(1) the Regional Context Plan,

(2) the Metropolitan Structure Plan, and

(3) Comprehensive Development Plans.

At the third level, the comprehensive plans comply with the "general plans" as defined by the Act. Within the former Greater Bangkok Area, three such plans are being pursued, separately for the area of BMA, changwat Nonthaburi and Samut Prakan. The present version for BMA still stays in the intial phase of consideration of the "Planning Advisory Board", although legal procedure began in 1982.

On the other hand, the Metropolitan Area Structure Plan, which is not bound by legally prescribed procedures, was drafted in conjunction with the Fifth National Plan (1982-1986). The conceptual framework resembles the one of the second revision but it points out, in much more definitive terms, the intended multinuclear structure. It is interesting that comprehensive metropolitan open space system, including flood protection zones in the eastern suburbs was included.

As the flood protection system had got much attention, a set of new bylaws under the Building Control Act was enacted to restrict concomitant development.

3.2 Action Plan for Non-Structural Measures

Action plan for implementation of non-structural measures toward the enforcement of the zoning regulations, is proposed as indicated in Table F.5.

3.2.1 Short Term Action Plan

(1) Mobilization of Non-Structural Measures Committee

In October 1983, the national-level flood protection committee for Bangkok and Vicinity was formed, as a consequent of serious 1983 flooding which extended not only BMA area but also Vicinity. The committee has implemented urgent flood protection measures in coordination with various organizations. The sub-committee for project designation has played a key role in planning and implementing urgent structural measures. The sub-committee for supporting activities are designated in planning and implementing non-structural measures.

(2) Recognition of Flood Plain Management

Such recognition is firstly required to be common in committee and each consisting agency that land use and development controls are major and fundamental measures for preventing the growth of the existing flood risk and damage problems.

For that purpose, publicizing of observed flood data, including flood extent, depth and duration and estimated flood data are effective. Above all, publicizing observed flood data can help as well residents recognize flood risk and damage problem.

However, the "Flood Authority" needs to continue to collect flood data for improvement of flood risk maps which will become the fundamental base of zoning. At the same time, "Planning Authority" needs to estimate future population and required urbanized area.

Table F.5 Action Plan for Non-Structural Measures

Authority in Charge	Flood Protection Committee (Overall Flood Control)	Flood Control & Operation Authority	Regional (DTCP) and City Planning (BMA) Authoity
Current Situation	* Sub-Committee for flood plain management	* Construction of Green Belt Dyke	* Green Belt area as open space (retarding area)
Short Term Action Plan	* Mobilization of sub-committee * Recognition of importance of flood plain management between relating agencies * Public education of flood plain management	* Publicizing observed flood area * Establishment of flood control operation system	* Projection of population and urbanized area
Intermediate Term Action Plan	* Inter-governmental recognition of zoning system in accordance with flood risk * Publicizing flood risk map	* Collection of flood data * Preparation of flood risk map * Improvement of flood control operation system	* Approval or disapproval of development applications based on building codes * Construction of roads and water supply, compatible with zoning system * Guidance for prohibition of land reclamation in retarding area * Multi-purpose retention pond in the park
Long Term Action Plan	* Zoning regulation * Property tax adjustment, reflecting zoning * Surcharge to developers		* Approval or disapproval of development applications based on zoning regulation

3.2.2 Intermediate Term Action Plan

As zoning regulations limit private rights to some extent, determination of zoning will face with various problems as has been faced long time in preparation of city planning and will not be effective within short time. Nevertheless, while waiting enforcement of zoning regulations flood risk and problem will undoubtedly continue to worsen because, for example, land will subside. Therefore, in order not to increase flood risk and problems, the following measures which are considered to be applied without much difficulty must be initiated firstly by the government agencies:

(1) Preliminary inter-governmental agreement of zoning system as, for example, proposed in this report.

(2) Road planning and construction in accordance with the zoning system:

The construction of roads has been the most important determinant of the spatial orientation of development. However, there has been little apparent attempt by the agencies responsible for road design and construction to assess or evaluate the growth-inducing effects of planned projects. Therefore, planning and construction of roads are proposed to comply with future development plan; zoning system. Such development plan can lead more efficient use of both land and infrastructure, at least until the maximum capacity of existing facilities is reached.

(3) Water supply expansion:

Expansion of water serviced area should also made to meet the zoning system.

(4) Prohibition of land reclamation in retention area (prohibiting urbanization area):

Land reclamation naturally loses natural water retention capacity. Hence, land reclamation is proposed to be prohibited in the designated retention area where low level property tax should be imposed for compensation.

(5) Flood Proofing:

Flood proofing is defined as those actions taken to avoid flood losses or damage to buildings, or structures. Some measures to be taken are as follows:

- Raising structures, houses are built on poles, piles or stilts.

- Raising land; houses are built on the reclaimed land only in promoting urbanization area.

(6) Retention Pond:

Multi-purpose retention pond in the parks and the yards of government agencies should be planned.

(7) Building Codes:

The important legal base for planning and planning control by BMA is the Building Control Act 1961. The 24 district offices of BMA play a key role in issuing the required building permits, whereas all applications for larger projects are processed by the central BMA office. The requirements of structural safety, sanitation, drainage and car parking are controlled by the building regulations. Building in the Green Belt Area is also controlled by these regulations because the Building Control Act enables the BMA to establish local bylaws, which represent an important planning instrument. Therefore revision of bylaws will

enable, to some extent, zoning control facilitate practically until the time-consuming imposition of zoning regulations are conducted.

3.3.3 Long Term Action Plan

(1) Zoning Regulations

Non-structural measures will be effective when they are executed under public participation. Zoning regulations are the very important measures. The restriction of new building by regulations should be applied to the retention area which is very dangerous area. No houses and vital installations such as hospitals, police stations, schools, telephone or telecommunication exchanges or electrical distribution centers should be located in any retention area. Existing buildings in retention area must be flood proofed.

(2) Retention Pond

As there are many flood-prone areas, some new houses are obliged to be built in flood-prone area. In this case, houses should be of flood-proofing and/or be built on the reclaimed land. However, land reclamation will lose natural retention capacity, causing adverse effect on the other urbanized area. In order to compensate for the lost capacity, retention ponds are recommended to be provided as shown in Table F.6 when houses are built.

(3) Tax Adjustment

Flood protection and drainage facilities themselves will increase effective supply of land, because the supply of developable land has been inflenced by the availability of infrastructure, especially roads.

Therefore, the construction of infrastructure should be accompanied by an increased property tax assessment. The increased property tax could become the most important financial resource of the construction of infrastructure including drainage facilities.

Table F.6(1) Measure for Establishment of Retention Area

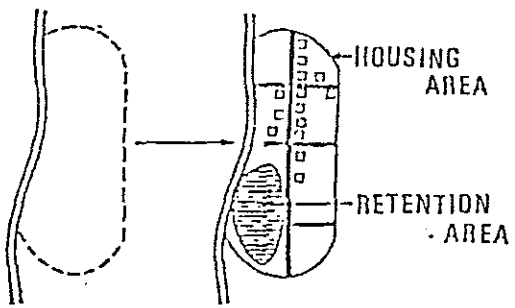
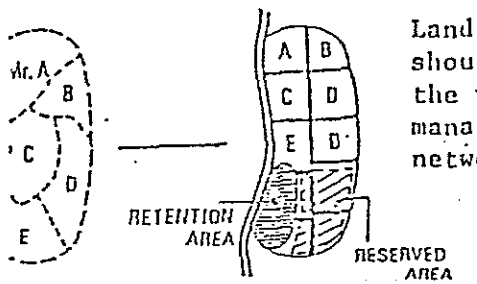
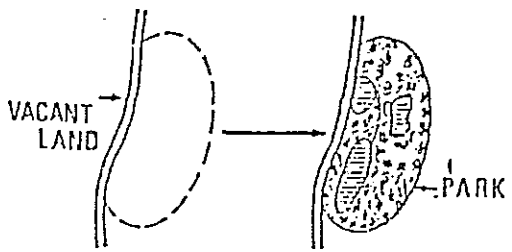
Measures	Proposal	Relevant Laws	Examples	Current Situation	Note
1. Urban Development Control	Each residential estate set out some percent of the land area as the retention area.	(Subdivision Law)	-	According to the sub-division Law, 4-5 percent of the land area must be planned as the park in each residential estate.	If 10 percent of each residential estate is set out as the retention area, $8km^2$ will be reserved as retention areas in 2000. For this purpose, some amendment of the Sub-division Law is necessary.
1) Development Permission					
2) Land Readjustment Project	As a kind of public facilities, retention areas are kept under the Land Readjustment Project.	(Land Consolidation Act)	(Some agricultural lands)		Land Readjustment Project should be executed from the viewpoints of flood management and road-network arrangement.

Table F.6(2) Measures for Establishment of Retention Area

Measures	Proposal	Relevant Laws	Examples	Current Situation	Note
2. Building Control	Each building lot installs a retention pond or sunk garden.	(Building Code)	-	According to the Building Code, 30 percent of the land area must be kept as the open space, paved or impaved, in each dwelling house.	If 10 percent of each dwelling lot is kept as the retention pond or sunk garden without landfill, only $5km^2$ will be reserved as retention areas in 2000. To keep 10 percent of the land area as the retention area, some amendment of the Building Code is necessary.
3. Land Acquisition	Public sectors should acquire vacant lands for parks or green areas. 	Land Acquisition Law	Makkasan Park (15 ha) Nonborn Park (80 ha)	For the long-range objective of park in BMA, green areas as $6.4m^2$ per person is planned.	According to this plan, $14km^2$ will be kept in eastern suburbs as retention areas.

