CHAPTER 7 FLOOD CONTROL OPERATION SYSTEM

The establishment of a centralized flood control operation system is recommended for effective and efficient facility operation. In this chapter, the necessity, roles and functions of the proposed flood control operation system are described.

7.1 General

The eastern suburbs (Preliminary Study Area, 501 km^2) is protected against inflow from outer areas by the Green Belt and Chao Phraya River dykes. Rainwater in the area is planned to be pumped out into the Chao Phraya River. Water levels in klongs are to be maintained at a lower level, by absorbing large amount of rainwater within the klongs. Consequently, careful attention needs to be paid to the operation of pumps.

The eastern half of the Preliminary Study Area, east of the Feasibility Study Area is planned to maintain its water retention function in order to protect the western half, and a partition dyke (second flood protection barrier) is planned between both areas. Therefore, the water level may rise in the eastern half during the rainy season, resulting possibly in conflicts between residents in both areas. If the accumulated rainwater in the eastern half is diverted through the gates along the second barrier into klongs and pumping stations in the western half, conflicts will be eased.

The pumped discharge into the Chao Phraya river may create a rise in river water levels as described in Chapter 4. Therefore, the main pumping stations located along the Chao Phraya river need be operated by taking into account the hydrological conditions both in the river and in the western half.

An inflow to Klong Tan from the City Core Area is planned. The impact of the pump from the City Core Area should be observed. To the contrary, if some rainwater is diverted into the City Core Area, flooding status in the western half can be improved in the case of heavy rainfall, exceeding the design rainfall occurs in the Eastern Suburbs and only light rainfall occurs in the Core Area. A similar operation can be expected from Bang Khen-Bang Sue polder to Phra Khanong polder through Klong Lat Phrao.

In conclusion, the proposed facilities have to be systematically operated to protect the western half area, by considering the hydrological conditions there. The facilities are also effective in alleviating flooding in neighboring areas of the eastern half, the City Core Area and the Green Belt area. This will occur when the facilities are operated by taking into account the hydrological conditions not only in the western half but also in the neighboring areas. In addition, the facilities are to be operated in order not to raise water levels.

For this purpose, the establishment of a flood control operation centre is recommended.

7.2 Roles and Effect of the Proposed Facilities

The proposed main flood protection/drainage facilities comprise 1) Green Belt dyke and gates, 2) Chao Phraya river dyke, 3) second dyke and gates and 4) pumping stations and klongs inside the polder. At present (1985) some of the main facilities such flood protection barriers (Green Belt dyke) and main pumping stations have been constructed. Fig. 7.1 shows the locations of main facilities. The hydraulic effects of these main facilities are large as shown in Fig. 7.2 and their operation will play a key role for flood protection.

Rainwater storage capacity of klongs and retention area is fully utilized by setting out a maintenance water level. The total storage capacity is designed to be almost equivalent to a rainfall of 46 mm which is 60% of the design areal average rainfall. Fig. 7.3 shows the conceptual roles of design storage capacities of each polder.

Fig. 7.4 shows the flooded areas in 1984 floods which occured after the construction of Green Belt dyke and main pumps as the urgent flood control measures. This figure indicates that the constructed facilities are not fully sufficient for a 1984 flood.

7.3 Existing Flood Control Operation System

Prior to proposing the control centre, the existing operation system is described.

The Department of Drainage and Sewerage (DDS) in BMA takes the responsibility for flood control and protection of the urbanized area in BMA. Flood Protection Centre is organized in DDS and a Flood Relief Centre is organized in BMA Head Office in the rainy season. Other departments in BMA and 24 district offices support the Centre to protect and mitigate flood effects in BMA.

Rainfall data and weather information are collected from the Meteorological Department through telefacsimile system. Hourly water levels at pump stations and regulating gates are transmitted by telephone.

The Royal Irrigation Department (RID) is principally in charge of flood control in the agricultural area and controls some watergates located along the Green Belt. Besides, RID controls some main pumping stations in the urbanized area at Bang Khen, Phra Khanong and Samut Prakan which are located at the outlet of the main klongs.

Flood Forecasting Centre (FFC) in the Electricity Generating Authority of Thailand (EGAT) forecasts the water level in Chao Phraya River at Memorial Bridge based on the hydrological data of Chao Phraya River Basin and tidal data. This Flood Forecasting Centre obtains the weather information from the Meteorological Department, daily rainfall data from Meteorological Department and RID, stream flow data from RID and regulated flow data from RID and EGAT.

The existing systems are lacking in the following;

- Centralized monitoring system of hydrological data
- Centralized observation system of operation conditions of pumps and gates
- Systematic and efficient operation of the facilities
- Reliability of collected data and
- Analysis of collected data over a long period

The existing flood control and data management system in DDS is a so called "Off-line System." By introducing the "Telemetering System. or "On-line System", the need is to establish a centralized monitoring system for hydrological data and the systematic and efficient operation of the facilities.

7.4 Proposed Flood Control Operation Centre

In general, the flood control operation system should cover not only eastern suburban Bangkok but also whole Bangkok Metropolitan Region because the Study Area is but one part of the Lower Chao Phraya Plain. However, such system needs much money, therefore it should be expanded stage by stage in conjunction with the development of the area.

The area covered at this stage are proposed for 600 km^2 of the City Core Area and Eastern Suburban Area which have high priority for flood protection measures in BMA Region.

7.4.1 Purposes

The purposes of the proposed system are (see Fig. 7.5):

(1) Collection of flood information

(2) Analysis, prediction, warning, data supply for operation of facilities.

(3) Establishment of operational rules and rules for the issue of flood warnings.

(4) Storage of flood information

(5) Public relations

(6) Collection of water quality data, establishment of operational rules for water quality control

(7) Training for staff in the Centre

The proposed system comprises of monitoring, transmitting and analysing functions (see Fig. 7.6).

7.4.2 Monitoring System

As a first step, fifteen monitoring stations are planned as described below (see Fig. 7.7) for control of main facilities, observation of flood conditions in inland and outer areas (see Table 7.1.).

(1) Water levels (both of klongs and the Chao Phraya River) at six pumping stations along the River i.e., Bang Sue, Sam Saen, Padung Krung Kasem, Rama IV, Phra Khanong and Bang Na.

(2) Water levels (both the eastern half and the western half) at two gates stations along the second barrier i.e., Klongs Saen Saep and Phra Khanong

(3) Water levels (both the eastern half and the Green Belt Area) at four gates along the Green Belt dyke i.e., Klongs Song, Nung, Saen Saep and Phra Khanong

(4) Water levels (both the City Core Area and the western half) at Klong Tan pumping station which pumps out stormwater from the City Core Area to the western half.

(5) Water levels in the western half; in the middle of Klong Lat Phrao and Bang Na area

(6) Raingauges are installed at the abovementioned 15 water level stations.

Table 7.1 Role and Site for Monitoring

Role of Monitoring	Contents of Monitoring	Monitoring Stations
Control of Main Facilities	·Water level in Main Klongs ·Control of maintaining water level in main klongs ·Control of klong environmental conditions	·Main klongs ·Main pumping station ·Main gates at green belt & 2nd barrier
Observation of Outer Conditions	·Water level condition in green belt area ·Water level condition in retarding area ·Water level in the Chao Phraya River	·Main pumping stations ·Main gates of green belt & 2nd barrier
Observation of Inland Flooding	·Water level in small klong ·Drainage operation of small klongs ·Control of maintaing water level in small klongs	·Small klong in the heavy past flood damaged area ·Pumping stations and gate

7.4.3 Data Transmission System

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

(1) Telephone circuit transmission system

(2) UHF radio transmission system

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

* Radio wave hindrance due to high buildings is large.

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

* According to the economic development project (EDP 1984–1988) of TOT, the number of telephone lines will increase from 380,000 lines to 900,000 lines and it 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 towers and equipment costs. Although in the former, a telephone charge is needed, the merit of the lower construction cost is large. From the comparison between the both total costs of initial cost and operation/maintenance cost for first 20 years of operation, the total cost of former is about 20 percent lower than the latter (Details are shown in Appendix G).

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

7.4.4 Major Equipments and Cost

The major items of equipment and their estimated cost for the proposed system are shown in Table 7.2. The total initial cost of 68 million Baht and operation and maintenance cost of 2 million Baht are estimated.

The schematic diagram of the monitoring system is shown in Fig. 7.7 and the schematic diagram of a monitoring station (rainfall and water level gage station) is shown in Fig. 7.8.

7.5 Flood Control Operation Rule

7.5.1 General Rules for Flood Control Operation

The facilities should be operated based on the rules determined by the centre (see Fig. 7.9.). Especially the preparatory operation of the main pumping station before

rainfall is important in order to maintain the designated maintenance water level in the klongs. The facility operation rules should be ammended from time to time according to the result of actual operations. Table 7.3 shows the examples of facility operation rules.

For facility operation the following should be taken into consideration;

(1) In the case when rainfall exceeds the design rainfall in one polder, the drainage facilities in the other polders should be systematically operated i.e., operation of gates located at the border of each polder or pump discharge from flooding area into other areas should be made.

(2) In the case when heavy rainfall occurs in and around the Study Area, facilities should be operated to alleviate overall flooding there.

For that purpose hydrological data not only in the Study Area but also in neighboring areas such as the Green Belt area, eastern half area and Core Area, and the Chao Phraya river must be collected and analysed.

(3) The distance between main pumping stations and the gates of the Green Belt dyke is upto 20 kilometres, thus the flow time between both stations will be over 14 hours. In operating these facilities, attention should be paid to this time lag.

7.5.2 Forecasting of Water Level

For the time being, water levels will be estimated by the past observed rainfall and water level data. These water levels are utilized as the basis for the facility operation.

7.6 Institutional Position of the Centre

At present, the proposed flood control operation centre is recommended to belong to the Sub-Committee on Project Designation because the existing major roles and actions for flood protection and drainage for Bangkok and Vicinity are executed by DDS and RID. This matter is also described in Chapter 8.

Table 7.2 Major Equipments and Estimated Cost

(Unit: Thousand yen)

	Item	Unit	Amount	Remarks
(1)	MASTER STATION		(325,900)	Without Back up machine
	1. Host Computer	1 set		
	2. Man-Machine sub-system Color Copier, 70" projector Mimic Panel, TV Camera, VTR Desk, etc.	1 unit		
	3. Communication sub-system	1 unit		
	4. Application Soft Ware	1 "		
	5. Power Supply System	1 "		
	6. Cables	1 "		
(2)	OUT STATIONS		(109,500)	
	1. OTU (STC-1000)	15 sets		
	2. Cabinet	15 "		
	3. Water Level Gage	28 "		
	4. Rainfall Gage	13 "		
	5. OTU Soft Ware	15 "		
	6. Cable	1 unit		
	7. Modification of Existing panel	1 "		
	8. DC Battery charger	15 "		
(3)	OTHERS		(190,200)	190,200
	1. Master Station Installation			
	2. Sub-Master Installation			
	3. OTU Installation			
	4. Site Testing			
	5. Spare Parts			
	6. Test Equipments			
	7. OTU House			
	8. TOT Telephone Line			
	9. One year Maintenance			
	10. Operation Training			
(4)	Total of Initial Cost		¥ 625,600	thousand yen
				68 Million ฿
(5)	Operation & Maintenance		(2 Million ฿/year)	
	1. Salary of Operator	2 Memb.		
	2. Operating Expense (TOT, EGAT, ETC)	1 "		
	3. Patroling Expense	1 "		
	4. Office Work Expense	1 "		

Table 7.3 Examples of Facility Operation Rules

	Rainy Season (July-December)	Dry Season (January-June)
Regulator Gate of Green Belt Levee	·Closed as a general rule · Open on the direction of the centre	·Controlled to keep the maintenance water level in klong
Regulator Gate of 2nd Barrier	·Closed as a general rule · Opened on the direction of the centre and the water level must be kept less than maintenance water level in klong	·Controlled to keep the maintenance water level in klong
Gate between each polder	· Closed as a general rule · Opened on the direction of the centre	·Opened as a general rule ·Controlled for klong flushing on the direction of the centre
Gate at pumping station	· Opened when the condition of outer water level is lower than inner water level · Closed on other conditions · Closed at night as a general rule	·Controlled to keep the maintenance water level in klong ·Controlled for klong flushing on the direction of the centre
Pumping Station	· Operated to keep the maintenance water level in klong polder	·Operated to keep the maintenance water level in klong ·Operated for klong flushing on the direction of the centre

CHAPTER 8 INSTITUTIONAL/ORGANIZATIONAL ASPECT

Following the previous studies of the Master Plan, this chapter contains the findings and recommendations on the institutional/organizational aspects. The detailed analysis and explanation are set out in Appendix H.

8.1 General

The recommendations for institutional strengthening are presented so that future works on the flood protection program and the Project in the Study Area could be best managed with efficiency and effectiveness.

The concept of institutional strengthening has two aspects, i.e.,

- institutional arrangements: framework in which relevent organizations are involved,
- individual organizations themselves

In reference to the first aspect, it is to be stressed in this report that the "National Flood Protection Board" and "Bangkok Flood Control Fund" proposed by the ADB report i.e. central managerial and coordinating organization is dealt as a given condition. Accordingly the analysis is limited in terms of allocation of roles and functions among organizations concerned for an efficient Project implementation (refer to Figs. 8.1 and 8.3).

Also it is to be emphasized with regard to the second aspect that the study aims to investigate and present necessary and sufficient solutions for an institutional and organizational framework with technical specifications. The numbers and the amount of the budget proposed hereinwith are the minimum requirements to implement the Project, being formulated on the basis of the expected workload and capability of the DDS officials involved.

8.2 Present Institutional Framework and its Shortcomings

At present time, there are involved almost fifty organizational units in flood control schemes in and around Metropolitan Bangkok, i.e.:

- The Cabinet
- The National Flood Protection Committee and its Sub-Committees
- Governments Department Agencies
- Local municipalities
- Bangkok Metropolitan Administration (BMA)
- BMA department agencies, DDS etc.
- Other agencies

(see Figs. 8.1 and 8.2)

With these big corps involved, multiplicity and overlapping of responsibilities of the different organizations in a feature of the current institutional aspect.

The National Flood Protection Committee (the Urgent Committee) came into the national flood protection scheme for the first time in October, 1983 and has benefited the national coordinating and monitoring functions of the existing organizations concerned. Though the Urgent Committee is particularly powerful and influential, its existence is of a temporary nature and these is no assurance of future full-time permanent activities.

BMA, a semi-autonomous governmental body which is responsible for flood control in the area, and the DDS, as its major executing hand in this regard, are also both suffering from a lack of autonomy, fragmented responsibilities, partial fulfillment of resources such as capital, personnel and facilities at its disposal, resulting in institutional inefficiency and mulfunction of the comprehensive anti-flood system/construction procedure (Fig. 8.4).

8.3 Recommendations for Organizational Aspects

In the Master Plan of '85, the following recommendations were made;

1) Structural measures at the project level:

A project implementing body with functions of,

- administration
- design
- construction and planning
- operation and maintenance

of the drainage facilities and emergency relief activities as well.

2) Non-structural measures at the regional and the Project level:

(1) Flood plain management

(2) Flood control operation centre

Based on these recommendations, the study team presents the following proposals in this report (See Fig. 8.3).

1) Institutional strengthening of DDS

2) Mobilization of the sub-committee on supporting activities

3) Establishing the flood control operation centre

8.3.1 Institutional Strengthening of DDS

The DDS is predominantly to become the main organization with required functions to implement the Project as the flood control drainage works are executed. While much assistance for significant construction and drainage facilities operation have been currently given by the Royal Irrigation Department (RID), the strategy of placing operation/maintenance responsibility on DDS requires a range of substantial institutional strengthening within its structure (Fig. 8.4).

