FEASIBILITY STUDY FOR SEPARATE SYSTEM
METROPOLITAN WATER WORKS AUTHORITY
BANGKOK
KINGDOM OF THAILAND

REPORT

— 1973 —

PREPARED FOR
OVERSEAS TECHNICAL COOPERATION AGENCY OF JAPAN
DESIGNED BY
PACIFIC CONSULTANTS INTERNATIONAL CO., LTD.
& NAKANIHON ENGINEERING CONSULTANTS CO., LTD.

FOREWORD

In compliance with the request of the Royal Thai Government, the Government of Japan undertook to offer its cooperation in the survey for the waterworks project covering the suburban area of Bangkok, and entrusted the Overseas Technical Cooperation Agency with the execution of the survey.

Cognizant of the importance of the project, the Agency sent an eight-member team headed by Mr. Kimio Shiozawa, Technical Superintendent of Waterworks Department, Nagoya City, to Thailand. The team stayed in Thailand for 31 days from March 21 to April 20, 1973 during which it conducted survey activities in five of the nine Amphurs surrounding Bangkok for the construction scheme of the Separate System waterworks facilities.

This report was prepared by compiling the survey results to introduce the basic approach to the Separate System and to provide technical data covering population prediction, water demand, water source, treatment plants, distribution system as well as a rough estimate of the construction cost.

I should be more than pleased if this report proves useful for the welfare of the residents in the suburban area of Bangkok and at the same time contributes to enhancing the friendly relations now existing between Japan and Thailand.

I avail myself of this opportunity to express my deep gratitude to the competent Thai authorities for the unlimited assistance offered to the team without which the survey could not have been completed successfully as originally scheduled.

Keiichi Tatsuke
Director-General
Overseas Technical Cooperation Agency,
Japanese Government

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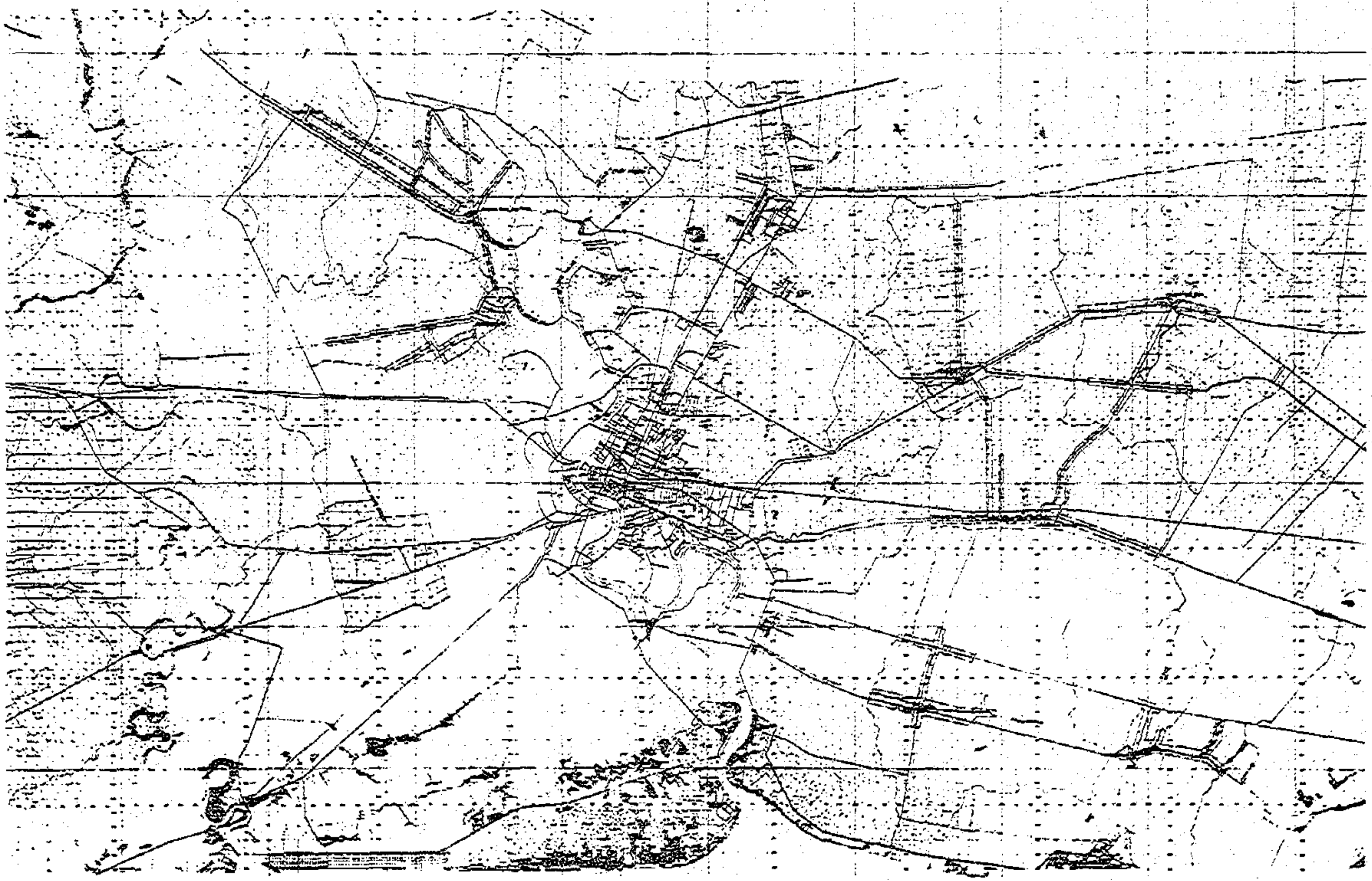
- LOCATION PLAN OF NINE SEPARATE SYSTEMS -



Chapter 1 Preface

1.1 Foreword

Works for Bangkok metropolitan water supply, which had been undertaken by the Provincial Waterworks Division of the Ministry of Interior, were transferred to the Metropolitan Waterworks Authority in 1967 after the latter was established. The authority, an executive agency of the Prime Minister's Office, was founded as a public enterprise on an independent account. In December 1968, the Metropolitan Waterworks Authority (hereafter mentioned as MWWA) entrusted the designing of the waterworks expansion project to an American consultant, Camp, Dresser & Mckee Company (CDM). The U.S. company was selected by the Board of Directors of MWWA out of a number of applicants from Thailand, Japan, the United States and Britain. CDM immediately started his work after his selection and completed a formation of the Master Plan in February 1970.

The Master Plan consisted of two parts: Summary Report and Technical Report. According to the basic concept, the giant project with the total construction cost estimated at about $600 million will be materialized in the MWWA water supply region which is technically divided into Central System and Separate System. The long-term development plan is based on the estimation that the population in 2000 A.D. will be 9,920,000, rate of house connection 86 per cent and daily maximum supply 5,500,000 m^3/d. The Separate System is a congregation of small-scale waterworks for an predicted population of 305,000, rate of house connection 74 per cent, water supply population 225,000 and daily maximum supply 36,000 m^3/d. Its total construction cost is about $7 million. As shown in Fig. 1.1, the Separate System covers satellite cities which contain 9 Amphurs surrounding the Central System and total administrative area are 1,513-square kilometers. The principal industry of the area is agriculture, but the area is gradually changing to a bed town. Construction of sites for modern industries is progressing although slowly, and plans are under way to build a new international airport and campus of universities.

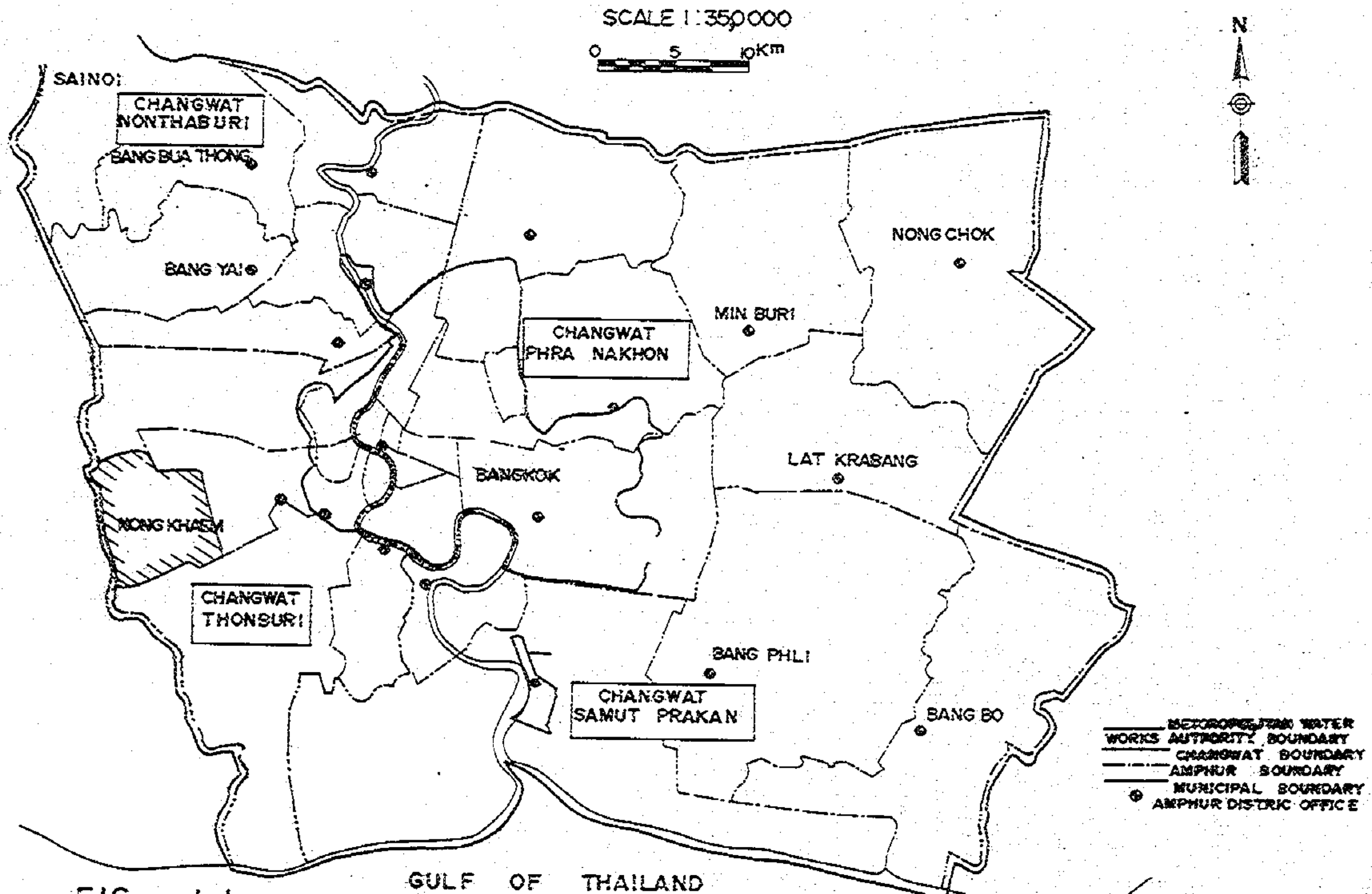


FIG. ~ 1.1

PLAN OF AMPHURS. CHANGWATS AND MUNICIPALITIES IN THE MWWA AREA

1.2 Visit to Thailand of the Separate System Survey Team

On the basis of the Master Plan made by CDM, MWWA entrusted CDM with the detailed design of the first-stage project (target year: 1977 for the Central system). As of May 1973, CDM has almost completed the works. As for the Separate System, the Department of Technical & Economic Cooperation (DTEC) sent a request to the Japanese Government for technical assistance in September 1971. The Government was also requested to appoint Dr. Sachiho Naito as a technical adviser for the MWWA project. Dr. Naito had been working for the Colombo Plan as a waterworks expert in the Public Works Department, Ministry of Interior.

In response to the request, the Government approved the appointment of Dr. Naito to the additional post. As for the technical assistance, the Government promised to make positive efforts in the process of budget formulation in 1973. Dr. Naito conducted basic surveys of the Nong Khaem district until March 1972 when his tenure terminated. Even after the end of his tenure, he continued researches and, on a private basis, compiled a pre-feasibility report and submitted it to General Manager, Prof. Chamras Chayabongse, MWWA. The report concerned pre-feasibility studies of only the Nong Khaem district, one of the nine Amphurs of the Separate System. The following persons cooperated for the compilation of the report:

Eijiro Ueno	:	Pacific Consultants K. K.
Ryuji Yanai	:	"
Kiyoshi Miyakura	:	"
Kiyoshi Asai	:	"
Saburo Matsumi	:	Nakanihon Engineering Consultant. Co.
Isao Kawamura	:	"
Kirthi Sri Senanayake	:	Kyowa Consultant Co.

Along with the 1973 budget deliberations, the Japanese Government examined various measures for the Separate System. As a result, it was found that the Master Plan was not enough for detailed design of the project. The Government recommended the Thai Government that preparatory works for the project be started with a feasibility study.

The Japanese recommendations were accepted by the Thai Government. Survey of all nine Amphurs as desired by MWWA was judged unable to execute within the fiscal year of 1973 due to the limit of budget and time. The Thai Government was thus informed of the Japanese plan to conduct survey of only five Amphurs out of nine in 1973.

All the Japanese proposals were accepted by the Thai Government. MWWA also expressed its strong desire to carry out the survey of four more Amphurs in addition to five. Agreement was reached on this matter, and a Japanese survey team, as introduced in the attached paper, visited Thailand on March 21, 1973. Mr. Kimio Shiozawa, chairman of the team, returned to Japan on March 30, but other team members stayed there to continue survey until April 20.

1.3 Contents of the work done by the Separate System Survey Team

The work by the Separate System Survey Team was carried out exclusively for five Amphurs. The survey of four other Amphurs was roughly involved in relating to the five Amphurs.

January 4, 1973

Prof. Chamras Chayabongse
Acting General Manager,
Metropolitan Water Works Authority.

Dear Prof. Chamras,

It is my privilege to submit our report on this date titled "Pre-Feasibility Study for Nong-Khaem Water Supply" which may be preferable to consider further steps of realization of water supply separate system in Metropolitan Great Bangkok.

Calling upon my personal position in MWWA as Colombo Plan Expert in the past, I have conducted pre-feasibility survey in my individual capacity even after expiration of the term of service to meet with your request, and I believe that our Government will despatch officially a Survey Mission of Separate System on coming soon in order to complete feasibility study for 9 Amphurs under the technical cooperation between both countries.

Until the occasion which our Survey Mission arrives Bangkok, would you mind to let your staff study this report and let them collect further data concerned, in views of technical and financial aspects.

Awating to meet you again in near future, I am.

Cordially yours,

S. Naito

Sachiho Naito,
Dr. of Engineering,
2nd Floor, Santoku-Yaesu Build., 5, No.5, Yaesu,
Chuo-Ku, Tokyo, Japan.

JAPANESE SURVEY TEAM FOR THE SEPARATE SYSTEM OF METROPOLITAN WATER SUPPLY WORKS

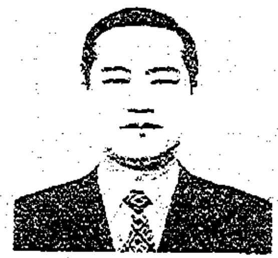
Mr. K. Shiozawa
Technical Superintendent,
Nagoya Water Works Authority
(Chairman of the Mission)

Dr. S. Naito
Technical Adviser, Japan Water
Works Association
(Vice-Chairman of the Mission)

Mr. M. Kaneko
Section Chief, Institute of Public
Health, Ministry of Health & Welfare
(Water Quality)

Mr. E. Ueno
Head, Water Supply &
Sewerage Division, Pacific
Consultants, K. K.
(General Planning & Layout)

Mr. M. Tanaka
Staff, Pacific Consultants, K. K.
(City Planning)



Mr. M. Nomura
Staff, Nakanihon Engineering
Consultants Co., Ltd.
(Intake & Treatment)

Mr. K. Miyakura
Staff, Pacific Consultant, K. K.
(Distribution System)

Mr. I. Nishino
Staff, Pacific Consultants, K. K.
(Survey & Structure)

SCOPE OF WORKS,
FEASIBILITY STUDY BY JAPANESE SURVEY TEAM
FOR THE SEPARATE SYSTEM OF METROPOLITAN WATER SUPPLY
IN BANGKOK, THAILAND

I. Introduction

1. The Government of Thailand, having plans to construct two water supply systems i.e., the Central System and the Separate System in Bangkok, requested the Government of Japan to carry out under its technical cooperation program detailed designing of the Separate System which consists of water supply systems in 9 Amphurs around Bangkok. Having carefully studied the above-mentioned request, the Government of Japan decided to carry out the feasibility study of the system in 5 Amphurs out of 9, and entrusted its implementation to the Overseas Technical Cooperation Agency (OTCA) of Japan. The five (5) Amphurs are as follows;

(a) Nong Khaem, Changwat Thonburi
(b) Lat Krabang, Changwat Phra Nakhon
(c) Bang Bua Thong, Changwat Nonthaburi
(d) Bang Yai, Changwat Nonthaburi
(e) Sai Noi, Changwat Nonthaburi

This document sets forth the scope of works in regard to the feasibility study for the project.

II. Scope of Works

2. The following surveys and investigations will be conducted for a period of 31 days.

(1) Data collection
- (a) Information on labor conditions, labor cost, construction materials, construction cost, construction machines, and design standard
- (b) Laws and regulations
- (c) Existing city planning, including population estimation in future
- (d) Existing geological and soil testing data
- (e) Meteorological data such as wind direction, wind velocity, temperature, rainfall, etc.

(2) Analysis of existing water supply system
- (a) Possibility of improvement of present facilities
- (b) Possibility of extension of present capacity

(3) Water reconnaissance
- (a) Various investigations of existing canal or klong
- (b) Quality and quantity of Chao Phya River and Nakorn Chai Si River throughout a year
- (c) Analysis of existing wells in the project area

3. The detailed study on the following items will be conducted by the Japanese experts.

(1) Population forecast for 2000 AD
(2) Water demand forecast for 2000 AD
(3) Proposed site of water intake and water treatment plant, and distribution area

(4) Layout plan of the following basic facilities

(a) Water intake facilities including pump, intake tower, receiving well

(b) Raw water main

(c) Purification facilities including mixing basin, flocculation basin, sedimentation basin, rapid sand filter, elevated tank for washing, and clear water tank

(d) Transmission line

(e) Distribution facilities including clear water reservoir, distribution main, distribution pump or elevated tank

(5) Cost estimation

(6) Construction schedule

(7) Economic analysis

III. Presentation of Documents

4. The feasibility report will be prepared in English and presented to the Government of Thailand.

IV. Counterparts and Facilities to be provided by the Government of Thailand

5. The followings are to be provided for the survey team by the Government of Thailand:

(a) Appointment of two counterparts

(b) A furnished office in Metropolitan Water Works Authority

(c) Two jeeps with chauffeurs

(d) Data and materials related to the project

(e) Necessary survey tools.

The contents of the survey work are shown in the following list of schedule. The survey was conducted during the mid-summer period in Thailand between March and April.

Date	Schedule	Contents of Survey work
March 21, Wed.	Haneda–Bangkok by LH flight 645	Arrive in Bangkok 21:40. Only Mr. Kaneko arrives later.
March 22, Thurs.	In Bangkok	Visit General Manager of MWWA for courtesy call and consultation. Visit OTCA overseas office of the Japanese Embassy for courtesy call and consultation. Inspection of Chao Phya river on the left-hand shore, study of existing waterworks and inspection of water source.
March 23, Fri.	Mr. Kaneko arrives in Bangkok by SR flight 307	Inspection of Nong Khaem area on the right-hand shore, study of existing waterworks and inspection of water source.
March 24, Sat.	In Bangkok	Map production, duplication, and compilation of specifications at MWWA.
March 25, Sun.		Map production, duplication, and compilation of specifications at MWWA.
March 26, Mon.		Inspection of the Sai Noi, Bang Bua Thong and Bang Yai areas on the right-hand shore, study of existing waterworks and inspection of water source.
March 27, Tues.		Inspection of the Bang Phli and Bang Bo areas on the left-hand shore, study of existing waterworks and inspection of water source.
March 28, Wed.		Inspection of the Nong Chock, Lat Krabang and Min Buri areas on the left-hand shore, study of existing waterworks and inspection of water source.
March 29, Thurs.		Consultation with MWWA Mr. Pracha and others.
March 30, Fri.	Team chairman, Mr. Shiozawa leaves for home.	Amendment of the original plan, summary of inspection at MWWA.
March 31, Sat.		Tracing of maps and preparation of specifications.
April 1, Sun.		Consultation among team members.
April 2, Mon.		Tracing of maps and preparation of specifications.
April 3, Tues.		Tracing of maps and preparation of specifications.
April 4, Wed.		Inspection of Samsen Water Purification Plant, collecting of reference data.

April 5, Thurs.		Inspection of the Nong Khaem area on the right-hand shore, collecting of more materials and gathering of samples for water quality analysis.
April 6, Fri.		Preparation of reference drawings study of specifications.
April 7, Sat.		Preparation of reference drawings study of specifications.
April 8, Sun.		Preparation of reference drawings study of specifications.
April 9, Mon.		Reinspection of Bang Yai and Nong Khaem areas on the right-hand shore, gathering of samples for water quality analysis.
April 10, Tues.		Reinspection of Lat Krabang area on the left-hand shore.
April 11, Wed.		Consultation between Deputy General Manager Amnuay Pranich and Mr. Leo A. St. Michel of CDM.
April 12, Thurs.		Another consultation with Mr. Pracha Tunsiri. Preparation of reference drawings, study of specifications.
April 14, Sat.		Another consultation with Mr. Pracha Tunsiri. Preparation of reference drawings, study of specifications.
April 15, Sun.		Another consultation with Mr. Pracha Tunsiri. Preparation of reference drawings, study of specifications.
April 16, Mon.		Another consultation with Mr. Pracha Tunsiri. Preparation of reference drawings, study of specifications.
April 17, Tues.		Reinspection of the Bang Bua Thong area on the right-hand shore.
April 18, Wed.		Printing of drawings, restudy of specifications.
April 19, Thurs.		Final consultation with General Manager, Prof. Chamras.
April 20, Fri.	Bangkok–Hong Kong by TWA Hong Kong–Tokyo by JAL 062	

1.4 Persons who cooperated for the survey

Persons who cooperated for the survey represented: Japanese side—Ministry of Foreign Affairs, Ministry of Health and Welfare; Embassy of Japan, OTCA, Japan Waterworks Association; Thai side—MWWA, DTEC and Public Works Department, Ministry of Interior. Their personal names are listed below. To those whose names are listed below and not mentioned here, deep appreciation is expressed for their sincere cooperation. Without their great contribution, the survey could not have been completed successfully.

Japanese side:

Mr. Kikuchi, Counselor of the Economic Cooperation Bureau, the Ministry of Foreign Affairs.

Mr. Yanagi, Chief; Mr. Komata, Deputy Chief; Mr. Suzuki, secretary; and Mr. Nakaki, Secretary; of the First Economic Cooperation Division, the Ministry of Foreign Affairs.

Mr. Urata, Director of the Department of Environmental Sanitation, the Ministry of Health and Welfare.

Mr. Kunikawa, Chief; Mr. Hayashi, Deputy Chief; and Mr. Kobayashi, Engineer; of the Water supply Division, Department of Environmental Sanitation, the Ministry of Health and Welfare.

Mr. Nanbu, Chief of the Sanitary Engineering Bureau, the Institute of Public Health, the Ministry of Health and Welfare.

Mr. Sezaki, First Secretary; and Mr. Tokuoka, First Secretary; of the Embassy of Japan, Bangkok, Thailand.

Mr. Kaido, Manager; Mr. Niinomi, Chief; and Mr. Mutsuro; of the Department of Development and Research, the Overseas Technical Cooperation Agency.

Mr. Miyamoto, Representative; and Mr. Kumagishi; and Mr. Morimoto; of the Bangkok Overseas Office of the Overseas Technical Cooperation Agency.

Mr. Nishikata, Director General; and Mr. Matsuda, Technical Superintendent; of the Japan Waterworks Association.

1.5 Interim report issued at the time of the on-spot survey

Vice Chairman, Dr. Naito's report (attached paper) was submitted to the consultation talks with General Manager at the meeting held on April 19, the last day of the survey team's stay in Bangkok. Naito's report states general concepts of the Separate System as a result of the survey work at that particular time, and it does not put restraint on the full concept of this feasibility study report.

Thai side:

MWWA Acting General Manager: Prof. Chamras Chayabongse

MWWA Deputy General Manager: Mr. Amnuay Pranich

MWWA Deputy General Manager: Mr. Prakob Chuangpanich

MWWA Deputy General Manager: Mr. Krachok Subhakivilekakarn

MWWA Assistant General Manager: Mr. Pracha Tunsiri

MWWA Chief, Research & Development Section: Mrs. Chuanpit Dhamasiri

MWWA Counter-Part: Mr. Dhanist Hirunrut

MWWA Counter-Part: Mr. Sittipong Srisisttinam

PWD Director, Provincial Water Supply Division: Mr. Kaslan Anambutr

PWD Chief, Provincial Water Supply Division: Mr. Sawasdi Orvichian

PWD Staff, Provincial Water Supply Division: Mr. Aroon Thaicharcon

OVERSEAS TECHNICAL COOPERATION AGENCY (OTCA)

BANGKOK OFFICE

19th April, 1973.

Prof. Chamras Chayabongse
Acting General Manager,
Metropolitan Water Works Authority,
Bangkok, Thailand

Dear Prof. Chamras,

On the behalf of Overseas Technical Cooperation Agency, the Japanese Government, it is pleased to submit herewith our interim report for the separate system to the extent of five Amphurs.

The interim report will cover especially the item of water reconnaisance, because the most important factor to establish master plan of water supply works for the separate system is to select the water source. Thus, the other items shall be covered by our feasibility report which is going to submit on sometime around September 1973.

Due to the limitation of time schedule and budget of the Survey Team, we regret very much that we have not covered whole Amphurs to carry out field study. In case, however, if your authority will over again request the feasibility study to cover the remaining four Amphurs, it is willing to convey your request to our Government to allocate necessary budget for the survey during this fiscal year 1973.

In closing, it is very much appreciated that MWWA gave us sincere hospitality and kindness during our staying in Thailand. I hope to see you again in near future when our Government will submit the feasibility report for the separate system.

Cordially yours,

Sachiho Naito

Vice-Chairman, the Japanese
Survey Team for the Separate
System

19th April 1973.

WATER RECONNAISSANCE FOR THE SEPARATE SYSTEM

(1) Well Water

In general speaking, it is commonly known that there are three water sources such as well, klong and river.

The possibility of ground water, in the past, has been hopefully expected in somewhere around northern part of Thonburi and Bangkok. Such possibility, however, had faded in Amphur Nong Khaem area as the result of test well done by your Authority in last year. In addition, the well for water supply have abandoned by being turned to brackish water in Amphur Sai Noi located at northmost area of Great Bangkok in right bank of Chao Phya river. And also at neighbouring Amphur Bang Bua Thong located in the south east of Sai Noi, the klong water has been used instead of using ground water. At Amphur Bang Yai located in the south of Amphur Sai Noi and Bang Bua Thong, notwithstanding they are using well water for their water supply, the water quantity pumping up is so small at present that such limited data can not make sure of continuous use for long period of time.

On the other hand, the Amphurs located in the left bank of Chao Phya river are still using wells for their water supply system. According to the present situation and CDM report, it is inferable that a risk of salinity of ground water will not be arisen within short period in future. At Amphur Nong Chok and Bang Phli, however, salinity content is now increasing even if it keeps lower than maximum tolerate level as a potable water (see also attached sheet-1 and 2), so that it is obvious warning sign for future use of ground water.

Therefore, at the right bank of Chao Phya river, due to the influence of over-pumping of ground water, it is considerably hopeless of underground water development as far as the Government use is concerned and also it may be possibly said that Bang Yai will have a salinity damage in ground water sooner or later. On the contrary, it is obviously able to use ground water for coming few years at the left bank of Chao Phya river, but it is considered that this circumstance might be fated some day as same as the one in the right bank of Chao Phya river.

It is, sooner or later, inevitable to regulate the quantity of pumping up ground water by law in the area of Great Bangkok and its environs, otherwise it might repeat same troubles which have faced in Tokyo Metropolis since few years ago. As you know, the reason of prohibiting use of well is mainly to protect against ground subsidence sinking so rapidly in Tokyo Metropolis. Even at Great Bangkok, as an example of the settlement of the National Theater Building near the Tha Chang bridge reported in newspaper recently, it can be said that it is the time now to consider the optimum capacity pumping up of ground water.

(2) Klong water

In case when it excludes the ground water from proposed sources for the project, the klong water is coming up in use for water supply. The Klong which is the legacy of our great ancestors has performed its functions surved as agricultural, navigational and human consumption. And it will be continuously utilized one of the important factors controlling human-life in future. However, the quality of the Klong water will be contaminated day after day according to applications of intelligence to human-life and also its improvement.

It is understood from the result of reconnaissance carried out by the Survey Team, for example, contaminated load at Klong Wattana already shows about 1.6 ppm of BOD value in average, and it means that contamination of Klong water approaches nearly two times compared with Klong Phrapa which is the water source for the central system. It can be said that the BOD value, 1.6 ppm is caused by human waste only along the Klong and no industrial water can be considered in this area, whereas another factors except BOD value of the water quality of the Klong have no particular problem involved as shown on the attached sheet-1.

It has been discussed for a long period of time how it should be the maximum tolerate value of contaminated load of raw water for a water supply system. Even though, it is very risky expression of using BOD value only for the contaminated load, BOD value for the Klong is to be 4 ppm as maximum based on the experience of water pollution which has been faced in Japan. It means that when BOD value exceeds 4 ppm, the Klong will lose its optimum function as a source for water supply.

It is understood that water treatment engineering is progressing day by day, and there is no fear from the engineering point of view although BOD value exceeds 4 ppm. However, as it requires considerable high cost for purifying water with such quality, it will cause unbalance between income and expenditure of public water works, it is hard to say there is more possibility of use such contaminated Klong water as a source in such case.

From such point of view mentioned above, when the BOD value of the Klong water will show nearly 4 ppm, namely it shows about two times as much as 1.6 ppm showing at present, in another word, when the number of inhabitants who are the major factor of the pollution of Klong increase twice as much as the number at present, the Klong will doubtfully be considered as a source for water supply, and it is assumed to be reached to such condition during the year between 1990 and 2000 AD, if no industry discharges its waste.

It is, therefore, recommended that the Authorities should establish suitable policy as soon as possible in order to have no more increasement of BOD value of the Klong. Meantime, it is hoped that the Klong which is going to be considered as a source in the master plan will be kept as good as possible.

(3) River water

It has to turn our eyes toward river water as a source at the time when the Klong can not be used for the purpose due to having contamination or another reason like no issue of taking water from the Klong. As it is well known, only two rivers, Chao Phya river as well as Nakorn Chai Si river, can be economically considered for surface water for intake nearby Great Bangkok. And when it takes into consideration in an emergency case and the quantity of intake water from Chao Phya river such a big amount like 6 MCM per day in future for the centeal system, it is preferable to take water from Nakorn Chai Si river for the separate system. In general, it is an inevitable factor to have at least two water sources for the Great Bangkok and it means to be avoided such a case that having only one water source.

The water from Nakorn Chai Si river should cover its service only the area in the right bank of Chao Phya river because of its location, but the intake scheme will cover on its service area where involves Amphurs Nong Khaem, Bang Yai, Bang Dua Thong and Sai Noi, or furthermore include municipal Thonburi if it is possible. However, it should be realized that the raw water conveying system to serve only the area within the separate system will be amounted to about US$6 M.

It is very difficult project to serve raw water to the separate system for the area in the left bank of Chao Phya river (Amphus Lat Krabang, Min Buri, Nong Chok, Bang Phli and Bang Bo). For example, if there is some possibility of taking and conveying water from Klong Phrapa, the raw water supply works will be required its cost amount to US$13 M, and accordingly the unit construction cost per capital or per nominal capacity will increase much higher than the usual rate, and this rate causes in trouble of finance to the water works.

However, the areas in the left bank of Chao Phya river, because of no alternative river for water source, must depend on either Klong Phrapa or Main river of Chao Phya for its purpose, by all means. Thus, problem is so complicated when it is considered for the future.

It is said with great interests, furthermore, the tendency of expansion at large cities in the world is moving toward east, and also this tendency is gradually recognized in several areas in the Southeast Asia. It should be noticed the development plan such as a new airport project or industrial planning in Great Bangkok also shows same tendency as well.

(4) Conclusion

As a conclusion of the study concerning water reconnaissance, it is recommended in this interim report as follows.

A) For the area in right bank of Chao Phya river it is preferable that no well is to be considered and the Klong water is to be taken into consideration for the time being, and meantime to convey raw water from Nakorn Chai Si to Amphur Nong Khaem as an alternative plan.

B) For the area in left bank of Chao Phya river, it is proposed to establish emergency program using ground water for coming few years and alternative plan from Klong will be considered in the master plan as a provision for the year when no ground water will be used. However, as no study other than Amphur Lat Krabang for the area in left bank of Chao Phya river due to the time and budget limit, the expansion plan served water to cover all Amphurs in the left bank will be remained until the next occasion of the survey.

Chapter 2 General consideration and recommendation

2.1 Foreword

General consideration and researches were made from various angles concerning the waterworks of Bangkok Metropolis and neighboring districts during the on-spot survey were carried out for one month from March 21, 1973. They can be summarized in four major points as follows:

1. The status of the Separate System in relation to the Central System.
2. Relations between emergency works and long-term measures.
3. Measures for water sources.
4. Independent accounting of a water supply enterprise and the financial support by the Government.

The Central System, controlled by MWWA since 1969, is gradually restoring its function through complicated processes and steadily moving toward the goal of attaining higher efficiency. As for the Separate System, no specific measures excepting the formulation of the Master Plan have been taken, and the gap between the two systems is widening further, causing unbalanced supply of water to the service areas. More than $150 million is needed to just restore the Central System to the normal condition, and it is extremely difficult to appropriate more funds for the Separate System. In Bangkok and neighboring districts where urbanization is progressing rapidly, construction of water supply facilities must be regarded as the civil minimum and carried out as soon as possible. To facilitate the construction work, it is necessary to modify the original plan of the Separate System properly so that the plan can become feasible technically and economically.

2.2 The status of the Separate System in relation to the Central System

During the period between September 1971 and March 1972 when Dr. Sachiho Naito conducted a preliminary survey of the Separate System, no attention was given inside the metropolis to the idea of expanding the water supply area of the Central System to include that of the Separate System or to the idea of supplying part of the water of the Central System to the area of the Separate System. It was solely because of the easy on way of thinking, as seen in the report of CDM, that waterworks of the Separate System could be constructed easily and that water sources could be found whenever wells were driven. Facing unexpected troubles such as the unsuccessfulness in the underground water reconnaissance in the Nong Khaem district carried out immediately after the basic survey and the serious salty water pollution of well water in Amphur Sai Noi, the Separate System plan had to be rescrutinized thoroughly from the view point of obtaining water sources. In other words, necessity arose to seek the possibility of finding a simpler solution by supplying the water for the Separate System from the Central System. It was almost impossible to satisfy all the demand in the Separate System with the water from the Central System, because the construction work in the Central System were under way in accordance with the original schedule. Moreover, it was considered to be economically impracticable to supply water of the Central System to distant districts of the Separate System. For these reasons, we discussed the feasibility of supplying water to Nong Khaem district situated close to the Thonburi. To supply water to Amphur Nong Khaem (the daily maximum consumption in 2000 A.D. will be 40,000 m^3/d), the water treatment capacity for Nong Khaem in the Central System (Bangken) must, as a rule, be raised by another 40,000 m^3/d. According to the design criterion for the Central System, the daily per-capital consumption is set at 500 liters, so that treatment capacity has a considerable margin. Therefore, no expansion plan at Bangken is considered in the process of further distributions. The Tha Phra Service Reservoir, the practical origin of water for Nong Khaem, was designed a capacity of 40,000 m^3. If it stores 38,000 m^3 or 10 per cent of the total daily water demand of 380,000 m^3/d, it has a margin of 2,000 m^3. If the storage capacity is required to increase of 4,000 m^3, corresponding to the water supply volume of 40,000 m^3, the reservoir capacity falls short of the required amount by 2,000 m^3 only. Therefore, the problem is whether or not the reservoir capacity shall expand from 40,000 m^3 to 42,000 m^3 theoretically.

If a service reservoir will be constructed in Amphur Nong Khaem, water pipes planned in the Thonburi shall be enlarged to convey additional water of the maximum daily flow for Nong Khaem of 40,000 m^3/d. For the demand until 1975, the pipe diameter will not have to be changed. No change is necessary in water supply pumps of the present plan which have a surplus both in the pumping capacity and the head. For the water supply from the Thonburi to Amphur Nong Khaem, new pipe line with the diameter of 350 mm shall be installed to meet the demand in 1975 A.D. and pipe line of 700 mm in diameter will be needed in 2000 A.D.

Concerning the necessity of these changes, the Survey Team submitted a letter of inquiry as in the separate sheet, which was in the name of the Vice Chairman of the Survey Team and dated June 8, 1973. However, a formal reply was not received by the end of June, 1973 when the draft of report had been compiled. Therefore, final study of this matter is not included in this report, and it will be reviewed in another report which will be prepared whenever required.

2.3 Relations between emergency works and long-term measures.

To establish concrete plans for each Amphur, the first step was to predict the water demand in 2000 A.D., and then draw out a waterworks project corresponding to the future demand and calculate the construction cost on the basis of the current unit price. As a rule, the construction work was designed to be carried out in three stages, and due consideration was taken so that emergency works to recover the normal condition preceded the first-stage of the construction.

In the case of the waterworks of this type, a large increase of water charge revenue cannot be expected because the population will not increase so much as the rise in the cost for new water pipes. The first-stage of the construction works was limited to Amphur Town and its vicinity where the population concentrated, and new pipes were scheduled to be installed in the second stage and in the latter half of the third stage. Therefore, it may be possible that upon the completion of the first-stage works, people will get water by sharing a common tap in some part of the region.

8th June, 1973

Mr. Pracha Tunsiri
Assistant General Manager,
Metropolitan Water Works Authority,
Siyak Mansri, Sapan Dum, Bangkok,
Thailand

Dear Mr. Pracha,

Following with the final discussion on the date of 19th April, we have studied the possibility of using fresh water from Tha Phra Distribution Reservoir for the Amphur Nong Khaem.

It is known that CDM made a master plan of water supply for the Thonburi through Tha Phra reservoir in the Central System. However, if we would follow with the subject which is understood as the extension of distribution pipe from Central System to Nong Khaem, we have to add the required water quantities (40,000 CMD in daily maximum) to be supplied for Nong Khaem onto the designed quantities made by CDM. Judging from these circumstances, followings are the result of our study to meet with our assignment for the subject.

(1) The output of the Bang Khaem purification plant has to be expanded for the demand of 40,000 CMD, but we would be able to neglect this modification because we assume it has some allowance in the figure 500 l/d per capita.

(2) When it considers to extend the distribution pipe originally designed till Amphur Nong Khaem from the end of Thonburi, it requires to enlarge pipe size, distribution pump capacity and Tha Phra reservoir capacity in order to cover the hourly maximum demand of Nong Khaem.

(3) However, if it considers that the daily maximum demand is to be conveyed through original pipeline in addition to the hourly maximum demand of Thonburi, new reservoir for Kong Khaem shall be constructed at Nong Khaem.

In any case, it is hardly to say "feasible" of the subjected plan unless otherwise to make some modifications abovementioned for distribution pipe, pump capacity and Tha Phra reservoir which are made by CDM. Therefore, you are kindly requested to advise us the following informations at your earliest convenience.

1. Flow rate, velocity, pumping head and hydraulic gradient through distribution pipe out going from Tha Phra reservoir to the end of Thonburi area, based on the CDM design.

2. Number, capacity and type of the distribution pumps to be installed at Tha Phra reservoir, based on the CDM design.

3. The possibility of a expansion of the Tha Phra reservoir and capacity increase of distribution pumps.

The followings are appendix of our calculation result based on existing data obtained.

1) Modification of pipe diameter

At 1975 AD, it can convoy water to Nong Khaem area without any modifications of pipe size, but it requires only extension of pipe of 350 mm in dia and 0.75 km in length from the end of original pipeline to Nong Khaem. But, the pipe diameter shall be changed as shown on the table at 2000 AD when 40,000 CMD is to be conveyed from Tha Phra reservoir to Nong Khaem.

	Distance	Original pipe dia	Modified dia
2000 AD	1.75 km	1,000 mm	1,200 mm
	2.00 km	800 mm	1,000 mm
	2.50 km	600 mm	900 mm
	1.40 km	400 mm	800 mm
	0.75 km	---	700 mm*

* Extension of original pipe line for Nong Khaem

2) Comment for Tha Phra reservoir

Original capacity of reservoir	40,000 ton
Net capacity, if be followed by 10% of daily maximum demand	38,000 ton
Allowance at 2000 AD	2,000 ton

Daily maximum demand for Nong Khaem is predicted 40,000 CMD, therefore, required reservoir capacity is 10% of 40,000 CMD, i.e. 4,000 ton. Hence, a total required capacity of Tha Phra reservoir is 42,000 (38,000 + 4,000). Therefore, a shortage of 2,000 ton of capacity is found from our calculation.

3) Expansion of pump

For conveying of water to Nong Khaem area, it requires to enlarge pump capacity or its number to meet with additional discharge of 40,000 CMD, but originally designed pumping head is sufficient to cover that purpose.

Awaiting with your kind cooperation, I am,

Cordially yours,

Sachiho Naito
Vice-Chairman,
Japanese Survey Team,
2nd Floor, Pacicon Build.
2, No. 8, 2-Chome, Jingu-mae,
Shibuya-Ku, Tokyo, Japan

2.4 Independent account for waterworks and financial support by the Government.

As for the construction cost needed for emergency works and the first-stage works, a financial plan on the independent accounting basis was contemplated. In this case, the water charge was assumed 3 bahts/m^3 revised price from current rate, and the construction expense was calculated on the condition that the loan for domestic current portion be repaid in 35 years with the interest rate of 6 per cent after a grace period of five years and that for foreign currency portion be redeemed in 25 years with the interest rate of 3.25 per cent after the same grace period. In both cases, a balance of account cannot be expected before time passes far beyond 2000 A.D. The problem is always faced in small scheme of the waterworks, particularly serious in the countryside where the population density is far below that of the urban areas. The reality is unavoidable especially because the water source is used commonly in the comprehensive waterworks project. Therefore, we reached the conclusion that the independent accounting system relying on water charges cannot be materialized unless about half of the total construction cost is paid with the national support by the Government.

At present, the national support is appropriated for installation and expansion of local waterworks managed by the Public Works Department, the Ministry of Interior, and waterworks bonds are not issued except in specific cases. Water charge is unified nationwide at 2 bahts/m^3, and the income is mainly used to pay wages for workers without following the principle of the independent cost account. Earlier, the detailed design of the Chieng Mai waterworks was completed with the grant base from the Japanese Government. Director of the Public Works Department stated that the national support is used for domestic currency and there is no plan of issuing waterworks bonds. We hope that, for the current project, too, a similar step be taken on the Government basis.

2.5 Measures for water sources

In the metropolitan region, 600,000 m^3/d of underground water is pumped with existing facilities and 200,000 m^3/d will be pumped with new facilities now being planned. The works for new deep wells are also scheduled in the Central System, too.

Chloride pollution caused by uncontrolled pumping of underground water is worsening day after day, and serious trouble may occur to the condition of underground water in the entire metropolitan region unless some restrictive measures are taken. The new plan of the Separate System is based on the use of underground water, and therefore, inability of lifting underground water in Amphur Nong Khaem and chloride pollution in Amphur Sai Noi are posing grave problems for the entire metropolitan region and for the Separate System as well. In this situation, MWWA has conducted experiments by using a test well in Amphur Bang Bua Thong and Sai Noi in an effort to find new possibilities of pumping up of water. However, it may not find new hopeful prospects even shortly after the completion of this interim report.

Today, water pumping is restricted in many cities of the world which are situated on relatively flat lands facing the sea. We must be prepared for the future situation in which water will, in a long run, have to be taken from surface water instead of underground water even if the use of the latter is possible in the Separate System at present.

Source of surface water can be found in Chao Phya River and Nakorn Chai Si River. However, the plan cannot be put into practice due to problems related with the scale and geographical position of the Separate System. The application of the long-range national project to the waterworks construction is a lofty ideal, but it is not necessarily practicable in the developing country which are now confronted with a number of emergent projects.

If the use of surface water of the two big rivers as the source of water for the Separate System is disregarded, the remaining possibility is to utilize Klongs which reticulate throughout the metropolitan region. During the current survey, elaborate analyses were made on Klong water quality, and we reached the conclusion that Klong water could be used for the time being as the water source if proper measures for water pollution control are taken.

Table 2.1

	Urgent Work (To be completed in 1977)	1st Stage Work (To be completed in 1981)	2nd Stage Work	3rd Stage Work	Total
Beneficiaries to be served (person)	30,000	26,000	20,000	27,500	103,500
Water supply capacity (Daily max. m³/day)	10,000	10,000	10,000	10,000	40,000
Kind of source	klong wattana	same as left	same as left	same as left	–
Purification facilities	Coagulation sedimentation, filtration	same as left	same as left	same as left	–
Cost of work (1,000 ฿)	122,486	20,929	24,431	29,397	197,243
Part for domestic currency	40,353	5,936	9,010	9,544	64,843
Part for foreign currency	82,133	14,993	15,421	19,853	132,400

Table 2.2

	Urgent Work (To be completed in 1975)	1st Stage Work (To be completed in 1978)	2nd Stage Work (To be completed in 1984)	3rd Stage Work (To be completed in 1990)	Total
Beneficiaries to be served (person)	14,000	5,000	6,000	8,750	33,750
Water supply capacity (Daily max. m³/day)	10,000	10,000	10,000	10,000	40,000
Kind of source	Deep well	Combined use of deep well and klong Phra Kha-nong	klong Phra Kha-nong	klong Phra Kha-nong	–
Purification facilities	Only disinfection	Coagulation, sedimentation, filtration	Same as left	Same as left	–
Cost of work (1,000 ฿)	3,270	29,149	11,152	10,342	53,913
Part for domestic currency	1,672	110,445	6,249	3,444	21,810
Part for foreign currency	1,598	18,704	4,903	6,898	32,103

2.6 Recommendation

The latest survey could not bring about conclusive findings for all the nine Amphurs included in the Separate System, but for the five Amphurs listed below, the following waterworks plan can be recommended as a practical idea:

2.6.1 Amphur Nong Khaem

Waterworks which will supply 40,000m³/d of water in 2000 A.D. by using Klong Wattana as the water source is recommended as the most practical project. In this case, a plan of taking purified water from the Central System is not included. In other words, when the supply of purified water from the Central System becomes possible, comparative studies will have to be made concerning that program and then hereby recommended plan of using the water of Klong Wattana. The outline of this plan is shown in Table 2.1.