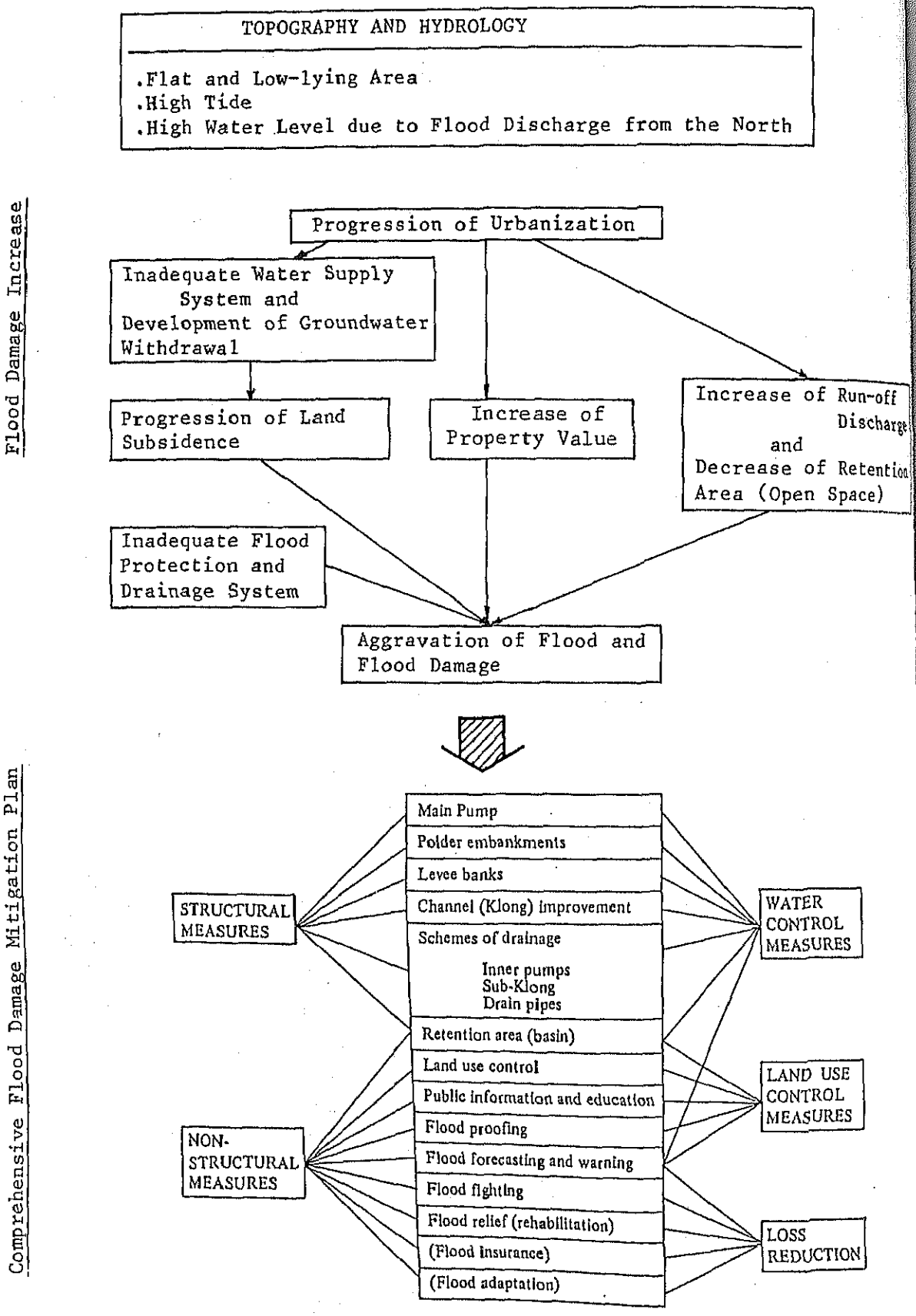


Fig. F.1 COMPREHENSIVE FLOOD DAMAGE MITIGATION MEASURES

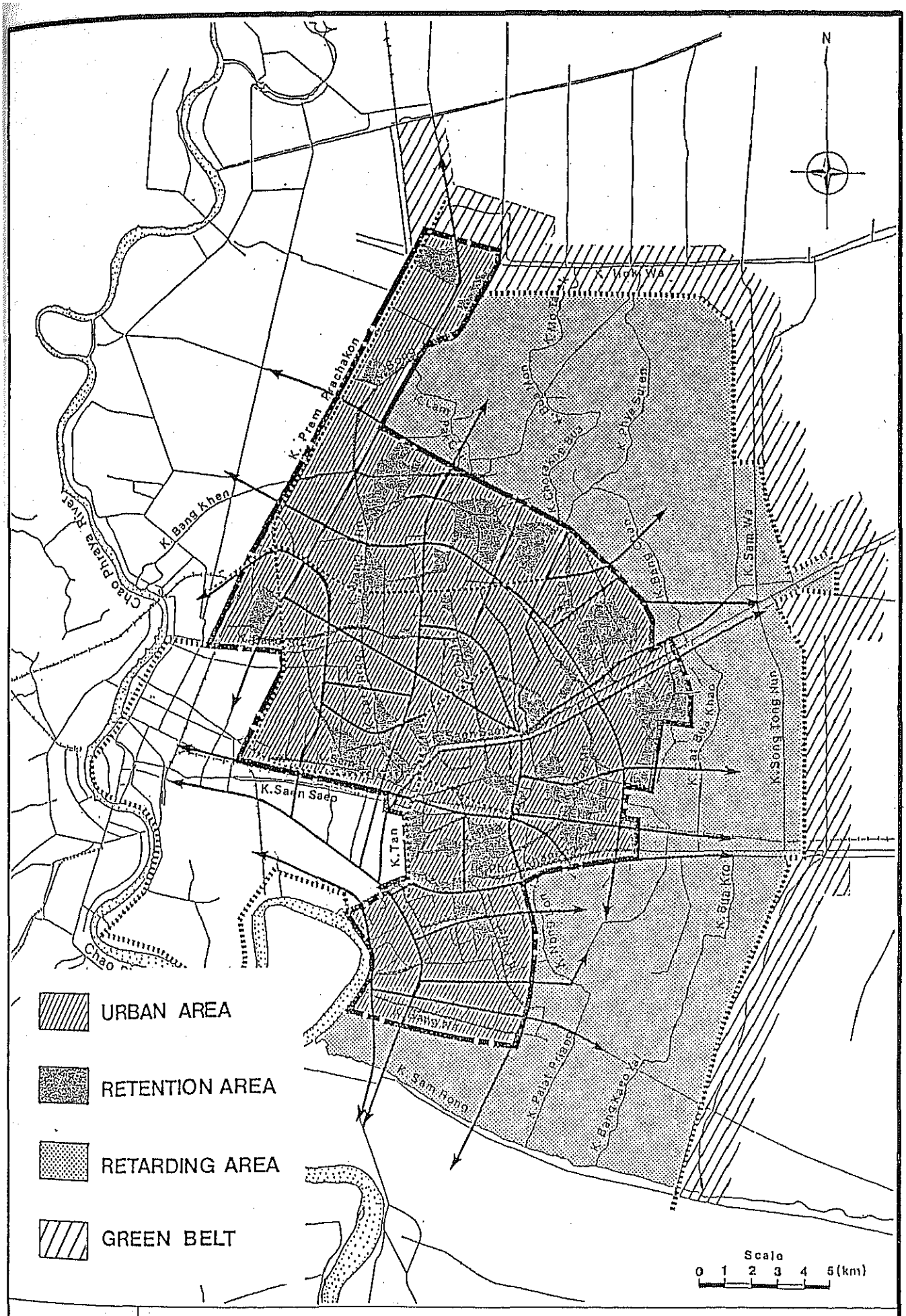


Fig. F.2 PROPOSED ZONING IN EASTERN SUBURBS

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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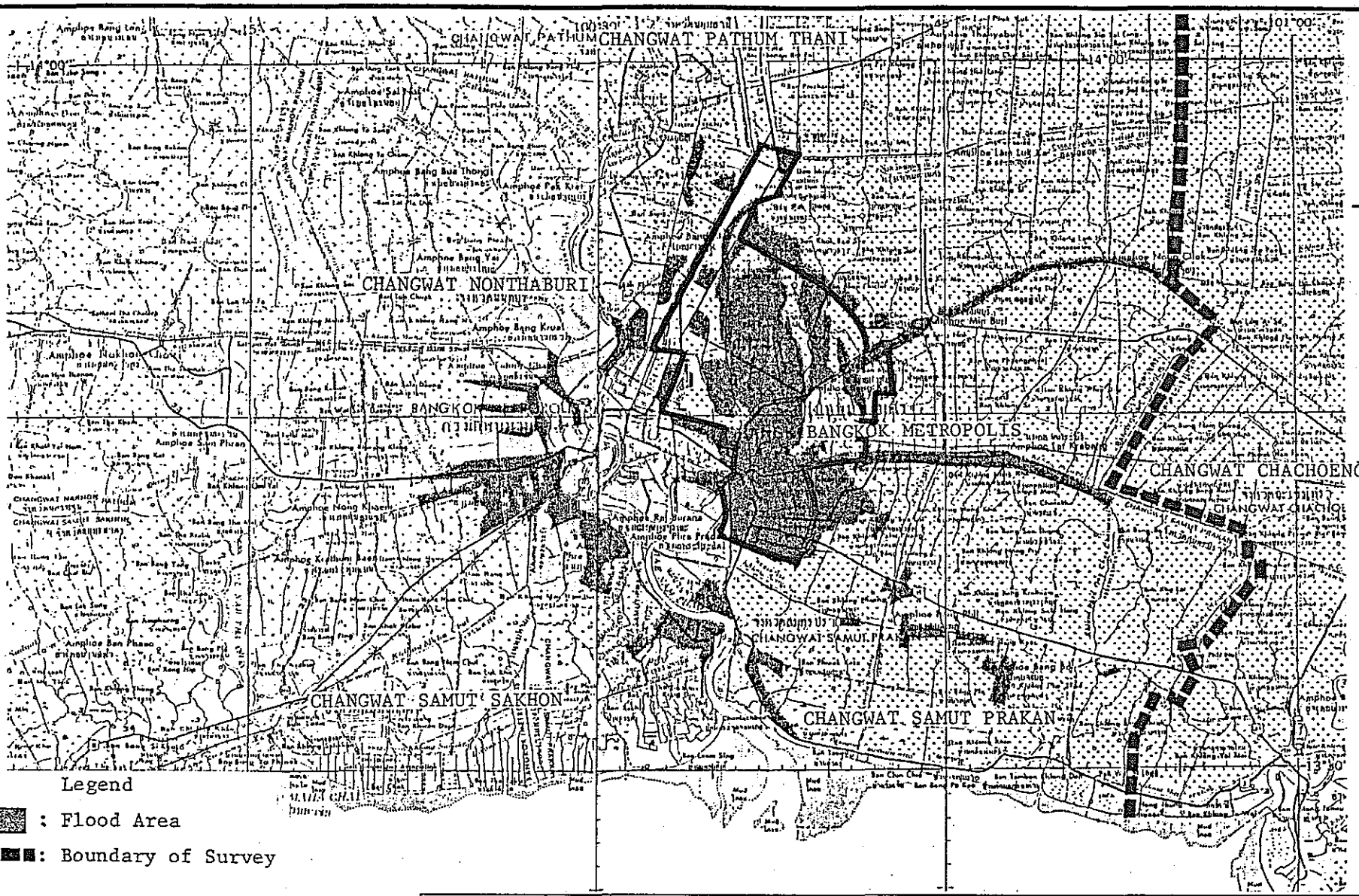

Legend

: Flood Area

: Boundary of Survey

[Source:Flood Damage Survey by NSO]

