Assuming the average depreciation (service life) of pumps and aerators as seven (7) years, the annual replacement cost of pumps and aerators are estimated as follows:

	Pumps	Aerators
Foreign portion :	4.18 million Baht per annum	2.4 million Baht per annum
Local portion :	0.32 million Baht per annum	0.31 million Baht per annum

3.3 Other Operation and Maintenance Costs

Other necessary work for the klong water purification project will be:

- Periodical water quality monitoring
- Data collection and processing, preparation of pump and gate operating methods, and transmission of the operating instructions

The above work is assumed to be conducted as a part of the DDS's routine work in the Flood Control Operation Center. Therefore, the operation and maintenance costs related to the above work was not appropriated for the klong water purification project.

3.4 Annual Operation and Maintenance Cost

Annual operation and maintenance cost of the proposed system of klong water purification plan is 56.3 million Baht per annum.

4. Institutional and Organizational Aspects

4.1 Introduction

Since 1960, the Government has established various laws and regulations required for the improvement and conservation of the water quality of public water bodies, such as rivers and klongs. Under these laws and regulations, improvement and conservation of the klongs in the Bangkok Metropolitan area have been delegated to the department of Drainage and Sewerage (DDS) of the Bangkok

Metropolitan Administration (BMA), which is under the jurisdiction of the Central Government such as the Ministry of Interior and other authorities concerned. Despite the untiring efforts of the DDS, the water pollution of the klongs has become worse year by year due to limited finance, lack of qualified engineers, lack of strict surveillance against illegal offenders, etc.

This chapter outlines the existing institutional and organizational framework including laws and regulations concerned to the klongs.

4.2 Existing Laws and Regulations with Regard to Purification of Klong Water

Major laws and regulations concerning the purification of the klong water is as follows:

(1) Improvement and Conservation of National Environmental Quality Act B.E.2518(1975), B.E.2521(1978),

(2) Public Health Act B.E.2484(1941),

(3) Act for the Cleanliness and Orderliness of the Country B.E.2503 (1960),

(4) By-Law of Bangkok Metropolis; Re : Maintenance of Cleanliness and Orderliness in Bangkok Metropolis Areas B.E.2523(1980),

(5) Factories Act B.E.2512(1969), and

(6) Poisonous Substance Act B.E.2510(1967), B.E.2516(1973).

(1) Improvement and Conservation of National Environmental Quality Act

This Act, which is a basic law for the conservation of environmental quality in Thailand, was enacted in 1975 and a part of that was revised in 1978. Main provisions of the Act are as follows:

- The National Environment Board (NEB), which was created under this Act, is a supreme administrative organization concerning the national environments (Article 4).

- Provisions of Articles 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 prescribe duties, responsibilities, functions, appointment and dismissal of members, and operation of the Board.

- The Office of National Environment Board (ONEB) executes the environmental administration under the supervision and control of the Secretary General of the NEB, and duties and responsibilities of the ONEB are provided in Article 12.

- Provisions in respect to the environmental administration are provided in Articles 18 and 19.

- Article 17 provides that the Prime Minister shall have the authority to announce the following prescriptions in the Government Gazette with the advice and consent of the NEB:

  (a) Category and size of the project and business of execution body which entails reporting and submitting to the NEB in respect to effects of the environmental quality,

  (b) Quality standard of environments, and

  (c) Method to be used for examining the environmental quality.

- In addition to the above provision, in Article 20 the authority of the Prime Minister is prescribed concerning the prevention of damage in case of emergency due to environmental pollution, and further in Article 28 it is prescribed that the Prime Minister shall be responsible for implementation of this Act.

- Cooperation of people regarding improvement and conservation of the environmental quality and penalties for violating the regulation of this Act are prescribed in seven (7) provisions from Article 21 to Article 27.

As mentioned above, this Act is a basic law which prescribes improvement and conservation of the national environmental quality, including the establishment of the NEB and the ONEB.

(2) Public Health Act

This Act, which was enacted in 1941, is a general law in respect to public health including public nuisance, and prescribes the authority and functions, of the regional government concerning the public health. The Minister of Interior is in charge of the execution of this Act and has the authority to issue the Ministerial Regulations for executing the provisions of this Act.

The Act consists of nine (9) chapters concerning sanitation, animals, water trading in food, ice and other articles, power of inspection, miscellaneous, transitory provisions and penalties, covering 78 articles. However this Act, which prescribes a general public health, has only a few provision with regard to the klong water as follows:

- Article 6 prescribes that the disposal of rubbish, filth and dirt in the area of any locality shall be within the competency of the authority of that locality, and that the local authority shall have the authority to issue the by-laws or rules of the local government for the fallowing purposes:

  (a) prohibiting the laying, pouring, throwing or causing into public places any rubbish, filth and dirt which are likely to impair health or cleanliness, and

  (b) taking any other measures which are deemed the necessary in order to conform to the sanitary conditions.

- Furthermore, Article 19 provides that the official of local government shall have the duty to remove, prohibit and abate nuisances in places which trend to impair or are likely to be prejudicial to the health, safety or right and liberty of the public, and that shall look after and keep free from nuisances all streets, roads, watercourses, gutters, trenches, canals and other places within their district.

- The legal procedures, which should be taken by the local official to control the nuisances, are prescribed in provisions from Article 20 to Article 30, and finally the penalties for violators of the local governmental by-laws or rules issued under this Act are provided in provisions from Article 67 to Article 78.

(3) Act for the Cleanliness and Orderliness of the Country

Apart from the said Public Health Act, there is a public cleanliness law which is called the "Act for the Cleanliness and Orderliness of the Country B.E.2503(1960)". This Act aims at maintaining the cleanliness and orderliness of the whole area of Thailand. The Ministry of Interior is in charge of this Act and the local authority is responsible for executing this Act.

The Act prescribes for conserving the klong and its water quality in the provision of Article 5, as follows:

- Persons bathing or washing on the road or in river or canal or at any places forbidden by the notice of the local authority, shall be punishable with a fine not exceeding 200 Baht.

Where, the Act defines that "local authority" in the municipal area as the Lord Mayor, in the health area as Chairman of the Health Committee and in areas outside the municipal or health areas as the Amphar officer.

(4) By-Law of Bangkok Metropolis: Re : Maintenance of Cleanliness and Orderliness in Bangkok Metropolis Areas

Under the said Act for Cleanliness and Orderliness of the Country, the Bangkok Metropolis enacted a municipality by-law called the "Maintenance of Cleanliness and Orderliness in the Bangkok Metropolis Areas" in 1980. Chapter 2 of this by-law prescribes the maintenance of drains in the Bangkok Metropolis areas, as follows:

- Any person who, without an appropriate cause, enters or leads, chases or direct animals into an area of public drains or water resources where Bangkok Metropolis has displayed a sign of prohibition is liable to a fine of not exceeding five hundred Baht.

- Any person who pours or throws animal remains and refuse into public drains or water resources is liable to a fine not exceeding one thousand Baht.

- Any person who pours or throws, acts in any manner to cause gravels, rocks, dirt, sand or construction material leavings to flow or fall into drain-pipes used for the public as drains is liable to a fine not exceeding two thousand Baht.

- Any person who pours, throws, releases or discharges the excretions and refuse from buildings or vehicles into the public drains or water resources is liable to a fine not exceeding three thousand Baht.

- Any person who fills or construct anything in drains or does anything in any way to clog and obstruct drains without the lawful permissions is liable to an imprisonment for a period not exceeding one (1) month or a fine not exceeding five (5) thousand Baht, or both.

Where, the by-law defines that the public drains mean river, canal, ditch, channel, passageway and drain-pipe used commonly for the public.

Despite the existence of said Act and by-law, purification of the klong water in the Bangkok city is still not achieved due to lack of sense of public morality and inadequate finance.

(5) Factories Act

The Factories Act, which was enacted in 1969 along with the repealment the Factories Acts of 1939 and 1960, is a basic law concerning establishment, operation and control of factories in Thailand. Afterwards, a part of provisions of the 1969 Factories Act was amended by the Factories Acts of No.2 (1975) and No.3 (1979).

This Act comprises five (5) chapters of (i) establishment and Operation of factories, (ii) control of factories, (iii) suspension and revocation of license, (iv) penalty provisions and (v) transitory provisions, with provisions of 55 articles, and it is prescribed in Article 5 that the execution of this Act is under the authority and control of the Minister of Industry.

Of provisions in this Act, Items (6) and (14) of Article 39 are directly concerned with the purification of klong water. Article 39 prescribes as follows:

- Persons who have a license to operate the factory shall have the following duties:

  (a) to make an arrangement for removal of sewage, drainage and ventilation, and

  (b) to carry out the factory work without causing any disturbance under the Public Health Act.

  Further, Article 50 prescribes a penalty for violators against the above-mentioned provision, as follows:

  Any person licensed to operate a factory who fails to comply with Article 39 (6) or (14) shall be punished with imprisonment not

exceeding one (1) month or fine not exceeding ten thousand Baht, or both.

A Ministerial Regulation under this Act was issued for the purpose of a concrete execution of the Act, and the Regulation prescribing the treatment of wastewater in provision of Article 8 is as follows:

- The factory with a drainage must provide a correct and suitable wastewater treatment equipment with a written explanation showing that the drainage does not cause danger, damage or any disturbance with the equipment.

(6) Poisonous Substance Act

The Poisonous Substance Act was enacted in 1967 (amended in 1973 partially) for the purpose of prementing the injury to persons, animals and property from various poisonous substances. This Act is operated under a joint jurisdiction of three Ministries ; Agriculture & Co-operatives, Industry and Public Health.

Under this Act, there is a committee called the "Poisonous Substance Restriction Committee". Members of the Committee consist of an Under-Secretary of the Ministry of Agriculture & Co-operatives and seven (7) representatives from four (4) Ministries of Interior, Defense, Commerce and Finance, and the said three (3) Ministries. The Committee has responsibilities to provide advice of notification and approval with respect to the poisonous substance to the Ministers concerned, and the said three (3) Ministers have the power to issue the notification of Ministry by the advice of the Committee.

This Act has no provisions which prescribe directly the water pollution of the klong due to the poisonous substance.

The Notification of the Ministries of Agriculture & Co-operatives, Industry and Public Health in 1982 has the following provisions relating to the klong water:

- In Article 3, poisonous chemical substances and their vessels shall not dispose in water areas, and

- factories manufacturing poisonous chemical substances shall provide the treatment equipment so that the wastewater would not harm to the people and living things.

As a provision of penal regulation to the violator of the above provisions,

- any person who fails to comply under Article 3 shall be punished with imprisonment not exceeding three (3) months or a fine not exceeding one thousand Baht, or both.

Further, the Notification of the Ministry of Agriculture & Co-operatives in 1982 prescribes for the manufacturer of poisonous substances as follows:

- In Article 1, the factories manufacturing the poisonous substance shall be located at distance not less than 100 meters from rivers and canals, and

- Wastewater including the poisonous substances and their vessels shall not flow into the public drainage canals and ditch.

4.3 Existing Organizational Structure of Authorities Concerned

As is obvious from laws and regulations in the previous section 4.2, that the National Environment Board (NEB) and the Office of the National Environment Board (ONEB) are the central government authorities responsible administration and execution of programmes concerning the conservation of environmental quality and pollution control of the country.

Ministry of Public Health, Ministry of Industry and Ministry of Agriculture & Co-operatives also are in charge of the affairs concerning the environmental pollution control through the

Ministerial Regulation and the Notification of Ministry in accordance with the laws such as the Public Health Act, the Industries Act and the Poisonous Substance Act.

The executing agency with regard to the operation and maintenance of the klong and its water quality in the Bangkok Metropolis area is the Department of Drainage and Sewerage (DDS) of the Bangkok Metropolitan Administration (BMA) under the administrative control of the Ministry of Interior.

Considering the present state of the environmental administration mentioned above, the organizational structure of the DDS and the BMA which relate directly to the Project are only mainly discussed in this section. Besides, the institutional and organizational structures of NEB and ONEB, which are the central authority of the environmental administration, are also outlined below.

(1) The National Environment Board (NEB) and the Office of the National Environment Board (ONEB)

1) The National Environment Board (NEB)

The National Environment Board (NEB), which was created under the "Improvement and Conservation of National Environmental Quality Act (1975)", is composed of a chairman who is the Deputy Prime Minister and other members, consisting the secretary general of this Board, the under-secretaries of the Ministries concerned, the secretary general of the National Economic and Social Development Board and other persons appointed by the Cabinet Council. Where, the Ministries concerned mean the Ministries of Defense, Interior, Agriculture & Co-operatives, Industry and Public Health.

Under the Improvement and Conservation of National Environmental Quality Act, the NEB is entrusted with the following duties and responsibilities:

- to recommend the national environmental policy to the Cabinet council,

- to formulate development plans for the implementation of environmental policy,

- to submit proposals for the promotion, improvement and conservation of environmental quality to the Cabinet council,

- to report any projects which may have an adverse environmental effect to the Cabinet council,

- to recommend environmental quality standards and enforcement measures to the Cabinet council,

- to recommend sanctions against violators of the environmental quality standards to the Cabinet council,

- to submit an annual report on the situation of the national environmental quality to the Cabinet council,

- to coordinate among Government agencies, state enterprises and private sectors in the matter of improvement and conservation of environmental quality,

- to consider any other matters concerned with environmental quality requested by the Prime Minister or the Cabinet council, and

- to perform any other functions to be duties and responsibilities of the NEB under the laws and regulations.

The NEB has an administrative sub-structure called the "Office of the National Environment Board", in carrying out the practical affairs of the NEB's activities.

2) The Office of the National Environment Board (ONEB)

The Office of the National Environment Board (ONEB) was created as an executive secretariat and operational arm to the NEB under the said Act. The organizational structure of ONEB is shown in Fig. G.3. Apart from the above affairs for the NEB, major duties and responsibilities of the ONEB are as follows:

- to analyze the environmental condition so as to conserve and enhance the national environmental quality,

- to coordinate the government agencies as an overall policy maker in proposed plans, standards, and administrative and legislative measures for the enhancement and conservation of environmental quality,

- to examine and evaluate the compliance with the laws and regulation regarding protection and conservation of the environmental quality, by government agencies, state enterprises and private sectors.

To perform these affairs, the ONEB administration is organized into five (5) divisions; Office of the Secretary, Information and Environmental Quality Promotion Division, Environmental Policy and Planning Division, Environmental Impact Evaluation Division and Environmental Quality Standards Division, and are assigned with the following duties:

(a) Office of the Secretary:

Is in charge, as an administrative organ for the ONEB, with record-keeping, liaison with other units in the ONEB, finances, and compilation and amendment of laws on the environment.

(b) Information and Environmental Quality Promotion Division:
Is in charge of the following affairs;

- to serve as a center for coordination and public relations on the promotion of environmental quality within the country and with foreign countries,

- to prepare, publish and distribute the ONEB journal, the official document and other information materials,

- to carry out the environmental education and training, and others.

(c) Environmental Policy and Planning Division:
Is in charge of the following affairs:

- to develop the alternatives of environmental policy,

- to formulate the management system, implementation programmes, and long-term and short-term plans of the ONEB activities, and

- to watch activities of the government agencies, state enterprises and private sectors to ensure compliance with the national environmental quality standards, including the prevention of pollution from industry, energy and agriculture.

