(2) BOD value varied to a large extent during a 24 hour period. The ranges of the maximum and minimum BOD variations are 50 mg/l and 10 mg/l respectively.

- Variation in water quality is intense in the klongs having a small discharge, which are also highly polluted.
- Water quality is rather stable in the klongs having a large discharge, which are less polluted.

(3) Klong water quality (BOD) varies along the flow route of klong, depending on the operation of the gates and pumps on the Chao Phraya River bank.

- When the gates are opened and dilution water is introduced in dry season, the klong water quality deteriorates in proportion to the distance inland from the Chao Phraya River. However beyond Lad Phrao, Tan, and Phra Khanong, the water quality improves to some extent due to the dilution effects of water from the eastern suburban areas.

- On the other hand, when the gates are closed and the pumps are operated to drain storm water in rainy season, the water quality deteriorates towards the Chao Phraya River from inland.

The average water quality variation along the klong in a typical dry and rainy seasons as BOD are shown in Fig. 3.15 and Fig. 3.16.

3.8 Public Opinion Survey on Purification of Klong Water

The JICA Study Team conducted a sampling house visit investigation to identify the existing status of klongs as assessed by the citizens of Bangkok and positive impacts of the purification of klong water on their every day lives as estimated by them. Also, the team conducted a sampling interview investigation to know positive impacts of klong water purification on tourism as estimated by foreign visitors.

The questions on positive impacts accruing from the klong water purification project were made based on the assumption that the project will improve the level of klong water quality to that of the Chao Phraya River.

3.8.1 Importance of Klong Water Purification

90.3% of interviewees answered affirmative for klong water purification.

Concerning the comparative importance of five major projects, namely mitigation of floods, new construction/expansion of water supply system, new construction/expansion of sewerage system and new construction/improvement of roads as well as purification of klong water, 25.0% of interviewees are convinced that purification of klong water is the most important. 20.7% selected new construction/ expansion of sewerage system as the most important project and 20.2% favoured mitigation of floods.

3.8.2 Uses and Conditions of Klongs

Today the most important use of klongs is sewerage: 52.9% of households visited replied that they use klongs for sewerage. The second most important use is living: 26.8% use klong water for washing and bathing. The third and fourth places are occupied by inland water navigation (18.4%) and shopping from floating market (14.5%), respectively. Other uses are garbage dumping (9.9%), recreation (swimming and fishing) (9.9%), and irrigation and agriculture (8.2%).

Regarding conditions of klongs, as much as 83.4% of interviewees replied klongs have obnoxious odour and filthy & dark-colored. Also, 52,3% replied that klongs are breeding ground of mosquitoes and germs. Only 6.5% replied that klongs are natural.

The use and condition of each klong was integrally evaluated by totalling the marks given on the respective positive and negative uses and conditions identified in the respective klong. The marks given on each use and condition was obtained from the number of the interviewees who recognized the use and condition. The results of evaluation for the major klongs in the Study Area is shown in Fig. 3.17.

3.8.3 Impacts of Klong Water Purification

(1) Overall Impacts

The citizens of Bangkok are daily annoyed by the stinks of klong water, because it has been revealed that the highest proportion, 87.7% of those interviewed, replied that removal of obnoxious odour is the most important effect required by klong water purification. Also, citizens are highly conscious of the ill effects of the existing klong conditions, as 70.8% of interviewees chose contribution to the improvement of hygiene/health and the reduction in diseases as important effects of klong water purification. The third most important effect is an increased use of klong water for living (washing, bathing, etc.), which was supported by 61.1%.

The other beneficial effects pointed out are:

- Disappearance of repulsive dark water and regaining natural scenic beauty (55.5%)
- Recovery of ecology (fish & plants) (44.9%)
- Regaining the status and functions as a place of recreational activities (39.3%)
- Revival of inland navigation (24.4%)
- Increased use for irrigation (16.2%)

(2) Impacts on Transport

6.9% of interviewees regularly use klong for commuting and 5.4% of them regularly use it for shopping and other purposes. Average frequency of use of klong transport by regular users is 4.00 times per week for commuting and 4.80 times per week for shopping and others. In case klong water is purified average frequency will rise to 4.32 times per week for commuting and to 5.56 times per week for shopping/others.

(3) Impacts on Market

29.8% of interviewees regularly visit floating market. Their average frequency of visits is 2.86 times per week. In case klong water is purified it will rise to 3.88 times per week.

(4) Impacts on Land Price

38.9% of interviewees replied that the price of housing lot near their address would rise if the klong water is purified. Average rate of rise estimated by those who predict a rise in the price of housing lot as a result of klong water purification is 24%.

(5) Willingness to Pay

72.4% of the interviewees answered that they were willing to pay tax for the klong water purification. Average amount of payment per month by those who are willing to pay is Baht 18.

(6) Impacts on Foreign Tourist

86.6% of the interviewed foreign tourists replied that they noticed the filthy, dark-colored and stinking water of the klongs. Out of the 86.6%, 44.6% think that the existing status of the klongs is a setback in attracting foreign visitors. 29.1% of the interviewed foreign tourists want to visit Bangkok more often if the klong water is cleaned.

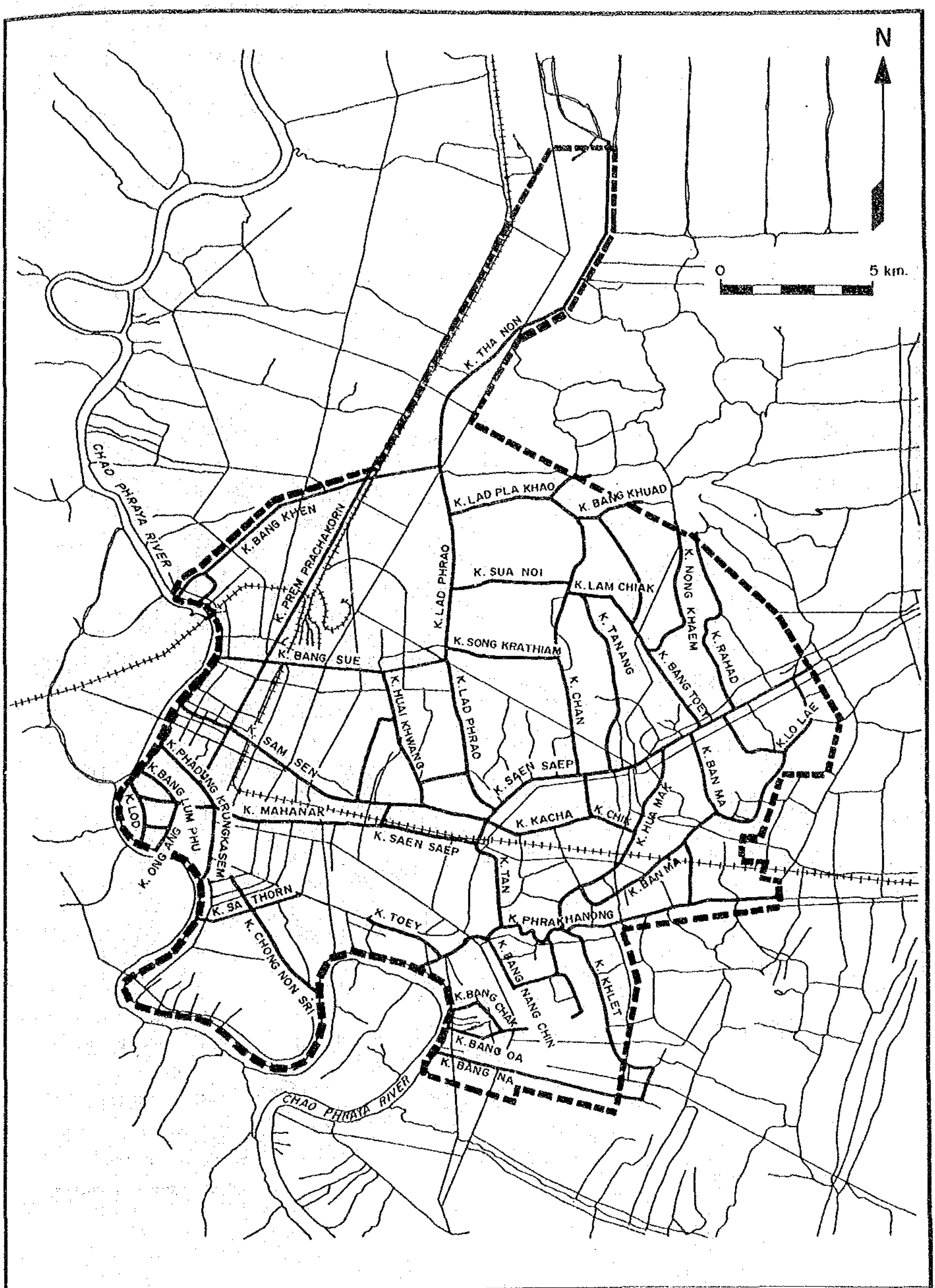


FIG. 3.1 SELECTED KLONG NETWORKS FOR STUDY

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

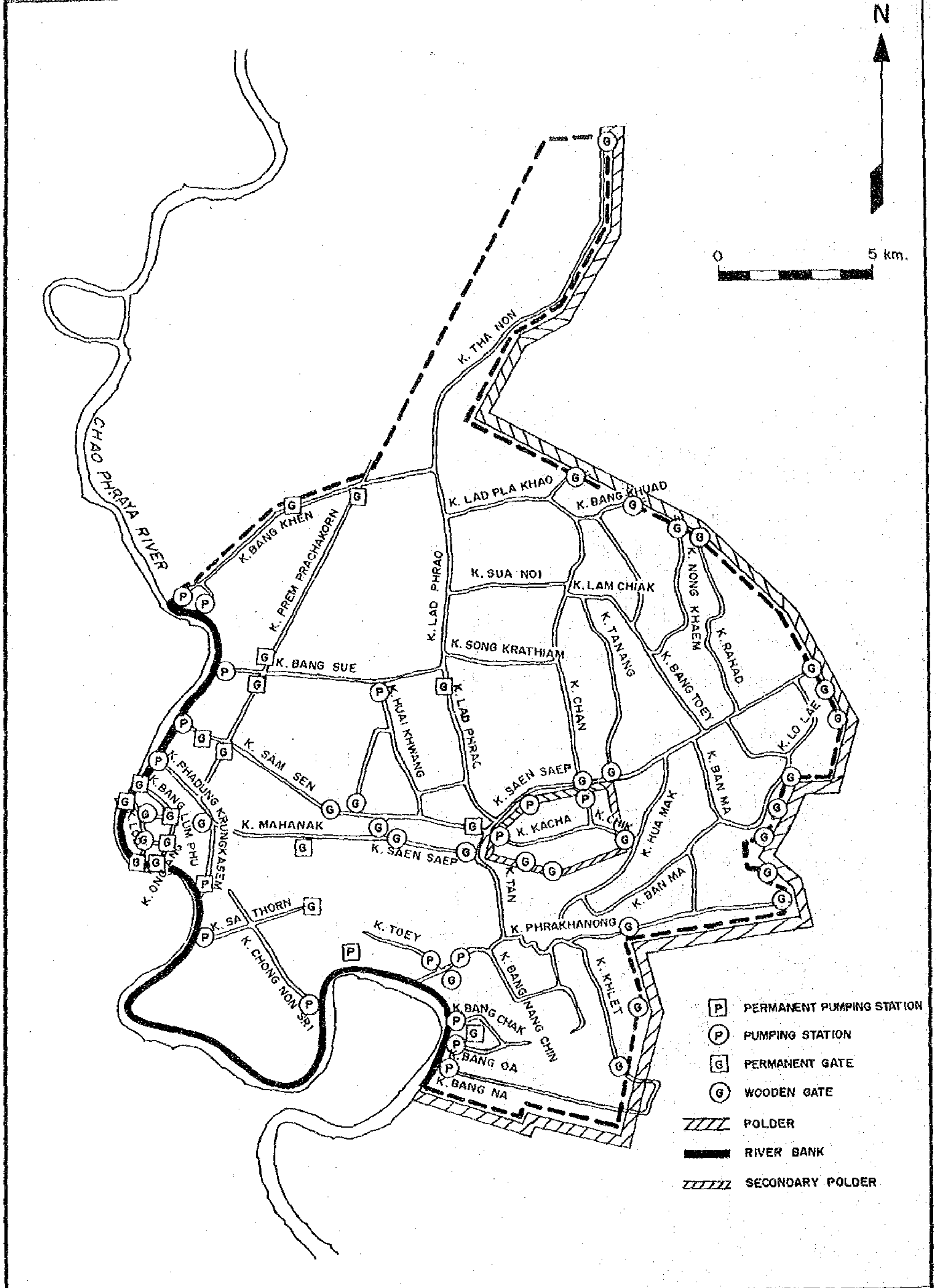
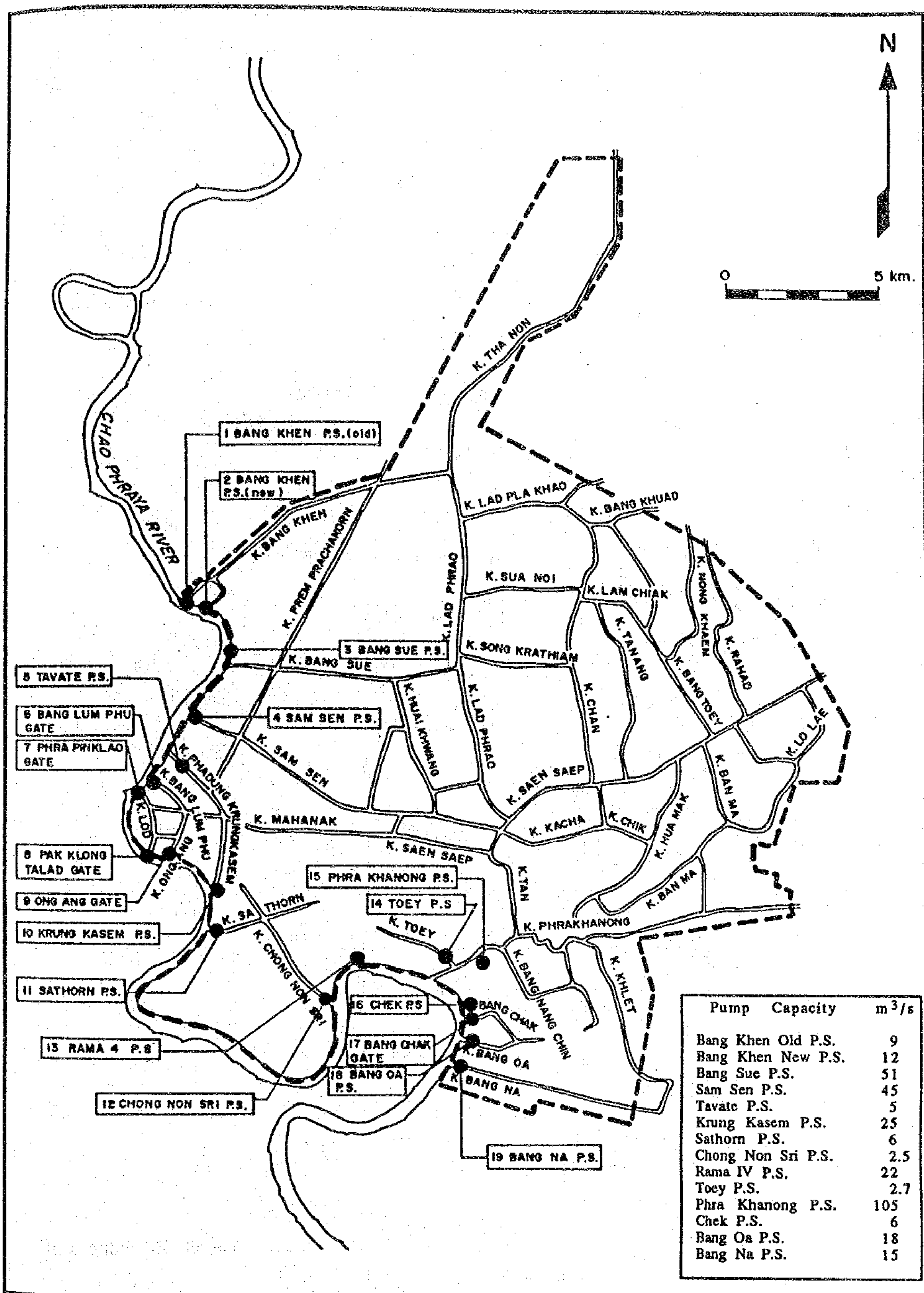


FIG. 3.2 EXISTING FLOOD CONTROL AND DRAINAGE FACILITIES

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.