Scale

0 2 4 6 8 10 20Km

Fig. F.3 FLOOD AREA IN GREATER BANGKOK IN 1983

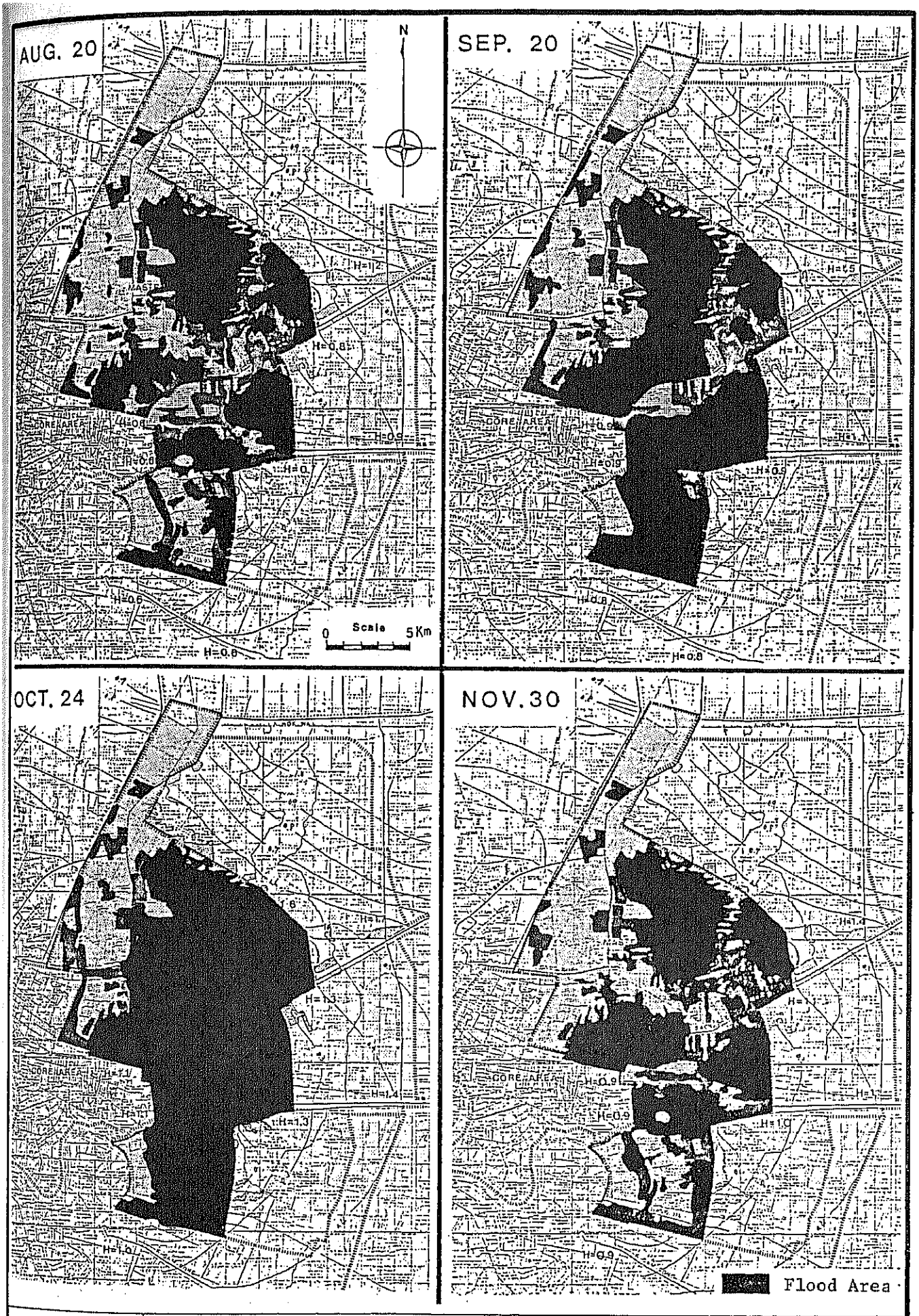

Fig. F.4 FLOOD AREA IN FEASIBILITY STUDY AREA IN 1983

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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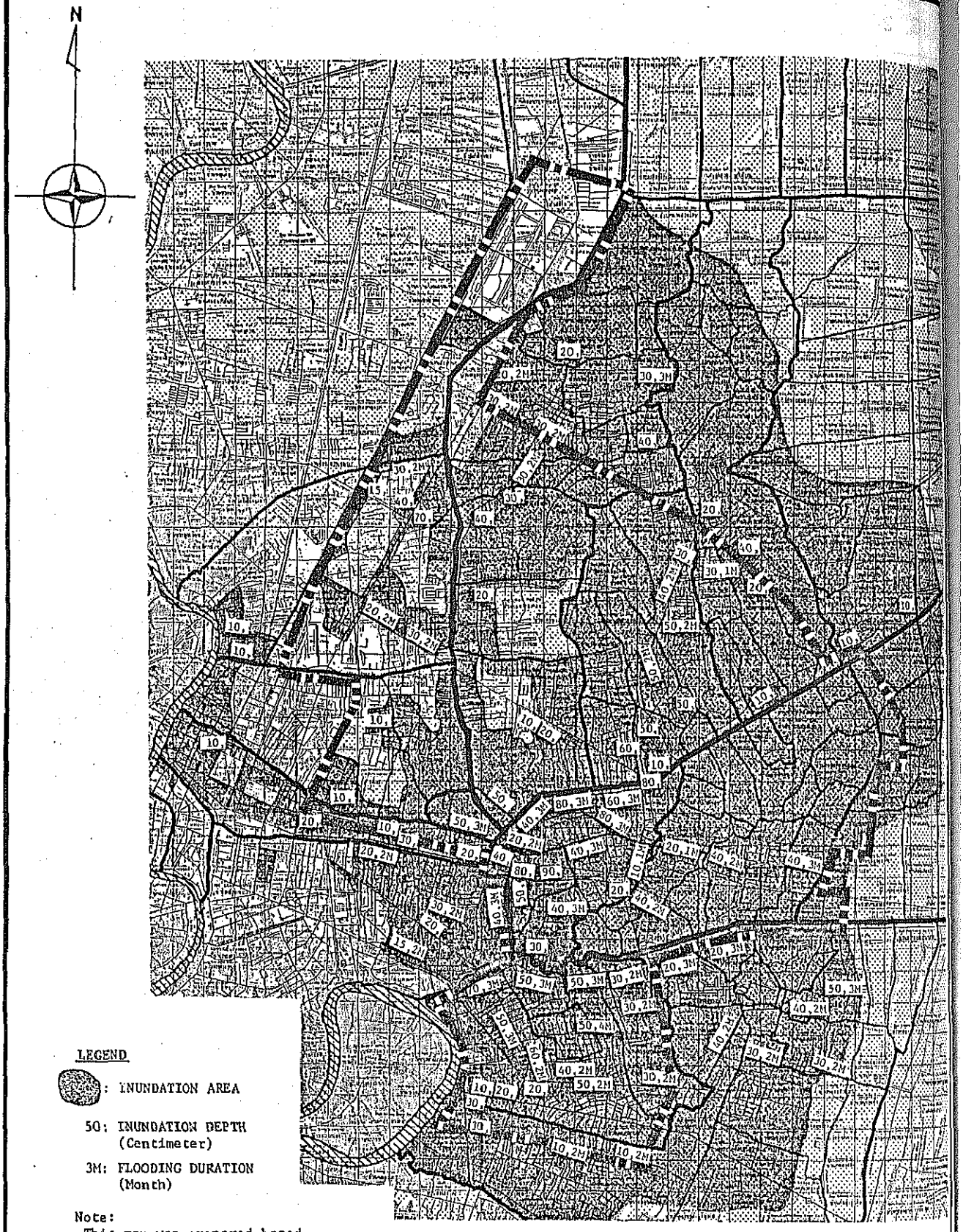
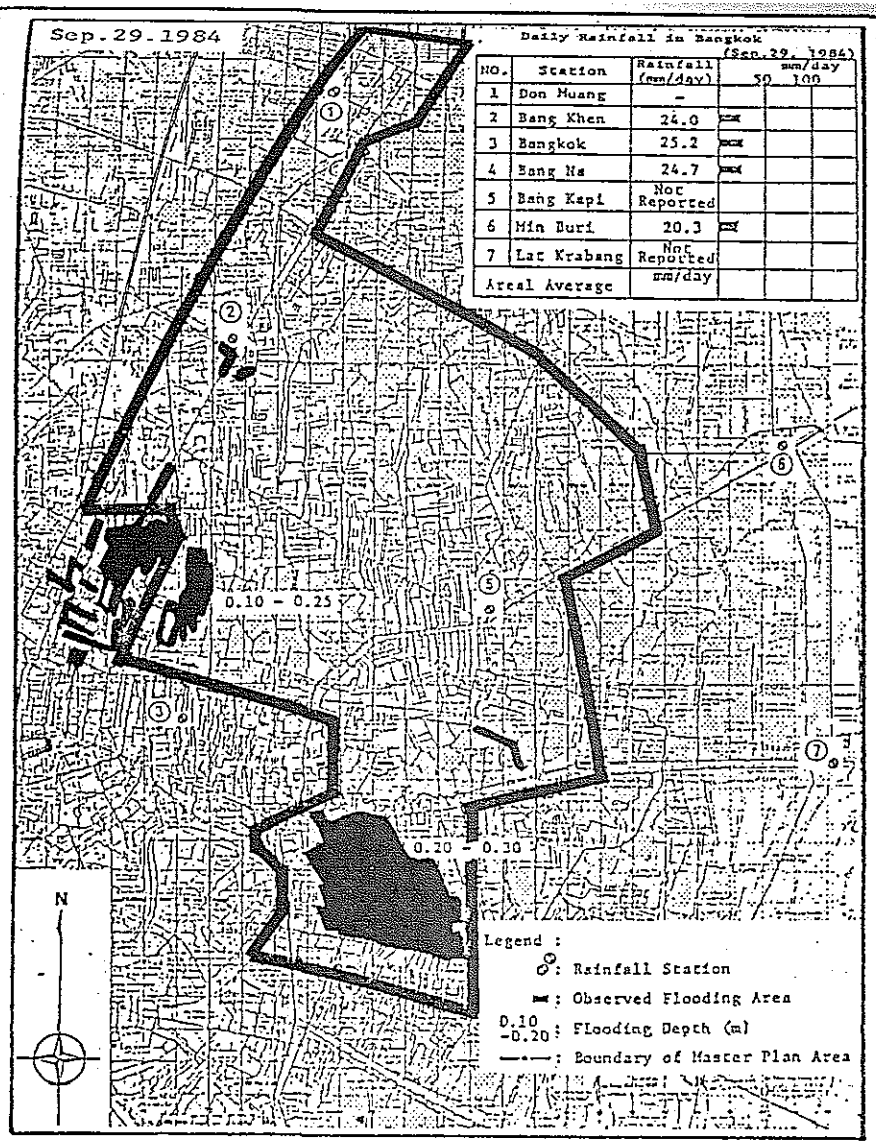


Fig. F.5 FLOOD AREA, DEPTH AND DURATION IN STUDY AREA (1983)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



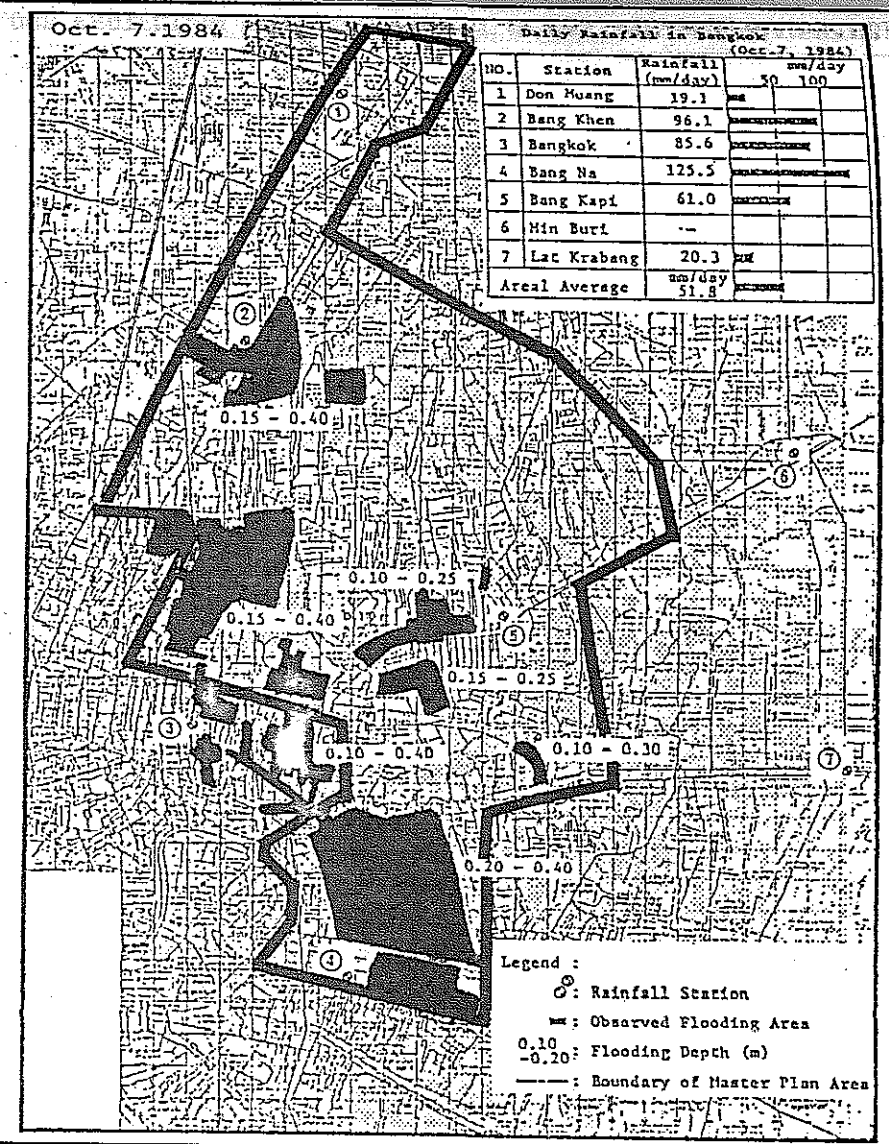
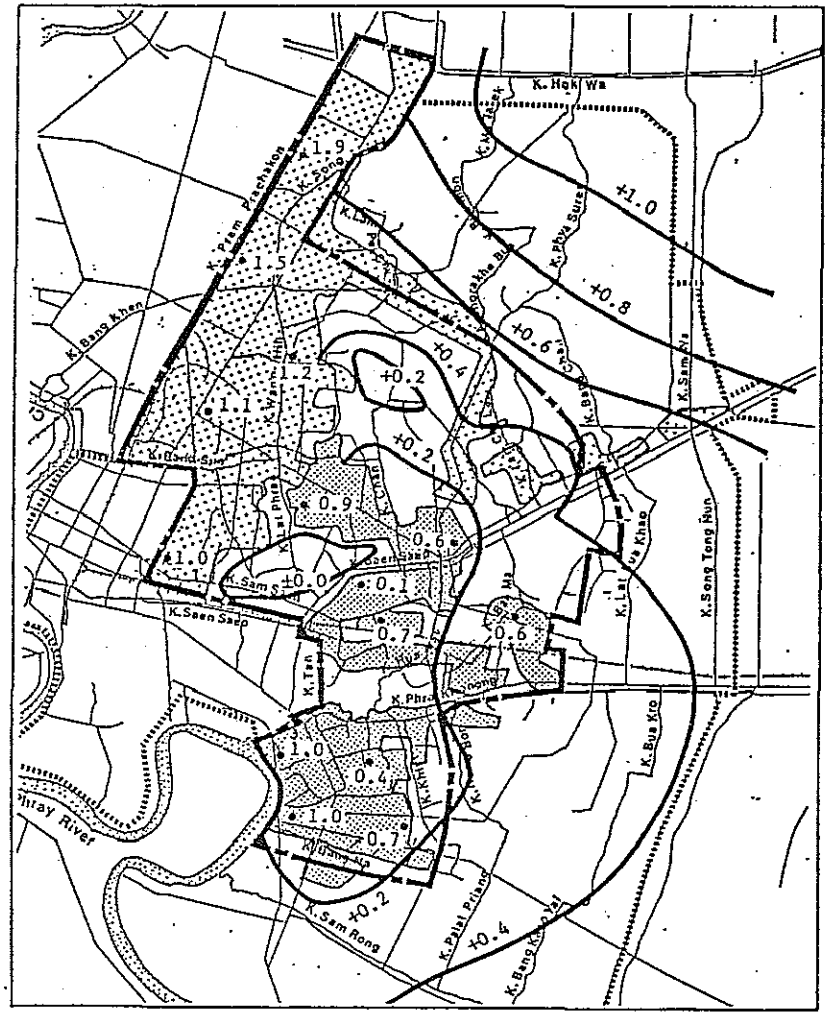
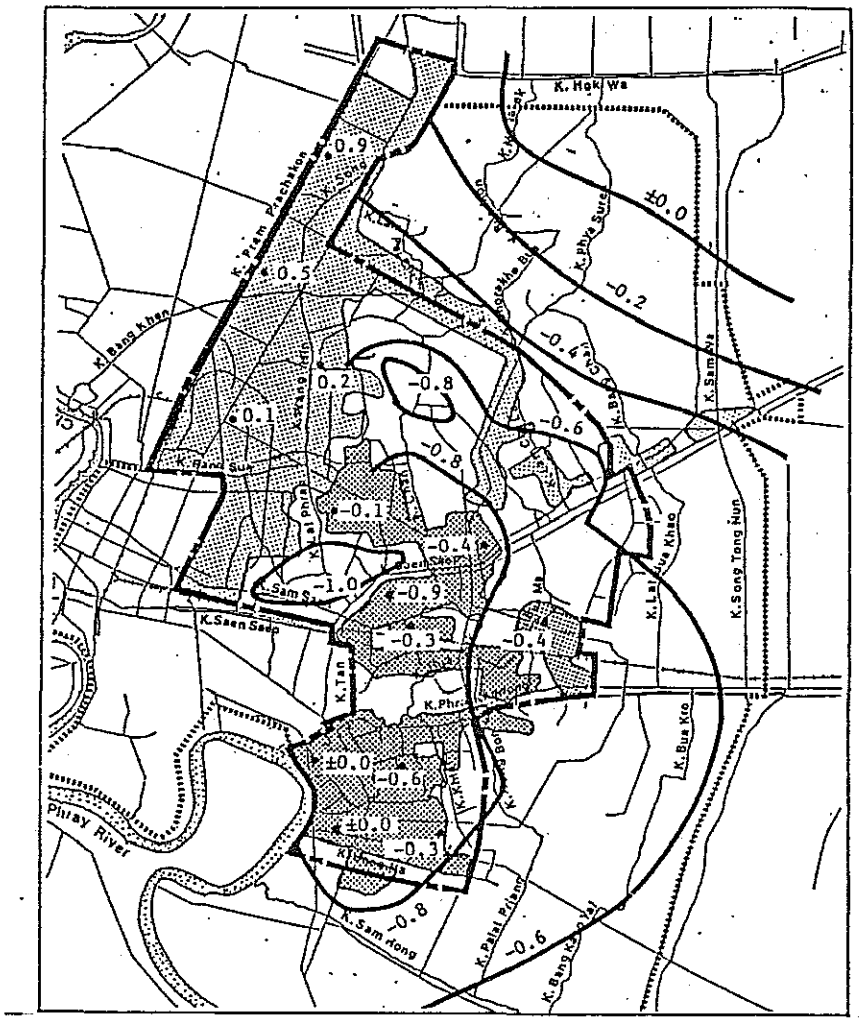


