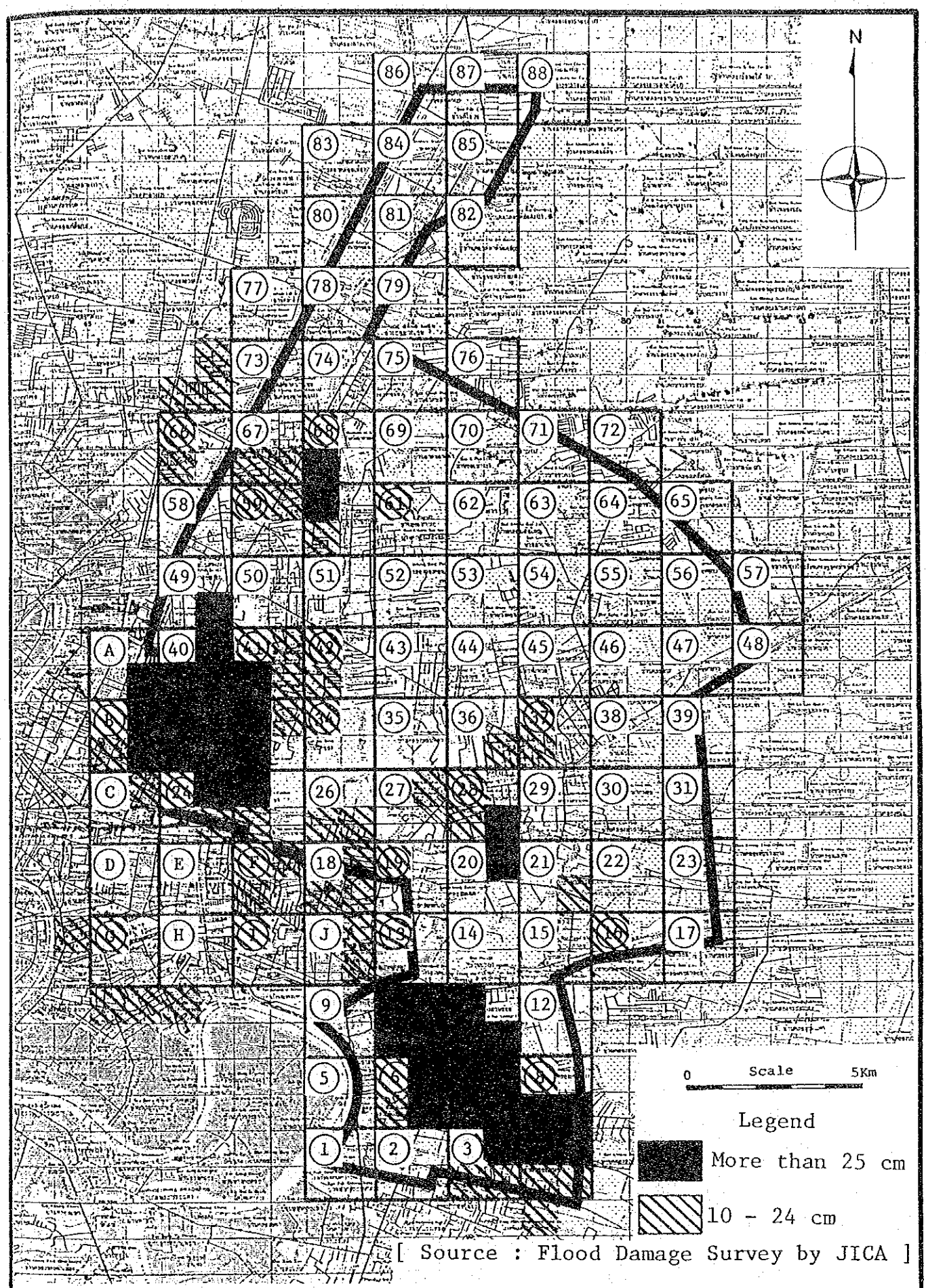


Fig. L.10 FLOOD DEPTH IN MASTER PLAN AREA IN 1984

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

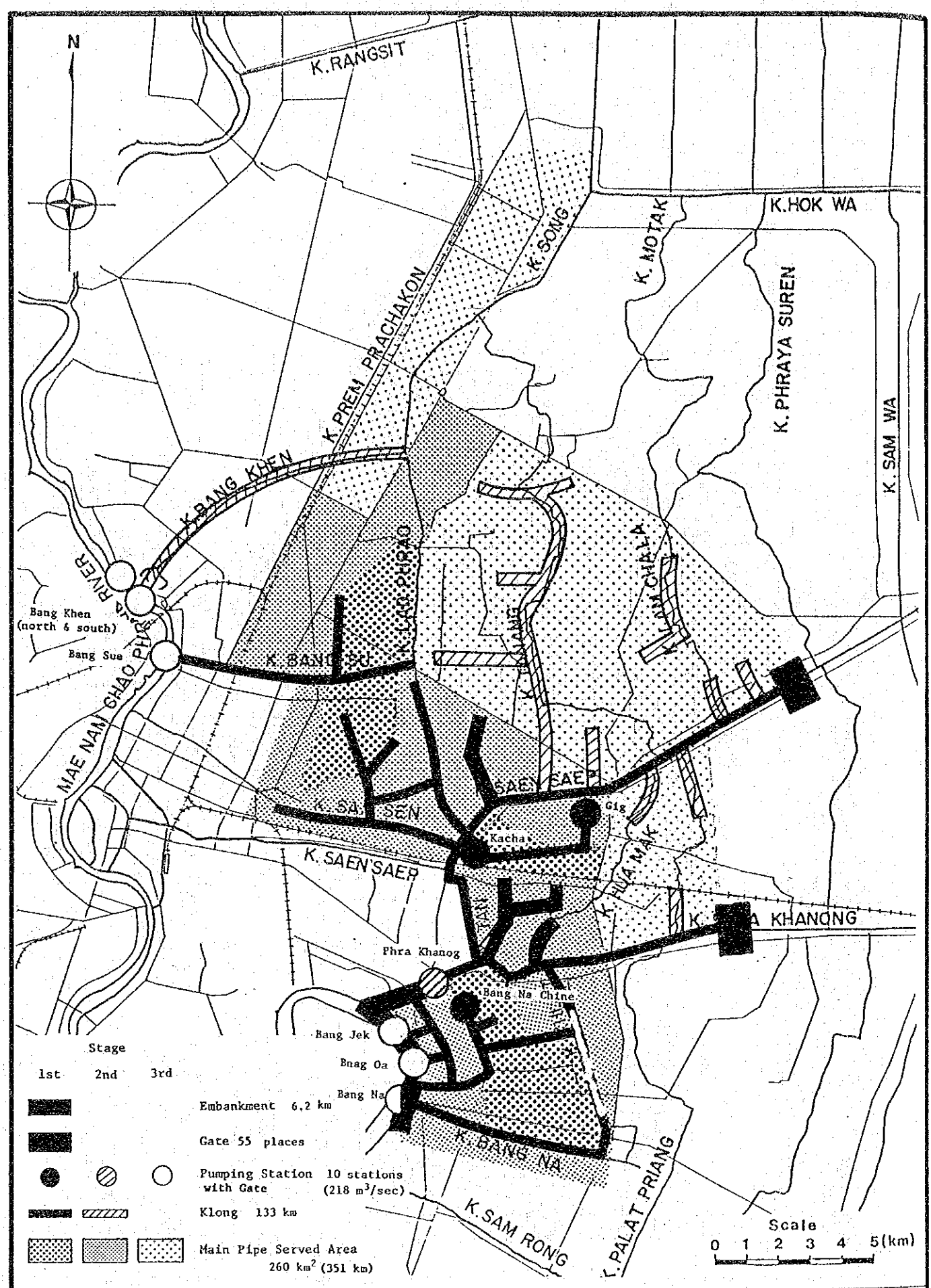