Pump	Capacity m³/s
Bang Khen Old P.S.	9
Bang Khen New P.S.	12
Bang Sue P.S.	51
Sam Sen P.S.	45
Tavate P.S.	5
Krung Kasem P.S.	25
Sathorn P.S.	6
Chong Non Sri P.S.	2.5
Rama IV P.S.	22
Toey P.S.	2.7
Phra Khanong P.S.	105
Chek P.S.	6
Bang Oa P.S.	18
Bang Na P.S.	15

FIG. 3.3 LOCATION OF EXISTING PUMP AND GATE ON THE CHAO PHRAYA RIVER BANK

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

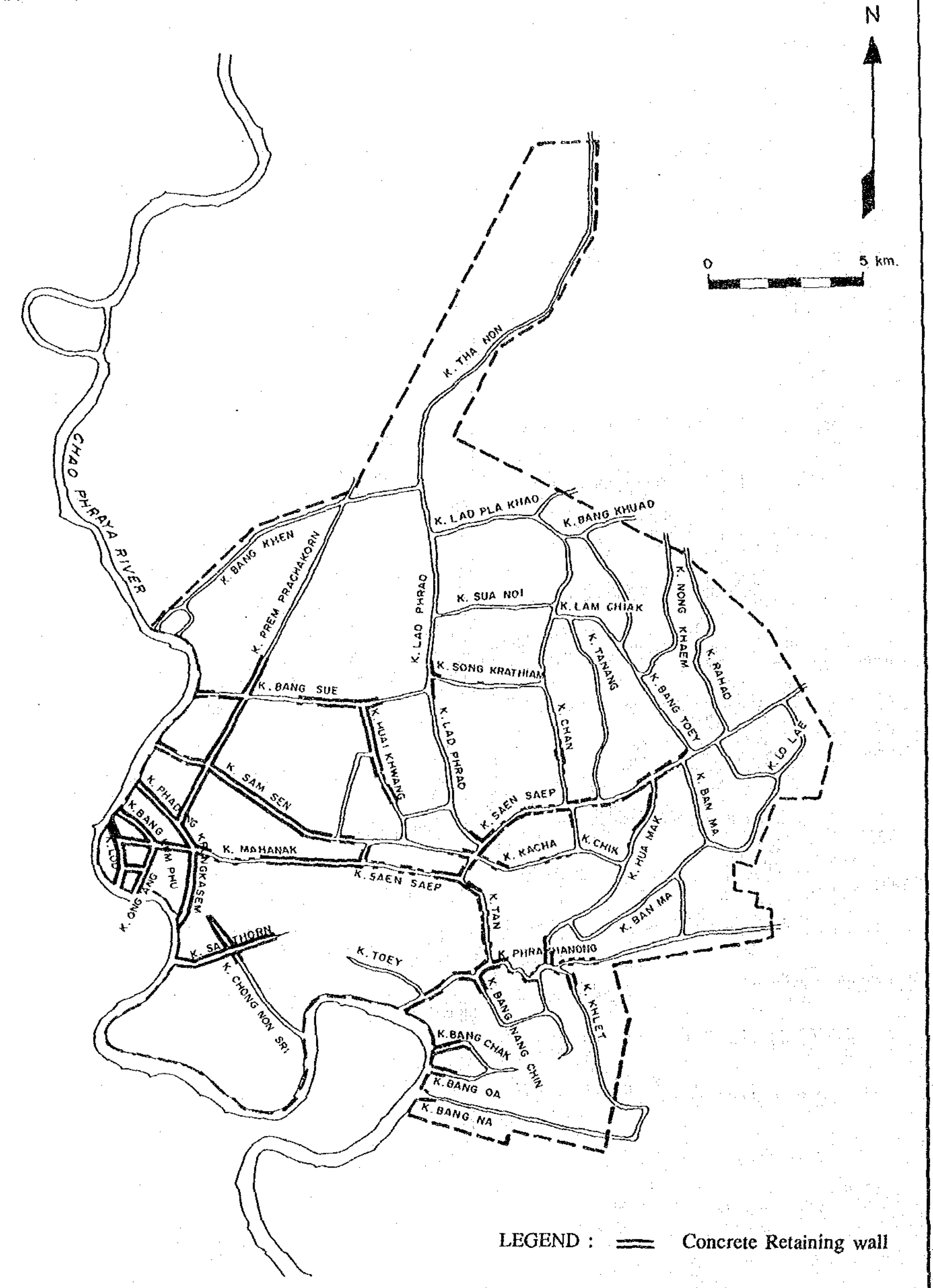


FIG. 3.4 LOCATION OF EXISTING CONCRETE RETAINING WALL

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

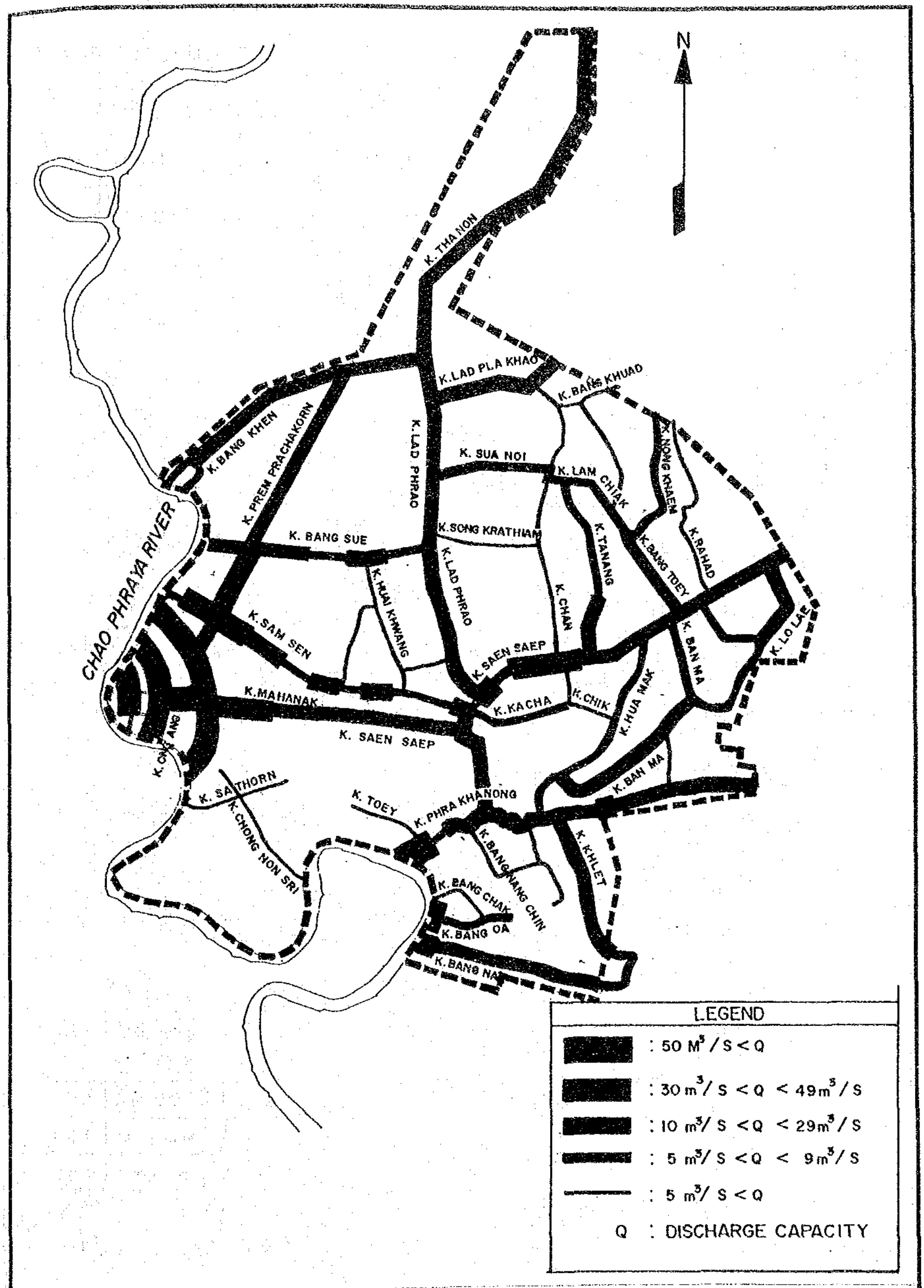


FIG. 3.5 CALCULATED MAXIMUM DISCHARGE CAPACITY OF MAJOR KLONGS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

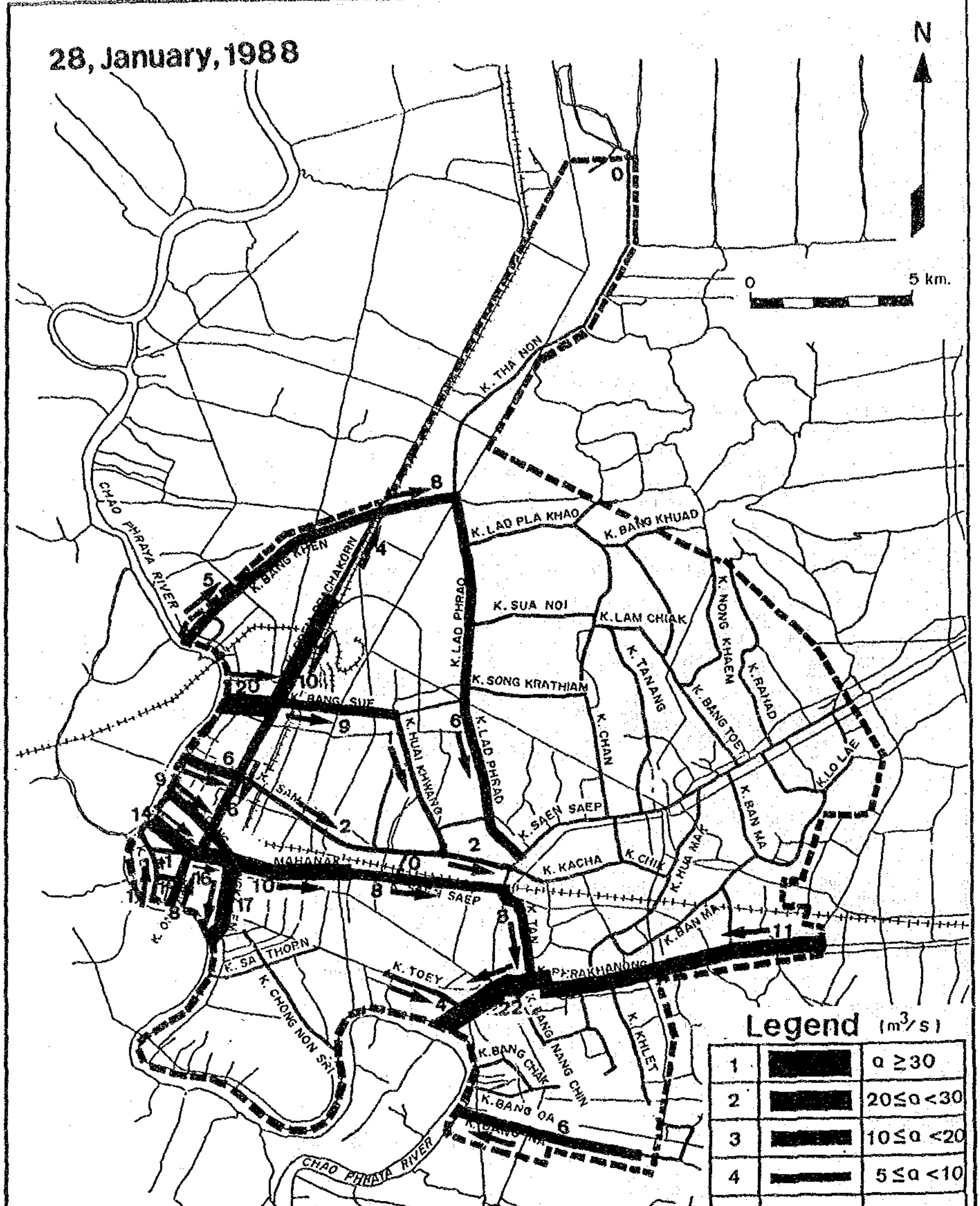


FIG. 3.6 (1)	OBSERVED MAXIMUM DISCHARGE IN TYPICAL DIRECTION OF DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