In order to gear up the Department to the Projects additional scopes of work, it is proposed for the DDS to be prepared with the right sort of staffing and finance in the following:

1) Staffing in total 41 (including supporting staffs):
(refer to Fig. 8.5)

Project Function	Sub-Function (Section)	Personnel
1) Construction Phase: (1988–1991)		41
*Project Manager		(1)
*Administration		(13)
	- Head	1
	- General Administration	3
	- Planning	3
	- Finance	3
	- Personnel	3
*Design		(10)
	- Head	1
	- Design	5
	- Engineering	4
*Construction Supervision		(17)
	- Head	1
	- Electricity	3
	- Mechanics	3
	- Civil Engineering (I) (Pumping Station, Gates)	5
	- Civil Engineering (II) (Klongs, Barriers)	5
2) Operation and Maintenance Phase: (1989 Onwards)		14
*Project Manager		(1)
*Deputy Manager		(1)
*Administration		(3)
	- General Administration	2
	- Finance	1
*Operation and Maintenance		(9)
	- Operation	3
	- Maintenance	3
	- Repair and Construction	3

2) Budget Model

(1) Office expenses in total: 2.6 – 3.8 million Baht per year

(2) Personnel Budget: 2.1 – 3.1 million Baht per year

3) Scope of work

(1) Administration ..... General administrative matters and construcure contract finance, budget disbursement, external relations, personnel policy and so forth.

(2) Design ..... Engineering design and specifications, hydraulic analysis and supervision of all design works relating to the construction works.

(3) Construction ..... Supervising all works related to construction, installation and commissioning of all the relevant machines, equipments, and plants.

(4) Operation and Maintenance .. Manage all the works regarding operation (bringing facilities into action at appropriate time) and maintenance (to ascertain the functional capabilities of the facilities at all times and to minimise deterioration.) including repairs (to put the accidental deterioration of facilities into order), and additional construction of facilities.
Preparation of maintenance and repair contract documents.

The above list are the minimum number to be engaged in the project implementation at each phase. Accordingly, it does not necessarily imply that the same persons are to be appointed at different phases of the project.

The setting up of the new branch office such as the Eastern Suburbs Drainage Office proposed in the Master Plan is excluded in this report mainly due to high administrative cost.

8.3.2 Mobilization of the Sub-Committee on Supporting Activities

While the hard-ware projects (pumping stations, klongs, gates, etc.) have proceeded in and around the Bangkok downtown area, urban planning, and non-structural measures such as;

- Land use planning with respect to drainage control
- Rainwater retention areal study
- Building codes for anti-flood construction
- Guidelines for flood plain management

also should be promoted.

Reflecting those jobs which have been done so far by the sub-committee on project designation and its secretariat, the sub-committee in charge of non-structural measures is also to be assisted by its own secretariat with the following staff and functions:

1) 5 Secretariat staff (including supporting staff)

(1)	Managerial Officer (1)	Director General or Deputy Director General of DDS could be concurrent this position.
(2)	Engineer (1)	Management, planning, design, co-ordination between the organizations concerned, supervising flood plain management program.
(3)	Draftsman, Secretary (3)	Assisting superior officers in drafts, day-to-day routine office work etc.

2) Study on land use plan in view of flood protection for approval by the Committee and commitment to public relations activities:

- Monitor and evaluate all the projects implemented in the past and report to the Committee for future improvement
- Obtain advice from foreign consultants in various aspects of non-structural policy and measures implementation
- Coordination between Government agencies, State enterprises and possibly private organizations on matters concerning flood prevention measures and applications.

3) In performance of above-mentioned duties, the Sub-Committee on Supporting Activities may entrust the secretariat with the operation or submission of recommendations to the sub-committee for further proceedings.

4) Budget Model

(1)	Office maintenance:	0.44 – 0.53 million Baht per year
(2)	Personnel Direct Cost:	0.36 – 0.43 million Baht per year

8.3.3 Flood Control Operation Centre

To carry out the flood protection scheme, an effective and efficient anti-flood operation and information system, both in terms of soft and hardware, is required for the successful implementation of the Project. With emphasis on operation and information dissemination function, as the focal point of the scheme, the flood control operation centre is proposed to be set up under the sub-committee to:

1) centralize the drainage facilities (pumping stations, gates, klongs and so forth) control and management through the telemetering information network system.

2) increase reliability of collected data so that those drainage facilities can be operated at the time of flood.

3) increase and utilize flood-related information and data of meteorology, hydrology, flood damage, facility operation and others in taking advantage of its large data processing capacity.

4) preparation of the operation manual,

5) public relations activities, and

6) training the workers who are in charge of the drainage facilities operation.

The director of the centre should be appointed from the high officials of the DDS because of the centre.s attributes and close cooperation with the flood control centre in the DDS, at least during the initial stage of the centre.s operation.

Scope of work, personnel-budget required (See Fig. 8.6) would be:

1) Scope of Work:

(1) Administration ..... general administrative matters including finance, budget plan, personnel policy and so forth

(2) Planning ..... development of system engineering for the total project implementation, preparation of drainage facilities operation, data storage and employee training for operation of machinery and equipment at a time of flood.

(3) Information ..... flood information and operational orders to each drainage facility and stations as well as ordinary public relations

(4) Technical Research ..... development of system engineering for data storage, date processing, collection of data and analysis, forecasting.

(5) Monitoring ..... computer operation, system maintenance and inspection of the facilities in the area

2) Personnel and Budget model

(1) Personnel ..... Total 22 staff including the Director and supporting staffs

(2) Budget model ..... Total budget of the centre (except the cost of hardware and its maintenance, replacement cost) would be 1.5 – 2.0 million Baht.
Personnel cost would be 1.2 – 1.6 million Baht

The centre is also assigned to utilise its data for environmental conservation programs, that is, low water management and planning for klong water quality control etc. during the dry season. A highly sophisticated computerized telemetering information and operational system is required to strengthen its work efficiency and to widen in co-operation with other relevant organizations such as range of jobs RID, EGAT, and Meteorological Department.

The centre is tentatively to be the affiliated organization of the "Committee on Flood Protection for Bangkok and Vicinity". There are 3-sub-committee i.e. project designation, project supervision and public relation and supporting activities. The roles of sub-committees are as follows:

1) Project Designation: Responsible for technical matter
2) Project Supervision and Public Relation: Responsible for public relation
3) Supporting Activities: Responsible for non-structural measures

Therefore, the flood control operation centre is under control of Sub-committee of Project Designation and other two Sub-committees get information from the center.

8.4 Staffing Schedule

In accordance with the Project implementation schedule which is referred in chapter 5, 80 staffs in total including technicians and supporting staffs are to be required in compliance with assignments in Project implementation in the following;

1) 1987 (the year in which the detail design would take place)
In total 20 staffs within the range from the senior level officer to the clerk typist.

2) 1988 (the first year of construction)
38 in total are to be required for the project implementation.

3) 1989 (the second year of construction)
In total 18 staffs is required.

4) 1990 (the third year of construction)
4 staff is input into the project.

8.5 Consultants Technical Assistance

In the view of the consultancy services, technical assistance would be required in the following fields,

- institutional and managerial advisory services (mainly relating to institutional strengthening of the DDS and flood plain management)
- set up of the computerized operational, information centre (in compliance with the flood control operation centre)

The major fields of assistance to be covered are;

- Financial and managerial evaluation and planning
- Operation performance and program monitoring
- Financial reporting system
- Public Relations
- Anti-flood operations and information system
- System engineering of the computer both in terms of soft and hardware

CHAPTER 9 FINANCIAL STUDY

Finance is a base of project execution. This chapter describes financial aspect.

9.1 Required Cost and Its Allocation

9.1.1 Project Cost

The project cost required to implement the first stage program of the Eastern Suburban-Bangkok Flood Protection and Drainage Project (hereinafter called "the Project") is estimated at Baht 2,655 million at 1985 prices.
Out of it Baht 1,261 million or 47.5% are accounted for by foreign exchange component and the balance of Baht 1,394 million or 52.5% will be locally financed.

Regarding the local component of Baht 1,394 million, it is assumed that the central government and BMA will equally share the capital cost. Baht 697 million (26.25%) deriving from BMA coffer and another Baht 697 million (26.25%) being transferred from national coffer. Governmental participation is recommended because of the public nature of the flood control project and takes the form of a grant.

Annual capital payments by BMA are shown in Table 9.1.

Table 9.1 Project Cost at 1985 Price

(Baht million)

Item	Total	1987	1988	1989	1990	1991
Project Cost	2,655	46	825	825	805	154
F/C	1,261	23	450	353	372	63
L/C	1,394	23	375	472	433	91
50% of L/C	697	11	188	236	217	45

Note: F/C = Foreign Component, L/C = Local Component

The lending terms on foreign loans are assumed to be soft: the annual interest rate of 3.5% and the repayment period of 30 years with the grace period of 10 years. The rate is much lower than the prevailing opportunity cost of capital at 16% and interest payments works out at Baht 1,078 million at 1985 prices, which is by 15% less than the amount of the loan. The average annual amount of repayment over 34 years is Baht 32 million.

9.1.2 Operation, Maintenance and Replacement Cost

To operate and maintain the Project, Baht 42 million will be required annually. In addition the replacement costs of flood control equipment are assumed to be Baht 129 million every 15 years, at 1985 prices.

9.2 Annual Costs for BMA

Supposing the prices increase for both foreign and local components by 5% annually, Table 9.1 will be converted to Table 9.2.

Table 9.2 Project Cost at Current Prices

(Baht million)

Item	Total	1987	1988	1989	1990	1991
Project Cost	3,242	51	955	1,003	1,027	206
F/C	1,534	25	521	429	475	84
L/C	1,708	26	434	574	552	122
50% of L/C	854	13	217	287	276	61

Under the Table 9.1 conditions the annual costs over the entire repayment period will be as shown in Table 9.3 and Fig. 9.1. In the peak year of 1990 Baht 290 million at 1985 prices will be required. At the end of the repayment period of 34 years BMA will have paid the cumulative cost of Baht 3,351 million, of which Baht 697 million (20.8%), Baht 1,078 million (32.2%) and Baht 1,576 million (47.0%) account for capital, repayment and O/M/R costs respectively.

Table 9.3 Annual Costs for Capital, Repayment and O/M/R

(Baht Million at 1985 prices)

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
CPTL	11.0	188.0	236.0	217.0	45.0	0.0	0.0	0.0	0.0	0.0
RP.F	0.8	16.5	28.1	39.8	40.1	38.2	36.4	34.6	33.0	31.4
O/M/R	0.0	6.7	19.8	33.0	40.9	42.0	42.0	42.0	42.0	42.0
TTL	11.8	211.2	283.9	289.8	126.0	80.2	78.3	76.6	75.0	73.4
Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
CPTL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RP.F	30.6	42.9	51.3	59.4	57.4	53.4	49.8	46.4	43.1	40.1
O/M/R	42.0	42.0	42.0	42.0	42.0	42.0	171.0	42.0	42.0	42.0
TTL	72.6	84.9	93.2	101.4	99.3	95.4	220.8	88.3	85.1	82.1
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CPTL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RP.F	37.3	34.6	32.2	29.8	27.7	25.6	23.7	21.9	20.3	18.7
O/M/R	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
TTL	79.3	76.6	74.2	71.8	69.7	67.6	65.7	63.9	62.3	60.7
Year	2017	2018	2019	2020						
CPTL	0.0	0.0	0.0	0.0						
RP.F	17.0	10.4	5.5	0.8						
O/M/R	42.0	171.0	42.0	42.0						
TTL	59.0	181.4	47.5	42.8						

NOTE: CPTL=capital cost; RP.F=repayment cost on foreign loan; TTL=total

9.3 Comparative Position of Project

The cost of infrastructure projects to be self-financed by BMA during the 6th Five Year Plan period is estimated at Baht 3,954 million.

Year-wise, sector-wise breakdown of Baht 3,954 million is shown in Table 9.4 and Fig. 9.2. In forecasting capital expenditure of BMA, it is assumed that the expenditure will be 30% of the total forecast budget of BMA. Appropriation to infrastructure projects during the 6th Five Year Plan period occupies 29.2% of the projected capital expenditure during the same period. Out of Baht 3,954 million flood control projects account for Baht 1,602 million or 40.5%. Out of Baht 1,602 million the Project occupies Baht 697 million or 43.5% (5.1% of capital expenditure). In the peak year of 1989 BMA will spend Baht 236 million for the Project, which corresponds to 8.8% of the projected capital expenditure in the same year.

Table 9.4 BMA Expenditure for Infrastructure Projects in 6th Five-Year Plan

(Baht million)

No.	Item	Code	1983	1984	1985	1986	Total
1.	Flood Protection						
		(B)	395	467	347	352	1,561
2.	Land Use and Traffic		1,062	1,043	769	427	3,301
3.	Total (1.+2.)	(C)	1,457	1,510	1,116	779	4,862
4.	Capital Expenditure of BMA	(D)	2,406	2,492	1,974	1,555	8,427
5.	(B)/(D)		16.4%	18.7%	17.6%	22.6%	18.5%
6.	(C)/(D)		60.6%	60.6%	56.5%	50.1%	57.7%

No.	Item	Code	6TH FIVE YEAR PLAN PERIOD 1987	1988	1989	1990	1991	Total
1.	Flood Control							
	1) City Core Phase I		176	174	62	15	-	427
	2) City Core Phase II		-	-	-	-	18	18
	3) Eastern Suburban Phase I	(A)	11	188	236	217	45	697
	4) Others		44	28	41	162	185	460
	Sub-Total	(B)	231	390	339	394	248	1,602
2.	Transportation		426	497	455	364	258	2,000
3.	Housing		71	71	70	70	70	352
4.	Total (1.+2.+3.)	(C)	728	958	864	828	576	3,954
5.	Capital Expenditure of BMA	(D)	2,217	2,439	2,683	2,951	3,246	13,536
6.	(A)/(D)		0.5%	7.7%	8.8%	7.4%	1.4%	5.1%
7.	(B)/(D)		10.4%	16.0%	12.6%	13.4%	7.6%	11.8%
8.	(C)/(D)		32.8%	39.3%	32.2%	28.1%	17.7%	29.2%

Note: Up to 1986=At current prices; From 1987=At 1985 prices

Source: Up to 1986=BMA Document; From 1987="BMR Study", Interim Report & JICA Estimation

9.4 Estimated Average Annual Damage and Loss per Capita

In average 495 Baht has been estimated as an annual damage and loss per capita in the area, at 1985 price level, subject to the following assumptions:

- Fourty years of project life
- 2.3 million of population in the year of 2005
- risk analysis in the context of one, two, five, ten and twenty year return period

As for project cost per capita, 54.5 Baht at the constant price level of 1985 cost to every person annually to implement the Project.

9.4 Analysis and Estimation of BMA Revenue

In the preceding section the relative position of the Project to the total number of infrastructure projects as well as the total capital expenditure budget of BMA has been established. In this section specific sections of the BMA budget are quantitatively analyzed. In Table 9.5, forecast BMA revenue increase is shown. It ranges from Baht 700 to 1,500 million over the period 1987 to 2000.