2.6.2 Amphur Lat Krabang

Emergency works are suggested to restore the normal condition by temporarily using 3,500 m³/d of existing well water as the water source, and after the first-stage work, waterworks utilizing Klong Phra Khanong as the water source can be recommended as the most practical plan. The waterworks are outlined in Table 2.2.

2.6.3 Amphur Bang Bua Thong, Bang Yai and Sai Noi

Recommendable as the most suitable plan is the regional waterworks which can supply the water of Klong Om to three Amphurs on the right bank of Chao Phya River simultaneously by using part of the existing purification plant of Bang Bua Thong. The major reason for adopting this idea is because deep well water of Amphur Sai Noi has become useless due to damage done by blackish water, and also because the feasibility is very low for the use of underground water in Amphur Bang Bua Thong and there already are waterworks utilizing surface water. The outline of the regional supply plan is given in Table 2.3.

Table 2.3

	Urgent Work (To be completed in 1975)	1st Stage Work (To be completed in 1977)	2nd Stage Work (To be completed in 1985)	3rd Stage Work (To be completed in 1992)	Total
Beneficiaries to be served (person)	15,000	9,000	11,000	15,250	50,250
Water supply capacity (Daily Max. m³/day)	(3,000)	4,000	4,000	4,000	12,000
Kind of source	Newly-established well, existing (klong) water	Newly-established (klong om), existing klong water	klong Om	klong Om	–
Purification facilities	Coagulation, sedimentation, filtration	same as left	same as left	same as left	–
Cost of work (1,000 ฿)	12,991	42,397	18,428	16,792	90,608
Part for domestic currency	9,731	13,098	11,882	7,994	42,705
Part for foreign currency	3,260	29,299	6,546	8,798	47,903

Chapter 3. Population prediction

3.1 Existing data

It is meaningful to study existing data prior to the prediction of the population to be served, which is a basic factor for the new project. The precision of the population prediction would increase if it is done in comparison with the data presently available.

3.1.1. Data as 1971 from the City Planning Division Office of the City Clerk, Bangkok Municipality.

The population of the Bangkok metropolitan area in 2000 A.D. is estimated at 6.5 million. The figure is under-estimated, because the population is growing at an annual rate of 5.1 per cent. In conclusion, the following measures must be taken in order to keep the 2000 A.D. population below 6.5 million:

1. Economic development of other municipalities outside Bangkok must be further promoted so as to step up the population outflow.
2. Transportation means must be reorganized to offer more convenience to the moving people.
3. Regional development must be designated as a national policy.
4. An effective family planning must be put in force in the metropolitan area.
5. Land utilization and regional development must be promoted along major highways in the finger type directions.
6. Efforts are needed to let factory workers live around the newly developed plant sites.
7. Existing Klongs must be accompanied by green areas where cars can be parked.
8. It is necessary to improve clean water and sewage facilities, utilize Klongs for drainage of rainwater and locate waste treatment plants at separate sites to prevent the water pollution.

Population density of various areas is regulated as follows:

TABLE 3.1 PRESENT AND FUTURE POPULATION OF AMPHUR TOWNS OUTSIDE THE CENTRAL SYSTEM

	Present Area, Square Kilometers		Estimated Population					
	Total	Amphur (1)	Year 2512(1969)		Year 2528(1985)		Year 2543(2000)	
Amphur	Amphur	Town	Total Amphur	Amphur Town	Total Amphur	Amphur Town	Total Amphur	Amphur Town
(Phra Nakorn)								
Minburi	161	2.0	39,000	6,500	54,400	20,000	97,000	50,000
Nong Chok	288	0.8	43,000	4,500	52,400	15,000	77,000	30,000
Lat Krabang	149	1.0	30,000	5,500	41,200	20,000	65,000	35,000
(Thonburi)								
Nong Khaem	48	0.6	20,600	3,400	41,000	20,000	62,000	35,000
(Nonthaburi)								
Bong Bua Thong	112	1.0	32,800	8,600	53,000	20,000	88,000	40,000
Bong Yai	92	1.7	30,800	3,800	43,000	20,000	63,000	40,000
Sai Noi	194	1.0	27,200	1,000	39,000	10,000	55,000	15,000
(Samut Prakan)								
Bang Phli	308	1.0	69,800	7,000	62,000	20,000	129,000	35,000
Bang Bo	211	3.0	56,100	4,100	70,000	16,000	103,000	25,000
TOTAL	1,518	12.1	339,300	43,800	456,000	156,000	789,000	305,000

(1) Sanitary District or Consultant's estimate. The Amphur Town area estimates are somewhat arbitrary. In the future, the area of each Amphur Town is expected to increase considerably. See Chapter 12, Separate Systems.

Prepared by CDM

Residential areas	
High population density	300 persons/rai = 187,000 persons/km²
Medium population density	40 persons/rai = 25,000 persons/km²
Low population density	14 persons/rai = 8,750 persons/km²
Commercial areas	
Central area	50 persons/rai = 31,200 persons/km²
Environs	6 persons/rai = 3,750 persons/km²
Industrial areas	8,200 persons/km²

3.1.2 Data based on the Master Plan of CDM (1970)

According to the Master Plan of CDM, the 2000 A.D. population is estimated at between 6,420,000 and 14,600,000, and after further calculations, the population of 9,920,000 is predicted (population density: 15,000 persons/km^2). The population in the districts where water is supplied from the Separate System is set at 739,000 (1,513 km^2, population density 488 persons/km^2), and the total population of the urban area (Amphur Town) is estimated at 305,000 (1.1 km^2, population density 25,200).

For this estimation, the maximum prediction values and the minimum prediction values for 1975, 1985 and 2000 A.D. were calculated, and within this range, the probable value was decided. The calculation was done in anticipation of a population increase of geometric progression which was predicted according to past population statistics, particularly the maximum and minimum values of annual population growth rates. Population prediction for various Amphurs is shown in Fig. 3.1.

3.2 Current prediction

The nine Amphurs which lie around the Central System have different social structures. Amphur Nong Khaem of Changwat Thonburi features a fast development as a large residential district, while Amphur Sai Noi of Nonthaburi has remained as a traditional agricultural region with houses located along Klongs. Amphur Lat Krabang of Changwat Phra Nakhom is undergoing a drastic change from an agricultural region to a modern town as the construction of a university campus and a new international airport is located.

The same method of population prediction for varied types of social structures would not necessarily correspond to actual situations. Prediction must be made for each Amphur separately by taking the population movement and other specific factors into consideration.

3.2.1 Amphur Nong Khaem

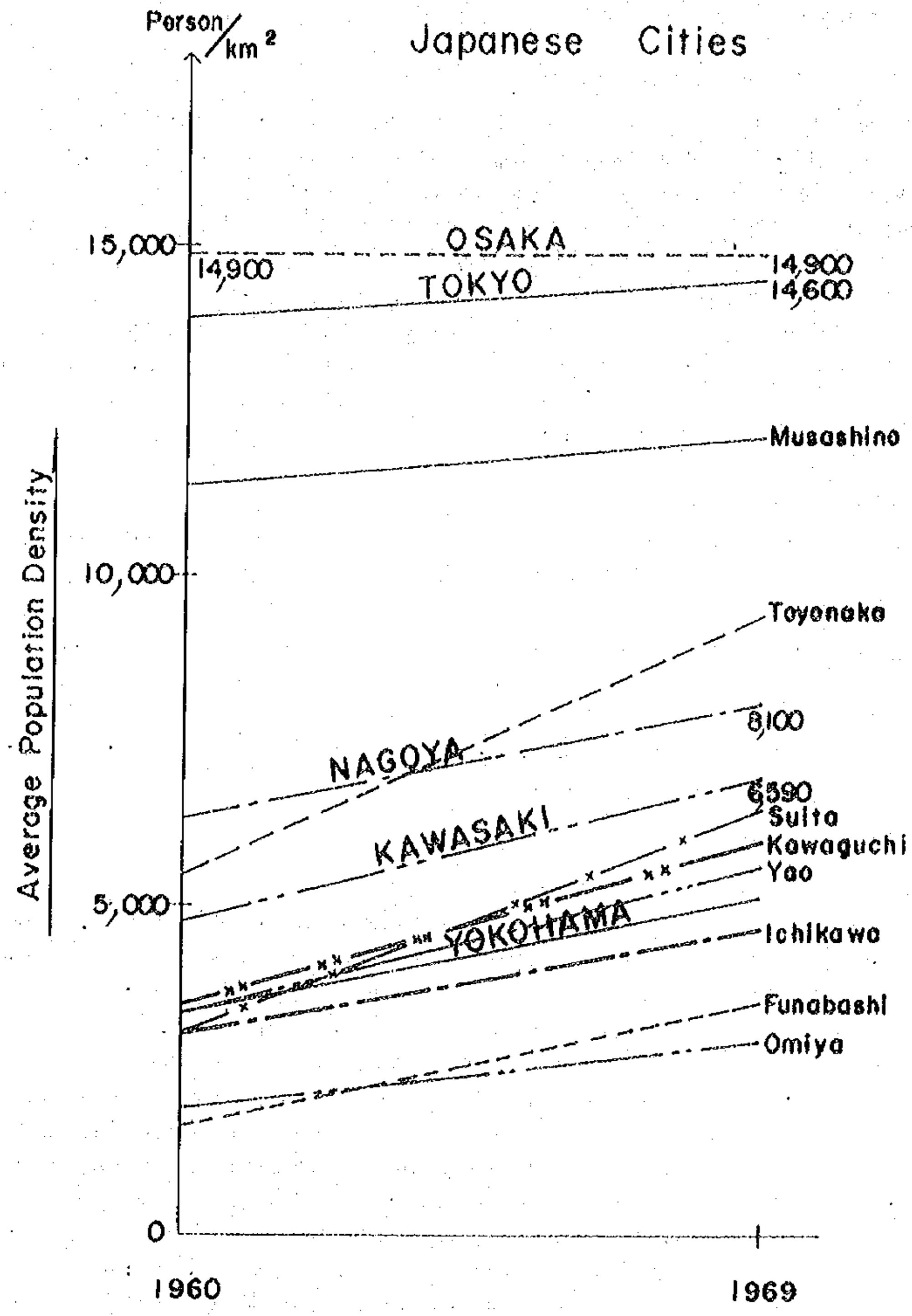
(1) Prediction of the total population on the basis of population density

As for fast-expanding satellite cities like Amphur Nong Khaem, the past population change is not a factor useful enough to predict future population. Therefore, we decided to predict a future population movement in accordance with the materials of other similar-type municipalities and changes of their population density.

Fig. 3.1 shows the population density of major Japanese cities and satellite cities. The population in mammoth cities of Tokyo and Osaka has remained almost unchanged, with the population density standing at 15,000 persons/km^2. On the other hand, the population of satellite cities around Tokyo and Osaka has increased rapidly. Especially, notable increases are marked in satellite cities around Osaka where the population density has reached a saturation point. This is because more and more people are finding their living places in suburban areas.

Nong Khaem can be compared with Kawaguchi and Ichikawa in Tokyo area, the fast expanding satellite cities near Tokyo. Using the data of the past several years and the saturated population density of 15,000 persons/km^2, the population was predicted with the logistic curve. Its result is shown in Fig. 3.2, and the prediction curve for Kawaguchi City is called Type-1 and that for Ichikawa City Type-2.

Fig 3-1 Average Population Density of Japanese Cities



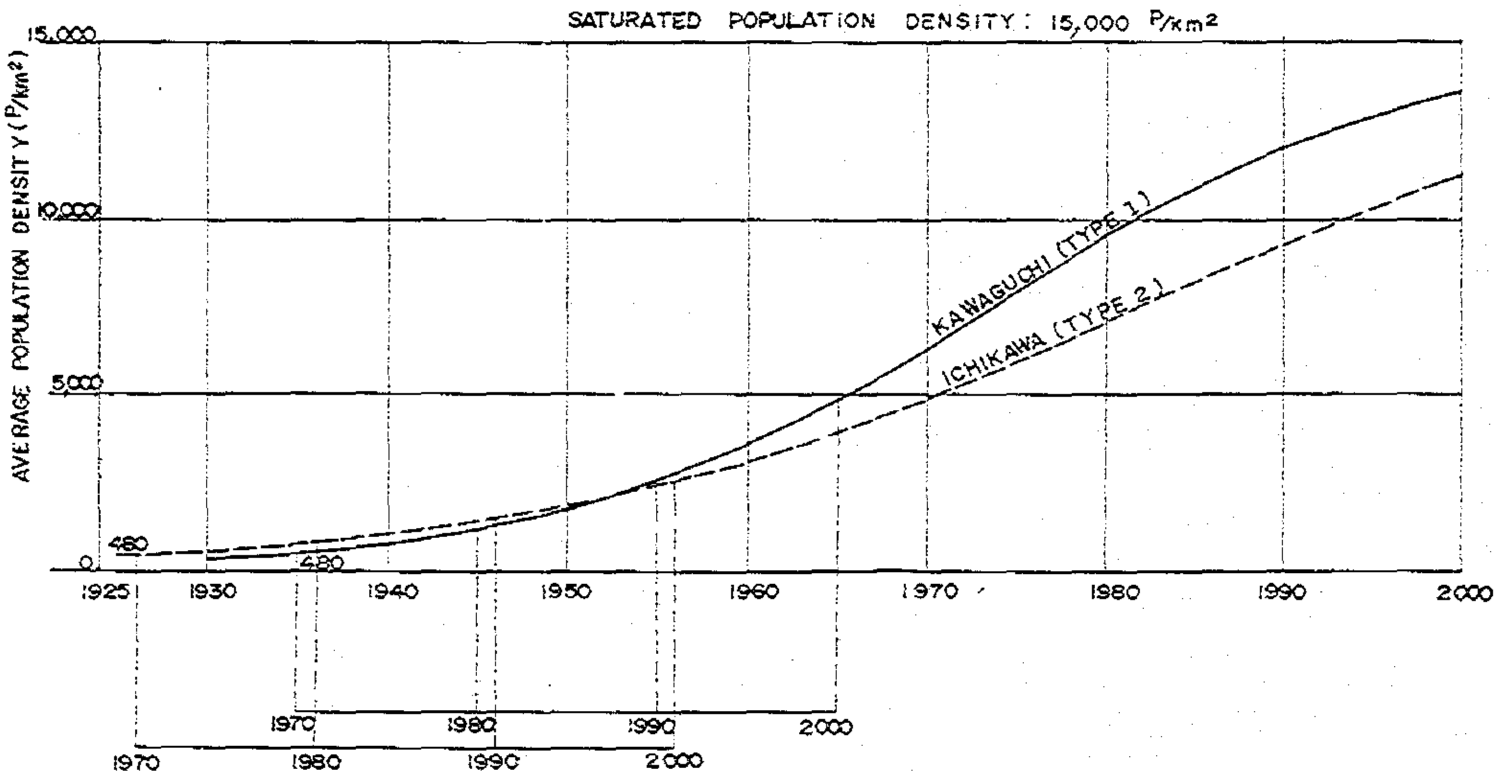


FIG3-2 FUTURE POPUIATION DENSITY ESTIMATION

The past population movement of Amphur Nong Khaem is shown below. Fig. 3.2 illustrates the 1970 population density of 480 persons/km² (23,064 persons/48 km² which is coordinated on Type-1 and Type-2 curves.

1965	16,969 persons
1966	17,936 persons
1967	19,406 persons
1968	20,780 persons
1969	22,034 persons
1970	23,069 persons

Fig. 3.3 shows the estimated population of Fig. 3.2 which is illustrated on the same origin, and it can also be shown as seen in Table 3.2.

Table 3.2 Presumption of Future Total Population

Year	Type 1		Type 2	
	Density of Population (Person/Km²)	Total Population	Density of Population (Person/Km²)	Total Population
1970	480	23,064	480	23,064
1980	1,190	57,000	850	41,000
1990	2,580	124,000	1,500	72,000
2000	4,820	281,000	2,500	120,000

Table 3.3 Increasing Rate of Future Population

Year	Type 1	Type 2
1970~1980	9.5%	6.0%
1980~1990	8.1%	5.8
1990~2000	6.4	5.3

Fig — 3.3 : Population & Density Predicted

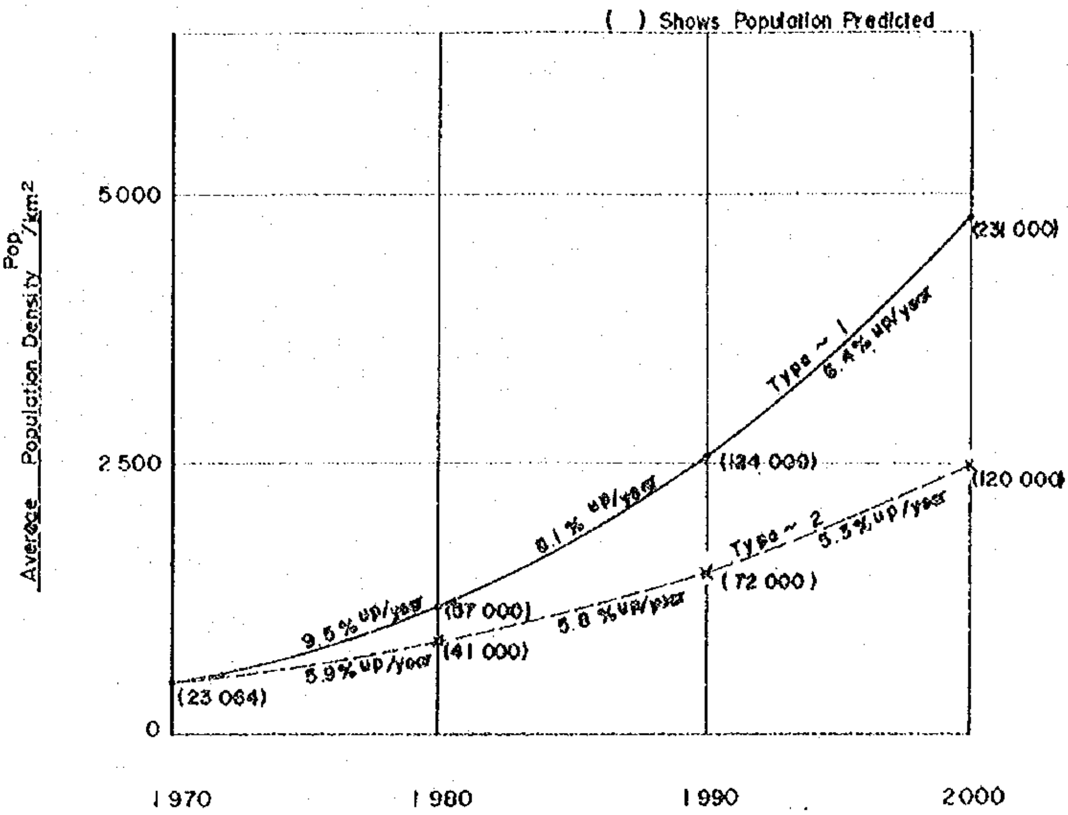
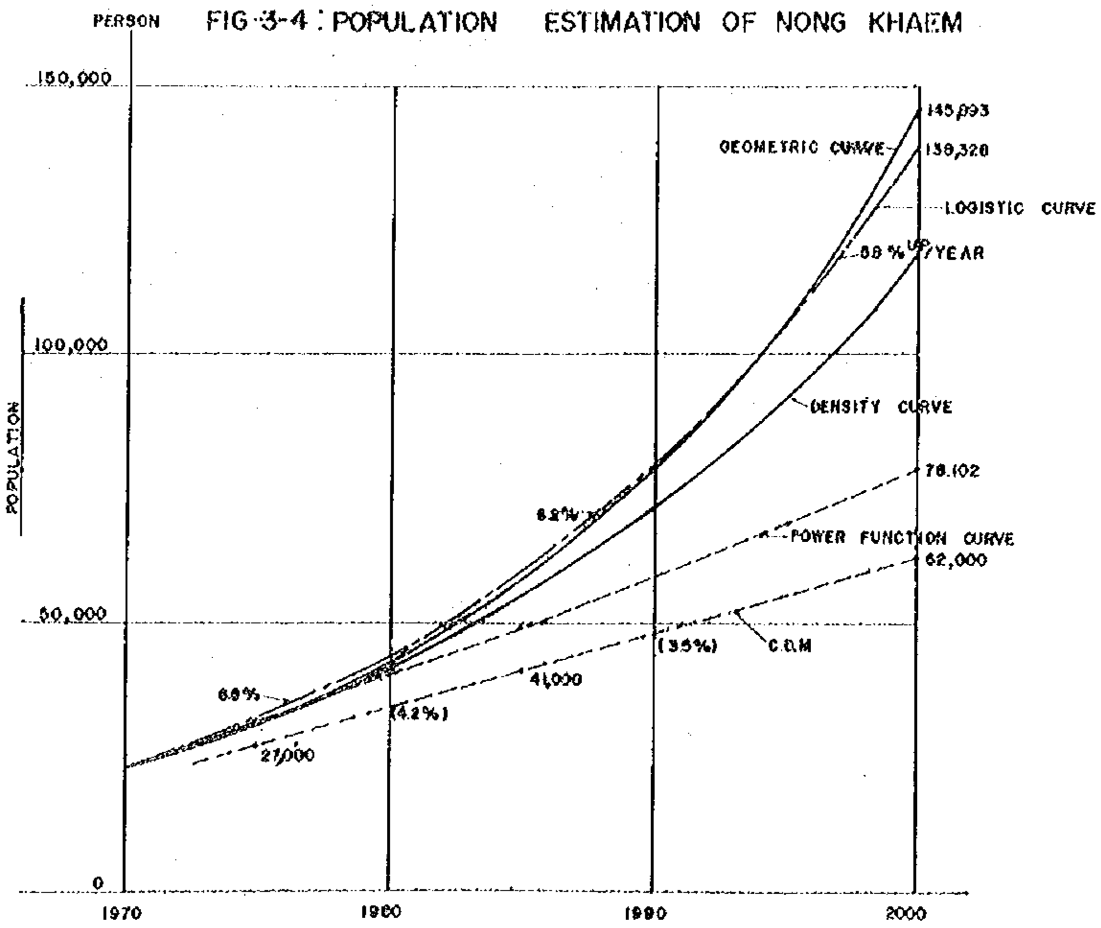


FIG 3-4 : POPULATION ESTIMATION OF NONG KHAEM



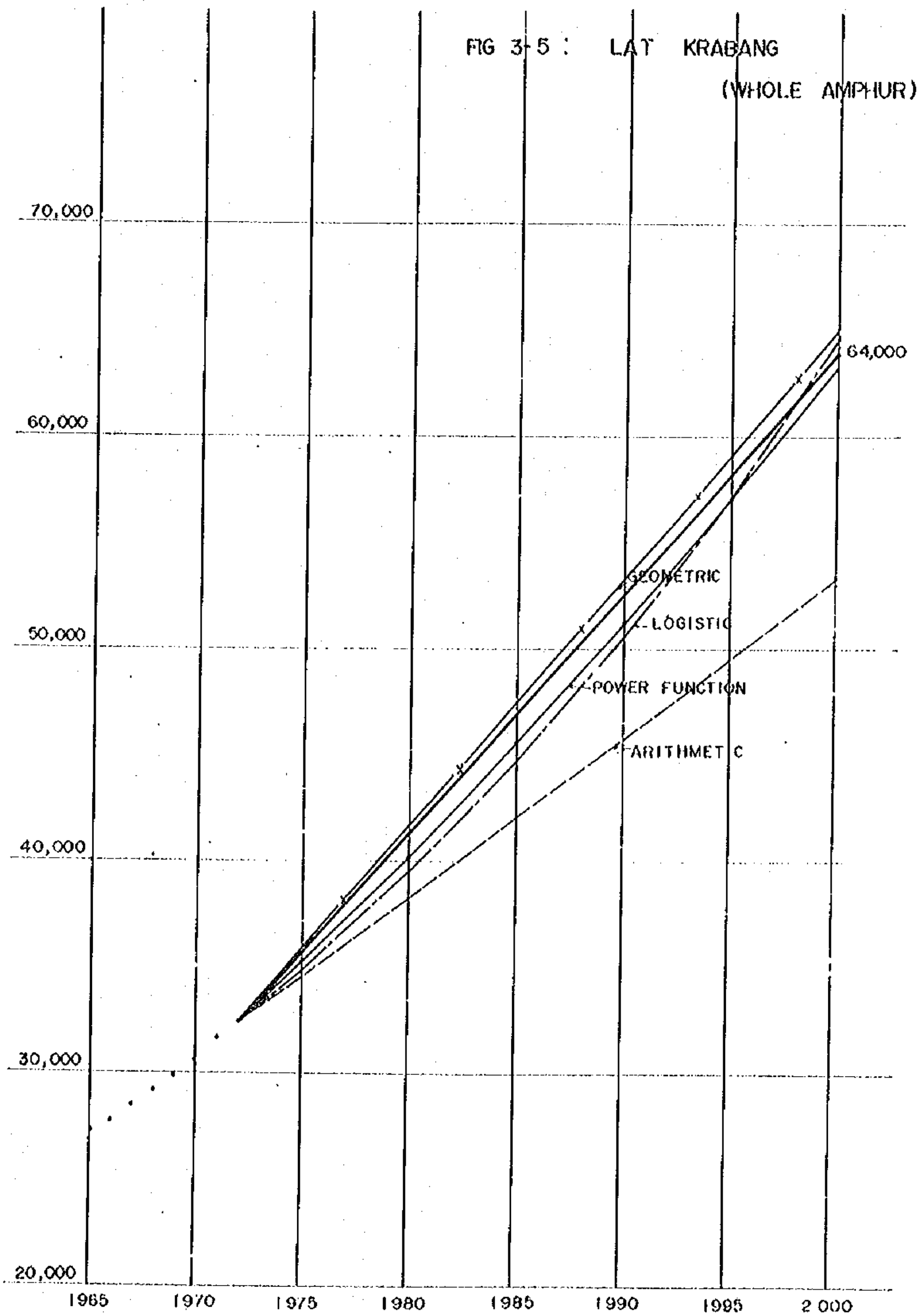
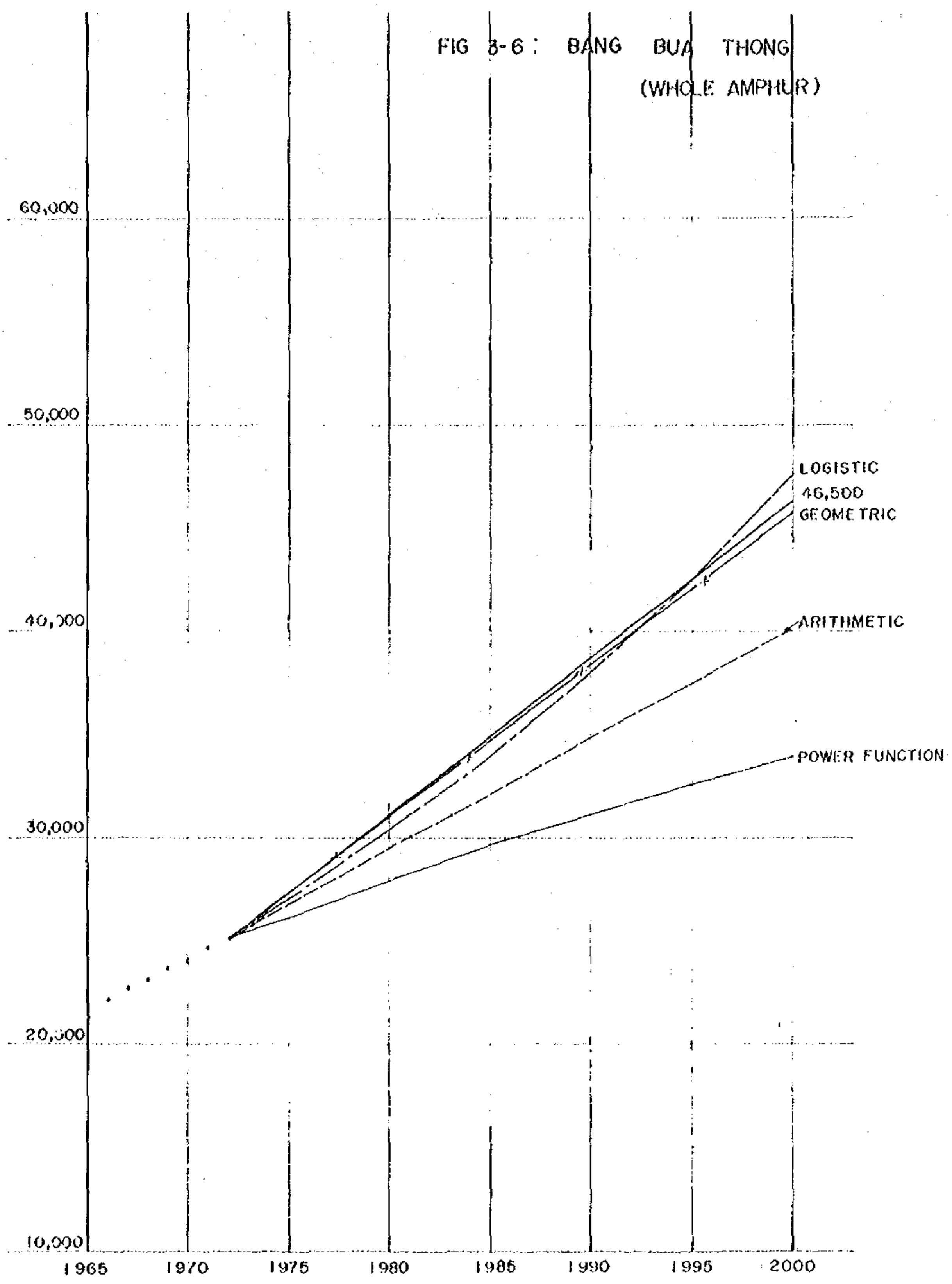


FIG 3-5 : LAT KRABANG
(WHOLE AMPHUR)
70,000
60,000
50,000
40,000
30,000
20,000
64,000
GEOMETRIC
LOGISTIC
POWER FUNCTION
ARITHMETIC
1965
1970
1975
1980
1985
1990
1995
2 000

FIG 3-6 : BANG BUA THONG
(WHOLE AMPHUR)



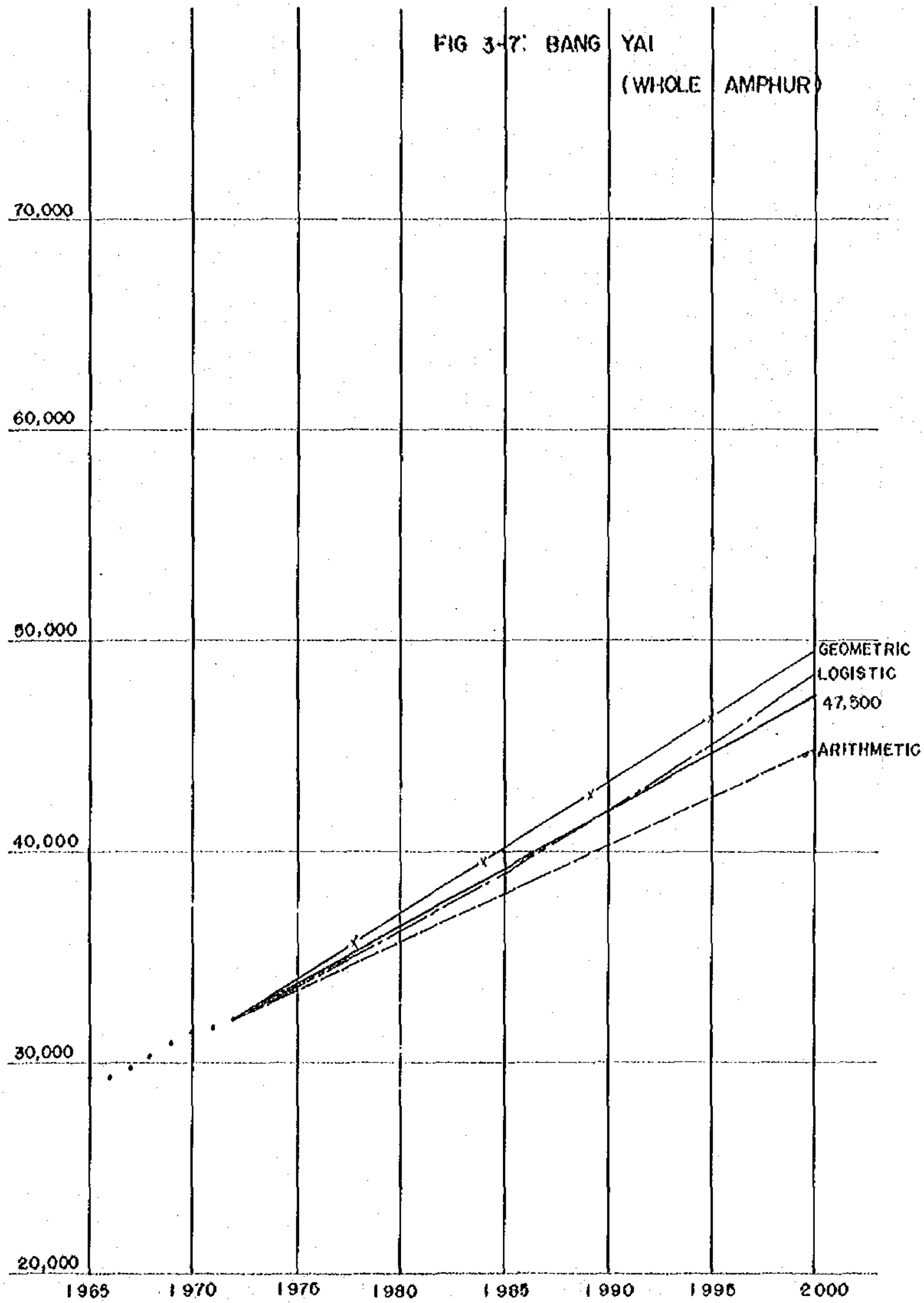


FIG 3-7: BANG YAI
(WHOLE AMPHUR)
70,000
60,000
50,000
40,000
30,000
20,000
1965
1970
1975
1980
1985
1990
1995
2000
GEOMETRIC
LOGISTIC
47,500
ARITHMETIC

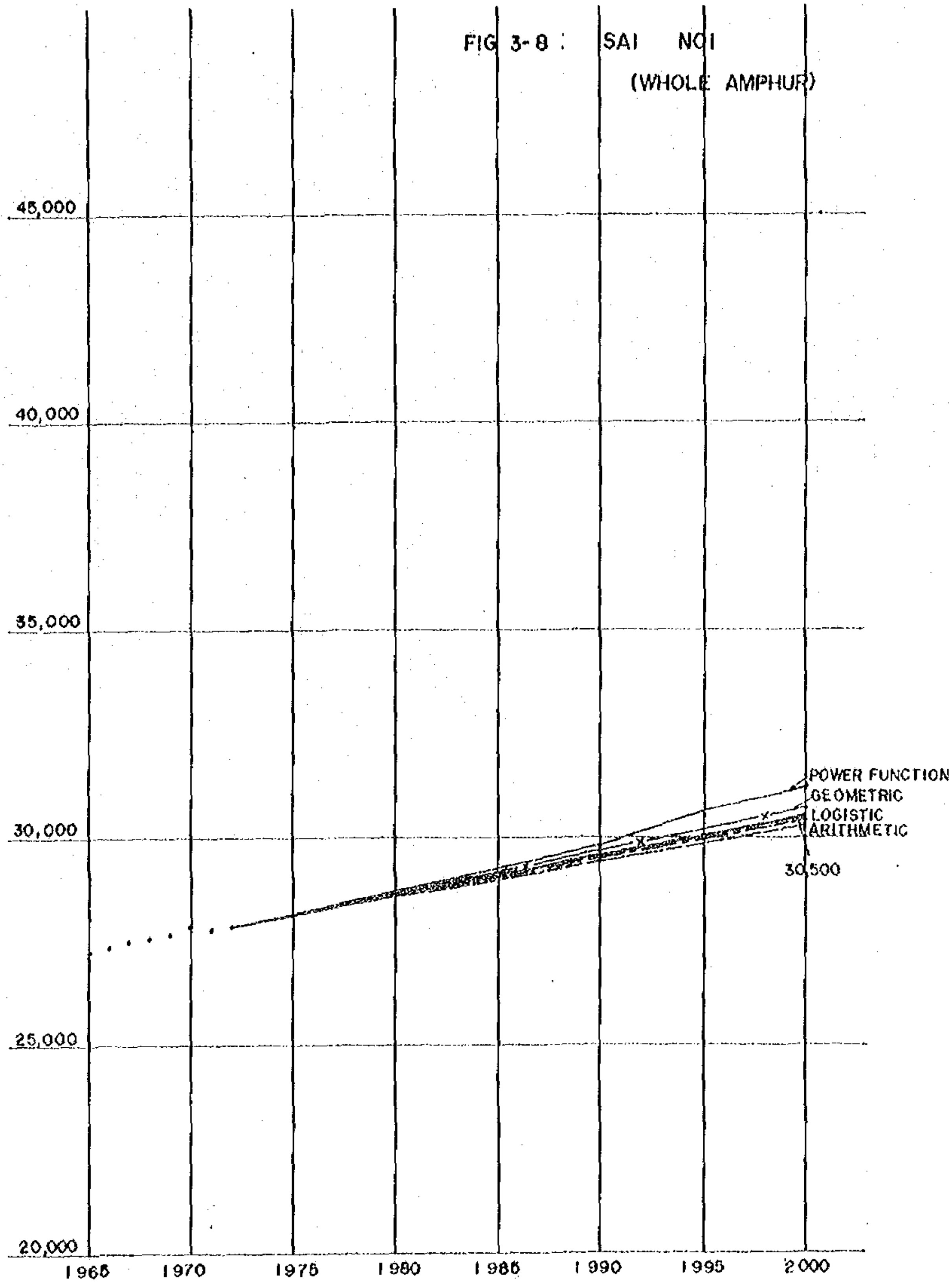


FIG 3-8 : SAI NOI
(WHOLE AMPHUR)
45,000
40,000
35,000
30,000
25,000
20,000
1965
1970
1975
1980
1985
1990
1995
2000
POWER FUNCTION
GEOMETRIC
LOGISTIC
ARITHMETIC
30,500

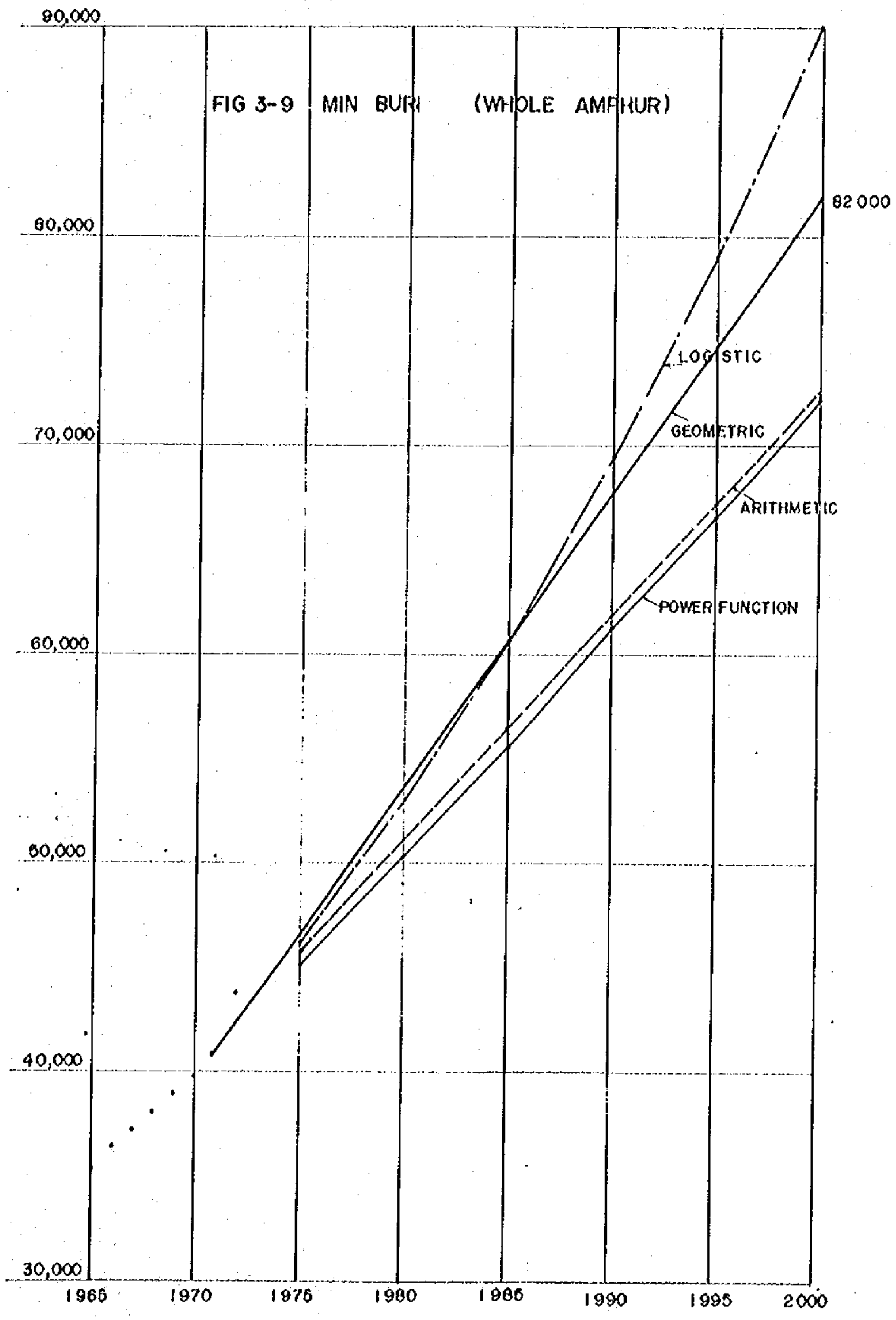


FIG 3-9 MIN BURI (WHOLE AMPHUR)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
82 000
LOGISTIC
GEOMETRIC
ARITHMETIC
POWER FUNCTION
1965
1970
1975
1980
1985
1990
1995
2000

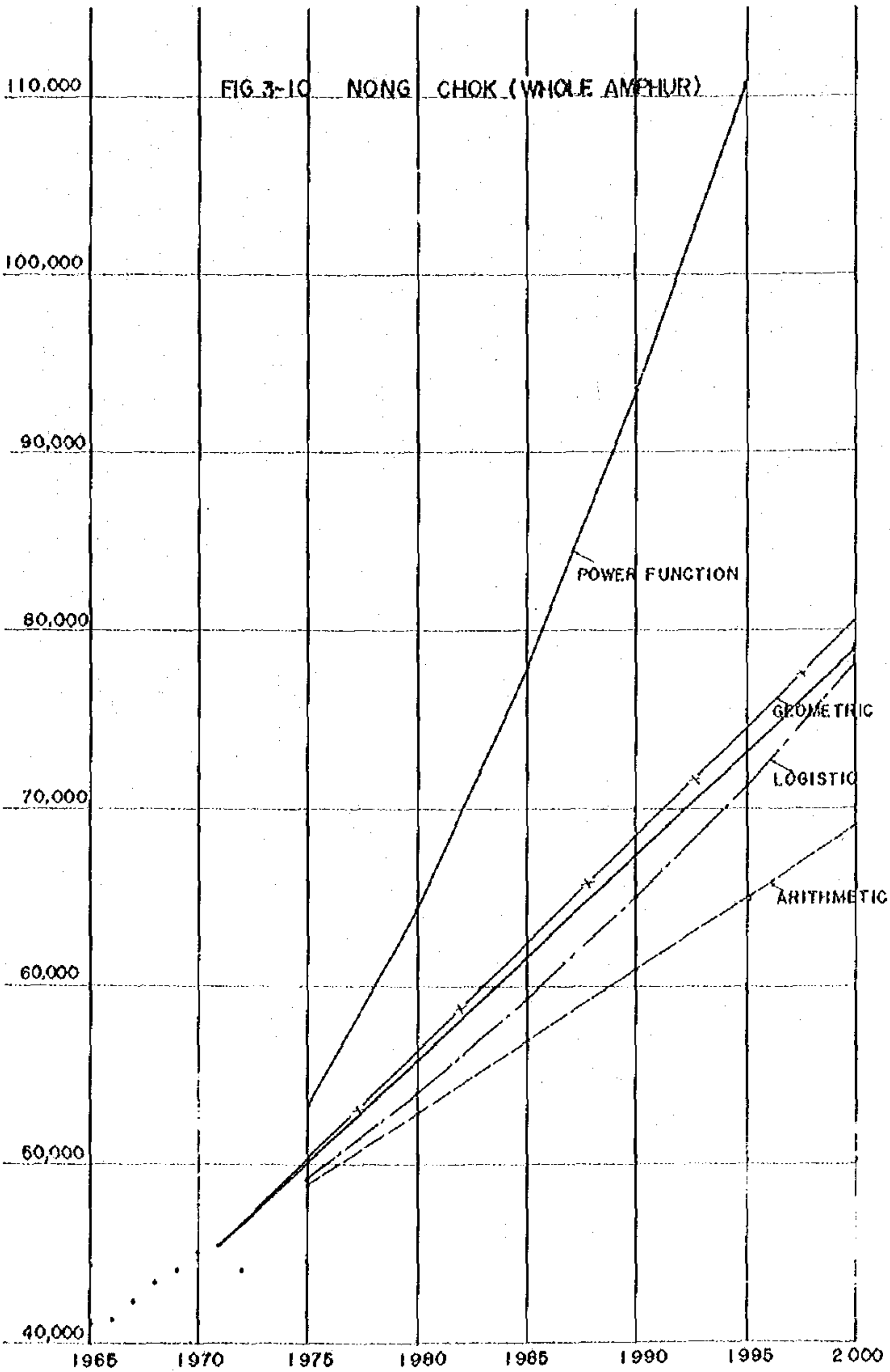


FIG 3-10 NONG CHOK (WHOLE AMPHUR)
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
POWER FUNCTION
GEOMETRIC
LOGISTIC
ARITHMETIC
1965
1970
1975
1980
1985
1990
1995
2000