(d) Environmental Impact Evaluation Division:
Is in charge of the following affairs:

- to supervise the planning, design and operation of development projects in the country to assure that these project incorporate reasonable measures for conserving the environmental resources,

- to implement the Environmental Impact Statement (EIS) program, including the provision of technical guidelines and advice for preparing the EIS reports by the project proposers, and

- to carry out the special studies and researches needed for planning the environmental protection for regions which are considered to be specially sensitive from the view-point of environment, including the Chao Phraya River, Mae Klong River, the Songkla Lake, the beach resorts of Pattaya and Phuket, the Khao Yai Park, and other special resources areas.

(e) Environmental Quality Standard Division:

Is in charge of the following affairs:

- to monitor the environmental quality and to collect the data needed for conservation of the environmental quality,

- to recommend the minimum criteria or standards needed for assuring the reasonable protection of environmental resources such as water, land, air, etc., and

- to study projects on the special environmental problems in cooperation with other government agencies.

(2) Bangkok Metropolitan Administration (BMA)

The Bangkok Metropolitan area, which is the most developed region in the country is under the jurisdiction of the Bangkok Metropolitan Administration (BMA). The BMA was established in 1975 under the Bangkok Metropolitan Administration Act (BMA Act). The BMA Act has been amended five (5) times since 1975 and at present the BMA Act

(No.5) 1985 is applied for the regulation of the BMA which is under the control of the Minister of Interior.

The administration of the Bangkok Metropolis consists of the Bangkok Metropolitan Assembly and the Governor under the BMA Act. The members of the Assembly and the Governor are elected by means of public voting by electors who are qualified under this Act. The total number of members of the Assembly is determined on the basis of one (1) member for every one hundred qualified inhabitants in the Bangkok Metropolitan area. The Assembly has the power such as the deliberation of by-laws and regulations concerning the BMA, the submission of bills, the supervision of administrative operation of the BMA, and the enactment of the Assembly's regulations. On the other hand, the Governor also has the special power to veto even by-laws and regulations which have been approved by the Assembly.

The Bangkok Metropolitan area, with an area of 1,569 km^2 and a population of 5.5 million in 1986, is administratively divided into 24 districts. The BMA, which administers this area, is at present composed of 11 departments, 4 offices and 24 district offices as illustrated in Fig. G.4. The said four (4) offices act as secretariats for the Governor, the Assembly, the Civil Service Commission and the Under-Secretary of State for the BMA, respectively.

Each department, under the control of the Governor and the Under-Secretary of State for the BMA, report to them concerning the functional aspects of each department and advice the districts regarding the techniques and the operational procedures. The BMA has duties and responsibilities, through the specialities of respective department, for the improvement and maintenance of transportation, communications, water supply, electricity, drainage, sewerage, public welfare, public health, medical services, cleanliness and orderliness, and environmental quality in the area.

Each department is composed of 5 to 30 divisions, and each division has sub-divisions or sections which are the smallest units in the organization of the BMA. These departments function as staff

agencies, while the district office function as operation agencies. Number of employees of the BMA in 1986 was about 40,000 in total, consisting of government officials of 13,000, permanent employee of 16,000 and temporary employee of 10,000. The staffing breakdown, except the temporary employee, is given by each office and department in Table G.3.

The revenue and budget expenditures of the BMA are prescribed by the by-law of the BMA. The budget of the BMA was 6,400 million Baht in 1987, and made no great annal fluctuation in amount as shown in Table G.4. Of the revenue, the taxation and the government subsidy accounted for 70% and 20% of the total revenue, respectively. On the other hand, in the budget expenditures in the same year, the cost of flood prevention and wastewater treatment was about 1,000 million Baht or 15% of the total expenditures, following 1,500 million Baht for the public works, 1,100 million Baht for the education and 1,100 million Baht for the administration.

Apart from the ordinary budget mentioned above, the budget expenditure for development in 1987 amounted 1,260 million Baht. The development budget of the flood prevention, drainage and wastewater treatment sectors in the same year was 139 million Baht or 11% of the total development budget. The government subsidy included in the development budget of the BMA in 1987 accounted for 23% in the total development budget, and 11% in the flood prevention, drainage and wastewater treatment sectors (see Table G.5). Such development budget will tend to increase for the time being, due to the stimulus of active investment by the domestic and foreign enterprises.

(3) Department of Drainage and Sewerage (DDS)

1) Organization and Functions

The Department of Drainage and Sewerage (DDS) was established in 1977 separately from the Department of Public Cleansing because of increase in affairs concerning the drainage and flood prevention. The DDS consists of one (1) office and four (5)

divisions; the Office of the Secretary, the Technical Division, the Drainage Control Division, the Canal Maintenance Division, the Wastewater Control Division and the Heavy Equipment Division, under the control of the Director and the Deputy Director. Further, each division is divided into 5 to 11 sections as shown in Fig. G.5 and its breakdown is summarized below:

Division	No. of Sections
(a) Office of the Secretary	6
(b) Technical Division	9
(c) Drainage Control Division	11
(d) Canal Maintenance Division	10
(e) Wastewater Control Division	5
(f) Heavy Equipment Division	5
Total	46

Respective office and divisions have responsibilities and functions as follows:

(a) Office of the Secretary is responsible for the general administration, financial, personnel, legal affairs and contracts.

(b) Technical Division is responsible for research and development, project planning on flood protection drainage and sewerage, design and construction supervision, and information analysis.

(c) Drainage Control Division is responsible for operation and maintenance of the flood protection, drainage, sewer and related facilities.

(d) Canal Maintenance Division is responsible for maintenance and improvement of klong, operation and maintenance of coffer dona and right of way control.

(e) Wastewater Control Division is responsible for the water quality monitoring, design and construction of small wastewater treatment plant (WTP), operation and maintenance of WTP.

(f) Heavy Equipment Division is responsible for the procurement, maintenance and services of heavy equipment, pumps, vehicles including the supply of fuel and lubricants.

The allocation of employers and officials to various divisions of DDS are shown respectively in Tables G.6 and G.7. As evident from these figures, the number of officials is only 13% of the total employee, and further only a 13% of the officials (about 60 persons) are engineers. Most of these engineers are engaged in the daily routine work, and the sanitary engineers who could be assigned for any specific project are very few. It seems that this matter is an important factor affecting the promotion of improvement of the klong and its water quality.

(2) Budget

The main job of the DDS at present is drainage control and canal maintenance, and more than four-fifth of the annual budget of the DDS are allocated for the Drainage Control and Canal Maintenance Divisions. The budget expenditures of the DDS increased from 420 million Baht in 1984 to 537 million Baht in 1988 at the average growth rate of 6% per annum, however the 1988 budget decreased by 140 million Baht compared with the 1987 budget of 677 million Baht (see Table G.8). This decrease was mainly due to reductions in the budgets for the klong maintenance and the city core flood protection project. But, considering the fact that the klong is in a very bad condition with respect to the environmental sanitation at present, and the purification of the klong water will accrue a great benefit, the budget is expected to be further increased for the said drainage control and klong maintenance sectors as well as the flood protection project.

Table G.1 Proposed Monitoring Station and Monitoring Indexes by the Project for the Procurement of Equipment for Flood Control Center in Bangkok and Its Vicinity

No. of Monitoring Station	Location of Monitoring Station	Monitoring Indexes						
		Rainfall	Water Level		Gate Opening	Pump Operation	Water Quality	
			Inside	Outside			D.O.	Conductance
M1	K. Song (Don Muang) W.D.	o	o	o	1			
M2	K. Prem Prachakorn W.G.	o	o	o	1			
M3	K. Lat Phrao	o	o					
M4	K. Lam Charat	o	o					
M5	K. Bang Khen (South) P.S.	o	o	o	1	4		
M6	K. Bang Sue P.S.		o		2	12		
M7	K. Lat Phrao W.G.	o	o	o	1			
M8	K.Saen Saep (Wat Banphen Tai) C.D.	o	o	o				
M9	K.Saen Saep (Minburi) W.G.	o	o	o	1			
M10	K. Sam Sen P.S.		o	o	2	10		
M11	K. Krung Kasem W.G.	o	o	o		5		
M12	Flood Control Center	o						
M13	K. Sam Sen W.G.		o	o	2			
M14	K. Saen Saep P.S.	o	o	o	2	5	o	o
M15	K. Saen Saep (Bang Kapi)	o	o					
M16	K. Krung Kasem P.S.	o	o	o	1	5	o	o
M17	Rama IV P.S.	o				4		
M18	K. Phrakanong P.S.	o	o	o	6	35		
M19	K. Bang Jek P.S.		o	o	2	2		
M20	K. Phrakanong (Wat Khachon Siri)	o	o					
M21	K. Phrakanong (Wat Krathum Sua Pra) C.D.	o	o	o				
M22	K. Phrakanong (Lat Krabang) W.G.	o	o	o	1			
M23	K. Wat Sai C.D.	o		o				
M24	K. Bang Oa P.S.	o	o		2	6		
M25	K. Bang Na P.S.		o	o	2	5		
M26	K. Sam Rong P.S.	o	o	o	3	25		
	M. D.							
	R. I. D.							
	Total	21	41		30	118	2	2

Table G.2 Comparison of Pump Operation Hours for Drainage and Water Purification

Station Name	Operation Time (unit: hours/year)	
	Normal Operation	Operation for Water Purification
Bang Sue	9,053	14,048 (1)
Sam Sen	4,420	10,072 (1)
Tavate	-	4,244 (1)
Phadung Krung Kasem	19,250	7,872 (2)
Sathorn	-	4,492 (1)
Chong Non Sri	718	3,810 (2)
Phra Khanong	63,325	48,480 (2)

Note: (1) The pump operation time for water purification at Bang Sue, Sam Sen, Tavate, and Sathorn indicates the hours required for introducing the purification (dilution) water.

(2) The pump operation time for water purification at Phadung Krung Kasem, Chong Non Sri, and Phra Khanong indicates the hours required for draining the purification water introduced at other pumping stations.

Table G.3 Personnel of BMA, 1986

Unit: Persons

Departments & Offices	Number of Government Officials	Number of Permanent Employees
1. Office of Secretary to the Governor	37	24
2. Office of Secretary to the BMA Assembly	17	5
3. Office of Civil Service Commission of BMA	136	3
4. Office of Permanent Secretary for BMA	902	223
5. Department of General Inspector	53	20
6. Department of Policy and Planning	80	9
7. Department of Medical Services	2,802	1,160
8. Department of Health	2,126	985
9. Department of Education	332	1,137
10. Department of Public Works	865	1,300
11. Department of Drainage and Sewerage	439	1,512
12. Department of Public Cleansing	395	1,530
13. Department of Social Welfare	621	938
14. Department of Finance	590	765
15. Department of Law Enforcement	66	6
16. District Offices	3,779	6,266
Total	13,240	15,883

Source: Statistical Profile of the Bangkok Metropolitan Administration, 1986, Department of Policy and Planning, BMA

Table G.4 Revenue and Expenditures of BMA, Fiscal Year 1984 - 1987

Unit: Million Baht

Functions	1984	1985	1986	1987
I. Revenue				
1. Taxation	3,732.0	4,294.1	4,794.0	4,563.0
2. Fee, Fine & Permits	105.9	119.5	125.1	164.8
3. BMA Properties	224.7	255.6	425.7	408.5
4. BMA Enterprises	10.3	8.8	6.3	6.7
5. Accumulate Fund	612.0	-	63.5	-
6. Government Grants	1,577.2	1,382.8	1,195.2	1,122.1
7. Miscellaneous	84.4	84.9	131.4	111.6
Total	6,346.5	6,145.7	6,741.2	6,376.7
II. Expenditures				
1. Cleaning Services & Keeping Orderliness	569.7	778.1	573.4	645.1
2. Flood Prevention & Wastewater Treatment	1,330.3	715.3	810.0	998.3
3. Administration	611.2	639.3	676.7	1,068.8
4. Public Works & Traffic Management System	1,350.2	1,339.8	1,968.6	1,511.2
5. Medical & Public Health Services	611.1	610.7	668.2	698.0
6. Social Services & Development	167.1	207.1	296.9	330.6
7. Education	986.8	1,007.9	1,039.9	1,124.6
8. Contingent Fund	717.9	707.9	707.0	-
9. Loan Payment	2.2	-	-	-
10. BMA Enterprise	183.8	253.7	66.3	57.0
Total	6,530.3	6,259.8	6,807.0	6,433.6

Source: Statistical Profile of The Bangkok Metropolitan Administration, 1986, Department of Policy and Planning, BMA

Table G.5 Budget Expenditure for Development of BMA, Fiscal Year 1987

Unit: Thousand Baht

Development Plans	Budget of BMA			Subsidies from Government			Grand Total	
	Capital Expenses	Operating Expenses	Total	Capital Expenses	Operating Expenses	Total	Amount	%
Flood Prevention, Drainage & Waste-water Treatment	123,565	-	123,565	15,000	-	15,000	138,565	11
Whole Plan	941,701	24,752	966,453	287,635	2,692	290,327	1,256,780	100

Source: Statistical Profile of The Bangkok Metropolitan Administration, 1986, Department of Policy and Planning, BMA

Table G.6 Number of Employees in DDS, 1989

Unit: Persons

Division	Number of Personnel			
	Officials	Permanent Employees	Temporary Employees	Total
1. Office of Secretary	59	76	5	140
2. Technical Division	82	100	6	188
3. Drainage Control Division	191	1,004	573	1,768
4. Canal Maintenance Division	101	727	443	1,271
5. Wastewater Control Division	75	117	6	198
6. Heavy Equipment Division	72	518	305	895
Total	580	2,542	1,338	4,460

Source: Office of the Secretary, DDS

Table G.7 Number of Officials in DDS, 1981 - 1989

Unit: Persons

Division	1981	1982	1983	1984	1985	1986	1987	1988	1989
1. Office of Secretary	43	43	43	44	44	44	44	44	59
2. Technical Division	65	65	65	65	66	66	67	67	82
3. Drainage Control Division	180	180	179	183	191	191	195	208	191
4. Canal Maintenance Division	103	103	103	103	103	102	101	101	101
5. Wastewater Treatment Division (Wastewater Control Division)	59	59	39	39	39	39	39	39	75
6. Heavy Equipment Division	-	-	-	-	-	-	-	-	72
Total	450	450	429	444	443	442	446	459	580

Source: Office of the Secretary, DDS

Table G.8 Annual Budget of DDS, 1984 - 1988

Unit: Thousand Baht

Item	1984	1985	1986	1987	1988
A. General Administration					
1. Secretary	4,536	6,264	5,693	5,898	5,909
2. Technical Administration	4,605	22,841	11,755	23,709	45,686
Sub-total (1)	9,141	29,105	17,448	29,607	51,595
B. Drainage & Sewerage					
1. Drainage Control	165,866	179,883	212,251	167,604	169,692
2. Sewer Cleaning	18,000	-	-	-	-
3. Klong Maintenance	100,995	143,178	355,304	390,652	296,627
4. Klong Improvement	7,402	-	-	-	-
5. Project Study for Thonburi	1,500	-	-	-	-
6. Project for Preserving Temples	20,000	45,000	-	-	-
7. Survey of Klong Network	-	224	-	-	-
8. Wastewater Treatment	5,051	4,882	7,115	8,313	8,092
9. City Core Flood Protection Project	31,622	40,008	35,776	81,164	11,828
10. Suburban Flood Protection Project	61,000	-	-	-	-
11. Others	-	-	12,790	-	-
Sub-total (2)	411,436	413,175	623,236	647,733	486,239
Total (1) + (2)	420,577	442,280	640,684	677,340	537,834