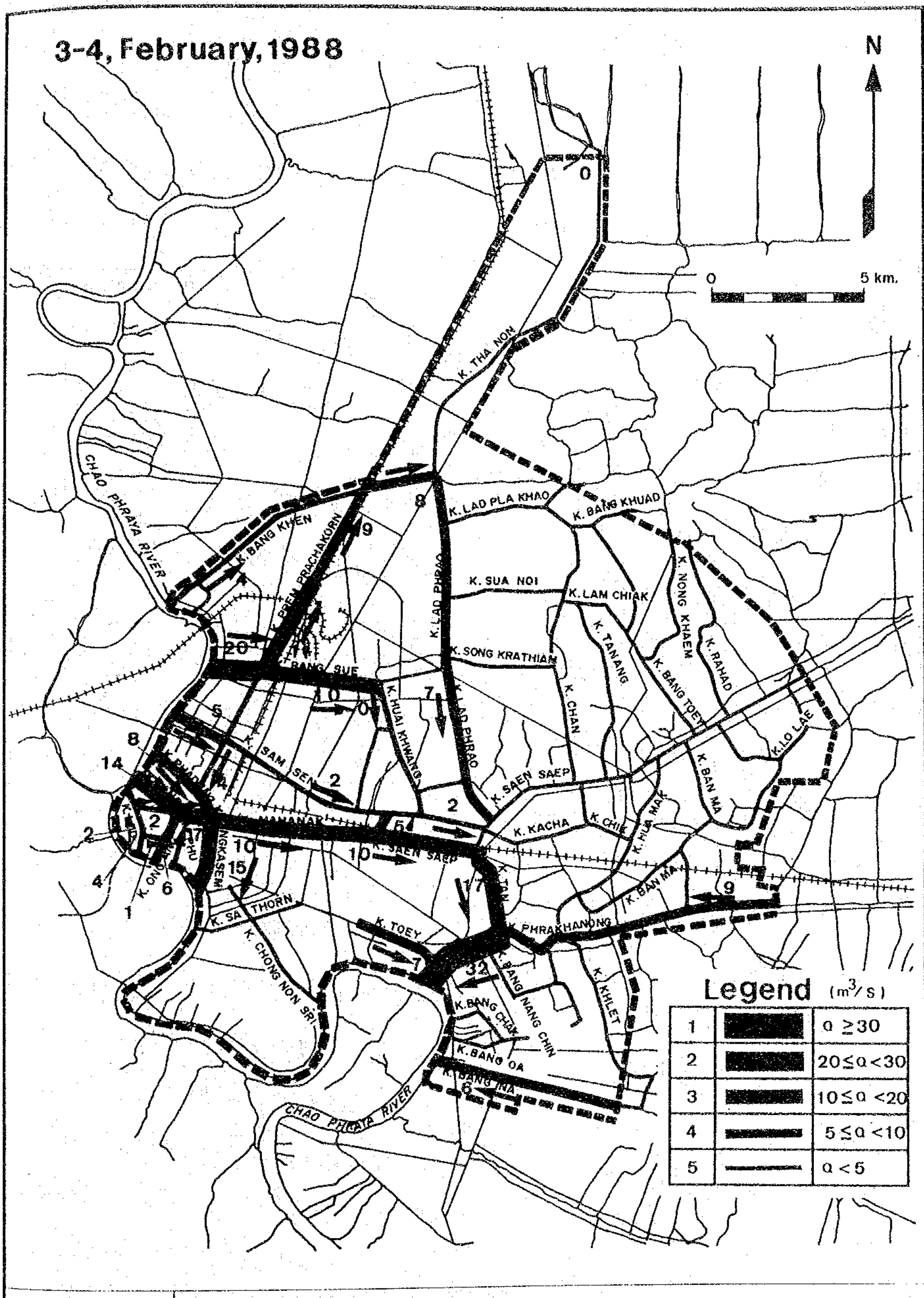


FIG. 3.6(2) OBSERVED MAXIMUM DISCHARGE IN NORMAL DIRECTION

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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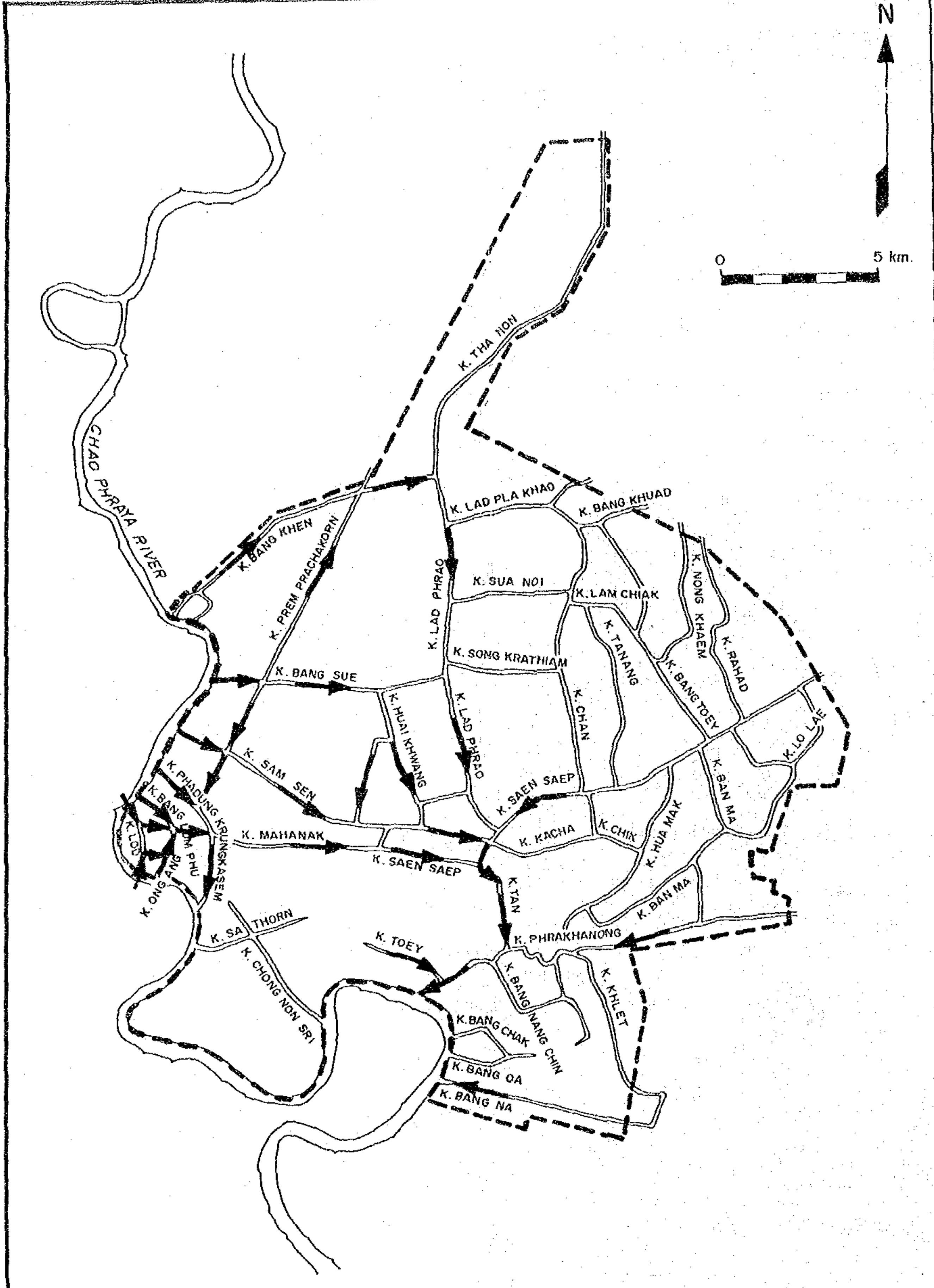

FIG. 3.7	DEFINITION OF NORMAL FLOW DIRECTION FOR FLUSHING PROJECT

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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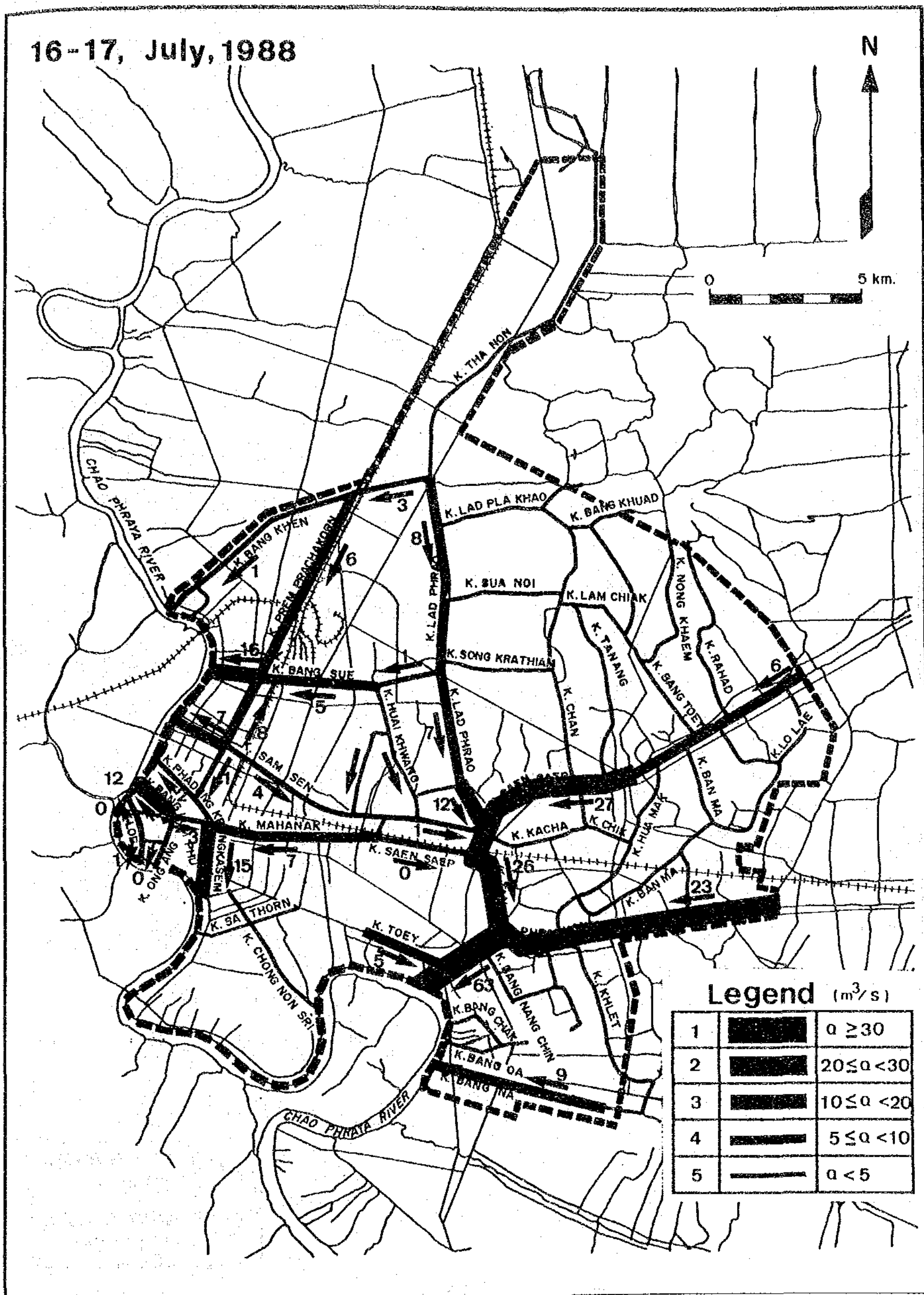

FIG. 3.8	OBSERVED MAXIMUM DISCHARGE IN TYPICAL DIRECTION OF RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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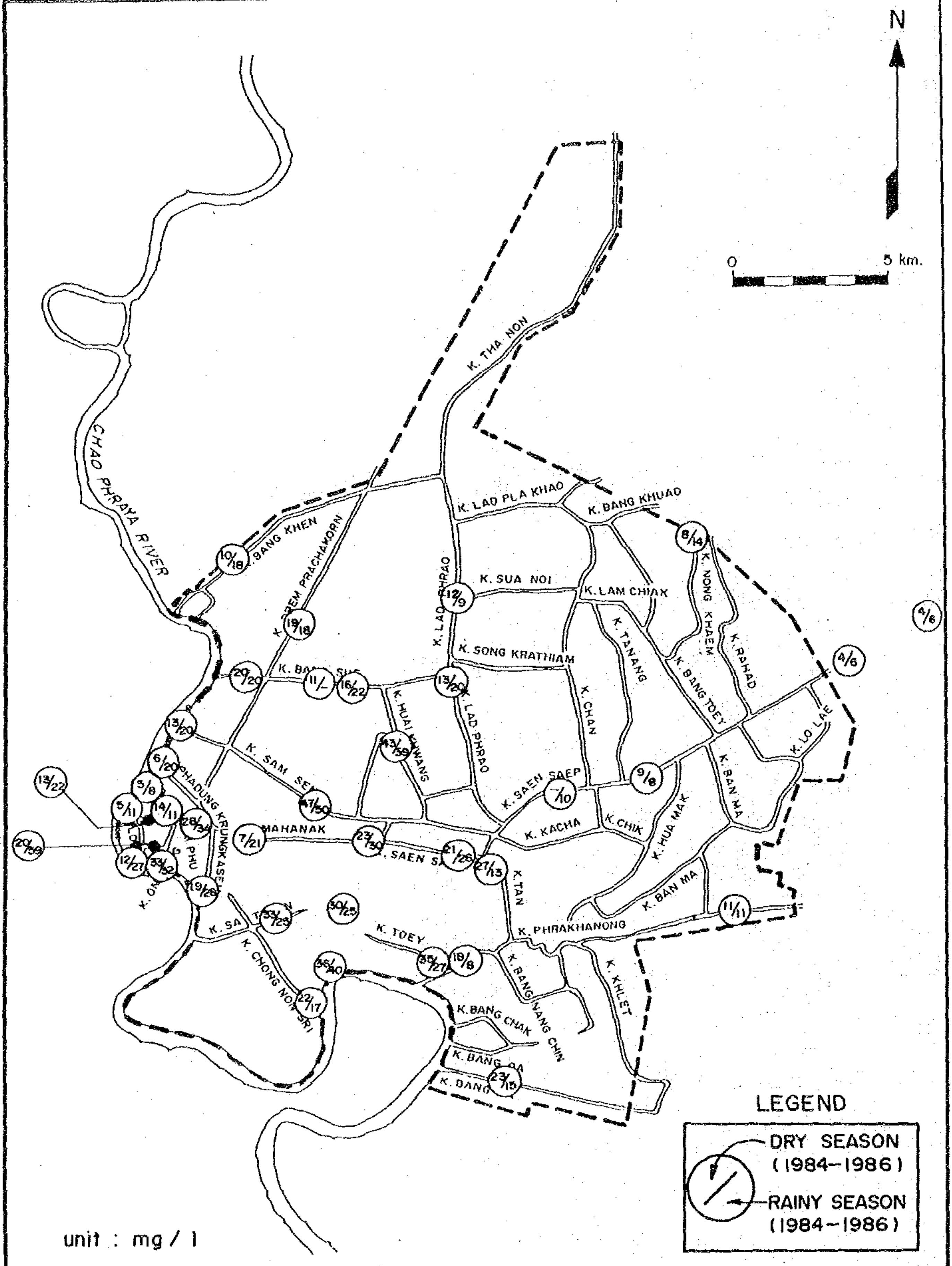

FIG. 3 . 9 COMPARISON OF AVERAGE BOD IN DRY AND RAINY SEASONS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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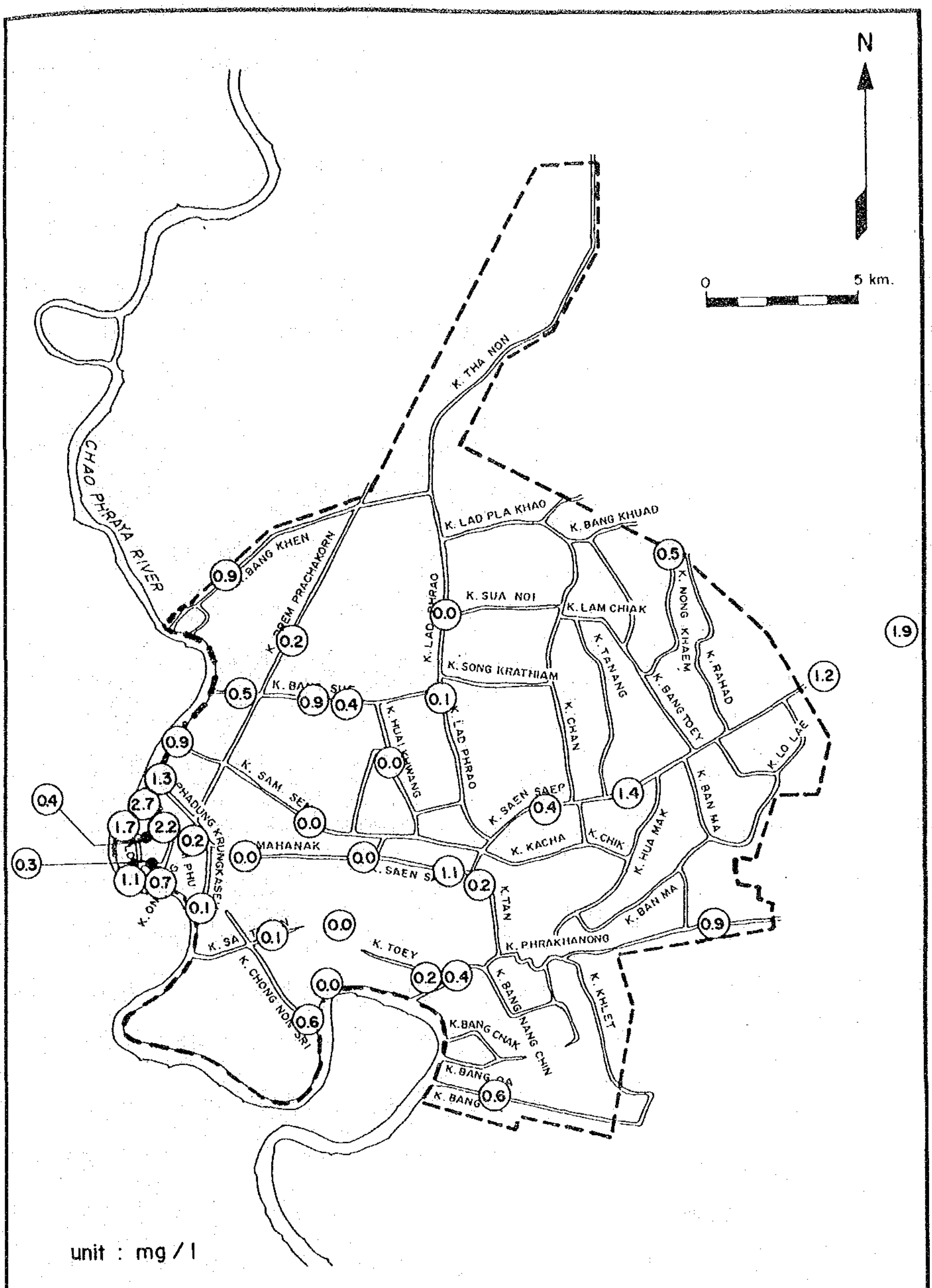