Table 9.5 Two Components of BMA Revenue Increase

(Baht million at 1985 prices)

Year	1987	1988	1989	1990	1991	1992	1993
N.IGR	388	412	436	463	490	520	551
MBIZ	302	320	339	360	381	404	428
TTL	690	732	775	823	871	924	979
BMA	7,390	8,120	8,942	9,836	10,820	11,902	13,092

1994	1995	1996	1997	1998	1999	2000
584	619	656	696	737	782	828
454	482	510	541	573	611	644
1,038	1,101	1,166	1,237	1,310	1,393	1,472
14,401	15,841	17,425	19,168	21,085	23,193	25,512

Note: N.IGR=natural increase of BMA revenue
MBIZ =mobilization of existing local taxes
TTL =total
BMA =total revenue of BMA (including other revenue increase)

9.5.1 Analysis of BMA Revenue Budget

Total amount of BMA revenue budget in 1985 is Baht 6,006 million as shown in Table 9.6. Out of it, 79.3% is fixed revenue and the remaining 20.7% is government subsidy. Tax revenue occupies 90.2% of the fixed revenue and therefore, it occupies 71.5% of the total revenue budget.

Tax revenue is composed of BMA local tax and shared tax, and their respective shares are 19.2% and 80.8%. Their respective shares in the total revenue budget are 13.7% and 57.8%. Shared tax which is primarily national tax raised by the central government and transferred in part to BMA comprizes a major part of tax revenue and total revenue budget.

As shown in Table 9.7 BMA local tax is virtually composed of two taxes, namely house and buildings tax and development tax. Also, shared tax is mainly consisted of two taxes, namely business tax and vehicle tax. Business tax is a major source of tax revenue occupying 63.4% of shared tax and 51.2% of total tax revenue in 1985. Potential sources of funds for capital raising and cost recovery for the Project can be found among the above four taxes.

9.5.2 Estimation of BMA Revenue Budget

It is said that the two local taxes are at present not efficiently or effectively practised. To rectify the situation, reinforcement of tax base centreing on tax mapping and creation of tax rolls is in progress. It is expected that it will be completed in these two years, and revenue from these sources will increase by 30% at least. The GRDP of Bangkok Metropolis has been assumed to grow at the average annual rate of 6%. Then, the natural increase rate of BMA tax and other revenues can be assumed to be the same. Based on these Table 9.5 has been prepared.

Table 9.6 BMA Annual Budget (1983 – 1985) – Revenue –

(Baht million; %)

Item	1983		1984		1985	
1. Tax Revenue	3,266.00	69.8	3,732.00	58.8	4,294.10	71.5
(BMA Local Tax)	(656.50)	(14.0)	(721.50)	(11.4)	(824.50)	(13.7)
(Shared Taxes)	(2,609.50)	(59.8)	(3,010.50)	(47.4)	(3,469.60)	(57.8)
2. Fee for Licencing & Permits	100.17	2.1	105.93	1.7	119.53	2.0
3. BMA Property Revenue	183.31	3.9	224.69	3.5	255.65	4.3
4. Business Revenue	8.90	0.2	10.30	0.2	8.80	0.1
5. Others	197.25	4.2	84.42	1.3	84.88	1.4
Sub-Total	3,755.63	80.3	4,157.34	65.5	4,762.96	79.3
6. Central Government Subsidy	921.20	19.7	2,189.13	34.5	1,243.07	20.7
Total	4,676.83	100.0	6,346.47	100.0	6,006.03	100.0

Source: BMA Document

Table 9.7 BMA Annual Budget (1983 – 1985) -- Breakdown of Tax Revenue --

(Baht million; %)

Item	1983		1984		1985	
1. BMA Local Tax	656.50	20.1	721.50	19.3	824.50	19.2
(House and Buildings Tax)	(585.85)	(17.9)	(560.00)	(15.0)	(660.00)	(15.4)
(Development Tax)	(103.83)	(3.2)	(110.00)	(2.9)	(110.00)	(2.6)
(Other Taxes)	(33.18)	(1.0)	(51.50)	(1.4)	(54.50)	(1.2)
2. Shared Tax	2,609.50	79.9	3,010.50	80.7	3,469.60	80.8
(Business Tax)	(1,454.81)	(44.5)	(1,925.00)	(51.6)	(2,200.00)	(51.2)
(Vehicle Tax)	(887.81)	(27.2)	(866.00)	(23.2)	(1,026.10)	(23.9)
(Other Taxes)	(266.88)	(8.2)	(219.50)	(5.9)	(243.50)	(5.7)
Total	3,266.00	(100.0)	3,732.00	(100.0)	4,294.10	(100.0)

Source: BMA Document

9.6 Capital Raising and Cost Recovery

To meet capital, repayment and O/M costs over the 5 year implementation period 1987 to 1991, it is proposed that one fourth of the revenues to be generated by natural increase and the mobilization of existing local taxes will be appropriated. To recover repayment and O/M costs from 1992 onwards, one sixth (1992 to 2006) and one ninth (2007 to 2020) of the revenue by the mobilization of existing local taxes will be allotted to the Project. The result is as shown in Table 9.8 and Fig. 9.3.

Cumulative amount of capital, repayment and O/M/R costs over the repayment period for 34 years is estimated at Baht 3,351 million. It has been established that they can be fully met by using some of the expected annual increase in BMA revenue.

Up to the end of the 6th Five-Year Plan period flood control projects will be publicly financed as envisaged in the "BMR Study" report by the World Bank in light of the public nature of the projects in which beneficiaries cannot be specified in a clear-cut manner. (After a project is implemented beneficiaries can witness actual benefits of the project, and then it will be reasonable to levy taxes on them.) After it, however, due to a growing magnitude of the expected spending on flood control projects introduction of new taxes or the like on the beneficiaries will beceme necessary. Thus, to finance the Eastern Suburban Project Phase II and III it is recommended that a development surcharge and the Urban Development Tax will be initiated as described in the Master Plan Study report.

Table 9.8 Capital Raising & Cost Recovery Schedule

(at 1985 prices) (Baht million)

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
RQRD	11.8	211.2	283.9	289.9	126.0	80.2	78.3	76.6	75.0	73.4
N.ICR	97.1	102.9	109.1	115.7	122.6	0.0	0.0	0.0	0.0	0.0
MBLZ	75.5	80.0	84.8	89.9	95.3	67.4	71.4	75.7	80.2	85.0
TTL	172.6	183.0	193.3	205.6	217.9	67.4	71.4	75.7	80.2	85.0
BLNC	+160.8	-28.2	-89.9	-84.2	+91.9	-12.8	-6.8	-0.9	+5.2	+11.6
CM BLNC	+160.8	+132.6	+42.6	-41.5	+50.3	+37.5	+30.6	+29.7	+34.9	+46.5

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
RQRD	72.6	84.9	93.2	101.4	99.3	95.4	220.8	88.3	85.1	82.1
N.ICR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBLZ	90.1	95.6	101.3	107.4	107.4	107.4	107.4	107.4	107.4	107.4
TTL	90.1	95.6	101.3	107.4	107.4	107.4	107.4	107.4	107.4	107.4
BLNC	+17.5	+10.7	+8.1	+6.0	+8.1	+12.0	-113.4	+19.1	+22.3	+25.3
CM BLNC	+64.1	+74.7	+82.8	+88.8	+96.9	+108.8	-4.5	+14.5	+36.7	+62.0

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RQRD	79.3	76.6	74.2	71.8	69.7	67.6	65.7	63.9	62.3	60.7
N.ICR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBLZ	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6
TTL	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6
BLNC	-7.7	-5.0	-2.6	-0.2	+1.9	+4.0	+5.9	+7.7	+9.3	+10.9
CM BLNC	+54.3	+49.3	+46.6	+46.4	+48.3	+52.3	+58.1	+65.8	+75.1	+86.0

Year	2017	2018	2019	2020
RQRD	59.0	181.4	47.5	42.8
N.ICR	0.0	0.0	0.0	0.0
MBLZ	71.6	71.6	71.6	71.6
TTL	71.6	71.6	71.6	71.6
BLNC	+12.6	-109.8	+24.1	+28.8
CM BLNC	+98.5	-11.2	+12.8	+41.6

NOTE: RQRD=required costs; N.ICR=natural increase of BMA revenue; MBLZ=revenue to be newly generated by mobilization of existing local taxes; TTL=total; BLNC=balance (=TTL-RQRD); CM BLNC=cumulative balance

9.7 Advisability of Project Implementation

The final judgement on whether the Project should be implemented or not is left to the economic evaluation. However, the advantages of implementing the Project will be treated here from the financial standpoint.

As seen already, out of the project cost of Baht 2,655 million Baht 1,261 million (47.5%) will be financed by foreign loans. The lending terms of the loans are assumed to be soft as typified by the annual interest rate of 3.5%, which is not only by far less than the opportunity cost of capital (16%), but also less than the forecast rate of price rise (5%).
The implications are that if the Project yields a return on the foreign component below the opportunity cost of capital it is acceptable and also that the amount of repayment (Baht 1,078 million) will be in real terms less than the amount of the loans.

Regarding the local component for both capital cost (Baht 697 million) and O/M cost (annually Baht 42 million) to be self-financed by BMA, it can be stated that since the growth of BMA tax revenues will continue to be robust in the future, the yearly expenditure on the project will become less burdensome.
These facts provide solid ground for supporting the early realization of the Project.

CHAPTER 10. ECONOMIC EVALUATION

Economic analysis is a key study for the project evaluation. In this chapter, the economic evaluation is carried out from the standpoint of national economy.

10.1 Economic Cost

For economic analysis of the Project, project cost is converted into economic cost. To do this, the portions of transfer payment (tax, duty and subsidy) must be exempted from the project cost. The total amount of transfer payment comes to Baht 159 million out of the project cost of Baht 2,655 million. Therefore, the economic cost of project implementation is Baht 2,496 million. As a result the conversion factor for the Project works out at 94.0%.

The annual operation and maintenance cost amounts to Baht 42 million. During the project life, some items of equipment will become life expired, and for such items the need of replacement arises. These are pumps, gates and electronic and other precise machines of the Flood Control Operation Centre. These, costing Baht 129 million in total, are assumed to be replaced every 15 years.

10.2 Economic Benefits

The economic benefit of flood protection and drainage derives from the reduced damage resulting from flood protection measures. The damage includes physical damages to houses, household effects, commercial/industrial establishments and public facilities, interruption/stoppage of commercial/industrial and social activities, prevention cost and medical care.

The damage is estimated under the concept of "Annual Average Flood Damage". The definition is as follows;

$$\bar{D} = \int_{Fo}^{\infty} Pr(F) \cdot D(F, Fo, S, Ls) \cdot dF$$

where

D	: Flood damage
$\bar{D}$	: Average annual flood damage
F	: Rainfall
Fo	: Capacity of flood control facilities
S	: Damage potential, e.g., population
Ls	: Land subsidence
Pr(F)	: Probability density function of F

The annual economic benefit is estimated by subtracting the amount of annual flood damage for the "with project" case from the amount of annual flood damage for the "without project" case. The result of the estimation is as follows:

(1) The Year, 1985 : Baht 254 million

(2) The Year, 2000 : Baht 632 million

10.3 Estimated Annual Economic Cost and Benefit per Capita

Economic cost and benefit (present worth of the cost and benefit discounted at the rate of 16% of the opportunity cost of capital) are as 19 and 24 Baht respectively for each person under the assumptions as follows:

* Fourty years of project life
* Population estimate as 2.3 million in the year of 2005 in the region
* Benefit = (Annual flood damage "without" the Project) – (Annual flood damage "with" the Project) from the year of 1987 through 2020.

10.4 Economic Justification

10.4.1 General

There are three indicates to evaluate the economic feasibility of a project. They are net present worth (NPW), benefit cost ratio (B/C) and economic internal rate of return (EIRR). They are mutually related to each other.

To get NPW and B/C of the Project, the annual benefits and costs are discounted by the prevailing opportunity cost of capital (around 16%) throughout the project life of 40 years. NPW is the difference between cumulative benefit and cumulative cost discounted in that way, while B/C is the ratio between them.

At the same time, the discount rate equalizing cumulative benefit and cumulative cost is computed to determine EIRR.

If a project is to be economically feasible, NPW must be more than 0, or B/C must be more than 1 or EIRR must be more than the opportunity cost of capital.

10.4.2 Economic Evaluation

Economic benefit and cost flow throughout the project life of 40 years is presented in Table 10.2 and the result of economic analysis is shown in Table 10.1. The value of NPW is above 0 and the value of B/C is 24% greater than unity. The value of EIRR is 4.2 points greater than the opportunity cost of capital. These economic indices give a safe economic viability to the Project.

The values of NPW, B/C and EIRR for the Master Plan Project are Baht 1,009 million, 1.5 and 26.5%, respectively. These are greater than the Master Plan Phase 1 despite the fact that Phase I is a priority project. This is because the Master Plan Project included the most effective pumping stations, gates and dykes which were constructed under the urgent measures policy.

As a result of the sensitivity analysis, even if benefit is assumed to be 10% less and at the same time the cost is assumed to be 10% more, the EIRR is 16.2%, exceeding the minimum requirement for economic feasibility.

Table 10.1 NPW, B/C and IRR

(Unit of NPW: Baht million)

Item	NPW	B/C
Value	425	1.24

COMPUTATION OF IRR

DF=discount factor; CM BNFT=cumulative benefit;
CM COST=cumulative cost; CM CSFL=cumulative
cash flow

(Baht million)

DF	CM BNFT	CM COST	CM CSFL
1	17,954	3,895	14,059
2	14,590	3,553	11,037
3	12,005	3,275	8,729
4	9,997	3,046	6,950
5	8,420	2,855	5,565
6	7,167	2,691	4,475
7	6,162	2,551	3,611
8	5,346	2,427	2,919
9	4,679	2,318	2,360
10	4,126	2,220	1,905
11	3,665	2,132	1,533
12	3,277	2,052	1,225
13	2,948	1,978	969
14	2,666	1,910	756
15	2,424	1,847	576
16	2,213	1,788	425
17	2,029	1,732	297
18	1,868	1,680	187
19	1,725	1,631	94
20	1,599	1,585	14
21	1,486	1,540	-53

IRR = 20.2

Table 10.2 Economic Benefit and Cost Flow (Discount Factor = 0%)

BNFIT=benefit; COST=cost; CSFL=cash flow (=BNFT-COST);
CM BNFT=cumulative benefit; CM COST=cumulative cost;
CM CSFL=cumulative cash flow

(Baht million)

Year	BNFT	COST	CSFL	CM BNFT	CM COST	CM CSFL
1987	0	39	-39	0	39	-39
1988	108	786	-678	108	825	-717
1989	226	795	-569	334	1,621	-1,286
1990	358	789	-430	693	2,410	-1,717
1991	405	185	219	1,098	2,596	-1,497
1992	430	42	388	1,529	2,638	-1,109
1993	455	42	413	1,984	2,680	-695
1994	481	42	439	2,465	2,722	-256
1995	506	42	464	2,972	2,764	207
1996	531	42	489	3,503	2,806	697
1997	556	42	514	4,060	2,848	1,212
1998	581	42	539	4,642	2,890	1,751
1999	607	42	565	5,249	2,932	2,317
2000	632	42	590	5,881	2,974	2,907
2001	632	42	590	6,514	3,016	3,497
2002	632	42	590	7,146	3,058	4,088
2003	632	171	461	7,778	3,229	4,549
2004	632	42	590	8,411	3,271	5,139
2005	632	42	590	9,043	3,313	5,730
2006	632	42	590	9,675	3,355	6,320
2007	632	42	590	10,308	3,397	6,910
2008	632	42	590	10,940	3,439	7,501
2009	632	42	590	11,572	3,481	8,091
2010	632	42	590	12,205	3,523	8,681
2011	632	42	590	12,837	3,565	9,272
2012	632	42	590	13,470	3,607	9,862
2013	632	42	590	14,102	3,649	10,452
2014	632	42	590	14,734	3,691	11,043
2015	632	42	590	15,367	3,733	11,633
2016	632	42	590	15,999	3,775	12,224
2017	632	42	590	16,631	3,817	12,814
2018	632	171	461	17,264	3,988	13,275
2019	632	42	590	17,896	4,030	13,866
2020	632	42	590	18,528	4,072	14,456
2021	632	42	590	19,161	4,114	15,046
2022	632	42	590	19,793	4,156	15,637
2023	632	42	590	20,425	4,198	16,227
2024	632	42	590	21,058	4,240	16,817
2025	632	42	590	21,690	4,282	17,408
2026	692	42	650	22,382	4,324	18,058

CHAPTER 11. JUSTIFICATION AND RECOMMENDATIONS

11.1 Justification

It is proved that the Project is economically feasible. That is to say, the Project is estimated to generate a benefit greater than the cost of project implementation and operation/maintenance during the project life of 40 years from the standpoint of the national economy.