Source: DDS data

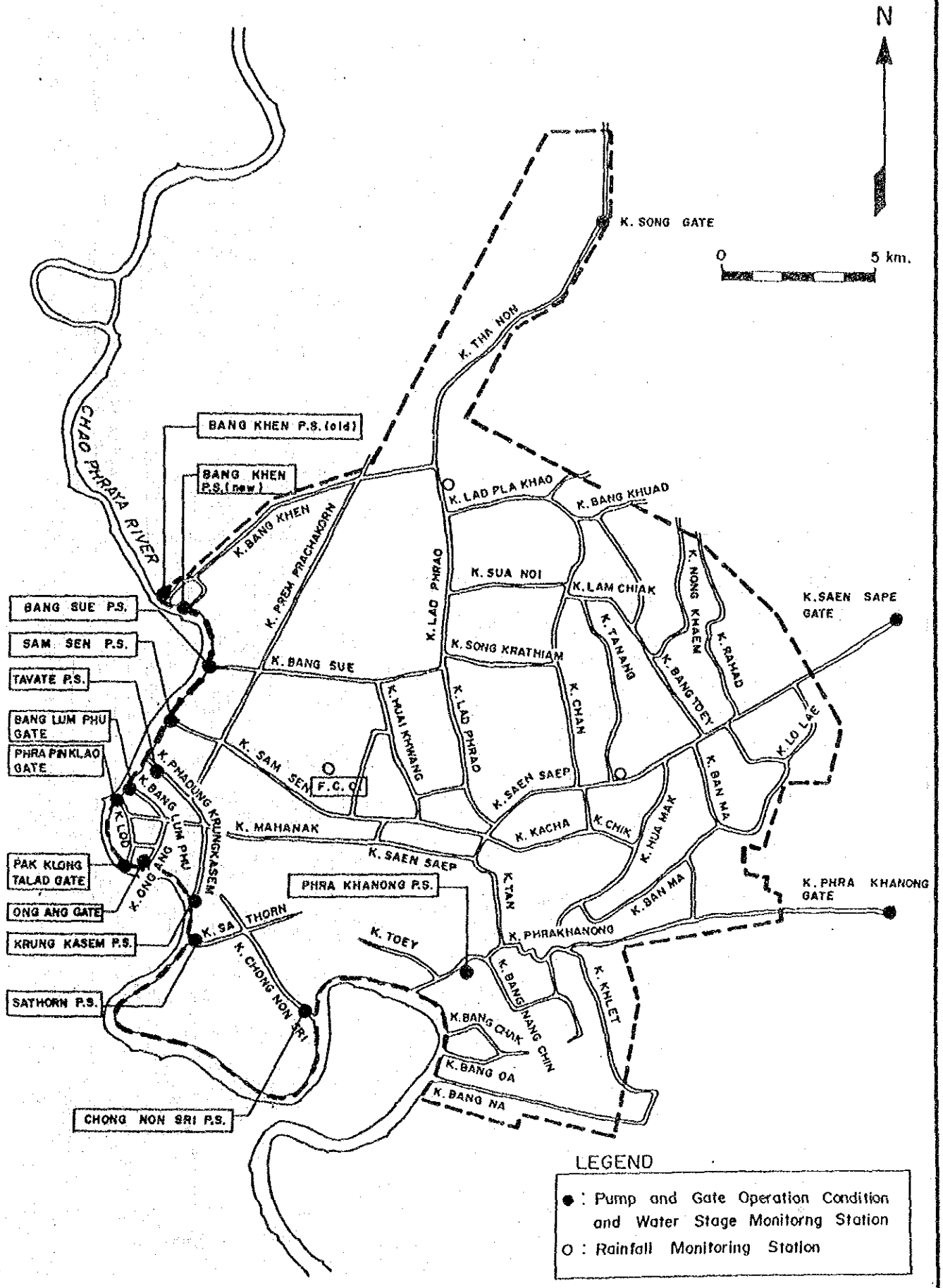


FIG. G . 1 LOCATION OF PROPOSED MONITORING STATIONS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

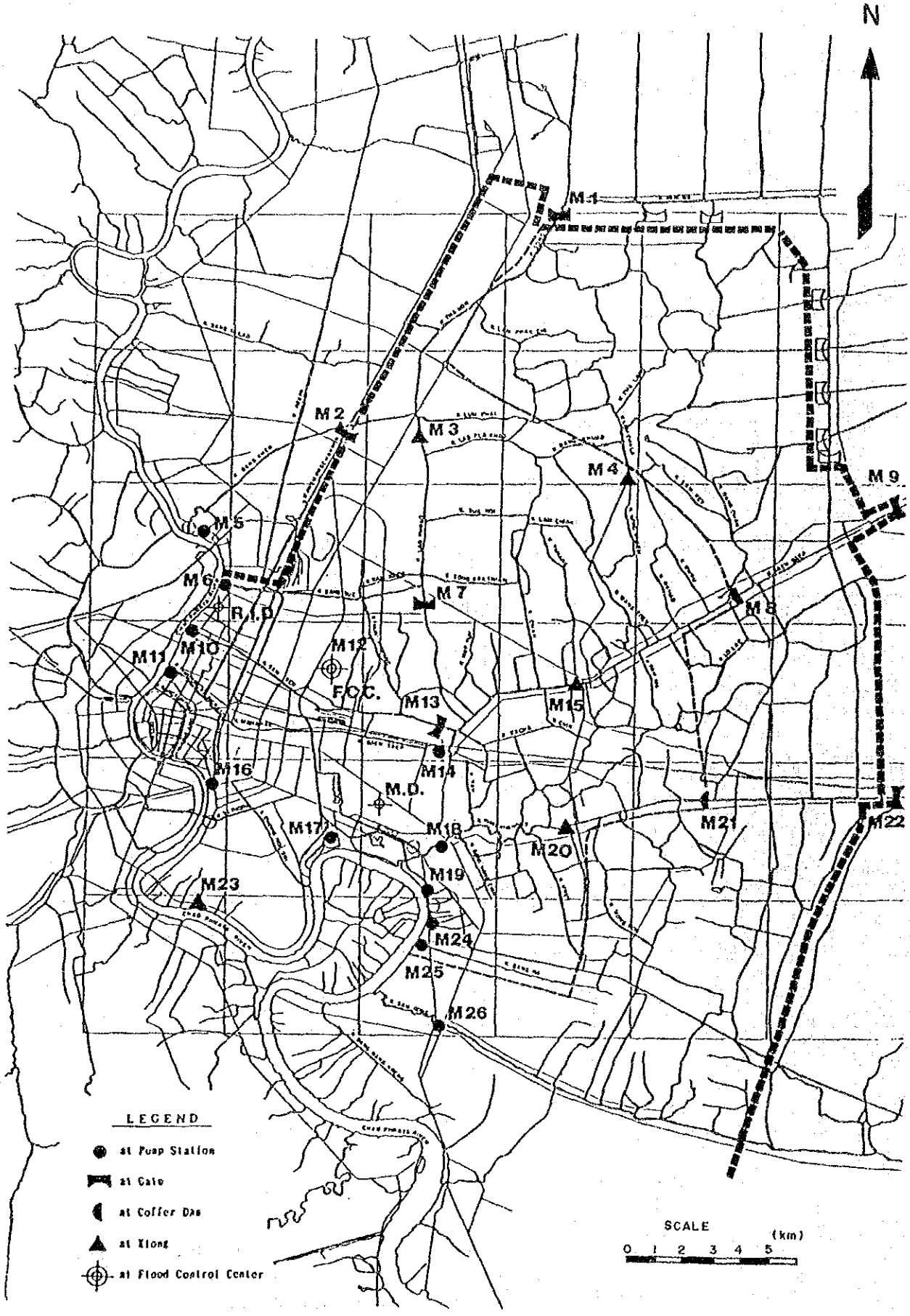


FIG. G . 2 PROPOSED MONITORING STATION BY THE PROJECT FOR THE PROCUREMENT OF EQUIPMENT FOR FLOOD CONTROL CENTER IN BANGKOK AND ITS VICINITY

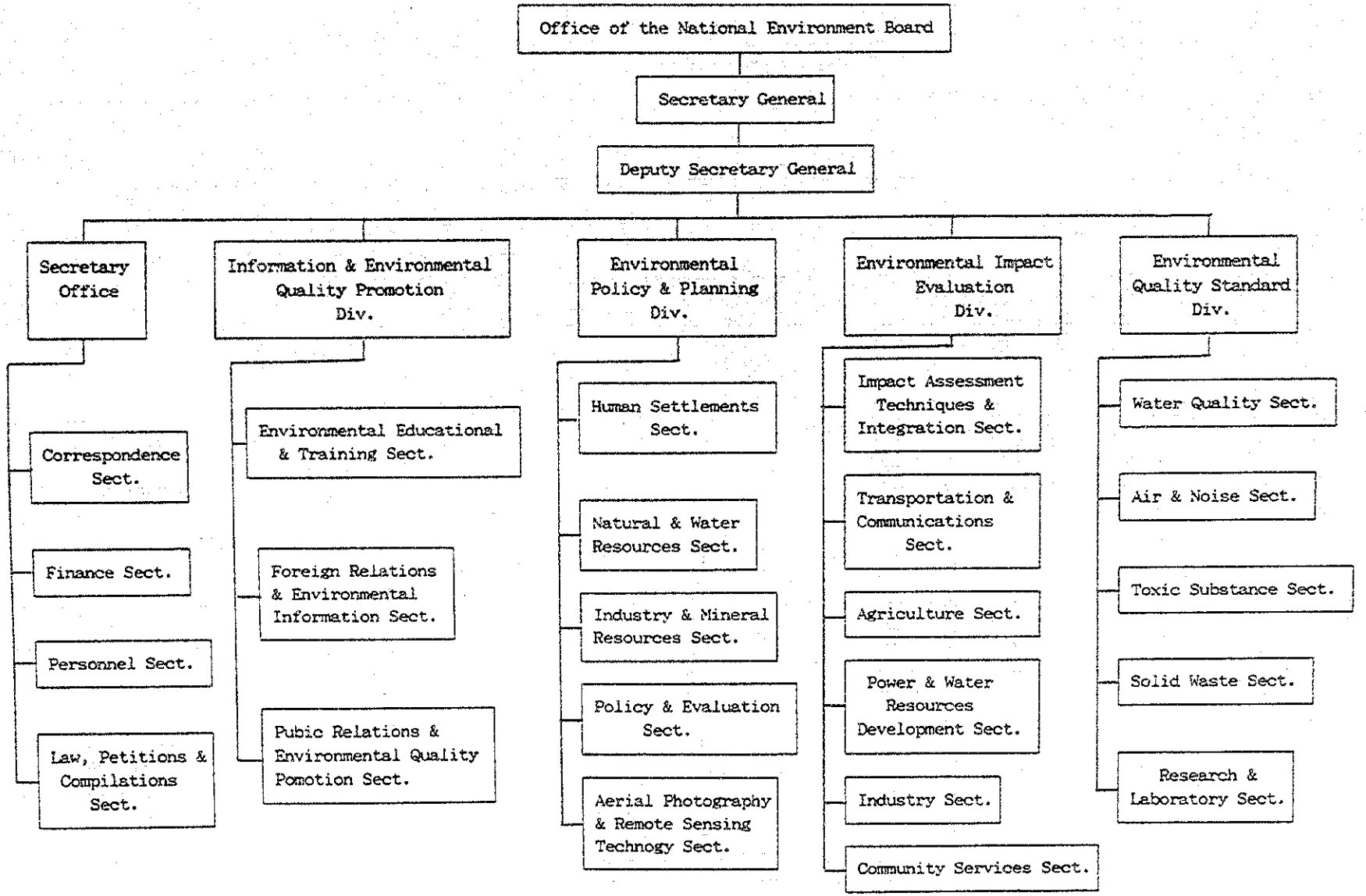
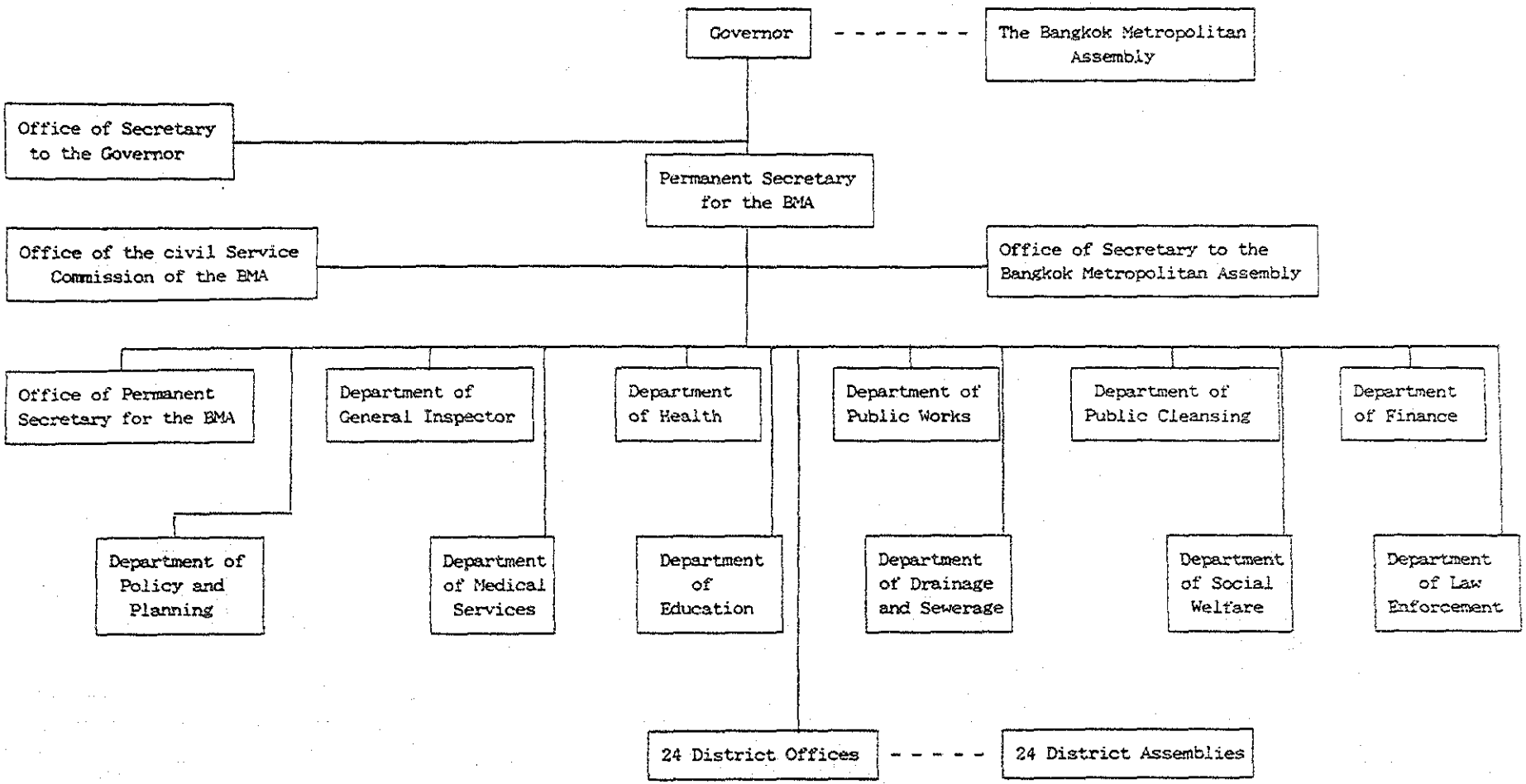


FIG. G . 3 ORGANIZATIONAL STRUCTURE OF OFFICE OF THE NATIONAL ENVIRONMENT BOAD

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532 B.E. 1989 A.D.