Fig. F.6 FLOOD RISK MAP (OBSERVED FLOOD AREA IN 1984)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



IN 1984



IN 2000

LEGEND

Embanked Area, More than MSL +1.00m

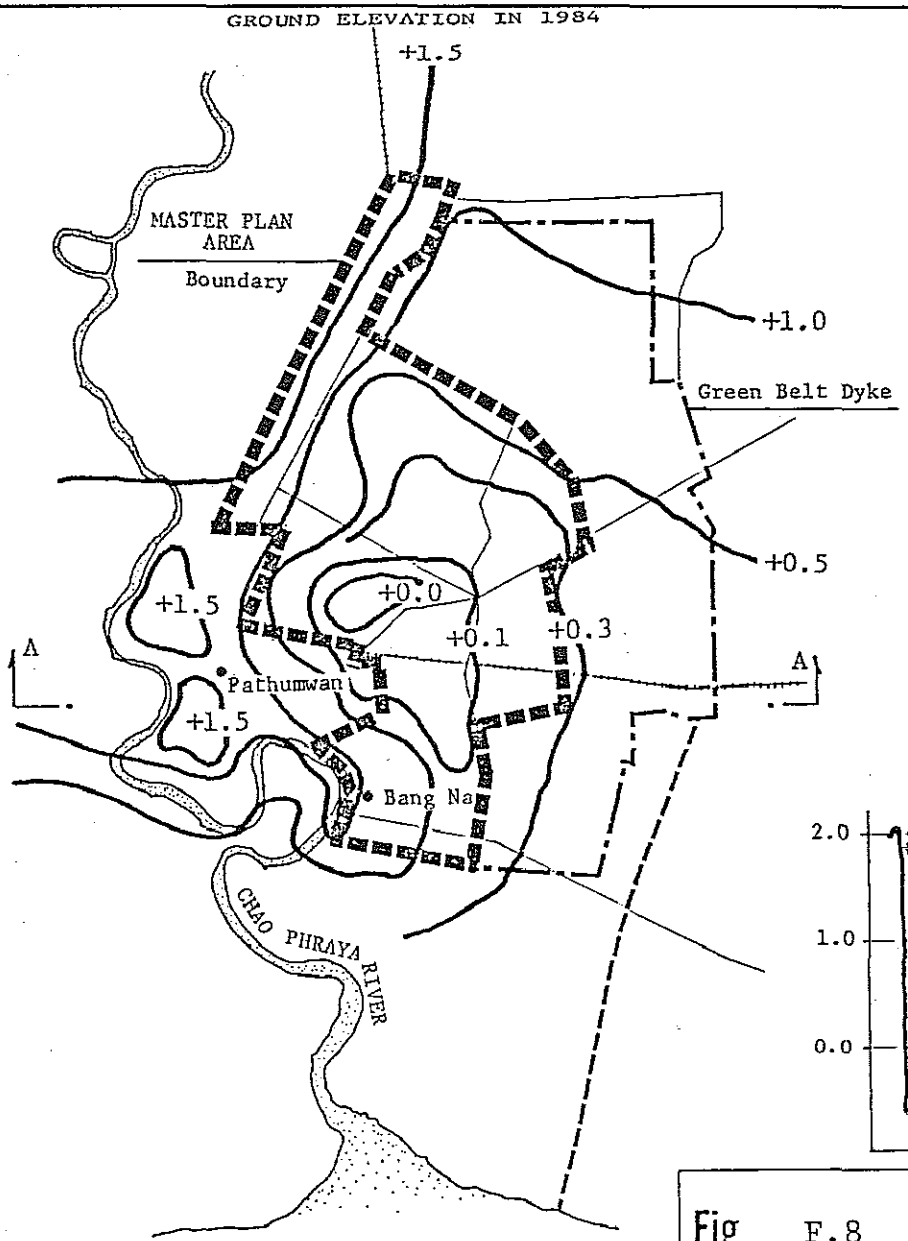
Embanked Area, MSL ±0.00~+1.00m

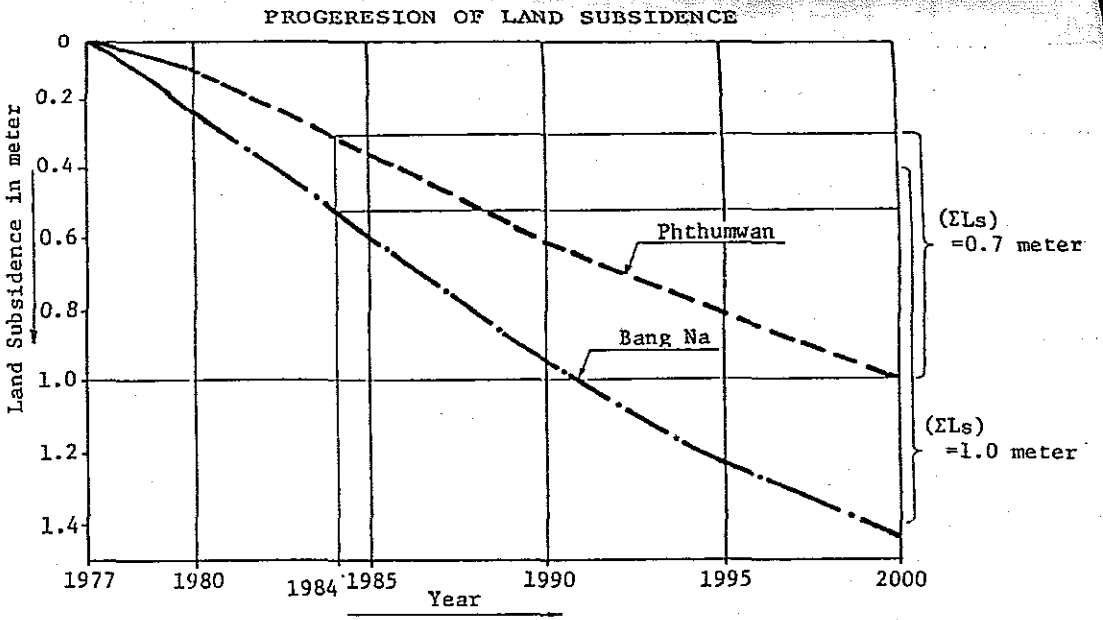
Embanked Area, Less than MSL±0.00

-0.4 Contour Line above MSL

Fig. F.7 GROUND ELEVATION IN FEASIBILITY STUDY AREA

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK





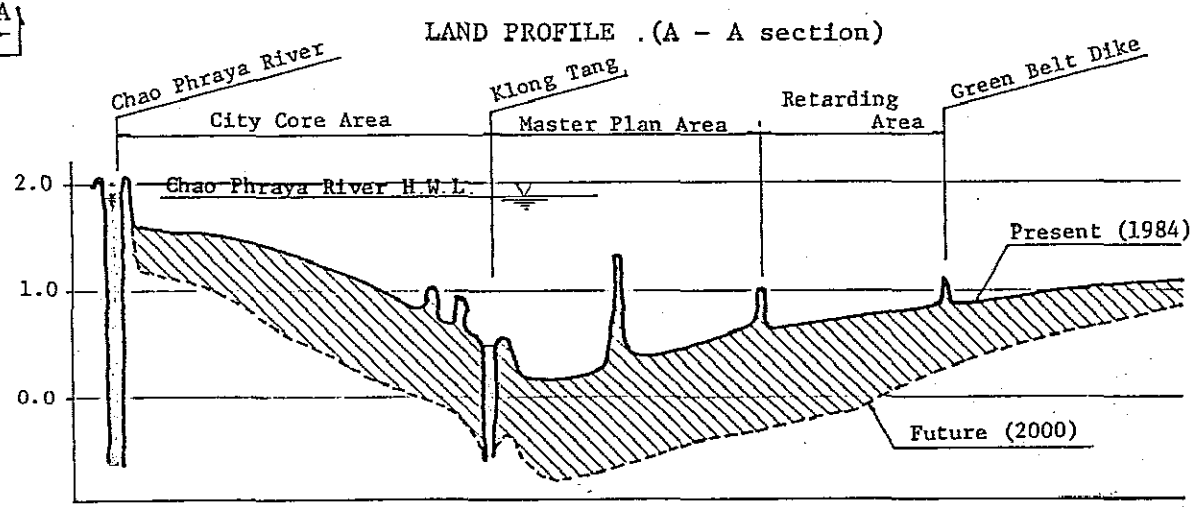


Fig. F.8 PROGRESSION OF LAND SUBSIDENCE