There are various standpoints from which to judge the feasibility of the Project.

11.1.1 Technical and Financial Aspects

Technically speaking, there is no problem or difficulty for the implementation of the Project.

Financially, it has been made clear that about half the project cost of Baht 2,655 million will be financed by a soft external loan, and that Baht 697 million or about one fourth of the project cost is to be self-financed by BMA. This will take one twentieth of the projected BMA capital expenditure, and the annual cost including capital, O/M/R and repayments will be one fiftieth of the projected annual budget of BMA during the 5 year implementation period and less than one hundredth after implementation. In short, the Project is proved to be financially attractive, unburdensome and feasible.

11.1.2 Socio-Economic and Political Aspects

Socio-economically, the implementation of the Project will relieve the psychological burden or stress of the citizens, enhance the amenity of life and the aesthetics of the environment, induce population and industry into the area, raise the value of land and develop the economy.

Politically, these benefits will jointly work to enhance the trust and support of the people towards the authorities concerned.

11.1.3 Conclusion

In conclusion, the implementation of the Project is justified and, therefore, strongly recommended. Additionally, it is a natural right for modern citizens to expect the civic authorities to protect them from floods.

11.2 Recommendations

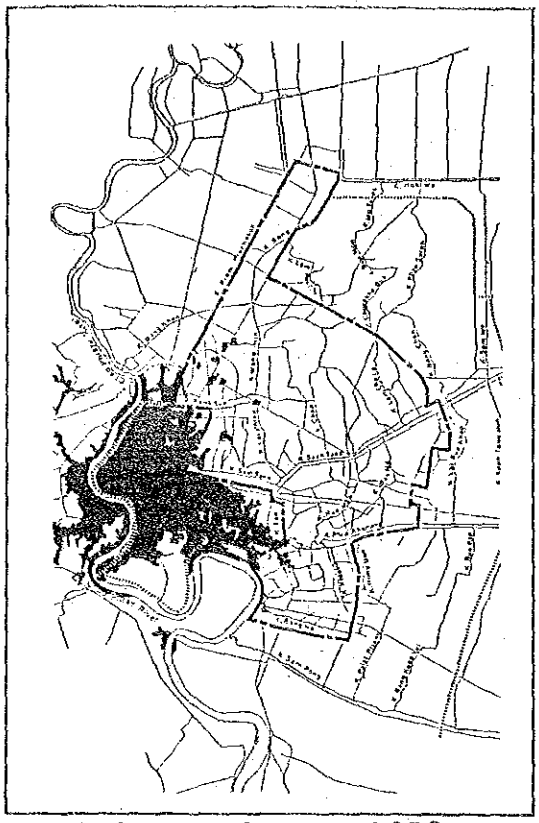
Preparatory works such as financial procurement and detailed design must be started as soon as possible to commence the Project in 1988. For example, foreign loans need at least two years after the negotiations between the Governments to become effective.

Similarly, DDS (executing agency) must be strengthened for the Project implementation and "Sub-Committee on Supporting Activities" be mobilized for flood plain management.

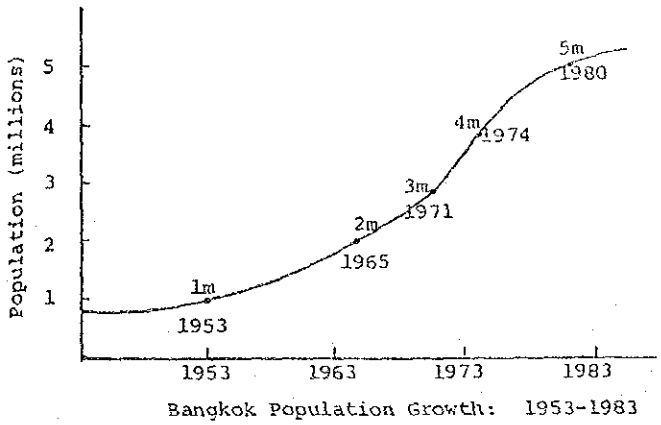
The terrain in the Study Area is very flat and, therefore, klongs and drains are gentle in slope, resulting in poor drainage. Hence these facilities are only effective when the facilities are operated efficiently and that large amounts of water are retained in the Area. For this, the flood control operation centre must be established and flood plain management conducted.

FIGURES

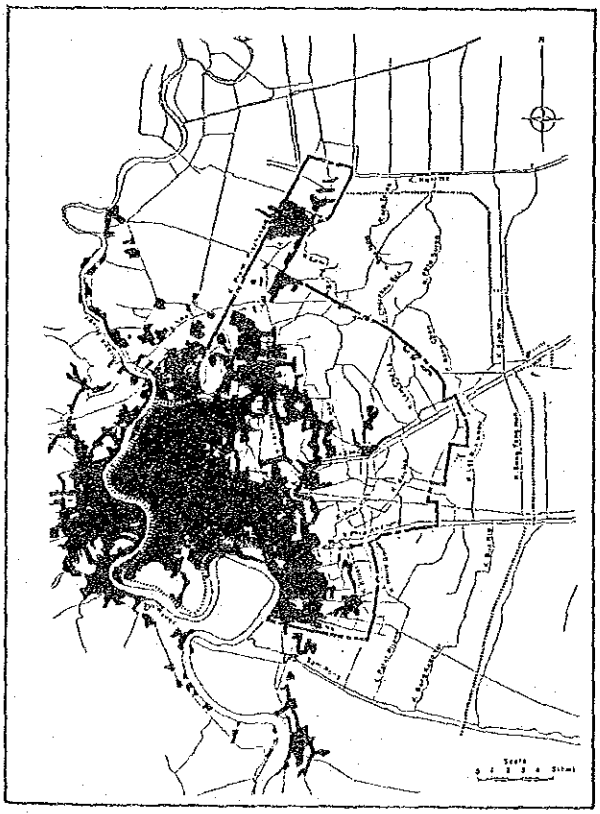
Chapter 2



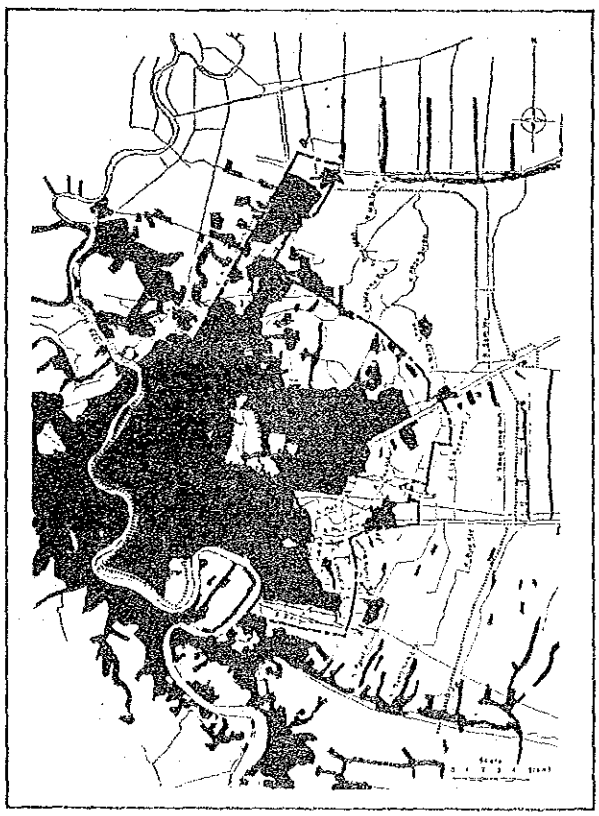
Urbanized Area 1958



Bangkok Population Growth: 1953-1983



1971

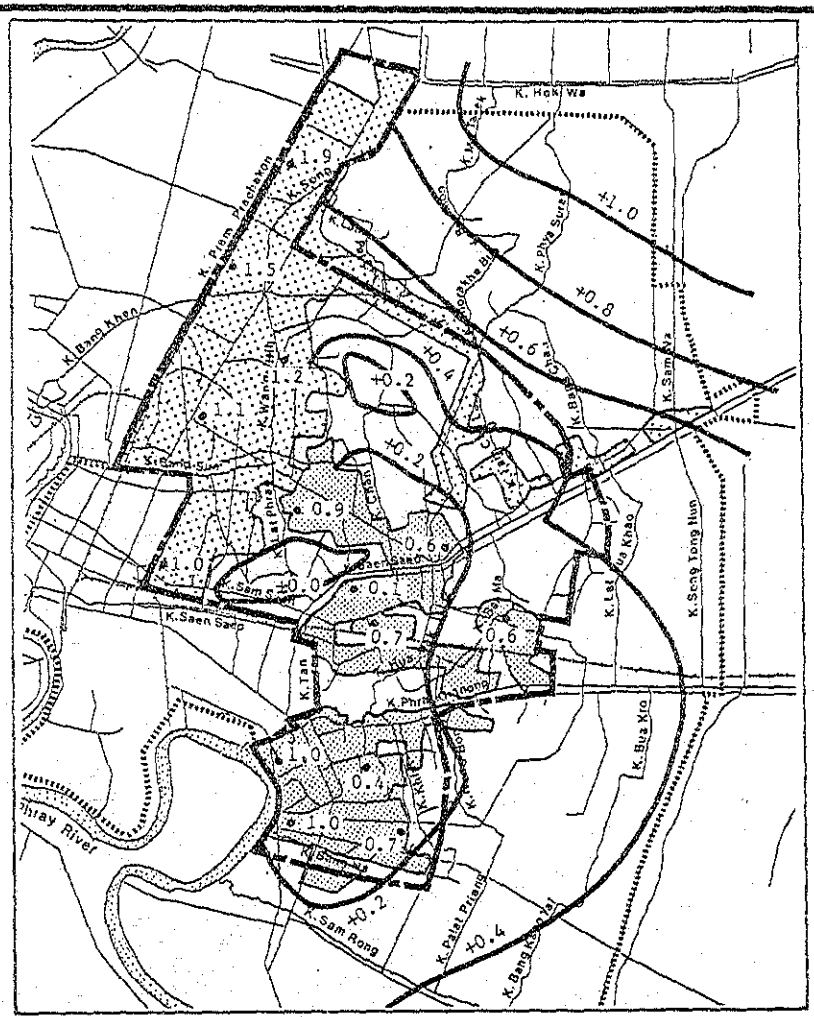


1984

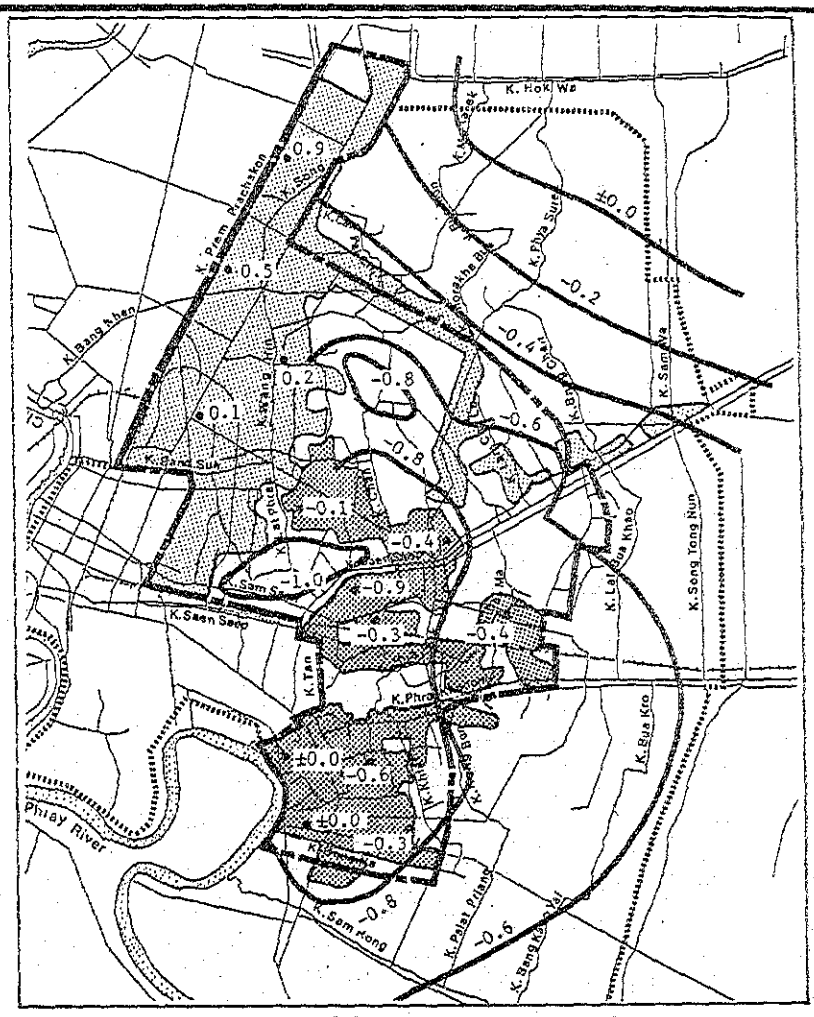
Fig. 2.1 PROGRESS OF URBANIZATION IN BANGKOK