Source : Statistical Profile of The Bangkok Metropolitan Administration, 1986, Department of Policy and Planning, BMA.

FIG. G . 4 ORGANIZATIONAL STRUCTURE OF THE BANGKOK METROPOLITAN ADMINISTRATION

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532 B.E. 1989 A.D.

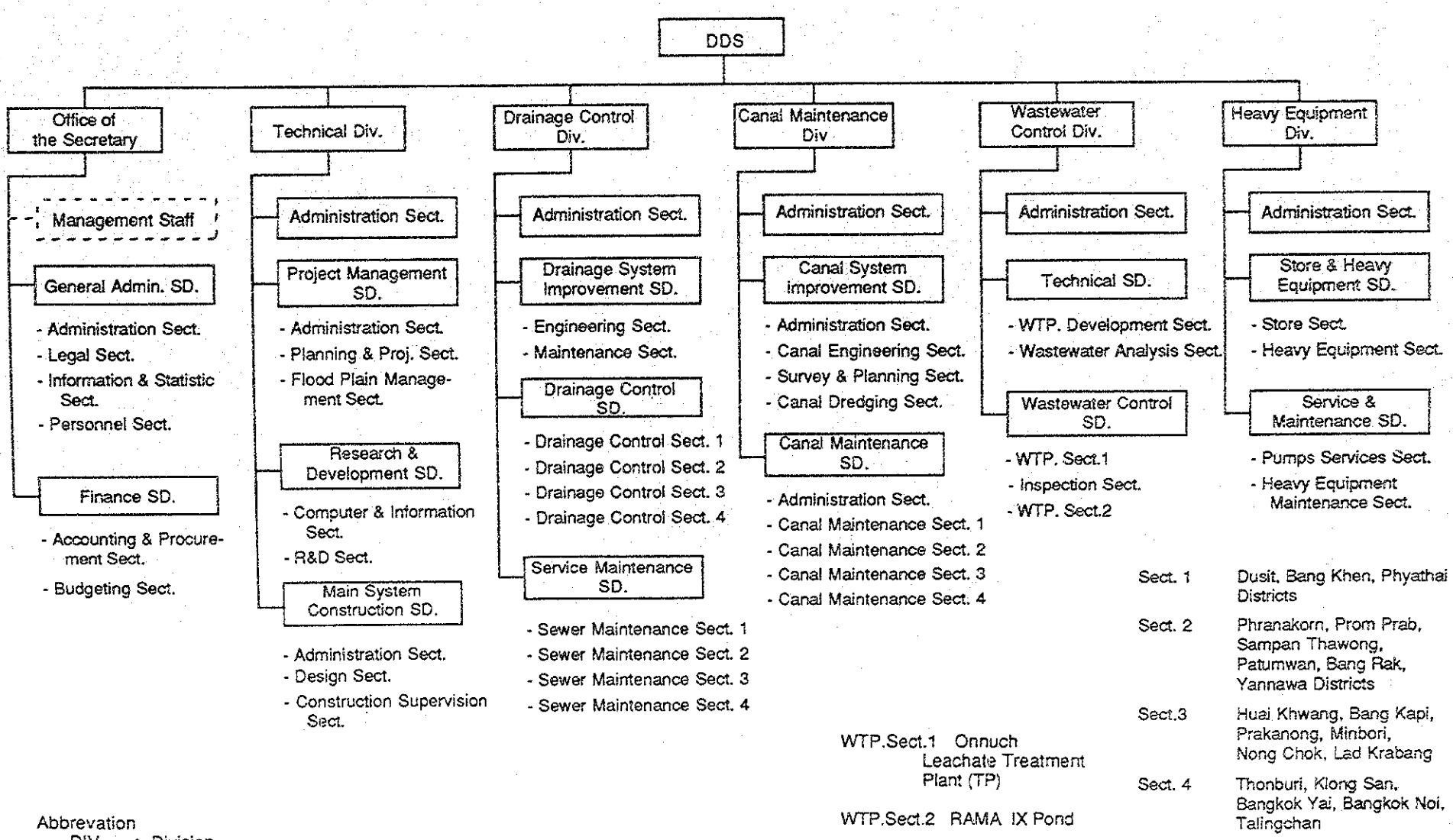


FIG. G . 5 ORGANIZATIONAL STRUCTURE OF THE DEPARTMENT OF DRAINAGE AND SEWERAGE

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

APPENDIX H.

PROJECT EVALUATION

APPENDIX H. PROJECT EVALUATION

1. Estimation of Benefits

1.1 General

When the klong water purification project is accomplished, it will accrue much benefits, both tangible and intangible, to Bangkok and its residents. They include removal of obnoxious odour, contribution to the improvement of hygiene/public health and to the reduction in diseases, greater use of klong water for living (washing, bathing, etc.), disappearance of repulsive blackish water and regaining natural scenic beauty, recovery of favourable ecology (fish & plants) in klong water, greater use of klongs for recreation (swimming, fishing, playing, etc.), revival of klong transport service, revival of klong floating market, etc. Also, a greater number of foreign tourists will visit Bangkok, a secondary benefit derived from the primary benefits mentioned above. Further, value of land especially in residential area near klongs will rise. The total incremental value of land can be interpreted to incorporate all the preceding benefits.

However, the benefits by the proposed klong water purification project is limited to the dry season of eight (8) months (November - June) only. In rainy season (July - October), the gates on the Chao Phraya River are closed and no dilution water is introduced in principle. The klong water quality is left as it is, with no improvement.

Benefits were quantified based on the results of sampling investigations and other data/information obtained from various sources. Every effort was made to quantify as many primary benefits as possible.

Detailed formula for the quantification of benefits are shown in Table H.1. Primary benefits are composed of 5 benefits, namely positive impacts on klong transport, klong floating market and public

health/hygiene, greater use of klong water for living and greater use of klongs for recreation. Such benefits as removal of obnoxious odour, disappearance of repulsive blackish water, recovery of ecology in klong water and positive impact on tourism were not quantified, and are left as intangible benefits.

The amount of tax the people concerned are willing to pay for the purification of klong water sheds a light on the extent of primary benefits assessed by them. The total estimated incremental value of land as a result of klong water purification can be used to check the total sum of separately estimated benefits.

1.2 Positive Impact on Klong Transport and Floating Market

To estimate benefit in a particular year for klong transport, firstly, the annual incremental frequency (in times) of the use of klong transport per household is estimated. Secondly, profit per time per customer for klong transport operators is estimated. Thirdly, the number of households in the project area in the particular year is estimated. Finally, these three estimates are mutually multiplied. It is expected that full benefits of klong water purification will be brought and felt from 1992 onwards. The benefit for klong transport in 1992 is calculated at Baht 4.3 million.

To estimate benefit in a particular year for klong floating market, firstly, the annual incremental frequency (in times) of the visits to klong floating market per household is estimated. Secondly, profit per time per customer for klong floating market operators is estimated. Thirdly, the number of households in the project area in the particular year is estimated. Fourthly, coefficient of negative impacts on open-air fruit market is determined. Finally, the above four estimates are mutually multiplied. The benefit for klong floating market in 1992 is calculated at Baht 17.3 million.

1.3 Positive Impact on Health & Hygiene

Contribution to the improvement of hygiene/health and to the reduction in diseases is one of the most important effects of klong water purification according to the results of the sampling investigation. However, quantification of such a benefit is very difficult and no fixed methodology for it has been developed.

One thing the Study Team paid attention to after interviews and discussions with various major sources concerned is the fact that the incidence of Japanese encephalitis in Bangkok is disproportionately high compared with the national total (337 versus 1,383 in 1988). According to authoritative sources it is directly connected with the existing turbid, stagnant state of klong water. Besides, the team noticed that quantitative information on this disease is available more than on any other diseases. Thus, it is decided to estimate quantitatively the reduction of this disease, and to treat this reduction as representative health benefit.

To estimate health benefit in the form of the reduction of Japanese encephalitis cases in a particular year, firstly, population living near klongs in the project area in that year is estimated. Secondly, incidence rate of the disease among people living near klongs is calculated.
Thirdly, medical and economic costs per patient are estimated. Fourthly, reduction rate of incidence of the disease is estimated. Finally, the above four figures along with the dry season coefficient are mutually multiplied. Health benefit in 1992 is calculated at Baht 12.9 million.

1.4 Greater Use of Klong Water for Living

The basic philosophy in estimating benefit to be derived from greater use of klong water for living is that it will reduce the requirements for urban water, which in turn will save the cost to construct and operate/maintain water supply system.

To estimate benefit in a particular year, firstly, the number of households living near klongs in the project area in that year is estimated. Secondly, incremental ratio of households to use klong water for living in the area near klongs is estimated. Thirdly, annual average payment for water supply per household in Bangkok is calculated. Fourthly, the ratio of the quantity of klong water used for living to the total requirement of water in a household in the area near klongs is estimated. Fifthly, the above four figures along with the dry season coefficient are mutually multiplied. By so doing, one gets benefit in a particular year, accruing from households living near klongs in the project area. By employing the same procedure, one gets benefit in the same year, accruing from households living away from klongs in the project area. Finally, both benefits are added together. The benefit in 1992 is calculated at Baht 27.2 million.

1.5 Greater Use of Klongs for Recreation

The basic philosophy in estimating benefit to be derived from greater use of klongs for recreation is that it will reduce the requirements for recreational facilities, thus saving the cost to construct and operate/maintain such facilities.

To estimate benefit in a particular year, firstly, population living near klongs in the project area in that year is estimated. Secondly, incremental ratio of population to use klongs for recreation in the area near klongs is estimated. Thirdly, the annual number of users of recreational facilities in Bangkok is compared with its population, and thus conversion coefficient is determined.
Fourthly, average investment and operation/maintenance cost of recreational facilities per user is estimated. Fifthly, the above four figures along with the dry season coefficient are mutually multiplied. By so doing, one gets benefit in a particular year, accruing from population living near klongs in the project area. By employing the same procedure, one gets benefit in the same year, accruing from population living away from klongs in the project area. Finally, both benefits are added together. The benefit in 1992 is calculated at Baht 0.1 million.

1.6 Willingness to Pay

The total amount of tax the households in the project area are willing to pay gives a hint on the extent of the benefits the purification of klong water will bring to them. It is estimated at Baht 65.5 million in 1992, which is incidentally similar to the summation of the five quantified primary benefits in the same year (Baht 61.9 million). There are other important primary benefits such as removal of obnoxious odour and disappearance of repulsive blackish water. That is to say, the total benefits the households concerned will derived from klong water purification will be much higher than Baht 61.9 million. Therefore, the "willingness to pay" accounts for only a part of the total benefits. Nevertheless, it is useful to check the propriety of the extent of quantified benefits.

To estimate the "willingness to pay" in a particular year, firstly, the average amount of tax a household living near klongs in the project area is willing to pay is estimated. Secondly, the number of households living near klongs in the project area in that year is estimated. Thirdly, the above two estimates are mutually multiplied. By so doing one gets the "willingness to pay" in a particular year, accruing from households living near klongs in the project area. By employing the same procedure, one gets the "willingness to pay" in the same year, accruing from households living away from klongs in the project area. Finally, both are added together.

1.7 Impact on Land Value

Supposing the benefits of klong water purification were fully realized in 1988, the total incremental value of residential space in the project area in the same year is estimated at Baht 6,179.6 million.

Actually the project for the purification of klong water will start in 1990 and the full realization of project benefits will be realised in 1992, and the present value (PV) of the total incremental value of residential space in the project area works out at Baht 4,398.5 million.

To estimate incremental land value, firstly, residential space near klongs in the project area is determined. Secondly, unit price of housing lot in the area near klongs is calculated. Thirdly, average rate of rise in the price of housing lot in the area near klongs when klong water is purified is estimated. Fourthly, the above three figures are mutually multiplied. By so doing one gets incremental land value in the area near klongs. By employing the same procedure, one gets incremental land value in the area away from klongs. Finally, both values are added together.

2. Economic Evaluation

2.1 Benefits and Costs

Five benefits, namely benefit for klong transport, benefit for klong floating market, health benefit, greater use of klong water for living and greater use of klongs for recreation have been taken up and incorporated in the project benefits, detailed account of which has been given in the preceding sections.

The project costs are divided into construction costs and operation/maintenance costs.

The former are composed of;

- Reconstruction costs of the pump stations for dilution water introduction
- Dredging costs of the klongs
- Construction costs of the aerated lagoon treatment system

The latter are composed of;

- Power costs for the pump stations
- Power costs for the aerated lagoon treatment system
- Other O&M costs for the pump stations and aerated lagoon treatment system
- Replacement costs for the pumps and aerators

Yearly flow of the required costs are shown in Table H.2.

2.2 Economic Analysis

Project life is assumed to be 21 years.

The cost and benefit streams of the Project are shown in Table H.2. The cumulative streams of the costs and benefits are shown in Table H.3. The cumulative streams discounted at opportunity cost of capital are shown in Table H.4.

The economic rate of return (EIRR) of the Project is calculated to be 5.5% as shown in Table H.6.

3. Impact of the Project on Water Quality of Chao Phraya River

Introduction of dilution water from the Chao Phraya River to the klongs may reduce the self purification potential of the klongs, resulting in an increase of pollution load run-off to the Chao Phraya River from the klongs.

Self purification due to settlement and biological dissolution of pollution loads in the klongs would generally decrease with decreasing retardation of the klong water and with decreasing concentration of pollution load in the klong water. Introduction of dilution water and its increase will lead to the above mentioned effects and their increase, thereby reducing the self purification capacity of the klongs resulting in increased pollution load to the Chao Phraya River.

Aerated lagoon treatment system is also incorporated into the proposed klong water purification project to cope with the adverse effect to the Chao Phraya River water quality caused by dilution water introduction.

BOD load balance of the Study Area in dry season for "Existing Condition " and "With Project" are calculated based on the results of the aerated lagoon treatment in APPENDIX D and of the dilution water

dilution water introduction method in APENDIX E. The calculeted BOD load balance are shown below (See Fig. H.1).

BOD Load Balance in Dry Season

(Unit : kg/day)

Load	Existing Condition	With Project
From Chao Phraya River	6,900	8,700
From Study Area	61,900	61,900
From Eastern Outer Area	4,300	4,300
Setllement and dissolution in the Klongs	23,400	19,600
Removal by Aerated Lagoon	-	4,470
To Chao Phraya River	49,700	50,830

Actual discharged BOD load to the Chao Phraya River under the "Existing Condition" and "With Proposed Project" is 42,800 kg/day and 42,130 kg/day respectively. As a result, BOD load to the Chao Phraya River will be reduced by 670 kg/day with the proposed project. Hence a marginal beneficial effect, no adverse effect, to the Chao Phraya River water quality will be expected.