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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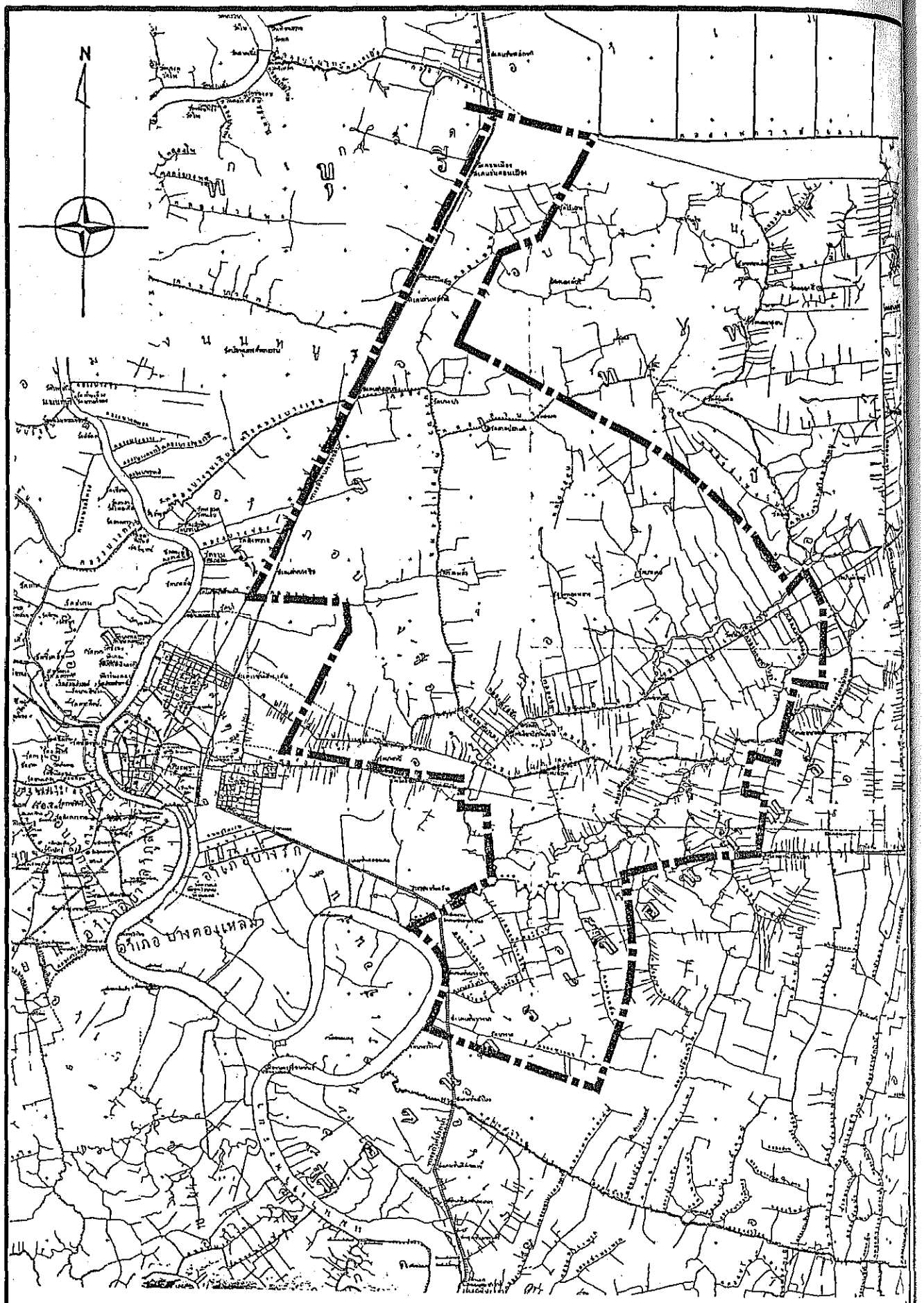

(Source:1910 Map of RTSD)

Fig. F.9 KLONG NETWORK IN EASTERN SUBURBS (1910)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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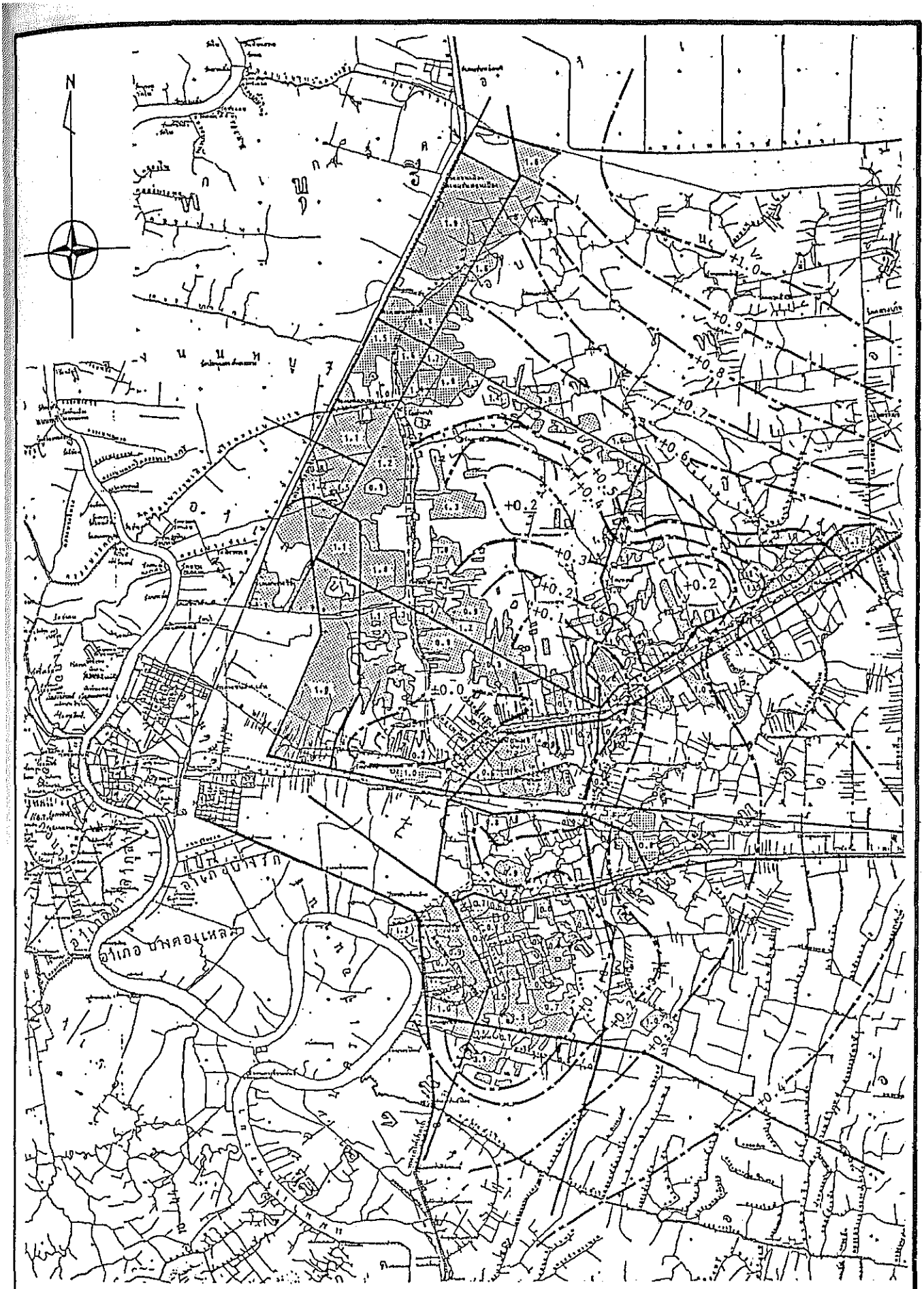

Fig. F.10 KLONG NETWORK (1910) AND GROUND ELEVATION (1984)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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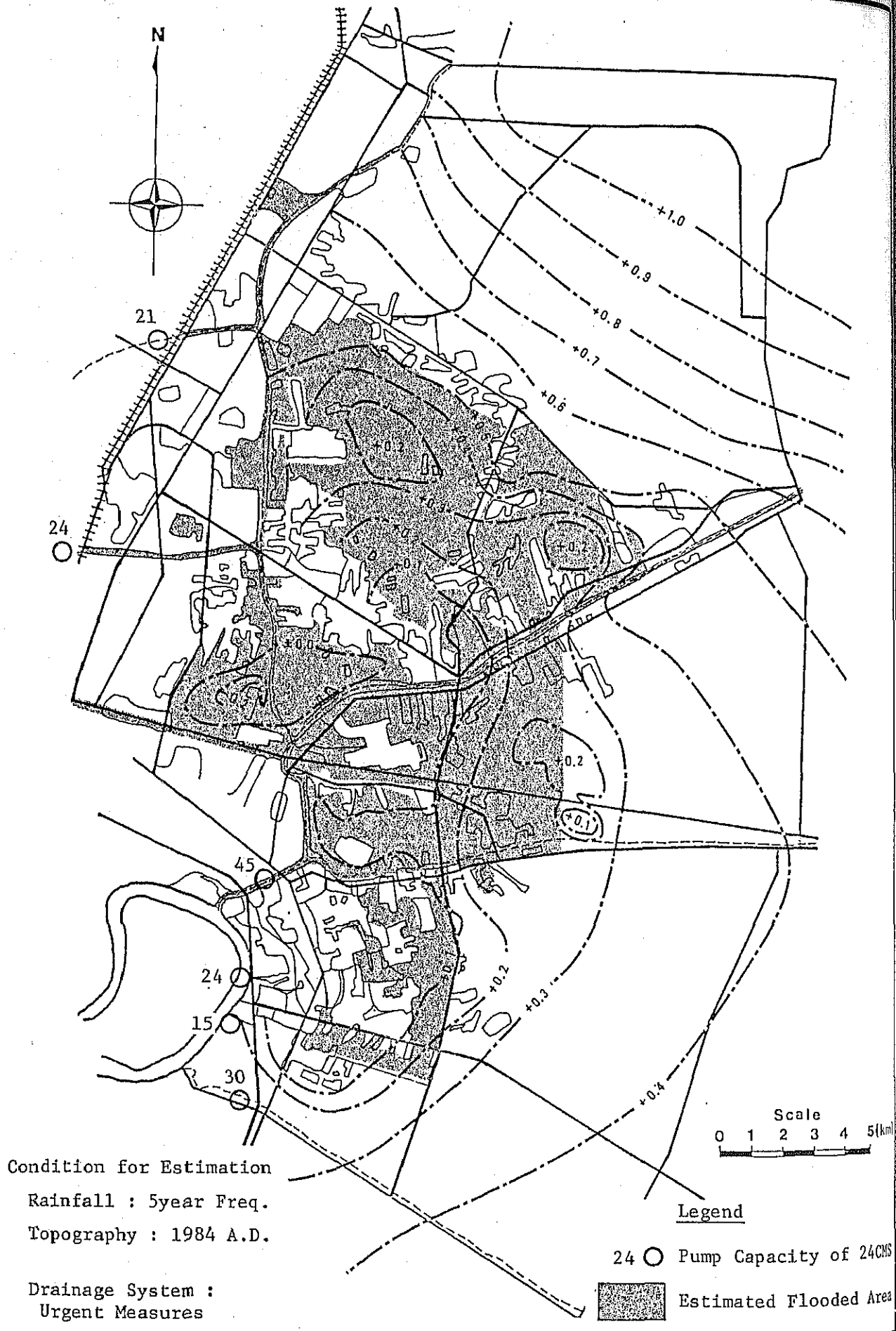