FIG. 3.10 REGIONAL DISTRIBUTION OF DO

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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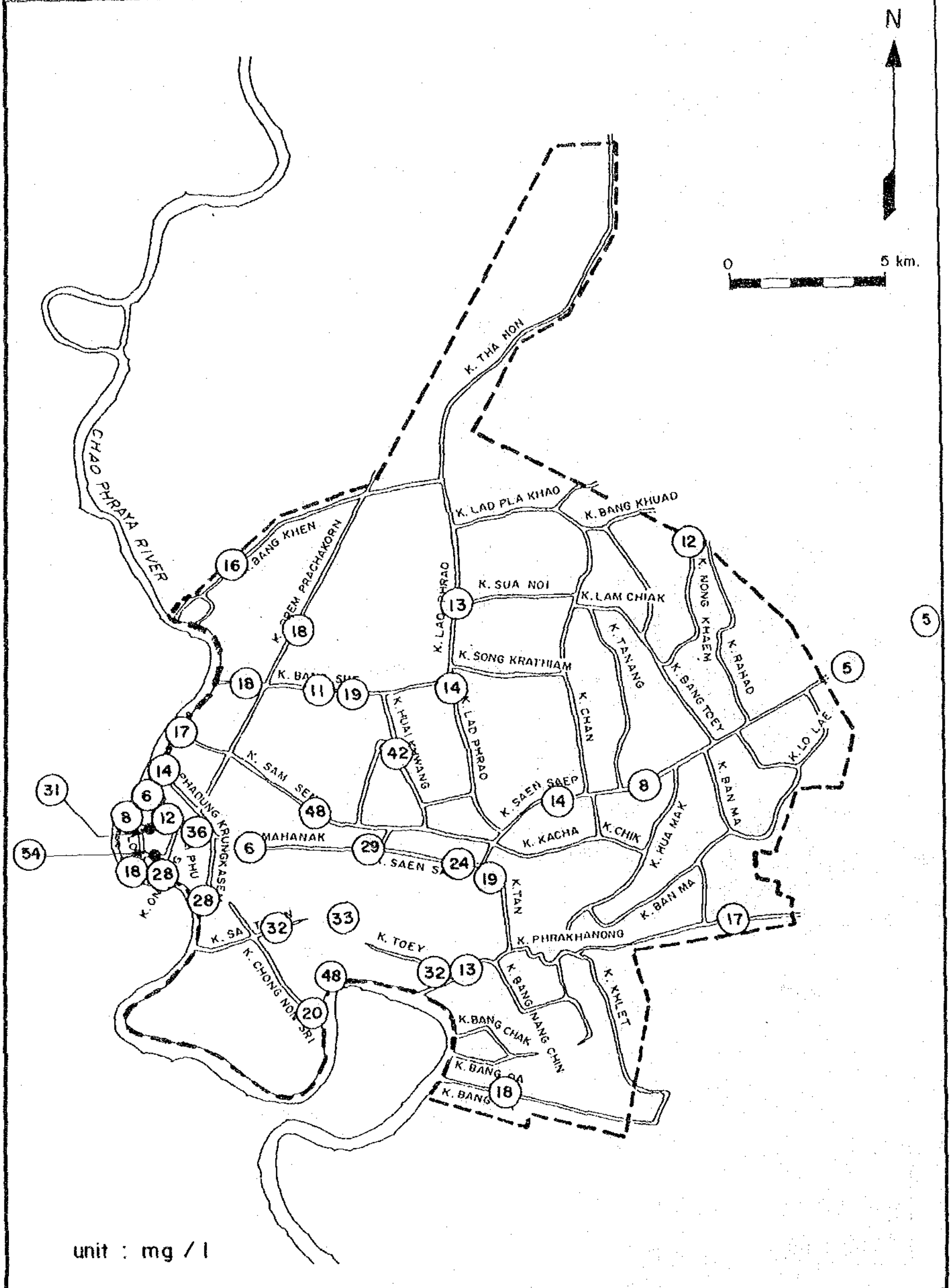

FIG. 3.11 REGIONAL DISTRIBUTION OF BOD

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

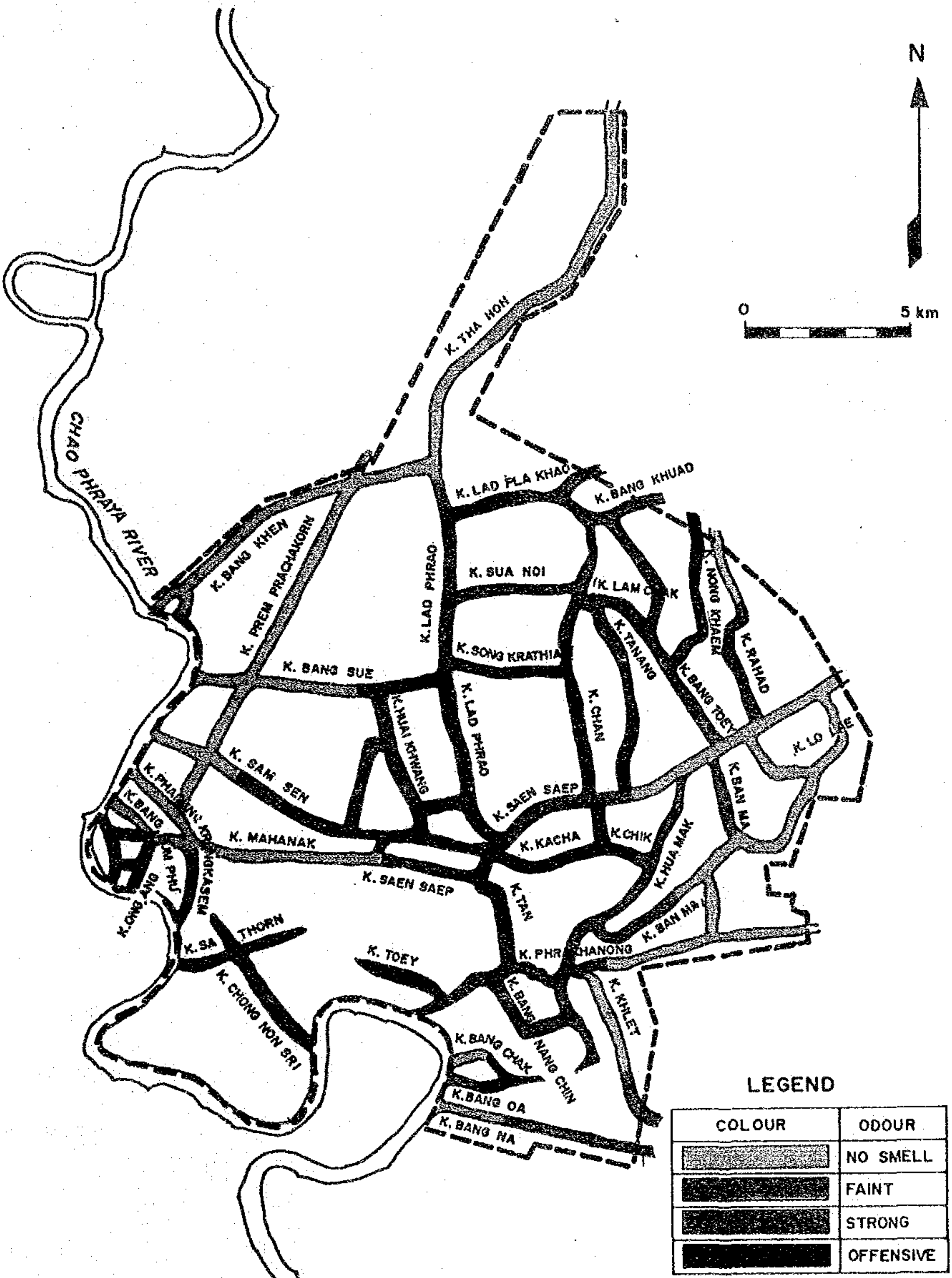

FIG. 3. 12	OBSERVED COLOUR AND ODOUR IN MID. OF MARCH 1988

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

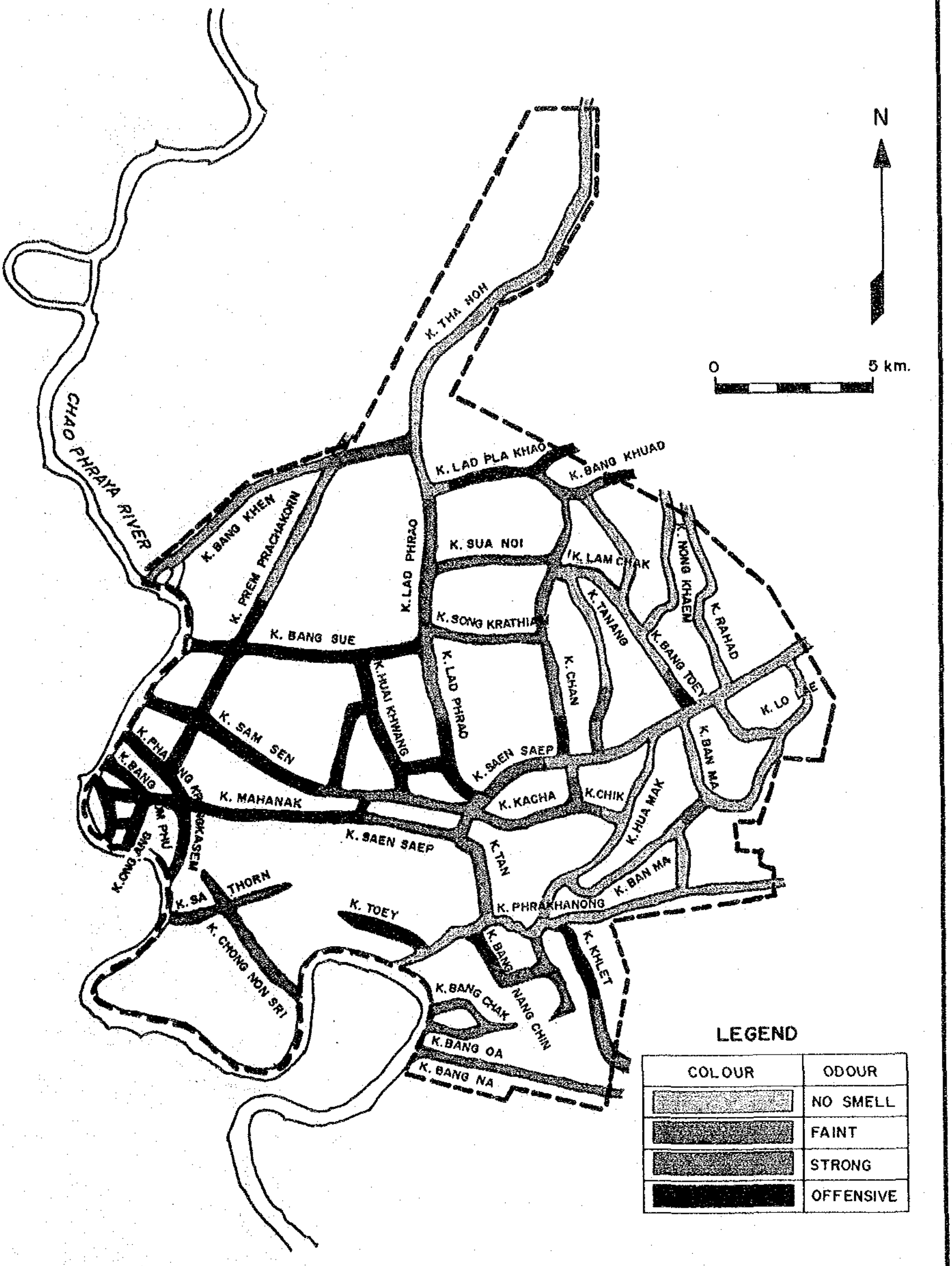

FIG. 3 . 13	OBSERVED COLOUR AND ODOUR IN BEGINNING OF AUG. 1988

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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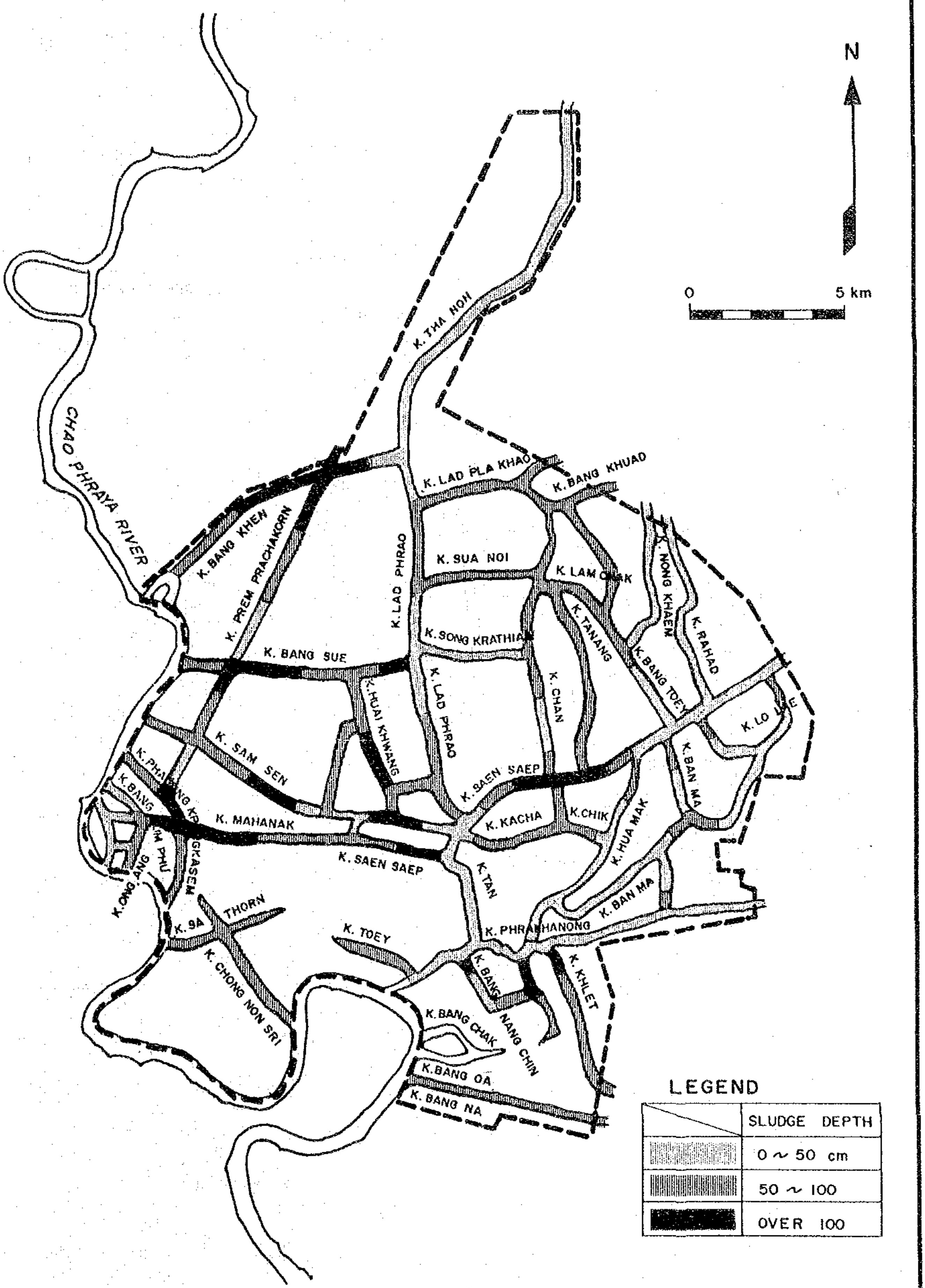