4 Necessity of Sewerage Development in Future

4.1 Estimation of Project Effects in the Year 2000

For estimating the effective life span of the klong water purification project, which consists of dilution water introduction from Chao Phraya River, dredging the klongs to facilitate the dilution water introduction and aerated lagoon treatment of klong water, a simulation analysis of future klong water quality in dry season in the year 2000 was carried out under the following two (2) alternative conditions.

(1) Case 1

Pollution Load Run-off

Pollution load run-off in the Study Area in the year 2000 is estimated in APPENDIX C.

Population of Study Area in the year 2000 will increase to 3.94 million from 2.92 million in 1986. The unit pollution load generation in the year 2000 will be 408 lcd in average from 298 lcd in 1986.

Accordingly, the total volume of wastewater generation in the year 2000 is estimated at 1.61 million m^3/day, which corresponds to a pollution load generation of 218,000 kg BOD/day. Of this future pollution load generation, 53 % or 116,600 kg BOD/day is estimated to be discharged into the klongs of the Study Area.

Ground Elevation

The ground elevation of the Study Area is assumed to be lowered by 0.5 m from the existing condition by the year 2000 due to the progressing land subsidence

All other conditions are assumed to be the same as those used in the simulation of existing condition of klong water quality as mentioned in Appendix E.

These condition include :

- Water stage and quality of the Chao Phraya River
- Inflow from the eastern outer areas and its water quality
- Gate and pump operating conditions
- Rainfall in the Study Area
- Manning's roughness coefficient of the Klongs
- Purification rate of klong water
- Sedimentation and dissolution of pollution load

(2) Case 2

Klong Sections

It is assumed that all klong improvement works proposed by the projects: "Flood Control and Drainage Project in the City Core Area, NEDECO, 1984", and "Flood Protection and Drainage Project in Eastern Suburban Bangkok, JICA 1986" will be fully completed before the year 2000.

All other conditions of simulation including that of ground elevation are the same as those of Case 1.

4.2 Effects of Klong Water Dilution in Dry Season

(1) Case 1

As a result of the land subsidence of 0.5 m, the amount of dilution water introduction from the Chao Phraya River could be increased to 3.02 million m^3/day from the existing introduced dilution water of 2.91 million m^3/day under the proposed project.

The projected water quality of major target klongs is summarized in Table H.7, in comparison to the results of the simulation analysis under the existing condition.

Similarly the projected daily average and maximum water quality in each target klong in the year 2000 (dry season) is shown in Table H.8. and Fig. H.2.

As evident from Fig. H.2 the projected klong water quality in the Ratanakosin area is better than that of the klongs in surrounding areas. In the Ratanakosin area, a BOD level of less than 15 mg/l could be maintained due to the dilution effects from the Chao Phraya River and not a very significant increase of pollution load generation in the area.

However, the water quality of klongs in the surrounding areas, including some klongs in the eastern suburban area, would deteriorate to a BOD level more than 25 mg/l due to a significant increase in pollution load generation and difficulty of dilution water introduction.

(2) Case 2

A large amount of dilution water of 4.1 million m^3/day can be introduced from the Chao Phraya River, consistently by gravity. This is due to the land subsidence of the Study Area and the increased discharge capacity of the improved klongs. Moreover, all the introduced dilution water could be drained by the continuous operation of the Phra Khanong and Krung Kasem pump stations.

As a result of this increased dilution water introduction the water quality of both the klongs in Ratanakosin area and the surrounding area would become better than that of Case 1. Even then the BOD of the klongs in surrournding area including the eastern suburban area could be improved to a level of 19 mg/l only, which is worser than the target water quality of the project, 15 mg/l as BOD (ref. Table H.7, Table H.8 and Fig.H.3).

4.3 Effects on the Chao Phraya River Water Quality

BOD load balance of the Study Area in dry season was studied for the above mentioned two (2) cases based on the results of the klong water simulation analysis. The calculated BOD load balance is shown below in comparison to that of the existing conditions (see Fig. H.4).

BOD Load Balance in Dry Season

(Unit : kg/day)

	1986		2000	
	Existing Condition	With Urgent Project	Case 1	Case 2
From Chao Phraya River	6,900	8,700	9,100	12,300
From Study Area	61,900	61,900	116,600	116,600
From Eastern Outer Area	4,300	4,300	4,300	4,300
Settlement & Dissolution	23,400	19,600	20,300	19,900
Removal by Aerated Lagoons	-	4,470	6,870	4,280
To Chao Phraya River	49,700	50,830	102,830	109,020

From the above Table, the net BOD load discharged from the Study Area to the Chao Phraya River is as follows :

Existing Condition	:	42,800 kg/day
With Urgent Project	:	42,130
Case 1 (2000)	:	93,730
Case 2 (2000)	:	96,720

The water quality of the Chao Phraya River in dry season in the year 2000 is estimated as follows for the proposed klong water purification project of Case 1 and Case 2, assuming that the average flow of the Chao Phraya River in dry season is 174 m^3/s and the existing water quality of the Chao Phraya River in dry season is 3 mg/l as stream BOD.

Existing Condition (1986)	:	BOD 3.0 mg/l
With Urgent Project (1986)	:	BOD 3.0 mg/l
Case 1 (2000)	:	BOD 6.4 mg/l
Case 2 (2000)	:	BOD 6.6 mg/l

The water quality of the Chao Phraya River at its downstream reaches of the Study Area would deteriorate to 6.4 mg/l and 6.6 mg/l as stream BOD, respectively under Case 1 and Case 2 conditions. This is due to the increase in pollution load generation in the Study Area by the year 2000.

It is to be noted that the proposed klong water purification project does not lead to net pollution load reduction except the fractional BOD removal in the aerated lagoon treatment, hence has only a marginal beneficial effects on the Chao Phraya River water quality, though it will improve the klong water quality mainly by dilution.

4.4 Conclusion

Sewerage development for the Study Area is essentially required even with the implementation of this project, which is only an urgent measure, in the near future preferably within the next five (5) to six (6) years due to the following reasons.

(1) The existing klong water quality of 20 mg/l as BOD in dry reason in the surrounding area will be improved to an acceptable level of 12 mg/l as BOD, immediately, by the proposed project. However, in future (year 2000) under the conditions of Case 1 and Case 2 it would deteriorate respectively to 24 mg/l and 15 mg/l in dry season (ref. Table H.7).

Fig. H.5 illustrates the domain of the klong water quality of the surrounding areas bounded by the Case 1 and Case 2 alternatives. Hence the future dry season water quality of this surrounding area until the year 2000 would probably vary within this domain, by the implementation of the proposed project.

Accordingly, as shown in Fig.H.5, the target water quality of 15 mg/l as BOD would probably be breached in five(5) to six(6) years.

(2) The water quality of the Chao Phraya River will continue to deteriorate to about 6.5 mg/l as stream BOD by the year 2000 from the existing level of 3 mg/l, due to increase in pollution load generation in the Study Area. The introduction of dilution water, except the small improvement by aerated lagoon treatment, does not result in any reduction in generated pollution load and has no beneficial effects on the Chao Phraya River water quality.

(3) The introduction of dilution water by this project is limited to dry season only. Hence the water quality of all the klongs in the Study Area in rainy season would continue to deteriorate with increasing pollution load generation in future as evident from Table H.9 and Table H.10 (ref. also Fig. H.6 and Fig. H.7). The water quality in rainy season in the year 2000 is anticipated to deteriorate to 20-50 mg/l as BOD in most klongs of the central Bangkok.

Table H.1 Formula for Quantification of Klong Water Purification Benefits

1. Positive Impact on Klong Transport

$$PPL(N) = \underset{A}{4452300} \times \underset{B}{1.021732103^{(N-1)}}$$

PPN : population of the project area

N : year, 1990 = 1

A : PPN in 1990

B : annual growth rate of PPN

$$BF1(N) = \underset{C}{(0.06911} \times \underset{D}{0.317} + \underset{E}{0.05399} \times \underset{F}{0.762}) \times \underset{G}{35} \times \underset{H}{1.2} \times \underset{I}{2} \times PPL(N)/\underset{J}{5.714}$$

BF1 : benefit for inland water transport on klongs

C : ratio of regular users[1/] of klong transport for commuting

D : weekly incremental frequency of use of klong transport for commuting by regular users in case klong water is purified

E : ratio of regular users of klong transport for shopping

F : weekly incremental frequency of use of klong transport for shopping by regular users in case klong water is purified

G : number of weeks in dry season per year

H : profit per trip per customer for klong transport operators in baht

I : 1 time in frequency = 1 round trip = 2 trips

J : average number of household members

Note : 1/ = on household basis

2. Positive Impact on Klong Floating Market

$$BF2(N) = \underset{A}{0.29805} \times \underset{B}{1.022} \times \underset{C}{35} \times \underset{D}{4} \times \underset{E}{PPL(N)/5.714} \times \underset{F}{0.5}$$

BF2 : benefit for floating market on klongs

A : ratio of regular buyers[1/] at klong floating market

B : weekly incremental frequency of buying at klong floating market by regular buyers in case klong water is purified

C : number of weeks in dry season per year

D : profit per visit per customer for klong floating market operators

E : average number of household members

F : coefficient of negative impacts on open air fruit market

Note : 1/ = on household basis

3. Positive Impact on Health & Hygiene

$$BF3(N) = \underset{A}{PPL(N)} \times \underset{B}{0.1075} \times \underset{C}{0.00053713824} \times \underset{D}{(5000} + \underset{E}{0.3} \times \underset{F}{0.5} \times \underset{G}{655536)} \times \underset{H}{0.7} \times 8/12$$

BF3 : benefit derived from reduction of medical cost, etc.

A : ratio of PPL living near klongs

B : ratio of the number of Japanese encephalitis patients to population living near klongs in Bangkok in 1988

C : medical cost per patient in baht

D : ratio of the number of those who suffer from severe and chronic complications (such as paralysis and dementia)

E : ratio of employment

F : estimated amount of earnings (in Baht) of the average age Bangkok worker (32 years old) during 18 years until he retires at 60

G : estimated reduction rate of incidence of Japanese encephalitis in case klong water is purified

H : ratio of dry season period

4. Greater Use of Klong Water for Living

$$BF4(N) = PPL(N) \times \underset{A}{0.1075} / \underset{B}{5.714} \times (\underset{C}{0.44055} - \underset{D}{0.19090}) \times \underset{E}{142} \times \underset{F}{12} \times \underset{G}{0.3} \times \underset{H}{8/12}$$

$$+ PPL(N) \times \underset{I}{0.8925} / \underset{J}{5.714} \times (\underset{K}{0.5200} - \underset{L}{0.2800}) \times 142 \times 12 \times 0.1 \times 8/12$$

BF4 : benefit derived from reduction of requirements for water supply system

A : ratio of population living near klongs

B : average number of household members

C : ratio of users1/ of klong water for living (washing & bathing) in the area near klongs in case klong water is purified

D : ratio of users of klong water for living in the area near klongs under the present circumstances

E : average monthly payment (in Baht) for water supply per household in Bangkok

F : number of months per year

G : estimated ratio of the quantity of klong water used for living to the total requirement for water in a household in the area near klongs

H : ratio of dry season period

I : ratio of population living away from klongs

J : ratio of users of klong water for living in the area away from klongs in case klong water is purified

K : ratio of users of klong water for living in the area away from klongs under the present circumstances

L : estimated ratio of the quantity of klong water used for living to the total requirement for water in a household in the area away from klongs

Note: 1/ = on household basis

5. Greater Use of Klongs for Recreation

$$BF5(N) = PPL(N) \times \underset{A}{0.1075} \times (\underset{B}{0.40909} - \underset{C}{0.10454}) \times \underset{D}{1.119691261} \times \underset{E}{0.4152} \times \underset{F}{8/12}$$

$$+ PPL(N) \times \underset{G}{0.8925} \times \underset{H}{0.08} \times 1.119691261 \times 0.4152 \times 8/12$$

BF5 : benefit derived from reduction of requirements for recreational facilities

A : ratio of population living near klongs

B : ratio of population to use klongs for recreation (swimming, fishing, etc.) in the area near klongs in case klong water is purified.

C : ratio of population using klongs for recreation in the area near klongs under the present circumstances

D : total number of users of recreational facilities (juvenile centers and playgrounds) in Bangkok divided by its population in 1988

E : average investment and operation / maintenance cost of recreational facilities per user in baht

F : ratio of dry season period

G : ratio of population living away from klongs

H : ratio of population to use klongs for recreation in the area away from klongs in case klong water is purified

Note : Ratio of population using klongs for recreation in the area away from klongs under the present circumstances is zero.

6. Willingness to Pay

$$W(N) = \underset{A}{14.8} \times \underset{B}{8} \times \underset{C}{PPL(N)/5.714} \times \underset{D}{0.1075} + \underset{E}{9.5} \times 8 \times PPL(N)/5.714 \times \underset{F}{0.8925}$$

W : amount of charge the households in the project area are willing to pay for the purification of klong water

A : average amount of monthly charge a household living near klongs is willing to pay in case klong water is purified (in Baht)

B : number of months in a year (dry season)

C : average number of household members

D : ratio of population living near klongs

E : average amount of monthly charge a household living away from klongs is willing to pay in case klong water is purified (in Baht)

F : ratio of population living away from klongs

7. Impact on Land Value

$$LV = \underset{A}{10729412} \times \underset{B}{0.39772} \times \underset{C}{0.24347} \times \underset{D}{2113} + \underset{E}{89079068} \times \underset{F}{0.20000} \times \underset{G}{0.11666} \times \underset{H}{1917}$$

$$= 6179601410$$

LV : total incremental value of residential space in the projected area (in Baht)

A : residential space near klongs in the project area (in square meters)

B : ratio of those who think the price of housing lot will rise when klong water is purified in the area near klongs

C : average rate of rise in the price of housing lot estimated by the above-mentioned people

D : average price of housing lot per m^2 in the area near klongs (in Baht)

E : residential space away from klongs in the project area (in square meters)

F : ratio of those who think the price of housing lot will rise when klong water is purified in the area away from klongs

H : average price of housing lot per m^2 in the area away from klongs (in Baht)

Sources : Results of questionnaires conducted by JICA; District Office of Talingchan; Harbour Dept.; Bangkok Mass Transit Authority; Vayiya Hospital, Dept. of Public Health, BMA; Div. of Communicable Diseases, BMA; DDS; Recreation Div., Dept. of Social Welfare, BMA; Fishery Dept., City Planning Div., BMA, National Statistical Office, "Bangkok 1986, Statistical Profile of the Bangkok Metropolitan Administration", BMA; "Quarterly Bulletin of Statistics., December 1985:, National Statistical Office; "Report of the Survey of Business Trade and Services 1985", National Statistical Office; "Estimated Account in Right and Juristic Register", Dept. of Land; etc.