Fig. F.11 ESTIMATED FLOOD AREA IN 1984 (FOR 5-YEAR RETURN PERIOD RAINFALL BY URGENT FLOOD PROTECTION MEASURES)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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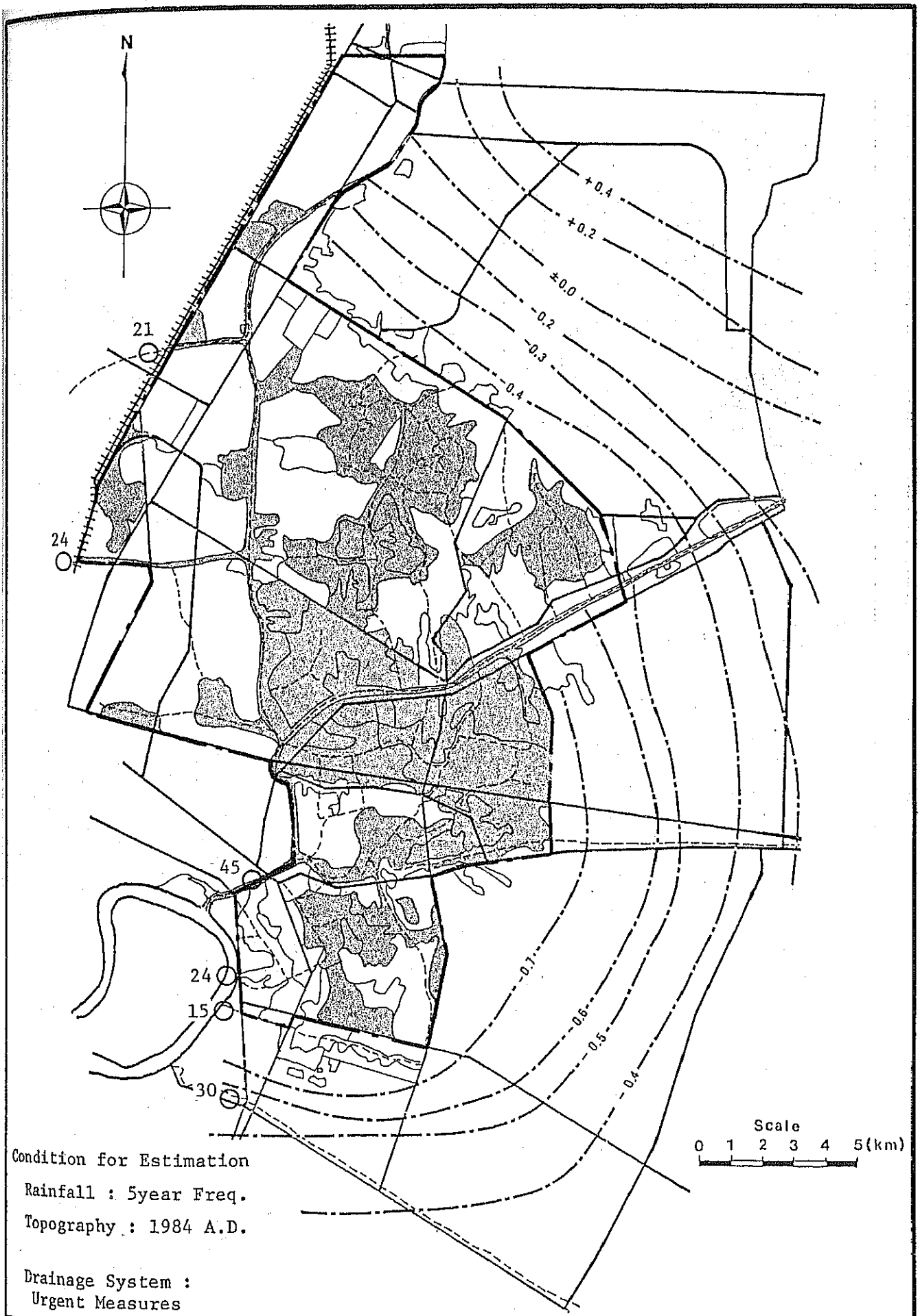

Fig. F.12 ESTIMATED FLOOD AREA IN 2000 (FOR 5-YEAR RETURN PERIOD RAINFALL BY URGENT FLOOD PROTECTION MEASURES)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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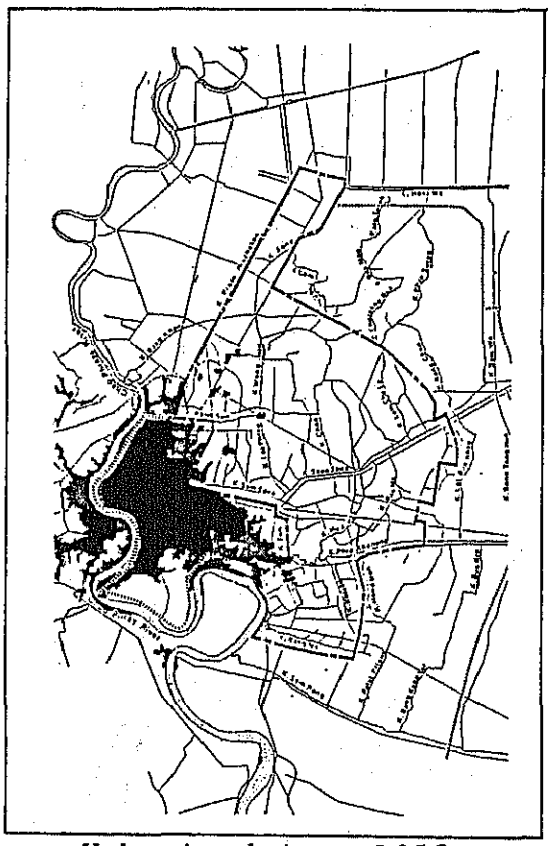
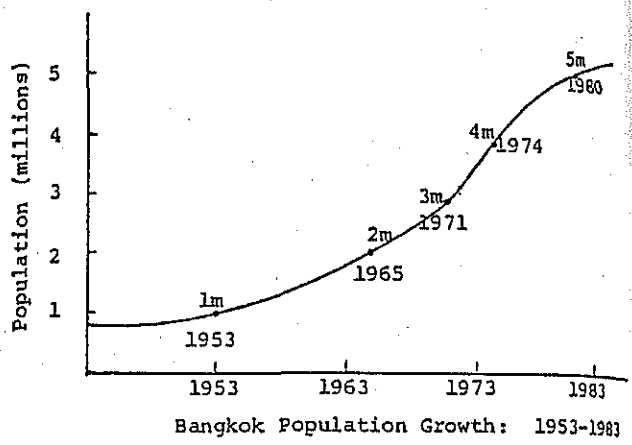
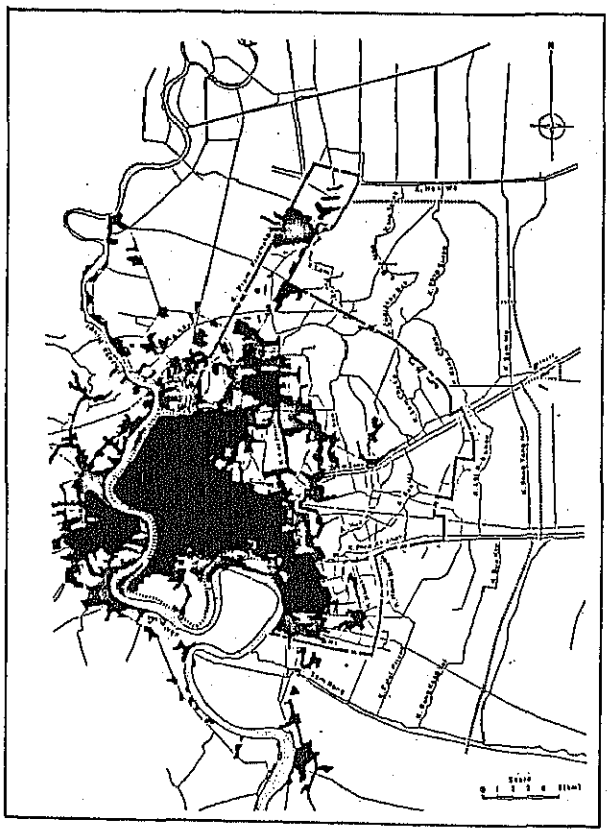