FIG. 3.14	EXISTING MUD DEPTH

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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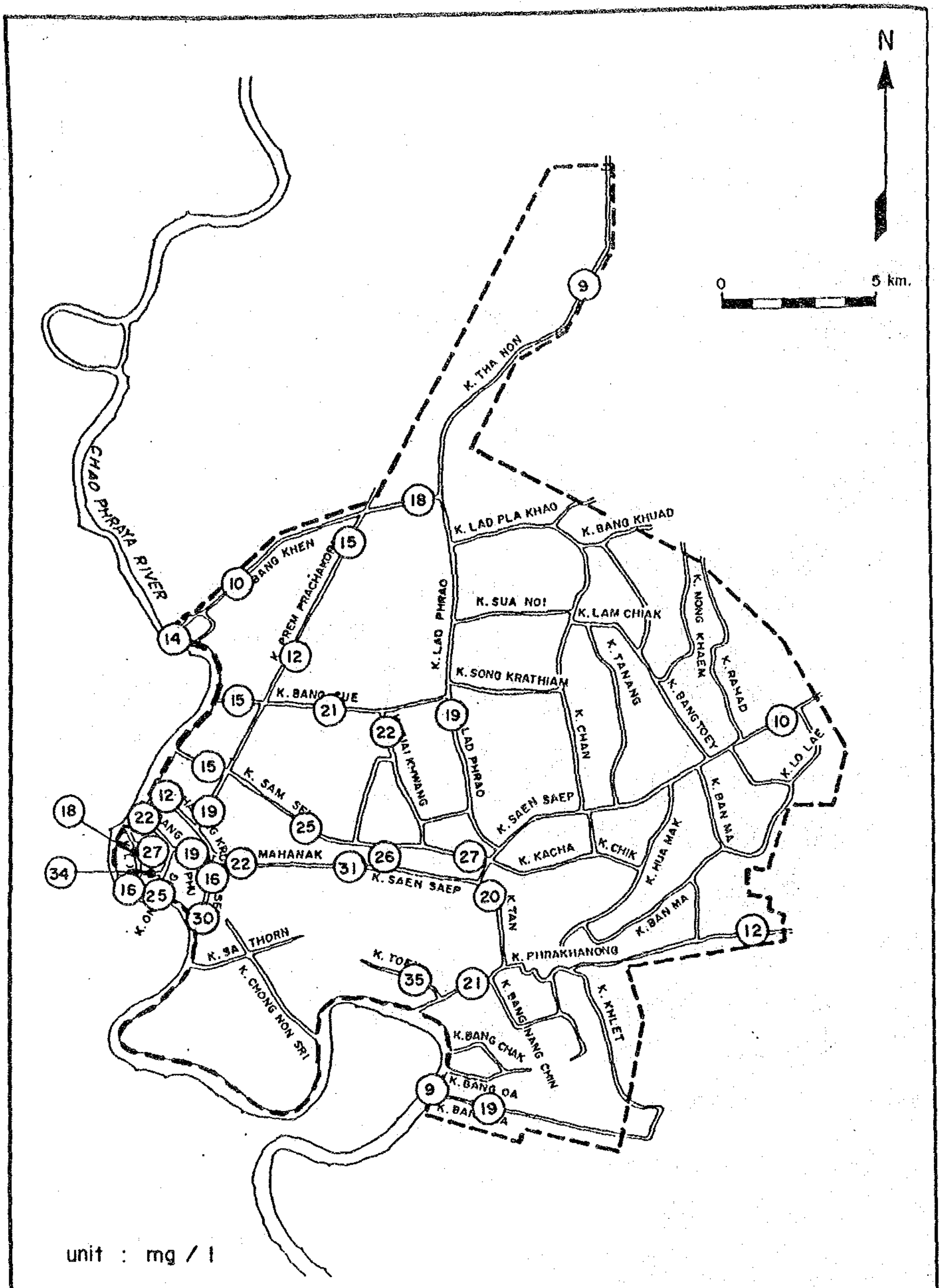

FIG. 3. 15 AVERAGE OBSERVED WATER QUALITY IN DRY SEASON 1988 (BOD)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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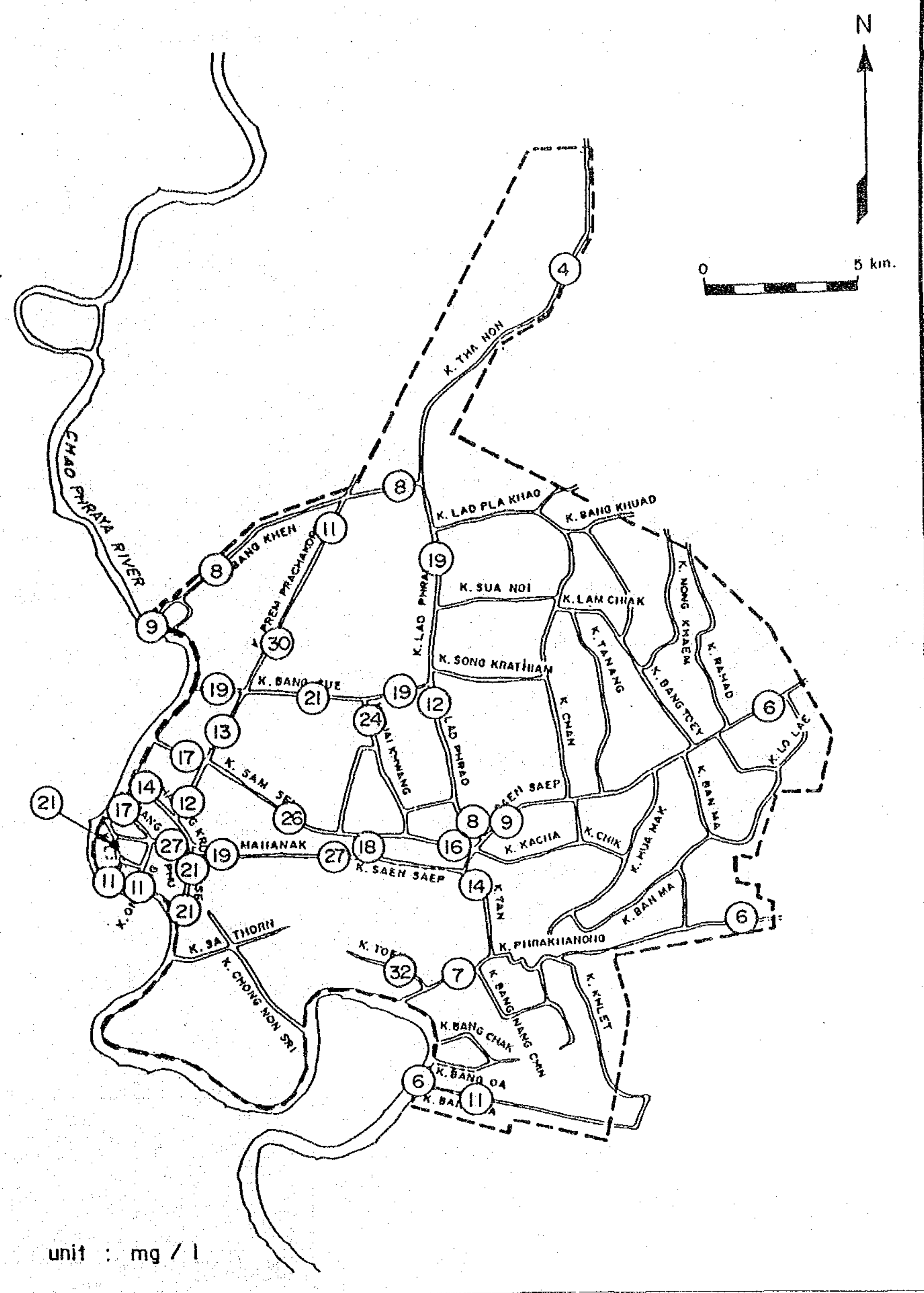

FIG. 3. 16	AVERAGE OBSERVED WATER QUALITY IN RAINY SEASON 1988 (BOD)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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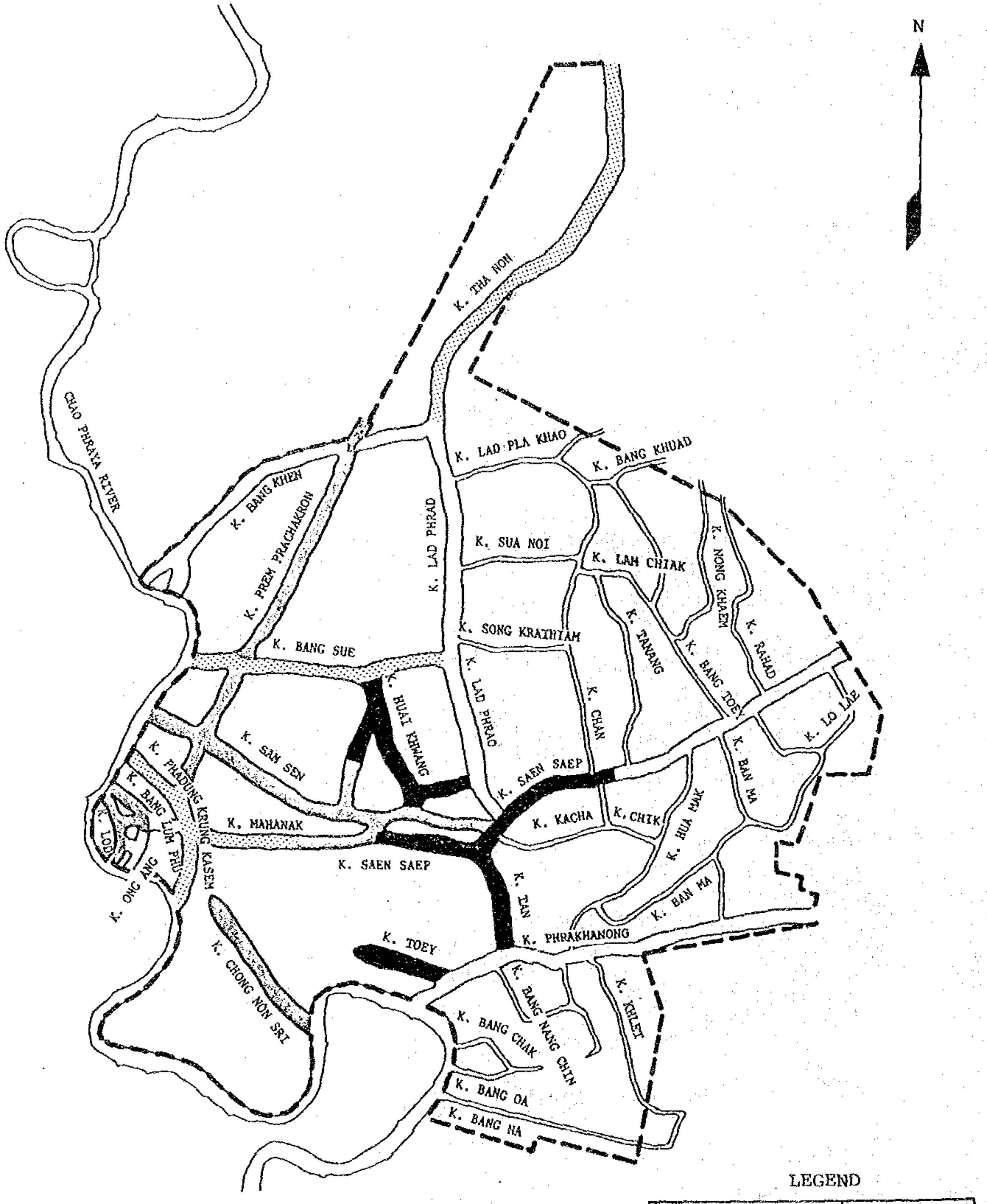


LEGEND

Pattern	Points*
(blank)	Over -100
(light dots)	-100 – -199
(dense dots)	-200 – -249
(solid black)	-250 & under

* The absolute value of the points expresses the degree and extent of negative uses and conditions of a klong.

FIG. 3. 17 USES & CONDITIONS OF KLONGS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

Chapter 4.

RELEVANT PROJECT

CHAPTER 4. RELEVANT PROJECT

4.1 Flood Control and Drainage Project in City Core Area

The flood control and drainage plan was prepared in November 1984 by a consortium of the engineering consultants lead by NEDECO for a 98 km^2 of city core area of Bangkok.

The plan divided the project area into six (6) zones and proposed a flood protection and drainage plan with polder system for each zone. The inside area of the polder is protected against floods from the outer areas and Chao Phraya River by polders with gates. Storm rainfall inside the polder is discharged by drainage pumps into the Chao Phraya River directly or through the klongs.

The proposed plan includes the following structural measures.

- Provision of the polders surrounding six (6) zones
- Construction of the dikes on the Chao Phraya River from K. Bang Sue to K. Phra Khanong
- Improvement of the klongs for a total length of 100 km
- Installation of 10 additional pump stations with a total capacity of 141 m^3/s

The project is now on-going. Among the proposed 10 pump stations, five (5) pump stations (total capacity 68.6 m^3/s) have been constructed.

The proposed flood protection and drainage system is shown in Fig. 4.1.

4.2 Flood Protection and Drainage Project in Eastern Suburban Bangkok

The study was conducted by JICA study team during May 1983 through February, 1986. A master plan was prepared for the area of 260 km^2 in the eastern suburban Bangkok in March, 1985. In February, 1986, a feasibility study was completed for the priority projects selected from the master plan.

The master plan recommended an integrated flood protection and drainage system including both structural and non-structural measures. The basic idea of the proposed structural plan was to attain an optimum flood protection and drainage for the project area by establishing polder systems in the same way as the Flood Control and Drainage Project in the City Core Area.

The proposed structural plan includes the following major works.

- Provision of the polders surrounding the project area
- Construction of the dikes on the Chao Phraya River for 6.2 km length
- Improvement of the klongs for 133 km length
- Installation of 10 additional pump stations with a total capacity of 218 m^3/s
- Installation of the main drainage pipes for 80 km^2

The project is now on-going. Among the proposed 10 pump stations, nine (9) pump stations (total capacity 219.9 m^3/s) have been completed.

The proposed flood protection and drainage facilities in the master plan is shown in Fig. 4.2.

4.3 Master Plan of Bangkok Sewerage System

The master plan was prepared by the JICA study team in 1981 for the area of 37,000 ha, covering the city core, eastern suburban and Tonburi areas.

The plan divided the project area into 10 sewerage zones and proposed a separate sewer system with a treatment plant for each zone except for the areas where public drains had been provided. For the areas provided with public drains, partially combined sewers were recommended.

The wastewater of the project area was estimated to be 1,653,000 m^3/d in the target year 2000. Modified aeration or aerated lagoon method was applied for treatment of the wastewater. The water quality of the wastewater to be discharged into the klongs was assumed to be of BOD 60 mg/l at the initial stage of the project.

The proposed plan includes the following sewerage facilities.

		Diameter	Length
- Sewer line	Main	ø400 - ø3,000 mm	127.23 km
	Branch	ø200 - ø900 mm	8,262.7 km
	Connection	ø150 mm	14,147.0 km

- 24 pump stations
- 9 treatment plants

The proposed plan has not yet been commenced due to difficulty in financing.

The proposed sewerage system is shown in Fig. 4.3.