Table H.2 Cost and Benefit Streams

CC1=construction/installation costs of pumping stations; CC2=costs for dredging of klongs;
CC3=construction cost of aerated lagoons;
OM1=power charges for pump operation; OM2=operation/maintenance costs of pumping stations(excl. power charges); OM3=replacement costs of pump; OM4=operation/maintenance costs of aerated lagoons; OM5=electrical charge of aerated lagoons; OM6=replacement cost of aerators and pumps;
BF1=benefit for klong transport; BF2=benefit for klong floating market; BF3=health benefits;
BF4=greater use of klong water for living; BF5=greater use of klongs for recreation;
SCS=summation of costs; SBF=summation of benefits

(Baht million)

YEAR	NO.	CC1	CC2	CC3	OM1	OM2	OM3	OM4	OM5	OM6	BF1	BF2	BF3	BF4	BF5	SCS	SBF
1990	1	46.0	13.3	74.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	133.4	0.0
1991	2	0.0	0.0	74.1	34.7	0.1	6.7	0.0	0.0	0.0	4.2	16.9	12.6	26.6	0.1	115.6	60.6
1992	3	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	4.3	17.3	12.9	27.2	0.1	56.3	61.9
1993	4	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	4.4	17.7	13.2	27.8	0.1	56.3	63.3
1994	5	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	4.4	18.1	13.5	28.4	0.1	56.3	64.6
1995	6	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	4.5	18.4	13.8	29.0	0.1	56.3	66.1
1996	7	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	4.6	18.9	14.1	29.6	0.1	56.3	67.5
1997	8	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	4.7	19.3	14.4	30.3	0.1	56.3	69.0
1998	9	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	4.9	19.7	14.7	30.9	0.1	56.3	70.5
1999	10	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	5.0	20.1	15.0	31.6	0.1	56.3	72.0
2000	11	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	5.1	20.5	15.3	32.3	0.1	56.3	73.6
2001	12	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	5.2	21.0	15.7	33.0	0.1	56.3	75.2
2002	13	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	5.3	21.5	16.0	33.7	0.1	56.3	76.8
2003	14	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	5.4	21.9	16.3	34.4	0.1	56.3	78.5
2004	15	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	5.5	22.4	16.7	35.2	0.1	56.3	80.2
2005	16	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	5.6	22.9	17.1	36.0	0.1	56.3	81.9
2006	17	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	5.8	23.4	17.4	36.7	0.2	56.3	83.7
2007	18	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	5.9	23.9	17.8	37.5	0.2	56.3	85.5
2008	19	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	6.0	24.4	18.2	38.4	0.2	56.3	87.4
2009	20	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	6.2	24.9	18.6	39.2	0.2	56.3	89.3
2010	21	0.0	0.0	0.0	34.7	0.1	6.7	1.3	6.3	7.2	6.3	25.5	19.0	40.1	0.2	56.3	91.2

Table H.3 Cumulative Cost and Benefit Streams

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	NO.	BNFT	COST	CSFL	CM BNFT	CM COST	CM CSFL
1990	1	0	133	-133	0	133	-133
1991	2	60	115	-54	60	249	-188
1992	3	61	56	5	122	305	-182
1993	4	63	56	7	185	361	-175
1994	5	64	56	8	250	417	-167
1995	6	66	56	9	316	474	-157
1996	7	67	56	11	384	530	-146
1997	8	69	56	12	453	586	-133
1998	9	70	56	14	523	643	-119
1999	10	72	56	15	595	699	-103
2000	11	73	56	17	669	755	-86
2001	12	75	56	18	744	812	-67
2002	13	76	56	20	821	868	-47
2003	14	78	56	22	900	924	-24
2004	15	80	56	23	980	981	0
2005	16	81	56	25	1,062	1,037	24
2006	17	83	56	27	1,145	1,093	52
2007	18	85	56	29	1,231	1,150	81
2008	19	87	56	31	1,318	1,206	112
2009	20	89	56	33	1,408	1,262	145
2010	21	91	56	34	1,499	1,319	180

Table H.4 Cumulative Streams at Present Value

DISCOUNT FACTOR = OPPORTUNITY COST OF CAPITAL (= 12%)

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	NO.	BNFT	COST	CSFL	CM BNFT	CM COST	CM CSFL
1990	1	0	119	-119	0	119	-119
1991	2	48	92	-43	48	211	-162
1992	3	44	40	4	92	251	-158
1993	4	40	35	4	132	287	-154
1994	5	36	31	4	169	319	-149
1995	6	33	28	4	202	347	-144
1996	7	30	25	5	233	373	-139
1997	8	27	22	5	261	395	-134
1998	9	25	20	5	286	416	-129
1999	10	23	18	5	309	434	-124
2000	11	21	16	4	331	450	-119
2001	12	19	14	4	350	464	-114
2002	13	17	12	4	368	477	-109
2003	14	16	11	4	384	489	-105
2004	15	14	10	4	398	499	-100
2005	16	13	9	4	412	508	-96
2006	17	12	8	3	424	517	-92
2007	18	11	7	3	435	524	-88
2008	19	10	6	3	445	530	-85
2009	20	9	5	3	454	536	-81
2010	21	8	5	3	463	541	-78

Table H.5 Net Present Value and Benefit Cost Ratio

(Unit of NPV: Baht million)

Item	NPV	B/C
Value	-78	0.85

Table H.6 Computation of Economic Internal Rate of Return

DF=discount factor; CM BNFT=cumulative benefit;
CM COST=cumulative cost; NPV=net present value;
B/C=benefit cost ratio

(Baht million)

DF	CM BNFT	CM COST	NPV	B/C
0	1,499	1,319	180	1.13
1	1,330	1,196	134	1.11
2	1,185	1,090	95	1.08
3	1,060	998	62	1.06
4	952	919	33	1.03
5	859	849	10	1.01
6	778	788	-10	0.98

IRR=5.5

Table H.7 Water Quality of Target Klongs in Dry Season

Unit: mg/l

			Present (1986)		Future (2000)	
			Existing Condition	With Urgent Project	Case 1	Case 2
Improved Water Quality in Dry Season (BOD: mg/l)	Ratanakosin Area	K. Wat Tep Tida & K. Wat Rajabopit	17 (56)	12 (24)	12 (25)	8 (18)
		Other Klongs /1	12 (22)	10 (18)	12 (23)	9 (15)
	Klongs in Surrounding Area /2		20 (33)	12 (16)	24 (45)	15 (27)
	K. Toey		23 (30)	25 (31)	30 (35)	30 (35)
	K. Sathorn & K. Chong Non Sri		47 (52)	12 (15)	17 (22)	17 (22)
Dilution Water Introduction ($10^6 m^3$ /day)			2.3	2.91	4.10	3.02

Note: 1) /1 ; Lod, Bang Lum Phu, Ong Ang, Phadung Krung Kasem, Mahanak

2) /2 ; Bang Sue, Sam Sen, Prem Prachakorn, Saen Saep, Bang Kapi, Huai Khwang, Tan, Phra Khanong

3) Figure within parenthesis is maximum water quality.

4) Figure with no parenthesis is average water quality.

Table H.8 Daily Average and Maximum Water Quality in Each Target Klong in Dry Season

Unit: mg/l

	Present (1986)		Future (2000)	
	Existing Condition	With Urgent Project	Case 1	Case 2
K. Bang Sue	11-13 (16-18)	8-10 (9-11)	21-24 (32-35)	13-14 (20-27)
K. Sam Sen	16-25 (26-28)	6-15 (7-16)	12-30 (28-35)	7-18 (16-22)
K. Prem Prachakorn	24-25 (29-32)	9-13 (11-15)	18-23 (33-35)	14-16 (25)
K. Huai Khwang	31 (33)	15 (15)	39 (45)	18 (23)
K. Mahanak - K. Saen Saep	14-25 (21-28)	11-14 (13-15)	11-23 (16-26)	8-17 (11-19)
K. Bang Kapi	24 (26)	14 (15)	28 (33)	16 (21)
K. Phadung Krungkasem	14-16 (20-22)	9-13 (10-13)	16-17 (21-23)	12 (14-15)
K. Bang Lamphu	8 (18)	11 (18)	11 (19)	8 (13)
K. Ong Ang	9 (15)	9 (13)	9 (15)	6 (10)
K. Lod	8-10 (17-19)	8 (12-13)	7-8 (13)	5-6 (8-9)
K. Wat Teptida	18 (56)	10 (16)	10 (16)	7 (12)
K. Wat Rajabopit	15 (30)	14 (24)	13 (25)	9 (18)
K. Tan	16 (17)	14 (14)	26 (28)	18 (19)
K. Phra Khanong	12 (13)	12 (13)	23 (24)	18 (19)
K. Toey	23 (30)	25 (31)	30 (35)	30 (35)
K. Sathorn	44 (45)	9 (13)	13 (19)	12 (17)
K. Chong Non Sri	50 (52)	14 (15)	20 (22)	19 (20)

Note: Figure in parenthesis indicates maximum BOD

Table H.9 Water Quality of Target Klongs in Rainy Season

Unit: mg/l

			Present (1986)		Future (2000)	
			Existing Condition	With Urgent Project	Case 1	Case 2
Improved Water Quality in Dry Season (BOD: mg/l)	Ratanakosin Area	K. Wat Tep Tida & K. Wat Rajabopit	36 (55)	49 (50)	53 (54)	53 (54)
		Other Klongs /1	24 (38)	40 (49)	50 (57)	51 (58)
	Klongs in Surrounding Area /2		17 (39)	15 (41)	28 (70)	26 (63)
	K. Toey		19 (26)	18 (23)	21 (27)	21 (27)
	K. Sathorn & K. Chong Non Sri		35 (37)	33 (35)	39 (41)	43 (45)

Note: 1) /1 ; Lod, Bang Lum Phu, Ong Ang, Phadung Krung Kasem, Mahanak

2) /2 ; Bang Sue, Sam Sen, Prem Prachakorn, Saen Saep, Bang Kapi, Huai Khwang, Tan, Phra Khanong

3) Figure within parenthesis is maximum water quality.

4) Figure with no parenthesis is average water quality.

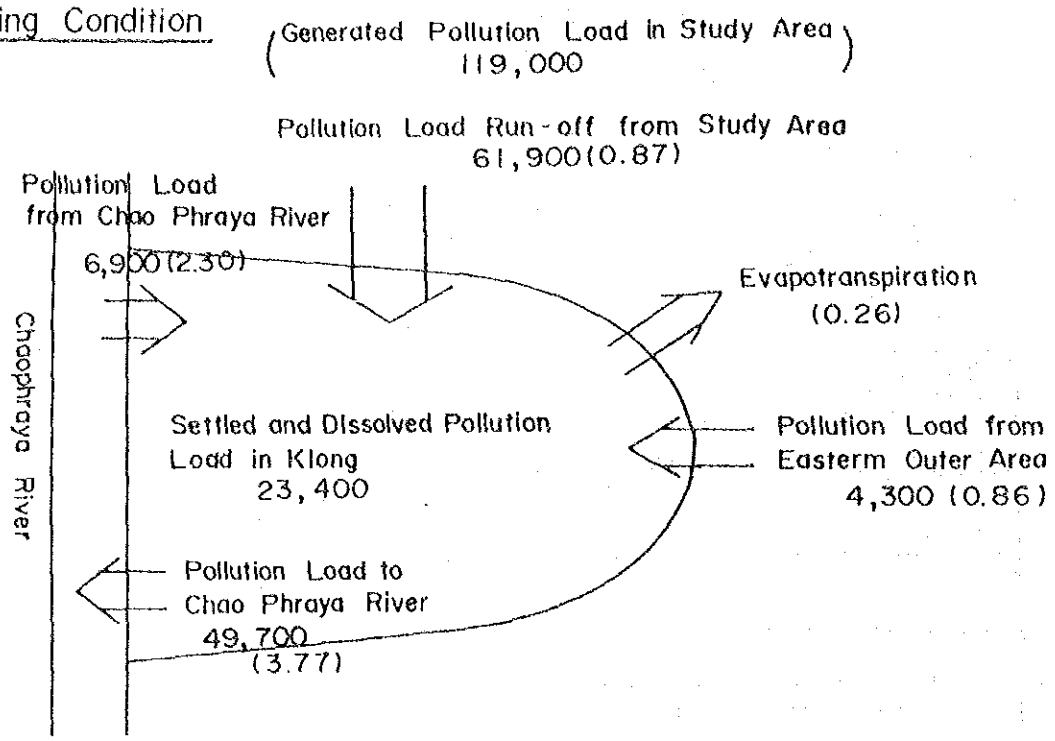
Table H.10 Daily Average and Maximum Water Quality in Each Target Klong in Rainy Season

Unit: mg/l

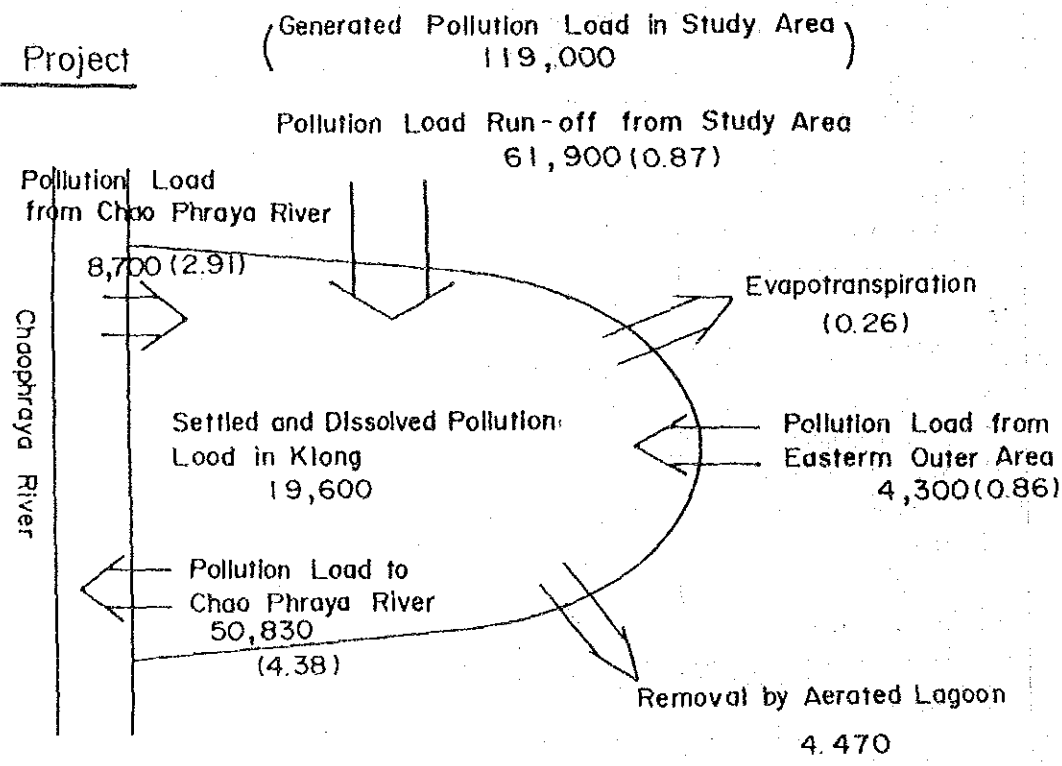
	Present (1986)		Future (2000)	
	Existing Condition	With Urgent Project	Case 1	Case 2
K. Bang Sue	8-14 (9-15)	8-17 (8-17)	22-30 (22-31)	19-27 (19-27)
K. Sam Sen	11-29 (15-30)	8-22 (8-23)	17-41 (17-41)	17-39 (17-39)
K. Prem Prachakorn	26-35 (27-39)	28-39 (28-41)	48-67 (48-70)	46-63 (46-63)
K. Huai Khwang	11 (11)	9 (9)	23 (23)	22 (22)
K. Mahanak - K. Saen Saep	20-22 (22-24)	15-45 (15-47)	25-55 (25-55)	25-56 (25-56)
K. Bang Kapi	16 (20)	8 (9)	18 (18)	18 (18)
K. Phadung Krungkasem	30-37 (30-38)	30-33 (31-34)	43-55 (44-57)	44-58 (44-58)
K. Bang Lamphu	18 (23)	48 (49)	57 (57)	58 (58)
K. Ong Ang	16 (22)	45 (46)	50 (51)	50 (50)
K. Lod	14-22 (18-24)	44-45 (45-46)	50 (50)	50 (50)
K. Wat Teptida	44 (55)	47 (47)	51 (52)	51 (51)
K. Wat Rajabopit	28 (33)	50 (50)	54 (54)	54 (54)
K. Tan	5 (5)	5 (5)	13 (14)	12 (12)
K. Phra Khanong	5 (6)	5 (5)	9 (9)	9 (9)
K. Toey	19 (26)	18 (23)	21 (27)	21 (27)
K. Sathorn	37 (37)	35 (35)	41 (41)	45 (45)
K. Chong Non Sri	32 (33)	30 (30)	36 (37)	41 (41)