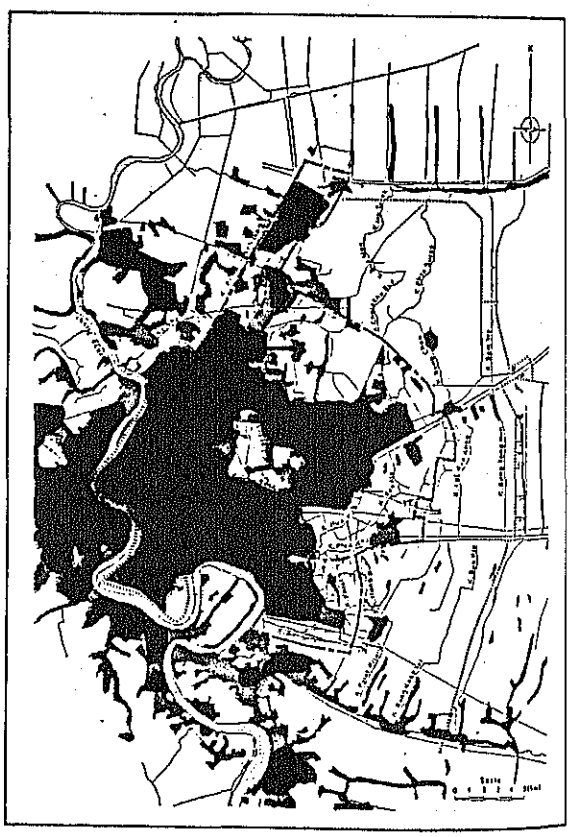
Urbanized Area 1958



Bangkok Population Growth: 1953-1983



1971



1984

Fig. F.13 PROGRESSION OF URBANIZATION IN BANGKOK

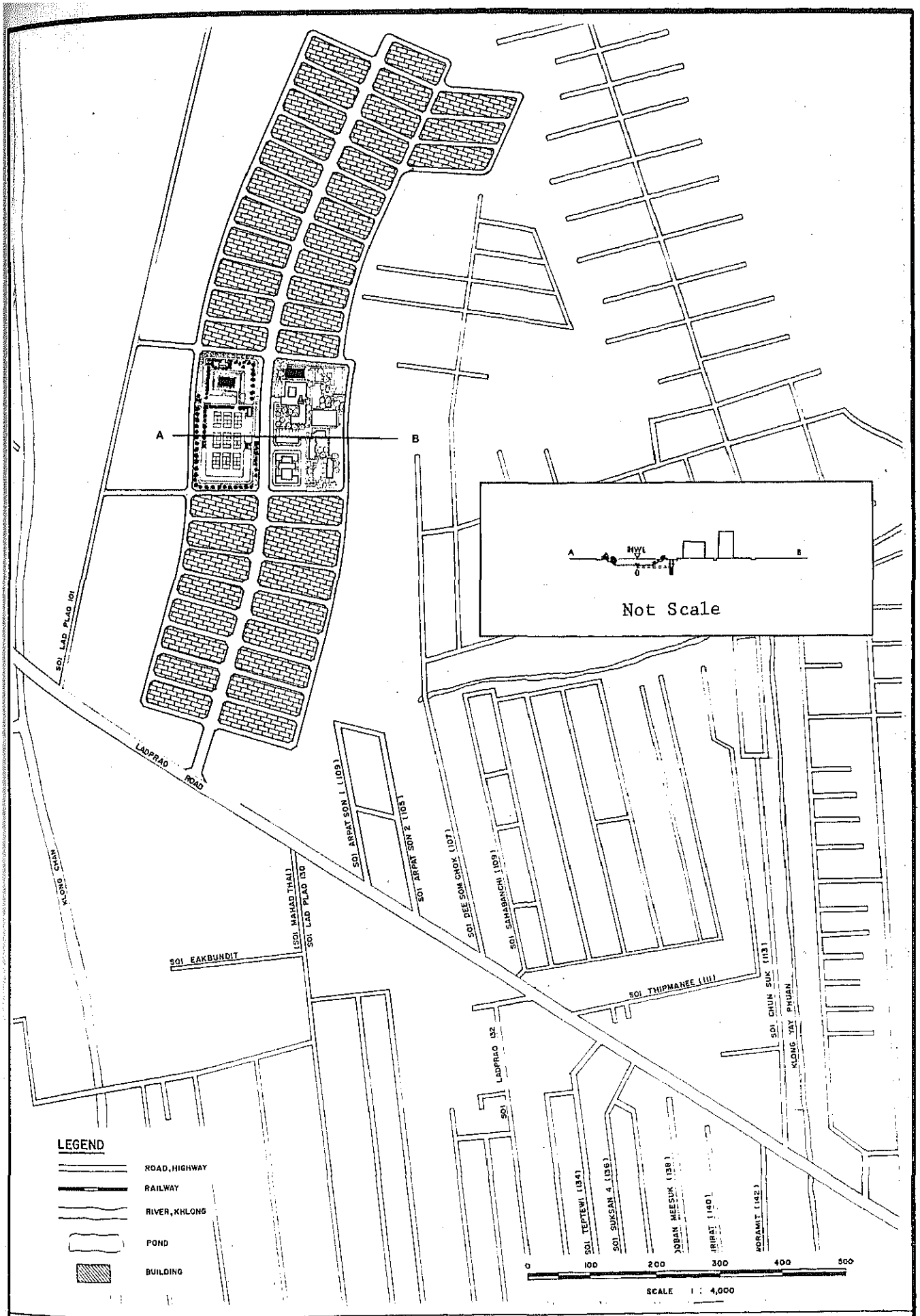


Fig. F.14 EXAMPLE OF RETENTION POND (1)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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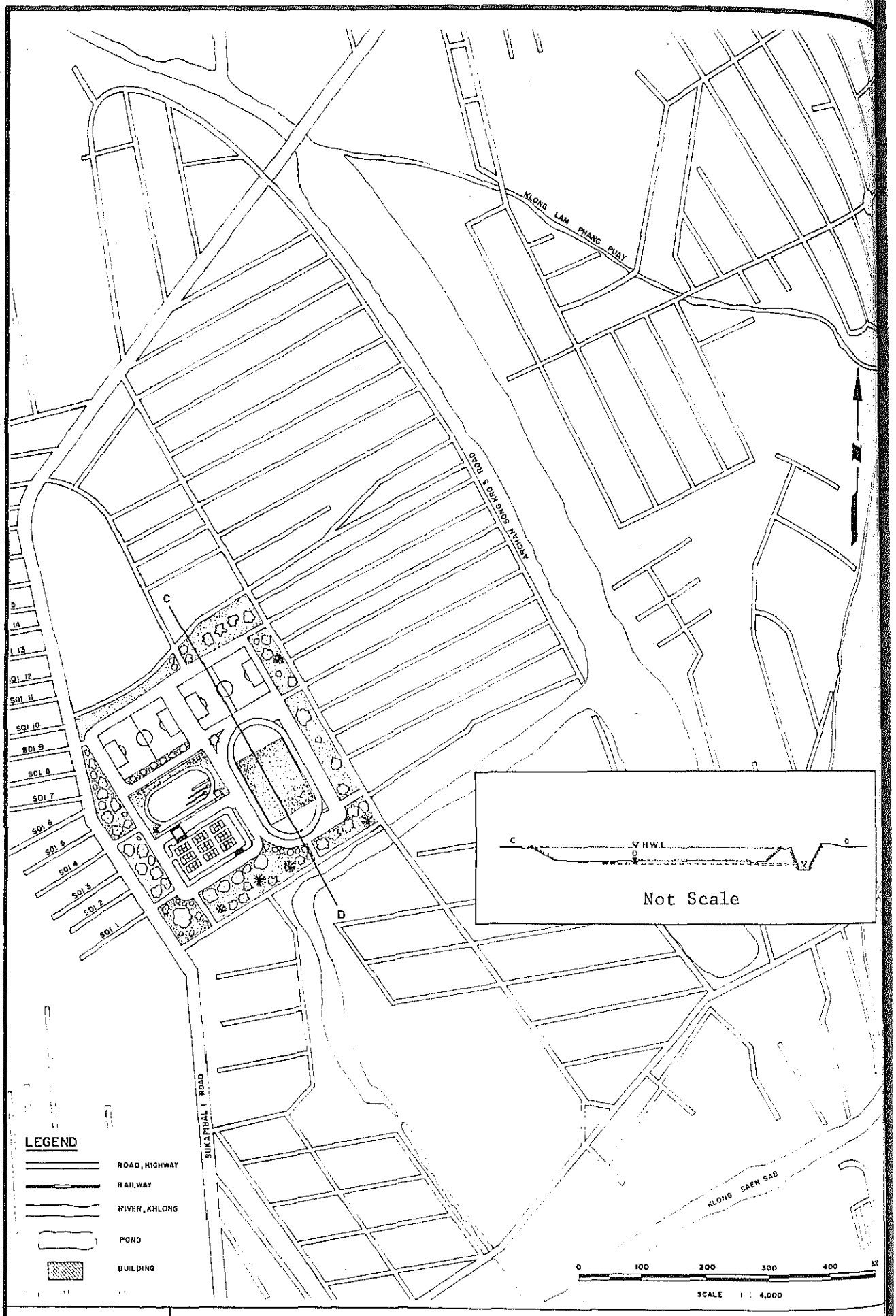

Fig. F.15 EXAMPLE OF RETENTION POND (2)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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APPENDIX G

FLOOD CONTROL OPERATION SYSTEM

APPENDIX G FLOOD CONTROL OPERATION SYSTEM

Table of Contents

List of Tables

List of Figures

1. Background of Necessity of Flood Control and Operation System

1.1 Existing Trunk Facilities.

At present in 1985 the trunk facilities such as flood protection barriers (Green Belt Levee, Embankment or Revetment) and main drainage pumping stations have been constructed (Fig G.1). These trunk facilities contribute to improve the flooding in the area. Fig. G.2 shows the hydraulic effect of Green Belt Levee, Fig G.3 Fig G.4 show the effect of main pumping station.

1.2 Purpose of Trunk Facilities

The purposes of trunk facilities are as follows.

(1) Prevention of inflow from outer area by flood protection barrier (Polder levee)
(2) Storm water drainage by main pumping stations
(3) Storage of storm water in klongs or retention area.

Fig. G.5 shows the role of green belt levee. Fig. G.6 show the relations between rainfall, water level and trunk facilities.

For storage of storm water in klongs or retension area, the maintenance water level should be carefully maintained by pump and gate operation.

1.3 Low Water Management and Klong Environmental Control

The flood control operation system should be furnished with the role of low water mangement and klong environmental control.
In dry season, all the gates at the estuary of the klong to Chao Phraya River will be usually closed in the future because of the land subsidence. Wasterwater from residence discharged to the klongs may not be flowed out by gravity to Chao Phraya River.

Therefore, the drainage pumps shall also work as the sewerage pump in dry season. In order to improve the klong water quality, the operation center shall inform the operation guidance to pump stations for discharging the wasterwater, and flushing work of klongs will be taken place.

* In rainy season, the maintenance water level in klong should be maintained / controlled for keeping effective storage capacity.
* Water level of klongs should be controlled in view of for stability of retaining wall, navigation clearance, water use.

The monitored water pollution indexs can be collected and analized at the center. Water pollution is closely connected with the operation of drainage facility and low water management.

The maintenance water levels are shown in Table G.1. The maintenance water level should be carefully controlled to maintain storm water storage capacity of the klongs in rainy season.

Table G.1 The maintenance water levels

Polder	Rainy Season		Dry Season	
	Present	Future (in 2000)	Present	Future (in 2000)
Bangkhen -Bang Sue	-0.50	-1.50	+0.00	-1.00
Phrakhanong	-0.80	-1.80	+0.00	-1.00
Bang Na	-0.80	-1.80	+0.00	-1.00
Retarding Area	+0.50	-0.30	+0.50	-0.30

2. Centralized Flood Control Operation System

2.1 Necessity of centralized flood control operation center

The flood control operation system should have following objectives.

(1) Flood control operation in Emergency
Monitoring, analysis, warning, operation of the facilities, flood fighting.

(2) Low water control
Preparation for flood, keeping maintenance water level in klongs, preparatory operation of pumps and gates.

(3) Flood information
Data collection & storage, establishment of operation rule, public relation

(4) Environmental control
Water quality control, data collection, flushing

For these objectives, the establishment of flood control operation center is proposed. Concept of the flood control operation system is shown in Fig. G.7.

2.2 Service Work of the Center

Main work of the flood control operation center are as follows:

(1) Collection of flood information
(2) Analysis, predication, warning, direction of operation of facilities
(3) Establishment of operation rule, rule of issuing warning
(4) Storage of information and issuing information
(5) Public relation
(6) Collection of water quality, establishment of operation rule for water quality control
(7) Training for staff in the Center

2.3 Institutional position of Center

Institutional position of the center is proposed to belong to the sub comittee of supervision and public relations as the plan A of Fig. G.8. When the National Flood Protection Board is established in future. The plan B of Fig. G.8 is recommended.

Based on the proposed institutional position of the center, a sample of the flow chart of information for flood control and operation is shown in Fig. G.9.

2.4 The Area covered by the System

In general, the flood control operation system should be covered by not only eastern suburban Bangkok but also whole of Bangkok Metropolitan Region for the centralizing flood control and operation. However, such system needs much money, therefore it should be planned to be expanded stage by stage coping with th development of area.

In this study, the areas covered by the system are selected a total about 600 km^2 of City Core Area and Eastern Suburban Area which have high priority for flood protection measures in BMA Region. However, for reference, following two cases are studied and described, i.e.

1) Total about 600 km^2 of City Core Area and Eastern Suburban Bangkok (Priority Package and Second Package)
2) Total about 4,800 km^2 of BMA and vicinity between Bang Pakong River and Tha Chin River (Whole Package)

3. Proposed Monitorning System

3.1 Functions of Proposed Monitoring System

The proposed monitoring system have the function as follows.

1) Telemetering monitoring for rainfall, water level and facility operation.
2) Telephone line of TOT is utilized for data transmission
3) Data analysis and management are treated by the host computer
4) Treated data are indicated on display panel and mimic panel
5) Hust computer can simulate the flood forecasting using monitored data.

3.2 Improvement and Expansion plan of Monitoring System

Under the consideration of the phased construction of the project, the flood control/operation system is proposed to be made in three stage. The priority package will be within the scope of work of feasibility study. The second and whole package will be made in future stage.

(1) Priority Package

The fifteen monitoring stations are planned to be made on-line. This is limited for only very important places for present flood control operation in BMA Region. Other existing monitoring stations remain as off-line system. The outline of this package is shown in Table G.2. Fig. G.10 shows the location map of monitoring stations.

(2) Second Package

The forty one one-line monitoring stations are planned. This package covers the area about (600 km^2) consisted of city core area and eastern suburban area. Other existing monitoring stations remain as off-line system.

The capacity of main computer installed in this package can be applied for future expansion as whole package.

The outline of this package is shown in Table G.2 and Fig. G.11 shows the location map of monitoring stations.

(3) Whole Package

This package covers the lower Chao Phraya basin between Bang Pakon river and Tha Chin river as area of 4,800 km^2.

Estimated numbers of on-line monitoring station are only tentative because the flood control/drainage plan on east bank of the Chao Phraya river is not yet studied.

The outline of this package is shown in Table G.2 and Fig. G.12 shows the concept of covered area for monitoring.

The costs of each package are shown in table G.8. The reference drawings of proposed system are shown in Fig. G.13 to Fig. G.17.

Analized data are figured out and key information are displayed on the mimic panel. Table G.3 and Fig. G.18 and G.19 show the example of display analysed.

Computer should have such capacity that it can simulate water level in main klongs by information of rainfall and operation conditions of the facilities.