Fig. L.11 IMPLEMENTATION SCHEDULE (ALTERNATIVE I)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

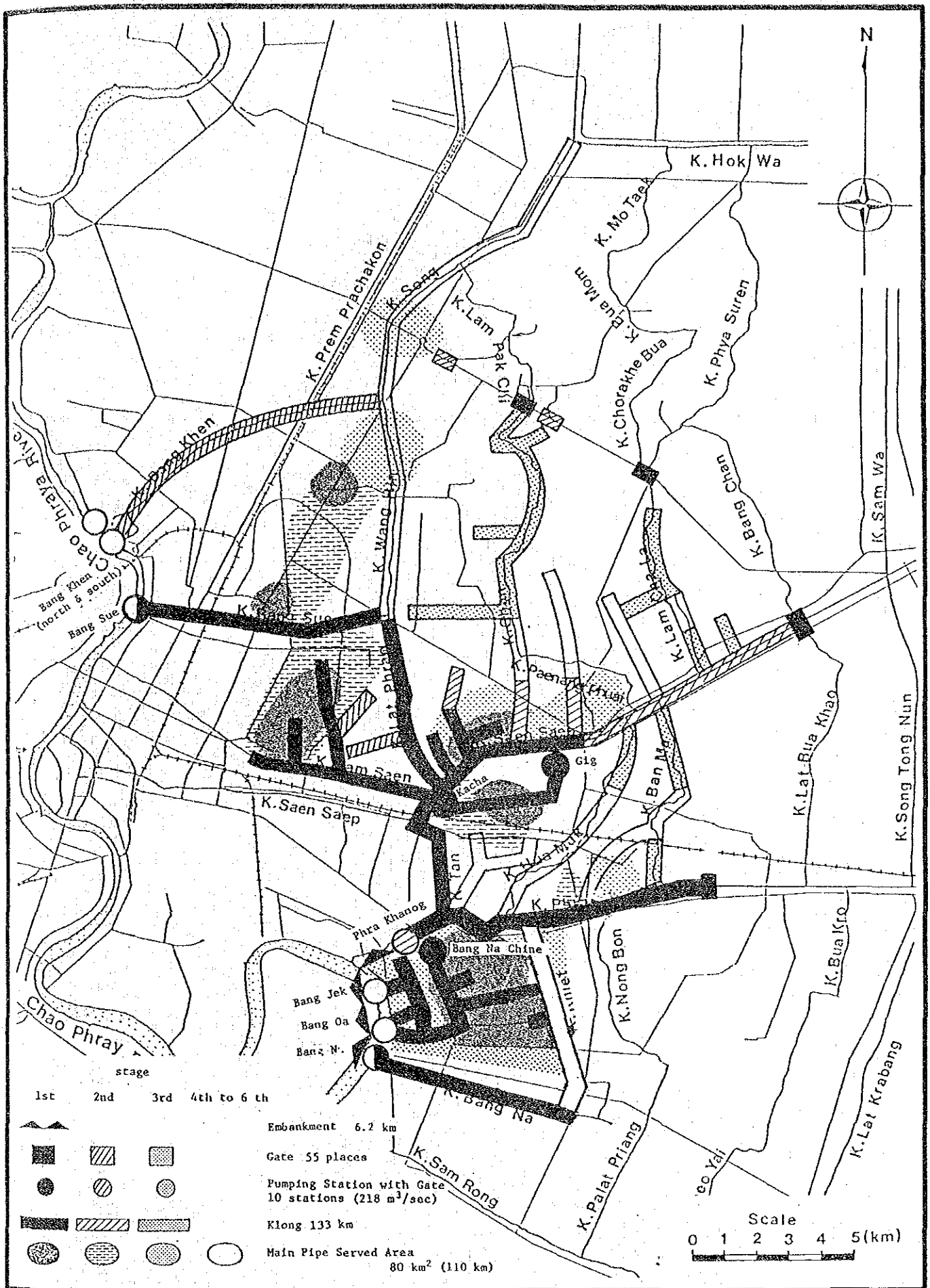


Fig. L.12 IMPLEMENTATION SCHEDULE (ALTERNATIVE II)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