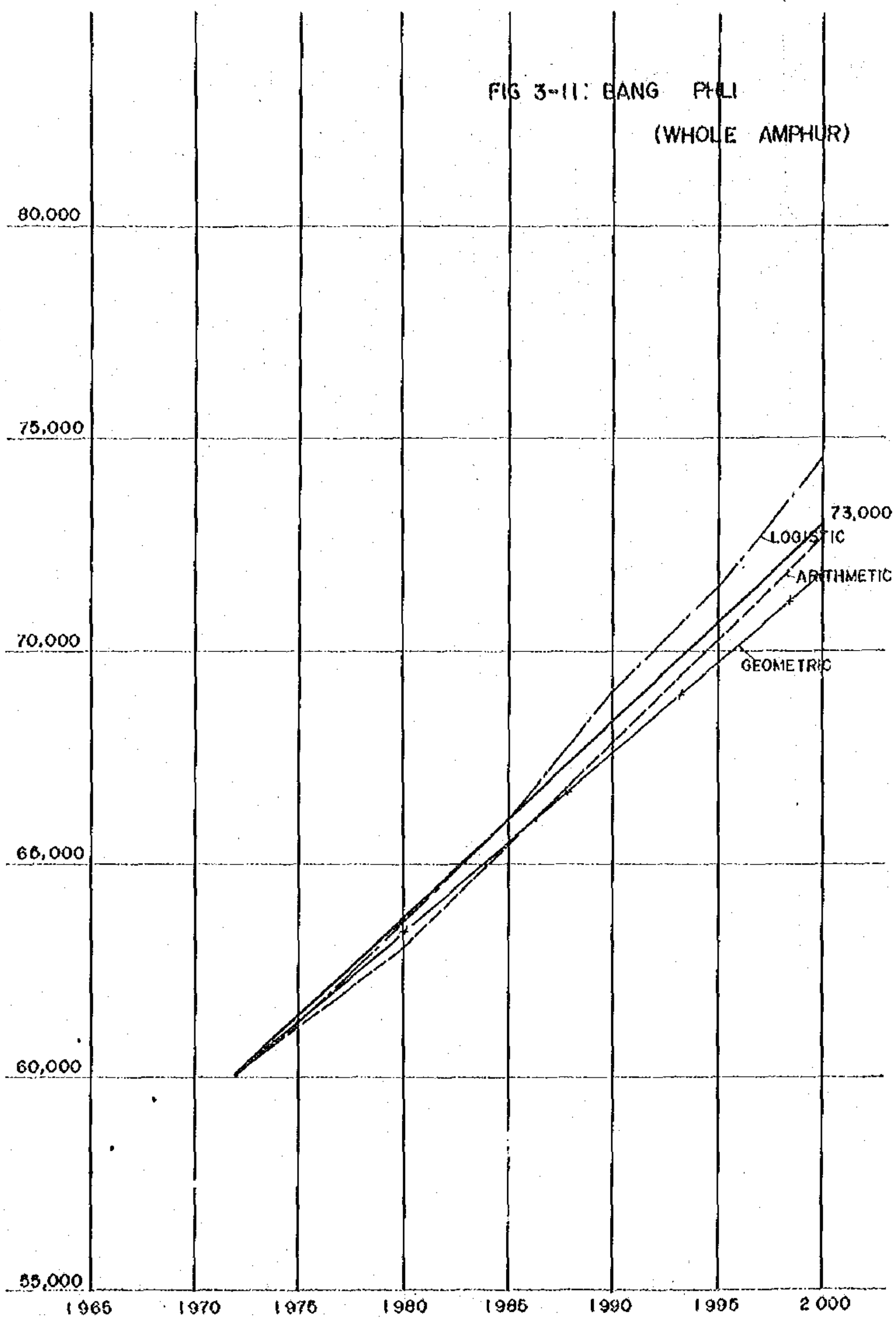


FIG 3-11: BANG PHLI
(WHOLE AMPHUR)
80,000
75,000
70,000
65,000
60,000
55,000
73,000
LOGISTIC
ARITHMETIC
GEOMETRIC
1965
1970
1975
1980
1985
1990
1995
2000

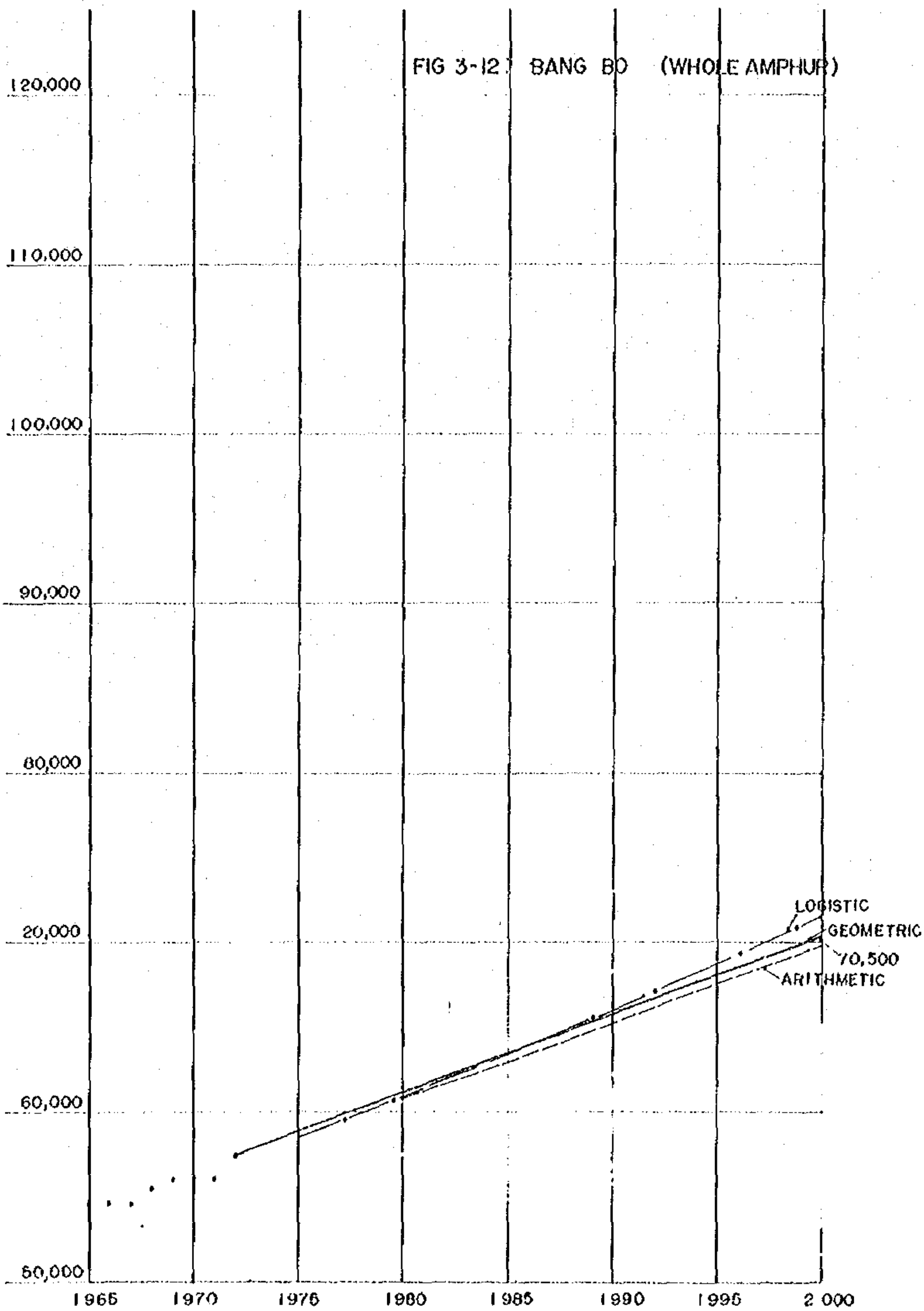


FIG 3-12 BANG BO (WHOLE AMPHUR)
120,000
110,000
100,000
90,000
80,000
20,000
60,000
50,000
1965
1970
1975
1980
1985
1990
1995
2 000
LOGISTIC
GEOMETRIC
70,500
ARITHMETIC

Population increase rates of the two types are compared in Fig. 3.2 and Table 3.3. The Type-1 increase is too sharp, but the Type-2 increase is not much different from the increase rate of 5.1 per cent as mentioned in 3.1.1 and is relatively closer to the actual situation.

(2) Estimation of the total population according to calculation systems

To find the possibility of population estimation by means of the population density as shown in Table 3.2, the future population was estimated on the basis of the past population changes in accordance with three calculation systems: Power Function System, Logistic Curve System and Geometric Increase System. They are revealed in Table 3.4.

Table 3.4 Presumption of Future Population (Comparison)

Year	Power Function Curve Type	Logistic Curve Type	Geometric Progression Type	From Table 3.2 (Type 2)
1970	23,064	23,064	23,064	23,064
1975	31,448	31,947	31,279	
1980	40,048	43,538	42,662	41,000
1985	49,095	58,973	58,014	
1990	58,491	79,242	78,891	72,000
1995	68,174	105,368	107,285	
2000	78,102	138,238	145,893	120,000

The above results are illustrated in Fig. 3.4, and the prediction as shown in Table 3.2 can be regarded as being reasonable. Taking the fast progress of house construction into consideration, the values produced by means of the logistic curve shown in Table 3.4 has been adopted in the way shown in Table 3.5.

Table 3.5 Decision of Future Total Population

1970	1975	1980	1985	1990	1995	2000
23,064	32,000	44,000	59,000	79,000	105,000	138,000

(3) Decision on the population to be served

Although Amphus Nong Khaem still has paddy fields and cultivated land, the entire district has been designated as a water supply region in anticipation of the fact that the district will be modernized at an accelerated tempo.

Northeast of the district, there are some areas which need water supply. The population in these areas is not included in that of Amphur Nong Khaem, and water supply will be studied separately.

3.2.2 Other Amphurs

(1) Prediction of the total population according to calculations

The total population of the remaining eight Amphurs estimated on the basis of past statistics is shown in Figs. 3.5 to 3.12. The medium value of the estimated population is regarded as the estimated population to be served, and it is shown with straight lines. The values are also seen in Table 3.6.

Table 3.6 Decision of Future Total Population in 8 Amphurs

Amphur	1975	1980	1985	1990	1995	2000
Lat krabang	35,700	41,400	47,000	52,600	57,300	64,000
Ban Bua Thong	27,300	31,100	34,900	37,700	42,500	46,500
Bang Yai	33,700	36,500	39,300	41,800	44,600	47,500
Sai Noi	28,200	28,700	29,200	29,600	30,100	30,500
Min Buri	46,700	53,800	60,800	68,000	74,800	82,000
Nong Chok	50,000	55,800	61,500	67,500	73,000	79,000
Bang Phli	61,500	63,700	66,100	68,400	70,700	73,000
Bang Bo	58,800	61,200	63,500	66,000	68,000	70,500

(2) Areas to be served

Many parts of the eight Amphurs other than Nong Khaem are still covered with paddy fields, cultivated land and jungles, and 60 to 70 per cent of the total population are concentrated in Amphur Town and others are scattered widely. It will be uneconomical unless waterworks are installed in and close to Amphur Town. Areas to be served must be decided according to the present pattern of population distribution, and after that, the population to be served must be predicted.

Areas to be served in each Amphur are shown in each Figure and their sizes are listed in Table 3.7.

Table 3.7 Water Supply Area of 8 Amphurs

Amphur	Water Supply Area (Km^2)	Remarks
Lat Krabang	18	Adjacent to New Air Port
Bang Bua Thong	18	
Bang Yai	16	
Sai Noi	6	Well polluted by salty water
Min Buri	22	Development to Residential Area
Nong Chok	18	
Bang Phli	15	
Bang Bo	10	

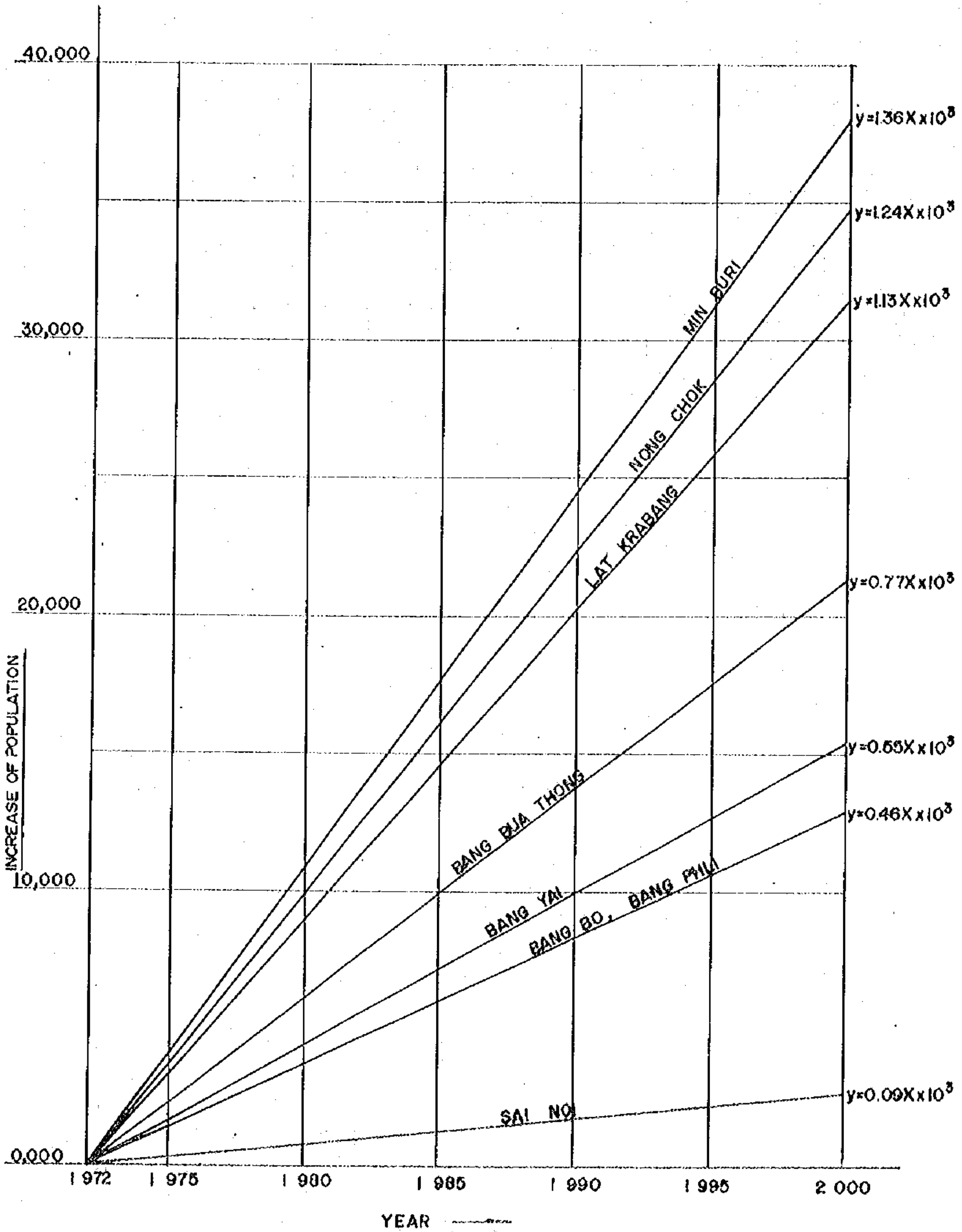


FIG -3- 13 CURVES OF POPULATION PREDICTED

(3) Decision on the population of the area to be served

Data are now available concerning the population of Amphur Town. Even if the population density of each Amphur is calculated, it is not instrumental because the value varies widely according to different Amphurs. If the value is depicted with a graded line coordinated to the origin of the predicted population curve of Fig. 3.12, it appears like in Fig. 13. The line of each of the eight Amphurs reveal a specific characteristic.

For instance, in Amphur Lat Krabang, Min Buri and Nong Chok, the population increase is sharp, and population concentration close to the degree of that of Amphur Nong Khaem is expected in these regions. Amphur Bang Bua Thong and Bang Yai are the regions which have developed along large Klongs. However, roads in these regions have not been properly reorganized, and population concentration as in Amphur Lat Krabang and Min Buri cannot be expected.

Other Amphurs are agricultural areas and they will remain so unless a modernized road network is established.

With these facts in mind, the maximum population density in 2000 A.D. is set in the same 2,500 persons/km^2 as in Amphur Nong Khaem and the minimum density at 15,000 persons/km^2. Then the population of the areas to be served in 2000 A.D. is calculated as shown in Table 3.8. The population in each year before 2000 A.D. was predicted by calculating back to the predicted population of 2000 A.D.

Table 3.8 Presumption of Population in Water Supply Area of 8 Amphurs

Amphur	1970	1975	1980	1985	1990	1995	2000	Water Supply Area (Km^2)	Density of Population (person/Km^2)
Lat Krabang	15,076	18,242	23,518	28,795	34,072	39,348	45,000	18	2,500
Bang Bua Thong	9,406	11,773	15,719	19,664	23,609	27,554	31,500	18	1,750
Bang Yai	3,467	5,935	10,048	14,161	18,274	22,387	26,500	16	1,650
Sai Noi	1,180	2,018	3,414	4,811	6,207	7,604	9,000	6	1,500
Min Buri	14,750	17,800	23,000	28,200	33,400	38,700	44,000	22	2,000
Nong Chok	4,564	7,000	11,000	15,000	19,000	23,000	27,000	18	1,500
Bang Phli	5,144	7,000	10,100	13,200	16,300	19,400	22,500	15	1,500
Bang Bo	4,345	5,500	7,400	9,300	11,200	13,100	15,000	10	1,500

Chapter 4 House Connection

4.1 House connection rate

Of the population in the areas to be served, as calculated in Chapter 3, the house connection rate of water supply to households differs according to various conditions such as characters of municipalities, customs and manners, and actual situation of household water consumption. After all, the house connection rate is expected to reach a saturation point after the construction of waterworks is completed. However, the saturation point in this case will mean 70 to 80 per cent, instead of 100 per cent.

In our survey, the house connection rate in 1970 is set at 60 per cent and that in 2000 A.D. at 80 per cent. The rate in each year is found in Table 4.1.

Table 4.1 Presumption of House Connection

1970	1975	1980	1985	1990	1995	2000
60.0	62.5	65.0	67.5	70.0	72.5	75.0

Chapter 5 Water demand

5.1 Daily mean consumption

To find mean consumption, analyses were made on the total consumption in 17 municipalities throughout Thailand between 1959 and 1966. The data are in Table 5.1.

Table 5.1 Results of Quantity Consumed

Name of City	Presumption of Population in 2000	1959	1960	1961	1962	1963	1964	1965	1966
Krathumbaem	12,000	30	32	27	28	28	27	30	29
Yala	109,000	—	48	—	72	—	64	—	140
Saraburi	68,000	52	83	91	81	53	66	64	—
Roi Et	28,000	36	77	—	93	93	104	100	114
Khichit	28,000	39	70	77	96	53	106	104	104
Pattani	74,000	—	65	81	112	56	208	200	62
Panat Nikhom	28,000	60	66	46	47	34	46	61	67
Photharam	13,000	103	77	70	148	76	79	142	274
Uthai Thani	13,000	—	49	—	55	—	122	—	—
Ratchaburi	60,000	86	63	58	130	56	137	200	215
Chiang Rai	28,000	56	50	48	48	68	82	95	—
Korat	172,000	—	125	—	150	—	160	—	—
Chiang Mai	136,000	—	114	—	68	—	75	—	113
Nakorn Sawan	100,000	—	142	—	107	—	137	—	131
Phathalung	18,000	74	59	70	98	86	88	78	108
Hua Hin	46,000	—	—	—	140	—	264	—	—
Samut Sakhorn	82,000	—	—	—	—	61	67	67	69

Tables 5.2~5.9 show standard deviations in each year. The data described in terms of histogram are shown in Fig. 5.1 and Fig. 5.2. Regarding Fig. 5.1 and Fig. 5.2, it can be said that the mean water consumption in increasing each year and the standard deviation is becoming larger. The increase of mean consumption is natural because of the improvement of living conditions, but the growth of the standard deviation signifies a growing gap of water consumption among municipalities of different scales. In other words, water consumption differs in various municipalities, and a unified value of consumption cannot be produced. In this respect, the amount of consumption was decided by dividing municipalities into three groups: those with the population of less than 50,000 persons; between 50,000 and 100,000 persons; and more than 100,000 persons (as of 2000 A.D.). In municipalities with less than 50,000 persons which is selected from Table 5.1, the mean value is calculated by omitting the upper and lower limits of each year. As for 1959, 30 and 103 are omitted, and mean value of the

Table 5-2

(1959)

Name of Municipality	Average Consumption per Capita per Day (X_i) (l/c/d)	$X_i - m$	$(X_i - m)^2$	Remarks
Krathumbaen	30	-29.6	876.16	
Roi-Et	36	-23.6	556.96	n = 9
Rhichit	39	-20.6	424.36	$m = \frac{\Sigma X_i}{9}$
Saraburi	52	-7.6	57.76	= 59.6
Chiang Rai	56	-3.6	12.96	$\sigma = \sqrt{\frac{\Sigma(X_i - m)^2}{n}}$
Panat-Nikhom	60	+0.4	0.16	$= \sqrt{\frac{4,716.24}{9}}$
Phathalung	74	+14.4	207.36	= 22.9
Ratchaburi	86	+26.4	696.96	
Rhotharam	103	+43.4	1,883.56	
Σ	536	-	4,716.24	

Table 5-3

(1960)

Name of Municipality	Average Consumption per Capita per Day (X_i) (l/c/d)	$X_i - m$	$(X_i - m)^2$	Remarks
Krathumbaen	32	-42.7	1,823.29	n = 15
Yala	48	-26.7	712.89	$m = \frac{\Sigma X_i}{n}$
Uthai-Thani	49	-25.7	660.09	= 74.7
Chiang-Rai	50	-24.7	610.09	
Phathalung	59	-15.7	246.49	$\sigma = \sqrt{\frac{\Sigma(X_i - m)^2}{n}}$
Ratchaburi	63	-11.7	136.89	= 29.5
Pattani	65	-9.7	94.09	
Panut-Nikhom	66	-8.7	75.69	
Phichit	70	-4.7	22.09	
Photharam	77	+2.3	5.29	
Roi-Et	77	+2.3	5.29	
Saraburi	83	+8.3	68.89	
Chiang-Mai	114	+39.3	1,544.49	
Korat	125	+50.3	2,530.09	
Nakorn-Sawan	142	+67.3	4,529.29	
Σ	1,120	-	13,065.35	

Table 5-4

(1961)

Name of Municipality	Average Consumption per Capita per Day (X_i) (l/c/d)	X_i - m	$(X_i - m)^2$	Remarks
Krathumbaen	27	-36.1	1,303.21	n = 9
Panat-Nikhom	46	-17.1	292.31	$m = \frac{\Sigma X_i}{n}$
Chiang-Rai	48	-15.1	228.01	= 63.1
Ratchaburi	58	-5.1	26.01	
Photharam	70	+6.9	47.61	$\sigma = \sqrt{\frac{\Sigma(X_i - m)^2}{n}}$
Phathalung	70	+6.9	47.61	
Phichit	77	+13.9	193.21	$= \sqrt{\frac{3,236.89}{9}}$
Pattani	81	+17.9	320.41	= 19.0
Saraburi	91	+27.9	778.41	
Σ	586	-	3,236.89	

Table 5-5

(1962)

Name of Municipality	Average Consumption per Capita per Day (X_i) (l/c/d)	X_i - m	$(X_i - m)^2$	Remarks
Krathumbaen	28	-63.8	4,070.44	n = 16
Panat-Nikhom	47	-44.8	2,077.04	$m = \frac{\Sigma X_i}{16}$
Chiang-Rai	48	-43.8	1,918.44	= 91.8
Uthai-Thani	55	-36.8	1,354.24	
Chiang-Mai	68	-23.8	566.44	$\sigma = \sqrt{\frac{\Sigma(X_i - m)^2}{n}}$
Yala	72	-19.8	392.04	= 36.6
Saraburi	81	-10.8	116.64	
Roi-Et	93	+1.2	1.44	
Phathalung	93	+1.2	1.44	
Phichit	96	+4.2	17.64	
Nakorn-Sawan	107	+15.2	231.04	
Pattani	112	+20.2	408.04	
Rathaburi	130	+38.2	1,459.24	
Hua-Hin	140	+48.2	2,323.24	
Photharam	148	+56.2	3,158.44	
Korat	150	+58.2	3,387.24	
Σ	1,468	-	21,413.04	

Table 5-6

(1963)

Name of Municipality	Average Consumption per Capita per Day (X_i) (l/c/d)	$X_i - m$	$(X_i - m)^2$	Remarks
Krathumbaen	28	-32.4	1,049.76	$n = 11$
Panat-Nikhom	34	-26.4	696.96	$m = \frac{\Sigma X_i}{n}$
Saraburi	53	-7.4	54.76	$= 60.4$
Phichit	53	-7.4	54.76	
Pattani	56	-4.4	19.36	$\sigma = \sqrt{\frac{\Sigma(X_i - m)^2}{n}}$
Ratchaburi	56	-4.4	19.36	$= 18.9$
Samut-Sakhorn	61	+0.6	0.36	
Chiang-Rai	68	+7.6	57.76	
Photharam	76	+15.6	243.36	
Phathalung	86	+25.6	655.36	
Roi-Et	93	+32.6	1,062.76	
Σ	664	-	3,914.56	

Table 5-7

(1964)

Name of Municipality	Average Consumption per Capita per Day (X_i) (l/c/d)	$X_i - m$	$(X_i - m)^2$	Remarks
Krathumbaen	27	-80.5	6,480.25	$n = 17$
Panat-Nikhom	46	-61.5	3,782.25	$m = \frac{\Sigma X_i}{n}$
Yala	64	-43.5	1,892.25	$= 107.5$
Saraburi	66	-41.5	1,722.25	
Samut-Sakhorn	67	-40.5	1,640.25	$\sigma = \sqrt{\frac{\Sigma(X_i - m)^2}{n}}$
Chiang-Mai	75	-32.5	1,056.25	$= 57.3$
Photharam	79	-28.5	812.25	
Chiang-Rai	82	-25.5	650.25	
Phathalung	88	-19.5	380.25	
Roi-Et	104	-3.5	12.25	
Phichit	106	-1.5	2.25	
Uthai-Thani	122	+14.5	210.25	
Ratchaburi	137	+19.5	380.25	
Nakorn-Sawan	137	+19.5	380.25	
Korat	160	+52.5	2,756.25	
Pattani	203	+95.5	9,120.25	
Hua-Hin	264	+156.5	24,492.25	
Σ	1,827	-	55,770.25	

Table 5-8

(1966)

Name of Municipality	Average Consumption per Capita per Day (X_i) (l/c/d)	X_i - m	$(X_i - m)^2$	Remarks
Krathumbaen	29	-89.8	8,064.04	n = 12
Pattani	62	-56.8	3,226.24	$m = \frac{\Sigma X_i}{n}$
Panat-Nikhom	67	-51.8	2,683.24	= 118.0
Samut-Sakhorn	69	-49.8	2,480.04	
Phichit	104	-14.8	219.04	$\sigma = \sqrt{\frac{\Sigma(X_i - m)^2}{n}}$
Phathalung	108	-10.8	116.64	= 65.1
Chiang-Mai	113	-5.8	33.64	
Roi-Et	114	-4.8	23.04	
Nakorn-Sawan	131	+12.2	148.84	
Yala	140	+21.2	449.44	
Ratchaburi	215	+96.2	9,254.44	
Photharam	274	+155.2	24,087.04	
Σ	1,426	-	50,785.64	

Table 5-9

(1965)

Name of Municipality	Average Consumption per Capita per Day (X_i) (l/c/d)	X_i - m	$(X_i - m)^2$	Remarks
Krathumbaen	30	-73.7	5,431.69	n = 11
Panut-Nikhom	61	-42.7	1,823.29	$m = \frac{\Sigma X_i}{n}$
Saraburi	64	-39.7	1,576.09	= 103.7
Samut-Sakhorn	67	-36.7	1,346.89	
Phathalung	78	-25.7	660.49	$\sigma = \sqrt{\frac{\Sigma(X_i - m)^2}{n}}$
Chiang-Rai	95	-8.7	75.69	= 53.0
Roi-Et	100	-3.7	13.69	
Phichit	104	+0.3	0.09	
Photharam	142	+38.3	1,466.89	
Pattani	200	+96.3	9,273.69	
Ratchaburi	200	+96.3	9,273.69	
Σ	1,141	-	30,942.19	

Figure 5 - 1

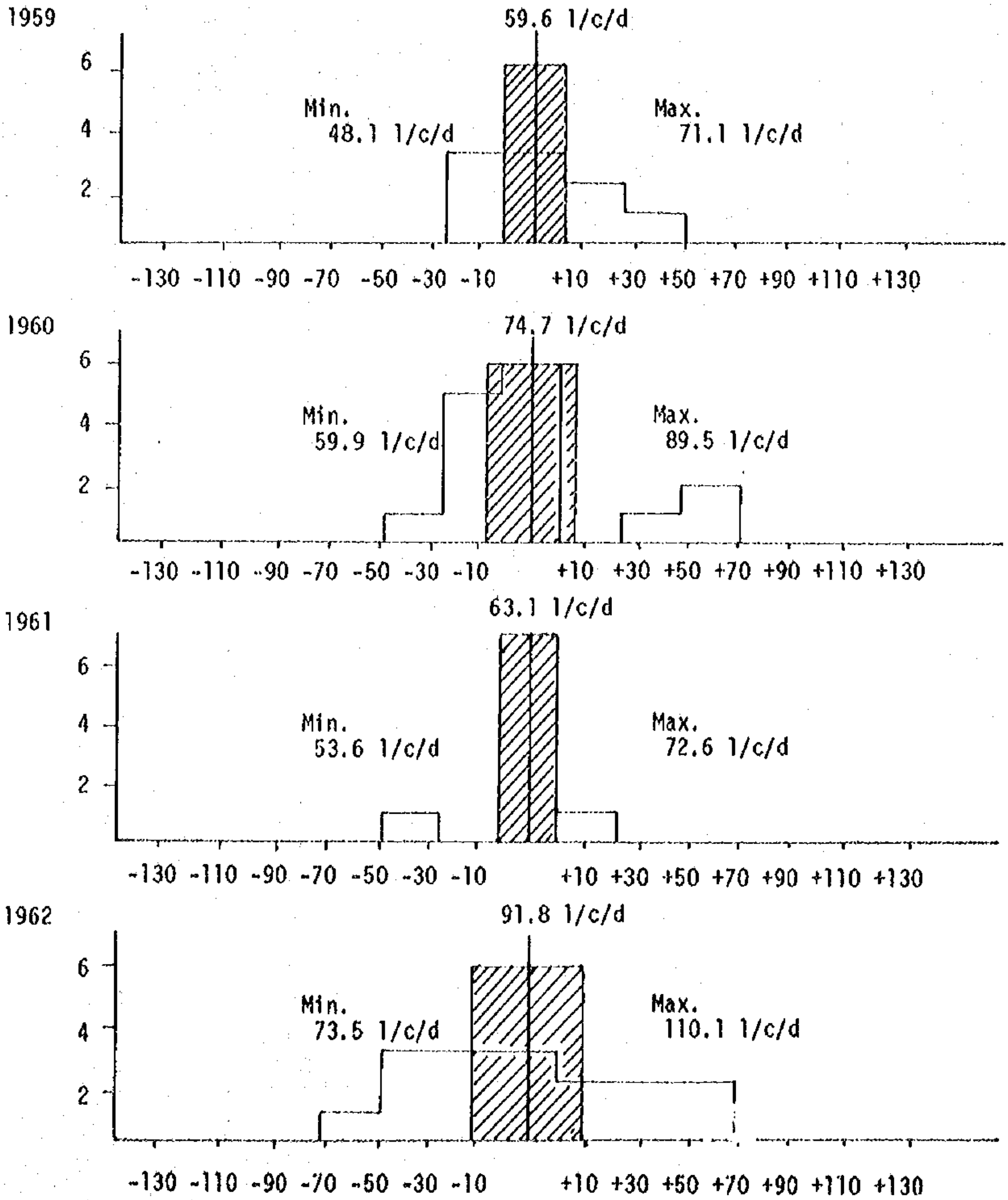
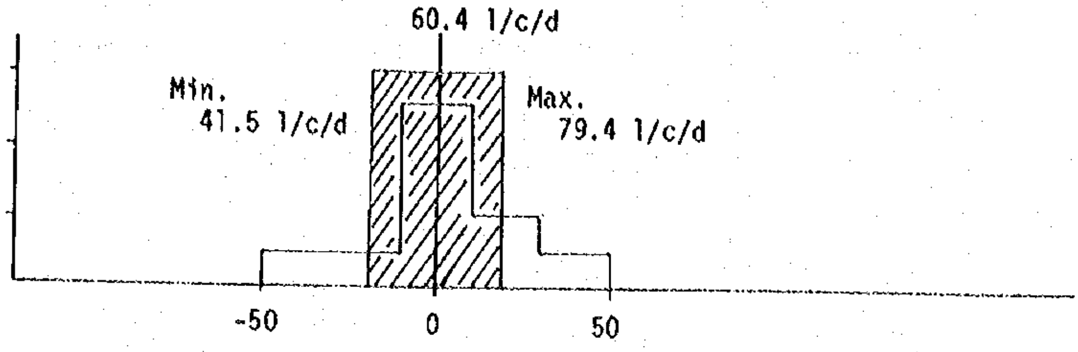
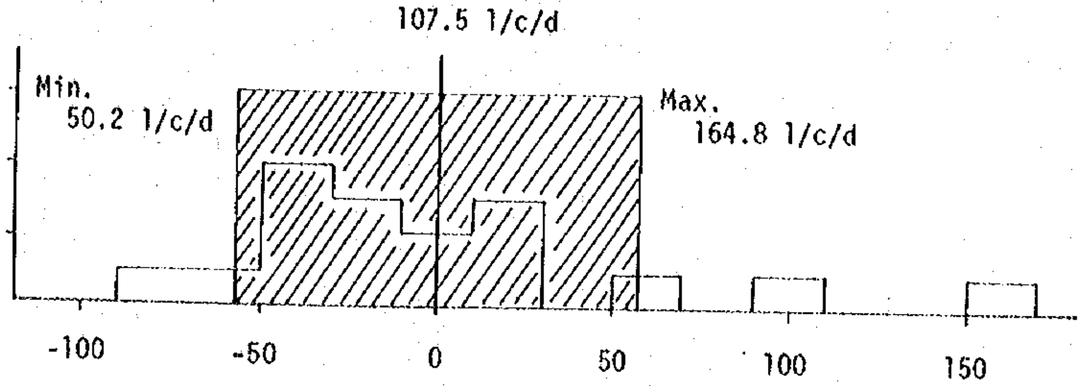

1959
59.6 l/c/d
Min.
48.1 l/c/d
Max.
71.1 l/c/d
6
4
2
-130 -110 -90 -70 -50 -30 -10 +10 +30 +50 +70 +90 +110 +130
1960
74.7 l/c/d
Min.
59.9 l/c/d
Max.
89.5 l/c/d
6
4
2
-130 -110 -90 -70 -50 -30 -10 +10 +30 +50 +70 +90 +110 +130
1961
63.1 l/c/d
Min.
53.6 l/c/d
Max.
72.6 l/c/d
6
4
2
-130 -110 -90 -70 -50 -30 -10 +10 +30 +50 +70 +90 +110 +130
1962
91.8 l/c/d
Min.
73.5 l/c/d
Max.
110.1 l/c/d
6
4
2
-130 -110 -90 -70 -50 -30 -10 +10 +30 +50 +70 +90 +110 +130

Figure 5-2

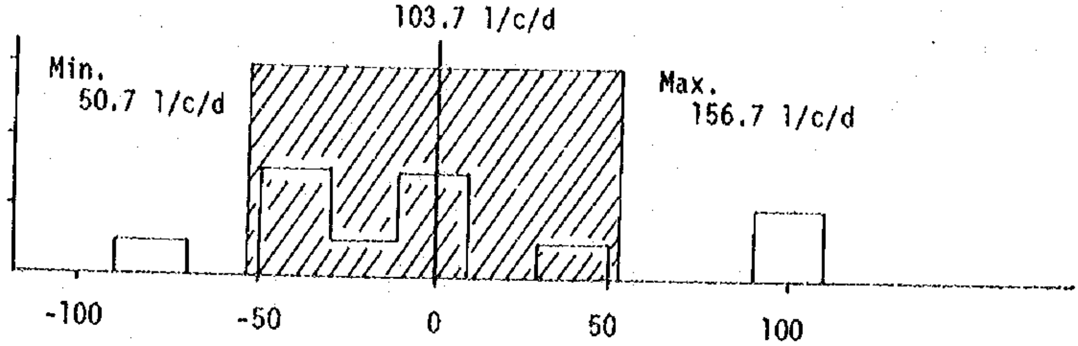
1963



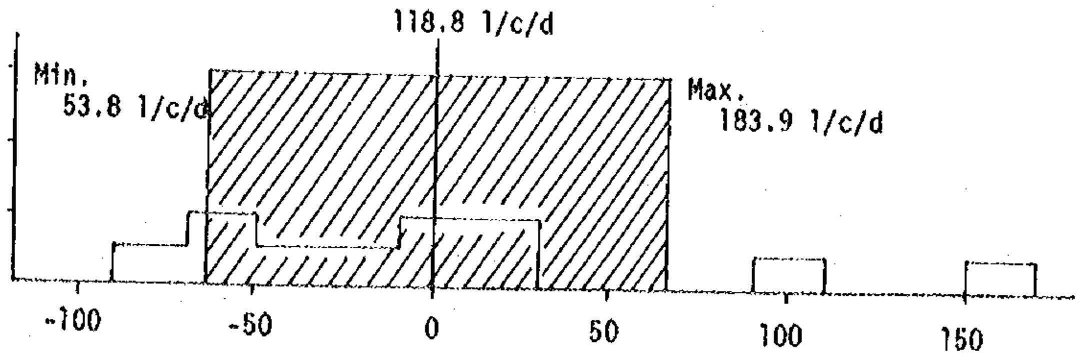
1964



1965



1966



remaining five figures---36, 39, 60, 56 and 74---is calculated.

(36 + 39 + 60 + 56 + 74) ÷ 5 = 53

When the result is induced into general formula such as $y = a\sqrt{x} + b$ according to the Least Square Method, Table 5.10 is obtained.

Table 5.10 Daily Consumption Mean Value Per Each Year

Year	x	Y	$X=\sqrt{x}$	X^2	XY
1959	0	53	0	0	0
1960	1	62	1.000	1	62.00
1961	2	62	1.414	2	87.67
1962	3	72	1.732	3	124.70
1963	4	71	2.000	4	142.00
1964	5	84	2.236	5	187.82
1965	6	88	2.449	6	215.51
1966	7	98	2.645	7	259.21
1967	8	99	2.828	8	279.97
Total	—	689	16.304	36	1358.88

$$a = \frac{n\Sigma XY - \Sigma X \Sigma Y}{n\Sigma X^2 - \Sigma X \Sigma X} = \frac{9 \times 1{,}358.88 - 16.304 \times 689}{9 \times 36 - (16.304)^2}$$

$= 17.1$ say 17

$$b = \frac{\Sigma X^2 \Sigma Y - \Sigma X \Sigma XY}{n\Sigma X^2 - \Sigma X \Sigma X} = \frac{36 \times 689 - 16.304 \times 1{,}358.88}{9 \times 36 - (16.304)^2}$$

$= 45.6$ say 45

Thus, $y = 17\sqrt{x} + 45$ is the basic equation for calculation of the mean water consumption in municipalities with less than 50,000 persons, and estimation of the future demand is made like in Table 5.11. Table 5.12 and Table 5.13 indicate the results obtained by applying similar calculation methods to the cases of municipalities with the population between 50,000 and 100,000 and population of more than 100,000.

Table 5.11 Demand Estimate of Municipalities with less than 50,000 Persons (ℓ/c.d.)

Year	x	y	Amendment Value	Remarks
1970	11	101	117	Basic Formula $y = 17\sqrt{x} + 45$
1980	21	123	127	
1990	31	140	137	
2000	41	155	147	

Table 5.12 Demand Estimate of Municipalities with 50,000~100,000 Persons (ℓ/c.d.)

Year	x	y	Amendment Value	Remarks
1970	11	121	127	Basic Formula $y = 17\sqrt{x} + 65$
1980	21	143	140	
1990	31	159	153	
2000	41	175	167	

Table 5.13 Demand Estimate of Municipalities with more than 100,000 Persons (ℓ/c.d.)

Year	x	y	Amendment Value	Remarks
1970	11	146	150	Basic Formula $y = 17\sqrt{x} + 90$
1980	21	168	167	
1990	31	185	138	
2000	41	200	200	

5.2 Daily maximum consumption

Seasonal changes of daily maximum consumption must be taken into consideration for the designing of water source, raw water main, purification plant and water transmission lines. The seasonal changes vary according to municipalities of different scales.

Very few statistics are available in Thailand, but a survey was conducted for two years between 1969 and 1970 in Sri-Racha, around 100 kilometers east of Bangkok. According to the survey (described in Table 5.14), daily maximum consumption is larger than the daily mean consumption by about 20 per cent and larger than the daily minimum consumption by about 50 per cent. It is questionable to obtain the value of daily maximum consumption out of these results, but this value is officially adopted on the ground that the Provisional Water Supply Division of the Public Works Department, Ministry of Interior decided several years ago to use the value which is 50 per cent larger than the daily mean consumption. In relation to the daily mean consumption as stated in 5.1, the daily maximum consumption is set like shown in Table 5.15.

Table 5-14 Water Consumption in Sri-racha

* : Assuming 7 families/meter

Month	No Meter 1969	No Meter 1970	Amount of Water 1969 (m^3/min)	Amount of Water 1970 (m^3/min)	Population* 1969	Population* 1970	Amount of Water 1969 (m^3/day)	Amount of Water 1970 (m^3/day)	l/c.d 1969	l/c.d 1970	Ratio 1969	Ratio 1970
1	1,252	1,443	45,351	49,272	8,764	10,101	1,511.7	1,642.4	172.5	162.6		
2	1,265	1,458	50,662	65.873	8,855	10,206	1,688.7	2,195.8	190.7	215.1		
3	1,269	1,476	45,019	59,609	8,883	10,332	1,500.6	1,987.0	168.9	192.3		
4	1,289	1,490	54,690	58,171	9,023	10,430	1,823.0	1,939.0	202.0	185.9		
5	1,297	1,513	47,925	64,452	9,079	10,591	1,597.5	2,148.4	176.0	202.9		
6	1,308	1,524	49,633	53,298	9,156	10,668	1,654.4	1,776.6	180.7	166.5		
7	1,328	1,566	51,506	60,505	9,296	10,962	1,716.8	2,016.8	184.7	184.0		
8	1,337	1,628	46,113	60,318	9,359	11,396	1,537.1	2,010.6	164.2	176.4		
9	1,350	1,635	46,964	58,243	9,450	11,445	1,565.5	1,941.4	165.7	169.6		
10	1,383	1,654	44,933	50,617	9,681	11,578	1,497.8	1,687.2	154.7	145.7		
11	1,399	1,683	44,041	67.714	9,793	11,781	1,468.0	2,257.1	149.9	191.6		
12	1,414	1,699	63,302	61,462	9,898	11,893	2,110.1	2,048.7	213.2	172.3		
Total									2,123.2	2,164.9		
Max.									213.2	215.1	1.21	1.19
Min.									149.9	145.7	0.85	0.81
Aver.									176.9	180.4	1.00	1.00

Table 5.15 Daily Maximum Quantity Consumed (ℓ/c.d.)

Year	Less than 50,000 Persons	50,000~10,000 Persons	More than 100,000 Persons
1975	182.5	190	225
1980	190	210	240
1990	205	230	270
2000	220	250	300

5.3 Hourly maximum consumption

Change of hourly consumption is an important factor for the designing of distribution system. The ratio of the hourly maximum consumption to the daily maximum consumption is high in small municipalities and low in large municipalities. There are few data about this problem in Thailand, but according to the survey in Sri-Racha, the consumption reaches the peak at 7 p.m. as shown in Table 5.16, and the value is 23 per cent larger than the daily maximum consumption.

Table 5.16 Hourly Variation of Water Consumption
(Mean Value for Three Days in Jan. 1971)

Time	Q (m^3/hr.)	Time	Q (m^3/hr.)
1	10.94	14	15.43
2	10.58	15	14.73
3	10.30	16	14.83
4	10.40	17	15.85
5	10.58	18	16.73
6	11.54	19	17.13
7	12.98	20	16.13
8	15.40	21	14.75
9	16.23	22	13.95
10	16.45	23	11.34
11	16.38	24	10.66
12	16.33	Total	335.39
13	15.75	Average	13.97

* : 17.13/13.97 ≒ 1.23

It is questionable to obtain the value of daily maximum consumption out of these results, but this result is adopted because the Provisional Water Supply Division of the Public Works Department, Ministry of Interior decided several years ago to use the value which is 50 per cent larger than the daily maximum consumption.

Chapter 6 Master plan of waterworks in Amphur Town

6.1 Amphur Nong Khaem

The Master Plan of waterworks in each Amphur is decided according to the findings as revealed between Chapter 3 and Chapter 5. The plan for Amphur Nong Khaem is outlined in Table 6.1 Water supply system to areas northeast of Amphur Nong Khaem are involved in this area to be served.

The construction plan in compliance with the increase of water demand (Table 6.1) was decided as follows, and the actual schedule is listed in Fig. 6.1

1. Emergency Program

Various facilities for the daily maximum supply of 10,000 m^3/d will be constructed in 1977.

2. First-stage work

In 1981, facilities for the supply of another 10,000 m^3/d will be constructed (the total supply amount will become 20,000 m^3/d).

3. Second-stage work

To be constructed in 1990 are facilities which will increase the daily maximum supply by 10,000 m^3/d (as a result, the total supply amount will rise to 30,000 m^3/d).