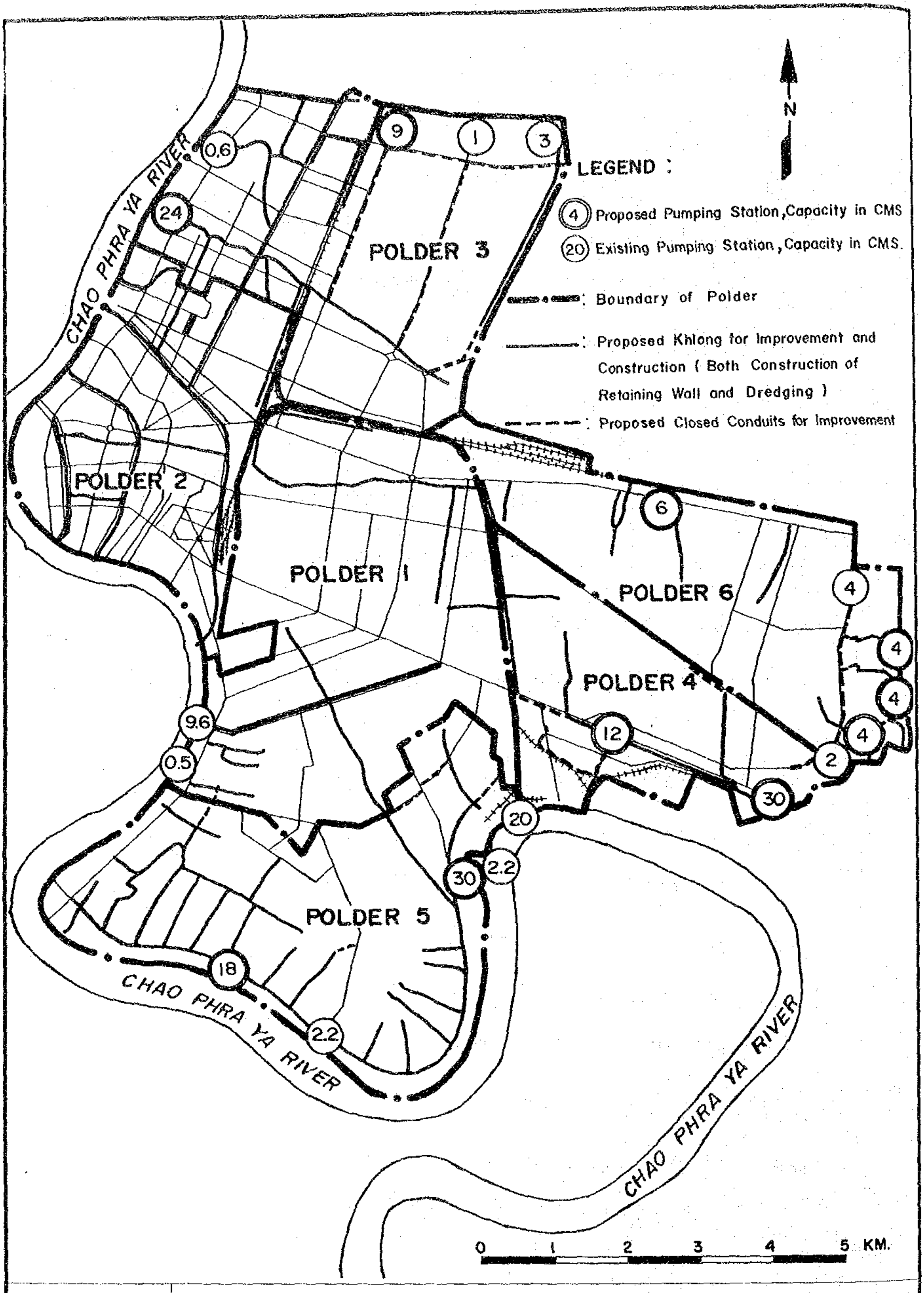


FIG. 4.1	PROPOSED DRAINAGE SYSTEM IN CITY CORE AREA BY NEDECO

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

Proposed Pump Capacity

	Polder	Area (km²)	Name of Pumping Station	Capacity (m³/sec)
MAIN POLDER	BANG KHEN & BANG SUE	64+29 = 93	Bang Khen	15
			Bang Sue	50
			Sub-Total	65
	PHRAKHANONG	165	Phra Khanong	90
	BANG NA	31	Jek	6
			Bang Oa	18
			Bang Na	21
			Bang Nang Chin	9
			Sub-Total	54
	Total	260+29 = 289		209
INNER POLDER	NORTH HUA MARK	9	Chik	3
			Kacha	6
			Sub-Total	9

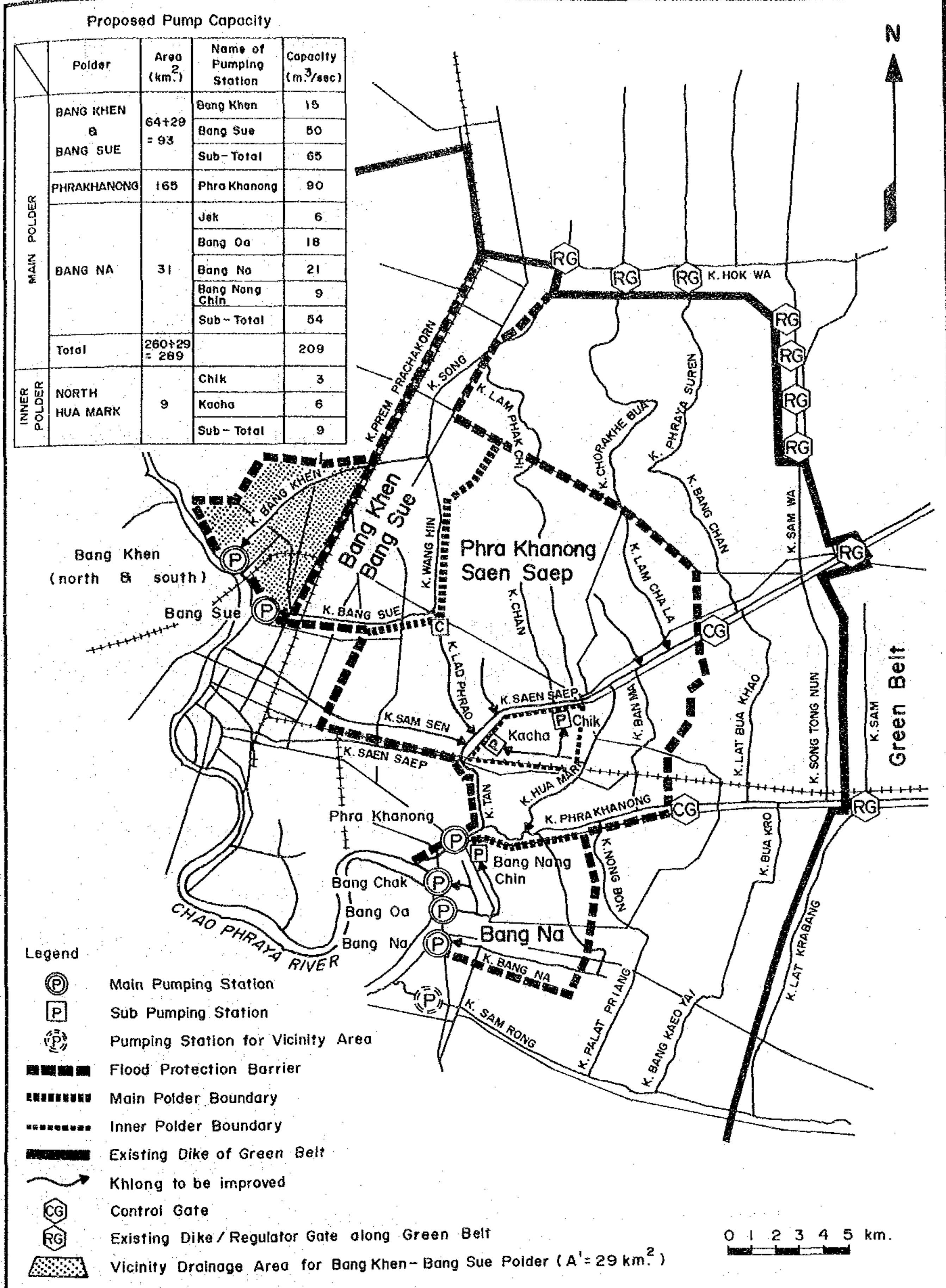


FIG. 4.2 PROPOSED FLOOD PROTECTION AND DRAINAGE FACILITIES BY JICA

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

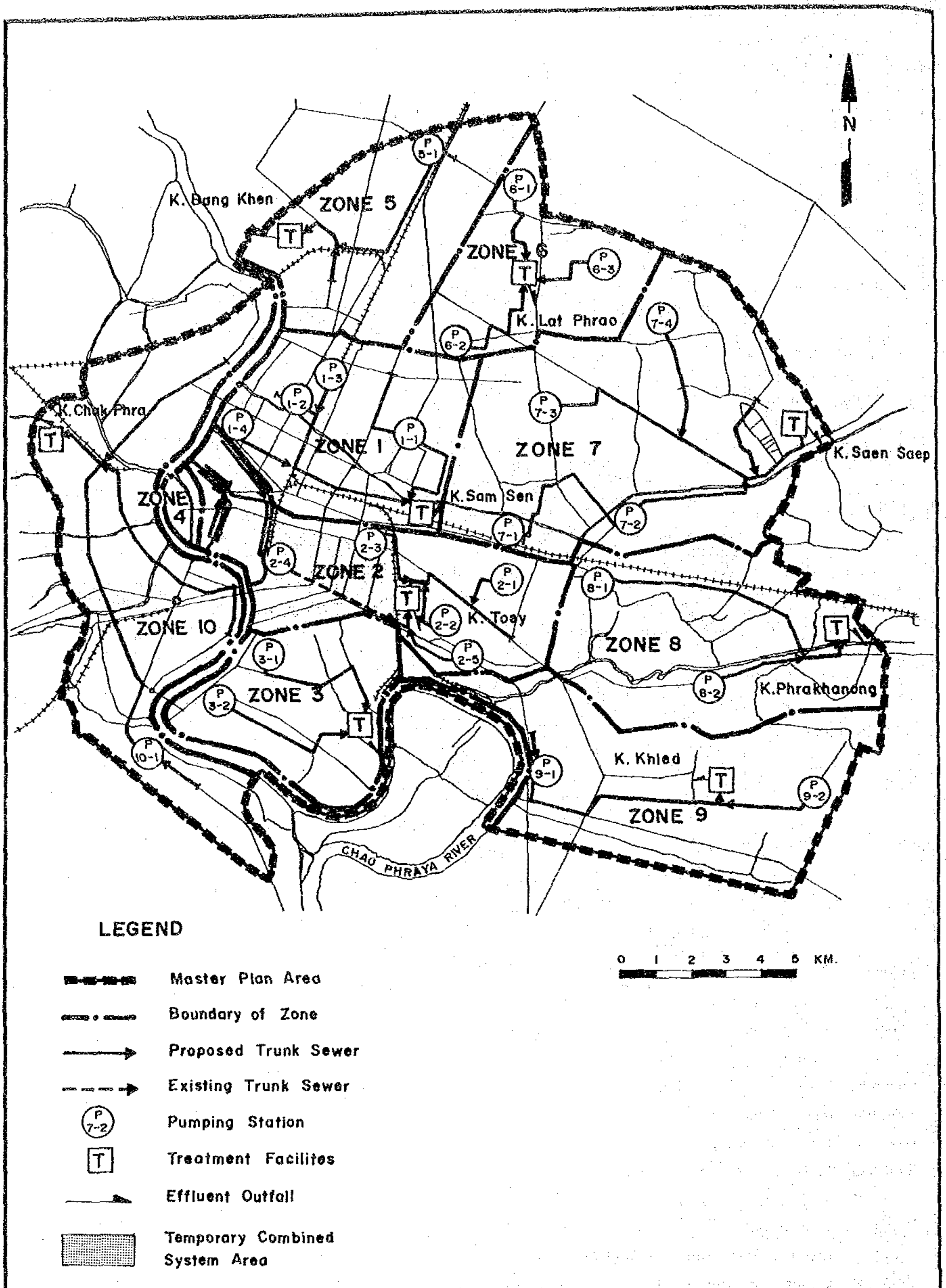


FIG. 4.3 SEWERAGE SYSTEM PROPOSED BY JICA (1981)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

Chapter 5.

POLLUTION LOAD

CHAPTER 5. POLLUTION LOAD

5.1 Population and Land Use

The Study Area covering 380 km^2 consists of 12 districts. It can be broadly divided into two (2) parts; city core area and eastern suburban area.

The present and future population of the Study Area are estimated to be 3,666,000 in 1986 and 4,751,000 in 2000 respectively. The population breakdown according to district is shown in Table 5.1.

The city core area is already highly urbanized, and no substantial change in the land use pattern will occur in future. While, the eastern suburban area will be highly developed to accommodate the increasing population. The urban land use will grow from 204 km^2 (53.7%) in 1980 to 286 km^2 (75.3%) in 2000. On the contrary, the agricultural use and open space will reduce from 176 km^2 (46.3%) in 1980 to 94 km^2 (24.7%) in 2000. The present and future land use classification is shown in Table 5.2. The present and future land use distributions are shown in Fig. 5.1 and Fig. 5.2.

5.2 Water Consumption in Study Area

The existing urban water for residential use, commercial and enterprise uses, and institutional use in the Study Area is supplied by the water supply system of the Metropolitan Waterworks Authority (MWA) and groundwater. Approximately 40% of the total population of the Study Area is served by the MWA surface water supply system and the remaining 60% is supplied by groundwater from the individual well or the MWA water supply system.

According to the MWA plan, the existing groundwater source will be all substituted by the MWA water supply before 2000 and all the water requirement in the year 2000 will be met by the MWA water supply system.

The average unit water consumption of the Study Area in 1986 is estimated to be 154 lcd for residential use and 132 lcd for commercial and other uses including enterprise and institutional uses. The calculated total water consumption of the Study Area in 1986 is 1,049,000 m^3/day.

The average unit water consumption of the Study Area in 2000 is projected to be 216 lcd for residential use and 186 lcd for commercial and other uses. The total water consumption in 2000 is calculated to be 1,910,000 m^3/day. Break-down of the unit and total water consumptions according to district under both the present and future conditions is shown in Table 5.3.

5.3 Unit Pollution Load Generation

5.3.1 Sources of Pollution Load

The major sources of pollution load in the Study Area are residential zones, large scale factory, small to medium scale factory and commercial enterprises. The pollution load generation of the Study Area is conceptualized as shown in Fig. 5.3.

Only the pollution loads from the housing estates and large scale factories are treated using wastewater treatment systems.

The general residences are provided with cess pool or septic tank for the treatment of toilet waste. However, no significant purification effects are expected from them since they are not controlled and maintained effectively. Therefore, in estimating the unit pollution load generation from general residences, the effects of septic tank and cess pool are not taken into consideration.

The pollution loads from the other sources are discharged into the klongs with no treatment.

5.3.2 Observation of Unit Pollution Load

A field survey on unit pollution load generation from two (2) housing estates of Din Daeng (population 1320) and Bon Kai (population 1900), typical residential sources, were conducted by the Study Team.

Both these *housing estates are provided with community wastewater* treatment plants.

Water quality of raw wastewater prior to treatment was observed. The results of observation are summarized in Table 5.4.

Also the Study Team carried out a field survey of unit pollution load generation from commercial enterprise for three (3) commercial areas of Suriwong Rd., Silom Rd. and Siam Square. The Suriwong Rd. and Silom Rd. are considered as the typical business areas and the Siam Square as the typical commercial area.

The results of the observation are summarized in Table 5.5.

5.3.3 Estimation of Unit Pollution Load Generation

The pollution load generation of general residences, commercial establishments, institutions and small to medium scale factories is estimated, based on an assumed unit pollution load generation (pollution load generation per capita per day). The pollution load generation of institutions and small to medium factories is included in that of commercial establishment. While, the pollution load generation of *the housing estates and* large *factories is determined* individually.

Unit pollution load generation is estimated by multiplying unit water consumption with average water quality of wastewater observed in this study. The average observed water quality (BOD) of residential and commercial wastewater are 130 mg/l and 145 mg/l respectively.

The estimated unit pollution load generation (BOD) in the Study Area varies regionally. It is in the range of 23.1 ~ 60.2 gcd in 1986 and will increase to 49.2 ~ 71.1 gcd in 2000. Break-down of the present and future unit pollution load according to district and type of wastewater is shown in Table 5.6.

5.3.4 Regional Distribution of Pollution Load Generation

Regional distribution of the pollution loads of residence, commercial establishment and others are obtained by multiplying the distributed population density by the assumed unit pollution load generation. While, the pollution load generations of each housing estate and large factory are determined individually at their respective locations.

The regional distribution of total pollution load generation in 1986 and 2000 are shown in Fig. 5.4. The total pollution load generation as BOD in 1986 and 2000 are 119,000 kg/day and 230,000 kg/day respectivelly.

5.4 Pollution Load Run-off

The pollution load run-off coefficient is defined as the ratio of the pollution load entering the klongs to the pollution load generated at the sources.

The Study Team made pollution load run-off observations at seven (7) sites for a continuous 24 hour period. The observation sites were selected from areas of various landuse pattern.

From the results of the observations, a high correlation was obtained between specific discharge and BOD run-off coefficient. BOD run-off coefficient corresponding to specific discharge is estimated as follows.

Existing average pollution load run-off coefficient of the Study Area is estimated approximately at 52% and pollution load run-off into the klongs is 61,900 kg/day as BOD in 1986.