APPENDIX M

OPERATION AND MAINTENANCE

APPENDIX M OPERATION AND MAINTENANCE

Table of Contents

List of Tables

List of Figures

Appendix M OPERATION AND MAINTENANCE

1. General

Flood protection and drainage systems consist of the following facilities:

- Embankments
- Drains
- Klongs (Canal)
- Gates
- Pumps

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

2. Existing Operations 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 the case of other areas, the surfaces of some roads have been raised temporarily by means of sand bags.

Some of the existing gates are powered, but most of them are manually operated. As many of the gates are of timber construction, operation is 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 larger 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 used to relieve the flooding 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 Drains

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

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

$$Q = A.V$$

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

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. M.1)

Drain gradients have flattened and some now have adverse slope as is shown in Fig. M.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 M.1, 0.2 to 0.3 cubic metres per metre is cleaned annually. This volume equals to the cross-sectional area of 600 mm-diameter

Table M.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]

drain pipe. The cleaning cost was 100 to 180 Baht per m^3, and 30 to 50 Baht per metre.

Due consideration of construction methods, types of structure etc. must be emphasized to prevent siltation, taking into account the large volume of siltation and the cost of its removal.

2.2 Klongs

Klongs are used by Bangkokians for various purposes like irrigation, drainage, transportation etc. The Canal maintenance division of the DDS has the responsibility of keeping the klongs' facilities in order 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
. truck 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 M.2 show some cost and production figures on garbage collection from the klongs.

(2) Cleaning

Table M.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 into dump trucks.
- by truck mounted excavator, working from the bank and dumping the material into dump trucks.
- by a pontoon mounted excavator, floating in the klong and dumping the spoil in barges.

Table M.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

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

Year	Zone:	Number of Klongs	Excavator		Transport		Labour		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	4,00
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 Gates

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, automatic operation is recommended.

2.4 Pumps

Many pumps are installed mainly in the city core area as shown in Fig. M2. 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. M4 to M.7) are presented in Table M.5.

All pumping stations except Rama IV pumping station (which is driven by diesel engine) are driven by electricity. More staff are required and higher running costs occur at Rama IV pumping station than at Padung Krung Kasem pumping station despite their similar capacity.

Much garbage is brought into these pumping stations through the open klongs except at Rama IV pumping station which is equipped with a shield trunk main. 1.5 tons per day of 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 means costs about 300 Baht per metre and 70 Baht per m^3, while dredging by manual labour cost about 200 Baht per metre and 80 Baht per m^3 as of 1982.

Table M.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
		Lengths (m)	1,750
		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 a more efficient operation of the pumps as shown in Fig. M.8. Efforts to reduce the garbage volume should be continued.

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

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

[Source DDS]

Note:

Type 1. Major Pumpign Station
2. Sub Pumping Station
3. Temporary Pumping Staion
4. Movable pump

3. Flushing

Water quality of klongs in the Master Plan Area is somewhat polluted but not so poor as that in the City Core Area. It is, however, expected to be more deteriorated by an increase of pollutant load due to urbanization in the Area.

According to a master plan for the Bangkok Seweage System Project covering an area of approximately 400 km^2, incliding almost all the Master Plan Area, which was conducted by JICA in 1981, waste water from domestic and commercial is planned to be treated by areated lagoon method from 260 ppm to about 50 ppm in terms of BOD. The treated water is planned to be discharged into main klongs such as Saen Saep, Phra Khanong and Lat Phrao. At that time, abundant water was assumed to flow through those main klongs based on CDM plan. However, as water from outer area is planned to be blocked by this Master Plan, flushing must be considered in order not to deteriorate ater quality of klongs.

Amount of water inflow is estimated as about 70 m^3/sec (CMD) at most. Under this condition, water quality will be generally improved as shown in Fig. M.9. This is similated by unsteady flow method. However, BOD of Klong Sam Saen and klongs in Bang Na drainage area is bad, over 20 ppm. Therefore, some measures will be necessary. These will need to be studied which includes the following:

- Diversion of Klong Sam Saen westward
- Improvement of waste water teratment by the areated lagoon method or, activated sludge method.