4. Third-stage work

To be constructed in 1995 are facilities which will increase the daily maximum supply by 10,000 m^3/d (as a result, the total supply amount will rise to 40,000 m^3/d)

Table 6.1 Basic Plan for Nong Khaem Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area (person)	32,000	44,000	59,000	79,000	105,000	138,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be served (person)	20,000	28,600	39,825	55,300	76,125	103,500
Daily Maximum (ℓ/c.d.)	225	240	255	270	285	300
Daily Maximum (m^3/day)	4,500	6,864	10,155	14,931	21,695	31,050
Out of Nong Khaem Area (c^3/c.d.)	500	1,136	3,845	5,069	6,305	8,950
Total	5,000	8,000	14,000	10,000	28,000	40,000

6.2 Amphur Lat Krabang

The Master Plan for waterworks in Amphur Lat Krabang is explained in Table 6.2. Based on the Master Plan, construction plans were decided as follows:

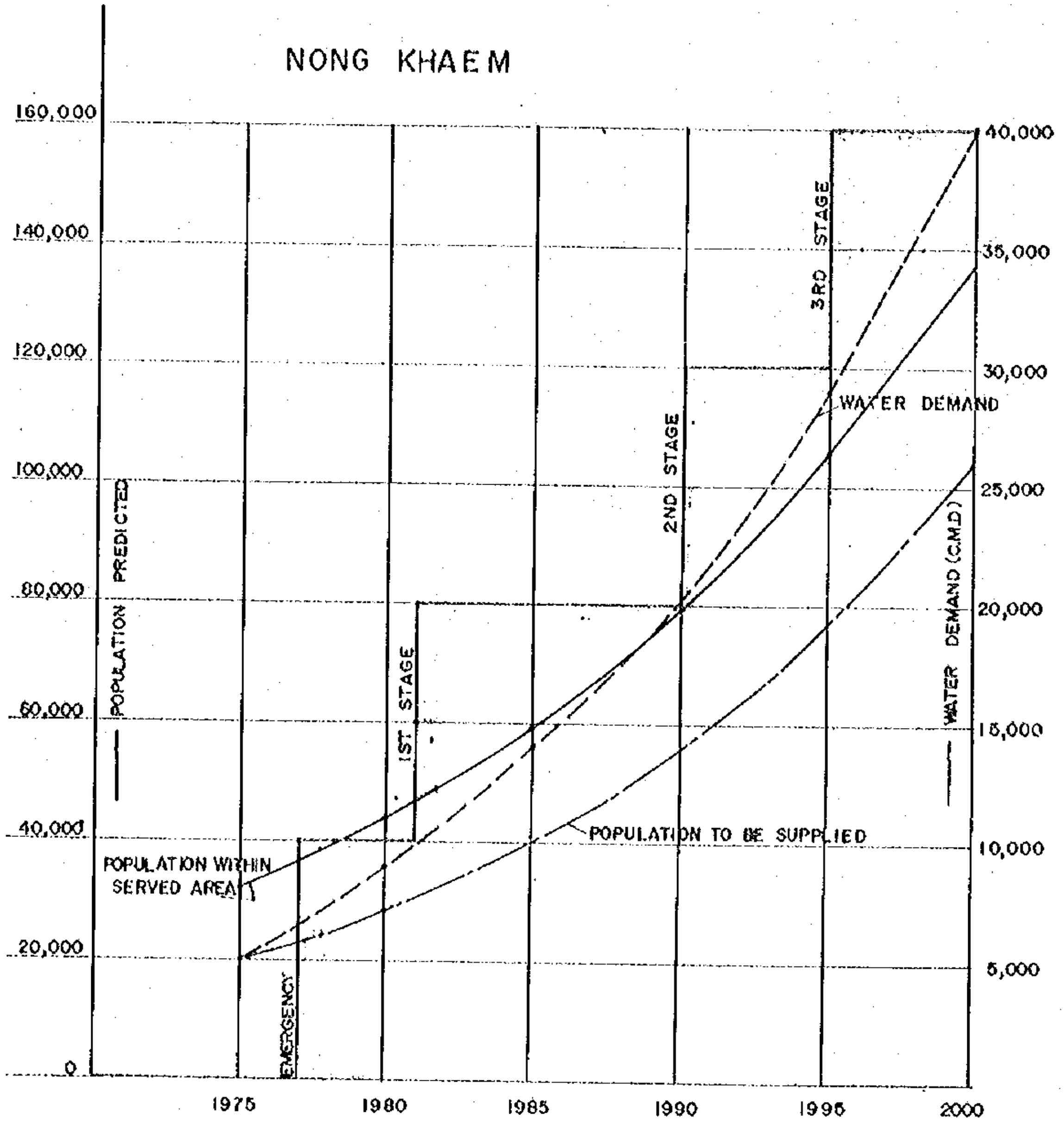
1. Emergency program

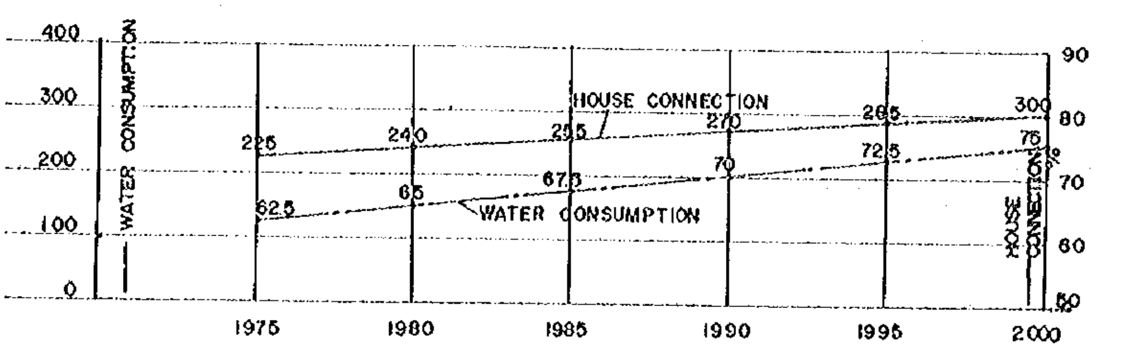
A rehabilitation work will be carried out to take 3,500 m^3/d of water from existing wells.

2. First-stage work

In 1978, facilities which can increase the daily maximum supply by 2,500 m^3/d will be constructed (In this

FIGURE6-I BASIC PLAN (NONG KHAEM)





case, the capacity of existing wells may decrease to 2,750 m^3/d, and thus the total supply amount will be 5,250 m^3/d).

3. Second-stage work

In 1984, new facilities will be constructed to increase the daily maximum supply by another 2,500 m^3/d (existing wells will be disregarded due to capacity decrease, and thus the total supply amount will be 5,000 m^3/d).

4. Third-stage work

In 1990, the supply will be boosted by another 2,500 m^3/d by constructing new facilities (the total supply amount will reach 7,500 m^3/d).

6.3 Amphur Bang Bua Thong

Table 6.3 shows the Master Plan of waterworks for Amphur Bang Bua Thong. Construction programs will be explained in the section devoted to the regional waterworks plan covering Bang Yai and Sai Noi districts.

Table 6.2 Basic Plan for Lat Krabang Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area (person)	18,242	23,518	28,795	34,072	39,348	45,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be served (person)	11,401	15,287	19,437	23,850	28,527	33,750
Daily Maximum (ℓ/c.d.)	182.5	190.0	197.5	20.5	212.5	220.0
Daily Maximum (m^3/day)	2,100	3,000	3,900	4,900	6,100	7,500

Table 6.3 Basic Plan for Bang Bua Thong Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area (person)	11,773	15,719	19,664	23,609	27,554	31,500
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be served (person)	7,358	10,217	13,273	16,526	19,977	23,625
Daily Maximum (ℓ/c.d.)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (m^3/day)	1,400	2,000	2,700	3,400	4,300	5,200

6.4 Amphur Bang Yai

The Master Plan is shown in Table 6,4 and construction programs will be explained in the section of the regional water supply plan.

FIGURE6-2 BASIC PLAN(LAT KRABANG)

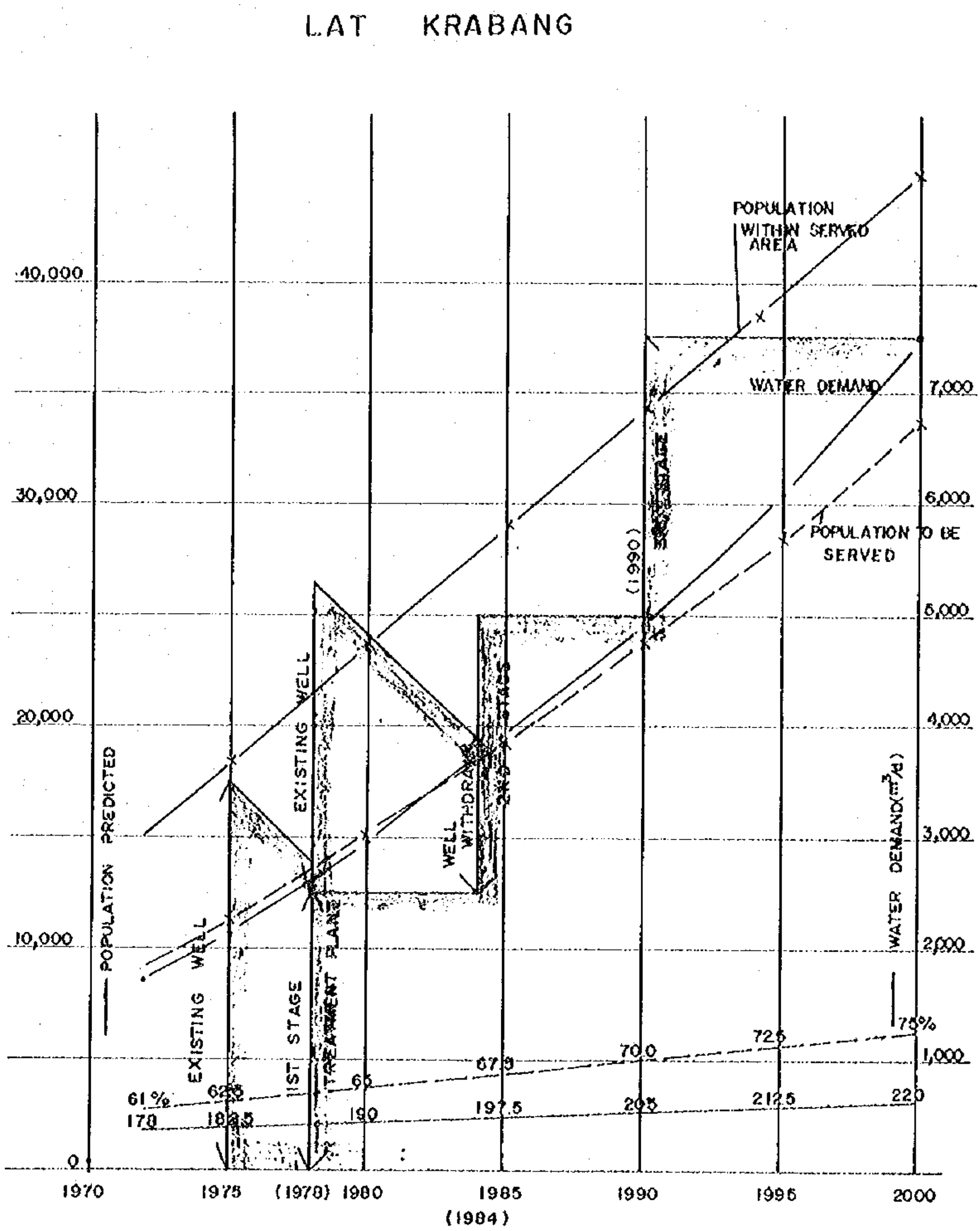


FIGURE 6-3 BASIC PLAN

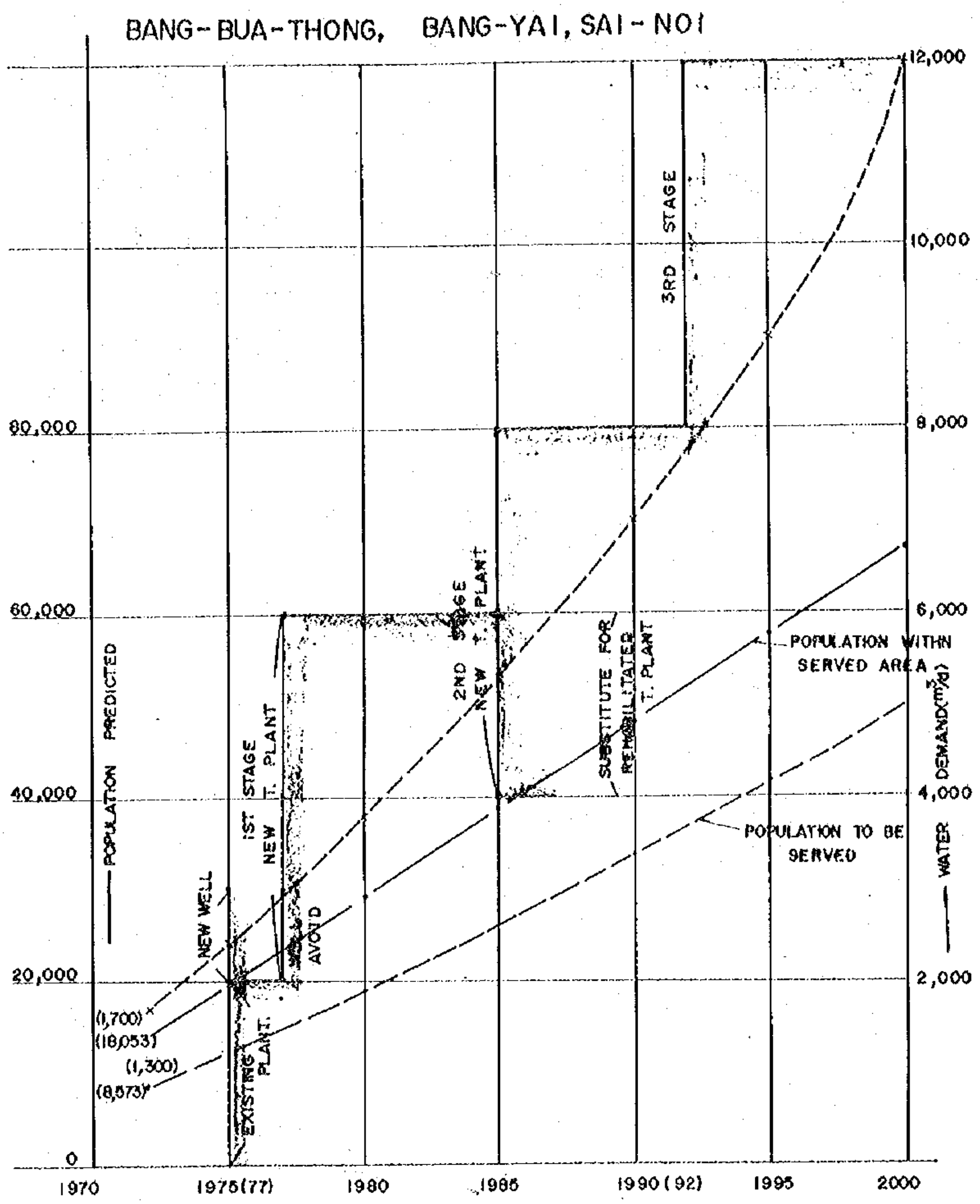


Table 6.4 Basic Plan for Bang Yai Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply (person)	5,935	10,048	14,161	18,274	22,387	26,500
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be served (person)	3,709	6,531	9,559	12,792	16,231	19,875
Daily Maximum (ℓ/c.d.)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum Supply (m^3/day)	700	1,300	1,900	2,700	3,500	4,400

6.5 Amphur Sai Noi

The Master Plan is in Table 6,5 and construction programs will be detailed in the section of the regional water supply plan, which will cover neighboring Amphur Bang Bua Thong and Bang Yai.

Table 6.5 Basic Plan for Sai Noi Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply (person)	2,018	3,414	4,811	6,207	7,604	9,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be served (person)	1,261	2,219	3,247	4,345	5,513	6,750
Daily Maximum (ℓ/c.d.)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum Supply (m^3/day)	300	500	700	900	1,300	1,500

6.6 Amphurs Bang Bua Thong, Bang Yai, and Sai Noi regional waterworks plan

For the reasons mentioned in Chapter 2, it was found that the regional water supply plan is more recommendable than separate water supply facilities in 2000 A.D. for the three Amphrs of Bang Bua Thong, Bang Yai and Sai Noi. This assumption gives rise to the Master Plan shown in Table 6.6. Accordingly, construction programs were arranged as follows, and the actual schedule is explained in Fig. 6.3.

1. Emergency program

New facilities will be constructed to take 3,000 m^3/d of water from existing waterworks and newly driven wells.

2. First-stage work

In 1977, new 4,000 m^3/d facilities will be built. Combined with the existing 2,000 m^3/d waterworks, the total capacity will rise to 6,000 m^3/d (in this case, the wells newly built in the emergency program will not be used more).

FIGURE6-4 BASIC PLAN (MIN BURI)

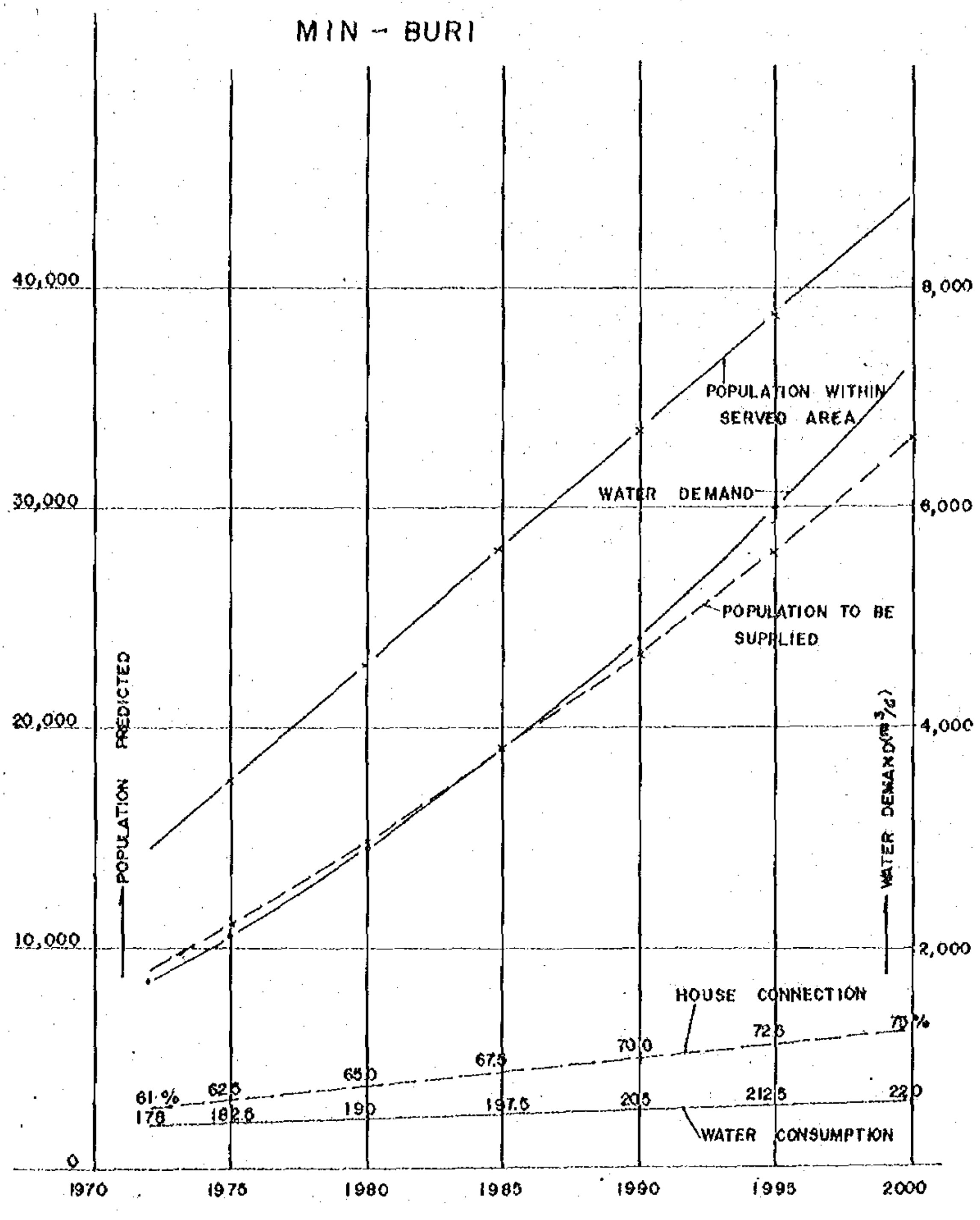
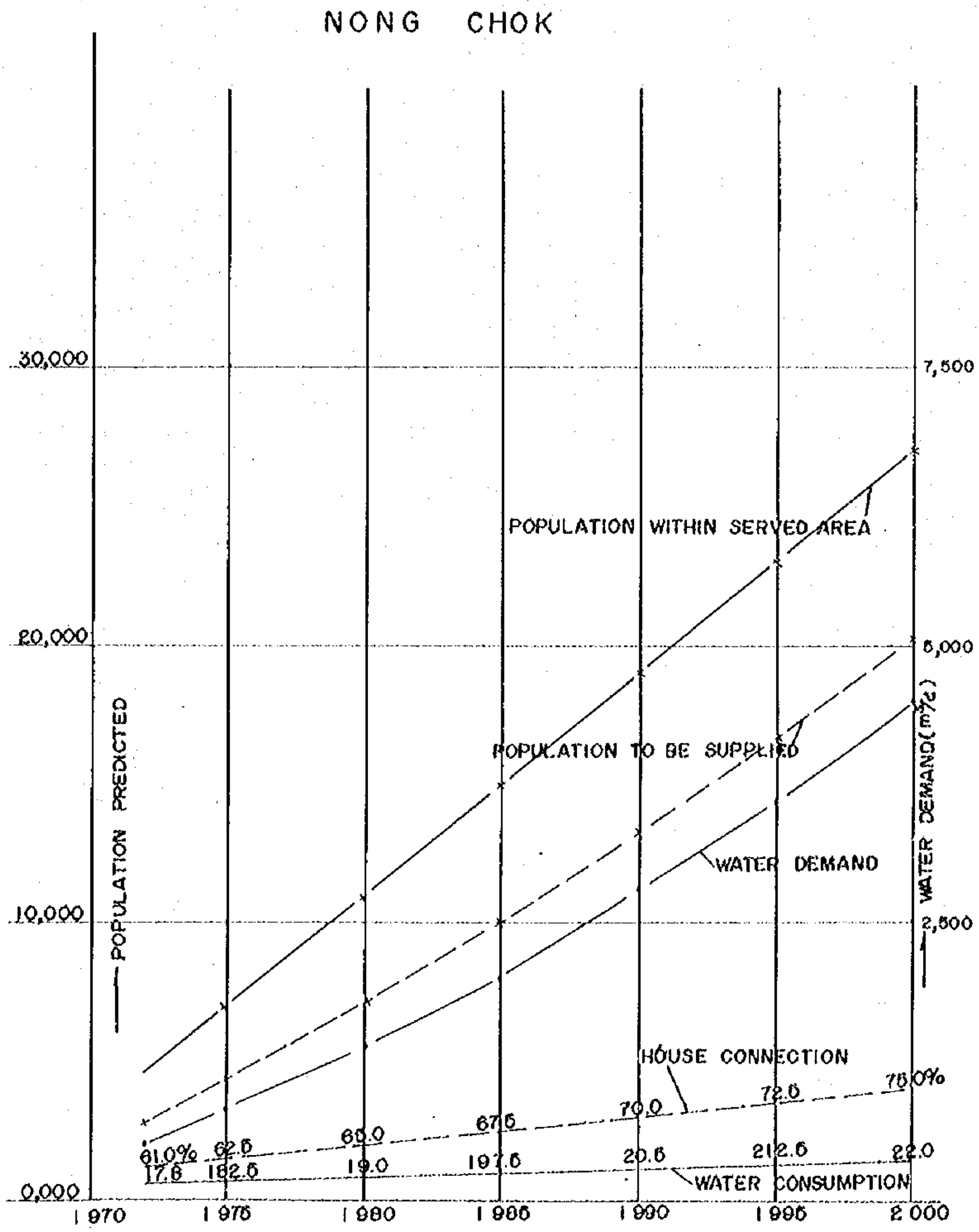


FIGURE 6-5 BASIC PLAN (NONG CHOK)



3. Second-stage work

In 1985, new 4,000 m^3/d facilities will be constructed, and original 2,000 m^3/d facilities will be abolished. As a result, facilities with the capacity of 8,000 m^3/d will be operated.

4. Third-stage work

Facilities of 4,000 m^3/d will be constructed in 1992, boosting the total capacity to 12,000 m^3/d.

Table 6.6 Basic Plan for Bang Bua Thong, Bang Yai, Sai Noi Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area (person)	19,726	29,181	38,636	48,090	57,545	67,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be served (person)	12,328	18,967	26,079	33,663	41,721	50,250
Daily Maximum (ℓ/c.d.)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (m^3/day)	2,400	3,800	5,300	7,000	9,000	12,000

6.7 Amphur Min Buri

The Master Plan is shown in Table 6.7 and Fig. 6.4.

Table 6.7 Basic Plan for Min Buri Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply (person)	17,800	23,000	28,200	33,400	38,700	44,000
House Connection (%)	6.25	65.0	67.5	70.0	72. 5	75.0
Population to be served (person)	11,125	14,950	19,035	23,380	28,058	33,000
Daily Maximum (ℓ/c.d.)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (m^3/day)	2,100	2,900	3,800	4,800	6,000	7,300

FIGURE 6-6 BASIC PLAN (BANG PHLI)

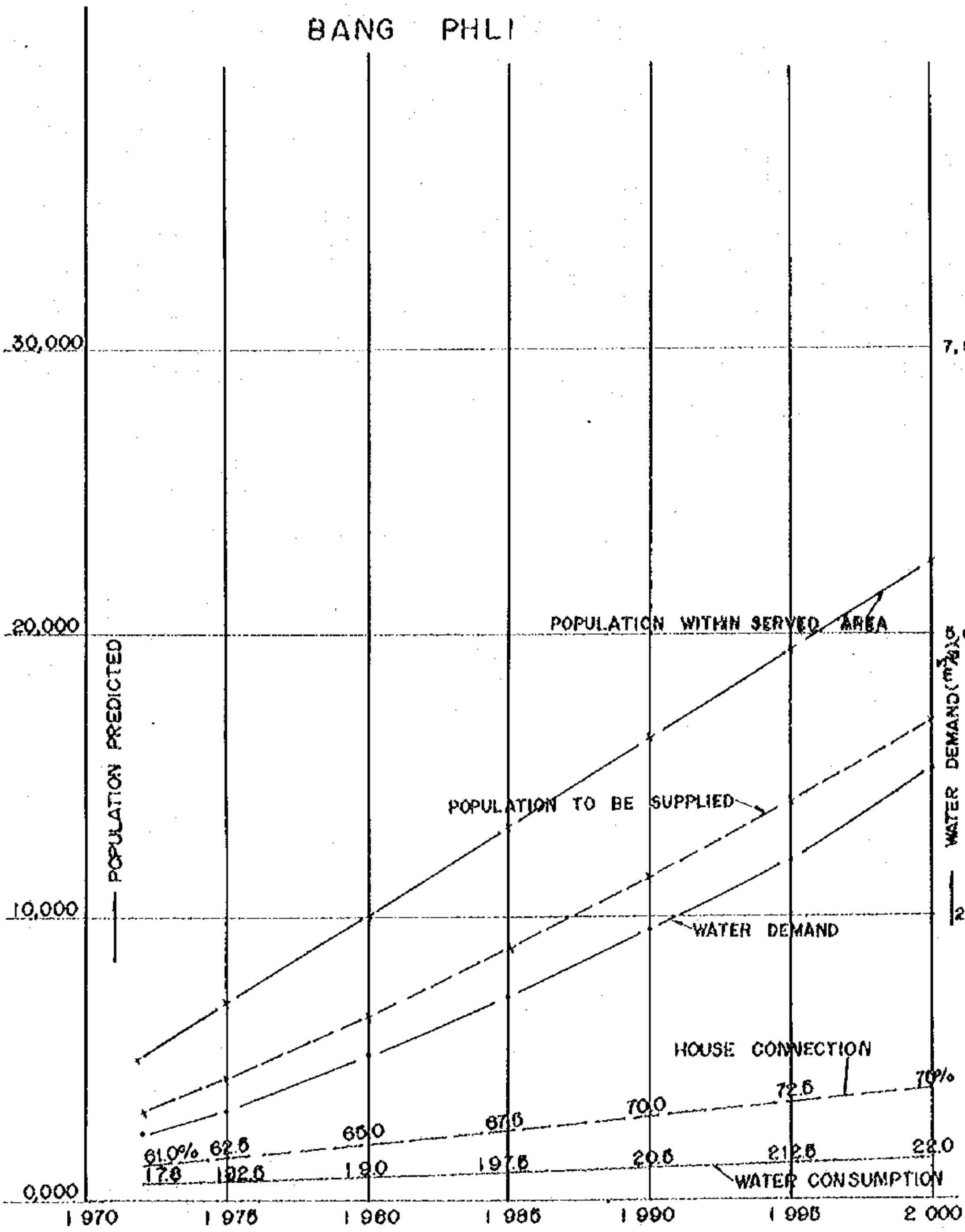
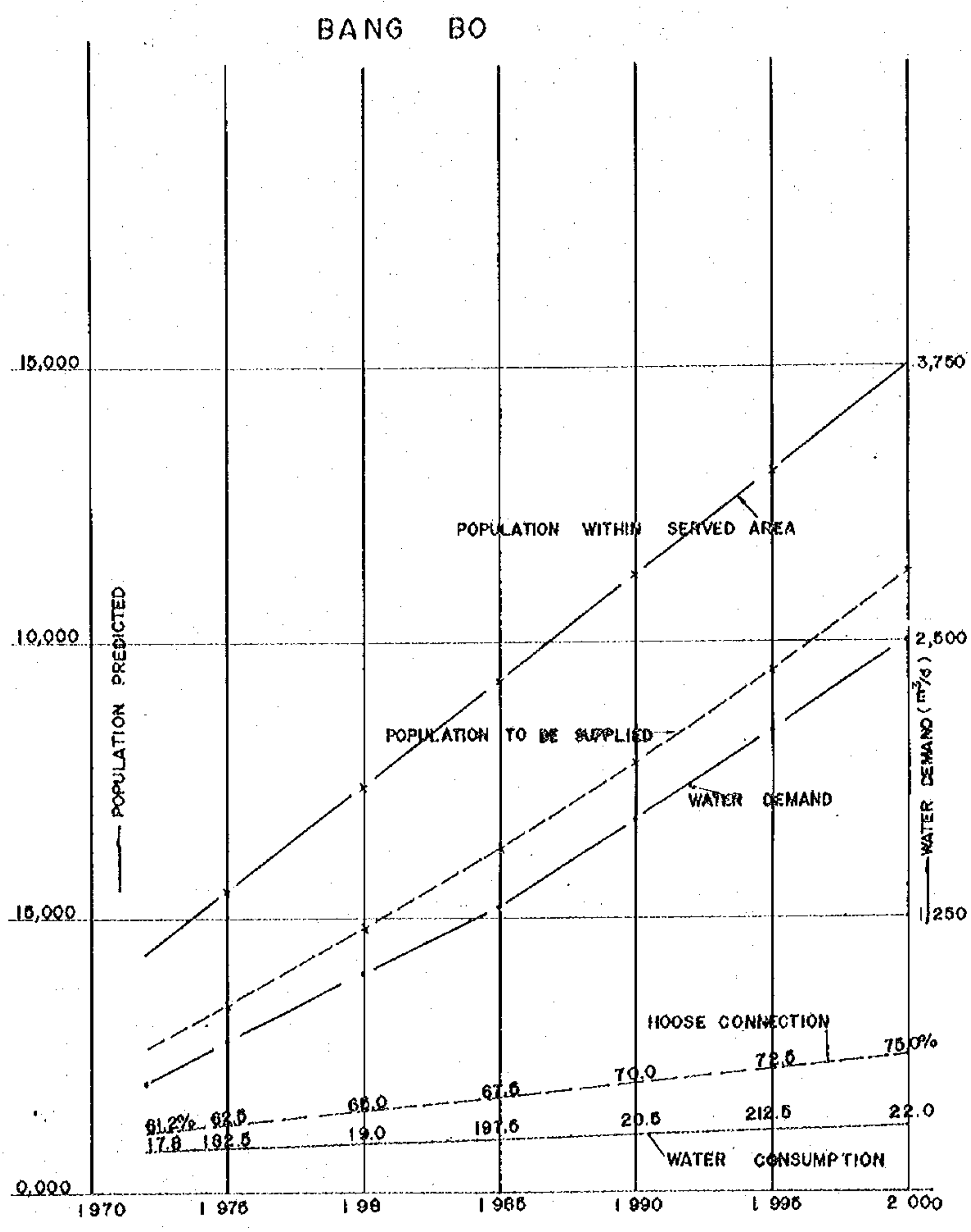


FIGURE 6 - 7 BASIC PLAN (BANG BO)



6.8 Amphur Nong Chok

The Master Plan is in Talbe 6.8 and Fig. 6.5

Table 6.8 Basic Plan for Nong Chok Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply (person)	7,000	11,000	15,000	19,000	23,000	27,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be served (person)	4,375	7,150	10,125	13,300	16,675	20,250
Daily Maximum (ℓ/c.d.)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (m^3/day)	800	1,400	2,000	2,800	3,600	4,500

6.9 Amphur Bang Phli

The Master Plan is in Table 6.9 and Fig. 6.6.

Table 6.9 Basic Plan for Bang Phli Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply (person)	7,000	10,100	13,200	16,300	19,400	22,500
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be served (person)	4,375	6,565	8,910	11,410	14,065	16,875
Daily Maximum (ℓ/c.d.)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (m^3/day)	800	1,300	1,800	2,400	3,000	3,800

6.10 Amphur Bang Bo

The Master Plan is shown in Table 6.10 and Fig. 6.7.

Table 6.10 Basic Plan for Bang Bo Area

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area (person)	5,500	7,400	9,300	11,200	13,100	15,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be served (person)	3,438	4,810	6,278	7,840	9,498	11,250
Daily Maximum (ℓ/c.d.)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (m^3/day)	700	1,000	1,300	1,700	2,100	2,500

Chapter 7 Water reconnaissance

7.1 Chao Phya River

Chao Phya River will have a great significance as the source of water for the Separate System when wells and Klong water becomes useless.

Even in Chao Phya River, the pollution is worsening. According to the pollution survey conducted in 1969 by the Ministry of Public Health, dissolved oxygen could not be found at all in the lower reaches beyond Thonburi Bridge. For this reason, the river cannot be said as a stable source of water supply. Efforts must be made in any way to maintain the unique character of Chao Phya as Thailand's biggest river. There is no problem concerning the quantity of water of the river, and the only thing to do is to check the back-water of saline content. Table 7.1 shows the data of the water quality survey conducted along Chao Phya River in January 1973. As the source of clean water, all the survey items showed satisfactory results. However, pH is in slightly acid side, and some measures are needed for the treatment of the water.

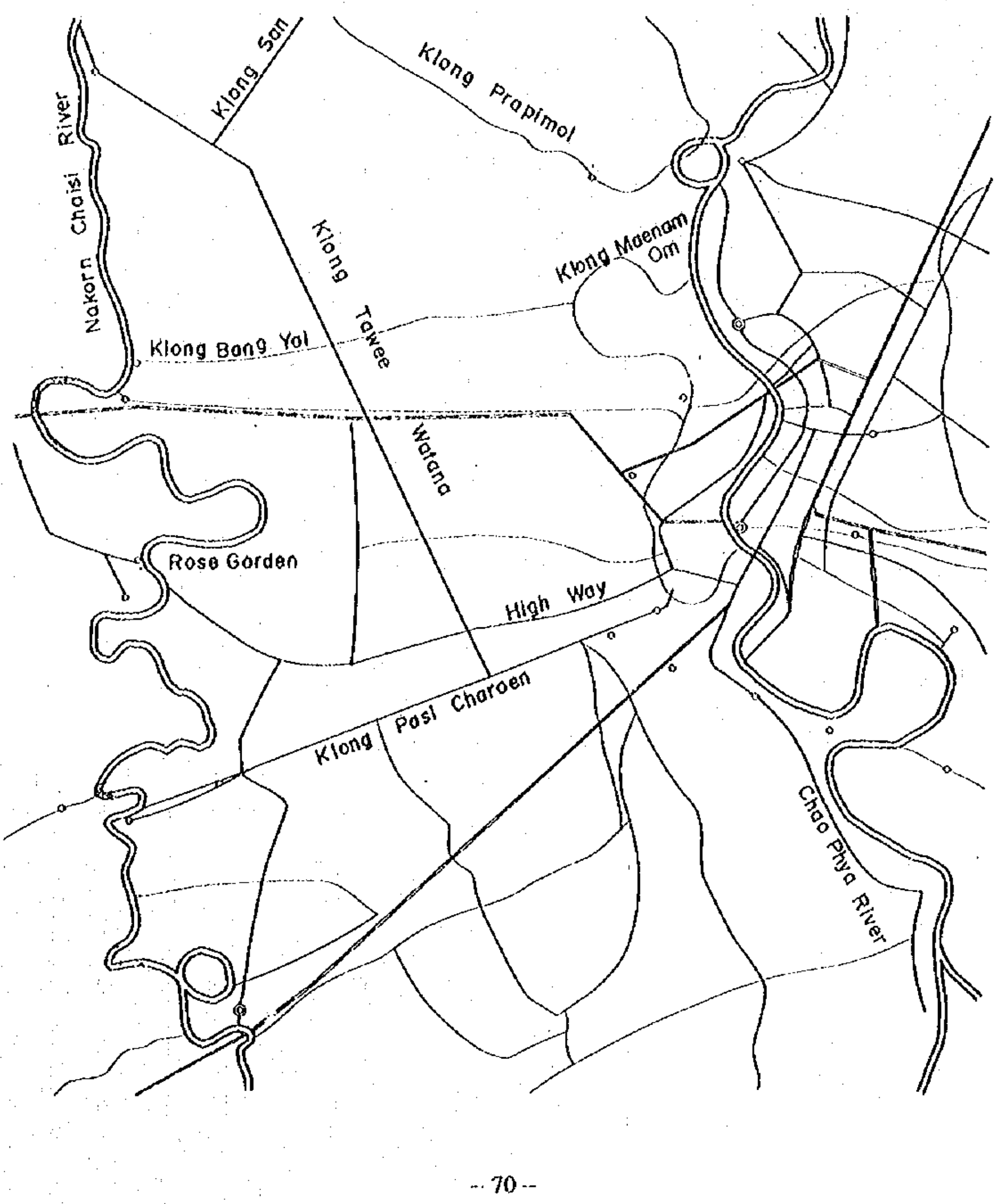
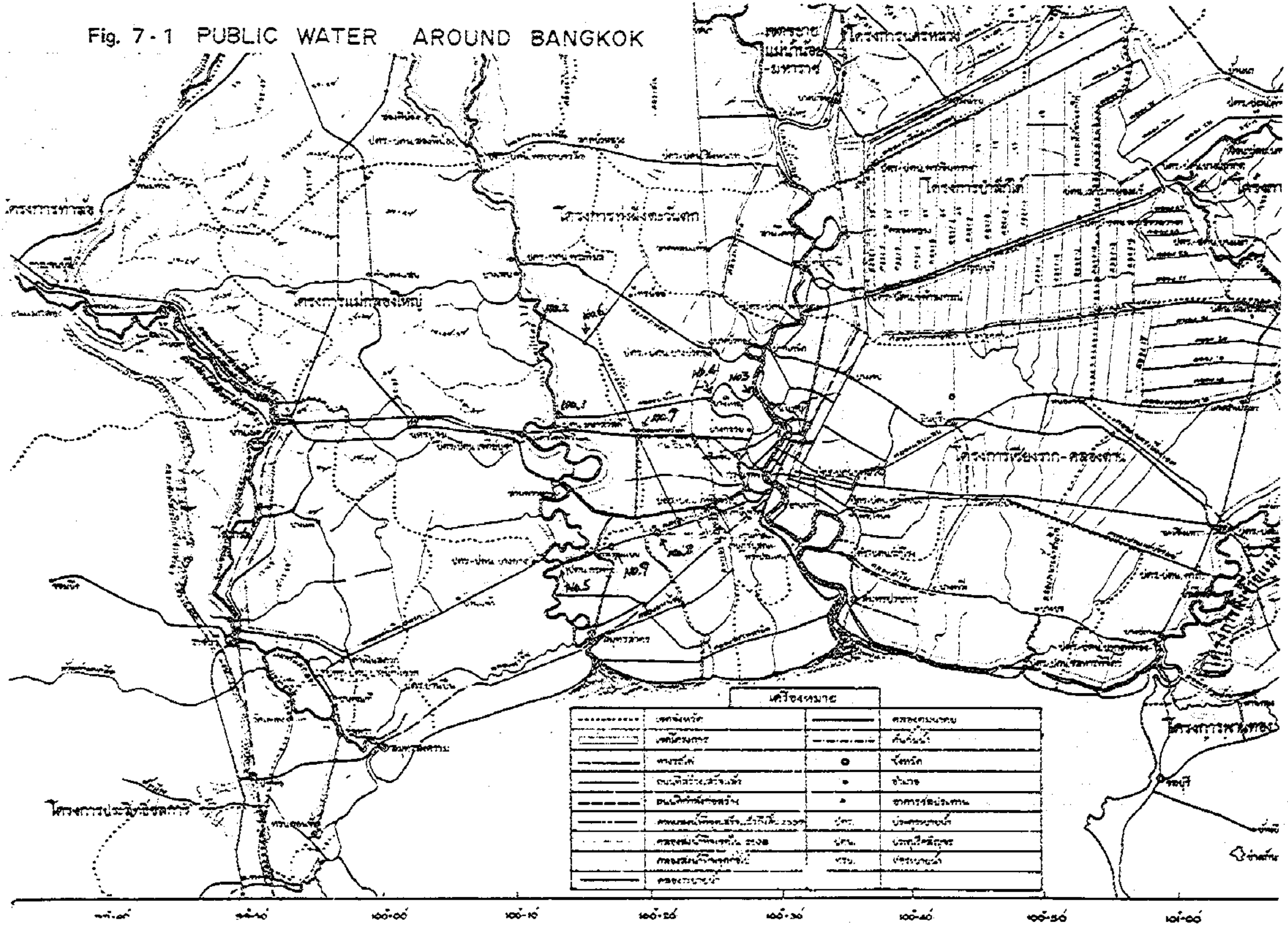


Table 7.1 Characteristics of Chao Phya River in Year 1973

Place	Day Month Year	Time	°C	pH	Oxygen Dissolved mg/l	Turbidity PPM SiO_2	Colour	Alkalinity PPM $CaCO_3$	Chlorides PPM $CaCO_3$	Free CO_2 mg/l	Hardness mg/l $CaCO_3$	Conductivity
A. Muang C. Singburi	24 Jan 1973	13:50	27.0	6.5	7.6	0–25	15	82	10	7.04	75	185
A. Muang C. Singburi	24 Jan 1973	13:30	27.5	6.5	7.6	0–25	15	72	9	6.16	85	185
A. Muang C. Singburi	26 Jan 1973	11:05	29.5	6.5	7.2	25	15	86	15	6.84	75	180
Chainat Dom C. Chainat	27 Jan 1973	10.05	30.5	6.5	7.7	25	15	81	11	6.16	72	175
A. Manorom C. Chainat	28 Jan 1973	13:35	27.5	6.5	7.1	0–25	15	73	15	6.84	68	170
A. Muang C. Phatum	21 Jan 1973	11:30	29.0	6.8	5.0	25–50	20	96	15	9.68	87	220
A. Samkok C. Phatum	21 Jan 1973	13:05	29.5	6.8	5.0	25–50	20	93	16	9.68	91	225
A. Bangpain C. Adudhaya	21 Jan 1973	15:25	29.5	6.8	5.6	25–50	20	88	10	7.04	95	260
A. Bangsai C. Adudhaya	22 Jan 1973	10:45	29	6.5	5.5	25–50	20	95	15	7.18	88	240
A. Muang C. Adudhaya	22 Jan 1973	12:30	28	6.6	6.8	25–50	15	87	14	6.16	82	220
A. Pamok C. Angthong	23 Jan 1973	13:20	28.5	6.5	7.0	25–50	15	93	10	7.92	84	215
A. Muang C. Angthong	23 Jan 1973	15:45	26.5	6.5	7.8	0–25	15	85	8	5.28	74	200
A. Muang C. Nakornsawan	29 Jan 1973	11:45	26	6.5	7.4	0–25	15	81	8	6.16	73	180
A. Payuhakiri C. Nakornsawan	30 Jan 1973	11:30	26.5	6.5	7.4	25–50	15	84	9	6.84	70	170

Fig. 7-1 PUBLIC WATER AROUND BANGKOK



Regarding the sample which the survey team collected when it travelled by boat from Bang Yai to Chao Phya River via Klong Maenam Om, chlorides content was 7 ppm, and no serious pollution was found (see No. 3 point in Fig. 7.2). The water of Chao Phya River can be considered to supply to four Amphurs of Bang Bua Thong, Bang Yai, Sai Noi and Nong Khaem situated on the right bank. Klong Maenam Om separates from the main stream of Chao Phya River, and there are no watergate and other facilities. Therefore, the quality of its water must be nearly the same as that of Chao Phya River. For supply of the river water to the right bank, No. 4 point shown in Fig. 7.1 can be used as an intake point. Data of the water quality test conducted at No. 4 point are introduced in the separate paper, and they are satisfactory. On the left bank, the water can be supplied to five Amphurs of Min Buri, Lat Krabang, Non Chok, Bang Phli and Bang Bo. In view of their geographical location and development of Amphurs on the left bank, no other means than the use of divided water from Klong Prapa as far as the surface water is concerned. The use of Klong Prapa as the water source harbors no problem because Klong Prapa is already being used as a water source for the Central System. The only problem is whether the water can be divided or not, in view of water quantity.

7.2 Nakorn Chai Si River

The river gradient is mild, but it has sharp zig-zag paths. For this reason, the damage by chloride emerges as a source of anxiety. Data concerning this study are few, but as shown in Fig. 7.2, 200 ppm of chlorides ion, which is very close to the permissible level for drinking water, was detected in an area 60 to 80 kilometers from the estuary in 1970. It was also reported that an abnormally high ratio of chloride ion was detected in 1968 (16,000 ppm at a site 60 kilometers from the estuary).

Tests conducted by the Japanese Survey Team are summarized in Tables 7.2 to 7.5. The water sample was taken at the spots shown in Fig. 7.1. The ratio of chloride ion was low and damage by saline water was not recognized.