Note: Figure in parenthesis indicates maximum BOD

Existing Condition



With Project



Note : Figures within parentheses mean water volume in million m^3/day
Figures with no parentheses mean pollution load in kg BOD/day

FIG. H.1 EXISTING POLLUTION LOAD BALANCE IN DRY SEASON (BOD)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

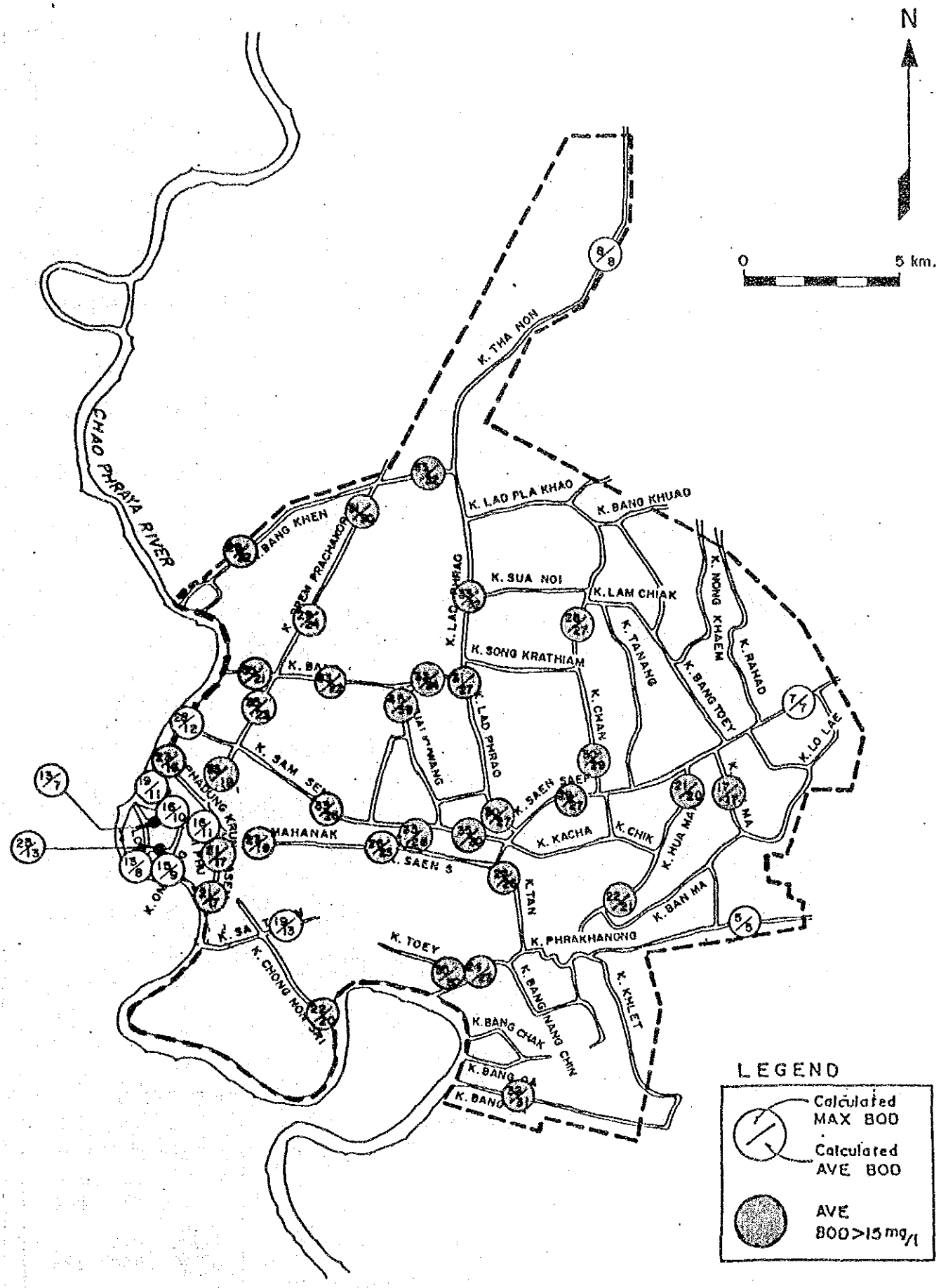


FIG. H.2 REGIONAL DISTRIBUTION OF KLONG WATER QUALITY IN 2000 FOR CASE I (DRY SEASON)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

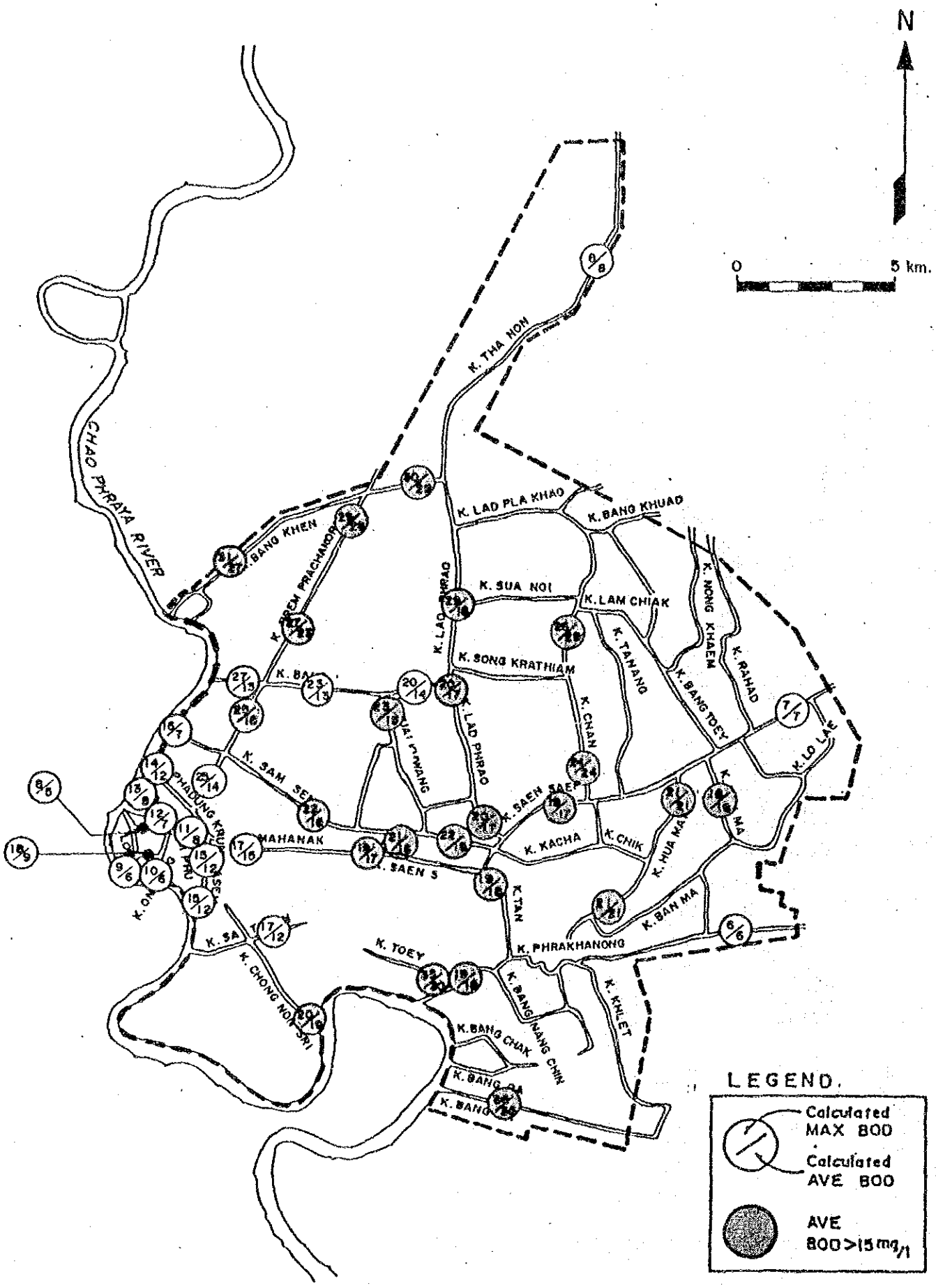
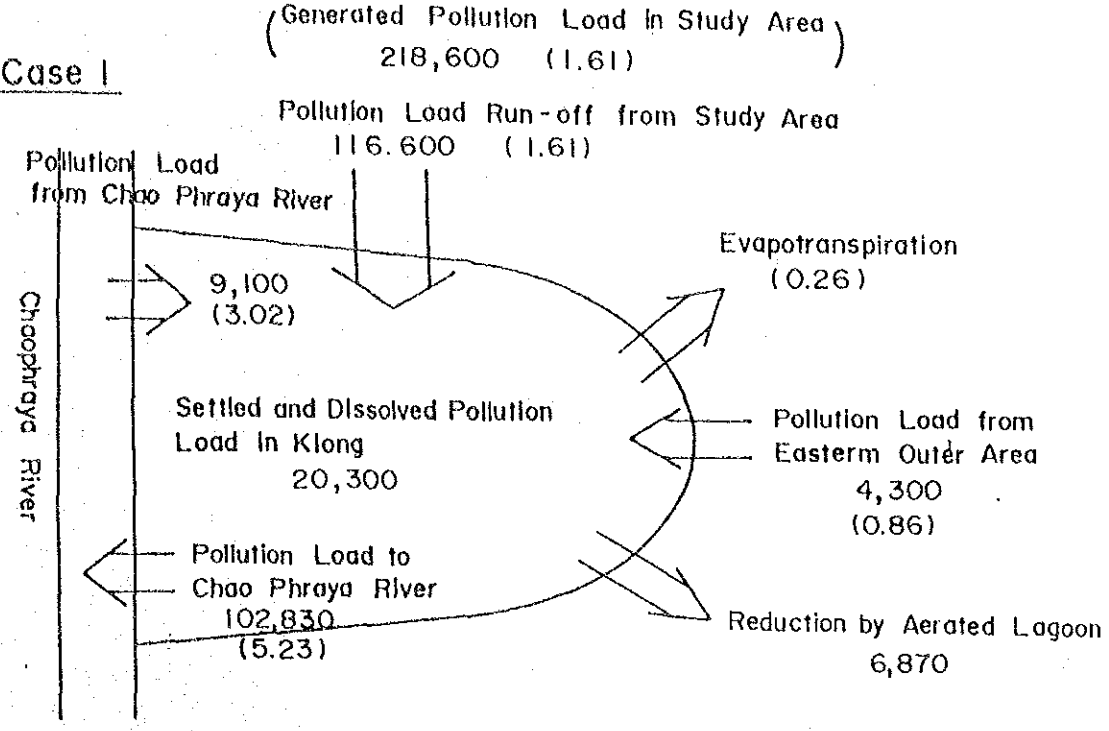


FIG. H.3 REGIONAL DISTRIBUTION OF KLONG WATER QUALITY IN 2000 FOR CASE 2 (DRY SEASON)

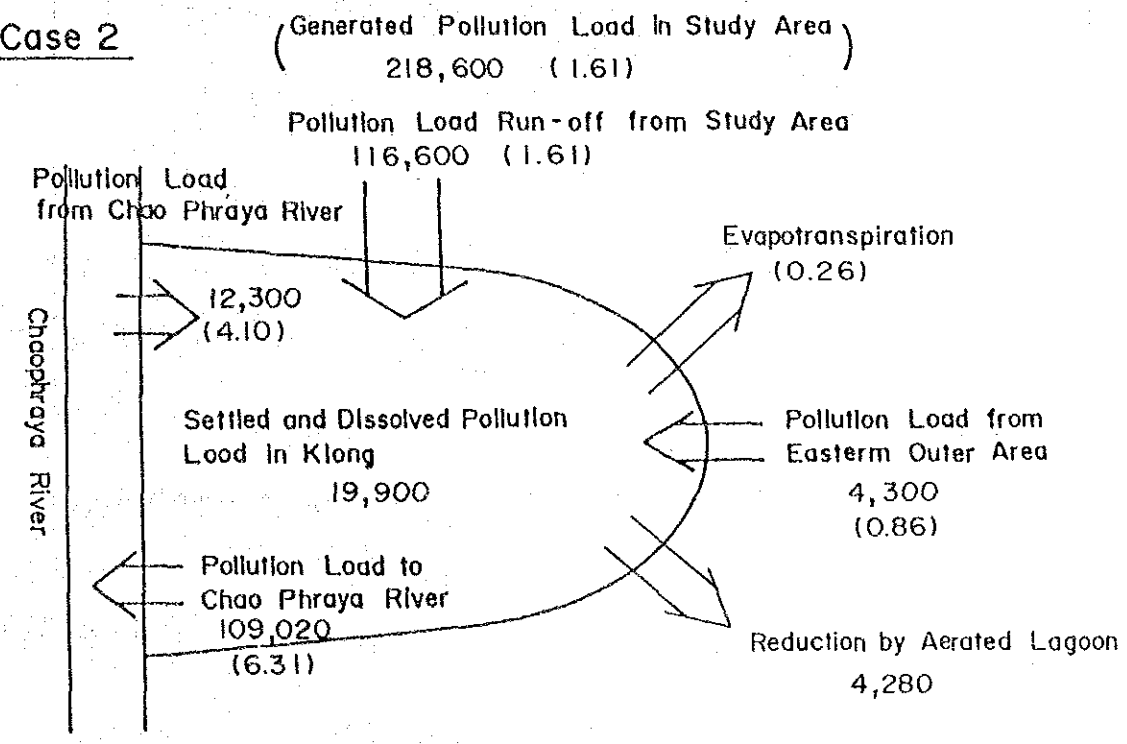
THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

Case 1



Case 2



Note : Figures within parentheses mean water volume in million m^3/day
Figures with no parentheses mean pollution load in kg BOD/ day