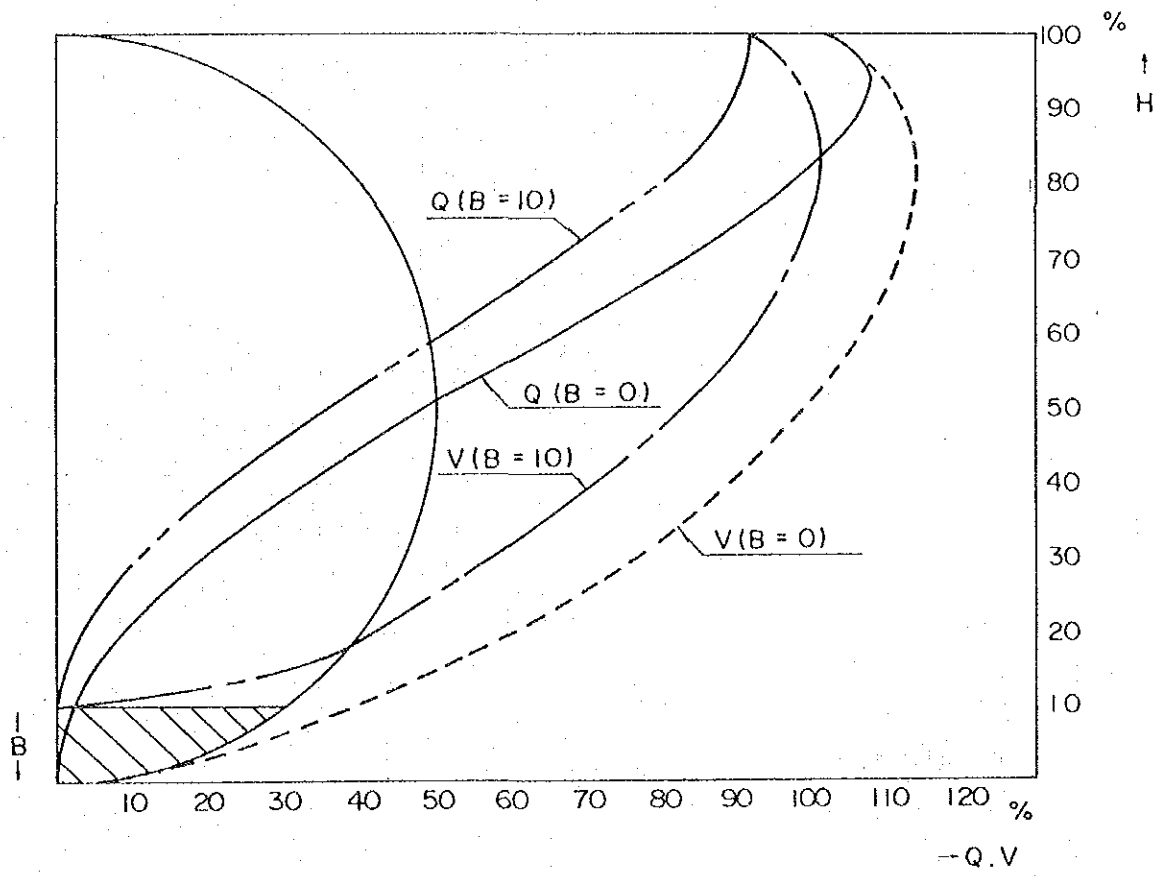


Fig. M.1 HYDRAULIC CHARACTERISTICS OF HUME PIPE

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

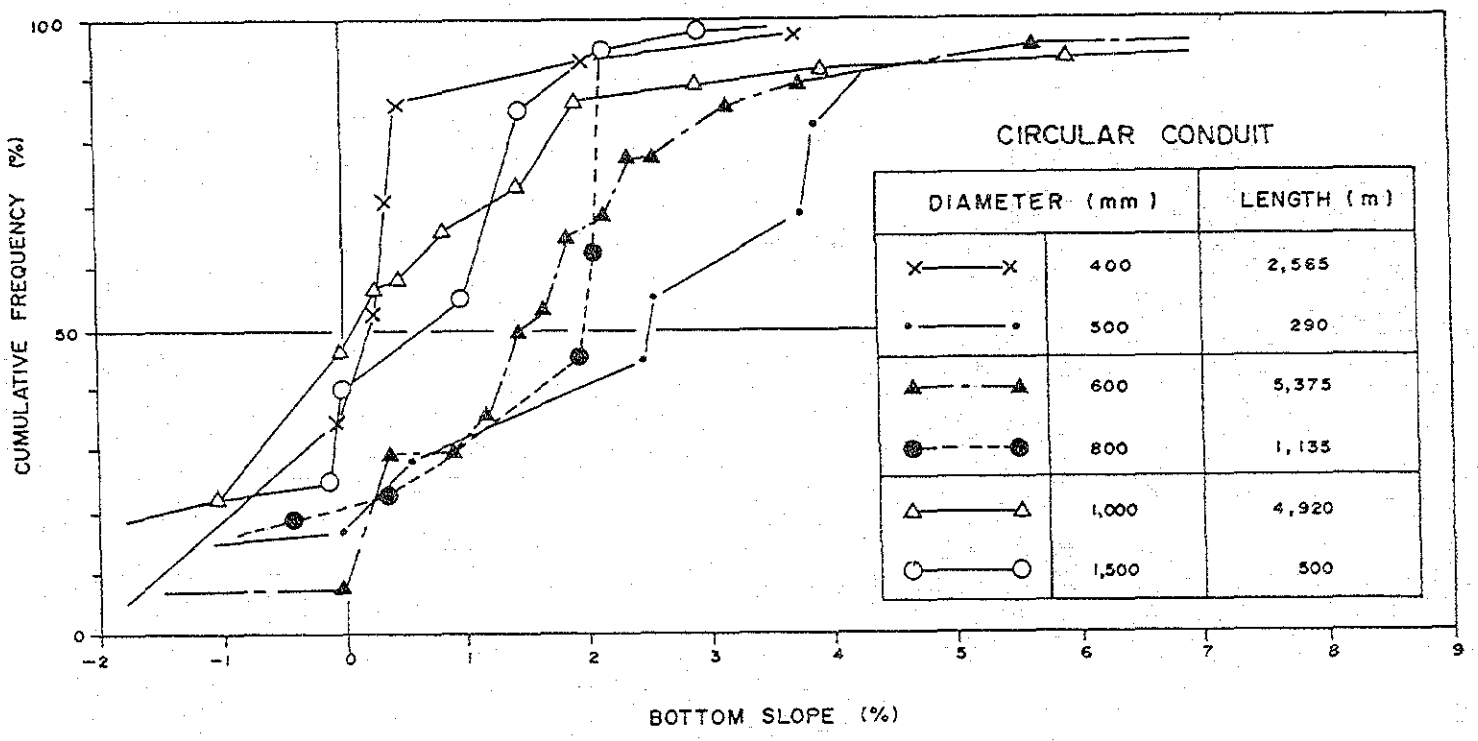
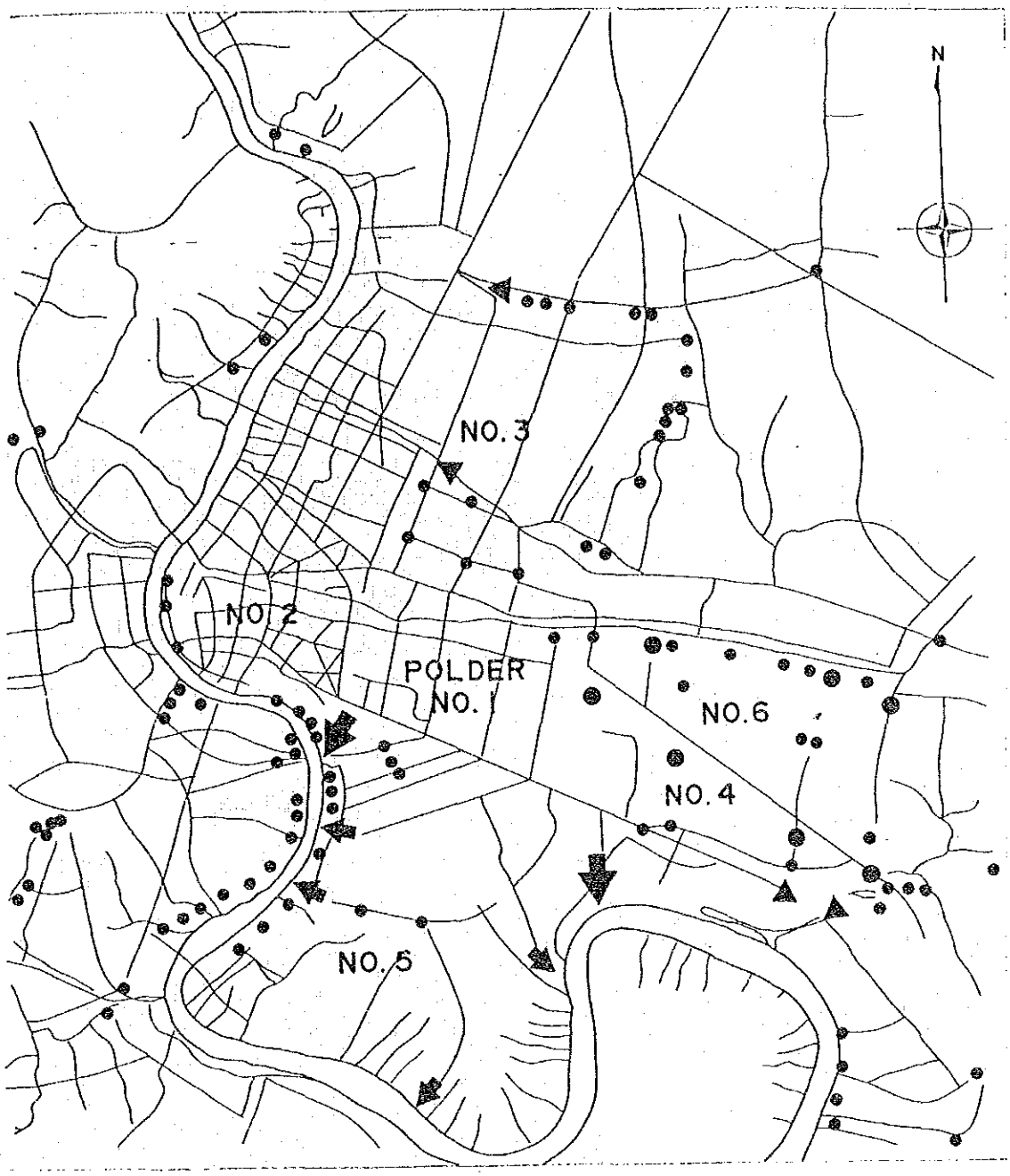


Fig. M.2 DISTRIBUTION OF EXISTING CIRCULAR CONDUIT SLOPE

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



POLDER AREA : CITY CORE

BOUNDARY PUMP (MAJOR STATION)

BOUNDARY PUMP (SUB STATION)

BOUNDARY PUMP (TEMPORARY STATION)

BOOSTER PUMP (STATION)

BOOSTER PUMP (MOVABLE PUMP)