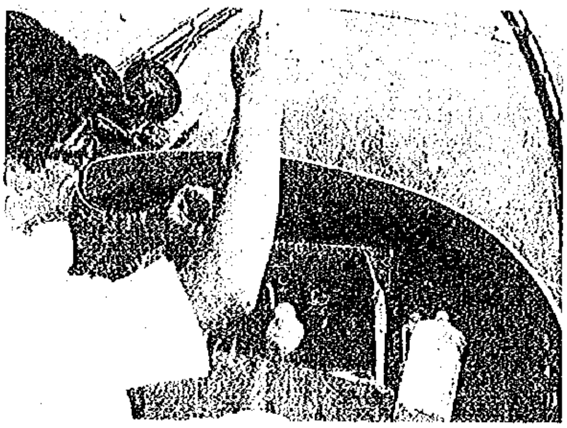


Table 7.6 reveals the results of the water quality test conducted by MWWA. Unfortunately, the survey on chloride test conducted by MWWA. Unfortunately, the survey on chloride ion was not satisfactory, and any conclusive findings could not be produced. Generally, it can be said that Nakorn Chai Si River is usable if water is taken from areas more than 80 kilometers away from the estuary. However, water analysis lasting at least for one year must be conducted before Nakorn Chai Si River can be designated as a water source.

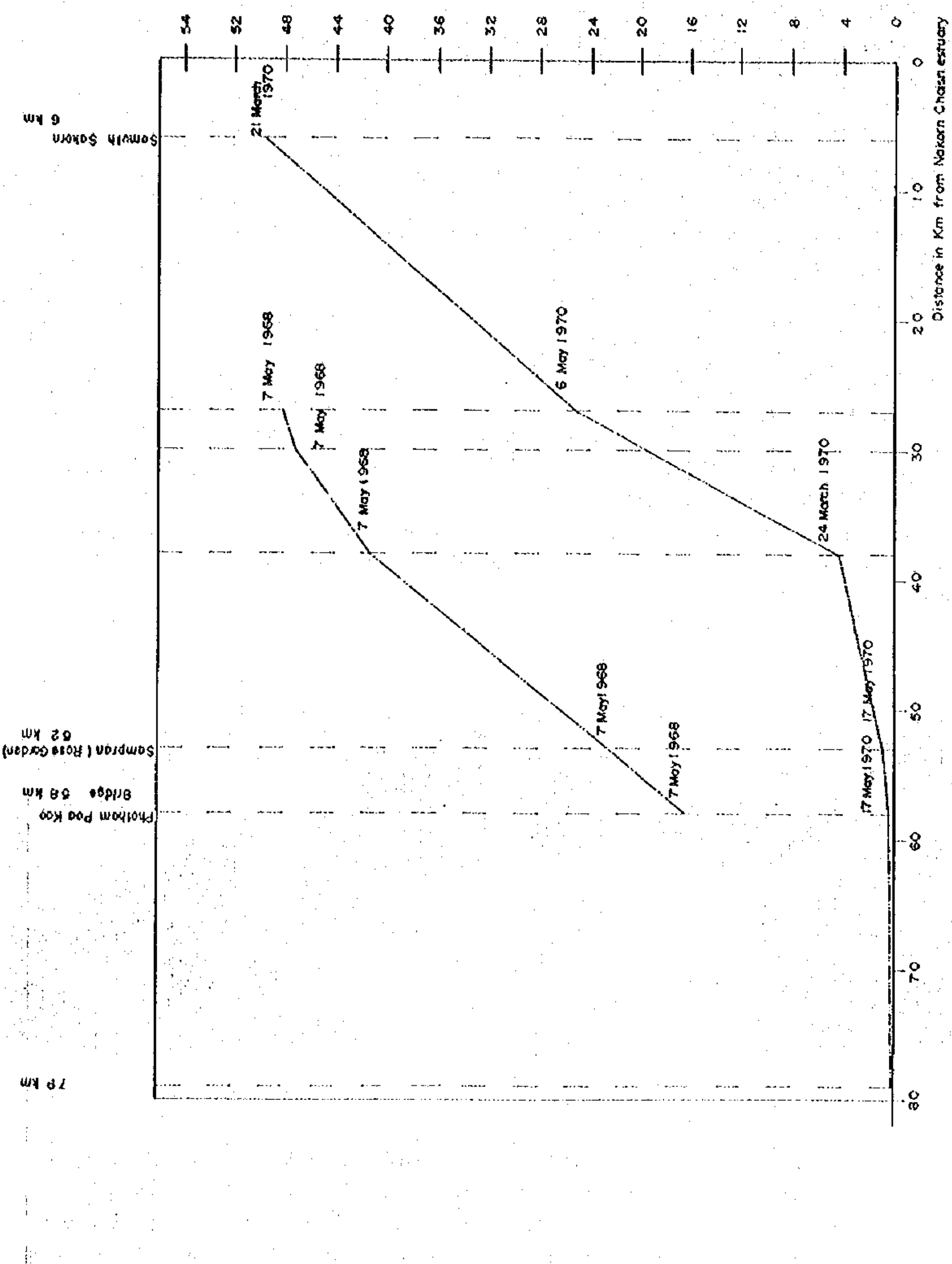


Fig — 7.2 : Salinity of Nakorn Chai Si River

Table-7. 2

แผนกควบคุมคุณภาพน้ำ

กองโรงกรองน้ำ การประปานครหลวง

หมายเลขวิเคราะห์น้ำที่ 45/15 Sample from Nakorn Chaisri River at Rose Garden.

ชนิดของตัวอย่างน้ำ คลอง เก็บเมื่อวันที่ 24 / ม.ค. / 15 จาก น้ำนครไชยศรี

Sampling 24/1/72

ตำบล – อำเภอ – จังหวัด –

ผู้ส่ง กองวิจัย รับวันที่ 25 / ม.ค. / 15 เก็บเวลา 12.00 น.

25 JAN. 1972 TIME noon.

ลักษณะทั่วไป

Color 25.0 Odor – Turbidity 15.0 p.p.m.

การวิเคราะห์ทางเคมี	จำนวนส่วนในน้ำล้านส่วน (ppm)
Methyl orange alkalinity	82.0
Phenolphtalein alkalinity	ไม่มี (nil)
Total Solids	140.0
Dissolved Solids	115.0
Total hardness	68.0
Carbonate hardness	68.0
Non-carbonate hardness	ไม่มี (nil)
Chloride, expressed as Cl_2	14.5
Sulphate, expressed as Na_2SO_4	19.88
Oxygen consumed 37 °C, 3 hrs	2.81
Ammonia, free, expressed as nitrogen	0.061
Albuminoid nitrogen, expressed as nitrogen	–
Organic nitrogen, expressed as nitrogen	–
Nitrate, expressed as nitrogen	–
Nitrite, expressed as nitrogen	0.009
Calcium	–
Copper	–
Iron	0.02
Fluoride	–
Manganese	–
pH	7.18

[signature] 26 ม.ค. 15

ผู้ทำการวิเคราะห์

การวิเคราะห์ทางบัคเตรีวิทยา

Bacteria per ml., agar, 37°C - 24 hrs

Test for Coliform group : M.P.N. for 100 ml

ผู้ทำการวิเคราะห์

หมายเหตุ

Table~7.3

แผนกควบคุมคุณภาพน้ำ

กองโรงกรองน้ำ การประปานครหลวง

หมายเลขวิเคราะห์ที่ 026/15

ชนิดของตัวอย่างน้ำ คลอง (Klong Water) เก็บเมื่อวันที่ - / ส.ค. / 15 จาก คลอง Rose Garden

ตำบล - อำเภอ - จังหวัด ธนบุรี

ผู้ส่ง กองวิจัย รับวันที่ 2 / ส.ค. / 15 เก็บเวลา - น.

ลักษณะทั่วไป

Color ไม่มี (no color?) Odor - Turbidity 41.0 p.p.m.

การวิเคราะห์ทางเคมี	จำนวนส่วนในน้ำล้านส่วน ppm
Methyl orange alkalinity	74.0
Phenolphtalein alkalinity	ไม่มี
Total Solids	- (not enough sample)
Dissolved Solids	193.0
Total hardness	114.0
Carbonate hardness	74.0
Non-carbonate hardness	40.0
Chloride, expressed as Cl_2	25.0
Sulphate, expressed as Na_2SO_4	113.60
Oxygen consumed 37 °C, 3 hrs	2.336
Ammonia, free, expressed as nitrogen	มีเล็กน้อย trace
Albuminoid nitrogen, expressed as nitrogen	0.190
Organic nitrogen, expressed as nitrogen	-
Nitrate, expressed as nitrogen	0.32
Nitrite, expressed as nitrogen	0.005
Calcium	32.0
Copper	-
Iron	1.62
Fluoride	0.60
Manganese	0.01
pH	7.05
N_4	8.10

การวิเคราะห์ทางบักเตรีวิทยา

ผู้ทำการวิเคราะห์ 18.8.15

Bacteria per ml., agar, 37°C - 24 hrs

Test for Coliform group : M.P.N. for 100 ml

ผู้ทำการวิเคราะห์

หมายเหตุ

Table 7.4

แบบควบคุมคุณภาพน้ำ
กองโรงกรองน้ำ การประปานครหลวง

หมายเลขวิเคราะห์น้ำที่ 47/15   *sample from Nakornchaisri river*

ชนิดของตัวอย่างน้ำ คลอง   เก็บเมื่อวันที่ 24 / ม.ค. / 15 (*sampling 24/1/72*)   จาก แม่น้ำนครไชยศรี

ตำบล -   อำเภอ -   จังหวัด -

ผู้ส่ง กองวิจัย   รับวันที่ 25 / ม.ค. / 15 (*25 Jan 972.*)   เก็บเวลา 14.30 น. (*TIME 2:30 PM*)

ลักษณะทั่วไป

Color 30.0   Odor -   Turbidity 18.5 p.p.m.

การวิเคราะห์ทางเคมี	จำนวนส่วนในน้ำล้านส่วน (ppm.)
Methyl orange alkalinity	85.0
Phenolphtalein alkalinity	ไม่มี (nil)
Total Solids	248.0
Dissolved Solids	119.0
Total hardness	84.0
Carbonate hardness	84.0
Non-carbonate hardness	ไม่มี (nil)
Chloride, expressed as Cl_2	12.0
Sulphate, expressed as Na_2SO_4	17.04
Oxygen consumed 37 °C, 3 hrs	2.372
Ammonia, free, expressed as nitrogen	0.0644
Albuminoid nitrogen, expressed as nitrogen	-
Organic nitrogen, expressed as nitrogen	-
Nitrate, expressed as nitrogen	-
Nitrite, expressed as nitrogen	0.016
Calcium	-
Copper	-
Iron	0.65
Fluoride	-
Manganese	-
pH	7.18

ผู้ทำการวิเคราะห์ (signature) 26.6.15

การวิเคราะห์ทางบักเตรีวิทยา

Bacteria per ml., agar, 37°C - 24 hrs

Test for Coliform group : M. P. N. for 100 ml

ผู้ทำการวิเคราะห์

หมายเหตุ

Table~7.5

แผนกควบคุมคุณภาพน้ำ

กองโรงกรองน้ำ การประปานครหลวง

หมายเลขวิเคราะห์น้ำที่ 021/15

ชนิดของตัวอย่างน้ำ คลอง เก็บเมื่อวันที่ - / ส.ค. / 15 จาก นครไชยศรี Nakorn Chaisri River

ตำบล - อำเภอ - จังหวัด

ผู้ส่ง กองวิจัย รับวันที่ 2 / ส.ค. / 15 เก็บเวลา - น.

ลักษณะทั่วไป

Color ไม่มี no color? Odor - Turbidity 54.0 p.p.m.

การวิเคราะห์ทางเคมี	จำนวนส่วนในน้ำล้านส่วน ppm
Methyl orange alkalinity	80.0
Phenolphtalein alkalinity	ไม่มี
Total Solids	- (ตัวอย่างไม่พอ) not enough sample
Dissolved Solids	230.0
Total hardness	138.0
Carbonate hardness	80.0
Non-carbonate hardness	58.0
Chloride, expressed as Cl_2	36.0
Sulphate, expressed as Na_2SO_4	134.9
Oxygen consumed 37 °C, 3 hrs	2.556
Ammonia, free, expressed as nitrogen	มีเล็กน้อย trace
Albuminoid nitrogen, expressed as nitrogen	0.190
Organic nitrogen, expressed as nitrogen	-
Nitrate, expressed as nitrogen	0.30
Nitrite, expressed as nitrogen	มีเล็กน้อย trace
Calcium	42.4
Copper	-
Iron	3.3
Fluoride	0.35
Manganese	0.01
pH	6.0
Mg	7.66

ผู้ทำการวิเคราะห์ [illegible signature] 15.8.15

การวิเคราะห์ทางบัคเตรีวิทยา

Bacteria per ml., agar, 37°C - 24 hrs

Test for Coliform group : M. P. N. for 100 ml

ผู้ทำการวิเคราะห์

หมายเหตุ

Table 7.6 Characteristics of NaKorn Chai Si River in Year 1972–1973

Place	Day Month Year	Time	°C	pH	Oxygen Dissolved mg/l	Turbidity PPM SIO_2	Colour	Alkalinity PPM $CaCO_3$	Chlorides PPM $CaCO_3$	Free CO_2 mg/l	Hardness mg/l $CaCO_3$	Conductivity	Coliform Bacteria
A. Singburi C. Chainat	17 Jan 1972	9:45	29.0	7.6	7.0	25–50	15					140	
A. Samchuk C. Supanburi	17 Jan 1972	15:14	24.5	7.0	6.0	25–50	–					–	
A. Sriprajun C. Supanburi	17 Jan 1972	14:12	24.0	7.0	3.8	25–50	–					–	
A. Muang C. Supanburi	12 Jan 1972	13:18	26.0	7.4	4.3	50	–					–	
Front of Majakarn Factory C. Supanburi	12 Jan 1972	15:20	27.0	7.2	3.4	75	–					230	
Wat Thakhlong C. Supanburi	12 Jan 1972	15:45	27.0	7.3	2.8	75	–					90	
A. Banglen C. NaKornpratom	12 Jan 1972	10:05	22.0	7.0	3.5	25–50	–					–	
A. Nakornchaisri C. Nakornpratom	15 Jan 1972	16:00	24.5	7.0	2.7	25–50	–					–	
Wat Bangpood A. Nakornchaisri C. Nakornpratom	11 Jan 1972	15:05	27.0	6.8	3.75	25	–					90	
Bhokae Bridge A. Samparn C. Nakornpratom	11 Jan 1972	14:30	27.0	6.8	3.25	25	–					90	
A. Kratumban C. Samutsakorn	11 Jan 1972	17:40	26.0	7.0	3.5	25	–	80				–	
A. Muang C. Samutsakorn	11 Jan 1972	16:20	27.0	7.4	4.0	25	–	110				–	

Place	Day Month Year	Time	°C	pH	Oxygen Dissolved mg/l	Turbidity PPM SiO_2	Colour	Alkalinity PPM $CaCO_3$	Chlorides PPM $CaCO_3$	Free CO_2 mg/l	Hardness mg/l $CaCO_3$	Conductivity	Coliform Bacteria
A. Muang C. Samutsakorn	25 Dec 1972	17:10	28.5	6.5	3.6	150	20	20			178	1,400	$0.093/10^5$
A. Banglen C. Nakornpatom	26 Dec 1972	12:01	28.5	6.5	3.0	0–25	20	10			51	200	$0.093/10^5$
North of A. Nakorn chaisri C. Nakornpatom	26 Dec 1972	15:30	28.5	6.5	2.6	0–25	20	10			65	190	$0.093/10^5$
South of A. Nakorn Chaisri5 C. Nakornpatom	26 Dec 1972	17:35	28.5	6.5	2.4	0–25	20	10			63	190	$0.093/10^5$
A. Sampam C. Nakornpatom	26 Dec 1972	14:12	29.0	6.5	3.0	0–25	20	10			55	190	–
Pokae Bridge A. Sampam C. Nakornpatom	28 Dec 1972	15:20	29.0	6.5	3.0	0–25	20	10			58	210	$0.15/10^5$
A. Kratumban C. Samutpakorn	29 Dec 1972	16:13	29.0	6.5	3.1	0–25	20	10			62	210	$0.24/10^5$
Ban Thakaeg A. Muang C. Chainat	26 Jan 1973	15:10	28.0	6.5	6.1	25	15	78	15	9.68	72	180	
A. Watsing C. Chainat	27 Jan 1973	14:45	28.0	6.5	6.1	25	15	73	15	8.8	72	175	

Table - 7.7 Water Analysis of Klong Water Through Separate System

Description	LAT KRABANG	" "	BANG BUA THONG	SAI NOI (A)	" " (E)	NONG CHOK	BANG BO		(Ground Water) NONG CHOK
Color	30	25	10	10	7	20	20		none
Turbidity	15	75	52	225	215	230	108		3.8
Methyl Orange Alkalinity	156	106	80	68	68	72	58		414
Phenolphtalein Alkalinity	none	none	none	none	none	none	none		2.8
Total Solids	495	435	317	291	380	418	450		1013
Dissolved Solids	280	230	150	130	125	130	220		800
Total Hardness	106	100	94	90	84	36	102		102
Carbonate Hardness	106	100	80	68	68	72	58		102
Non-carbonate Hardness	none	none	14	22	16	14	44		none
Chloride, expressed as Cl_2	45	38	11	2	1	10	43		140
Sulphate expressed as Na_2SO_4	36.92	49.7	39.76	52.54	38.34	41.18	55.38		51.12
Oxygen- consumed 37°C, 3 hours									
Ammonia, free expressed as Nitrogen									
Albuminoid Nitrogen, expressed as Nitrogen									
Organic Nitrogen, expressed as Nitrogen									
Nitrate, expressed as Nitrogen	0.017								
Nitrite, expressed as Nitrogen	28	0.12	0.001	0.01	trace	0.013	0.03		0.01
Calcium		20.8	25.6	24	22.4	22.4	19.2		22.4
Copper									
Iron	0.62	1.6	1.0	0.785	1.13	3.04	1.26		trace
Fluoride									
Manganese	none	0.216	trace	none	none	0.02	0.01		0.216
Magnesium	8.64	11.52	7.20	7.20	6.72	7.20	12.96		11.04
pH	7.30	7.05	7.55	7.35	7.35	7.50	7.25		1.95
Free CO_2	20	15	8	6	7	9	16		none

Table - 7.8 Water Quality Analysis of Klong Water

	Bang - Yai Klong Mae Nam Oxm	Nong Khaem (A) Klong Tawee Watana	" (B)	" (C)	" (D)
Color	10	10	15	15	20
Turbidity (JTU)	63	375	135	100	275
Methyl Orange Alkalinity	82.0	72.0	80.0	98.0	84.0
Phenolphtalein Alkalinity	nil	nil	nil	nil	nil
Total Solids	200.0	863.0	350.0	360.0	633.0
Dissolved Solids	97.0	150.0	175.0	230.0	190.0
Total Hardness	76.0	96.0	102.0	140.0	112.0
Carbonate Hardness	76.0	72.0	80.0	98.0	84.0
Non-carbonate Hardness	nil	24.0	22.0	42.0	28.0
Chloride, expressed as Cl_2	4.0	9.0	12.0	25.0	21.0
Sulphate, expressed as Na_2SO_4	nil	38.34	38.34	49.7	14.2
Oxygen-consumed 37° C, 3hours	2.06	2.78	28.2	29.9	29.9
Ammonia, free, expressed as Nitrogen	nil	trace	trace	nil	0.03
Organic Nitrogen, expressed as Nitrogen	0.14	0.14	0.17	0.23	0.20
Nitrate, expressed as Nitrogen	1.550	0.443	1.772	1.994	1.772
Nitrite, expressed as Nitrogen	0.003	0.02	0.001	0.004	0.10
Calcium	21.6	27.2	27.2	33.6	25.6
Copper					
Iron	1.22	4.62	2.2	1.44	5.48
Fluoride	0.41				
Manganeese	trace	0.548	0.216	0.434	0.508
Magnesium	5.28	6.72	8.16	13.44	11.52
pH	6.98	6.85	7.25	7.10	7.22
Phosphorus	0.17	2.6	0.17	0.17	0.17
Free CO_2		10.0	8.0	9.0	8.0
Albuminoid Nitrogen, expressed as Nitrogen	0.12	0.13	0.125	0.16	0.15
B O D		1.6		1.6	1.8

7.3 Klong

Klongs which cover entire Thailand like a huge net have played an important role for the development of the country. Today, however, Thailand is no exception as far as the problem of pollution is concerned. It is now at a time when the use of Klongs must be restudied from the standpoint of water pollution control.

In fact, many people in Thailand are opposed to the use of Klong as a water source. An elaborate scientific analysis is needed before making the final decision.

(1) Water quality

Results of the water quality test are recorded in Table 7.7 and Table 7.8. Water quality is almost the same in various Klongs. Turbidity is between 50 and 400 degrees and is more than 100 in most places. The high turbidity seems to be the main characteristic of Klong water. It is probably caused by high degrees of methyl orange alkalinity, plenty of total solids, high hardness and a large quantity of iron which originate in earth and rock. Unlike the case which results from human pollution like organic substances, the water may become usable if the turbidity is successfully removed. The removal is rather easy with the present chemical technology, and there are no serious problems at all for the use of Klong as a water source.

Regarding alkalinity, phenolphtalein alkalinity was not detected, but a high content of methyl orange alkalinity was found. This can be considered as alkalinity caused by bicarbonate. This is attributed to a specific nature of soil. Water containing carbonic acid gas interacts with carbonate in soil and produces calcium and magnesium. The analysis reveals that high alkalinity is the major reason for the high degree of turbidity. Alkalinity is related with aluminum sulphate treatment of water. As shown in Table 7.9, tens of ppm of aluminum sulphate is injected into the water due to the high turbidity and high alkalinity. At the same time, the high alkalinity limits pH at a low level. Judging from a jar test, the most suitable dosing rate is about 90 ppm, but considering residual turbidity and pH control by lime or soda ash, the dosing rate of 60 to 70 ppm would be accepted. The ratio, however, changes according to the change of water quality. Hardness is about 100 ppm, and it is mainly caused by bicarbonate hardness. Free carbon dioxides is less than 20 ppm. These are not harmful to consumers of the water. From the amount of free CO_2, the density of erosive carbonic acid is calculated. In Amphur Lat Krabang where the largest amount of free CO_2 is found, the content is 10 ppm, while in Amphur Sai Noi, it is 4.6 ppm. Langerier index is always more than 1 in all Klongs. Thus, the Klong water has a little erosive action but does not give any harm to drinking purposes, as long as pH of purified water is kept near the neutral level.

Table 7.9 Jar Test of Klong Water

(A) Nong Khaem Raw Water

Alum dose (mg/ℓ)	40	50	60	70	80	90	100
pH after 15 min Settling	6.68	6.63	6.60	6.58	6.46	6.43	6.40
Alkalinity (mg/ℓ)	78	70	70	66	62	56	54
Turbidity (JTU)	8.0	7.2	8.65	8.7	4.9	5.2	2.8

Quality of Raw Water are shown in Table 2.

(B) Lat Krabang

Alum dose (mg/ℓ)	50	60	70	80	90
pH after 15 min Settling	6.65	6.60	6.53	6.45	6.35
Alkalinity (mg/ℓ)	136	129	122	120	118
Turbidity (JTU)	13.0	13.0	7.8	7.5	5.6

Before adding alum, Raw water has turbidity 105 JTU
Alkalinity 160 mg/ℓ
pH 7.15

The content of chlorine ion in Bang Bo is 40 ppm which is higher than in any other Amphurs. This indicates the fact that Amphur Bang Bo on the left bank of Chao Phya is affected by sea-water. However, sulphate ion ratio does not differ much from contents in other Amphurs. Thus it is assumed that the effect of sea-water, if any, is not a serious problem, and water pollution may be caused by some other factors. It is hard to understand why sulphate ion was detected in Amphur Bang Yai. Some accidents occurred during the inspection work. The chloride iron content near Amphur Bang Yai was 7.0 mg/l.

Iron is responsible for reddish water and odor and causes iron bacteria to propagate. In drinking water, the iron content must be less than 0.3 ppm. Klong water contains 1 to 5 ppm of iron, but it is included in turbid substances, and high turbidity gives rise to the high content of iron. The analysis of iron, shown in Table 7.7 and 7.8, was made on total iron which was produced by extracting iron from the sample containing turbid substances with hydrochloric acid. This is why plenty of iron was found in turbid substances. The content of total iron found in the water with turbidity of over 100 ppm is 1 to 5 ppm, and this is found commonly. The fact means that if Klong water is treated with the coagulation and sedimentation method and turbid substances are removed, the amount of iron eventually decreases. However, ferrous iron was not measured, and in paddy fields, there was a red-brown colony apparently caused by Crenothrix (without a microscopic test, the name of the organism was not identified). For these reasons, it would be necessary to analyze ferrous iron or total iron obtained after coagulation, sedimentation or filtration.

Manganese coexists with iron in many cases, and they have similar chemical behaviors, but the amount of manganese is smaller than that of iron. Even a minute amount of manganese becomes a cause of black water, and therefore, it must be limited below 0.05 ppm. Otherwise, some specific measures must be taken to remove it. In Klong water, it usually is less than 0.5 ppm. Compared with others, Klong Tawee Wattana has much manganese, but it can be removed in the process of coagulation, sedimentation and filtration.

Oxygen consumption, nitrogenous compound and phosphate concentration are much larger and higher than those of clean surface water. This means the fact that the water has too large pollution load to be the source of water supply. According to environment surveys, the turbidity is apparently caused by human excreta. Besides the fact that the water is contaminated by organic compounds, there is a fear that it may cause contageous diseases of digestic organs, and severe precautionary measures are needed. This is not a very difficult problem to solve. Usual purification process and chlorination will be good enough. Germ test was omitted in the latest survey. To prevent germ contamination, pre-chlorination treatment is advised.

Because of the above-mentioned facts, Klong could be used as the source of water only after successful solution of two problems: removal of turbid substances by means of coagulation, sedimentation and filtration; and complete by chlorination. Therefore, Klong water tested at any sites were found to be usable if it is treated properly.

(2) Inquiries concerning water turbidity

As stated above, Klong can be used as the source of water, but its turbidity is considerably high because Klong is closely related with people's daily activities. As the population increase and life pattern is more diversified, the turbidity of Klong water will probably worsen. As a result, there may be unknown harmful compounds in the water. Besides this, deoxygenation by organic compounds will become more prominent, bringing consumers to an anaerobic state. In that case, Klong water will no longer be usable and will become a serious environmental problem. According to the survey on the water of Chao Phya River which was conducted by the Ministry of Public Health in 1969, the water was found to be seriously contaminated, and no dissolved oxygen was found in the lower reaches beyond Thonburi Bridge. The Ministry's report emphasized that preventive measures must be put into practice immediately. The results of surveys carried out between 1965 and 1966 revealed that coliform bacteria in Klong water was $20 \times 10^3 \sim 140 \times 10^3/100$ ml.

It is not sure whether Klong water will remain usable in the future. Klong in suburban area, along which there are some living houses, is in better conditions than other Klong running through Bangkok, but prediction of water quality change and antipollution measures are indispensable for the procurement of water sources and maintenance of sanitary environment.

Since the latest survey was not intended to check water pollution, there are not enough data that can be utilized for elaborate studies. However, relations between water quality and pollution load can be analyzed on the basis of the results of BOD tests and on-spot investigation.

As far as pollution is concerned, all Klongs around Bangkok are in the same situation, and the data about one Klong can also be applied to others. The following are the results of DO and BOD analyses conducted in Klong Tawee Wattana of Amphur Nong Khaem. The BOD value of Klong in Amphur Lat Krabang was 2.0 ppm.

Without precise data about water flow, population, the number of livestock and pollution load unit, prediction must be made from a hypothetical angle. Suppose a 20-meter-wide and 2-meter-deep Klong is accompanied on its both banks by living houses, each being 20 meters wide and having an average population of six persons. In less congested areas, houses are separated from each other by more than 20 meters. Taking livestock into consideration, their virtual distance would be equivalent to about 20 meters. Pollution load unit is 13 g/capita-day in terms of night soil, and BOD load is set at 26 g/capita-day. Then, BOD load for Klong per one day can be described as 0.78 ppm in terms of density.

$(26 \times 6 \times 2) \div 400 = 0.78$

The area between A spot and D spot of Klong is divided into six blocks. If the water in one block is replaced once per day (i.e. rate of flow 15 km $\div$ 6 = 2.5 km/d), C spot is in the fifth spot and D spot in the sixth. Decrease of BOD is generally described with the following linear reaction formula:

$$L = L_0 \cdot 10^{-K_1 t}$$

Here, L : BOD after t days

L_0: BOD of t = 0

K_1: deoxygenation constant

Precise deoxygenation constant must be obtained in scientific experiments, but hereby, the average value is set at 0.1 at 20°C.

With the following formula, K_1 value at 33°C is found to be 0.18.

$$K_{1-T} = K_{1-20} \, (1.047^{T-20})$$

$$= 0.1 \, (1.047^{33-20}) = 0.18$$

Since the load of population in the n-th block and the load of upper reaches are added to BOD in the n-th block, BOD at the edge of the n-th can be estimated from the following formula.

$$L_n = L(10^{-K_1} + 10^{-2K_1} + \ldots\ldots + 10^{-(n-1)K_1} + \ldots\ldots\ 10^{-n \cdot K_1})$$

Here, L : Pollution load (0.78 ppm/d)

Ln: BOD in the n-th block

n : Number of block

When L = 0.78 and K_1 = 0.18 are coordinated into the above formula, BOD at C spot and D spot are found to be 1.3 and 1.4 ppm respectively. As a matter of fact, population distribution is uneven, and it is particularly rough in the area between C spot and D spot. As there are many uncertain factors, the above estimated value is not much different from the real value, and it is assumed that the above data are representing the realistic situation. As seen in the above formula, Ln does not grow infinitely even if n is expanded to maximum, and therefore, Ln remains smaller than 2 ppm. In this respect, the estimated value of Ln can be obtained without establishing hypothetical block like above. A certain extent of water flow was recognized, and at least 2.5 km/d was considered. In still water areas, if total nitrogen constitutes 0.3 ppm, and total phosphorus over 0.015 ppm, an eutrophication phenomenon occurs, causing the development of plenty of algae. In Klong of Amphur Lat Krabang, total nitrogen was 6.3 mg/l and total phosphate 0.65 mg/l, largely exceeding the level of eutrophication. However, occurrence of algae was not observed. This means that the apparently stationary water of Klong is moving at a certain speed, and replacement of water was confirmed. According to the experiences in Japan, the maximum BOD value is set at 4 ppm, and then:

$$4 \text{ ppm} = L \times 1.787$$

$$\therefore L = 2.24 \doteqdot 2$$

Daily pollution load of 2 ppm in terms of density is permissible. If the pollution load unit is set at 26 g/capita-day, then the population corresponding to 2 ppm is 31 persons.

$$(26 \times x) \div 400 \text{ m}^3 = 2 \qquad \therefore x = 31$$

If the living pattern does not change and the pollution load unit remains the same,

$$31 \div 12 = 2.5$$

About 2.5 times or, for safety, 2 times can be said as the limit of population increase in the light of the protection of water sources or Klongs.

If BOD of Klong water becomes 4 ppm, BOD load in downstream is assumed at zero. With the length of time spent for dissolved oxygen to be reduced to the minimum and with the oxygen saturation level, the deficit amount is calculated as follows. In this case, oxygen deficit at a spot with 4 ppm of BOD is set at 3 ppm.

$$D = \frac{K_1 L}{K_2 - K_1}(10^{-K_1 t} - 10^{-K_2 t}) + D_a \cdot 10^{-K_2 t}$$

Here, D : Oxygen saturation deficit

K_1 : Deoxygenation const., 0.18

K_2 : Reaeration const., 0.12

Da : Oxygen saturation deficit at point of t = 0 (Say 3 ppm)

If $\frac{K_2}{K_1} = f$, and dissolved oxygen is reduced to the minimum, and if t is tc,

$$tc = \frac{1}{K_1(f-1)} \log f \left[1-(f-1)\frac{Da}{L}\right]$$

By inserting L = 4 into the above formula, it is found that $t_c = 1.3$ days. When t = 1.3, it is gained that D = 3.5 ppm. This calculation reveals that if BOD is limited to loss than 4 ppm and if there is no BOD load in downstream, the quality of water in lower reaches can be maintained on the same level as today.

To keep the BOD load limit at 4 ppm, population increase rate must be kept at below 2 times. However, the prosperity of Amphur naturally causes population increase, and when the living standard improves, pollution load rises further. Along with the diffusion of waterworks, effective measures for waste disposal must be established. Necessity is also keenly felt for elaborate pollution studies.

7.4 Underground water

Various types of researches have been conducted on underground water in and around the metropolitan Bangkok, and a considerable number of reports have been prepared. The "Ground Water Resources of the Bangkok Metropolitan Area" which was compiled by CDM in 1969 is highly evaluated as an epitome of a variety of documents produced in the past.

For the drafting of the new waterworks plan, researches should have been made on the subjects that were not taken up in the report. Due to excessive consumption of deep well water, infiltration of sea-water was recognized, and areas in such a situation were expanding toward the north.

At present, there are more than 1,000 deep wells in and around the metropolitan district, and a total of 600,000 m^3/d of deep well water is being taken up. According to a new plan, 200,000 m^3/d or more will be consumed in the future. Underground water is taken from aquifer, 85 to 200 meters deep, and most of it is from aquifer about 150 meters deep. In southern areas of the metropolis, sea-water infiltration into 150-meter-deep aquifer is confirmed, as shown in Fig. 7.3, but in northern areas, the infiltration is not observed.

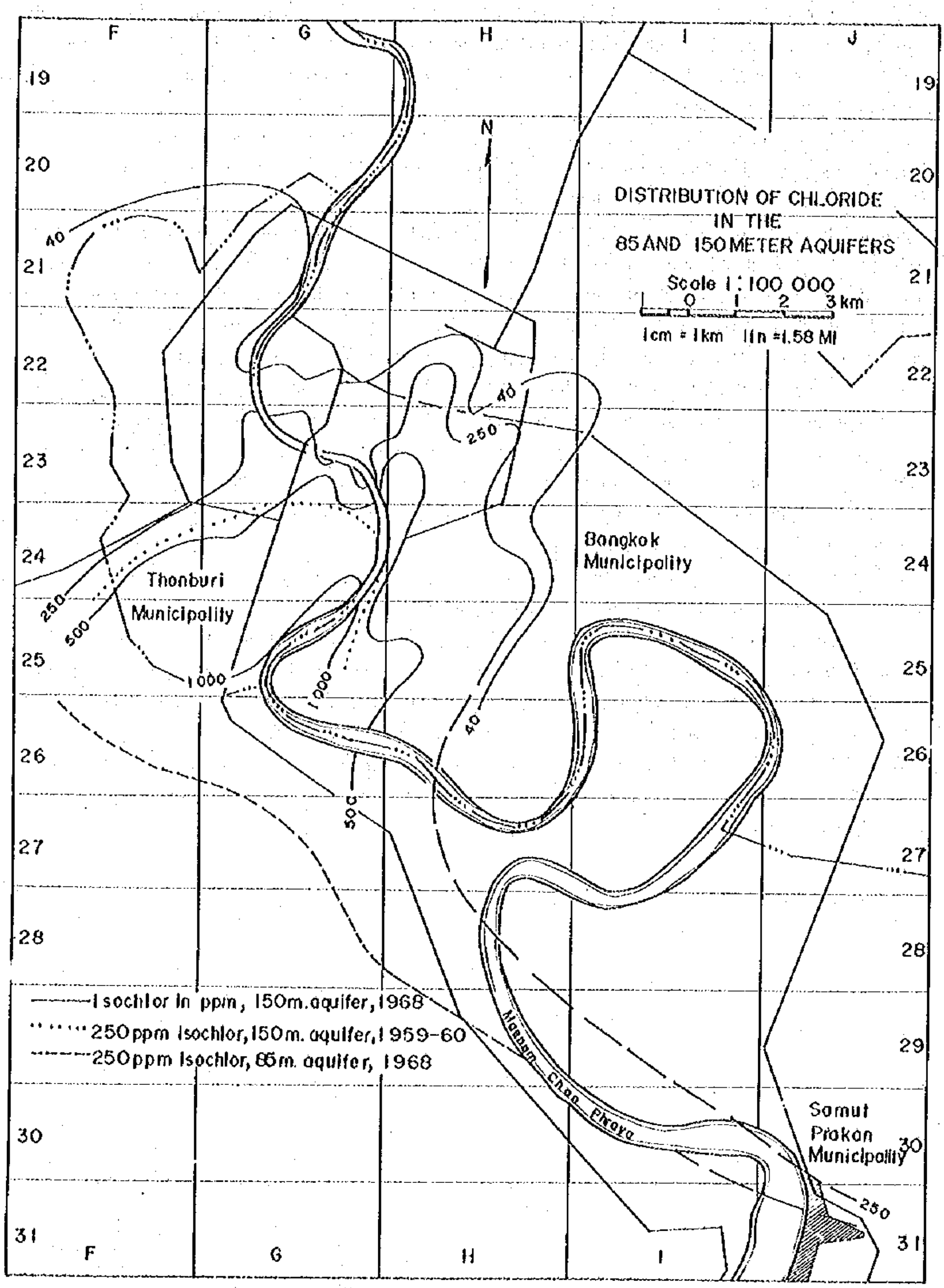
Generally, six aquifers exist to the depth of 200 meters. Rock layers seem to be more than 500 meters deep. Detention water tends to infiltrate up and down, if slowly, and water is not necessarily lifted from stable aquifer.

The 1,000 deep wells are scattered over an area of 450 km^2. If depth of aquifer is estimated at 10 m (if porosity is 20 per cent), the storage capacity must be about 9×10^8 m^3. The lifting volume of about 800,000 m^3/day (2.92×10^8 m^3/year) is too much larger than the storage capacity, and this may be considered as a main reason for the expansion of infiltration to the north.

In Amphur Sai Noi where water lifting continued until the year before last, deep wells became useless due to chloride pollution, apparently due to the excessive lifting of underground water.

To test the feasibility of using deep wells, MWWA dug an experimental well to the depth of 1,550 ft. in Amphur Nong Khaein, and as a result, Fig. 7.4 was produced. From the analysis of samples taken from five aquifers, it was found that a shallow aquifer and three other deeper ones were evidently affected by the infiltration of sea-water. Chloride ion accounting for 90 ppm was detected in aquifers between 1,550 and 1,565 ft. (Table 7.10~7.14). The content is lower than tolerate level of drinking water but does not allow long-time use of the water. For reference, the comments given by Thai Rock Products, Co. which tested the experimental well, are introduced in a separate sheet.

FIGURE - 7.3


DISTRIBUTION OF CHLORIDE IN THE 85 AND 150 METER AQUIFERS
Scale 1 : 100 000
1 0 1 2 3 km
1cm = 1km 1in =1.58 MI
N
F G H I J
19 20 21 22 23 24 25 26 27 28 29 30 31
Thonburi Municipality
Bangkok Municipality
Samut Prakan Municipality
Maenam Chao Phraya
40
250
500
1000
———Isochlor in ppm, 150m. aquifer, 1968
······250 ppm Isochlor, 150m. aquifer, 1959-60
-------250 ppm Isochlor, 85m. aquifer, 1968

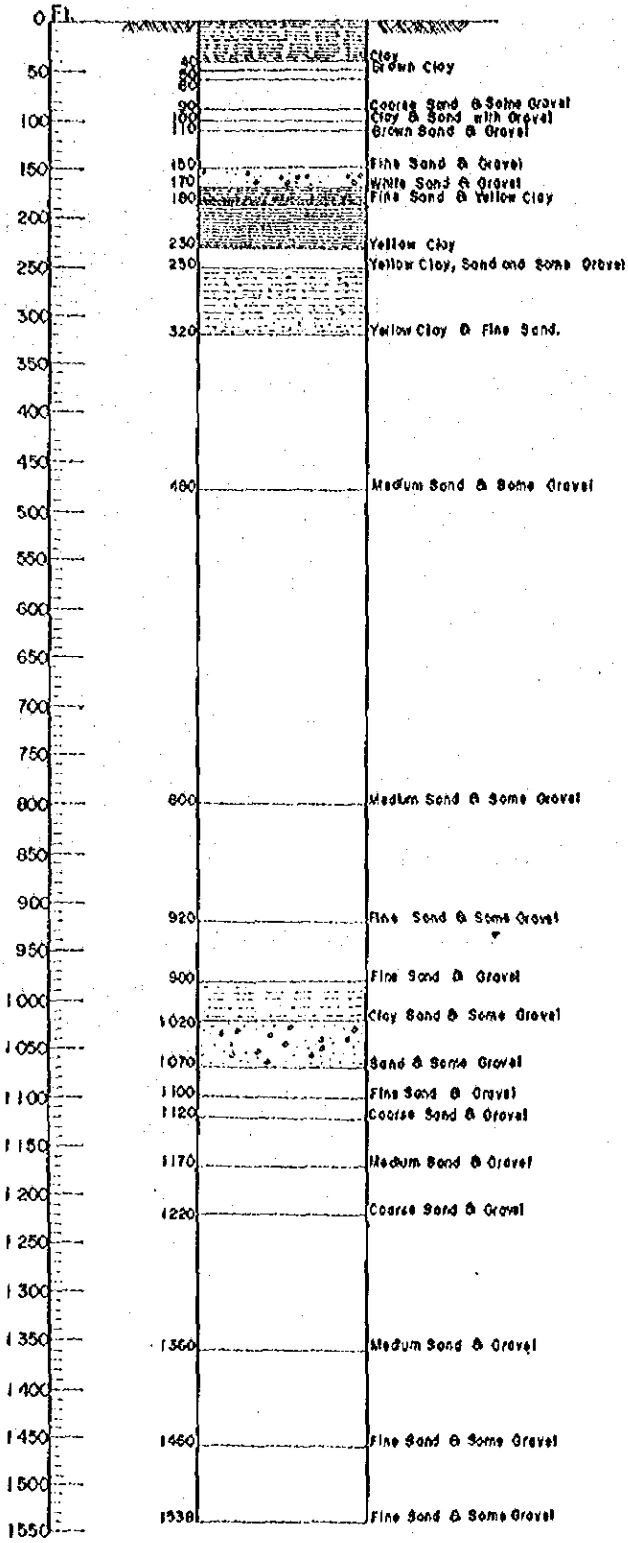


Fig-7.4: Test Well of Nong-Khaen

UR... Table-7.10

Our Ref. No. U4021 **21071**

DEPARTMENT OF SCIENCE
RAMA VI STREET, BANGKOK 4, THAILAND

4 October 1972

Thai Rock Products Co., Ltd.
25/12 Piboonsongkram Road
Bangkok 3

Sirs,

We beg to report on the samples of "Deep well water"
received on 27September1972 with letter / your request no. 6959, dated 27September1972

Yours truly,
Nidnai Suchaokul
(Mrs. Nidnai Suchaokatul)
Chief, Division of Chemistry
for Director-General.

REPORT

This report is valid for the received sample/s only and is not to be used for advertising purposes.

On "Deep well water"

Laboratory No. HB.33

HB.33	Collected from	H.W.W.4/Project, Nong-Khem, Thonburi, at 214-229 ft.depth	By the sender	Date	Time
	Collected from		By	Date	Time
	Collected from		By	Date	Time
	Collected from		By	Date	Time

Physical Examination:

		HB.33
Colour	in terms of Hazen units	less than 5
Odour		odourless
Taste		salty
Turbidity	in terms of Silica scale	10.2
pH value		7.7
Electrical conductivity at 20°C	micromhos/cm	8500

Chemical Examination: parts per million

Total solids	5720.0
Loss on ignition	32.0
Suspended solids	216.0
Dissolved solids	5512.0
Total hardness, expressed as calcium carbonate	1469.0
Temporary hardness, do.	142.0
Permanent hardness, do.	1327.0
Residual alkalinity, do.	nil
Chlorides, expressed as chlorine	2735.0
Chlorides, expressed as sodium chloride	4500.9
Oxygen consumed, determined at 100°C for 10 minutes	–
Saline ammonia, expressed as ammonia	0.930
Albuminoid ammonia, expressed as ammonia	0.076
Nitrates, expressed as nitrogen	0.008
Nitrites, expressed as nitrogen	0.140
Iron	0.30
Lead	–
Arsenic	–

หมายเหตุ..................
หนังสือนำส่งเลขที่..................

DEPARTMENT OF SCIENCE
RAMA VI ROAD, BANGKOK 4, THAILAND

[illegible]

This sample does not conform to the standard for drinking water because

1. Total solids exceed 1000 p.p.m.
2. Total hardness, expressed as $CaCO_3$ exceeds 200 "
3. Chlorides, expressed as NaCl exceed 350 "
4. Turbidity exceeds 5 (turbidity units)

Udom Sukkhum

(Mr. Udom Sukkhum)

Senior Technical Officer

Table-7.11

21070

DEPARTMENT OF [illegible]
BANGKOK, [illegible]

4 October 1972

Thai Rock Products Co., Ltd.
25/12 Piboonsongkram Road
Bangkok 5.

Sir/s,

We beg to report on the samples of "Deep well water"
received on 27 September 1972 with letter / your request no. 6955, dated 27 September 1972

Yours truly,

Nidnoi Sucharitakul
(Mrs. Nidnoi Sucharitakul)
Chief, Division of Chemistry
for Director-General.

REPORT

This report is valid for the received sample/s only and is not to be used for advertising purposes.

On "Deep well water"

Laboratory No. ND.32

ND.32	Collected from H.W.W.4/Project, Nong-Khaem, Thonburi at 325-340 ft.depth	By the sender	Date	Time
	Collected from	By	Date	Time
	Collected from	By	Date	Time
	Collected from	By	Date	Time

Physical Examination:

	ND.32
Colour ... in terms of Hazen units	less than 5
Odour	odourless
Taste	salty
Turbidity ... in terms of Silica scale	47.0
pH value	7.7
Electrical conductivity at 20°C, micromhos/cm	3000

Chemical Examination: parts per million

Total solids	2462.0
Loss on ignition	20.0
Suspended solids	122.0
Dissolved solids	2340.0
Total hardness, expressed as calcium carbonate	953.0
Temporary hardness, do.	161.0
Permanent hardness, do.	792.0
Residual alkalinity, do.	nil
Chlorides, expressed as chlorine	823.0
Chlorides, expressed as sodium chloride	1356.0
Oxygen consumed, determined at 100°C for 10 minutes	-
Saline ammonia, expressed as ammonia	0.371
Albuminoid ammonia, expressed as ammonia	0.116
Nitrates, expressed as nitrogen	0.016
Nitrites, expressed as nitrogen	nil
Iron	0.79
Lead	-
Arsenic	-

หมายเหตุ..................

หนังสือนำส่งเลขที่..................