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

JICA 2529B.E 1986A.D



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

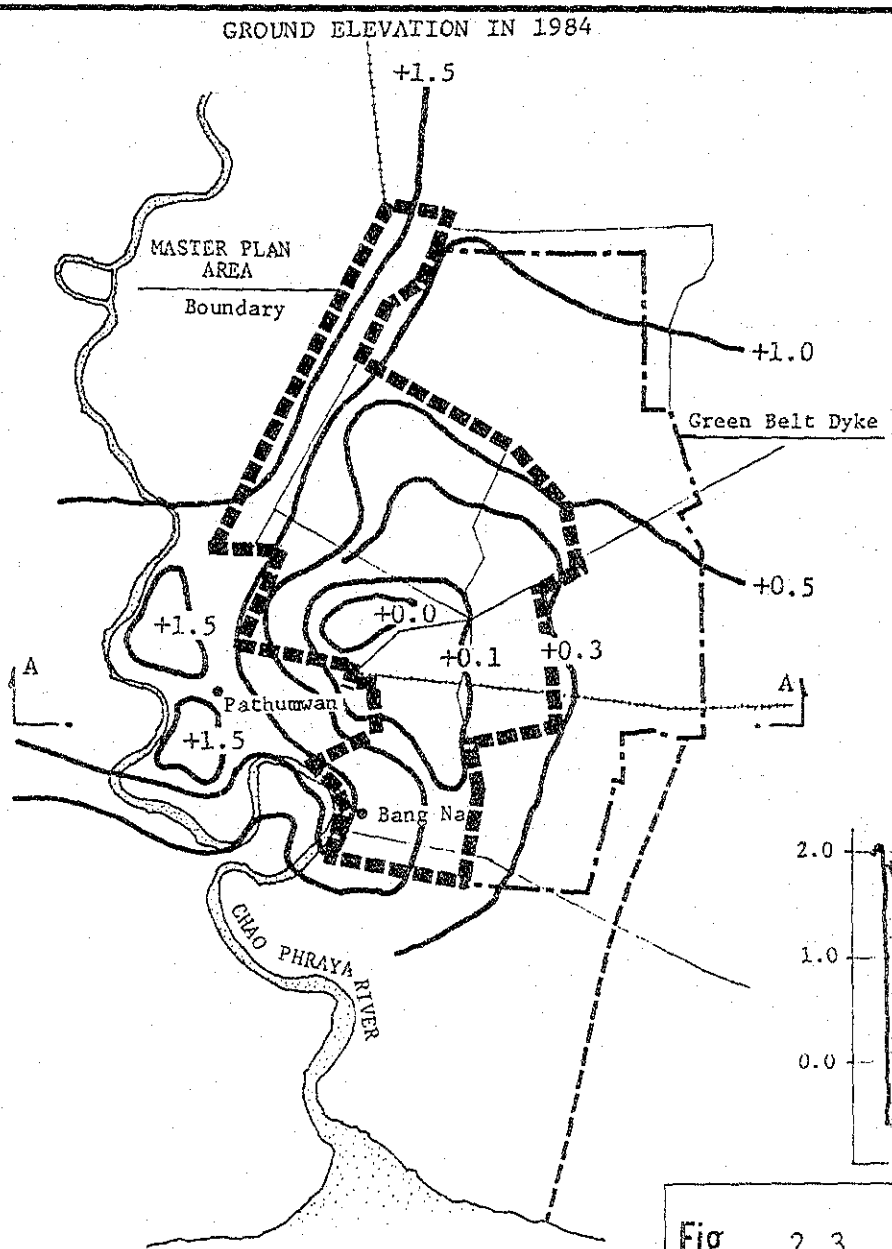
Unit; m MSL

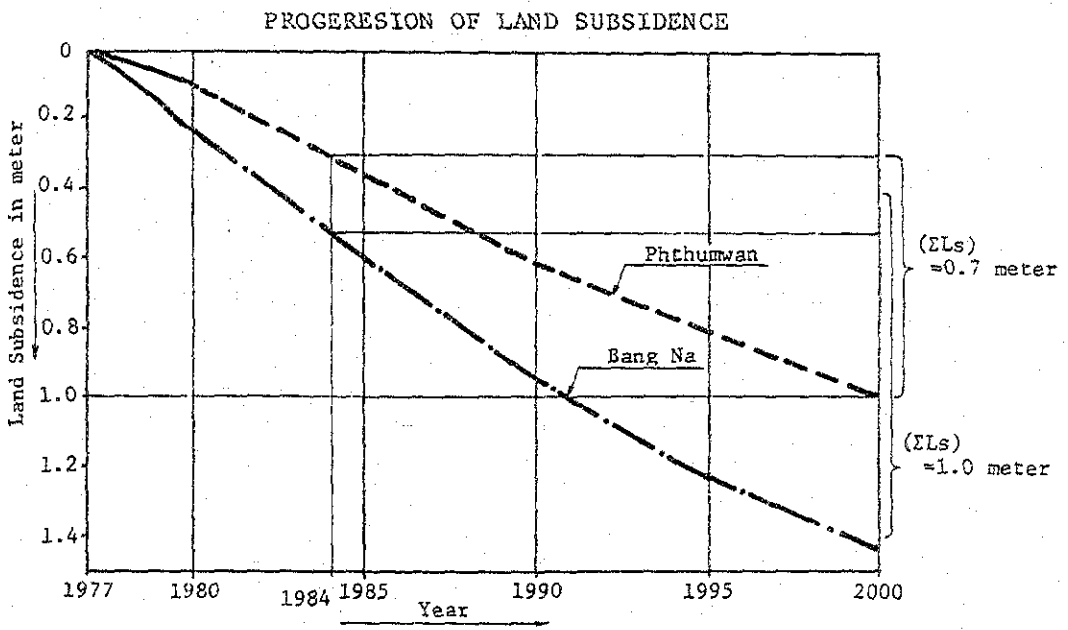
(Source; JICA Study Team)

Fig. 2.2 GROUND ELEVATION IN FEASIBILITY STUDY AREA

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

JICA 2529B.E 1986A.D





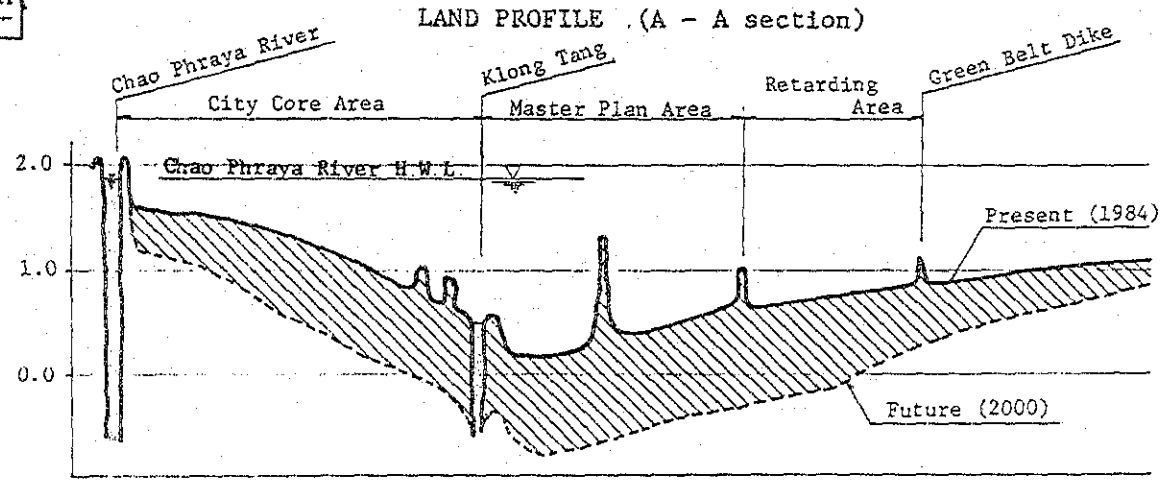
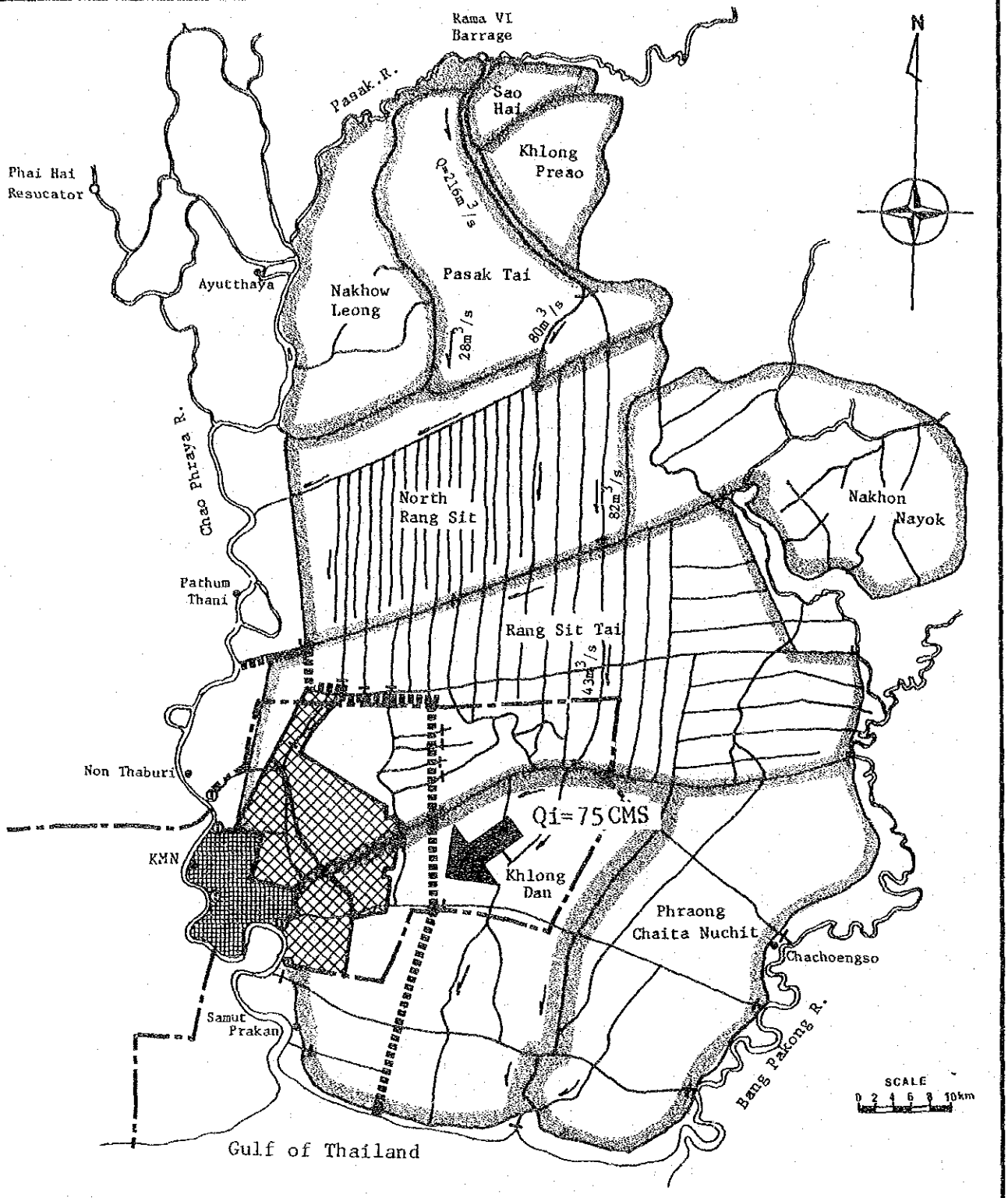


Fig. 2.3 PROGRESSION OF LAND SUBSIDENCE

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

JICA 2529B.E 1986A.D



: Irrigation Zone of RID

: Master Plan Area and Feasibility Study Area (JICA)

: City Core Area

: Green Belt Dyke

: Regulator Gate

: Main Pumping Station (Existing and Planned)