Fig. M.3 LOCATION OF PUMPING STATION

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

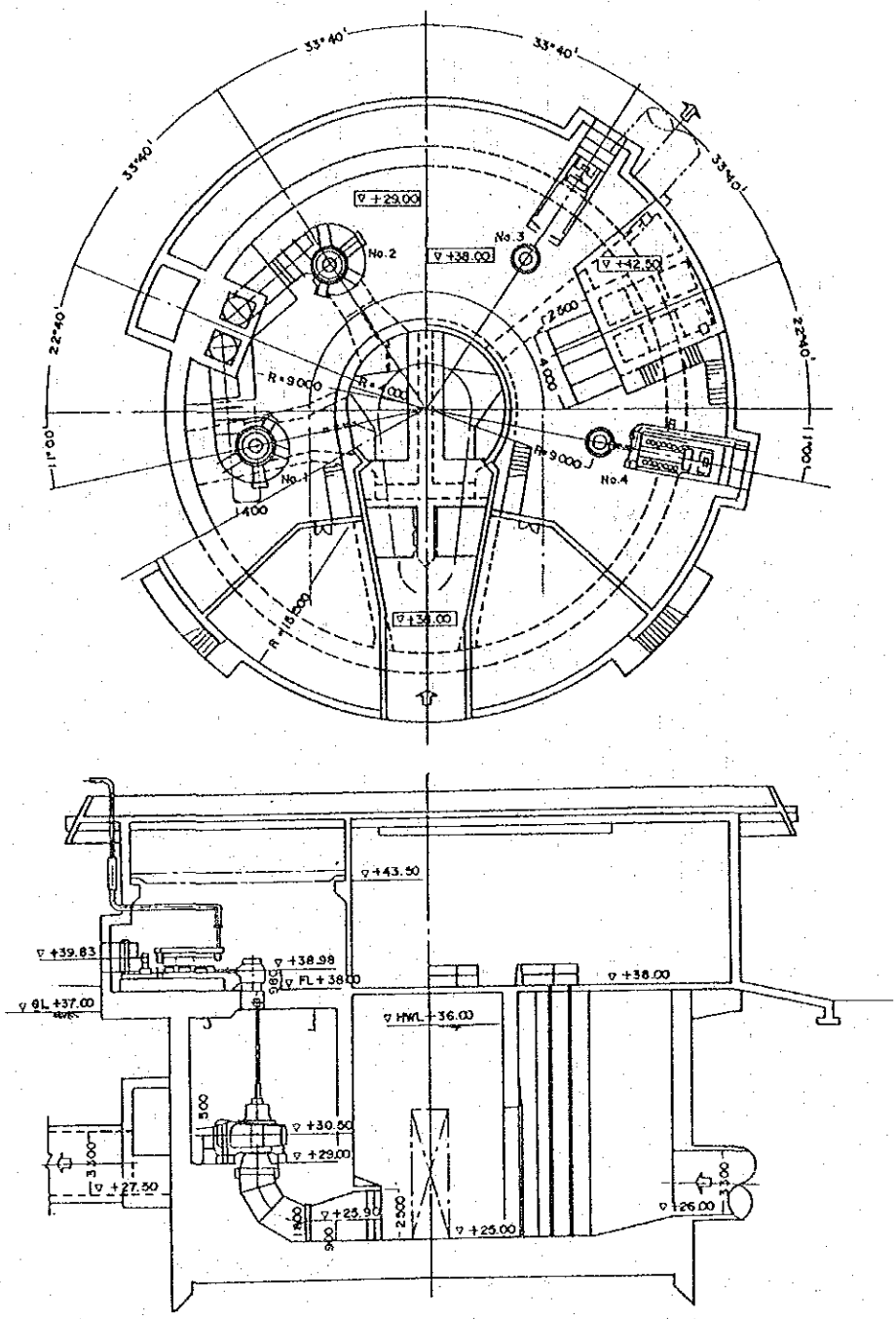
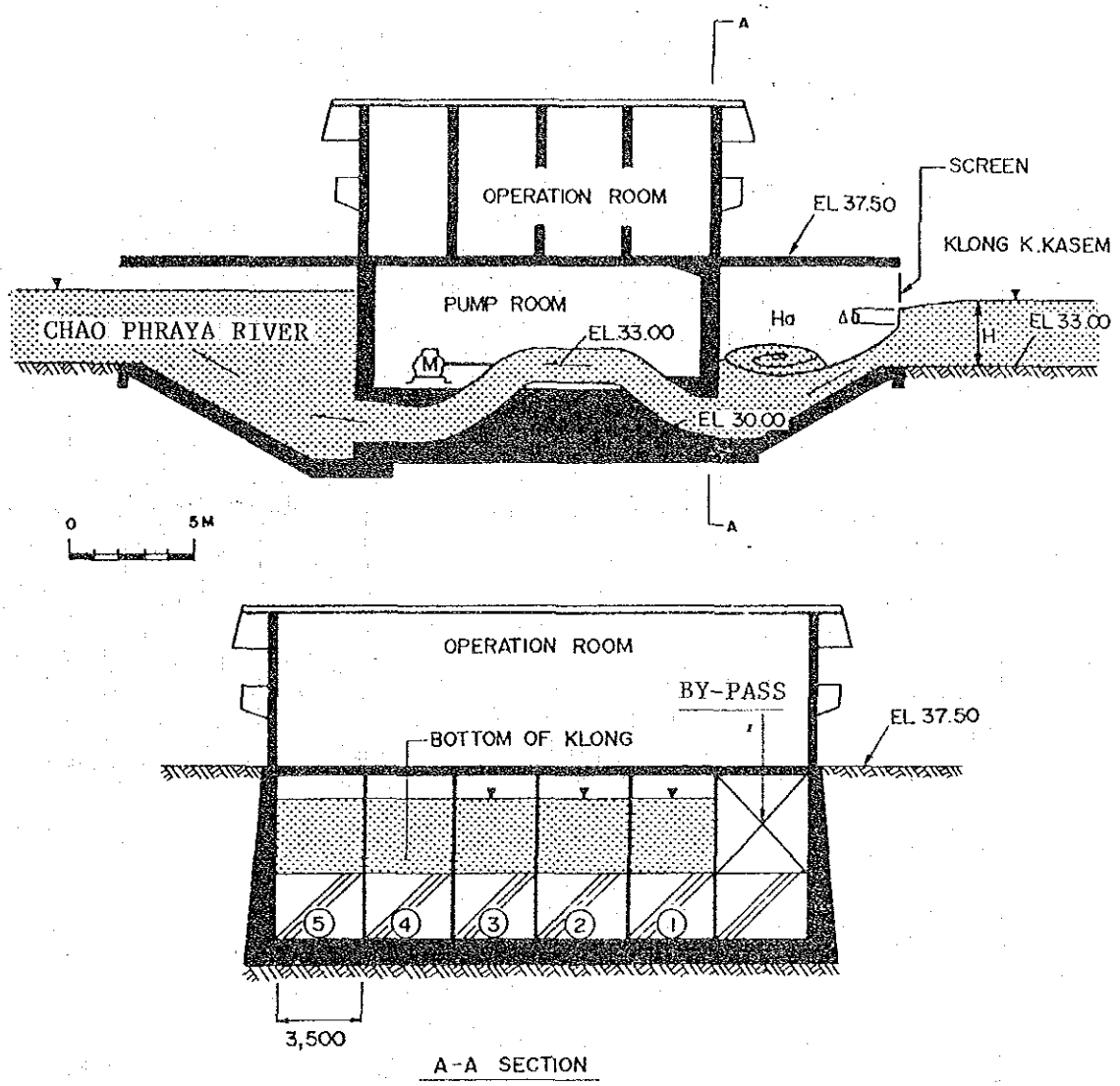