Table. G.2 Packages of Flood Control Operation System

Stage / Package / Item	Feasibility Stage	Future Stage	
	Priority Package	Second Package	Whole Package
1. Covered Area	City Core Area and Master Plan Area	City Core Area and Eastern Suburban	Bang Pakong River to Tha Ching River
2. Monitoring Stations ON-Line	15 stations	41 stations	75 stations
OFF-Line	Existing Rainfall Gage·····83 st. Existing station can be utilized as supplemental data. Water Level Gage·····42 st.		
3. Data Collection ON-Line	Real time collection by telephone line of TOT		
OFF-Line	Oral or Recorded		
4. Monitoring Method ON-Line	Real time telemetering by senser		
OFF-Line	Reading by observer		
5. Master Station	Host Computer (1 Mega bytes) CRT Display 70" Projector	Host Computer (2 Mega bytes) CRT Display 70" Projector	Host Computer (2 Mega bytes) CRT Display 70" Projector
6. Data Input	ON-Line (Automatic) OFF-Line (Manual)	Automatic	Automatic
7. Sub Master Station		5 stations with personal Computer	8 stations with personal Computer
8. Cost Initial Cost	68 MB	161 MB	235 MB
Operation and Maintenance Cost	2 MB/year	5 MB/year	6 MB/year

Table G.3 Example of Displaying

	TITLE OF PICTURE	OBJECTIVE	NUMBER OF PICTURE	EXPRESSION		DATA SOURCE	DATA	EXPRESSION
				ACCENT	METHOD			
A-1	Intensity Distribution Of Rainfall (Gage)	All Area	1	3 Level Tone	Mesh	Rainfall Gage	Point Rainfall	Hourly Rainfall Intensity
A-2	Intensity Distribution of Rainfall (Rader)	All Area	1	3 Level Tone	Mesh	Rader	Area Rainfall	Hourly Rainfall Intensity
A-3	Accumulated Rainfall Depth (Gage)	All Area	1	9 Level Tone	Mesh	Rainfall Gage	Point Rainfall	Accumulated Rainfall With Operated Time
A-4	Point Rainfall Records	Each Point	60	Graph	Bar Trend	Rainfall Gage	Point Rainfall	Daily Rainfall (6 Months) Hourly Rainfall (2 Days)
A-5	Areal Average Rainfall Record	Each Polder	10	Graph	Bar Trend	Rainfall Gage	Average Area Rainfall	Daily Rainfall (6 Months) Hourly Rainfall (2 Days)
B-1	Waterlevel Profile	Each Area	10	Topography And Waterlevel Profile		Waterlevel Gage		Measured Waterlevel
B-2	Waterlevel Profile (Klong)	Main Klong	10	Waterlevel Profile		Waterlevel Gage		Measured Waterlevel
B-3	Waterlevel Record-1	Main Klong	50	Klong And Waterlevel Profile		Waterlevel Gage		Hourly Waterlevel (2 Days)
B-4a	Waterlevel Record-1/2	Each Waterlevel Meter	50	Rainfall Graph And Waterlevel Graph		Waterlevel Gage Rainfall Gage	Average Area Rainfall	Hourly Averaged Area Rainfall Hourly Waterlevel Trend (2 Days)
B-4b	Waterlevel Record-2/2	Each Waterlevel Meter	10	Rainfall Graph And Waterlevel Graph		Waterlevel Gage Rainfall Gage	Point Rainfall	Hourly Point Rainfall Hourly Waterlevel Trend (2 Days)
B-5	Waterlevel Record 3	Each Pump Station	1	Rainfall Equipment Operation Waterlevel Graph		Waterlevel Rainfall Gage	Average Area Rainfall	Hourly Averaged Area Rainfall Hourly Waterlevel Trend Gate/Pump Dispiacement Trend
C-1	Water Balance Record	Each Polder	10	Trend Graph		Analazed Date		ΣQ ΣQ ΣQ ΣQ ΣQ ΣQ (1 Month)
D-1	Inundation Area Map-1		1	3 Level Tone	Mesh $4Km^2$	By Flood Figther		Inundation Level Time
D-2	Inundation Area Map-2	Each Polder	10	12 Level Tone	Mesh $1Km^2$	By Flood Figther		Inundation Level Time

3.3 Major Equipments for Priority Package

(1) Major Equipments of master station in the Center

- Host Computer : ..... 1 set
  World Length : 16 kits,
  Memory: One mega-bytes-4 mega-bytes (expansion)
- Data Transmission Equipment ..... 1 set
- Uninterruptible Power Supply Unit ..... 1 set
  (thyristor inverter system with alkaline battery)
- Cathode Ray Tube Display ..... 2 units
  (Color display with keyboard)
- Overall Supervision Panel (Mimic Panel)..... 1 unit
  (3 x 1.8 meter size with a map of control area)
- Color Projector ..... 1 unit
  (70 inch screen, VTR TV camera and Recorder)
- Hard Copier ..... 1 unit
- Printer ..... 2 units

(2) Equipment for out stations

(Standard contents for one station)

- Transmission equipment (Remote station)..... 1 unit
- Interface for pump (ON-OFF)..... 1 set
- Interface for gate (open-close) ..... 1 set
- Rainfall gage ..... 1 unit
- Inside and outside water level gage ..... 2 units
- Power supply unit..... 1 unit

Total number of out station are 15 for priority package and the actual numbers of rainfall and water level gage are shown in Fig. G.10. The skematic diagram of monitoring stations is shown in Fig. G.15.

3.4 Reference for data transmission system

In general, there are two kind of data transmission system such as

(1) Telephone circuit transmission system
(2) UHF radio transmission system

In this project the former is adopted due to the following reasons:

* Radio wave hindrance due to the high buildings is very large.

* The radio band is severely regulated by the army and it will take a long time to obtain its permission.

* According to the economic development project (EDP 1984-1988) of TOT, the telephone lines will be increased from existing 380,000 lines to 900,000 lines and is easy to obtain lines.

* The initial cost of the former is estimated at about 68 million Baht, and the latter is about 113 million Baht. The higher cost of the latter is mainly due to the construction cost of high radio tower and necessary equipment cost. Although in the former, telephone charge is needed, the merit of lower consturction is very large. From the comparison between total cost of initial cost and operation maintenance cost for first 20 years of operation the cost of former is about 20 percent lower than later. Details are shown in Tables G.4 and 5.

* The maintenance and future expansion works will be done by TOT in case of the former, and in case of the latter, the works should be done by the organization in charge.

Table G.4 Comparison of Data Transmission Systems Between Telephone Circuit and UHF Radio

Item		Telephone Circuit Transmission System	UHF Radio Transmission System
Permission Authority		Application of TOT line	Permission is necessary from the Post Telegraph Dept. The Band is strongly regulated by army.
Availability		less-availability in flooding	Obstruction for radio wave
Reliability		Getting better for TOT's expansion and improvement	Getting worse for construction of high building (Radio wave hindrance)
Maintenance		By TOT	By oneself
Expansion		By TOT	By oneself
Distance from master station to monitoring station		No limitation	Dependent to transmitting power
Cost for Priority Package	Initial Cost	68 Million Baht	113 Million Baht
	Operation & Maintenance Cost	2.0 Million Baht/Year	1.2 Million Baht/Year
Total Expense for the equipment life (20years) at 1985 price.		108 Million Baht	137 Million Baht
		Life Time: 20years	
Judgement		Adopted	Not Adopted

Table G.5 Cost Comparison of Data Transmission Systems

	Telephone Circuit Transmission System		UHF Radio Transmission System	
	Unit	Amount	Unit	Amount
(1) Master Station		325,900,000		505,900,000
1. Host Computer	1 set	40,500,000	1 set	40,500,000
2. Man Machine Sub System	1 unit	76,000,000	1 unit	76,000,000
3. Communication Sub System	"	60,000,000	"	60,000,000
4. Application Soft Ware	"	100,000,000	"	100,000,000
5. Power Supply System	"	39,400,000	"	39,400,000
6. Cables	"	10,000,000	"	10,000,000
7. Equipment of UHF Radio Wave	-	-	"	60,000,000
8. Radio Wave Tower (H=100m)	-	-	"	120,000,000
(2) Out Stations		109,500,000		270,000,000
1. Outer Station Terminal Unit	15 sets	33,750,000	15 sets	33,750,000
2. Cabinet	15 "	14,400,000	15 "	14,400,000
3. Water Level Gage	28 "	25,200,000	28 "	25,200,000
4. Rainfall Gage	13 "	3,250,000	13 "	3,250,000
5. OTU Soft Ware	15 "	4,500,000	15 "	4,500,000
6. Cables	1 unit	8,600,000	1 unit	8,600,000
7. Modefication of Exist.Panel	1 "	4,800,000	1 "	4,800,000
8. Equipment of UHF Radio Wave	-	-	15 sets	55,500,000
9. Sub-Radio Wave Tower (H=40m)	-	-	15 "	105,000,000
10. DC Battery Charger	15 sets	15,000,000	15 "	15,000,000
(3) Others		190,200,000		263,800,000
1. Master Station Installation	1 unit	12,000,000	1 unit	16,800,000
2. OTU Installation	"	20,000,000	"	28,000,000
3. Site Testing	"	60,000,000	"	84,000,000
4. Spare Parts	"	30,000,000	"	52,000,000
5. Test Equipment	"	15,000,000	"	25,000,000
6. OTU House	"	15,000,000	"	15,000,000
7. TOT Telephone Line	"	9,200,000	"	-
8. One year Maintenance	"	9,000,000		15,000,000
9. Operation Training	"	20,000,000		28,000,000
(4) Total		¥ 625,600,000		¥ 1,039,700,000
		68 Million ฿		113 Million ฿
(5) Operation & Maintenance				
1. Operator Wage	2 memb.	0.5 M฿	2 memb.	0.5 M฿
2. Operation Expenses (TOT,EGAT)	1 unit	1.0 M฿	1 unit	Negligible
3. Patroiling	1 "	0.3 M฿	1 "	0.5 M฿
4. Office Work Expenses	1 "	0.2 M฿	1 "	0.2 M฿
Total		2.0 M฿		1.2 M฿

4. Example of Flood Control Operation Manual

4.1 Flood Forecasting

The Center announces flood forecast. The anouncement will be made in two steps by water level in klongs. In first step flood caution, in second step, flood danger are anounced.

The forecast by rainfall is tentatively shown in Table G.6.

Table G.6 Example of Forecasting

Water Level \ Site / Forecasting		Chao Phraya River	Green Belt Levee	2nd Barrier Dyke	Klongs in polder
Outer Water Level	Caution	recorded Level in 1983	100 years frequency level	5 years frequency level in Retarding Area	—
	Warning	Same level of top elevation of Levee	100 years frequency +0.3 meter level	Same level of top elevation of dyke	—
Inner Water Level	Caution	—	—	—	Minimum Residential Land Level or Designed High Water Level
	Warning	—	—	—	the level of 0.2 meter plused above metions

4.2 Operation of Facilities

The operation rule of facilities are tentatively shown in table G.7.

Table G.7 Operation Code of Facilities

	Rainy Season (July~December)	Dry Season (January~June)
Regulator Gate of Green Belt Levee	• Closed as a general rule • Opened with the Permisson of the Center	• Controled to keep the maintenance water level in klong
Regulator Gate of 2nd Barrier	• Closed as a general rule • Opened with the permission of the Center and the water level must be kept less than maintenance water level in klong	• Controled to keeping the maintenance water level in klong
Gate between each polder	• Closed as a general rule • Opened with the permission of the Center	• Opened as a general rule • Controled for klong flushing action by the indication of the Center
Gate at pumping station	• Opened when the condition of outer water level is below than inner water level • Closed on other conditions • Closed in night as a general rule	• Controled to keeping the maintenance water level in klong • Controled for klong flushing action by the indication of the Center
Pumping Station	• Operated to keep the maintenance water level in klong polder	• Operated to keeping the maintenance water level in klong • Operated for klong flushing action by the indication of the Center

5. Training Items for Flood Control Operation System

A staff of trained personnel is needed for the operation of the flood protection and drainage facilities.
In the training, firstly the basic principles and concept of the project shall be understood and secondly the operation and management of the facilities will be factors of the basic principles shall be appreciated.

5.1 Training for managers

The managers of the project have responsibility for the coordination with relevant projects and the execution and management of flood control measures.
Therefore, the managers should have complete understanding, knowledge and skillness for flood control operation.

The following items are to be trained for the managers.

1) Management of forecasting and warning system and flood control information.
2) Design and operation of flood control and drainage facility
3) Understanding of the comprehensive flood control countermeasures.
4) Management of water pollution control.

5.2 Training of technicians

The technician has specific assignment as follows.

1) Computer operation and system Maintenance
2) Compiling or recompiling of softwares for computer
3) Surveying
4) Hydrology and Hydraulics
5) Meteorology
6) Pump mechanism and operation rule
7) Measurement of rainfall and water stage
8) Evaluation and public relations of flood and flood damage
9) Relations of rainfall, runoff, water storage, and drainage facilities