: BMA Boundary

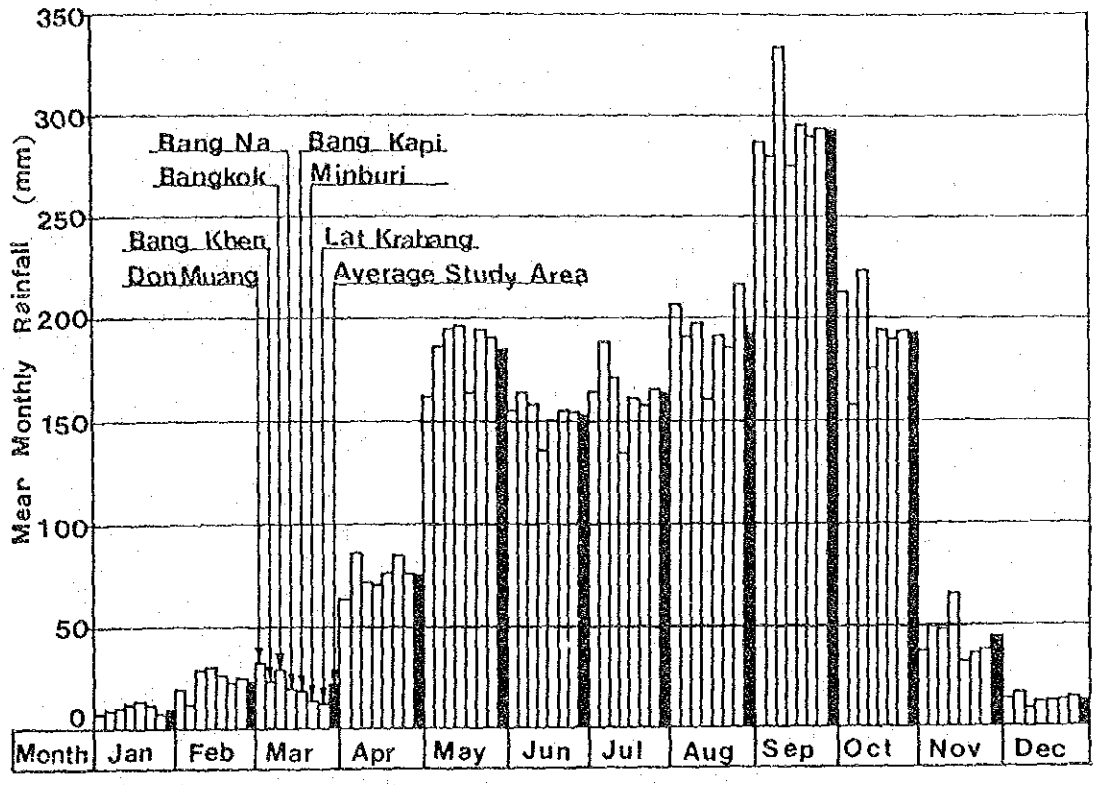
$80m^3/s$: Discharge of Irrigation

Qi: Inflow from Outer Area observed in 1983 by JICA Study Team

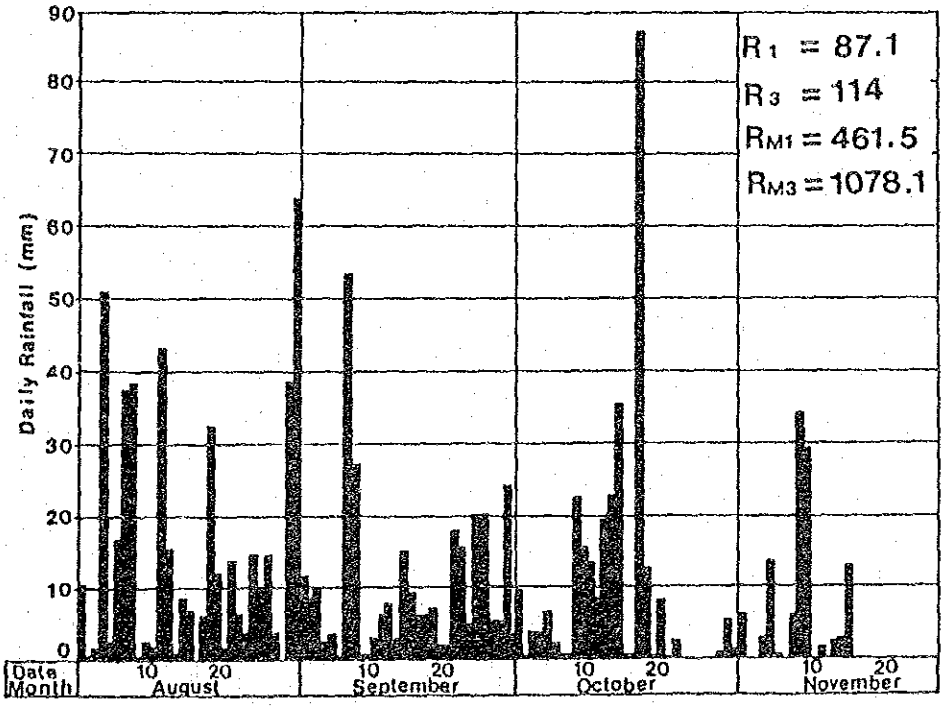
Fig. 2.4 KLONG NETWORK IN EAST BANK OF THE CHAO PHRAYA RIVER

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

JICA 2529B.E 1986A.D



AVERAGE POINT AND AREAL MONTHLY RAINFALL DURIND PAST 30 YEARS



AVERAGE AREAL DAILY RAINFALL IN FLOOD SEASON IN 1983

Legend

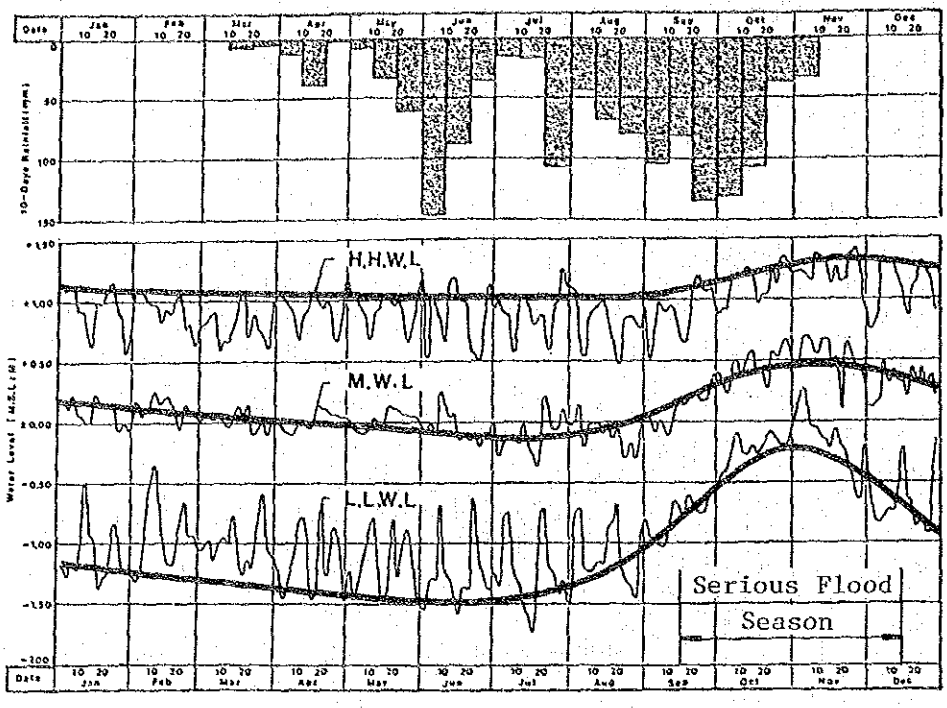
R_1 : Maximum Daily Rainfall (mm)
R_3 : Maximum 3-Day Rainfall (mm)
Rm_1 : Maximum Monthly Rainfall (mm)
Rm_3 : Maximum 3-Month Rainfall (mm)

Source :Meteolorogical Department

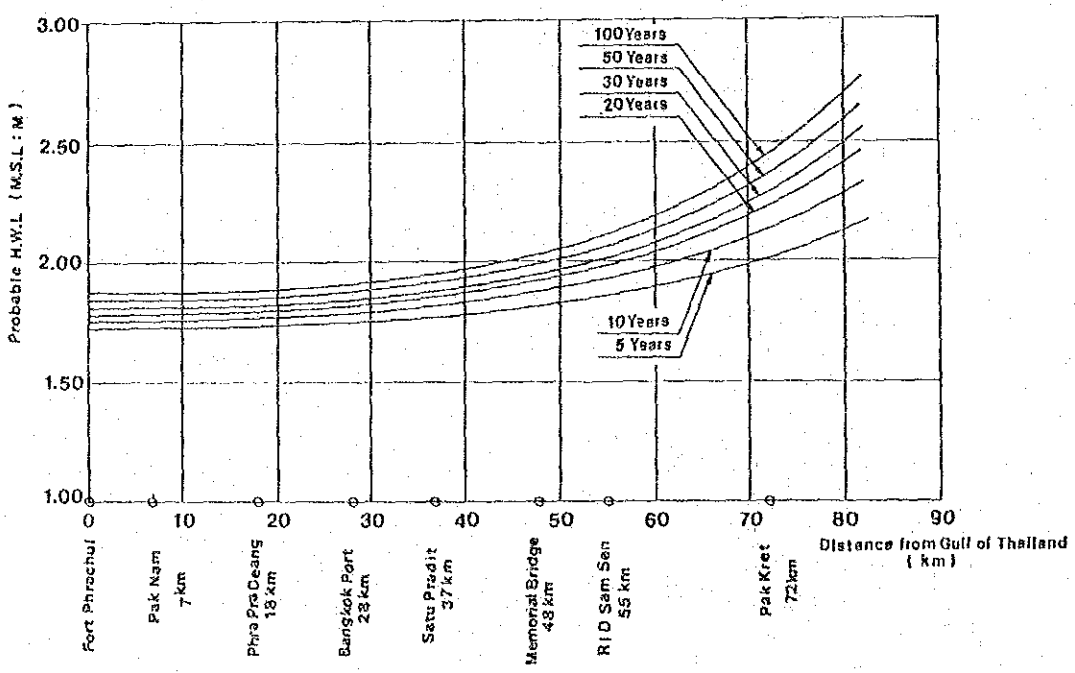
Fig. 2.5 MONTHLY AND AVERAGE AREAL DAILY RAINFALL IN THE STUDY AREA

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

JICA 2529B.E 1986A.D



SEASONAL CHANGES OF RAINFALL IN THE MASTER PLAN AREA AND WATER LEVEL AT BANGKOK PORT IN 1980



PROBABLE FLOOD WATER LEVEL OF CHAO PHRAYA RIVER

Source : Meteorological Department and Port Authority of Thailand

Fig. 2.6	WATER LEVEL OF CHAO PHRAYA RIVER

Chapter 3

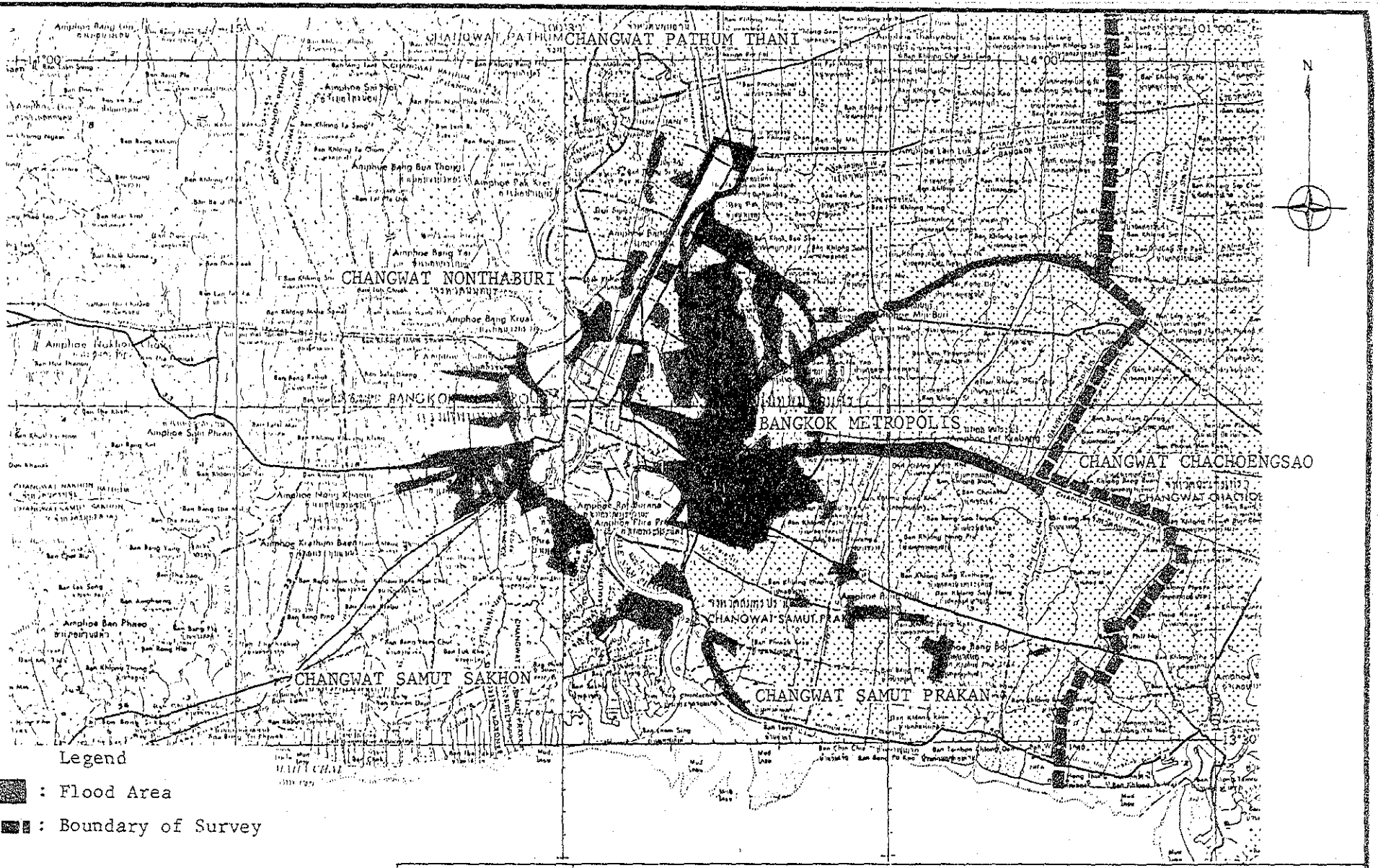
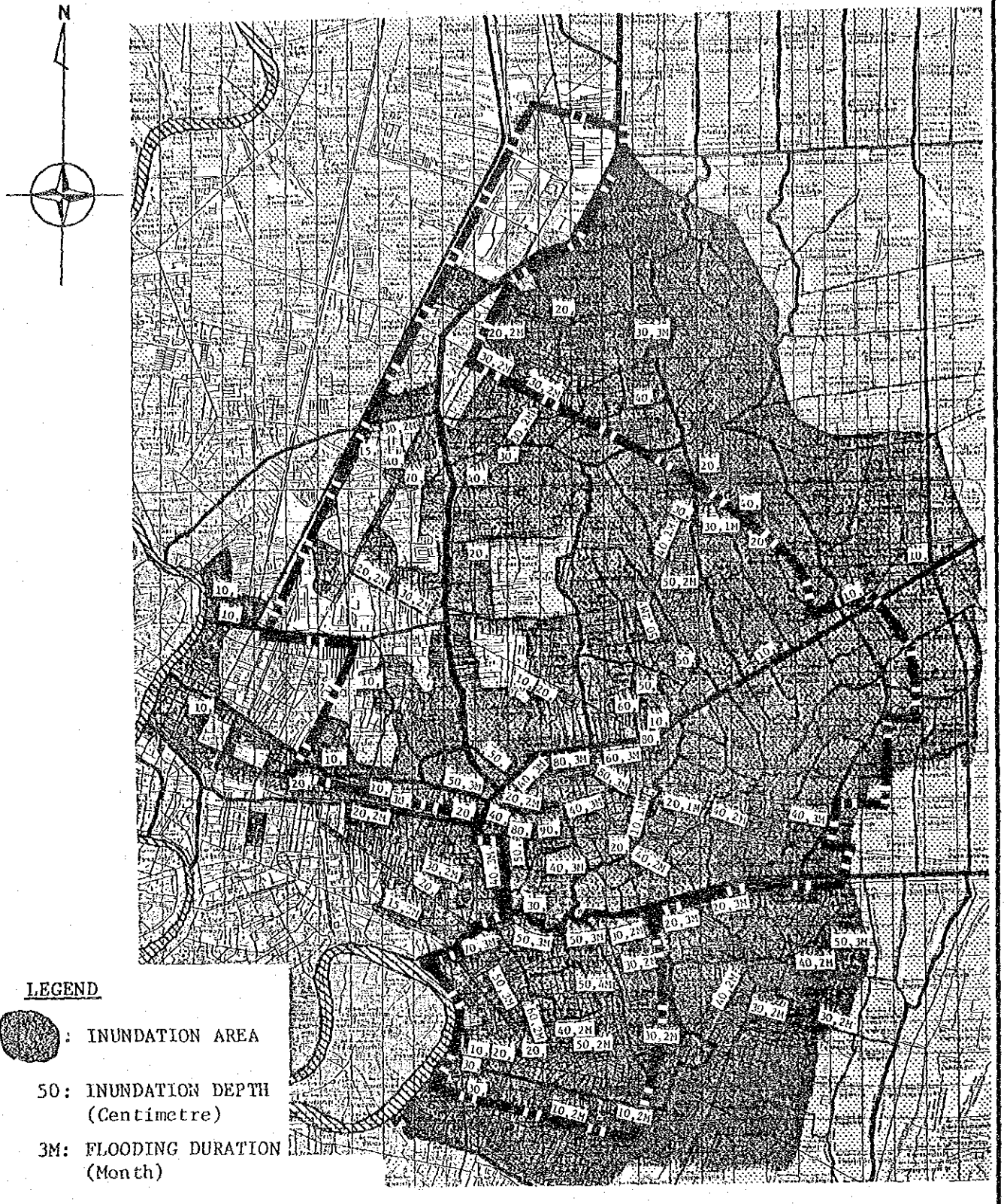


Fig. 3.1 FLOOD AREA IN GREATER BANGKOK IN 1983

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



LEGEND

: INUNDATION AREA

50: INUNDATION DEPTH (Centimetre)

3M: FLOODING DURATION (Month)

Note:
This map was prepared based on the ① hearing from residents in the flood damaged area and ② estimation from definite flood marks.