Fig. M.4	GENERAL VIEW OF RAMA IV PUMPING STATION

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



A-A SECTION

Fig. M.5 GENERAL VIEW OF PADUNG KRUNG KASEM PUMPING STATION

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

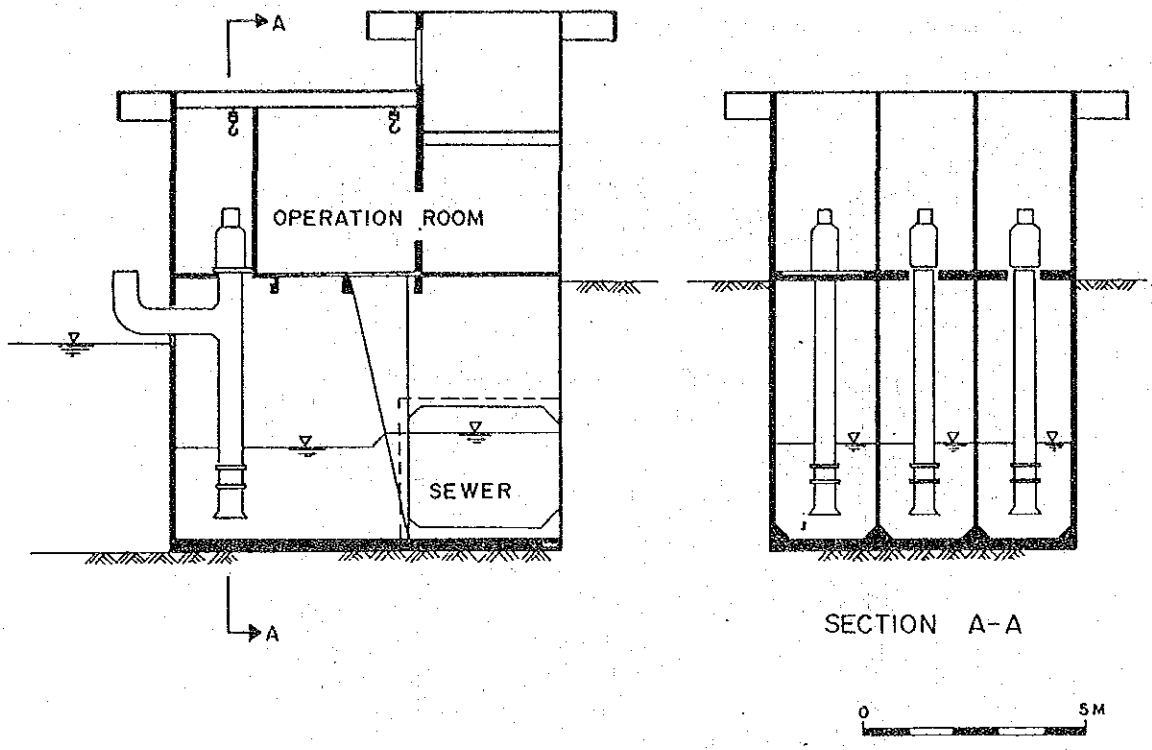


Fig. M.6 GENERAL VIEW OF NANG LINGEE PUMPING STATION