Specific Discharge (10^3 $m^3/day/km^2$)	BOD Run-off Coefficient (%)
0 - 10	50
10 - 20	60
20 - 30	80
>30	90

Table 5.1 Present and Future Population of Study Area

District	Present Population (1986)	Future Population (2000)
Phra Nakhon	111,875	112,000
Pom Prab Sattru Pai	87,955	88,000
Sampanthawong	51,121	51,000
Pathumwan	143,199	143,000
Phya Thai	359,604	360,000
Huai Khwang	255,774	359,000
Phra Khanong	629,386	840,000
Bang Kapi	409,785	710,000
Bang Khen	548,078	809,000
Bang Rak	90,672	91,000
Dusit	562,990	772,000
Yan Nawa	415,703	416,000
Total	3,666,142	4,751,000

Table 5.2 Present and Future Land Use of Study Area

(Unit: km^2)

Land Use Classification	Present (1980)	Future (2000)
Residential	134	222
Commercial	16	24
Industrial	6	6
Institutional	37	15
Park, Sport Groud etc	11	19
Agricultural & Open Space	176	94
Total	380	380

Table 5.3 Present and Future Water Consumption in the Study Area

(Unit: m^3 /day)

District	Present (Year 1986)						Future (Year 2000)					
	Population	Residential		Commercial & Others		Total	Popula-tion	Residential		Commercial & Others		Total
		lcd	Consump-tion	lcd	Consump-tion			lcd	Consump-tion	lcd	Consump-tion	
Phra Nakhon	111,875	158	17,676	274	30,654	48,330	112,000	215	24,080	297	33,264	57,344
Pom Prab Sattru Pai	87,955	158	13,897	274	24,100	37,997	88,000	215	18,920	297	26,136	45,056
Sampanthawong	51,121	158	8,077	274	14,007	22,084	51,000	215	10,965	297	15,147	26,112
Pathumwan	143,199	158	22,625	274	39,237	61,862	143,000	215	30,745	297	42,471	73,216
Phya Thai	359,604	133	47,827	61	21,936	69,763	360,000	215	77,400	146	52,560	129,960
Huai Khwang	255,774	133	34,018	61	15,602	49,620	359,000	215	77,185	146	52,414	129,599
Phra Khanong	629,386	209	131,542	126	79,303	210,845	840,000	221	185,640	146	122,640	308,280
Bang Kapi	409,785	133	54,501	40	16,391	70,892	710,000	215	152,650	146	103,660	256,310
Bang Khen	548,078	133	72,894	40	21,923	94,817	809,000	215	173,935	146	118,114	292,049
Bang Rak	90,672	158	14,326	274	24,844	39,170	91,000	215	19,565	297	27,027	46,592
Dusit	562,990	158	88,952	274	154,259	243,211	772,000	215	165,980	297	229,284	395,264
Yan Nawa	415,703	138	57,367	103	42,817	100,184	416,000	215	89,440	146	60,736	150,176
Total	3,666,142	154	563,702	132	485,073	1,048,775	4,751,000	216	1,026,505	186	883,453	1,909,958

Table 5.4 Survey Results of Unit Pollution Load Generation from Residential Sources

Site	Date	Flow (m^3/d)	Quality (mg/l)			Pollution Load (kg/d)			Population	Per Capita Flow (lcd)	Per Capita Pollution Load (gcd)		
			BOD	COD	SS	BOD	COD	SS			BOD	COD	SS
Din Daeng	Feb. 24-25	267	99	273	91	26.4	73.0	24.2	1320	202	20.0	55.3	18.3
Din Daeng	Jul. 21-22	175	80	187	77	14.0	32.7	13.5	1320	133	10.6	24.8	10.2
Din Daeng	Sep. 7-8	190	132	308	120	25.0	58.6	22.8	1320	144	18.9	44.4	17.3
Bon Kai	Aug. 10-11	266	109	192	98	28.9	51.0	26.1	1900	140	15.2	26.8	13.7
Bon Kai	Sep. 7-8	315	220	385	154	69.5	121.5	48.5	1900	165	36.6	63.9	25.5
Total	-	1213	*128	*269	*108	163.8	336.8	135.1	7760	*157	*20.3	*43.0	*17.0

* Average

Table 5.5 Survey Results of Unit Pollution Load Generation from Commercial Sources

Name	Flow m^3/d	Water Quality (mg/l)			Pollution Load (kg/d)		
		BOD	COD	SS	BOD	COD	SS
Suriwong Rd.	5108	74	137	30	375.6	698.0	153.4
Silom Rd.	15064	60	115	75	905.5	1725.3	1134.6
Siam Square	-	305	457	133	-	-	-
Average	-	146	236	79	-	-	-

Table 5.6 Present and Future Estimated Unit Pollution Load Generation (BOD)

District	Item	Present (1986 Year)			Future (2000 Year)			Remarks
		Residen.	Commer.	Total	Residen.	Commer.	Total	
	Quality	130 mg/l	145 mg/l	-	130 mg/l	145 mg/l	-	
Dusit Phra Nakhon Pom Prab Sattru Pai Sampanthawong Pathmwan Bang Rak	Discharge	158 lcd	274 lcd	432 lcd	215 lcd	297 lcd	512 lcd	
	Pollution Load	20.5 gcd	39.7 gcd	60.2 gcd	28.0 gcd	43.1 gcd	71.1 gcd	
Phya Thai Huai Khwang	Discharge	133 lcd	61 lcd	194 lcd	215 lcd	146 lcd	361 lcd	
	Load	17.3 gcd	8.8 gcd	26.1 gcd	28.0 gcd	21.2 gcd	49.2 gcd	
Phra Khanong	Discharge	209 lcd	126 lcd	335 lcd	221 lcd	146 lcd	367 lcd	
	Load	27.2 gcd	18.3 gcd	45.5 gcd	28.7 gcd	21.2 gcd	49.9 gcd	
Bang Kapi Bang Khen	Discharge	133 lcd	40 lcd	173 lcd	215 lcd	146 lcd	361 lcd	
	Load	17.3 gcd	5.8 gcd	23.1 gcd	28.0 gcd	21.2 gcd	49.2 gcd	
Yan Nawa	Discharge	138 lcd	103 lcd	241 lcd	215 lcd	146 lcd	361 lcd	
	Load	17.9 gcd	14.9 gcd	32.8 gcd	28.0 gcd	21.2 gcd	49.2 gcd	