DEPARTMENT OF SCIENCE
RAMA VI ROAD BANGKOK 4, THAILAND

No.32

This sample does not conform to the standard for drinking water because

1. Total solids exceed 1500 ppm.
2. Total hardness, expressed as $CaCO_3$ exceeds 500 ppm.
3. Chlorides, expressed as NaCl exceed 550 "
4. Iron exceeds 0.5 "
5. Turbidity exceeds 5 (turbidity units)

Udom Sukkhum

(Mr. Udom Sukkhum)
Senior Technical Officer

Table～7.12

Our Ref. No. 0802/ 21069

DEPARTMENT OF SCIENCE
RAMA VI STREET, BANGKOK 4, THAILAND

4 October 1978

Thai Rock Products Co., Ltd.
25/12 Piboonsongkram Road
Bangkok 8

Sir/s,

We beg to report on the samples of "Deep well water"
received on 27September1978 with letter / your request no. 6955, dated 27September1978

Yours truly,
Nidnoi Sucharitakul
(Mrs. Nidnoi Sucharitakul)
Chief, Division of Chemistry
for Director-General.

REPORT

This report is valid for the received sample/s only and is not to be used for advertising purposes.

On "Deep well water"

Laboratory No. HB.31-

HB.31	Collected from H.W.W.4/Project, Nong-Khem, Thonburi at 660-675 ft.depth	By the sender	Date	Time
	Collected from	By	Date	Time
	Collected from	By	Date	Time
	Collected from	By	Date	Time

Physical Examination:

	HB.31
Colour in terms of Hazen units	less than 5
Odour	odourless
Taste	salty
Turbidity in terms of Silica scale	89.5
pH value	7.4
Electrical conductivity at 20°C micromhos/cm	15000

Chemical Examination: parts per million

Total solids	11706.0
Loss on ignition	50.0
Suspended solids	298.0
Dissolved solids	11408.0
Total hardness, expressed as calcium carbonate	4395.0
Temporary hardness, do.	165.0
Permanent hardness, do.	4230.0
Residual alkalinity, do.	nil
Chlorides, expressed as chlorine	5580.0
Chlorides, expressed as sodium chloride	9200.8
Oxygen consumed, determined at 100°C for 10 minutes	-
Saline ammonia, expressed as ammonia	0.429
Albuminoid ammonia, expressed as ammonia	0.111
Nitrates, expressed as nitrogen	0.014
Nitrites, expressed as nitrogen	traces
Iron	0.05
Lead	-
Arsenic	-

[illegible]
[illegible]

DEPARTMENT OF SCIENCE
RAMA VI ROAD, BANGKOK 4, THAILAND

NB.II

This sample does not conform to the standard for drinking water because

1. Total solids exceed 1000 ppm.
2. Total hardness, expressed as $CaCO_3$ exceeds 500 ppm.
3. Chlorides expressed as NaCl exceed 350 "
4. Iron exceeds 0.5 "
5. Turbidity exceeds 5 (turbidity units)

Udom Sukkham
(Mr. Udom Sukkham)
Senior Technical Officer

URGENT Table-7.13

Our Ref. No. 0402/ 21068

DEPARTMENT OF SCIENCE
RAMA VI STREET, BANGKOK 4, THAILAND

4 October 1972

Thai Rock Products Co., Ltd.
25/12 Piboonsongkram Road
Bangkok 3

Sirs,

We beg to report on the samples of "Deep well water" received on 27 September 1972 with letter / your request no. 6955, dated 27 September 1972.

Yours truly,

(Mrs. [illegible])
Chief, Division of Chemistry
for Director-General.

REPORT

This report is valid for the received sample/s only and is not to be used for advertising purposes.

On "Deep well water"

Laboratory No. HB.30

HB.30	Collected from M.W.W. 4/Project, Nong-Khaem, Thonburi at 1004-1015 ft. depth	By the sender	Date -	Time -
	Collected from	By	Date	Time
	Collected from	By	Date	Time
	Collected from	By	Date	Time

Physical Examination:

	HB.30
Colour in terms of Hazen units	Less than 5
Odour	Odourless
Taste	Salty
Turbidity in terms of Silica scale	35.0
pH value	7.4
Electrical conductivity at 20°C, micromhos/cm	30,000

Chemical Examination: parts per million

	HB.30
Total solids	19,450.0
Loss on ignition	64.0
Suspended solids	1,170.0
Dissolved solids	18,280.0
Total hardness, expressed as calcium carbonate	7,300.0
Temporary hardness, do.	160.0
Permanent hardness, do.	7,140.0
Residual alkalinity, do.	nil
Chlorides, expressed as chlorine	11,030.0
Chlorides, expressed as sodium chloride	18,184.5
Oxygen consumed, determined at 100°C for 30 minutes	-
Saline ammonia, expressed as ammonia	0.562
Albuminoid ammonia, expressed as ammonia	0.020
Nitrates, expressed as nitrogen	0.006
Nitrites, expressed as nitrogen	nil
Iron	0.85
Lead	-
Arsenic	-

[illegible]
[illegible]

DEPARTMENT OF SCIENCE
RAMA VI ROAD, BANGKOK 4, THAILAND.

III.30

This sample does not conform to the standard for drinking water because:-

1. Total solids exceed 1000 ppm.
2. Total hardness, expressed as $CaCO_3$ exceeds 300 ppm.
3. Chlorides, expressed as NaCl exceed 550 "
4. Iron exceeds 0.5 "
5. Turbidity exceeds 5 (turbidity units)

Udom Sukkham

(Mr. Udom Sukkham)

Senior Technical Officer

URGENT Table ~ 7.14

Our Ref. No. 04021 21067

DEPARTMENT OF SCIENCE
RAMA VI STREET, BANGKOK 4, THAILAND

4 October 1972

Thai Rock Products Co., Ltd.,
25/12 Piboonsongkram Road
Bangkok 3

Sirs,

We beg to report on the samples of "Deep well water"
received on 27 September 1972 with letter / your request no. 6955, dated 27 September 1972.

Yours truly,

Nitaya Sucharitakul
(Mrs. Nitaya Sucharitakul)
Chief, Division of Chemistry
for Director-General.

REPORT

This report is valid for the received sample/s only and is not to be used for advertising purposes.

On "Deep well water"

Laboratory No. NB.29

NB.29	Collected from	N.W.W. 4/Project, Nong-Kham, Thonburi, at 1550-1565 ft. depth	By the sender	Date -	Time -
	Collected from		By	Date	Time
	Collected from		By	Date	Time
	Collected from		By	Date	Time

Physical Examination:

	NB.29
Colour in terms of Hazen units	Less than 5
Odour	Odourless
Taste	Normal
Turbidity in terms of Silica scale	84.0
pH value	8.0
Electrical conductivity at 20°C, Micromhos/cm	600

Chemical Examination: parts per million

Total solids	548.0
Loss on ignition	26.0
Suspended solids	114.0
Dissolved solids	436.0
Total hardness, expressed as calcium carbonate	153.0
Temporary hardness, do.	153.0
Permanent hardness, do.	nil
Residual alkalinity, do.	56.0
Chlorides, expressed as chlorine	55.0
Chlorides, expressed as sodium chloride	90.7
Oxygen consumed, determined at 100°C for 10 minutes	-
Saline ammonia, expressed as ammonia	0.054
Albuminoid ammonia, expressed as ammonia	0.022
Nitrates, expressed as nitrogen	0.003
Nitrites, expressed as nitrogen	nil
Iron	0.66
Lead	-
Arsenic	-

[illegible]
[illegible]

DEPARTMENT OF SCIENCE
RAMA VI ROAD, BANGKOK 4, THAILAND

[illegible]

This sample does not conform to the standard for drinking water because

1. Iron exceeds 0.5 ppm.
2. Turbidity exceeds 5 (turbidity units)

(Mr. Udom Sukkhum)

Senior Technical Officer

THAI ROCK PRODUCTS COMPANY LTD.

A' ROC'AYE: BIRD & SONS, INC., OAKLAND, CALIFORNIA
OFFICE & PLANT: 28/18 PIBUL SONGKRAM ROAD, AMPUR DUSIT, BANGKOK.

October 6, 1972

Research Division
Metropolitan Water Works Authority
Bangkok

Attn: Khun Chuanpit,

Comments on Water Analyses

We have now received the analyses from the Department of Science of the water samples obtained from the test well at Nong Kham.

These are generally disappointing except for the test taken on the deepest aquifer. This formation appeared unimpressive on the electric log but has in fact yielded water almost of drinking quality. The two undesirable elements are high turbidity and iron content but I suspect that these would be much lower if the water had been produced from the same formation in a production well. Water samples taken by the air lift method generally have a higher turbidity than normal and high iron content is relatively cheap to threat. This formation does not show a high porosity on the electric log or much thickness, however, a number of smaller sands in the same vicinity appear as if they may be inter-connected. These sands may give a reasonable supply of water as the formation pressure is quite high. (static water level measured after water sampling was 20'9"). No reliable predictions can be made regarding the specific capacity of this formation on the basis of the airlift test. However, it was observed that the formation began to pump easily and pumped at the maximum at which the 2 1/2" x 3/4" airlift is efficiently capable, approximately 30 gallons per minute.

I feel that consideration should be given to constructing a small diameter test production well (8" or 6") to produce from these sands below 1500 feet to determine aquifer characteristics in a controlled pumping test.

Yours sincerely,

L. R. Bird
Supervisor
Water Systems Div.

Report on Drilling and Testing of Metropolitan Water Works Authority Test Well at Nongkham

Drilling was commenced on June 21, 1972 with a direct circulation Winterweiss "Portadrill" Model 522. 50 feet of 10" surface conductor pipe was cemented in before drilling continued with a 7 5/8" bit. Drilling progressed without incident to a depth of 980 feet when a cone was lost off the rock bit which stuck the pipe in the hole. This was successfully fished from the hole and drilling continued to a depth of a 1,538 feet. The pipe again became stuck at this depth and while attempting to pull this free, the drill stem parted at a depth of 110 feet below ground level.

The rig was then moved over 820 feet and a new hole commenced. While drilling this hole some trouble was experienced with the surface clays caving causing ground subsidence but this was remedied by running 120 feet of 8" surface casing in the hole. Drilling was then continued to a total depth of 1,590 feet. The pipes were then removed from the hole and electric and gamma ray logs run in the well. From these logs, five zones of potential interest were selected for testing. The intervals tested were 214-229', 325-340', 660-675;1,000-1,015; 1,550-1,565'.

Testing was carried out by backfilling to just below the interval to be tested with dust stone and then placing a clay seal on top this. The 2 7/8" tubing used for testing was then run in the hole with 15 feet of performations set at the zone to be tested, the annular space between the slotted pipe and the hole was then filled with gravel. A clay and dust stone seal was then placed on top of the gravel pack to prevent water being drawn from aquifers higher up in the hole. An airlift pump was then placed in the tubing which pumped water which flowed from the formation in the immediate vicinity of the slotted pipe. It was observed that all formations tested in this well flowed freely without the need of any stimulation or development. Water produced during the test was pumped till it was clean and clear before a sample was taken, the average pumping time being 6 hours. After the sample had been taken and the pump stopped, the water level was allowed to recover inside the tubing for not less than 6 hours before a measurement was made of the static water level. After this the tubing was pulled out and the hole backfilled to the next higher interval to be tested and then the same procedure followed.

When all testing was completed, the hole was backfilled to surface and the site restored to its original condition.

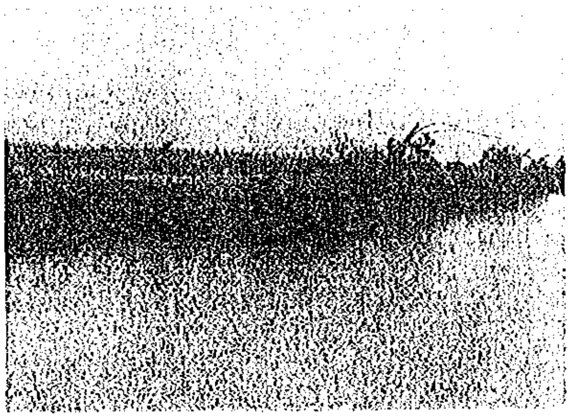
P. R. Bird

Chapter 8 Comparative study

8.1 Basic concept of comprehensive waterworks plan for raw water supply

The use of underground water in big municipalities was possible in the initial stage, but the situation usually worsens gradually. This trend is particularly notable in the metropolitan Bangkok district. Underground water consumption will most probably be restricted severely in the near future when the problems of sea-water infiltration and sinking of the ground come to the fore.

On the other hand, there are growing doubts on the permanent use of Klong water which is also being affected by the pollution. At a time when the use of underground water and Klong water is given up in the future, we will have to depend upon large rivers as the source of water supply. This is similar to the situation for the Central System which must rely on Chao Phya River. Because of the fact that the metropolitan Bangkok is



Intake Spot at Klong Wattana

fast expanding to become Greater Bangkok, it would be advisable to find water sources in Chao Phya River and Nakorn Chai Si River. If so, the water of Nakorn Chai Si River is supplied to the right bank of Chao Phya River, and the water of Chao Phya River to areas on the left bank.

If water sources are found in distant areas, the water supply plan must be a comprehensive one. If indications are that by the time the comprehensive water supply plan materializes, water supply facilities may be constructed in each Amphur. For this reason, it would be reasonable if the comprehensive water supply facilities are designed for the supply of raw water.

(1) Raw water supply comprehensive system on the right bank of Chao Phya River

To-be-served areas on the right bank of Chao Phya River are Amphurs Nong Khaem, Bang Yai, Bang Bua Thong and Sai Noi, and Chao Phya River and Nakorn Chai Si River are regarded as the water source. In view of the fact that the Central System depends on Chao Phya River and the comprehensive water supply facilities on the left bank of Chao Phya River are operated with the water of Chao Phya River, the comprehensive waterworks on the right bank of Chao Phya must rely on Nakorn Chai Si River.

As stated above, Nakorn Chai Si River is a tidal river, and therefore, the position of the water source must be located more than 80 km from the estuary. Water must be sent to each Amphur by utilizing roads (including planned roads) as much as possible. Most of the areas to be served are flat, and therefore, reasonable values must be produced by making a comperative designing in accordance with the relations between the lift of driving pumps and friction of pipes. In the comparative designing, analyses were made on construction and maintenance costs, and the following figures were found to be most feasible:

Daily max. demand

Nong Khaem	40,000 m³/day
Bang Bua Thong	5,200 m³/day
Bang Yai	1,500 m³/day
Sai Noi	1,500 m³/day
Total	51,100 m³/day

Raw water demand	60,000 m³/day
Water source facilities	Omitted
Pumping facilities	Omitted
Raw water pumps	φ350X13.9m³/min.X44mX141KWX4 Units
Booster pumps	φ200X3.19m³/min.X41mX35KWX 4 Units
Booster pumps	φ200X2.84m³/min.X48mX34KWX3 Units
Booster pumps	φ150X1.31m³/min.X71mX27KWX2 Units

Raw water main

Ductile cast iron pipes	φ800mm	ℓ = 13,200m
Ductile cast iron pipes	φ450mm	ℓ = 12,200m
Ductile cast iron pipes	φ350mm	ℓ = 9,400m
Ductile cast iron pipes	φ200mm	ℓ = 14,600m

Estimation of construction cost

Pipe material	52,330,000฿
Earthworks	2,010,000฿
Pipe-laying	550,000฿
Pumps	1,450,000฿ (including pump-house)
Total	56,340,000฿

Data of water source, land to be used, aqueduct and inverted siphon are excluded.

(2) Raw water supply comprehensive plan on the left bank of Chao QPhya River

Areas to be served on the left bank of Chao Phya River are five Amphurs of Lat Krabang, Min Buri, Bang Bo, Bang Phli and Nong Chok. Chao Phya River is the only river conceivable as the water source. The problem is whether water is taken from the main stream of Chao Phya River or from Klong Phrapa (a conveyance duct for the Central System which is divided from Chao Phya River).

Klong Phrapa is in a convenient geographical position for the supply of water to the left bank of Chao Phya River, but its water intake capacity must be checked beforehand. However, there is no doubt on the capacity because only 30,000 m³/d of water is supplied to the left bank of Chao Phya River '

Chloride content is not a troublesome problem for the intake of water from Klong Phrapa. The only thing that must be done is to designate the point of water intake so that pipes can be properly installed under the roads.

Daily max. demand	
Lat Krabang	7,500 m^3/day
Min Buri	7,300 m^3/day
Bang Bo	2,500 m^3/day
Bang Phli	3,800 m^3/day
Nong Chok	4,500 m^3/day
Total	25,600 m^3/day
Raw water demand	30,000m^3/day
Water source facilities	Omitted
Pumping facilities	
Raw water pumps	ϕ250X7.2m^3/min.X91mX164KWX4 Units
Booster pumps	ϕ250X5.1m^3/min.X84mX107KWX4 Units
Booster pumps	ϕ150X2.6m^3/min.X41mX29KWX3 Units
Booster pumps	ϕ100X1.1m^3/min.X64mX21KWX3 Units

Raw water main

Ductile cast iron pipes	ϕ600mm	ℓ=22,500m
Ductile cast iron pipes	ϕ450mm	ℓ=10,400m
Ductile cast iron pipes	ϕ350mm	ℓ=19,200m
Ductile cast iron pipes	ϕ300mm	ℓ=14,900m
Ductile cast iron pipes	ϕ250mm	ℓ=14,600m

Estimation of construction cost

Pipe material	66,760,000฿	
Earthwork	3,020,000฿	
Pipe-laying	700,000฿	
pumps	1,950,000฿	(Including pump-house)
Total	72,430,000฿	

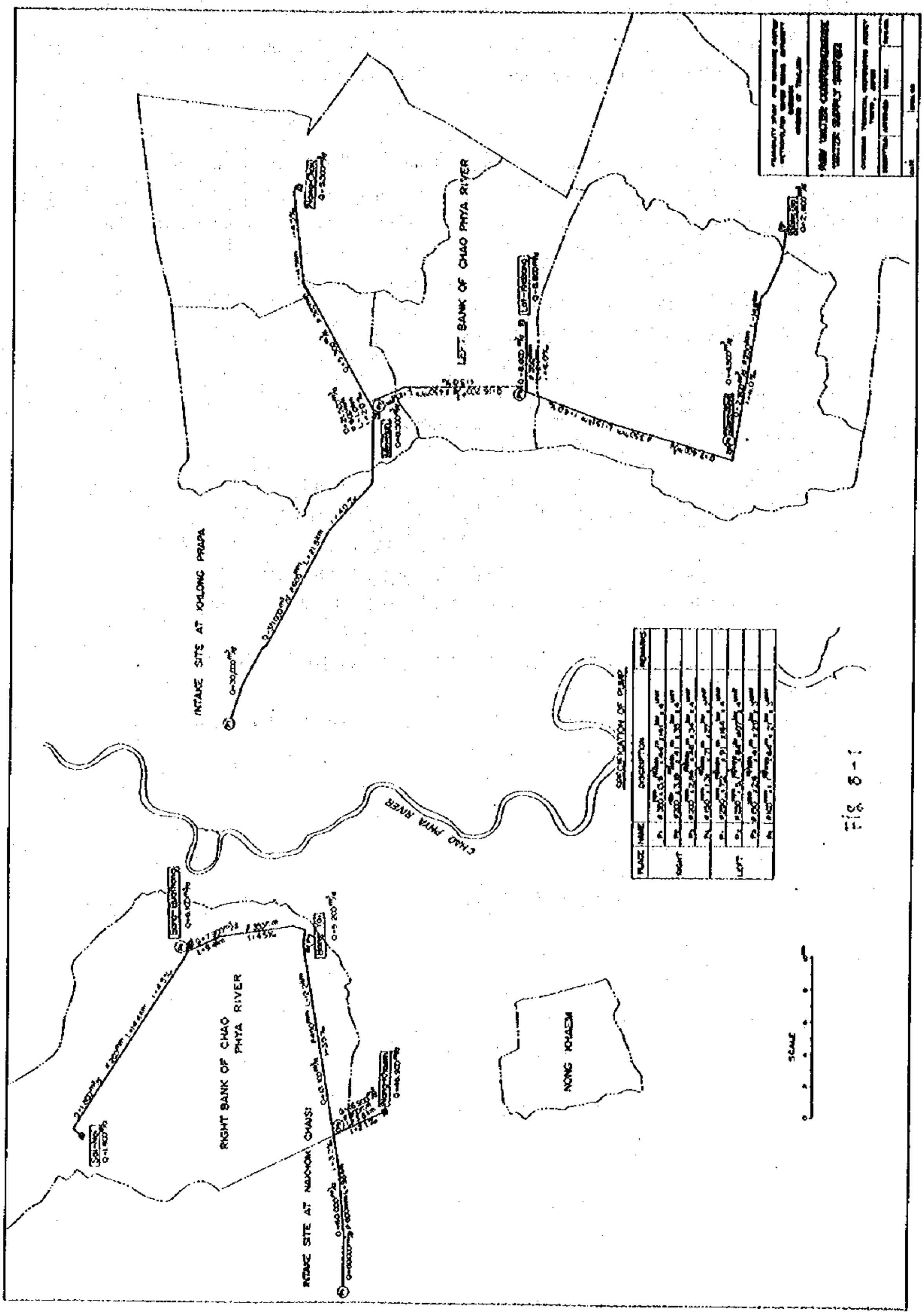

INTAKE SITES AT KHLONG PRAPA
LEFT BANK OF CHAO PHYA RIVER
RIGHT BANK OF CHAO PHYA RIVER
INTAKE SITE AT NAKHON CHAISI
CHAO PHYA RIVER
NONG KHAEM
SPECIFICATION OF PUMP
SCALE

Fig 8-1

8.2 Amphur Nong Khaem

For the construction of independent facilities for Amphur Nong Khaem, the following three types of waterworks can be considered besides the raw water supply comprehensive plan.

(1) Intake from Klong Wattana

To take water from Klong Wattana, it is the most suitable, for reasons stated in Chapter 7, to find the water source at a point where a railway line and Klong Wattana intersect. After the intake process, the water is purified. The purified water is then sent to a service reservoir to be built in the central part of Amphur Nong Khaem and is distributed with service pumps.

Daily maximum supply	40,000 m^3/day
Hourly maximum supply	60,000 m^3/day
Raw water demand	44,000 m^3/day
Water source system	
Raw water pumps	7.63m^3/min.X15mX30KWX5 Units
Water purification system	
Receiving well	3.5m(W) X 8m(L) X 2.5m X 1 basin
Chemical coagulation basin	2.3m(W) X 2.3m(L) X 2.65m(H) X 4 basins
	Vorti – Mixer ~ 4 Units
Flocculation basin	9.35m(W) X 5.6m(L) X 2.65m(H) X 8 basins
Chemical sedimentation basin	9.35m(W) X 24m(L) X 3.3m(H) X 8 basins
Rapid sand filter	12m^2 X32 basins
Clear water reservoir	16m(W) X 28m(L) X 4m(H) X 1 basin
Water transmission system	
Water transmission pumps	ϕ250X6.95m^3/min.X55mX95KWX5 Units
Water transmission pipes	
Ductile cast iron pipes	ϕ700X12km
Distribution system	
Water distribution pumps	
ϕ200X5.21m^3/min.X75KWX2 Units	
ϕ300X10.41m^3/min.X150KWX3 Units	
Service reservoir	
40m(W) X 40m(L) X 3.5m(H) X2 basins	
Distribution pipes	
Ductile cast iron pipes	ϕ700X850m
Ductile cast iron pipes	ϕ600X1,450m
Ductile cast iron pipes	ϕ500X3,000m
Ductile cast iron pipes	ϕ350X3,600m
Asbestos cement pipes	ϕ300X3,600m
Asbestos cement pipes	ϕ250X7,100m
Asbestos cement pipes	ϕ200X7,900m
Asbestos cement pipes	ϕ150X11,750m
Asbestos cement pipes	ϕ100X6,750m
Construction cost	
Total construction cost	197,243,000฿

(2) Water is taken from Nakorn Chai Si River and sent to the purification plant stated in (1)

In case Klong Wattana is found useless due to pollution, Nakorn Chai Si River can be considered as the source of surface water. For this purpose, the comprehensive water supply facilities may be better than independent facilities for Amphur Nong Khaem. However, the latter is analyzed below, because, as explained in 8.1, a large construction for raw water pipes is required in the case of the comprehensive supply plan.

Raw water pumps	ϕ300mmX9.27m³/min.X27mX68KWX4 units	
Raw water main		
Ductile cast iron pipes	ϕ700mm	ℓ12,200m

Estimation of construction cost

Raw water pumps	250,000₿
Pipe material	15,140,000₿
Pipe-laying	5,330,000₿
Total	20,720,000₿

Therefore, the additional cost as above is needed.

(3) Inclusion of Amphurs Bang Bua Thong, Bang Yai and Sai Noi in the regional supply system

The supply of purified water from the regional waterworks of Bang Bua Thong, Bang Yai and Sai Noi (water source: Klong Om) to Amphur Nong Khaem is not inconceivable, but it is a very uneconomical type of waterworks.

Construction cost

Water source system	2,288,000₿
Purification system	86,840,000₿
Water transmission system	92,511,000₿
Control system	33,280,000₿
Distribution system	79,494,000₿
Others	55,938,000₿
Total	350,351,000₿

8.3 Amphur Lat Krabang

Types of waterworks conceivable in addition to the comprehensive plan are the intake from Klong Phra Khanong and the use of well water. There are some Klongs with better-quality water east of Amphur Lat Krabang, but its absolute value of pollution is about the same as in other Klongs. Therefore, Klong Phra Khanong which is nearer from Amphur Lat Krabang can be chosen as the most suitable source of water.

As explained in 8.1, the lifting amount of underground water is limited, but there is no need of finding new water sources because existing wells have the capacity of 3,500 m³/d and the ratio of chloride ion is still endurable. Meanwhile, the lifting amount of underground water is decreasing gradually and some restrictive measures are expected in the future. In this respect, it is impossible to heavily depend upon underground water. When the capacity of existing wells falls below the demand level, the surface water of Kong Phra Khanong will have to be utilized. In 10 years when the second-stage expansion work is needed, the use of underground water will be suspended and waterworks for surface water will be expanded.

In designating Kong Phra Khanong and existing wells as water sources, the regional supply plan covering the neighboring Amphur of Min Buri and Bang Phli will not be taken into consideration as such a plan is technically unreasonable.

Raw water system	
Raw water pumps	ϕ125X1.91m^3/min.X15mX7.5KWX4 Units
Purification system	
Receiving well	1.5m(W) X 3.5m(L) X 2.5m(H) X 1 basin
Chemical coagulation basin	1.3m(W) X 1.3m(L) X 2.2m(H) X 3 basins
Flocculation basin	4.0m(W) X 4.0m(L) X 2.2m(H) X 6 basins
Chemical sedimentation basin	4.0m(W) X 15.0m(L) X 3.5m(H) X 6 basins
Rapid sand filter	3m^2 X 24 basins
Distribution system	
Service reservoir	10m(W) X 18m(L) X 3.5m(H) X 3 basins
Distribution pumps	ϕ100X1.0m^3/min.X50mX15KWX2 Units ϕ150X2.3m^3/min.X50mX37KWX4 Units
Distribution pipes	
Ductile cast iron pipes	400mmX4,000m
Ductile case iron pipes	350mmX2,500m
Asbestos cement pipes	300mmX1,200m
Asbestos cement pipes	250mmX5,950m
Asbestos cement pipes	200mmX9,200m
Asbestos cement pipes	150mmX9,450m
Asbestos cement pipes	100mmX8,600m
Construction cost	53,913,000฿

8.4 Amphur Bang Bua Thong

An independent supply plan for Amphur Bang Bua Thong can be established because the area has the surface water supply capacity of 2,000^3/d. This is possible only if regional plans are set up for the neighboring Sai Noi and Bang Yai districts. Only the use of surface water is analyzed here because feasibility of using underground water has not been confirmed yet.

Daily maximum supply	5,200m^3/day
Hourly maximum supply	7,800m^3/day
Raw water demand	5,720m^3/day
Raw water system	
Raw water pumps	1.4m^3/min.X4 Units
Raw water main	
Raw water pipes	ϕ300X20m
Purification system	
Chemical coagulation, sedimentation and filtration method	
Distribution system	
Distribution pumps	1.0m^3/min.X3 Units
Distribution pumps	1.7m^3/min.X3 Units
Distribution pipes	
Asbestos cement pipes	ϕ300X750m
Asbestos cement pipes	ϕ250X500m
Asbestos cement pipes	ϕ200X10,250m
Asbestos cement pipes	ϕ150X23,950m
Asbestos cement pipes	ϕ100X14,350m

Construction cost

Raw water system	714,000฿
Purification system	19,375,000฿
Control system	4,810,000฿
Distribution system	11,021,000฿
Others	7,254,000฿
Total	43,174,000฿

8.5 Amphur Bang Yai

For the planning of independent supply facilities for Amphur Bang Yai, wells and Klong Maenam Om are the possible sources of water supply. Underground water is being taken from a few number of wells which exist in this district. The feasibility of using underground water must be re-examined if the entire Bang Yai district is to be served. For this purpose, a well is installed so that it is used for emergency works, and after the first-stage work, efforts will be concentrated on the construction of facilities for surface water.

Daily maximum supply	4,400m^3/day
Hourly maximum supply	6,600m^3/day
Raw water demand	4,840m^3/day
Raw water system	
Raw water pumps	1.68 m^3/min.X3 Units
Raw water system	
Raw water pipes	ϕ250X20m
Clean water system	
Chemical coagulation, sedimentation and filtration method	
Distribution system	
Distribution pumps	1.15m^3/min.X3 Units
Distribution pumps	2.29m^3/min.X2 Units
Distribution pipes	
Asbestos cement pipes	ϕ300X4,050m
Asbestos cement pipes	ϕ250X3,300m
Asbestos cement pipes	ϕ200X4,100m
Asbestos cement pipes	ϕ150X7,200m
Asbestos cement pipes	ϕ100X7,100m
Construction cost	
Raw water system	543,000฿
Purification system	15,431,000฿
Control system	4,092,000฿
Distribution system	8,730,000฿
Others	6,632,000฿
Total	35,428,000฿

8.6 Amphur Sai Noi

An independent supply plan is very difficult to materialize here because wells in this districts were once damaged seriously by chloride. About the feasibility of using underground water, experiments have been repeated by using a test well. The analyses here mainly concern the plan about surface water from Klong Phra Phimon.

Daily maximum supply	1,500m³/day	
Hourly maximum supply	2,250m³/day	
Raw water demand	1,650m³/day	
Raw water pumps	0.557m³/min.X3 Units	
Raw water main	Asbestos cement pipe	φ200X20m
Purification system	Chemical coagulation, sedimentation and filtration method	
Distribution system	Distribution pumps	0.56m³/min.X2 Units
	Distribution pumps	1.00m³/min.X2 Units
	Distribution pipes	
	Asbestos cement pipes	φ150X6,250m
	Asbestos cement pipes	φ100X7,550m

Construction cost

Raw water system	526,000฿
Purification system	12,877,000฿
Control system	1,425,000฿
Distribution system	3,210,000฿
Others	3,427,000฿
Total	21,465,000฿

8.7 Amphurs Bang Bua Thong, Bang Yai and Sai Noi regional waterworks plan

Due to the salinity of underground water and from the standpoint of effective maintenance, a regional planning seems to be more desirable than separate supply plans for these three districts. A weak point of the regional plan is that distribution pipes must be installed even in aparsely populated areas.

Daily maximum supply	12,000m³/day
Hourly maximum supply	18,000m³/day
Raw water demand	13,200m³/day

(1) Plan of construction a purification plant in Amphur Bang Bua Thong by taking water from Klong Maenam Om (part of the existing purification plant is remodeled).

Raw water system

Raw water pumps φ200X3.06m³/min.X25mX22KWX4 Units

Raw water main

Ductile cast iron pipes φ500X4.7km

Purification system

Receiving well	2.8m(W) X 6.0m(L) X 2.5m(H) X 1 basin
Chemical coagulation basin	1.5m(W) X 1.5m(L) X 2.5m(H) X 3 basins
Flocculation basin	4.7m(W) X 3.6m(L) X 2.5m(H) X 6 basins
Chemical sedimentation basin	4.7m(W) X 18m(L) X 3.5m(H) X 6 basins
Rapid sand filter	4.8m² X32 basins

Distribution system

Service reservoir	1.5m(W) X 20m(L) X 3.5m(H) X 3 basins
Distribution pumps	1.6m³/min.X2 Units
Distribution pumps	3.7m³/min.X4 Units

Distribution pipes	Ductile cast iron pipes	φ350X5,450m
	Asbestos cement pipes	φ300X4,550m
	Asbestos cement pipes	φ250X8,700m
	Asbestos cement pipes	φ200X25,200m
	Asbestos cement pipes	φ150X26,550m
	Asbestos cement pipes	φ100X18,850m

Construction cost	Water source system	7,852,000฿
	Purification system	22,502,000฿
	Control system	10,532,000฿
	Distribution system	33,918,000฿
	Others	15,804,000฿
	Total	90,608,000฿

(2) Plan of constructing a purification plant in Bang Yai with water taken from Klong Maenam Om

Raw water system	Same as (1)	
Raw water main	Ductile cast iron pipes	φ500X50m
Purification system	Same as (1)	
Distribution system		
Service reservoir	Same as (1)	
Distribution pumps	Same as (1)	
Distribution pipes	Ductile cast iron pipes	φ400X4,700m
	Ductile cast iron pipes	φ350X750m
	Asbestos cement pipes	φ300X4,550m
	Asbestos cement pipes	φ250X8,700m
	Asbestos cement pipes	φ200X25,200m
	Asbestos cement pipes	φ150X26,550m
	Asbestos cement pipes	φ100X18,850m

Construction cost	Water source system	1,166,000฿
	Purification system	32,775,000฿
	Control system	10,532,000฿
	Distribution system	34,848,000฿
	Others	16,661,000฿
	Total	95,982,000฿

Chapter 9 Feasibility study

9.1 Selection of feasible plan

It is not an easy task to select the most reasonable plan, technically and economically, out of a large number of comparative designs that were explained in Chapter 8. Although the promotion of water supply projects is mentioned in the contents of the third five-year project, it is not possible to confirm right now that the prevention of water pollution and procurement of water sources are fully guaranteed.

So many problems remain unsettled that technically and economically feasible projects cannot be declared as practicable from the administrative point of view. However, it is possible to present a draft plan which may help establish a Master Plan for waterworks projects, although such appears to be too heavy a work for a developing country.

By so doing, it is necessary to realize the importance of various problems involving the water supply. Even practicable plans cannot materialize unless sufficient funds are prepared, and the necessity of receiving the national support is a grave problem for the Metropolitan Waterworks Authority which is pursuing the independent accounting principle.

Of the experimental plans explained in Chapter 8, the following are considered to be feasible technically and economically:

(1) Amphur Nong Khaem water supply plan with Klong Wattana as water source.

(2) Amphur Lat Krabang water supply plan with Klong Phra Khanong as water source.

(3) Amphurs Bang Bua Thong, Bang Yai and Sai Noi regional water supply plan with Klong Maenam Om as water source.

9.2 Feasible plan for Amphur Nong Khaem

9.2.1 Decision on various factors

Designing conditions:	Intake capacity	44,000 m^3/d
	Purification capacity	40,000 m^3/d
	Distribution capacity	60,000 m^3/d

Purification capacity:

This concerns facilities with the capacity of 40,000 m^3/d. The project can be divided into four terms, and purification of 10,000 m^3/d is scheduled for each stages.

9.2.2 Intake facilities

Water source:	Klong Wattana
Intake method:	Intake with pumps The capacity is 44,000 m^3/d, and the number of pumps will be increased during the period of expansion.
Target year:	Target year is 2000 A.D., and the period by that time is divided into four stages, and in each stage, facilities of 10,000 m^3/d will be constructed.

1) Intake

Collection of water : 44,000 m^3/d

Inflow velocity : 0.3 m/sec

Cross section of intake : 44,000 ÷ 86,400 ÷ 0.3 = 1.7 m^2

2) Raw water pumps : five units (one of them reserved)

Lift : 44,400 m^3/d ÷ 4 = 11,000 m^3/d per unit = 7.63 m^3/min per unit

Total head : 15m

Horse power of pump : P_s = 0.163 X 1 X 7.63 X 15 ÷ 0.7 = 26.65 kW

Diameter of pump : D = 146 $\sqrt{7.63/2.5}$ = 255, Say 250 mm

Specific speed : 525.2 rpm

Motor : P = 26.65 (1.+ 0.15)/1.0 = 30.6 kW

Double suction centrifugal pump : five units (one of them reserved)

3) Raw water main: ϕ700, ℓ = 50m, Ductile cast iron pipes

9.2.3 Purification system

1) Receiving well: Capacity, 2.5 min X $\frac{40,000\ m^3/d}{1,400\ min}$ = 69.4 m^3

then, W 3.5m X L 8.0m X H 2.5m X 1 basin

2) Chemical coagulator (Vortex Type)

Data ranging the first stage to the receiving well are decided on the basis of the capacity in 2000 A.D. After the receiving well, the plan is mapped out for expansion worked for four stages, setting the single stage capacity at 10,000 m^3/d.

Facilities of 10,000^3/d are constructed in the initial stage.

Detention & capacity: 2.0 minutes X $\frac{10,000\ m^3/d}{1,440\ min}$ = 13.9 m^3

then, W 2.3m X L 2.3m X H 2.65m X 1 basin

3) Flocculator

Like the chemical coagulator, the flocculator is of the mechanical type.

Detention & capacity: 40 minutes X $\frac{10,000\ m^3/d}{1,440\ min}$ = 278 m^3

If this is divided into two systems, the capacity per one system is 278m^3 ÷ 2 = 139m^2

Equipment: Paddle-type coagulator

4) Chemical sedimentation basin:

Capacity: 3.5 hours

Equipment: Link-belt type clarifier 3.5 hr X $\frac{10,000\ m^3/d}{24\ hr}$ = 1,458 m^3

If this is divided into two systems, the capacity per one system is 1,458 m^3 ÷ 2 = 729 m^3

then, W 9.35m X L 24m X H 3.3m X 2 basins

Taking weir loading into consideration, a water collection through is installed at the edge of the sedimentation basin.

5) Chemical dosing equipment

Chemicals used: alum, lime

Rational dosing rate: According to a jar-test, alum rate is 50~100 ppm, and lime 25~50 ppm

Dosing volume and pumps

Alum: 10,000 m^3/d X 100 ppm X $\frac{14}{8}$ X $\frac{1}{1.32}$ = 1.33 m^3/d, Say 55.4 ℓ/hr

Max. 56 ℓ/hr, two units (one is reserved)

Lime: Max. 28 ℓ/hr, two units (one is reserved)

Storage tank: alum 5 m^3 X 2 units

Solution tank: lime 3 m^3 X 2 units

6) Rapid sand filter:

Automatic back washing system is the base for the rapid sand filter. Adopted here is the green-leaf filter which has more excellent features than many other types.

Rate of filtration: 120 m/d

Area of filtration: 10,000 m^3/d ÷ 120 m/d = 83.3m^2, say 12 m^2 X 8 units

Surface washing pump: 12 m^2/unit X 0.2 m^3/min. = 2.4 m^3/min.

Head: 30 m

Power: 19 kW

ϕ150 X 30 m X 19KW X 1.450 rpm, two units (one is reserved)

7) Clear water basin

Detension: one hour, 40,000 m^3/d X $\frac{1}{24}$ = 1,666 m^3

Water depth: 4 m, then 1,666 m^3 ÷ 4 m = 417 m^2

8) Disinfection equipment

Chlorination is conducted with liquid chlorine, and pre-chlorination is made possible, if any.

40,000 m^3/d X 2 ppm X 10^{-6} X 10^3 X 1/24 = 3.3 ℓ/hr

9.2.4 Water transmission system

Water is sent out with a service pump pit directly connected to the purification basin and then pressed into the service reservoir with the service pumps. The pumps are interchangeable.

Transmission pumps: 40,000 m^3/d ÷ 4 stages = 10,000 m^3/d → 6.95 m^3/min.

Overall head:	Actual head	5.5 m
	Friction loss	48
	Others	1.5 m
	Total	55 m

Horse power of pump: P_s = 0.163 X 1 X 6.95 X 55 ÷ 0.75 = 83 kW

Diameter of pump ; D = 146 $\sqrt{6.95/2.5}$ = 250 mm

Transmission pipes: Ductile cast iron pipes, ϕ700, ℓ = 12 km

Specific speed: 189.5 rpm

Motor : P = 83 (1 + 0.1)/1 = 91.3 KW, say 95 KW

Type and number of transmission pumps

Stage	Unit	Flow
Emergency	1 (one reserved)	6.95 m^3/min
1st	1	ditto
2nd	1	ditto
3rd	1	ditto
Total	4 (one reserved)	

Receiving capacity of electricity:

Power-transmission lines of 115,000 V and 380 V run nearly, and thus the 115,000 V line is used as power source.

Stage	Main equipment	Capacity	Electricity consumed
Emergency program	Raw water pump	30KW X 2 = 60KW	30KW X 1 = 30KW
	Surface washing pump	19KW X 2 = 38KW	19KW X 1 = 19KW
	Transmission pump	95KW X 2 = 190KW	95KW X 1 = 95KW
	Auxiliary equipment, measuring and lighting equipment	30KW	30KW
	Sub-total	318KW	174KW
1st stage	Raw water pump	30KW X 1 = 30KW	30KW X 1 = 30KW
	Transmission pump	95KW X 1 = 95KW	95KW X 1 = 95KW
	Ausiliary equipment, measuring and lighting equipment	20KW	20KW
	Sub-total	145KW	145KW
Total		463KW	319KW

2nd: Same as 1st stage program

Sub-total	145 KW	145 KW
Grand total	608 KW	464 KW

3rd: Same as 2nd stage program

Sub-total	145 KW	145 KW
Total	753 KW	609 KW

According to this, power receiving plan is mapped out. In view of the loading situation, dividing into three would be most suitable. Emergency power source should be strong enough to handle emergency load.

Emergency: 250 KVA, 50 HZ, 3ϕ4c, 115,000/380

1st stage: ditto

2nd stage: ditto

Generator: 250 KVA, 380 V, 50 HZ, 3ϕ4c

Diesel engine: 350 Ps, 6 cylinders

9.2.5 Distribution system

The distribution system is designed to send water to the service reservoir installed in each Amphur and distribute it with pumps.

Lift: 40,000 m^3/d X 1.5 ÷ 4 stages = 15,000 m^3/d = 10,41 m^3/min

Overall head: 50 m

Pump plan:

Stage	Small capacity	Large capacity	Total
Emergency	2 (one reserved)		22,500 m^3/d
1st		1 (one reserved)	30,000
2nd		1	15,000
3rd		1	15,000
Total	2 (one reserved)	3 (one reserved)	82,500

Small capacity pump:

Lift: 5.21 m^3/min

Overall head: 50 m

Diameter: $D = 146\sqrt{5.21 / 2.5} = 210$ mm

Horse power: $P_s = 0.163 \times 5.21 \times 50 \div 0.7 = 60.65$ KW

Motor: $P = 60.65 (1 + 0.1) / 1.0 = 66.7$ KW, say 75 KW

Large capacity pump: ϕ300 X 200 X 10.41 m^3/min X 150 KW X 1,450 rpm

Service reservoir: 40m W X 40m L X 3.5m H X 2 basins

Capacity: 5,000 m^3 per basin

Distribution pipes:

Ductile cast iron pipes	ϕ700,	ℓ = 850 m
Ductile cast iron pipes	ϕ600,	ℓ = 1,450 m
Ductile cast iron pipes	ϕ500,	ℓ = 3,000 m
Ductile cast iron pipes	ϕ450,	ℓ = 850 m
Ductile cast iron pipes	ϕ350,	ℓ = 3,600 m
Asbestos cement pipes	ϕ300,	ℓ = 3,600 m
Asbestos cement pipes	ϕ250,	ℓ = 7,100 m
Asbestos cement pipes	ϕ200,	ℓ = 7,900 m
Asbestos cement pipes	ϕ150,	ℓ = 11,750 m
Asbestos cement pipes	ϕ100,	ℓ = 6,750 m

9.3 Feasible plan for Lat Krabang

9.3.1 Decision on various factors

Designing condition: Raw water demand 7,500 m^3/d X 1.1 = 8,250 m^3/d

Clear water demand 7,500 m^3/d

Purification system: 2,500 m^3/d X 3 stages = 7,500 m^3/d

9.3.2 Raw water system

Water source: Klong water

Collecting method: Pumping

The capacity is 8,250 m^3/d, and the number of pumps is increased during the period of expansion work.

Target year:

2000 A.D. is set as the target year. By dividing the period into three stages, facilities will be increased at the rate of 2,500 m^3/day.

(1) Raw water pump: four units (one is reserved)

Lift: 8,250 $m^3/d \div 3 = 2,750\ m^3/d$ per unit = 1.91 m^3/min

Overall head: 15 m

Horse power of pump: $P_s = 0.163 \times 1 \times 1.91 \times 15 \div 0.7 = 6.7$ KW

Diameter of pump: $D = 146\sqrt{1.91 / 2.5} = 128$ mm, say 125 mm

Specific speed: 264 rpm

Motor: $P = 6.7 (1 + 0.1) = 7.5$ KW

Single suction centrifugal pump: ϕ125 X 1.91 m^3/min X 15 m X 7.5 KW X 1,450 rpm X 4 units

2) Raw water pump plant:

Floor space : 72 m^2

3) Raw water pipes

Ductile cast iron pipes : ϕ350, ℓ = 50 m

9.3.3 Purification system

1) Receiving well: $7,500\ m^3/d \times \frac{2.5\ min}{1,440\ min} = 13\ m^3$

2) Chemical coagulator

Data up to the receiving well are decided on the basis of the capacity in 2000 A.D., and after that, expansion work is done until the third stage, with the single stage capacity standing at 2,500 m^3/d. Location plan is made for overall facilities totaling 7,500 m^3/d, and 2,500 m^3/d of them are constructed in the initial stage.

Detention and capacity: $2.0\ \text{minutes} \times \frac{2,500\ m^3/d}{1,440\ min} = 3.47\ m^3$

then, W 1.3 m X L 1.3 m X H 2.2 m X 1 basin

(three times in 2000 A.D.)

(3) Like the chemical coagulator, the flocculator is of the mechanical type. Since the treatment volume is small, Vortex type is adopted.

Coagulation seems easy as turbidity is high and relatively stable. For management and technical reasons, the treatment lasts for about 40 minutes.

This is planned in two separate systems. Capacity for one system is

(three times in 2000 A.D.)