FIG. H.4 POLLUTION LOAD BALANCE IN DRY SEASON IN 2000

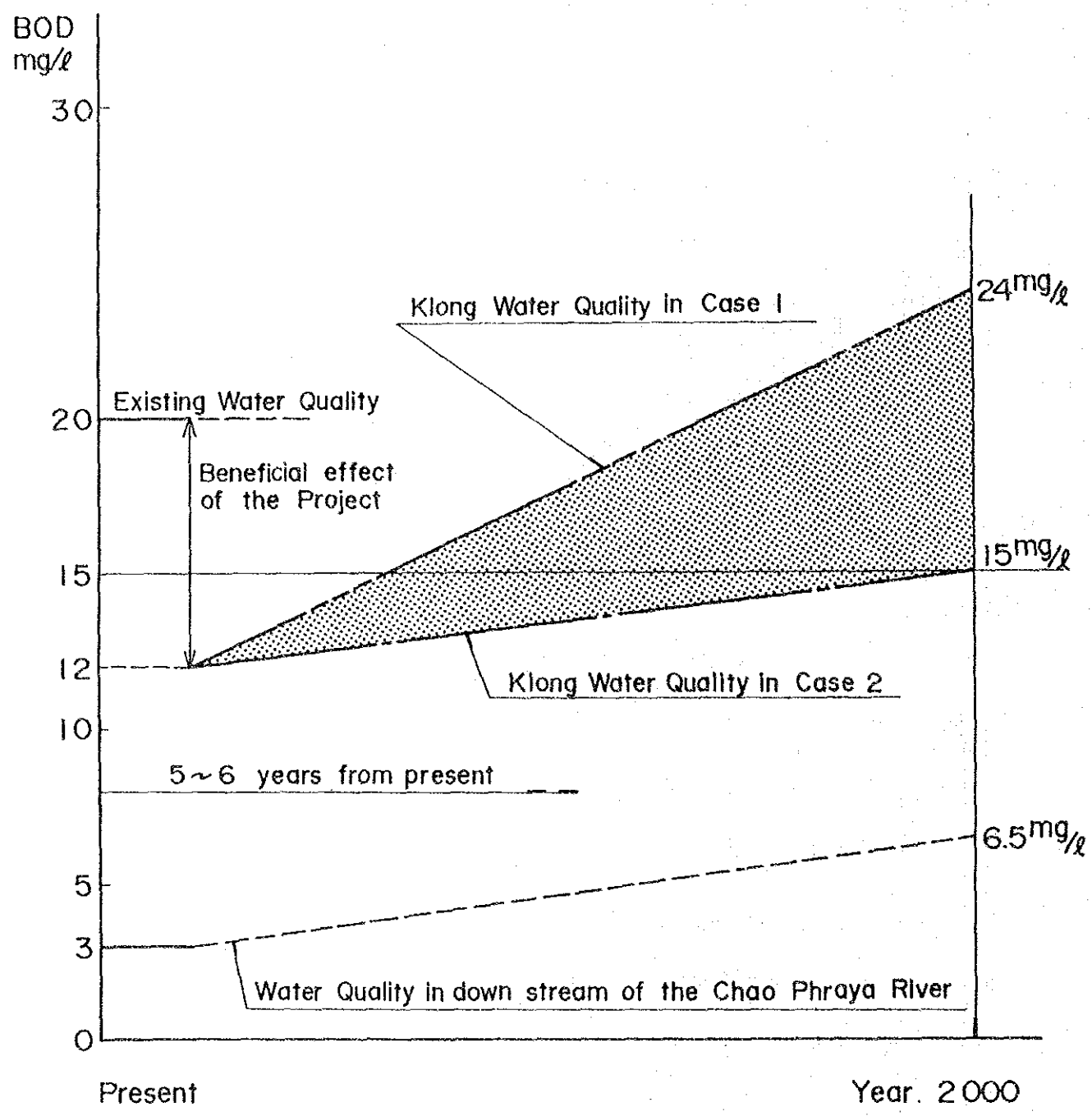


FIG. H.5 ESTIMATED AVERAGE WATER QUALITY IN BOD OF KLONGS IN SURROUNDING AREA AND CHAO PHRAYA RIVER

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

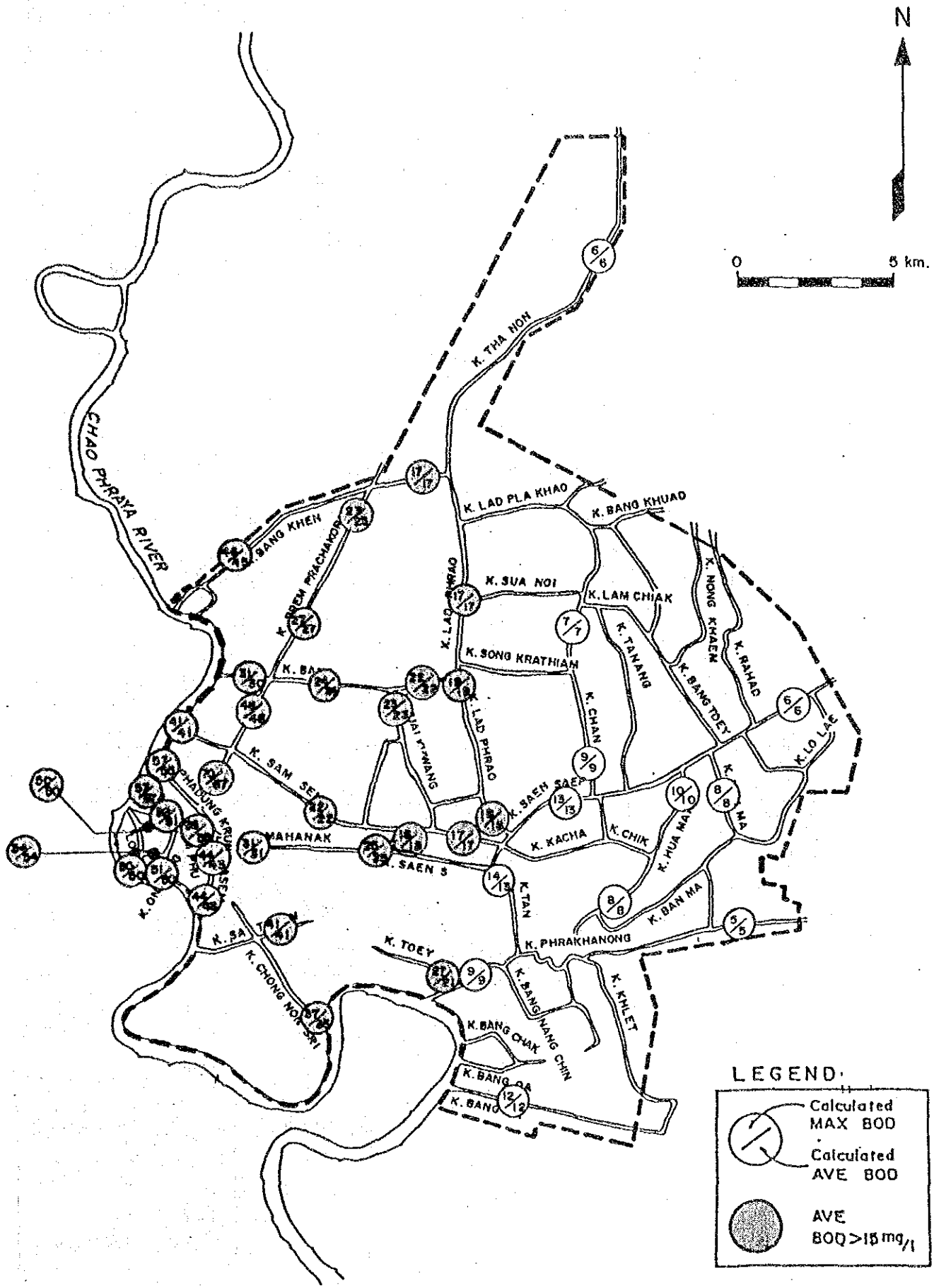


FIG. H.6 REGIONAL DISTRIBUTION OF KLONG WATER QUALITY IN 2000 FOR CASE I (RAINY SEASON)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

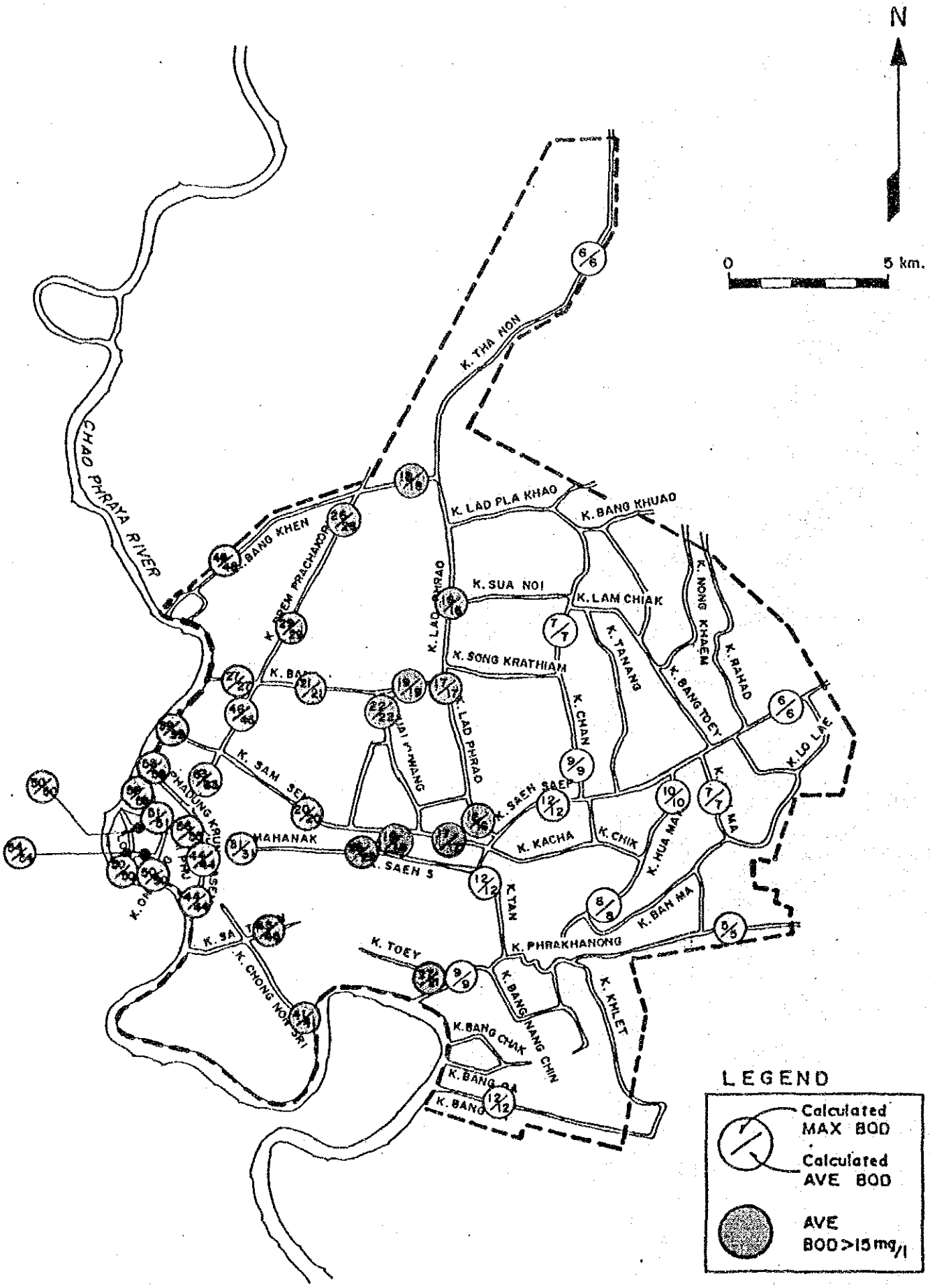
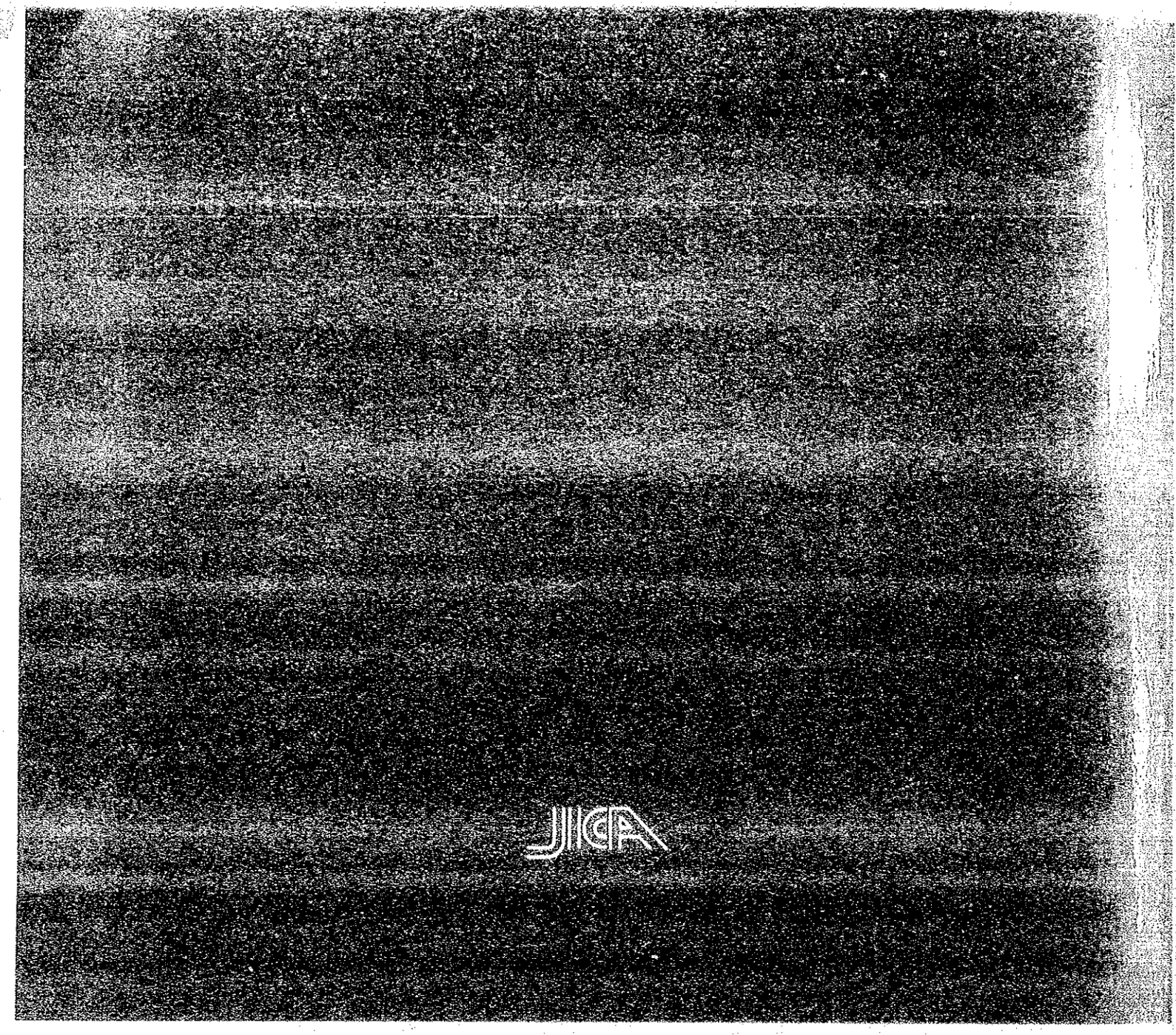


FIG. H.7 REGIONAL DISTRIBUTION OF KLONG WATER QUALITY IN 2000 FOR CASE 2 (RAINY SEASON)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.


JICA