Fig. 3.2 FLOOD AREA, DEPTH AND DURATION IN STUDY AREA (1983)

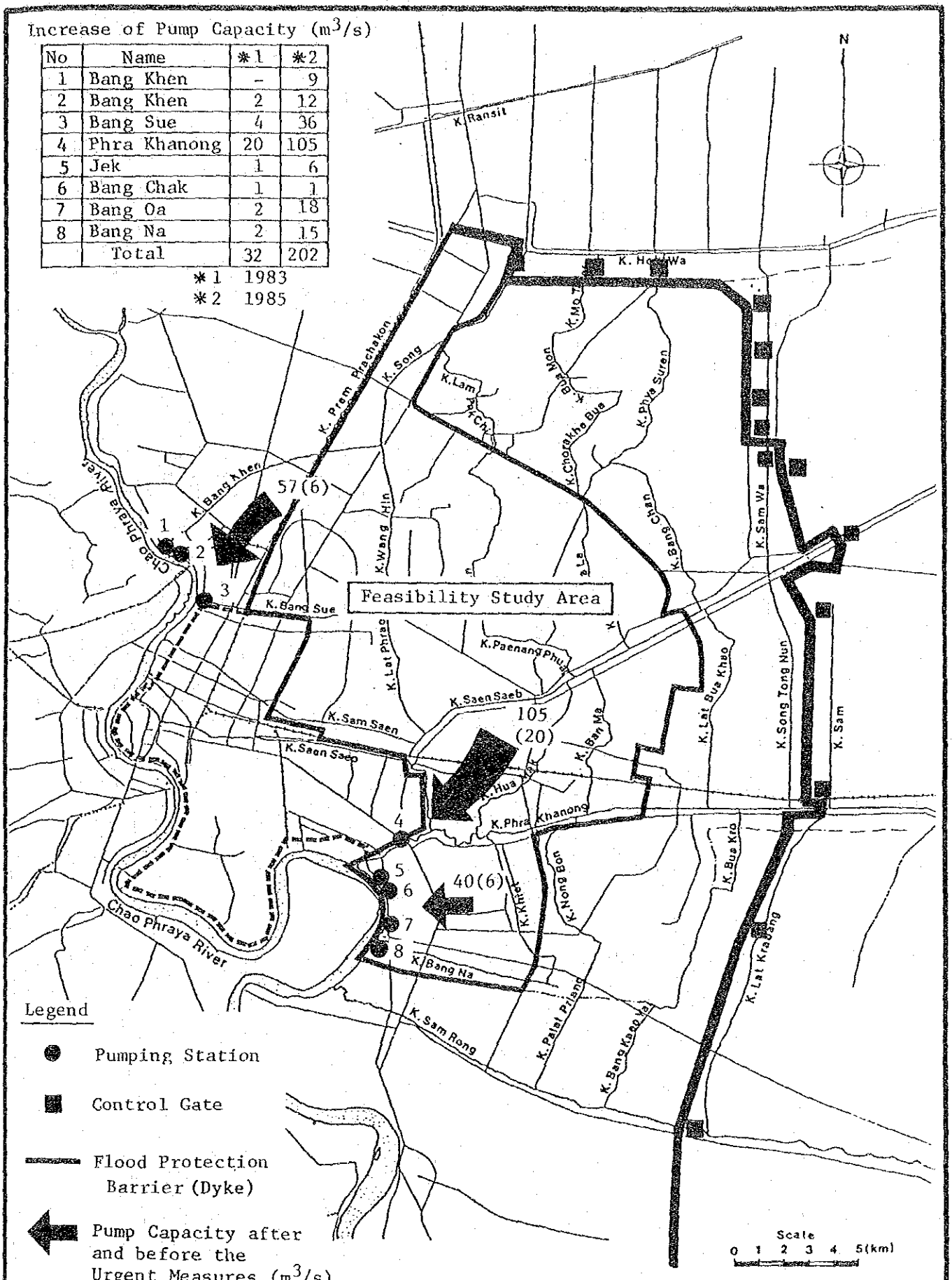
FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2529B.E 1986A.D

Increase of Pump Capacity (m^3/s)

No	Name	*1	*2
1	Bang Khen	-	9
2	Bang Khen	2	12
3	Bang Sue	4	36
4	Phra Khanong	20	105
5	Jek	1	6
6	Bang Chak	1	1
7	Bang Oa	2	18
8	Bang Na	2	15
	Total	32	202

*1 1983
*2 1985



Legend

- Pumping Station
- Control Gate
- Flood Protection Barrier (Dyke)
- Pump Capacity after and before the Urgent Measures (m^3/s)

Fig. 3.3 FACILITIES CONSTRUCTED AS URGENT MEASURES

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

JICA 2529B.E 1986A.D

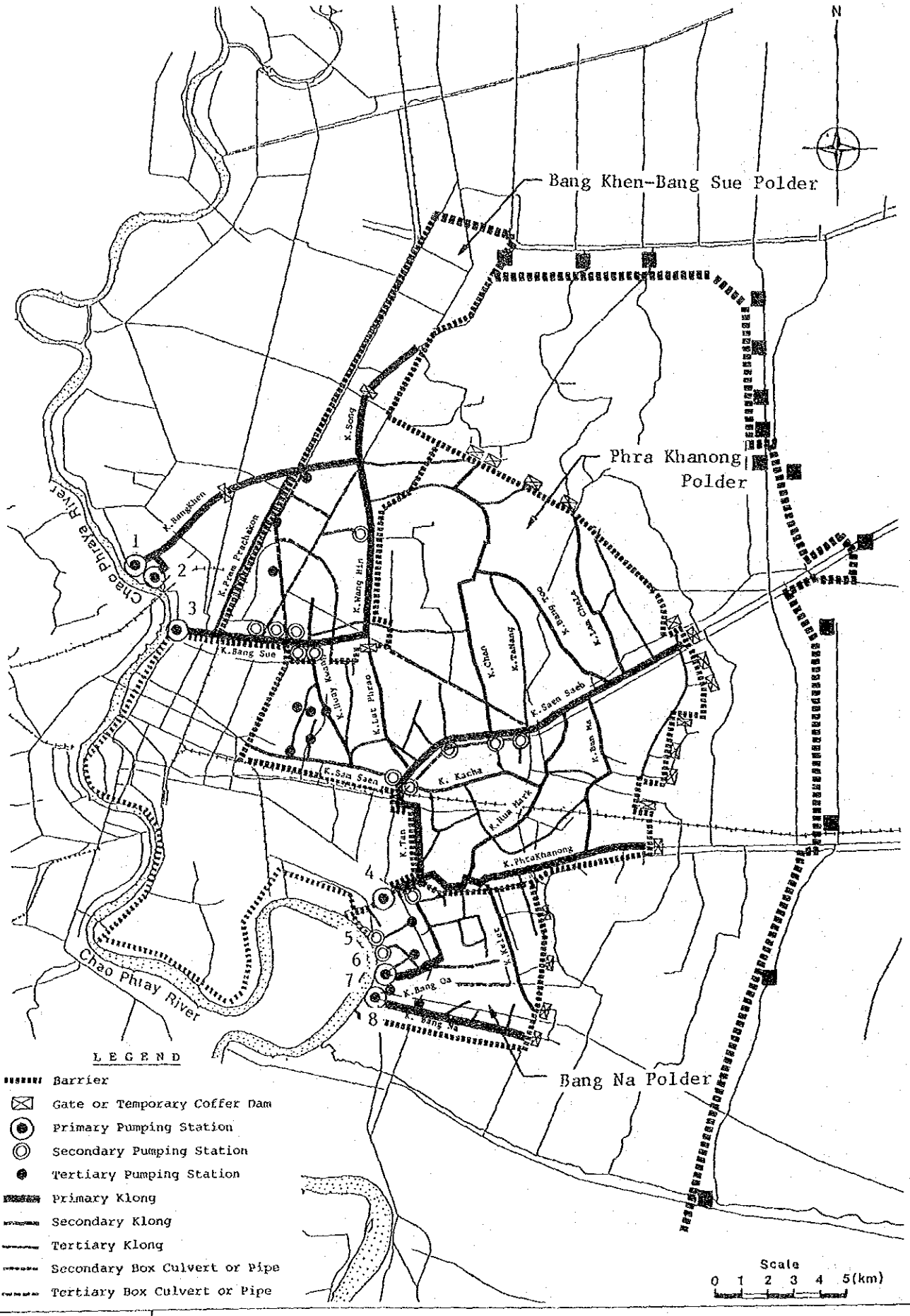


Fig. 3.4 EXISTING FLOOD PROTECTION AND DRAINAGE FACILITIES

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

JICA 2529B.E 1986A.D

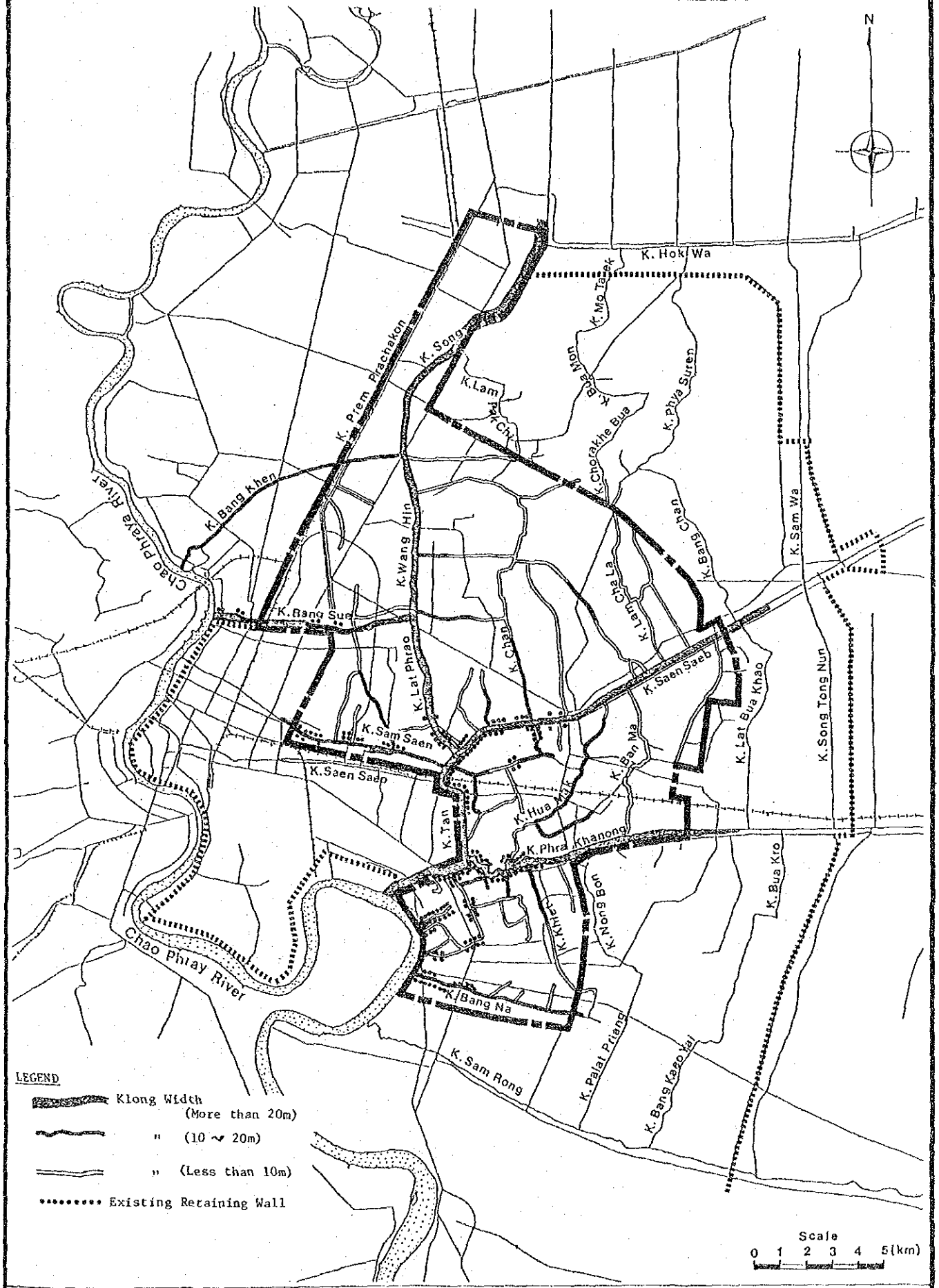


Fig. 3.5 EXISTING KLONG WIDTH AND RETAINING WALL

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

JICA 2529B.E 1986A.D

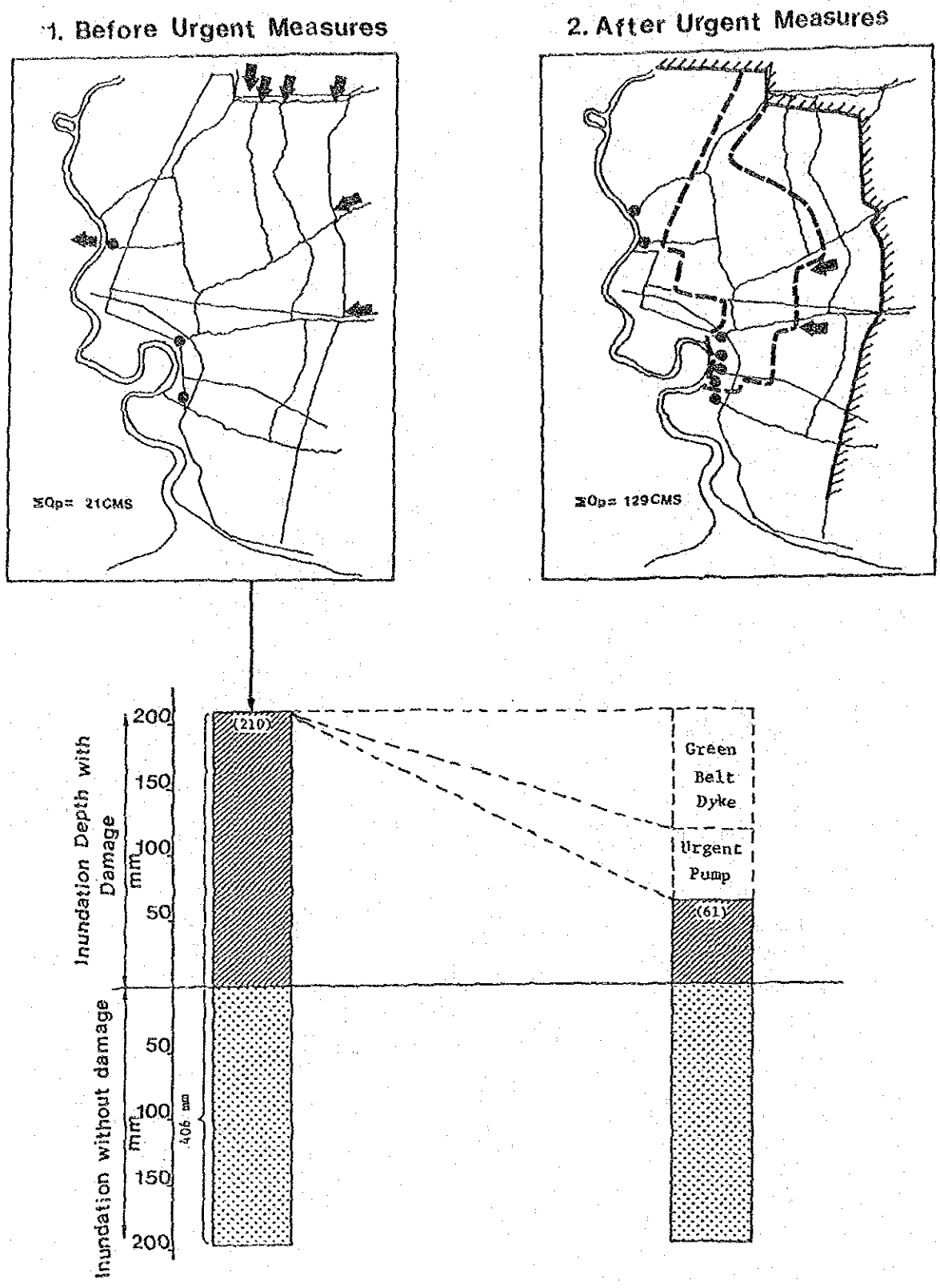
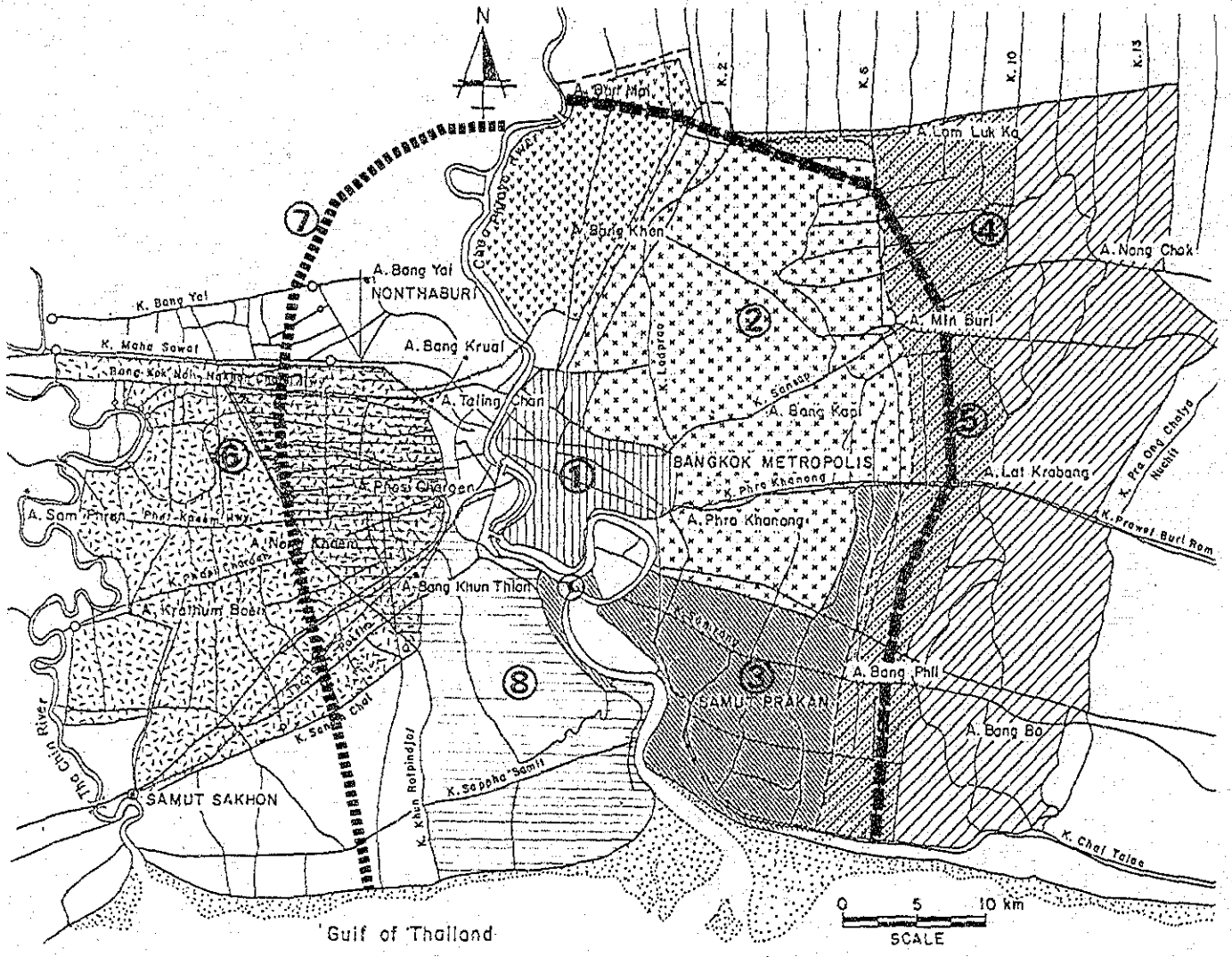