4) Chemical sedimentation basin

Capacity: 3.5 hours, $2,500\ m^3/d \times \frac{3.5}{24} = 365\ m^3$

Auxiliary equipment: link belt type

Capacity for one system is $365\ m^3 \div 2 = 183\ m^3$

then, W 4.0 m X L 15.0 m X H 3.5 m X 2 basins

(three times in 2000 A.D.)

5) Dosing equipment

Chemicals used: alum & lime

Rational dosing rate:

According to a jar-test, alum rate is 50~100 ppm, and lime 25~50 ppm.

Dosing volume and pump: $7,500\ m^3/d \times 100 \times 10^{-6} \times \frac{14}{8} \times \frac{1}{1.32} = 0.994\ m^3/d$

Alum: Max. 20 ℓ/hr, diaphragm pump three units (one is reserved) or plunger pump

Lime: Max. 10 ℓ/hr, diaphragm pump three units (one is reserved) or plunger pump

Solution tank: alum 2 m^3 X 2 units
lime 1 m^3 X 2 units

6) Rapid sand filtration basin:

Automatic back washing system is adopted for the rapid sand filter. Adopted here is the green-leaf filter which has more excellent features than many other types.

Rate of filtration: 120 m/d
Filtration area: 2,500 m^3/d ÷ 120 m/d = 21 m^2
Then, 3 m^2 X 8 units (three times in 2000 A.D.)
Surface washing pump (single suction centrifugal pump)
Lift: 3 m^2 X 0.2 m^3/min = 0.6 m^3/min.
Head: 30 m
Power: 5.5 KW

7) Distribution basin:

Capacity: six hours, 2,500 m^3/d X 6/24 = 625 m^3
then, W 10m X L 18m X H 3.5m (three times in 2000 A.D.)

9.3.4 Distribution system

1) Distribution pump

The lift of the distribution pump is calculated as the hourly maximum supply.

Hourly maximum supply = 1.5 X daily maximum supply = 1.5 X 7,500 m^3/d
= 11,200 m^3/d, say 7.78 m^3/min.
Dividing the period into three stages, the supply in one stage is 7.78 m^3/min ÷ 3 = 2.6 m^3/min.
Types and number of distribution pumps:

Stage	1.0 m^3/min	2.3 m^3/min	Total (m^3/min)
1st stage	1 + (1)	1 + (1)	3.3 (6.6)
2nd stage		1	2.3
3rd stage		1	2.3
Total	1 + (1)	3 + (1)	7.9 (11.2)

Actual head: 40m
Overall head: 50m

a) 1.0 m^3/min. pump: (turbine pump)
Diameter: $D = 146\sqrt{1.0/2.5} = 92$mm, say 100 mm
Horse power: $P_s = 0.163 \times 50 \times 1.0/0.7 = 11.6$ KW
Motor: $P = 11.6(1 + 0.15) = 13.4$ KW, say 15 KW
Specific speed: 77.1 rpm
φ100 X 1.0 m^3/min X 50m X 15 KW X 2 units (one is reserved)

b) 2.3 m^3/min. pump:

Diameter: $D = 146\sqrt{2.3/2.5} = 140$ mm, say 150 mm

Specific speed: 116 rpm

Horse power: $P_s = 0.16 \times 2.3 \times 50 \div 0.7 = 26.8$ KW

Motor: $P = 26.8 (1 + 0.15) = 30.8$ KW, say 37 KW

ϕ150 X 2.6 m^3/min X 50 m X 37 KW X 4 (one is reserved)

Receiving capacity (distribution pump, surface washing pump)

1st stage		Load capacity	
15 KW X 2 units	(one is reserved)	15 KW	
37 KW X 2 units	(one is reserved)	37 KW	
5.5 KW X 2 units	(for surface washing) (one is reserved)	5.5 KW	
Auxiliary equipment, measuring and lighting equipment		10 KW	
	Total	67.5 KW	
	(for independent electricity reception and transmission)		

2nd stage:

for 1st stage 57.5 KW

Auxiliary equipment, measuring and lighting equipment 10 KW

Total 67.5 KW

(for independent electricity reception and transmission)

3rd stage:

Until 2nd stage 104.5 KW

37 KW 30 KW

Total 150 KW (for independent electricity reception and transmission)

Independent power plant

There are no PEA regulations concerning the capacity to be received from 380 V line. Direct receiving of large-capacity power from the 380 V line must be avoided to maintain voltage stability. If the received capacity exceeds 100 kw, a 115/380 V transformer is installed.

1st stage:

Raw water pumps	7.5 KW X 2 = 15 KW	7.5 KW X 1 = 7.5 KW
Distribution pumps	15 KW X 2 = 30 KW (one reserved)	15 KW
Distribution pumps	37 KW X 2 = 74 KW (one reserved	37 KW
Surface washing pumps	5.5 KW X 2 = 11 KW (one reserved)	5.5 KW
Auxiliary equipment, measuring and lighting equipment	10 KW	10 KW
Sub-total	125 KW	75 KW

2nd stage

Raw water pumps	7.5 KW X 1 = 7.5 KW	7.5 KW
Distribution pumps	37 KW X 1 = 37 KW	37 KW
Sub-total	44.5 KW	44.5 KW

3rd stage:

Raw water pumps	7.5 KW X 1 = 7.5 KW	7.5 KW
Distribution pumps	37 KW X 1 = 37 KW	37 KW
Sub-total	44.5 KW	44.5 KW
Total	224 KW	164 KW

By the end of the first stage, direct receiving from 380 V 4 C is possible, but in the second stage, an independent electric power plant is needed. Therefore, construction of the independent plant is scheduled from the beginning.

About the power receiving system, examinations are needed on the following points:

(1) Total consumption depends on supplied power, and as an emergency source, half or one-third of the capacity is produced with the independent power generator.

(2) All power is generated with the independent plant;

In the case of (1), an independent plant is included in the original construction plan. For safe and economical operation of facilities, emergency power source that can cover about one-third of the required capacity, is regarded as most suitable.

As an investment for the future, emergency power source of about 60 kw is prepared.

Generation capacity: 60 KW X 1.2 = 72 KVA

Motor capacity: 110 P_s (diesel engine battery driven)

Equipment for independent electricity reception and transmission:

164 KW X 1.2 = 200 KVA

Taking the loading situation into consideration, two sets of 1,000 KVA 3 115,000/380 V are installed.

In the case of (2) (this is just for reference and cannot be adopted), all power is produced with the independent plant, but the plant facilities must be divided into two, because the capacity is 75 kw in one term and 164 kw in three terms.

Generation capacity: 82 KW X 1.2 = 98.4 KVA, say 100 KVA

Engine capacity: 160 P_s

Two units including a reserved one are prepared at the outset, and three units in the final stage.

.2) Distribution pipes

Ductile cast iron pipes	ϕ400	ℓ = 4,000 m
Ductile cast iron pipes	ϕ350	ℓ = 2,500 m
Asbestos cement pipes	ϕ300	ℓ = 1,200 m
Asbestos cement pipes	ϕ250	ℓ = 5,950 m
Asbestos cement pipes	ϕ200	ℓ = 9,200 m
Asbestos cement pipes	ϕ150	ℓ = 9,450 m
Asbestos cement pipes	ϕ100	ℓ = 8,600 m

9.4 Feasible plan for comprehensive water supply in Bang Bua Thong, Bang Yai and Sai Noi

9.4.1 Decision on various factors

Designing condition: Raw water demand 12,000 m^3/d X 1.1 = 13,200 m^3/d

Clear water demand 12,000 m^3/d

Purification system: 4,000 m^3/d X 3 stages = 12,000 m^3/d

9.4.2 Water collection and conveyance system

Water source: Klong water

Collecting method: pumping

The scale of the intake plant is 13,200 m^3/d, and the number of pumps is increased during three periods of expansion works.

Target year:

Target year of this plan is 2000 A.D., and the period in between is divided into three. The three terms are:

1st stage: eight years 1977 ~ 1985

2nd stage: seven years 1985 ~ 1995

3rd stage: eight years 1992 ~ 2000

1) Raw water pumps: four (one reserved)

Lift: 13,200 $m^3/d \div 3 = 4,400\ m^3/d = 3.06\ m^3/min$.

Overall head: Actual head 10 m

Friction loss 9.4 m

Others 3 m

Total 22.4 m, Say 25 m

Horse power of pumps: $P_s = 0.163 \times 3.06 \times 25 \div 0.7 = 17.8$ KW

Diameter of pumps: $D = 146\sqrt{3.06/2.5} = 160$ mm

Specific speed: 225 rpm

Motor: $P = 17.8\,(1 + 0.15) = 20.5$ KW, Say 22 KW

ϕ200/150, Double suction centrifugal pump

Receiving capacity: 22 KW X 3 = 66 KW

Others 10 KW

Total 76 KW

76 KW X 1.2 ≑ 100 KVA (for indpendent electricity reception and transmission)

2) Raw water pipes Ductile cast iron pipes, ϕ500, ℓ = 4,700 m

9.4.3 Purification system

1) Receiving well

Capacity: 2.5 minutes

12,000 $m^3/d \times 2.5/1,440 = 20.83\ m^3$, then W 2.0m X L 4.5m X H 2.5m X 1 basin

2) Chemical dosing basin (or chemical coagulation bath):

Up to the receiving well, data are decided on the basis of the capacity in 2000 A.D., and after that, 4,000 m^3/d facilities are constructed in the first stage, and expansion works continue until the third stage. Of the 12,000 m^3/d facilities, 4,000 m^3/d are constructed in the initial stage.

Capacity: 2.0 minutes 4,000 $m^3/d \times \frac{2}{1,440} = 5.56\ m^3$

then, W 1.5m X L 1.5m X H 2.5m X 1 basin

3) Flocculation basin (2 systems):

Capacity: 40 minutes

Therefore, the capacity of one system is 4,000 X 40/1,440 = 111 m^3

then, W 4.7m X L 4.7m X H 2.5m X 2 basins

4) Chemical dosing equipment:

Chemicals used: alum & lime

Rational dosing rate: according to a jar-test, alum dosing rate is 50~100 ppm.

Chemical dosing rate and dosing pump: 25~50 ℓ/hr

Max. 37.5 ℓ/hr, plunger pump three units (one reserved)

If lime is about one half of alum, dosing pumps are Max. 37.5 ℓ/hr, plunger pumps three units (one reserved).

Solution tank: alum 4 m^3 X 2 units

lime 2 m^3 X 2 units

5) Chemical sedimentation basin: (2 systems)

Capacity: 3.5 hours

Therefore, the capacity of one system is 4,000 m^3/d X $\frac{3.5}{24}$ = 583.3 m^3

then, W 4.7m X L 18.0m X H 3.5m X 2 basins

(6) Rapid sand filter

Automatic back washing system is adopted for the rapid sand filter. Adopted here is the green-leaf filter which has more excellent features than other types.

Filtration rate: 120 m/d

Filtration area: 4,000 m^3/d ÷ 120 m/d = 33.4 m^2 X $\frac{8}{7}$ = 38.1 m^2 = 4.8 m^2 X 8 basins

Surface washing pump (single suction centrifugal pump):

Lift: 4.8 m^2 X 0.2 m^3/min = 0.96 m^3/min.

Head: 30 m

Power: 7.5 KW

7) Service reservoir:

Capacity: 6 hours, 4,000 m^3/d X $\frac{6}{24}$ = 1,000 m^3

then, W 15.0m X L 20.0m X H 3.5m

9.4.4 Distribution system

1) Distribution pumps:

Lift: Hourly maximum supply = 1.5 X 12,000 m^3/d = 18,000 m^3/d.

Supply in one stage is 18,000 m^3/d ÷ 3 = 6,000 m^3/d ≑ 4.2 m^3/min.

Types and number of distribution pumps:

Stage	1.6 m^3/min.	3.7 m^3/min.	Total (m^3/min.)
1st stage	1 + (1)	1 + (1)	5.2
2nd stage		1	3.7
3rd stage		1	3.7
Total	1 + (1)	3 + (1)	12.6 + (5.3)

Actual head: 40 m Overall head: 50 m

a) 1.6 m^3/min. pump:

Diameter: $146\sqrt{1.6/2.5}$ = 116.8 mm, Say 125 mm

Specific speed: 97.4 rpm

Horse power: P_s = 0.168 X 1.6 X 50 ÷ 0.7 = 18.6

Motor: P = 18.6 (1 + 0.15) = 21.39, Say 22 KW

ϕ125 X 1.0 m^3/min X 50m X 22 KW X 2 (one reserved)

b) 3.7 m^3/min. pump:

Diameter: $146\sqrt{3.7/2.5}$ = 177, Say 200 mm

Specific speed: 148 rpm

Horse power: P_s = 0.163 X 3.7 X 50 ÷ 0.7 = 43.1

Motor: P = 43.1 (1 + 0.15) = 49.53 KW, Say 55 KW

ϕ200/150 X 3.7m^3/min X 50m X 55 KW X 4 units (one reserved)

Generator equipment (distribution pumps)

1st stage			Equipment capacity	Load capacity
	22 KW X 2		44	22
	55 KW X 2	(one reserved)	110	55
For surface washing				
	7.5 KW X 2	(one reserved)	15	7.5
	Auxiliary equipment		10	10
		Sub-total	179	94.5
2nd stage	55 KW X 1	Sub-total	55	55
3rd stage	55 KW X 1	Sub-total	55	55
		Total	289 KW	204.5 KW

According to this, direct receiving from 380 V 4 C is possible by the end of the first stage work, but inclusion of a plan for the independent power plant in the original schedule is recommended. Problems which require examinations on the power receiving system are:

(1) Total consumption depends on supplied power, and as an emergency source, half or one-third of the capacity is produced with the independent power generator.

(2) All power is generated with the independent plant.

In the case of (1), an independent plant is included in the original construction plan. For safe and economical operation of facilities, emergency power source that can cover about one-third of the required power, is regarded as most suitable.

Therefore, as an investment for the future, emergency power source of about 80 KW is prepared.

Generation capacity: 80 KW X 96 KVA

Motor capacity: 96 KVA X 1.36 X 1 ÷ 0.9 = 145 P_s, Say 150 P_s

Facilities initially planned for independent electricity reception and transmission account for about a half of the entire facilities.

At the final stage, the above figure could be doubled. Therefore,

115,000/380 V, 3,450 Hz, 150 KVA, 2 sets.

In the case of (2) (just for reference), it is desirable to divide independent power plant facilities into two parts for technical and economic reasons because the first-stage facilities total 104 KW and the second-stage facilities 208 KW.

Generation capacity: 103 KW X 1.2 = 124 KVA, Say 150 KVA

Engine capacity: 150 KVA X 1.36 X 1 ÷ 0.9 = 226 P_s, Say 230 P_s

Therefore, two units including a reserved one are constructed in the first stage, and another in the second stage.

150 KVA X 230 P_s X 3 (one reserved)

2) Distribution pipes:

Ductile cast iron pipes	:	ϕ350,	ℓ = 5,450 m
Asbestos cement pipes	:	ϕ300,	ℓ = 4,450
Asbestos cement pipes	:	ϕ250,	ℓ = 8,700
Asbestos cement pipes	:	ϕ200,	ℓ = 25,000
Asbestos cement;pipes	:	ϕ150,	ℓ = 26,500
Asbestos cement pipes	:	ϕ100,	ℓ = 18,850

Chapter 10 Construction cost and financial plan

10.1 Construction cost

Rough estimate of the cost for emergency works, first, second and third stages is shown in Table 10.1, 10.2, 10.3. Future price increase was not taken into account. Local cost was calculated in the current value which was recognized by the Japanese Survey Team during its stay in Bangkok, and foreign cost was found by adding import tariffs to the current values of Japanese products (U.S. dollar 20 bahts; 1 baht 12.5 yen).

Personnel Expenditure;

Worker	Lat Krabang		Ban Bua Thong		Nong Khaem	
	Emergency	1st	Emergency	1st	Emergency	1st
Super Intendent	(1) 1,800	(1) 1,800	(1) 1,800	(1) 1,800	(1) 1,800	(1.5) 2,700
Senior Engineer	–	(1) 1,320	–	(1) 1,320	(1) 1,320	(1.5) 1,980
Junior Engineer	–	(1) 1,200	–	(1) 1,200	(1) 1,200	(1.5) 1,800
Mechanics	(1) 1,000	(2) 2,000	(1) 1,000	(2) 2,000	(2) 2,000	(3) 3,000
Workers	(2) 1,300	(3) 1,950	(2) 1,300	(3) 1,950	(3) 1,950	(4.5) 2,925
Total	(4) 4,100	(8) 8,270	(4) 4,100	(8) 8,270	(8) 8,270	(12) 12,405
Annual Total	49,200	99,240	49,200	99,240	99,240	148,860
Extra	800	8,760	800	8,760	8,760	13,140
Grand Total	50,000	108,000	50,000	108,000	108,000	162,000

General Management; 20% of Personnel Expenditure

Period	Lat Krabang Ban Bua Thong	Nong Khaem
Emergency	10,000	21,600
1st	21,600	32,400

power Cast;

Lat Krabang

	KW	฿/KW	KWX0.7X24hrX365days
Emergency	74	0.7	453,768
1st	75	0.7	459,900

Ban Bua Thong

	KW	฿/KW	KWX0.7X24hrX365days
Emergency	75	0.7	459,900
1st	94.5	0.7	579,474

Nong Khaem

	KW	฿/KW	KWX0.7X24hrX365days
Emergency	174	0.7	1,066,968
1st	319	0.7	1,956,108

LAT KRABANG SYSTEM. BREAKDOWN OF COST

Table－10.1

(UNIT 1,000 BAHT)

ITEM	EMERGENCY			FIRST STAGE			SECOND STAGE			THIRD STAGE			GRAND TOTAL		
	F.C	L.C	S.T	F.C	L.C	S.T	F.C	L.C	S.T	F.C	L.C	S.T	F.C	L.C	S.T
(1) INTAKE FACILITY & RAW WATER MAIN				(179)	(359)	(538)	(89)	(18)	(107)	(89)	(18)	(107)	(357)	(395)	(752)
INTAKE FACILITY				179	241	420	89	18	107	89	18	107	357	277	634
WARE HOUSE					118	118								118	118
RAW WATER MAIN															
SITE PREPARATION															
2. WATER TREATMENT PLANT				(5,967)	(6,393)	(12360)	(3,715)	(1,689)	(5,404)	(3,701)	(1,692)	(5,393)	(13,383)	(9,774)	(23,157)
RECEIVING WELL					32	32								32	32
SEDIMANTATION BASIN & RAPID SANDFILTER				3,545	1,113	4,658	3,545	1,113	4,658	3,545	1,113	4,658	10,635	3,339	13,974
CLEAN WATER BASIN & RESERVOIR					554	554		554	554		554	554		1,662	1,662
PUMP WELL				565	325	890	134	15	149	134	15	149	833	355	1,188
CHEMICAL EQUIPMENT				1,672	267	1,939							1,672	267	1,939
PIPING FOR FACILITY				161	23	184	31	5	36	17	8	25	209	36	245
SLUDGE & DRAINAGE				24	93	117	5	2	7	5	2	7	34	97	131
CONTROL ROOM & OFFICE					326	326								326	326
ELECTRIC & CHEMICAL ROOM					189	189								189	189
DORMITORY					326	326								326	326
SITE PREPARATION					3,145	3,145								3,145	3,145
(3) DISTRIBUTION MAIN	(1,343)	(1,405)	(2,748)	(4,257)	(969)	(5,226)	(164)	(3,380)	(3,544)	(1,854)	(1,180)	(3,034)	(7,618)	(6,934)	(14,552)
DISTRIBUTION PIPE	1,343	1,405	2,748	4,257	969	5,226	164	3,380	3,544	93	840	933	5,857	6,594	12451
BOOSTER PUMP										1,761	340	2,101	1,761	340	2,101
(4) CONTROL SYSTEM (ELECTRIC & INSTRUMENT)				(5,314)	(1,056)	(6,370)	(152)	(164)	(316)	(152)	(4)	(156)	(5,618)	(1,224)	(6,842)
SUB TOTAL	1,343	1,405	2,748	15,717	8,777	24,494	4,120	5,251	9,371	5,796	2,894	8,690	25,976	18,327	45,303
ENGINEERING FEE (5%)	67	70	137	786	439	1,225	206	263	469	290	145	435	1,349	917	2266
ADMINISTRATION (4%)	54	56	110	629	351	980	165	210	375	232	116	348	1,080	733	1,813
RESERVE (10%)	134	141	275	1,572	878	2,450	412	525	937	580	289	869	2,698	1,833	4,531
SUB TOTAL	255	267	522	2987	1,668	4,655	783	998	1,781	1,102	550	1,652	5,127	3,483	8,610
GRAND TOTAL	1,598	1,672	3,270	18,704	10,445	29,149	4,903	6,249	11,152	6,898	3,444	10,342	32,103	21,810	53,913

( ) sub total

Table－1 0.2

BANG BUA THONG, BANG YAI & SAI NOI SYSTEM, BREAKDOWN OF COST

(UNIT 1,000 BAHT)

ITEM	EMERGENCY			FIRST STAGE			SECOND STAGE			THIRD STAGE			GRAND TOTAL		
	F.C	L.C	S.T	F.C	L.C	S.T	F.C	L.C	S.T	F.C	L.C	S.T	F.C	L.C	S.T
1. INTAKE FACILITY & RAW WATER MAIN				(6,108)	(1,458)	(7,566)	(124)	(19)	(143)	(124)	(19)	(143)	(6,356)	(1,496)	(7,852)
INTAKE FACILITY				485	258	743	124	19	143	124	91	143	733	296	1,029
WARE HOUSE					137	137								137	137
RAW WATER MAIN				5,623	964	6,587							5,623	964	6,587
SITE PREPARATION					99	99								99	99
2. WATER TREATMENT PLANT	(263)	(98)	(361)	(6,677)	(3,550)	(10,227)	(4,134)	(2,138)	(6,272)	(4,071)	(1,932)	(6,003)	(15,145)	(7,718)	(22,863)
RECEIVING WELL					62	62								62	62
SEDIMENTATION BASIN & RAPID SANDFILTER				3,809	1,312	5,121	3,809	1,312	5,121	3,809	1,312	5,121	11,427	3,936	15,363
CLEAN WATER BASIN & RESERVOIR					587	587		587	587		587	587		1,761	1,761
PUMP WELL				681	326	1,007	162	17	179	162	17	179	1,005	360	1,365
CHEMICAL EQUIPMENT				1,726	276	2,002							1,726	276	2,002
PIPING FOR FACILITY				408	28	436	153	14	167	90	13	103	651	55	706
SLUDGE & DRAINAGE				53	118	171	10	3	13	10	3	13	73	124	197
CONTROL ROOM & OFFICE					326	326								326	326
ELECTRIC & CHEMICAL ROOM					189	189								189	189
DORMITORY					326	326								326	326
SITE PREPARATION	(REHABILITATION) 263	98	361					205	205				263	303	566
3. DISTRIBUTION MAIN	(1,746)	(7,834)	(9,580)	(3,640)	(4,158)	(7,798)	(1,022)	(7,753)	(8,775)	(3,003)	(4,762)	(7,765)	(9,411)	(24,507)	(33,918)
DISTRIBUTION PIPE	779	7,624	8,403	3,640	4,158	7,798	308	7,610	7,918	149	4,158	4,307	4,876	23,550	28,426
BOOSTER PUMP	967	210	1,177				714	143	857	2,854	604	3,458	4,535	957	5,492
4. CONTROL SYSTEM (ELECTRIC & INSTRUMENT)				(8,196)	(1,841)	(10,037)	(221)	(75)	(296)	(195)	(4)	(199)	(8,612)	(1,920)	(10,532)
5. WELL	(730)	(245)	(975)										(730)	(245)	(975)
SUB TOTAL	2,739	8,177	10,916	24,621	11,007	35,628	5,501	9,985	15,486	7,393	6,717	14,110	40,254	35,886	76,140
ENGINEERING FEE (5%)	137	409	546	1,231	550	1,781	275	499	774	370	336	706	2,013	1,794	3,807
ADMINISTRATION (4%)	110	327	437	985	440	1,425	220	399	619	296	269	565	1,611	1,435	3,046
RESERVE (10%)	274	818	1,092	2,462	1,101	3,563	550	999	1,549	739	672	1,411	4,025	3,590	7,615
SUB TOTAL	521	1,554	2,075	4,678	2,091	6,769	1,045	1,897	2,942	1,405	1,277	2,682	7,649	6,819	14,468
GRAND TOTAL	3,260	9,731	12,991	29,299	13,098	42,397	6,546	11,882	18,428	8,798	7,994	16,792	47,903	42,705	90,608

( ) sub total

Table－10.3

NONG KHAEM SYSTEM, BREAKDOWN OF COST

(UNIT 1,000 BAHT)

ITEM	EMERGENCY			FIRST STAGE			SECOND STAGE			THIRD STAGE			GRAND TOTAL		
	F.C	L.C	S.T	F.C	L.C	S.T	F.C	L.C	S.T	F.C	L.C	S.T	F.C	L.C	S.T
1. INTAKE FACILITY & RAW WATER MAIN	(577)	(391)	(968)	(235)	(49)	(284)	(235)	(49)	(284)	(235)	(49)	(284)	(1,282)	(538)	(1,820)
INTAKE FACILITY	470	328	798	235	49	284	235	49	284	235	49	284	1,175	475	1,650
RAW WATER MAIN	107	12	119										107	12	119
SITE PREPARATION		51	51											51	51
2. WATER TREATMENT PLANT	(41,566)	(18,918)	(60,484)	(9,519)	(3,779)	(13,298)	(9,665)	(2,791)	(13,456)	(9,481)	(3,787)	(13,268)	(70,231)	(30,275)	(100,506)
RECEIVING WELL		122	122											122	122
SEDIMENTATION BASIN & RAPID SANDFILTER	9,080	3,714	12,794	9,080	3,714	12,794	9,080	3,714	12,794	9,080	3,714	12,794	36,320	14,856	51,176
CLEAN WATER BASIN	664	1,043	1,707	289	50	339	289	50	339	289	50	339	1,531	1,193	2,724
CHEMICAL EQUIPMENT	5,413	816	6,229										5,413	816	6,229
PIPING FOR FACILITY	536	17	553	139	8	147	275	19	294	101	15	116	1,051	59	1,110
SLUDE & DRAINAGE	83	125	208	11	7	18	21	8	29	11	8	19	126	148	274
TRANSMISSION	25,790	2,717	28,507										25,790	2,717	28,507
CONTROL ROOM & OFFICE		1,492	1,492											1,492	1,492
ELECTRIC & GENERATOR ROOM		114	114											114	114
DORMITORY		392	392											392	392
SITE PREPARATION		8,366	8,366											8,366	8,366
3. DISTRIBUTION MAIN	(7,434)	(11,156)	(18,590)	(746)	(1,078)	(1,824)	(1,485)	(3,649)	(5,134)	(5,394)	(4,102)	(9,496)	(15,059)	(19,985)	(35,044)
SERVICE RESERVOIR		2,709	2,709					2,709	2,709					5,418	5,418
PUMPING WELL	677	597	1,274	727	114	841	364	57	421	364	57	421	2,132	825	2,957
SITE PREPARATION		1,266	1,266											1,266	1,266
WARE HOUSE		490	490											490	490
DISTRIBUTION PIPE	6,757	6,094	12,851	19	964	983	1,121	882	2,004	4,422	3,913	8,335	12,319	11,854	24,173
BOOSTER PUMP										608	132	740	608	132	740
4. CONTROL SYSTEM (ELECTRIC & INSTRUMENT)	(19,442)	(3,445)	(22,887)	(2,099)	(82)	(2,181)	(1,574)	(82)	(1,656)	(1,574)	(82)	(1,656)	(24,689)	(3,691)	(28,380)
SUB TOTAL	69,019	33,910	102,929	12,599	4,988	17,587	12,959	7,571	20,530	16,684	8,020	24,704	111,261	54,489	165,750
ENGINEERING FEE (5%)	3,451	1,696	5,147	630	249	879	648	379	1,027	834	401	1,235	5,563	2,725	8,288
ADMINISTRATION (4%)	2,761	1,356	4,117	504	200	704	518	303	821	667	321	988	4,450	2,180	6,630
RESERVE (10%)	6,902	3,391	10,293	1,260	499	1,759	1,296	757	2,053	1,668	802	2,470	11,126	5,449	16,575
SUB TOTAL	13,114	6,443	19,557	2,394	948	3,342	2,462	1,439	3,901	3,169	1,524	4,693	21,139	10,354	31,493
GRAND TOTAL	82,133	40,353	122,486	14,993	5,936	20,929	15,421	9,010	24,431	19,853	9,544	29,397	132,400	64,843	197,243

( ) sub total

10.2 Financial plan

On the independent accounting basis, the financial plan was formed under the conditions as follows: follows:

1) General management expenditure

Maintenance expenditure : 0.04 ฿/m³

Repair expenditure : 0.02 ฿/m³

Chemical cost:

Alum	75 ppm	0.11 ฿/m³
Lime	35 ppm	0.02 ฿/m³
Chlorine	2 ppm	0.02 ฿/m³
Total		0.15 ฿/m³

2) Repayment plan

Local currency:

Interest: 6%

Grace period: 5 years

Term of redemption: 35 years

Totaling 40 years

Foreign currency:

Interest: 3.25 %

Grace period: 5 years

Term of redemption: 25 years

Totaling 30 years

3) Water charge

Charged water volume accounts for 75 per cent of the average annual supply, and water charge is set at 3 bahts/m³ (presently 2 bahts/m³ in provincial municipalities). Under the above conditions, financial plan of each Amphur was analyzed. As a result, it was found that a favorable balance cannot be achieved before time passes far beyond 2000 A.D. This is because the population density is too low and the cost for facilitiexs per head is enormous. This can well be expected in the case of the regional water supply project. Such a project can never materialize without national support. Analyses were also made on how the waterworks account improves if national supports are extended, and the results are shown in Table 10.4. If water charge is 3 bahts/m³, 50 per cent of the total construction cost in Amphurs Lat Krabang and Bang Bua Thong must be covered with national support in order to prevent a deficit in the waterworks account. However, in Amphur Nong Khaem where there are no facilities at all, the initial investment is too large, and even if 50 percent of the total cost is covered with national support, the balance will not turn favorable until 2012 A.D. National support must be further strengthened particularly in Amphur Nong Khaem. The financial plan is detailed in a separate volume

Table 10.4

	Lat Krabang		Ban Bua Thong		Nong Khaem		Remark
	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	
Emergency	1,672,000	1,598,000	9,731,000	3,260,000	40,353,000	82,133,000	
1 st	10,445,000	18,704,000	13,098,000	29,299,000	5,936,000	14,993,000	No
Total	12,117,000	20,302,000	22,829,000	32,559,000	46,289,000	97,126,000	Subsidies
Time of Balancing	Over 2026AD		Over 2026AD		Over 2029AD		
Emergency	1,170,400	1,118,600	6,811,700	2,282,000	28,247,000	57,493,000	
1 st	7,311,500	13,092,800	9,168,600	20,509,300	4,155,000	10,495,000	30 %
Total	8,481,900	14,211,400	15,980,300	22,791,300	32,402,000	67,988,000	Subsidies
Time of Balancing	2017AD		2020AD		2025AD		
Emergency	836,000	799,000	4,865,500	1,630,000	20,177,000	41,067,000	
1 st	5,222,500	9,352,000	6,549,000	14,649,500	2,968,000	7,497,000	50 %
Total	6,058,500	10,151,000	11,414,500	16,279,500	23,145,000	48,564,000	Subsidies
Time of Balancing	1975AD		1974AD		2012AD		

10.3 Re-assess

The unit cost used in the report for the estimates of construction cost and the financial schedule is based on the current rate as of April 1973. It is very difficult, however, to forecast the future escalation of labour cost and material cost at the time when the construction starts under the circumstances of world-wide inflation nowadays.

It is, therefore, inevitable to re-assess the construction cost and the financial schedule based on the up-to-date rate at the time when the project is executed.

ACCOUNT STATEMENT OF FINANCIAL PROGRAM

(DATA)

1. NONG KHAEM AREA

BASIC DATA

P. C. K. K. ELECT. COMP. DEPT.   AMORTIZATION SCHEDULE   JOB BANGKOK SEPARATE SYSTEM

********** EFFECTIVE RATE OF WATER SUPPLY **********

(1)	POPULATION		PERSON
(2)	HOUSE CONNECTION		PERCENT
(3)	MAX. DAILY DEMAND PER CAPITA		L / C * D
(4)	MAX. DAILY DEMAND		M**3 / D
(5)	AVERAGE DEMAND	1.50	M**3 / D
(6)	AVERAGE DEMAND		M**3 / YR.
(7)	EFFECTIVE RATIO		PERCENT
(8)	EFFECTIVE QUANTITY FOR REVENUE		M**3 / YR.

YEAR	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1976	0.	0.	0.	0.	0.	0.	0.	0.
1977	36500.0	63.5	231.0	5354.0	3569.3	1302807.3	75.0	977105.5
1978	39000.0	64.0	234.0	5840.6	3893.8	1421222.4	75.0	1065916.8
1979	41500.0	64.5	237.0	6343.9	4229.3	1543681.7	75.0	1157761.3
1980	44000.0	65.0	240.0	6864.0	4576.0	1670240.0	75.0	1252680.0
1981	46500.0	65.5	243.0	7401.2	4934.1	1800952.0	75.0	1350714.0
1982	49500.0	66.0	246.0	8036.8	5357.9	1955626.2	75.0	1466719.6
1983	52500.0	66.5	249.0	8693.2	5795.5	2115348.4	75.0	1586511.3
1984	56000.0	67.0	252.0	9455.0	6303.4	2300726.4	75.0	1725544.8
1985	59000.0	67.5	255.0	10155.4	6770.3	2471141.2	75.0	1853355.9
1986	62500.0	68.0	258.0	10965.0	7310.0	2668150.0	75.0	2001112.5
1987	66500.0	68.5	261.0	11889.2	7926.1	2893039.3	75.0	2169779.5
1988	70500.0	69.0	264.0	12842.3	8561.5	3124954.8	75.0	2343716.1
1989	74500.0	69.5	267.0	13824.6	9216.4	3363984.2	75.0	2522988.1
1990	79000.0	70.0	270.0	14931.0	9954.0	3633210.0	75.0	2724907.5

********** COST OF MAINTENANCE AND MANAGEMENT **********

(1) AVERAGE DEMAND
(2) MAINTENANCE EXPENDITURE
(3) REPAIR EXPENDITURE
(4) CHEMICAL COST
(5) SLUDGE TREATMENT COST
(6) OTHERS
(7) PERSONNEL EXPENDITURE
(8) GENERAL MANAGEMENT
(9) POWER COST

UNIT (1000)

YEAR	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	TOTAL
1976	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1977	1303.	78.	39.	322.	0.	0.	108.	22.	1067.	1636.
1978	1421.	85.	43.	352.	0.	0.	108.	22.	1067.	1676.
1979	1544.	93.	46.	382.	0.	0.	108.	22.	1067.	1718.
1980	1670.	100.	50.	413.	0.	0.	108.	22.	1067.	1760.
1981	1801.	108.	54.	446.	0.	0.	162.	32.	1956.	2758.
1982	1956.	117.	59.	484.	0.	0.	162.	32.	1956.	2811.
1983	2115.	127.	63.	524.	0.	0.	162.	32.	1956.	2864.
1984	2301.	138.	69.	569.	0.	0.	162.	32.	1956.	2927.
1985	2471.	148.	74.	612.	0.	0.	162.	32.	1956.	2985.
1986	2668.	160.	80.	660.	0.	0.	162.	32.	1956.	3051.
1987	2893.	174.	87.	716.	0.	0.	162.	32.	1956.	3127.
1988	3125.	187.	94.	773.	0.	0.	162.	32.	1956.	3205.
1989	3364.	202.	101.	833.	0.	0.	162.	32.	1956.	3286.
1990	3633.	218.	109.	899.	0.	0.	162.	32.	1956.	3377.

SETTLEMENT OF ACCOUNTS

CASE 1

In Case without Government Subsidy

P.C.K.K. ELECT. COMP. DEPT.　　AMORTIZATION SCHEDULE　　JOB BANGKOK SEPARATE SYSTEM

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****************************************
*                WATER RATE            *
*  CASE - 1 :       3.0                *
*            (CHARGE / M**3)           *
****************************************
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	INTEREST	(1)	(2)
(A) :	6.00 :	5	35 :
(B) :	3.35 :	5	25 :
(C) :	0. :	0	0 :
	(PERCENT)	(YEAR)	

(1) = THE TERM OF LOAN
(2) = THE TERM OF PAYMENT

(UNIT : 1000)

YEAR	BORROWING (A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
1976	40353.	82133.	0.	0.	0.	5173.	5173.	-5173.	-5173.
1977	0.	0.	0.	2931.	1636.	5173.	6809.	-3878.	-9050.
1978	0.	0.	0.	3198.	1676.	5173.	6849.	-3651.	-12701.
1979	0.	0.	0.	3473.	1718.	5173.	6890.	-3417.	-16118.
1980	5930.	14993.	0.	3758.	1760.	6031.	7791.	-4033.	-20152.
1981	0.	0.	0.	4052.	2758.	8544.	11303.	-7250.	-27402.
1982	0.	0.	0.	4400.	2811.	8544.	11355.	-6955.	-34357.
1983	0.	0.	0.	4760.	2864.	8544.	11409.	-6649.	-41006.
1984	0.	0.	0.	5177.	2927.	8544.	11471.	-6295.	-47301.
1985	0.	0.	0.	5560.	2985.	8990.	11975.	-6415.	-53715.
1986	0.	0.	0.	6003.	3051.	8990.	12041.	-6038.	-59753.
1987	0.	0.	0.	6509.	3127.	8990.	12117.	-5608.	-65361.
1988	0.	0.	0.	7031.	3205.	8990.	12195.	-5164.	-70525.
1989	0.	0.	0.	7569.	3286.	8990.	12276.	-4707.	-75232.
1990	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-79424.
1991	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-83617.
1992	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-87809.
1993	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-92001.
1994	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-96193.
1995	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-100386.
1996	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-104578.
1997	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-108770.
1998	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-112962.
1999	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-117154.
2000	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-121347.
2001	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-125539.
2002	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-129731.
2003	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-133923.
2004	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-138116.
2005	0.	0.	0.	8175.	3377.	8990.	12367.	-4192.	-142308.
2006	0.	0.	0.	8175.	3377.	4083.	7464.	710.	-141597.
2007	0.	0.	0.	8175.	3377.	4088.	7464.	710.	-140887.
2008	0.	0.	0.	8175.	3377.	4088.	7464.	710.	-140177.
2009	0.	0.	0.	8175.	3377.	4088.	7464.	710.	-139466.
2010	0.	0.	0.	8175.	3377.	3193.	6569.	1605.	-137861.
2011	0.	0.	0.	8175.	3377.	3193.	6569.	1605.	-136256.
2012	0.	0.	0.	8175.	3377.	3193.	6569.	1605.	-134651.
2013	0.	0.	0.	8175.	3377.	3193.	6569.	1605.	-133045.
2014	0.	0.	0.	8175.	3377.	3193.	6569.	1605.	-131440.
2015	0.	0.	0.	8175.	3377.	3193.	6569.	1605.	-129835.
2016	0.	0.	0.	8175.	3377.	409.	3786.	4389.	-125446.
2017	0.	0.	0.	8175.	3377.	409.	3786.	4389.	-121058.
2018	0.	0.	0.	8175.	3377.	409.	3786.	4389.	-116669.
2019	0.	0.	0.	8175.	3377.	409.	3786.	4389.	-112280.
2020	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-107482.
2021	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-102684.

P. C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
2006	3377.	2783.	0.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	7464.
2007	3377.	2783.	0.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	7464.
2008	3377.	2783.	0.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	7464.
2009	3377.	2783.	0.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	7464.
2010	3377.	2783.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	6569.
2011	3377.	2783.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	6569.
2012	3377.	2783.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	6569.
2013	3377.	2783.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	6569.
2014	3377.	2783.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	6569.
2015	3377.	2783.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	6569.
2016	3377.	0.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	3786.
2017	3377.	0.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	3786.
2018	3377.	0.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	3786.
2019	3377.	0.	0.	0.	409.	0.	0.	0.	0.	0.	0.	0.	0.	3786.
2020	3377.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3377.

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

********** EXPENDITURE **********

(1) MANAGEMENT
(2) AMORTIZATION FOR ( )
(3) TOTAL

INTEREST (PERCENT)	** A ** _ 6.000	** 8 ** - 3.350	** C ** - 0.
BORROWING			
1976	40353000.000	82133000.000	0.
1980	5936000.000	14993000.000	0.
0	0.	0.	0.
0	0.	0.	0.

YEAR	(1)	(2) - (EMERGENCY) A	B	C	(2) - (1ST) A	B	C	(2) - (2ND) A	B	C	(2) - (3RD) A	B	C	(3)
1976		2421.	2751.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
1977	1636.	2421.	2751.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5173.
1978	1676.	2421.	2751.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	6809.
1979	1718.	2421.	2751.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	6849.
1980	1760.	2421.	2751.	0.	356.	502.	0.	0.	0.	0.	0.	0.	0.	6890.
1981	2758.	2783.	4903.	0.	356.	502.	0.	0.	0.	0.	0.	0.	0.	7791.
1982	2811.	2783.	4903.	0.	356.	502.	0.	0.	0.	0.	0.	0.	0.	11303.
1983	2864.	2783.	4903.	0.	356.	502.	0.	0.	0.	0.	0.	0.	0.	11355.
1984	2927.	2783.	4903.	0.	356.	502.	0.	0.	0.	0.	0.	0.	0.	11409.
1985	2965.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	11471.
1986	3051.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	11975.
1987	3127.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12041.
1988	3205.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12117.
1989	3286.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12195.
1990	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12276.
1991	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
1992	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
1993	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
1994	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
1995	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
1996	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
1997	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
1998	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
1999	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
2000	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
2001	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
2002	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
2003	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
2004	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.
2005	3377.	2783.	4903.	0.	409.	895.	0.	0.	0.	0.	0.	0.	0.	12367.

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

(UNIT : 1000)

YEAR	(A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
2022	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-97886.
2023	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-93088.
2024	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-88290.
2025	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-83492.
2026	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-78694.
2027	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-73896.
2028	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-69098.
2029	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-64300.

CASE 2

In Case of 30 % Government Subsidy

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

*********** EXPEDITURE ***********

(1) MANAGEMENT
(2) AMORTIZATION FOR ( )
(3) TOTAL

	** A **	** B **	** C **
INTEREST (PERCENT)	6.00	3.350	0.
BORROWING			
1976	28247100.000	57493100.000	0.
1980	4155200.000	10495100.000	0.
0	0.	0.	0.
0	0.	0.	0.

YEAR	(1)	(2) - (EMERGENCY) A	B	C	(2) - (1ST) A	B	C	(2) - (2ND) A	B	C	(2) - (3RD) A	B	C	(3)
1976	0.	1695.	1926.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3621.
1977	1636.	1695.	1926.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5257.
1978	1676.	1695.	1926.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5297.
1979	1718.	1695.	1926.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5338.
1980	1760.	1695.	1926.	0.	249.	352.	0.	0.	0.	0.	0.	0.	0.	5982.
1981	2758.	1948.	3432.	0.	249.	352.	0.	0.	0.	0.	0.	0.	0.	8739.
1982	2811.	1948.	3432.	0.	249.	352.	0.	0.	0.	0.	0.	0.	0.	8792.
1983	2864.	1948.	3432.	0.	249.	352.	0.	0.	0.	0.	0.	0.	0.	8845.
1984	2927.	1948.	3432.	0.	249.	352.	0.	0.	0.	0.	0.	0.	0.	8908.
1985	2985.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9278.
1986	3051.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9344.
1987	3127.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9420.
1988	3205.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9498.
1989	3286.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9579.
1990	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
1991	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
1992	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
1993	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
1994	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
1995	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
1996	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
1997	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
1998	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
1999	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
2000	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
2001	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
2002	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
2003	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
2004	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.
2005	3377.	1948.	3432.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	9670.

P. C. K. K. ELECT. COMP. DEPT.　　AMORTIZATION SCHEDULE　　JOB BANGKOK SEPARATE SYSTEM

YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
2006	3377.	1948.	0.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	6238.
2007	3377.	1948.	0.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	6238.
2008	3377.	1948.	0.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	6238.
2009	3377.	1948.	0.	0.	287.	626.	0.	0.	0.	0.	0.	0.	0.	6238.
2010	3377.	1948.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	5612.
2011	3377.	1948.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	5612.
2012	3377.	1948.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	5612.
2013	3377.	1948.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	5612.
2014	3377.	1948.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	5612.
2015	3377.	1948.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	5612.
2016	3377.	0.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	3663.
2017	3377.	0.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	3663.
2018	3377.	0.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	3663.
2019	3377.	0.	0.	0.	287.	0.	0.	0.	0.	0.	0.	0.	0.	3663.
2020	3377.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3377.

P. C. K. K. ELECTR. COMP. DEPT.   AMORTIZATION SCHEDULE   JOB BANGKOK SEPARATE SYSTEM

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*                WATER RATE        *
*  CASE - 2 :       3.0            *
*            (CHARGE / M**3)       *
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	INTEREST	(1)	(2)
(A) :	6.00 :	5	35 :
(B) :	3.35 :	5	25 :
(C) :	0. :	0	0 :
	(PERCENT)	(YEAR)	

(1) = THE TERM OF LOAN

(2) = THE TERM OF PAYMENT

(UNIT : 1000)

YEAR	(A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
1976	28247.	57493.	0.	0.	0.	3621.	3621.	-3621.	-3621.
1977	0.	0.	0.	2931.	1636.	3621.	5257.	-2326.	-5947.
1978	0.	0.	0.	3198.	1676.	3621.	5297.	-2099.	-8046.
1979	0.	0.	0.	3473.	1718.	3621.	5338.	-1865.	-9911.
1980	4155.	10495.	0.	3758.	1760.	4222.	5982.	-2224.	-12135.
1981	0.	0.	0.	4052.	2758.	5981.	8739.	-4687.	-16822.
1982	0.	0.	0.	4400.	2811.	5981.	8792.	-4391.	-21214.
1983	0.	0.	0.	4760.	2864.	5981.	8845.	-4086.	-25300.
1984	0.	0.	0.	5177.	2927.	5981.	8908.	-3731.	-29031.
1985	0.	0.	0.	5560.	2985.	6293.	9278.	-3718.	-32748.
1986.	0.	0.	0.	6003.	3051.	6293.	9344.	-3341.	-36089.
1987	0.	0.	0.	6509.	3127.	6293.	9420.	-2911.	-39000.
1988	0.	0.	0.	7031.	3205.	6293.	9498.	-2467.	-41467.
1989	0.	0.	0.	7569.	3286.	6293.	9579.	-2010.	-43477.
1990	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-44972.
1991	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-46468.
1992	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-47963.
1993	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-49458.
1994	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-50953.
1995	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-52448.
1996	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-53943.
1997	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-55438.
1998	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-56934.
1999	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-58429.
2000	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-59924.
2001	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-61419.
2002	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-62914.
2003	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-64409.
2004	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-65905.
2005	0.	0.	0.	8175.	3377.	6293.	9670.	-1495.	-67400.
2006	0.	0.	0.	8175.	3377.	2861.	6238.	1937.	-65463.
2007	0.	0.	0.	8175.	3377.	2861.	6238.	1937.	-63526.
2008	0.	0.	0.	8175.	3377.	2861.	6238.	1937.	-61590.
2009	0.	0.	0.	8175.	3377.	2861.	6238.	1937.	-59653.
2010	0.	0.	0.	8175.	3377.	2235.	5612.	2563.	-57090.
2011	0.	0.	0.	8175.	3377.	2235.	5612.	2563.	-54527.
2012	0.	0.	0.	8175.	3377.	2235.	5612.	2563.	-51964.
2013	0.	0.	0.	8175.	3377.	2235.	5612.	2563.	-49401.
2014	0.	0.	0.	8175.	3377.	2235.	5612.	2563.	-46838.
2015	0.	0.	0.	8175.	3377.	2235.	5612.	2563.	-44275.
2016	0.	0.	0.	8175.	3377.	287.	3663.	4511.	-39763.
2017	0.	0.	0.	8175.	3377.	287.	3663.	4511.	-35252.
2018	0.	0.	0.	8175.	3377.	287.	3663.	4511.	-30740.
2019	0.	0.	0.	8175.	3377.	287.	3663.	4511.	-26229.
2020	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-21413.
2021	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-16633.