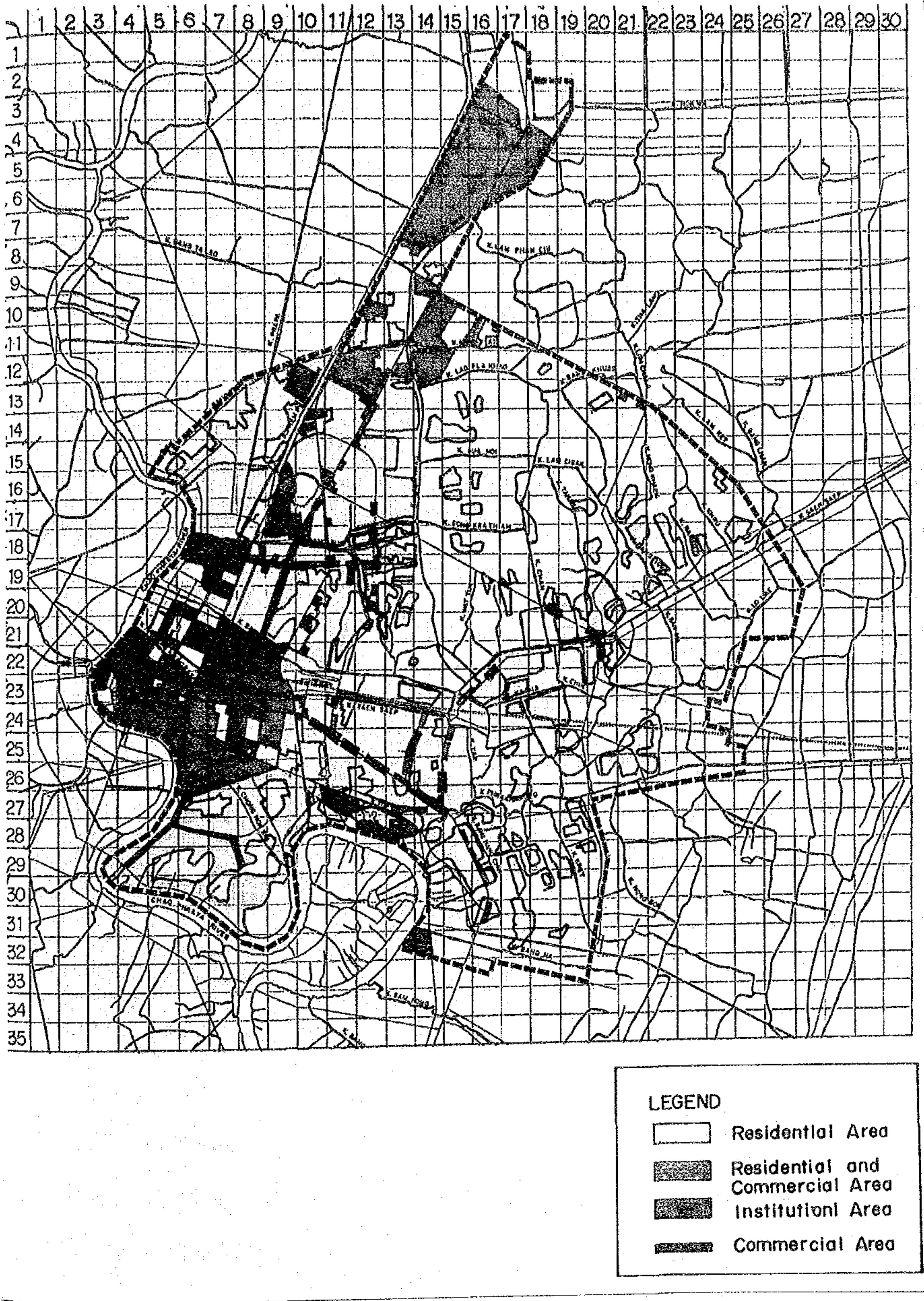


FIG. 5 . 1 EXISTING LAND USE

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

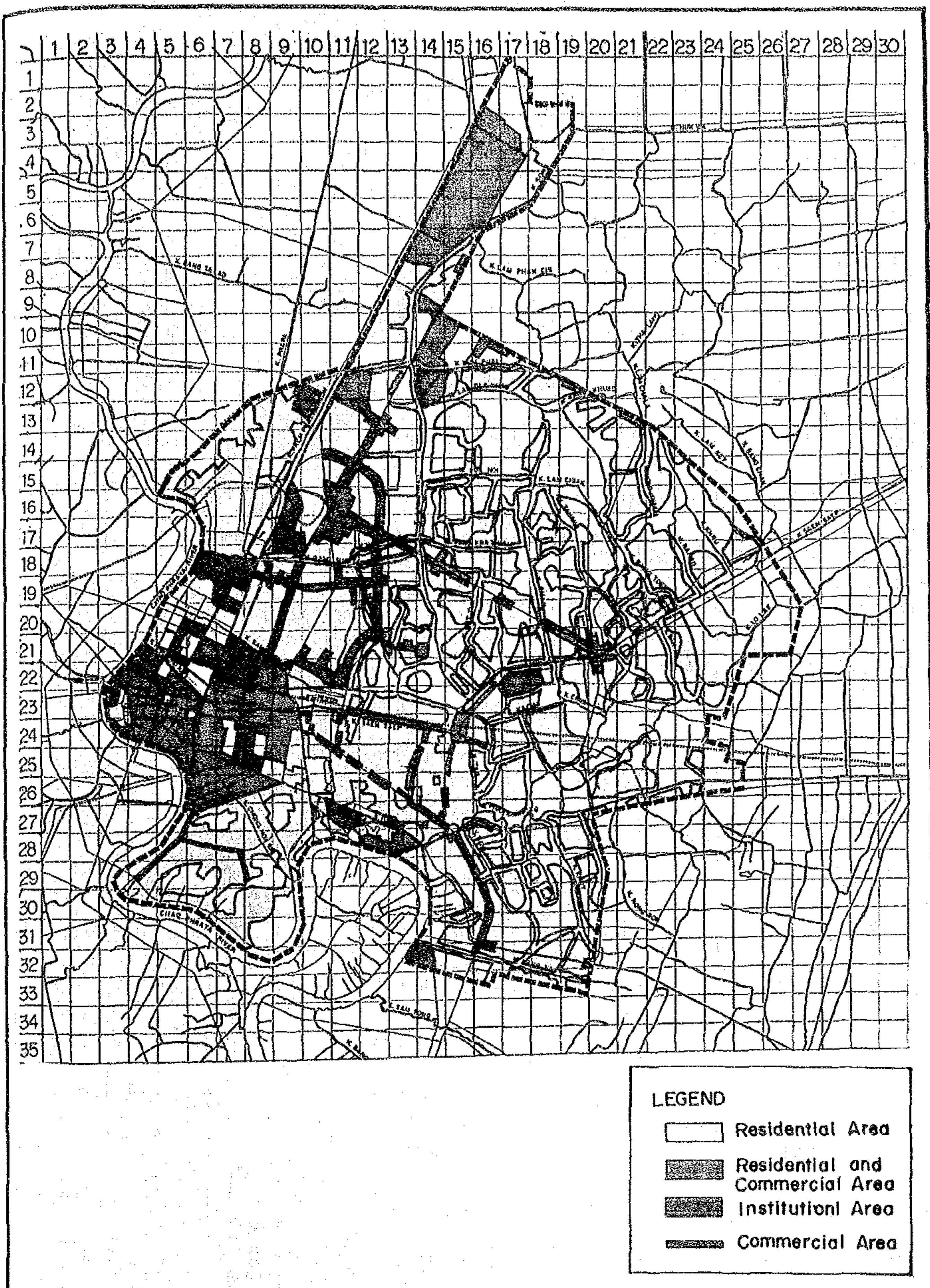


FIG. 5.2 FUTURE LAND USE

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

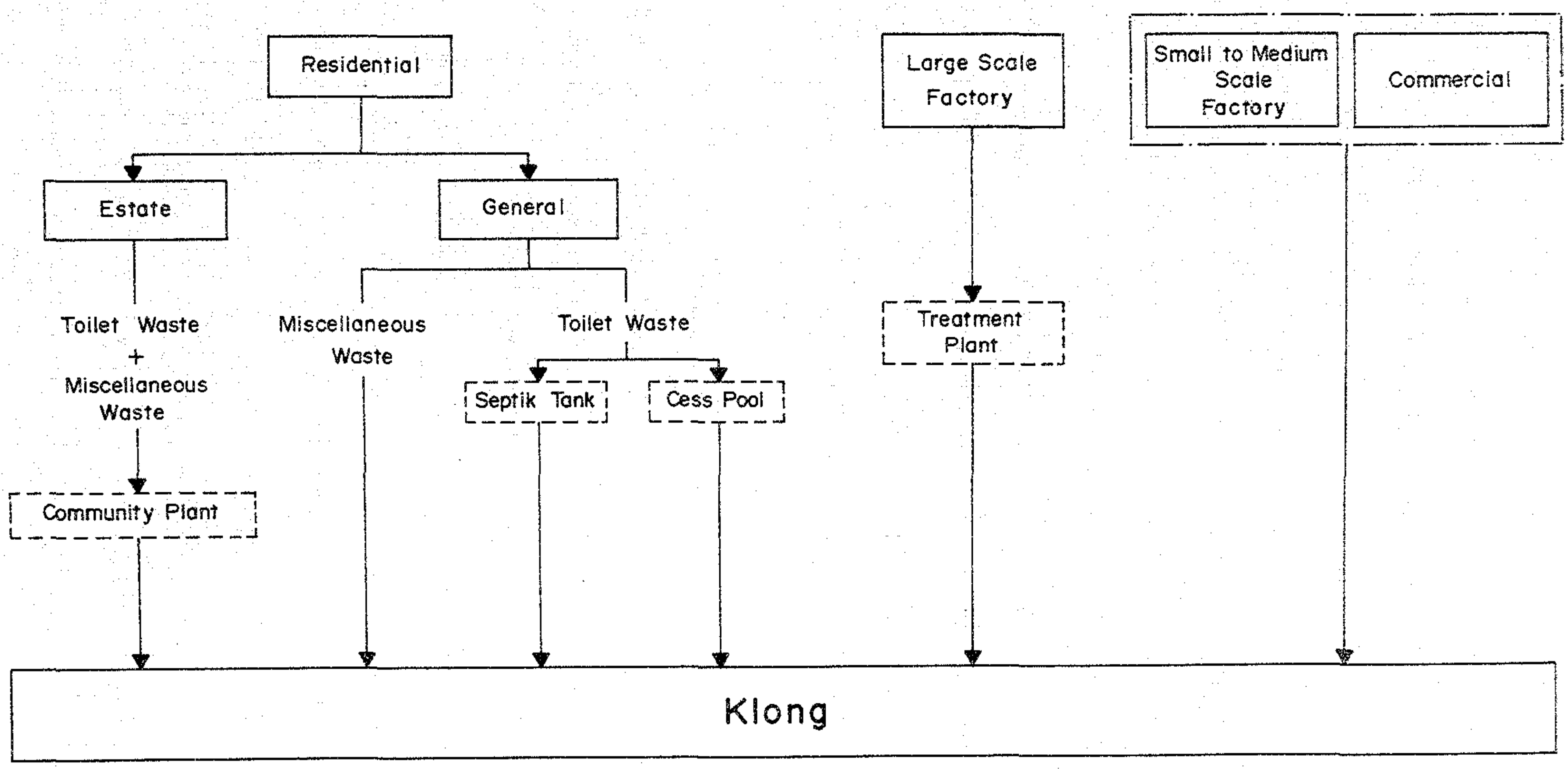
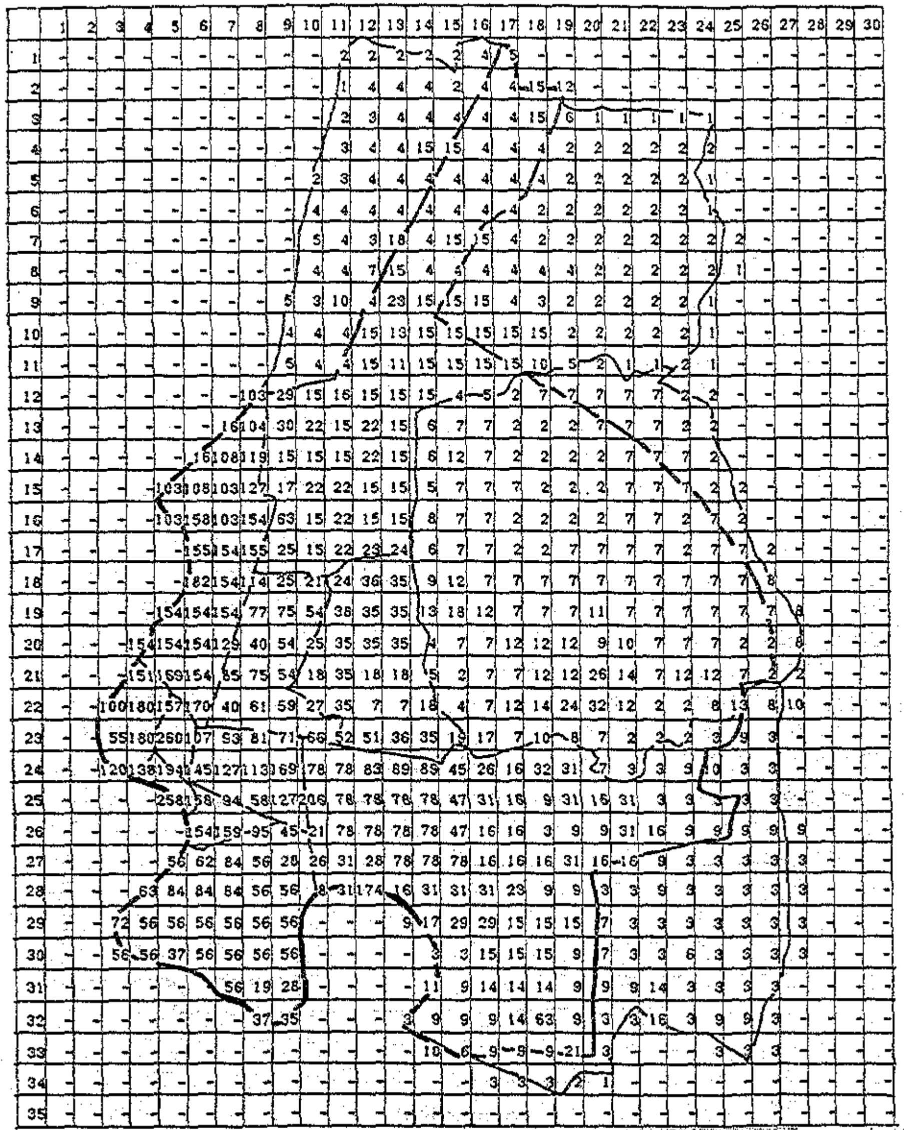


FIG. 5 . 3 CONCEPT OF POLLUTION LOAD GENERATION

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

(BOD-Exisiting)



(BOD-Future)

UNIT : *10 Kg/ d - Km²

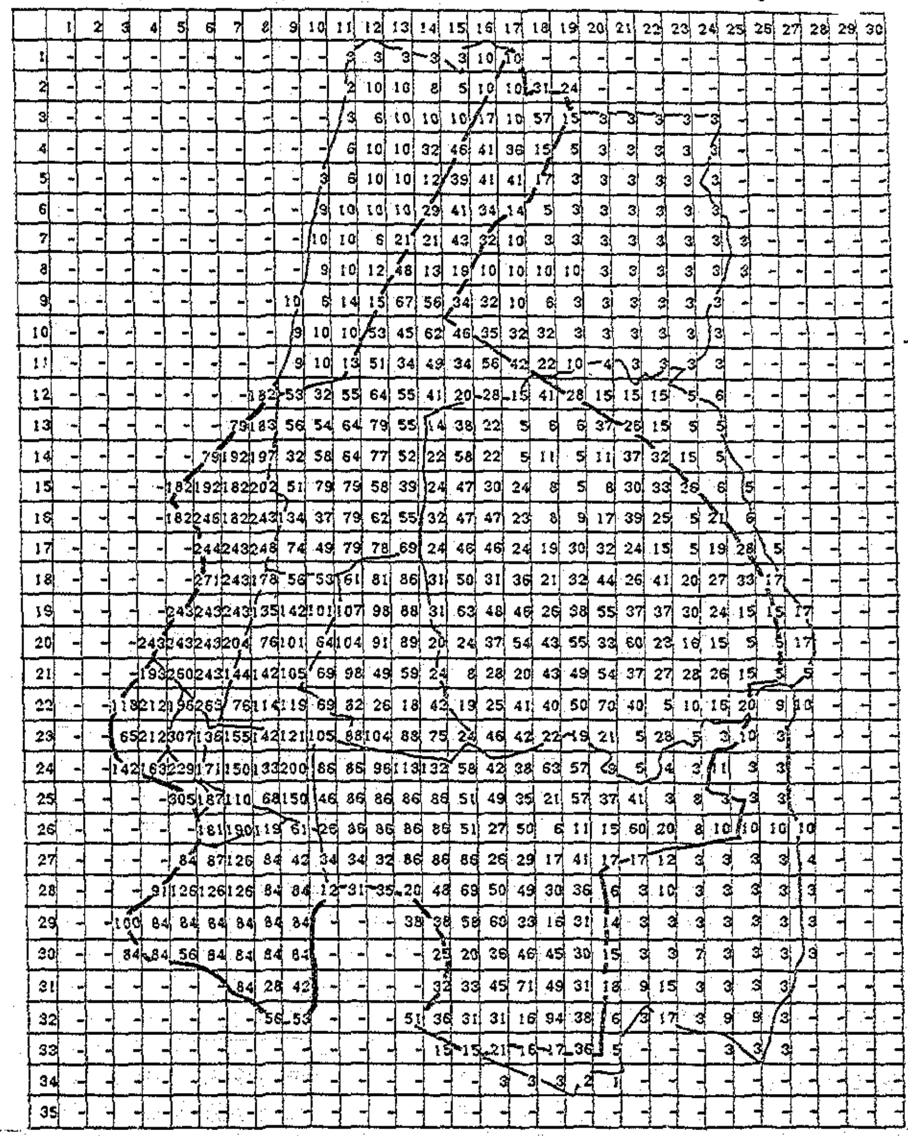


FIG. 5 . 4

REGIONAL DISTRIBUTION OF EXISTING AND FUTURE POLLUTION LOAD GENERATION (BOD)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

Chapter 6.

AERATED LAGOON TREATMENT

CHAPTER 6. AERATED LAGOON TREATMENT

6.1 General

Rama IX Pond was used in this Study to investigate the feasibility of klong water treatment by lagoon methods as a low cost option and to collect the necessary basic data for the klong water purification plan. Location of the Rama IX Pond is shown in Fig. 6.1.

Experiments were performed during both dry and rainy seasons, as these two seasons represent very different hydraulic conditions in the klongs. During each season, a number of alternatives with various pond detention times were studied to understand the effects of different detention times on treatment efficiencies and hence the water quality improvement of the klongs.

6.2 Experimental Plan

6.2.1 Overview of the Plan

The processes used in this study are as below.

Aerated lagoon → Facultative Pond → Maturation Pond

The klong water is treated in each pond, which have different biological and ecological conditions.

In the Aerated Lagoon, 3 floating type aerators were used to maintain aerobic conditions.

The Facultative Pond receives the effluent from the Aerated Lagoon. The upper layer of the Pond is aerobic, while the lower layer is anaerobic. Symbiosis between algae and bacteria, and the resultant photosynthetic oxygen is a prime source of day time DO for microbial oxidation of pollutants.

The Maturation Pond is the last stage in the treatment scheme and polishes the treated water, including the removal of pathogenic organisms, is in effect equivalent to disinfection.

6.2.2 Treatment Facilities

The pond (Rama IX Pond) draws polluted water from Klong Lad Phrao and discharges the treated water into the same klong as shown in Fig. 6.2. The water quality of klong water drawn from K. Lad Phrao during the experimental period was in the range of 13 mg/l and 22 mg/l as BOD.

The important characteristic features/specification of all facilities and equipment are as shown below.

(1) Inlet Facility	Pump 20 m^3/min. x 2 units
(2) Aerator	Floating type 11 Kw x 3 units
(3) Aerated Lagoon	Capacity 19,200 m^3 (Depth 3 m, Surface Area 6,400 m^2)
(4) Open Channel	Length 120 m, Depth 3 m
(5) Facultative Pond	Capacity 49,700 m^3 (Depth 2.5 m, Surface Area 19,900 m^2)
(6) Maturation Pond	Capacity 45,900 m^3 (Depth 2.5 m, Surface Area 18,400 m^2)
(7) Outlet Facility	Stop Log Width 2 m

6.3 Experimental Method

(1) Experimental Conditions

Several experimental cases, obtained by varying detention time, were studied. These cases of experiment are described in Table 6.1. Accordingly, four (4) number of cases with varying detention times of aerated lagoon, facultative pond and maturation pond were investigated (Case 1 ~ Case 4). Of these Case-1 and Case-3 consisted respectively of three (3), Case 1-1 ~

Case 1-3, and two (2), Case 3-1 ~ Case 3-2, experimental phases, whereas Case 2 and Case 4 consisted of one single phase for each.

(2) Experimental Schedule

The experimental work was conducted from the beginning of February to the middle of August. The schedule of the experimental work is shown in Fig. 6.3.

(3) Water Quality Analysis

1) Sampling Points

To evaluate the effectiveness of the lagoon treatment, mass balance analysis was performed across all three (3) ponds. Sampling was carried out at the following five (5) locations (ref. Fig. 6.2).

Point ① Inlet of the Aerated Lagoon
Point ② Outlet of the Aerated Lagoon
Point ③ Outlet of the Open Channel (Inlet of Facultative Pond)
Point ④ Outlet of the Facultative Pond
Point ⑤ Outlet of the Maturation Pond

2) Sampling Frequency and Time

As the minimum detention time used in this study, even in the Aerated Lagoon, is at least 8 hours, the daily variation in the influent water quality could possibly be averaged. Accordingly, sampling was done once a day at 10 AM. This sampling time is found to be quite representative to the whole day average, based on the water quality data of K. Lad Phrao.

3) Water Quality Parameter

The water quality parameters of analysis are given in Table 6.2.

6.4 Results and Discussion

The daily experimental data obtained for all the seven (7) number experiments (Case 1-1, Case 1-2, Case 1-3, Case 2, Case 3-1, Case 3-2 and Case 4) averaged over the respective ones are illustrated in Appendix-D. The daily experimental data are given in Data Book.

The removal efficiencies of BOD, COD, and Coliform Density observed at each section of the treatment system, Aerated Lagoon, Open Channel, Facultative Pond and Maturation Pond (ref. Fig. 6.2), for all four (4) experimental cases, Case 1 ~ Case 4, are given respectively in Table 6.3 ~ Table 6.6. Accordingly the T-BOD removal efficiency in Aerated Lagoon is of about 40-60%. This may be due to the low BOD of the influent water from klong Lad Phrao.

Fig. 6.4 shows the correlation between the removal efficiencies of T-BOD and T-COD and the detention time in the Aerated Lagoon for all 4 cases. In this figure, the value of each removal efficiency was averaged for all the phases of Case 1 and Case 3 where the same operational conditions prevailed. As such, each case is represented only by a single point.

While T-BOD removal efficiency remained practically unchanged over the whole detention times studied, the T-COD removal is related to the detention time and/or the magnitude of aeration. Therefore, from the point of view of COD removal, it seems about one day detention time in Aerated Lagoon is required for the satisfactory treatment of klong water.

6.5 Experimental Conclusion

The experimental results of all cases were discussed in details in Appendix-D, and based on these, the following conclusions were made.

(1) From the experimental results obtained using the lagoon system it is clear that the variation in detention time and magnitude of aeration of the Aerated Lagoon, did not exert any significant influence on the overall treatment efficiency of BOD. This may be attributed to low pollution load of influent wastewater.

(2) A very significant improvement in color and odor is attained in the three (3) ponds. Black color in klong water changed to brown color in the Aerated Lagoon and to green color in the Facultative and Maturation Ponds, respectively. Odor was almost undetectable in any ponds.

(3) The Aerated Lagoon is effective with respect to BOD and COD removals. The removal efficiencies of T-BOD and T-COD in the Aerated Lagoon are approximately 50% and 30%, respectively, when the detention time is almost one (1) day.

(4) Algal growth in facultative and maturation ponds affect the overall removal efficiencies of T-BOD and T-COD. However, if some method of algal harvesting at the outlet of the Maturation Pond can be considered, it can be inferred that these removal efficiencies be increased.

(5) With respect to the effect of removal of pathogens, the Facultative and Maturation Ponds exhibit very high removal efficiencies, an important advantage from a public health viewpoint, though the algal growth contribute to increase in effluent BOD load.

6.6 Potential Ponds for Klong Water Purification

Eight (8) pond sites, locations of which are shown in Fig. 6.5, were identified in the Study Area as potential ponds for klong water purification.

The name, area, depth, storage capacity, land ownership of the ponds and the klong waters that could be diverted along with their pollution levels are given below.

Name of Pond	Area (ha) & Depth	Storage Capacity (m^3)	Target Klong (Name) & Pollution Level	Ownership
(1) Paholyothin Cargo Station	10 (S)	220,000	K. Premprachakon (M)	Government
(2) Makkasan	16 (S)	310,000	K. Sam Sen (H)	Government
(3) Tobacco Factory	20 (S)	680,000	(Sewage Line) (H)	Government
(4) Huai Khwang	6 (D)	570,000	K. Lad Phrao (H)	Private
(5) Rama IX Pond	20 (S)	300,000	K. Lad Phrao (H)	Government
(6) Klong Chan	6 (D)	250,000	K. Tanang (M)	Government
(7) Klong Kum	2.5 (S)	30,000	K. Bang Toei (M)	Government
(8) Rama IX Park	10 (S)	90,000	K. Nung Bon (M)	Government
Total	90.5	2,450,000		

S: Shallow (pond depth less than 4 m)
D: Deep (pond depth more than 4 m)
H: Highly polluted klong
M: Moderately polluted klong