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

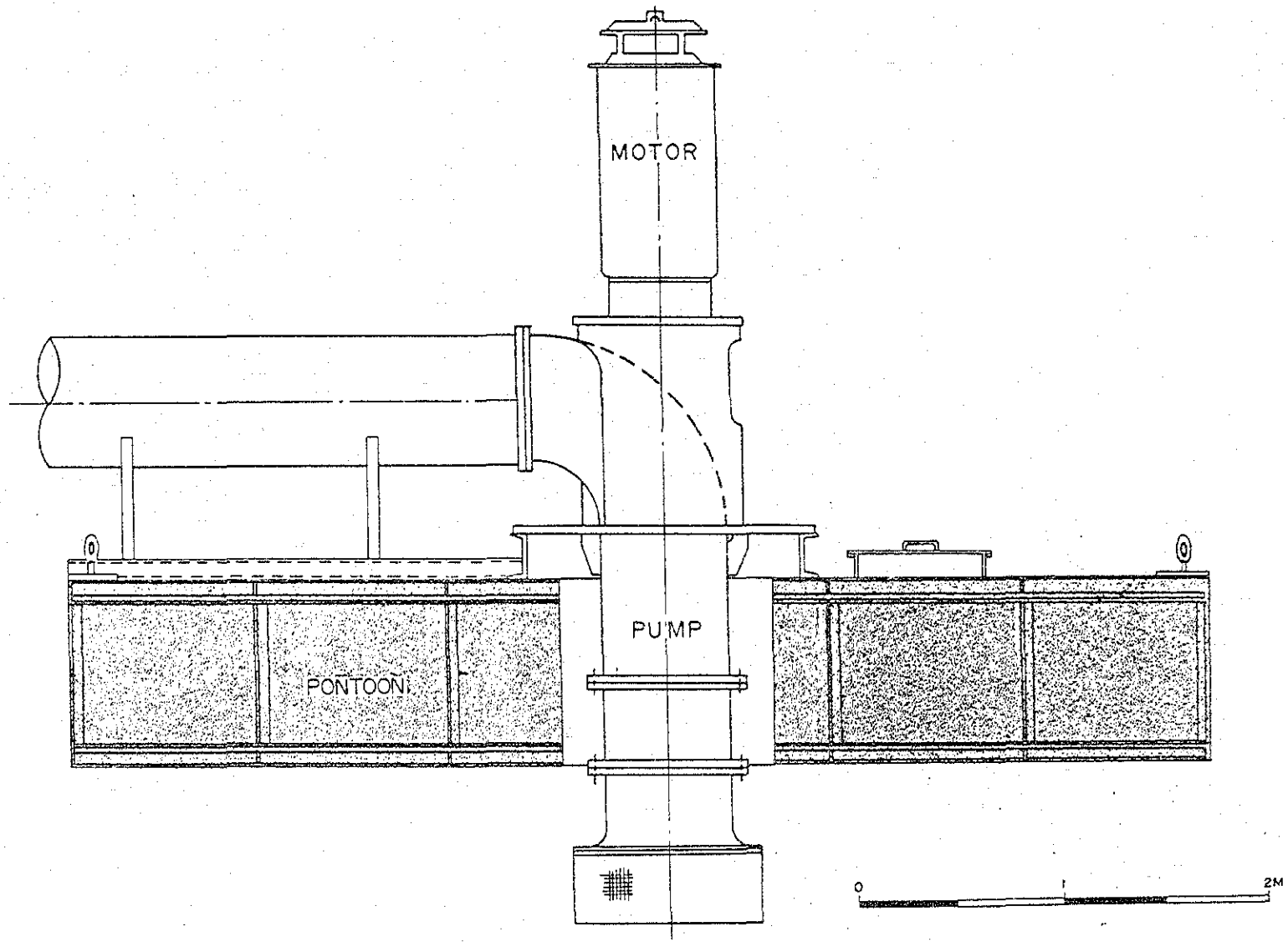


Fig. M.7 SECTIONAL VIEW OF PONTOON-MOUNTING PUMP

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

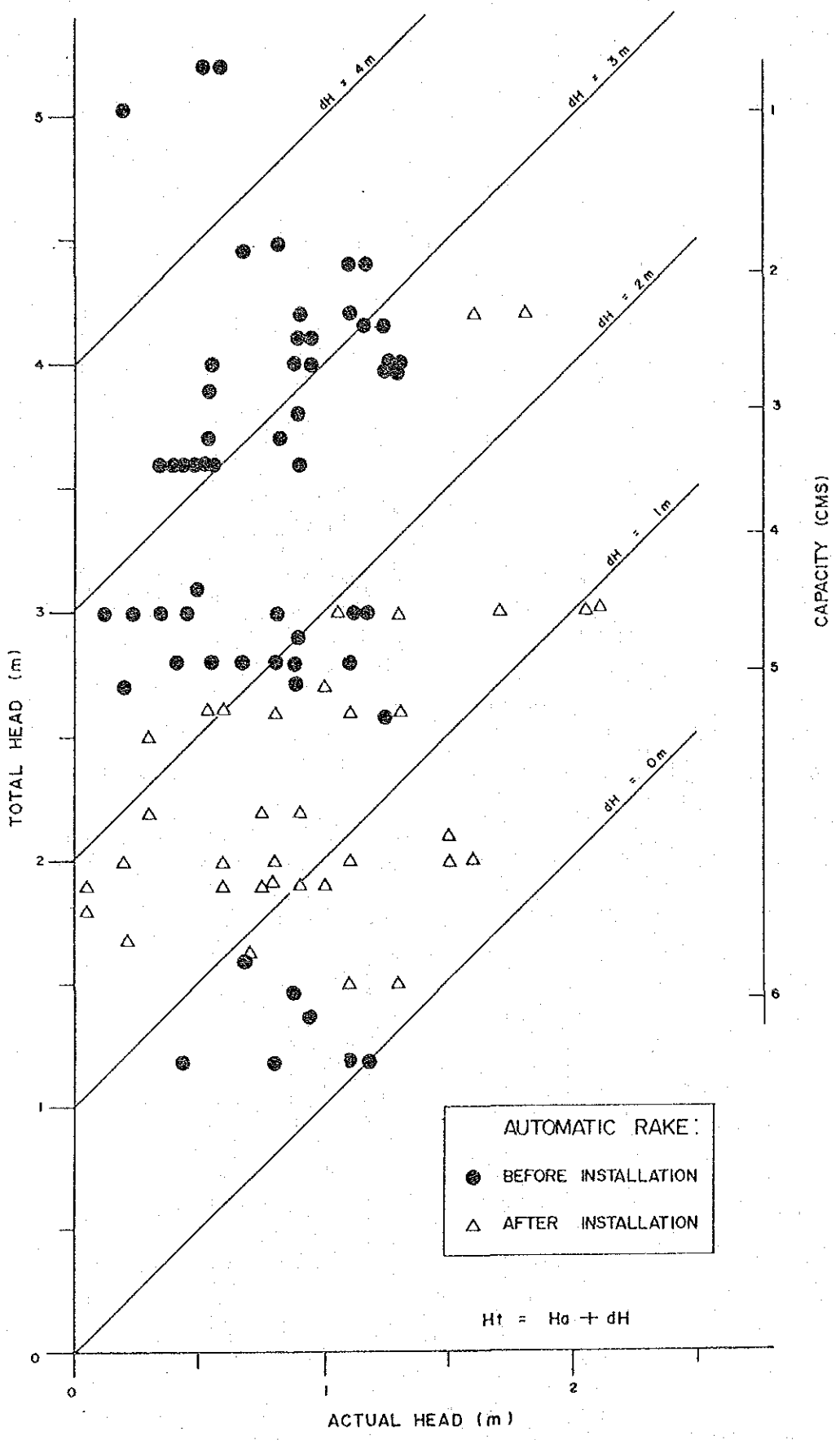


Fig. M.8 EFFECT OF AUTOMATIC RAKE IN PADUNG KRUNG KASEM PUMPING STATION

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E. 1985A.D.