Fig. 3.6 EFFECT OF URGENT MEASURES

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

JICA 2529B.E 1986A.D



LEGEND

① Bangkok Flood Control and Drainage Project (City Core) : NEDECO

② Preliminary Study and Master Plan on Flood Protection/Drainage Project in Eastern Suburban Bangkok : JICA

③ Samut Prakan Project : TISTR

④ Green Belt Project (King,s Project)

⑤ Flood Routing and Control Alternatives of Chao Phraya River of Bangkok : AIT

⑥ Improvement of Canals Connecting Klong Tawee Wattana and Klong Khoon RatPiniJai Project : AIT

⑦ Integrated Flood Relief Plan of the West Bank : Austria

⑧ Master Plan for Flood Protection and Drainage of Thonburi and Samut Prakan West Project : NEDECO

OVERALL PROJECT

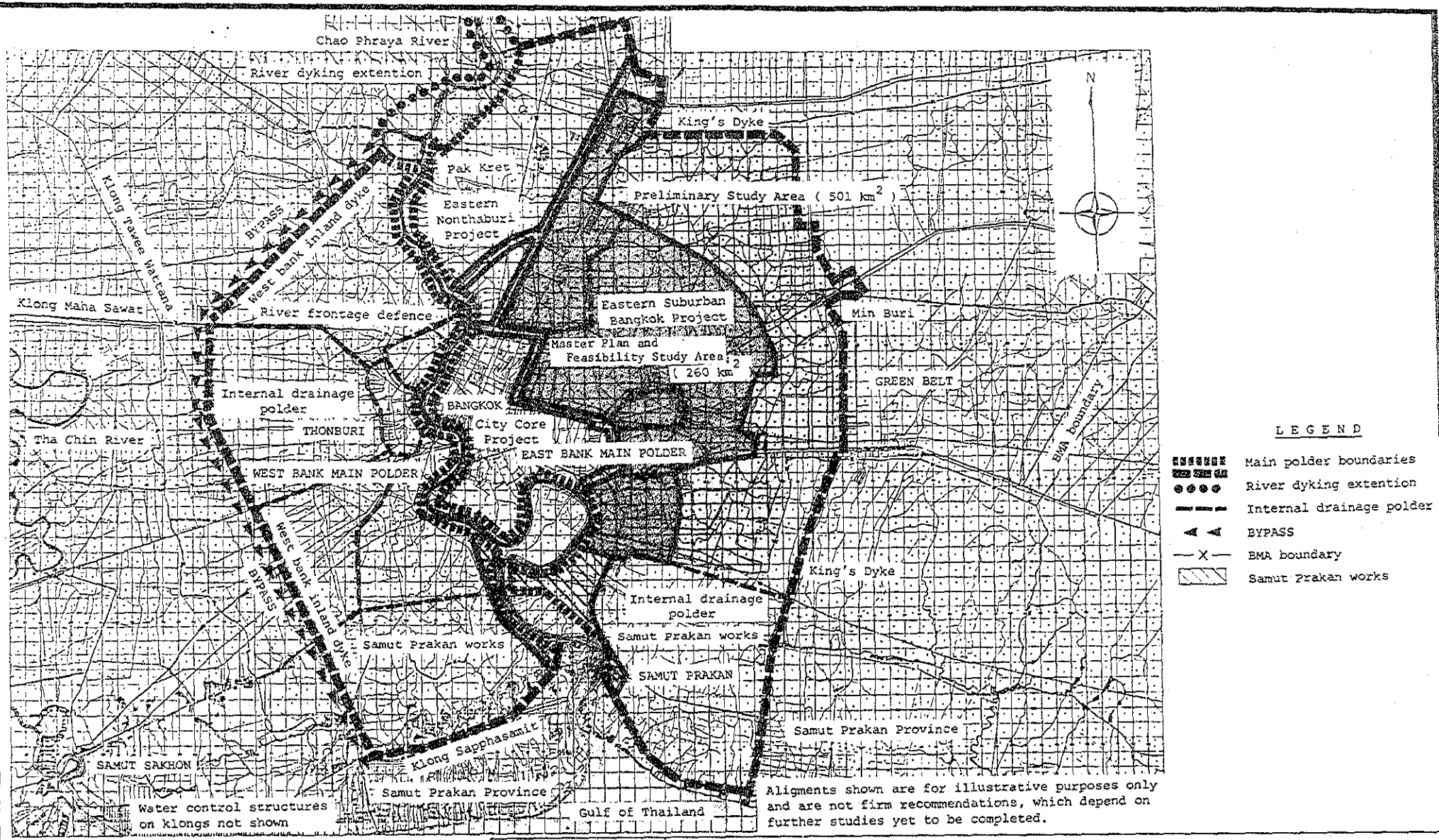
Bangkok Flood Control Management Project : ADB

Bangkok Flood Alleviation Study of Model Feasibility : CIDA

Flood Control Management Planning : USA

Fig. 3.7 RELEVANT PLANS AND PROJECTS

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



Source : ADB Report

Fig. 3.8 ILLUSTRATIVE FLOOD PROTECTION AND DRAINAGE SYSTEM IN BANGKOK (ADB REPORT)

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

Chapter 4

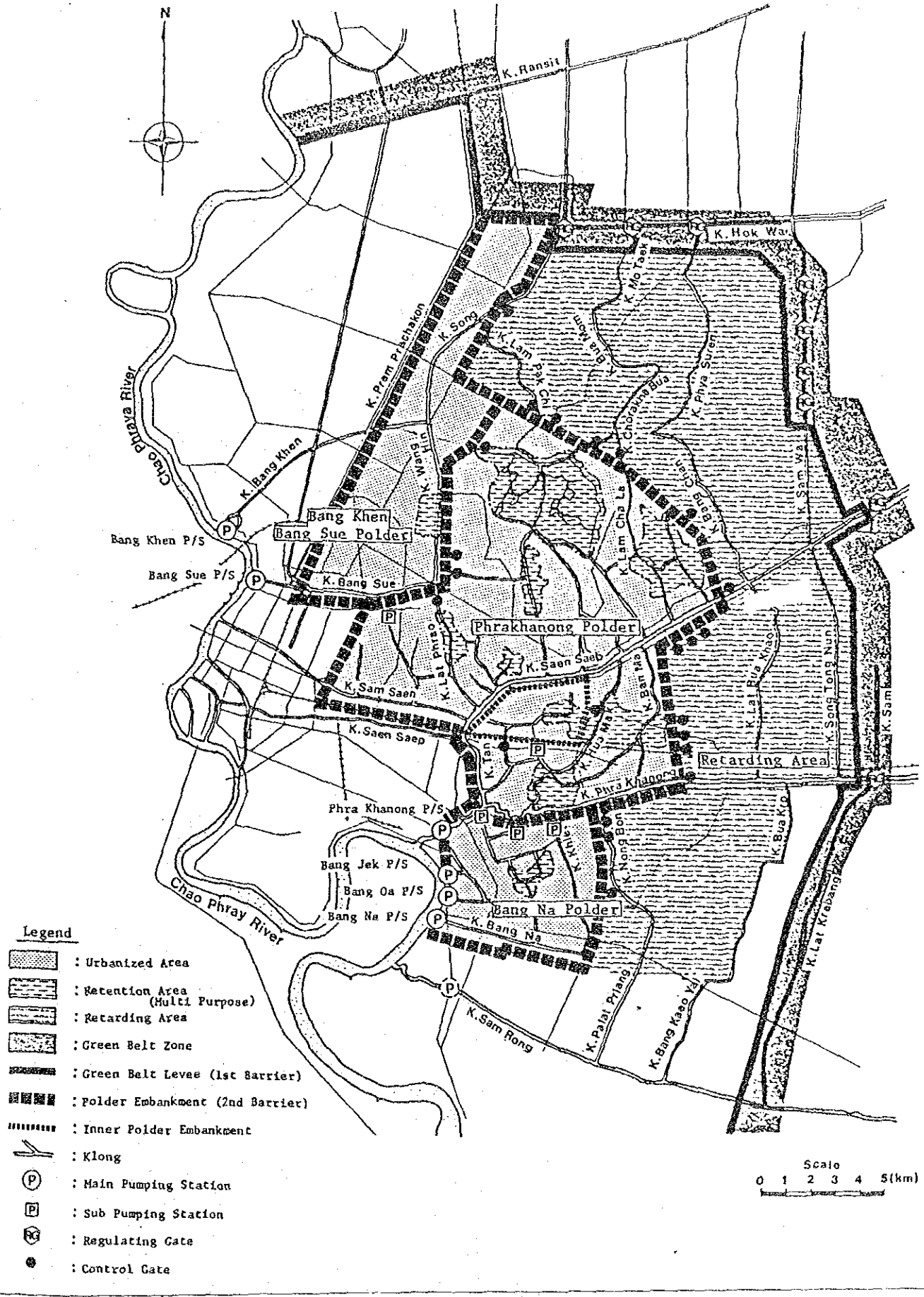


Fig. 4.1 CONCEPTURAL FLOOD PROTECTION/DRAINAGE SYSTEM IN EASTERN SUBURBAN-BANGKOK

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

JICA 2529B.E 1986A.D

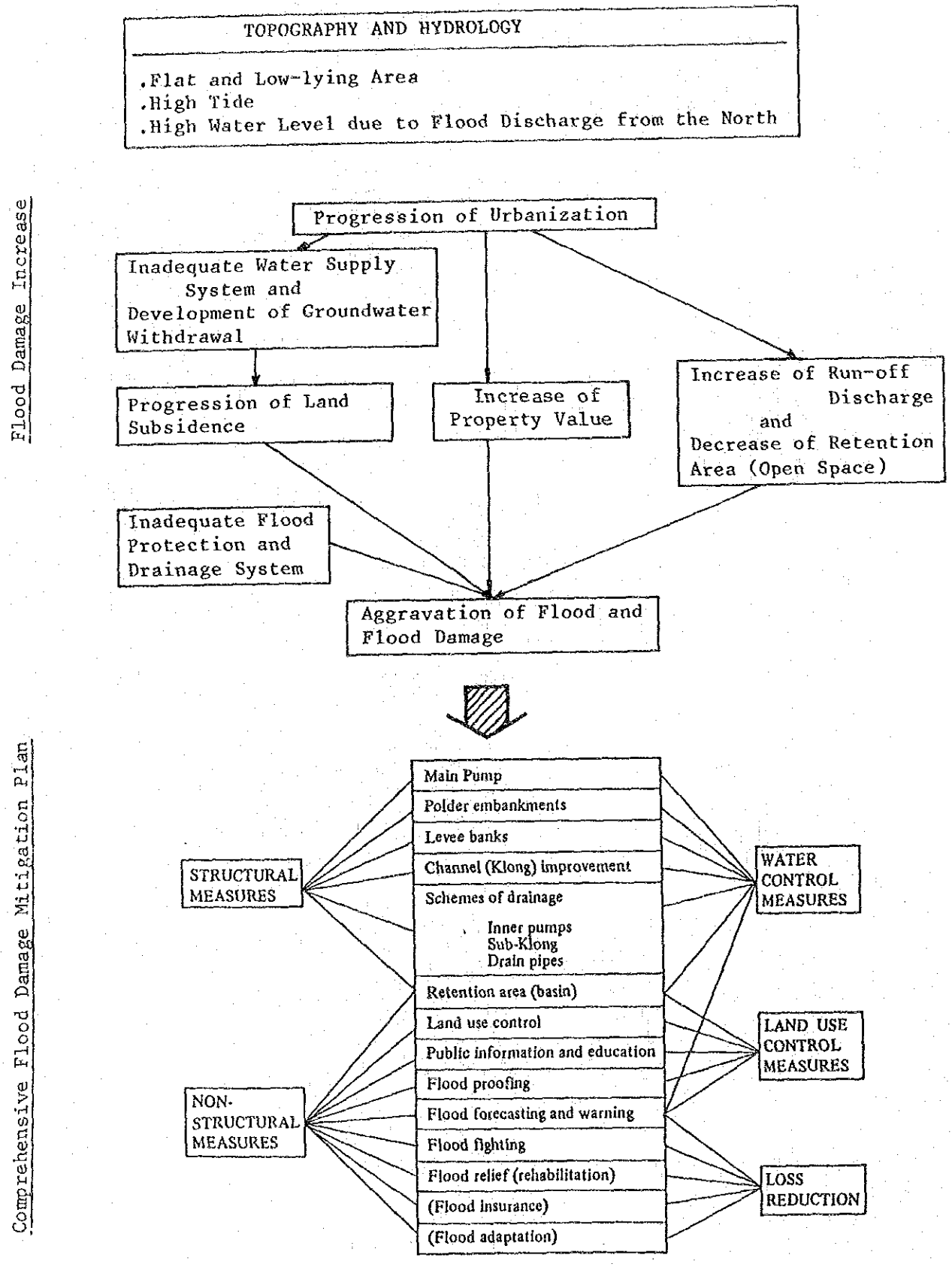


Fig. 4.2 COMPREHENSIVE FLOOD DAMAGE MITIGATION MEASURES