P. C. K. K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

(UNIT : 1000)

YEAR	(A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
2022	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-11835.
2023	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-7037.
2024	0.	0.	0.	8175.	3377.	0.	3377.	4798.	-2239.
2025	0.	0.	0.	8175.	3377.	0.	3377.	4798.	2559.

CASE 3

In Case of 50 % Government Subsidy

P. C. K. K. ELECT. COMP. DEPT.　　AMORTIZATION SCHEDULE　　JOB BANGKOK SEPARATE SYSTEM

********** EXPENDITURE **********

(1) MANAGEMENT
(2) AMORTIZATION FOR ( )
(3) TOTAL

INTEREST (PERCENT)		** A ** - 6.00	** B ** - 3.350	** C ** - 0.
BORROWING	1976	20176500.00	41066500.000	0.
	1980	2968000.00	7496500.000	0.
	0	0	0	0.
	0	0	0	0.

YEAR	(1)	(2) - (EMERGENCY) A	B	C	(2) - (1ST) A	B	C	(2) - (2ND) A	B	C	(2) - (3RD) A	B	C	(3)
1976	0.	1211.	1376.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2586.
1977	1636.	1211.	1376.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4223.
1978	1676.	1211.	1376.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4263.
1979	1718.	1211.	1376.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4304.
1980	1760.	1211.	1376.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4776.
1981	2758.	1392.	2451.	0.	178.	251.	0.	0.	0.	0.	0.	0.	0.	7030.
1982	2811.	1392.	2451.	0.	178.	251.	0.	0.	0.	0.	0.	0.	0.	7083.
1983	2864.	1392.	2451.	0.	178.	251.	0.	0.	0.	0.	0.	0.	0.	7137.
1984	2927.	1392.	2451.	0.	178.	251.	0.	0.	0.	0.	0.	0.	0.	7199.
1985	2985.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7480.
1986	3051.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7546.
1987	3127.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7622.
1988	3205.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7700.
1989	3286.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7781.
1990	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
1991	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
1992	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
1993	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
1994	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
1995	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
1996	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
1997	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
1998	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
1999	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
2000	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
2001	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
2002	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
2003	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
2004	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.
2005	3377.	1392.	2451.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	7872.

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

YEAR	(1)	(2) - (EMERGENCY) A	B	C	(2) - (1ST) A	B	C	(2) - (2ND) A	B	C	(2) - (3RD) A	B	C	(3)
2006	3377.	1392.	0.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	5421.
2007	3377.	1392.	0.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	5421.
2008	3377.	1392.	0.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	5421.
2009	3377.	1392.	0.	0.	205.	447.	0.	0.	0.	0.	0.	0.	0.	5421.
2010	3377.	1392.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	4973.
2011	3377.	1392.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	4973.
2012	3377.	1392.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	4973.
2013	3377.	1392.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	4973.
2014	3377.	1392.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	4973.
2015	3377.	1392.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	4973.
2016	3377.	0.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	3581.
2017	3377.	0.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	3581.
2018	3377.	0.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	3581.
2019	3377.	0.	0.	0.	205.	0.	0.	0.	0.	0.	0.	0.	0.	3581.
2020	3377.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3377.

P. C. K. K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

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*                WATER RATE        *
*   CASE - 3 :      3.0            *
*              (CHARGE / M**3)     *
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	INTEREST	(1)	(2)
(A) :	6.00 :	5	35 :
(B) :	3.35 :	5	25 :
(C) :	0. :	0	0 :
	(PERCENT)	(YEAR)	

(1) = THE TERM OF LOAN

(2) = THE TERM OF PAYMENT

(UNIT : 1000)

YEAR	BORROWING (A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
1976	20177.	41067.	0.	0.	0.	2586.	2586.	-2586.	-2586.
1977	0.	0.	0.	2931.	1636.	2586.	4223.	-1291.	-3878.
1978	0.	0.	0.	3198.	1676.	2586.	4263.	-1065.	-4942.
1979	0.	0.	0.	3473.	1718.	2586.	4304.	-831.	-5773.
1980	2968.	7497.	0.	3758.	1760.	3016.	4776.	-1018.	-6791.
1981	0.	0.	0.	4052.	2758.	4272.	7030.	-2978.	-9769.
1982	0.	0.	0.	4400.	2811.	4272.	7083.	-2683.	-12452.
1983	0.	0.	0.	4760.	2864.	4272.	7137.	-2377.	-14829.
1984	0.	0.	0.	5177.	2927.	4272.	7199.	-2023.	-16851.
1985	0.	0.	0.	5560.	2985.	4495.	7480.	-1920.	-18771.
1986	0.	0.	0.	6003.	3051.	4495.	7546.	-1543.	-20313.
1987	0.	0.	0.	6509.	3127.	4495.	7622.	-1113.	-21426.
1988	0.	0.	0.	7031.	3205.	4495.	7700.	-669.	-22095.
1989	0.	0.	0.	7569.	3286.	4495.	7781.	-212.	-22307.
1990	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-22004.
1991	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-21702.
1992	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-21399.
1993	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-21096.
1994	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-20793.
1995	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-20490.
1996	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-20187.
1997	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-19884.
1998	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-19581.
1999	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-19278.
2000	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-18975.
2001	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-18673.
2002	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-18370.
2003	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-18067.
2004	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-17764.
2005	0.	0.	0.	8175.	3377.	4495.	7872.	303.	-17461.
2006	0.	0.	0.	8175.	3377.	2044.	5421.	2754.	-14707.
2007	0.	0.	0.	8175.	3377.	2044.	5421.	2754.	-11953.
2008	0.	0.	0.	8175.	3377.	2044.	5421.	2754.	-9198.
2009	0.	0.	0.	8175.	3377.	2044.	5421.	2754.	-6444.
2010	0.	0.	0.	8175.	3377.	1596.	4973.	3202.	-3243.
2011	0.	0.	0.	8175.	3377.	1596.	4973.	3202.	-41.
2012	0.	0.	0.	8175.	3377.	1596.	4973.	3202.	3161.
2013	0.	0.	0.	8175.	3377.	1596.	4973.	3202.	6362.
2014	0.	0.	0.	8175.	3377.	1596.	4973.	3202.	9564.
2015	0.	0.	0.	8175.	3377.	1596.	4973.	3202.	12766.
2016	0.	0.	0.	8175.	3377.	205.	3581.	4593.	17359.
2017	0.	0.	0.	8175.	3377.	205.	3581.	4593	21952.
2018	0.	0.	0.	8175.	3377.	205.	3581.	4593	26545.
2019	0.	0.	0.	8175.	3377.	205.	3581.	4593.	31139.

2. LAT KRABANG AREA

BASIC DATA

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

********** EFFECTIVE RATE OF WATER SUPPLY **********

(1)	POPULATION		PERSON
(2)	HOUSE CONNECTION		PERCENT
(3)	MAX. DAILY DEMAND PER CAPITA		L / C * D
(4)	MAX. DAILY DEMAND		M**3 / D
(5)	AVERAGE DEMAND	1.50	M**3 / D
(6)	AVERAGE DEMAND		M**3 / YR.
(7)	EFFECTIVE RATIO		PERCENT
(8)	EFFECTIVE QUANTITY FOR REVENUE		M**3 / YR.

YEAR	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1974	0.	0.	0.	0.	0.	0.	0.	0.
1975	18282.0	62.5	182.5	2085.3	1390.2	507420.7	75.0	380565.5
1976	19350.0	63.0	184.0	2243.1	1495.4	545809.3	75.0	409357.0
1977	20420.0	63.5	185.5	2405.3	1603.5	585295.2	75.0	438971.4
1978	21488.0	64.0	187.0	2571.7	1714.5	625776.4	75.0	469332.3
1979	22557.0	64.5	188.5	2742.5	1828.4	667350.5	75.0	500512.9
1980	23625.0	65.0	190.0	2917.7	1945.1	709970.6	75.0	532478.0
1981	24694.0	65.5	191.5	3097.4	2065.0	753708.0	75.0	565281.0
1982	25763.0	66.0	193.0	3281.7	2187.8	798544.3	75.0	598908.6
1983	26832.0	66.5	194.5	3470.5	2313.7	844492.7	75.0	633369.5
1984	27901.0	67.0	196.0	3664.0	2442.6	891563.4	75.0	668672.6
1985	28969.0	67.5	197.5	3861.9	2574.6	939736.3	75.0	704802.2

P.C.K.K. ELECT. COMP. DEPT.　　AMORTIZATION SCHEDULE　　JOB BANGKOK SEPARATE SYSTEM

********** COST OF MAINTENANCE AND MANAGEMENT **********

(1) AVERAGE DEMAND
(2) MAINTENANCE EXPENDITURE
(3) REPAIR EXPENDITURE
(4) CHEMICAL COST
(5) SLUDGE TREATMENT COST
(6) OTHERS
(7) PERSONNEL EXPENDITURE
(8) GENERAL MANAGEMENT
(9) POWER COST

UNIT (1000)

YEAR	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	TOTAL
1974	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1975	507.	30.	15.	126.	0.	0.	50.	10.	454.	685.
1976	546.	33.	16.	135.	0.	0.	50.	10.	454.	698.
1977	585.	35.	18.	145.	0.	0.	50.	10.	454.	711.
1978	626.	38.	19.	155.	0.	0.	108.	22.	460.	801.
1979	667.	40.	20.	165.	0.	0.	108.	22.	460.	815.
1980	710.	43.	21.	176.	0.	0.	108.	22.	460.	829.
1981	754.	45.	23.	187.	0.	0.	108.	22.	460.	844.
1982	799.	48.	24.	198.	0.	0.	108.	22.	460.	859.
1983	844.	51.	25.	209.	0.	0.	108.	22.	460.	875.
1984	892.	53.	27.	221.	0.	0.	108.	22.	460.	890.
1985	940.	56.	28.	233.	0.	0.	108.	22.	460.	907.

SETTLEMENT OF ACCOUNTS

CASE 1

In Case without Government Subsidy

P. C. K. K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

********** EXPENDITURE **********

(1) MANAGEMENT
(2) AMORTIZATION FOR ( )
(3) TOTAL

		** A **	** B **	** C **
INTEREST (PERCENT)		6.000	3.250	0.
BORROWING	1974	1672000.000	1598000.000	0.
	1977	10445000.000	18704000.000	0.
	0	0.	0.	0.
	0	0.	0.	0.

YEAR	(1)	(2) - (EMERGENCY) A	B	C	(2) - (1ST) A	B	C	(2) - (2ND) A	B	C	(2) - (3RD) A	B	C	(3)
1974	0.	100.	52.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	152.
1975	685.	100.	52.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	837.
1976	698.	100.	52.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	850.
1977	711.	100.	52.	0.	627.	608.	0.	0.	0.	0.	0.	0.	0.	2098.
1978	801.	100.	52.	0.	627.	608.	0.	0.	0.	0.	0.	0.	0.	2188.
1979	815.	115.	94.	0.	627.	608.	0.	0.	0.	0.	0.	0.	0.	2259.
1980	829.	115.	94.	0.	627.	608.	0.	0.	0.	0.	0.	0.	0.	2273.
1981	844.	115.	94.	0.	627.	608.	0.	0.	0.	0.	0.	0.	0.	2288.
1982	859.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2893.
1983	875.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2909.
1984	890.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2925.
1985	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1986	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1987	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1988	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1989	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1990	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1991	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1992	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1993	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1994	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1995	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1996	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1997	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1998	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
1999	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
2000	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
2001	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
2002	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.
2003	907.	115.	94.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2941.

P. C. K. K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
2004	907.	115.	0.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2847.
2005	907.	115.	0.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2847.
2006	907.	115.	0.	0.	720.	1104.	0.	0.	0.	0.	0.	0.	0.	2847.
2007	907.	115.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1742
2008	907.	115.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1742.
2009	907.	115.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1742.
2010	907.	115.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1742.
2011	907.	115.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1742.
2012	907.	115.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1742.
2013	907.	115.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1742.
2014	907.	0.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1627.
2015	907.	0.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1627.
2016	907.	0.	0.	0.	720.	0.	0.	0.	0.	0.	0.	0.	0.	1627.
2017	907.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	907.

P. C. K. K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

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************************************
*               WATER RATE         *
*  CASE - 1 :      3.0             *
*            (CHARGE / M**3)       *
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	INTEREST	(1)	(2)
(A) :	6.00 :	5	35 :
(B) :	3.25 :	5	25 :
(C) :	0. :	0	0 :
	(PERCENT)	(YEAR)	

(1) = THE TERM OF LOAN

(2) = THE TERM OF PAYMENT

(UNIT : 1000)

YEAR	BORROWING (A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	EXPENDITURE TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
1974	1672.	1598.	0.	0.	0.	152.	152.	-152.	-152.
1975	0.	0.	0.	1142.	685.	152.	837.	304.	152.
1976	0.	0.	0.	1228.	698.	152.	850.	378.	530.
1977	10445.	18704.	0.	1317.	711.	1387.	2098.	-781.	-251.
1978	0.	0.	0.	1408.	801.	1387.	2188.	-780.	-1031.
1979	0.	0.	0.	1502.	815.	1444.	2259.	-757.	-1788.
1980	0.	0.	0.	1597.	829.	1444.	2273.	-676.	-2464.
1981	0.	0.	0.	1696.	844.	1444.	2288.	-592.	-3056.
1982	0.	0.	0.	1797.	859.	2034.	2893.	-1097.	-4153.
1983	0.	0.	0.	1900.	875.	2034.	2909.	-1009.	-5162.
1984	0.	0.	0.	2006.	890.	2034.	2925.	-919.	-6081.
1985	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-6907.
1986	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-7734.
1987	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-8560.
1988	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-9387.
1989	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-10214.
1990	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-11040.
1991	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-11867.
1992	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-12694.
1993	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-13520.
1994	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-14347.
1995	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-15174.
1996	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-16000.
1997	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-16827.
1998	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-17653.
1999	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-18480.
2000	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-19307.
2001	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-20133.
2002	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-20960.
2003	0.	0.	0.	2114.	907.	2034.	2941.	-827.	-21787.
2004	0.	0.	0.	2114.	907.	1940.	2847.	-732.	-22519.
2005	0.	0.	0.	2114.	907.	1940.	2847.	-732.	-23251.
2006	0.	0.	0.	2114.	907.	1940.	2847.	-732.	-23983.
2007	0.	0.	0.	2114.	907.	836.	1742.	372.	-23611.
2008	0.	0.	0.	2114.	907.	836.	1742.	372.	-23239.
2009	0.	0.	0.	2114.	907.	836.	1742.	372.	-22867.
2010	0.	0.	0.	2114.	907.	836.	1742.	372.	-22495.
2011	0.	0.	0.	2114.	907.	836.	1742.	372.	-22123.
2012	0.	0.	0.	2114.	907.	836.	1742.	372.	-21751.
2013	0.	0.	0.	2114.	907.	836.	1742.	372.	-21379.
2014	0.	0.	0.	2114.	907.	720.	1627.	487.	-20892.
2015	0.	0.	0.	2114.	907.	720.	1627.	487.	-20405.
2016	0.	0.	0.	2114.	907.	720.	1627.	487.	-19918.
2017	0.	0.	0.	2114.	907.	0.	907.	1208.	-18710.
2018	0.	0.	0.	2114.	907.	0.	907.	1208.	-17502.
2019	0.	0.	0.	2114.	907.	0.	907.	1208.	-16294.

P.C.K.K. ELECT. COMP. DEPT.   AMORTIZATION SCHEDULE   JOB BANGKOK SEPARATE SYSTEM

(UNIT : 1000)

YEAR	(A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
2020	0.	0.	0.	2114.	907.	0.	907.	1208.	-15807.
2021	0.	0.	0.	2114.	907.	0.	907.	1208.	-13879.
2022	0.	0.	0.	2114.	907.	0.	907.	1208.	-12671.
2023	0.	0.	0.	2114.	907.	0.	907.	1208.	-11463.
2024	0.	0.	0.	2114.	907.	0.	907.	1208.	-10256.
2025	0.	0.	0.	2114.	907.	0.	907.	1208.	-9048.
2026	0.	0.	0.	2114.	907.	0.	907.	1208.	-7840.

CASE 2

In Case of 30 % Government Subsidy

P.C.K.K. ELECT. COMP. DEPT.   AMORTIZATION SCHEDULE   JOB BANGKOK SEPARATE SYSTEM

********** EXPENDITURE **********

(1) MANAGEMENT
(2) AMORTIZATION FOR ( )
(3) TOTAL

		** A ** - 6.000	** B ** - 3.250	** C ** - 0.
INTEREST (PERCENT)				
BORROWING	1974	1170400.000	1118600.000	0.
	1977	7311500.000	13092800.000	0.
	0	0.	0.	0.
	0	0.	0.	0.

YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
1974	0.	70.	36.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	107.
1975	685.	70.	36.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	792.
1976	698.	70.	36.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	805.
1977	711.	70.	36.	0.	439.	426.	0.	0.	0.	0.	0.	0.	0.	1682.
1978	801.	70.	36.	0.	439.	426.	0.	0.	0.	0.	0.	0.	0.	1771.
1979	815.	81.	66.	0.	439.	426.	0.	0.	0.	0.	0.	0.	0.	1826.
1980	829.	81.	66.	0.	439.	426.	0.	0.	0.	0.	0.	0.	0.	1840.
1981	844.	81.	66.	0.	439.	426.	0.	0.	0.	0.	0.	0.	0.	1855.
1982	859.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2283.
1983	875.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2299.
1984	890.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2314.
1985	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1986	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1987	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1988	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1989	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1990	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1991	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1992	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1993	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1994	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1995	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1996	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1997	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1998	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
1999	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
2000	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
2001	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
2002	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.
2003	907.	81.	66.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2331.

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YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
2004	907.	81.	0.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2265.
2005	907.	81.	0.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2265.
2006	907.	81.	0.	0.	504.	773.	0.	0.	0.	0.	0.	0.	0.	2265.
2007	907.	81.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1492.
2008	907.	81.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1492.
2009	907.	81.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1492.
2010	907.	81.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1492.
2011	907.	81.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1492.
2012	907.	81.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1492.
2013	907.	81.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1492.
2014	907.	0.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1411.
2015	907.	0.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1411.
2016	907.	0.	0.	0.	504.	0.	0.	0.	0.	0.	0.	0.	0.	1411.
2017	907.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	907.

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

CASE - 2 : WATER RATE 3.0 (CHARGE / M**3)		INTEREST (PERCENT)	(1) (YEAR)	(2) (YEAR)
	(A) :	6.00	5	35
	(B) :	3.25	5	25
	(C) :	0.	0	0

(1) = THE TERM OF LOAN
(2) = THE TERM OF PAYMENT

(UNIT : 1000)

YEAR	BORROWING (A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	EXPENDITURE TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
1974	1170.	1119.	0.	0.	0.	107.	107.	-107.	-107.
1975	0.	0.	0.	1142.	685.	107.	792.	350.	244.
1976	0.	0.	0.	1228.	698.	107.	805.	424.	667.
1977	7312.	13093.	0.	1317.	711.	971.	1682.	-365.	302.
1978	0.	0.	0.	1408.	801.	971.	1771.	-363.	-62.
1979	0.	0.	0.	1502.	815.	1011.	1826.	-324.	-386.
1980	0.	0.	0.	1597.	829.	1011.	1840.	-243.	-628.
1981	0.	0.	0.	1696.	844.	1011.	1855.	-159.	-787.
1982	0.	0.	0.	1797.	859.	1424.	2283.	-486.	-1274.
1983	0.	0.	0.	1900.	875.	1424.	2299.	-398.	-1672.
1984	0.	0.	0.	2006.	890.	1424.	2314.	-308.	-1981.
1985	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-2197.
1986	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-2413.
1987	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-2630.
1988	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-2846.
1989	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-3062.
1990	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-3279.
1991	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-3495.
1992	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-3711.
1993	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-3928.
1994	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-4144.
1995	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-4360.
1996	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-4577.
1997	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-4793.
1998	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-5009.
1999	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-5225.
2000	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-5442.
2001	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-5658.
2002	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-5874.
2003	0.	0.	0.	2114.	907.	1424.	2331.	-216.	-6091.
2004	0.	0.	0.	2114.	907.	1358.	2265.	-150.	-6241.
2005	0.	0.	0.	2114.	907.	1358.	2265.	-150.	-6391.
2006	0.	0.	0.	2114.	907.	1358.	2265.	-150.	-6542.
2007	0.	0.	0.	2114.	907.	585.	1492.	623.	-5919.
2008	0.	0.	0.	2114.	907.	585.	1492.	623.	-5296.
2009	0.	0.	0.	2114.	907.	585.	1492.	623.	-4673.
2010	0.	0.	0.	2114.	907.	585.	1492.	623.	-4051.
2011	0.	0.	0.	2114.	907.	585.	1492.	623.	-3428.
2012	0.	0.	0.	2114.	907.	585.	1492.	623.	-2805.
2013	0.	0.	0.	2114.	907.	585.	1492.	623.	-2183.
2014	0.	0.	0.	2114.	907.	504.	1411.	703.	-1479.
2015	0.	0.	0.	2114.	907.	504.	1411.	703.	-776.
2016	0.	0.	0.	2114.	907.	504.	1411.	703.	-72.
2017	0.	0.	0.	2114.	907.	0.	907.	1208.	1136.

CASE 3

In Case of 50 % Government Subsidy

P.C.K.K. ELECT. COMP. DEPT.   AMORTIZATION SCHEDULE   JOB BANGKOK SEPARATE SYSTEM

********** EXPENDITURE **********

(1) MANAGEMENT
(2) AMORTIZATION FOR ( )
(3) TOTAL

INTEREST (PERCENT)	** A ** - 6.000	** B ** - 3.250	** C ** - 0.
BORROWING			
1974	836000.000	799000.000	0.
1977	5222500.000	9352000.000	0.
0	0.	0.	0.
0	0.	0.	0.

YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
1974	0.	50.	26.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	76.
1975	685.	50.	26.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	761.
1976	698.	50.	26.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	774.
1977	711.	50.	26.	0.	313.	304.	0.	0.	0.	0.	0.	0.	0.	1405.
1978	801.	50.	26.	0.	313.	304.	0.	0.	0.	0.	0.	0.	0.	1494.
1979	815.	58.	47.	0.	313.	304.	0.	0.	0.	0.	0.	0.	0.	1537.
1980	829.	58.	47.	0.	313.	304.	0.	0.	0.	0.	0.	0.	0.	1551.
1981	844.	58.	47.	0.	313.	304.	0.	0.	0.	0.	0.	0.	0.	1566.
1982	859.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1876.
1983	875.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1892.
1984	890.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1908.
1985	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1986	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1987	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1988	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1989	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1990	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1991	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1992	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1993	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1994	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1995	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1996	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1997	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1998	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
1999	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
2000	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
2001	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
2002	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.
2003	907.	58.	47.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1924.

P.C.K.K. ELECT. COMP. DEPT.   AMORTIZATION SCHEDULE   JOB BANGKOK SEPARATE SYSTEM

YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
2004	907.	58.	0.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1877.
2005	907.	58.	0.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1877.
2006	907.	58.	0.	0.	360.	552.	0.	0.	0.	0.	0.	0.	0.	1877.
2007	907.	58.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1325.
2008	907.	58.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1325.
2009	907.	58.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1325.
2010	907.	58.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1325.
2011	907.	58.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1325.
2012	907.	58.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1325.
2013	907.	58.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1325.
2014	907.	0.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1267.
2015	907.	0.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1267.
2016	907.	0.	0.	0.	360.	0.	0.	0.	0.	0.	0.	0.	0.	1267.
2017	907.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	907.

P. C. K. K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

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**************************************
*            WATER RATE              *
* CASE - 3 :    3.0                  *
*          (CHARGE / M**3)           *
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	INTEREST	(1)	(2)	
(A) :	6.00 :	5	35 :	(1) = THE TERM OF LOAN
(B) :	3.25 :	5	25 :	(2) = THE TERM OF PAYMENT
(C) :	0. :	0	0 :	
	(PERCENT)	(YEAR)		

(UNIT : 1000)

YEAR	BORROWING			INCOME	EXPENDITURE			BALANCE	
	(A)	(B)	(C)	WATER CHARGE	MANAGEMENT	AMORTIZATION	TOTAL	PER YEAR	ACCUMULATION
1974	836.	799.	0.	0.	0.	76.	76.	-76.	-76.
1975	0.	0.	0.	1142.	685.	76.	761.	381.	304.
1976	0.	0.	0.	1228.	698.	76.	774.	454.	758.
1977	5223.	9352.	0.	1317.	711.	693.	1405.	-88.	671.
1978	0.	0.	0.	1408.	801.	693.	1494.	-86.	584.
1979	0.	0.	0.	1502.	815.	722.	1537.	-35.	549.
1980	0.	0.	0.	1597.	829.	722.	1551.	46.	595.
1981	0.	0.	0.	1696.	844.	722.	1566.	130.	725.
1982	0.	0.	0.	1797.	859.	1017.	1876.	-79.	646.
1983	0.	0.	0.	1900.	875.	1017.	1892.	8.	654.
1984	0.	0.	0.	2006.	890.	1017.	1908.	98.	753.
1985	0.	0.	0.	2114.	907.	1017.	1924.	191.	943.
1986	0.	0.	0.	2114.	907.	1017.	1924.	191.	1134.
1987	0.	0.	0.	2114.	907.	1017.	1924.	191.	1324.
1988	0.	0.	0.	2114.	907.	1017.	1924.	191.	1515.
1989	0.	0.	0.	2114.	907.	1017.	1924.	191.	1705.
1990	0.	0.	0.	2114.	907.	1017.	1924.	191.	1896.
1991	0.	0.	0.	2114.	907.	1017.	1924.	191.	2086.
1992	0.	0.	0.	2114.	907.	1017.	1924.	191.	2277.
1993	0.	0.	0.	2114.	907.	1017.	1924.	191.	2468.
1994	0.	0.	0.	2114.	907.	1017.	1924.	191.	2658.
1995	0.	0.	0.	2114.	907.	1017.	1924.	191.	2849.
1996	0.	0.	0.	2114.	907.	1017.	1924.	191.	3039.
1997	0.	0.	0.	2114.	907.	1017.	1924.	191.	3230.
1998	0.	0.	0.	2114.	907.	1017.	1924.	191.	3420.
1999	0.	0.	0.	2114.	907.	1017.	1924.	191.	3611.
2000	0.	0.	0.	2114.	907.	1017.	1924.	191.	3801.
2001	0.	0.	0.	2114.	907.	1017.	1924.	191.	3992.
2002	0.	0.	0.	2114.	907.	1017.	1924.	191.	4183.
2003	0.	0.	0.	2114.	907.	1017.	1924.	191.	4373.
2004	0.	0.	0.	2114.	907.	970.	1877.	238.	4611.
2005	0.	0.	0.	2114.	907.	970.	1877.	238.	4849.
2006	0.	0.	0.	2114.	907.	970.	1877.	238.	5086.
2007	0.	0.	0.	2114.	907.	418.	1325.	790.	5876.
2008	0.	0.	0.	2114.	907.	418.	1325.	790.	6666.
2009	0.	0.	0.	2114.	907.	418.	1325.	790.	7456.
2010	0.	0.	0.	2114.	907.	418.	1325.	790.	8246.
2011	0.	0.	0.	2114.	907.	418.	1325.	790.	9036.
2012	0.	0.	0.	2114.	907.	418.	1325.	790.	9826.
2013	0.	0.	0.	2114.	907.	418.	1325.	790.	10615.
2014	0.	0.	0.	2114.	907.	360.	1267.	848.	11463.
2015	0.	0.	0.	2114.	907.	360.	1267.	848.	12310.
2016	0.	0.	0.	2114.	907.	360.	1267.	848.	13158.

3. BANG BUA THONG, BANG YAI & SAI NOI AREA

BASIC DATA

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

********** EFFECTIVE RATE OF WATER SUPPLY ********** .

(1)	POPULATION.		PERSON
(2)	HOUSE CONNECTION		PERCENT
(3)	MAX. DAILY DEMAND PER CAPITA		L / C * D
(4)	MAX. DAILY DEMAND		M**3 / D
(5)	AVERAGE DEMAND	1.50	M**3 / D
(6)	AVERAGE DEMAND		M**3 / YR.
(7)	EFFECTIVE RATIO		PERCENT
(8)	EFFECTIVE QUANTITY FOR REVENUE		M**3 / YR.

YEAR	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1974	0.	0.	0.	0.	0.	0.	0.	0.
1975	19726.0	62.5	182.5	2250.0	1500.0	547499.2	75.0	410624.4
1976	21617.0	63.0	184.0	2505.8	1670.6	609755.0	75.0	457316.3
1977	23508.0	63.5	185.5	2769.1	1846.0	673806.1	75.0	505354.6
1978	25399.0	64.0	187.0	3039.8	2026.5	739673.1	75.0	504754.8
1979	27290.0	64.5	188.5	3318.0	2212.0	807376.7	75.0	605532.5
1980	29181.0	65.0	190.0	3603.9	2402.6	876937.7	75.0	657703.3
1981	31072.0	65.5	191.5	3897.4	2598.3	948376.7	75.0	711282.6
1982	32963.0	66.0	193.0	4198.8	2799.2	1021714.6	75.0	766285.9
1983	34854.0	66.5	194.5	4508.1	3005.4	1096971.9	75.0	822728.9
1984	36745.0	67.0	196.0	4825.4	3216.9	1174169.3	75.0	880627.0
1985	38636.0	67.5	197.5	5150.7	3433.8	1253327.7	75.0	939995.8
1986	40526.0	68.0	199.0	5484.0	3656.0	1334434.7	75.0	1000826.0
1987	42417.0	68.5	200.5	5825.7	3883.8	1417576.5	75.0	1063182.4

P.C.K.K. ELECT. COMP. DEPT.   AMORTIZATION SCHEDULE   JOB BANGKOK SEPARATE SYSTEM

********** COST OF MAINTENANCE AND MANAGEMENT **********

(1) AVERAGE DEMAND
(2) MAINTENANCE EXPENDITURE
(3) REPAIR EXPENDITURE
(4) CHEMICAL COST
(5) SLUDGE TREATMENT COST
(6) OTHERS
(7) PERSONNEL EXPENDITURE
(8) GENERAL MANAGEMENT
(9) POWER COST
UNIT (1000)

YEAR	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	TOTAL
1974	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1975	547.	33.	16.	136.	0.	0.	50.	10.	460.	705.
1976	610.	37.	18.	151.	0.	0.	50.	10.	460.	726.
1977	674.	40.	20.	167.	0.	0.	108.	22.	579.	936.
1978	740.	44.	22.	183.	0.	0.	108.	22.	579.	959.
1979	807.	48.	24.	200.	0.	0.	108.	22.	579.	982.
1980	877.	53.	26.	217.	0.	0.	108.	22.	579.	1005.
1981	948.	57.	28.	235.	0.	0.	108.	22.	579.	1029.
1982	1022.	61.	31.	253.	0.	0.	108.	22.	579.	1054.
1983	1097.	66.	33.	272.	0.	0.	108.	22.	579.	1079.
1984	1174.	70.	35.	291.	0.	0.	108.	22.	579.	1105.
1985	1253.	75.	38.	310.	0.	0.	108.	22.	579.	1132.
1986	1334.	80.	40.	330.	0.	0.	108.	22.	579.	1159.
1987	1418.	85.	43.	351.	0.	0.	108.	22.	579.	1188.

SETTLEMENT OF ACCOUNTS

CASE 1

In Case without Government Subsidy

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

********** EXPENDITURE **********

(1) MANAGEMENT
(2) AMORTIZATION FOR ( )
(3) TOTAL

INTEREST (PERCENT)	** A ** - 6.000	** B ** - 3.250	** C ** - 0.
BORROWING			
1974	9731000.000	3260000.000	0.
1976	13098000.000	29299000.000	0.
0	0.	0.	0.
0	0.	0.	0.

YEAR	(1)	(2) - (EMERGENCY) A	B	C	(2) - (1ST) A	B	C	(2) - (2ND) A	B	C	(2) - (3RD) A	B	C	(3)
1974	0.	584.	106.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	690.
1975	705.	584.	106.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1394.
1976	726.	584.	106.	0.	786.	952.	0.	0.	0.	0.	0.	0.	0.	3154.
1977	936.	584.	106.	0.	786.	952.	0.	0.	0.	0.	0.	0.	0.	3364.
1978	959.	584.	106.	0.	786.	952.	0.	0.	0.	0.	0.	0.	0.	3387.
1979	982.	671.	192.	0.	786.	952.	0.	0.	0.	0.	0.	0.	0.	3583.
1980	1005.	671.	192.	0.	786.	952.	0.	0.	0.	0.	0.	0.	0.	3607.
1981	1029.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4526.
1982	1054.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4551.
1983	1079.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4576.
1984	1105.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4602.
1985	1132.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4629.
1986	1159.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4656.
1987	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1988	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1989	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1990	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1991	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1992	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1993	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1994	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1995	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	00.	4684.
1996	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1997	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1998	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
1999	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
2000	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
2001	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
2002	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.
2003	1188.	671.	192.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4684.

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

YEAR	(1)	(2) - (EMERGENCY) A	B	C	(2) - (1ST) A	B	C	(2) - (2ND) A	B	C	(2) - (3RD) A	B	C	(3)
2004	1188.	671.	0.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4492.
2005	1188.	671.	0.	0.	903.	1730.	0.	0.	0.	0.	0.	0.	0.	4492.
2006	1188.	671.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2762.
2007	1188.	671.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2762.
2008	1188.	671.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2762.
2009	1188.	671.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2762.
2010	1188.	671.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2762.
2011	1188.	671.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2762.
2012	1188.	671.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2762.
2013	1188.	671.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2762.
2014	1188.	0.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2762.
2015	1188.	0.	0.	0.	903.	0.	0.	0.	0.	0.	0.	0.	0.	2091.
2016	1188.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2091.

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

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*********************************
*              WATER RATE        *     (A) :   6.00  :   5  35  :     (1) = THE TERM OF LOAN
*  CASE - 1 :     3.0            *     (B) :   3.25  :   5  25  :
*           (CHARGE / M**3)      *     (C) :   0.    :   0   0  :     (2) = THE TERM OF PAYMENT
*********************************             (PERCENT)   (YEAR)
                                          INTEREST    (1) (2)
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(UNIT : 1000)

YEAR	BORROWING (A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
1974	9731.	3260.	0.	0.	0.	690.	690.	-690.	-690.
1975	0.	0.	0.	1232.	705.	690.	1394.	-163.	-852.
1976	13098.	29299.	0.	1372.	726.	2428.	3154.	-1782.	-2634.
1977	0.	0.	0.	1516.	936.	2428.	3364.	-1848.	-4482.
1978	0.	0.	0.	1664.	959.	2428.	3387.	-1722.	-6205.
1979	0.	0.	0.	1817.	982.	2602.	3583.	-1767.	-7971.
1980	0.	0.	0.	1973.	1005.	2602.	3607.	-1634.	-9605.
1981	0.	0.	0.	2134.	1029.	3497.	4526.	-2392.	-11997.
1982	0.	0.	0.	2299.	1054.	3497.	4551.	-2252.	-14249.
1983	0.	0.	0.	2468.	1079.	3497.	4576.	-2108.	-16357.
1984	0.	0.	0.	2642.	1105.	3497.	4602.	-1960.	-18318.
1985	0.	0.	0.	2820.	1132.	3497.	4629.	-1809.	-20127.
1986	0.	0.	0.	3002.	1159.	3497.	4656.	-1654.	-21780.
1987	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-23275.
1988	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-24770.
1989	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-26265.
1990	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-27760.
1991	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-29254.
1992	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-30749.
1993	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-32244.
1994	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-33739.
1995	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-35234.
1996	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-36729.
1997	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-38223.
1998	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-39718.
1999	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-41213.
2000	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-42708.
2001	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-44203.
2002	0.	0.	0.	3190.	1188.	3497.	4684.	-1495.	-45698.
2003	0.	0.	0.	3190	1188.	3497.	4684.	-1495.	-47192.
2004	0.	0.	0.	3190.	1188.	3304.	4492.	-1302.	-48495.
2005	0.	0.	0.	3190.	1188.	3304.	4492.	-1302.	-49797.
2006	0.	0.	0.	3190.	1188.	1575.	2762.	427.	-49370.
2007	0.	0.	0.	3190.	1188.	1575.	2762.	427.	-48942.
2008	0.	0.	0.	3190.	1188.	1575.	2762.	427.	-48515.
2009	0.	0.	0.	3190.	1188.	1575.	2762.	427.	-48087.
2010	0.	0.	0.	3190.	1188.	1575.	2762.	427.	-47660.
2011	0.	0.	0.	3190.	1188.	1575.	2762.	427.	-47232.
2012	0.	0.	0.	3190.	1188.	1575.	2762.	427.	-46805.
2013	0.	0.	0.	3190.	1188.	1575.	2762.	427.	-46378.
2014	0.	0.	0.	3190.	1188.	903.	2091.	1099.	-45279.
2015	0.	0.	0.	3190.	1188.	903.	2091.	1099.	-44180.
2016	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-42178.
2017	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-40176.
2018	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-38174.
2019	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-36172.

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

(UNIT : 1000)

YEAR	BORROWING (A)	BORROWING (B)	BORROWING (C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
2020	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-34170.
2021	0.	0.	0.	3190	1188.	0.	1188.	2002.	-32168.
2022	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-30166.
2023	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-28164.
2024	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-26162.
2025	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-24160.

CASE 2

In Case 30 % Government Subsidy

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

********** EXPENDITURE **********

(1) MANAGEMENT
(2) AMORTIZATION FOR ( )
(3) TOTAL

		** A ** - 6.000	** B ** - 3.250	** C ** - 0.
INTEREST (PERCENT)				
BORROWING	1974	6811700.000	2282000.000	0.
	1976	9168600.000	20509300.000	0.
	0	0.	0.	0.
	0	0.	0.	0.

YEAR	(1)	(2) - (EMERGENCY) A	B	C	(2) - (1ST) A	B	C	(2) - (2ND) A	B	C	(2) - (3RD) A	B	C	(3)
1974	0.	409.	74.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	483.
1975	705.	409.	74.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1188.
1976	726.	409.	74.	0.	550.	667.	0.	0.	0.	0.	0.	0.	0.	2425.
1977	936.	409.	74.	0.	550.	667.	0.	0.	0.	0.	0.	0.	0.	2636.
1978	959.	409.	74.	0.	550.	667.	0.	0.	0.	0.	0.	0.	0.	2658.
1979	982.	470.	135.	0.	550.	667.	0.	0.	0.	0.	0.	0.	0.	2803.
1980	1005.	470.	135.	0.	550.	667.	0.	0.	0.	0.	0.	0.	0.	2826.
1981	1029.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3477.
1982	1054.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3502.
1983	1079.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3527.
1984	1105.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3553.
1985	1132.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3580.
1986	1159.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3607.
1987	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1988	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1989	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1990	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1991	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1992	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1993	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1994	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1995	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1996	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1997	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1998	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
1999	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
2000	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
2001	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
2002	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.
2003	1188.	470.	135.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3635.

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
2004	1188.	470.	0.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3501.
2005	1188.	470.	0.	0.	632.	1211.	0.	0.	0.	0.	0.	0.	0.	3501.
2006	1188.	470.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	2290.
2007	1188.	470.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	2290.
2008	1188.	470.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	2290.
2009	1188.	470.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	2290.
2010	1188.	470.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	2290.
2011	1188.	470.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	2290.
2012	1188.	470.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	2290.
2013	1188.	470.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	2290.
2014	1188.	0.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	1820.
2015	1188.	0.	0.	0.	632.	0.	0.	0.	0.	0.	0.	0.	0.	1820.
2016	1188.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1188.

P. C. K. K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

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*              WATER RATE             *
* CASE - 2 :      3.0                 *
*            (CHARGE / M**3)          *
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	INTEREST	(1)	(2)
(A) :	6.00 :	5	35 :
(B) :	3.25 :	5	25 :
(C) :	0. :	0	0 :
	(PERCENT)	(YEAR)	

(1) = THE TERM OF LOAN

(2) = THE TERM OF PAYMENT

(UNIT : 1000)

YEAR	BORROWING (A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	EXPENDITURE AMORTIZATION	TOTAL	BALANCE PER YEAR	BALANCE ACCUMULATION
1974	6812.	2282.	0.	0.	0.	483.	483.	-483.	-483.
1975	0.	0.	0.	1232.	705.	483.	1188.	44.	-439.
1976	9169.	20509.	0.	1372.	726.	1700.	2425.	-1053.	-1492.
1977	0.	0.	0.	1516.	936.	1700.	2636.	-1120.	-2612.
1978	0.	0.	0.	1664.	959.	1700.	2658.	-994.	-3606.
1979	0.	0.	0.	1817.	982.	1821.	2803.	-986.	-4592.
1980	0.	0.	0.	1973.	1005.	1821.	2826.	-853.	-5445.
1981	0.	0.	0.	2134.	1029.	2448.	3477.	-1343.	-6788.
1982	0.	0.	0.	2299.	1054.	2448.	3502.	-1203.	-7991.
1983	0.	0.	0.	2468.	1079.	2448.	3527.	-1059.	-9050.
1984	0.	0.	0.	2642.	1105.	2448.	3553.	-911.	-9961.
1985	0.	0.	0.	2820.	1132.	2448.	3580.	-760.	-10721.
1986	0.	0.	0.	3002.	1159.	2448.	3607.	-605.	-11326.
1987	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-11772.
1988	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-12217.
1989	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-12663.
1990	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-13109.
1991	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-13555.
1992	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-14001.
1993	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-14446.
1994	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-14892.
1995	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-15338.
1996	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-15784.
1997	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-16229.
1998	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-16675.
1999	0.	0.	0.	3190.	1188.	2248.	3635.	-446.	-17121.
2000	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-17567.
2001	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-18012.
2002	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-18458.
2003	0.	0.	0.	3190.	1188.	2448.	3635.	-446.	-18904.
2004	0.	0.	0.	3190	1188.	2313	3501.	-311.	-19215.
2005	0.	0.	0.	3190.	1188.	2313.	3501.	-311.	-19526.
2006	0.	0.	0.	3190.	1188.	1102.	2290.	900.	-18626.
2007	0.	0.	0.	3190.	1188.	1102.	2290.	900.	-17726.
2008	0.	0.	0.	3190.	1188.	1102.	2290.	900.	-16827.
2009	0.	0.	0.	3190.	1188.	1102.	2290.	900.	-15927.
2010	0.	0.	0.	3190.	1188.	1102.	2290.	900.	-15027.
2011	0.	0.	0.	3190.	1188.	1102.	2290.	900.	-14127.
2012	0.	0.	0.	3190.	1188.	1102.	2290.	900.	-13227.
2013	0.	0.	0.	3190.	1188.	1102.	2290.	900.	-12327.
2014	0.	0.	0.	3190.	1188.	632.	1820.	1370.	-10958.
2015	0.	0.	0.	3190.	1188.	632.	1820.	1370.	-9588.
2016	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-7586.
2017	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-5584.
2018	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-3582.
2019	0.	0.	0.	3190.	1188.	0.	1188.	2002.	-1580.

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(UNIT : 1000)

YEAR		BORROWING		INCOME	EXPENDITURE			BALANCE	
	(A)	(B)	(C)	WATER CHARGE	MANAGEMENT	AMORTIZATION	TOTAL	PER YEAR	ACCUMULATION
2020	0.	0.	0.	3190.	1188.	0.	1188.	2002.	422.

CASE 3

In Case of 50 % Government Subsidy

P.C.K.K. ELECT. COMP. DEPT.   AMORTIZATION SCHEDULE   JOB BANGKOK SEPARATE SYSTEM

********** EXPENDITURE **********

(1) MANAGEMENT
(2) AMORTIZATION FOR ( )
(3) TOTAL

INTEREST (PERCENT)		** A ** - 6.000	** B ** - 3.250	** C ** - 0.
BORROWING				
	1974	4865500.000	1630000.000	0.
	1976	6549000.000	14649500.000	0.
	0	0.	0.	0.
	0	0.	0.	0.

YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
1974	0.	292.	53.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	345.
1975	705.	292.	53.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1050.
1976	726.	292.	53.	0.	393.	476.	0.	0.	0.	0.	0.	0.	0.	1940.
1977	936.	292.	53.	0.	393.	476.	0.	0.	0.	0.	0.	0.	0.	2150.
1978	959.	292.	53.	0.	393.	476.	0.	0.	0.	0.	0.	0.	0.	2173.
1979	982.	336.	96.	0.	393.	476.	0.	0.	0.	0.	0.	0.	0.	2282.
1980	1005.	336.	96.	0.	393.	476.	0.	0.	0.	0.	0.	0.	0.	2306.
1981	1029.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2778.
1982	1054.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2802.
1983	1079.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2828.
1984	1105.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2854.
1985	1132.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2881.
1986	1159.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2908.
1987	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1988	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1989	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1990	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1991	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1992	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1993	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1994	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1995	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1996	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1997	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1998	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
1999	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
2000	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
2001	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
2002	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.
2003	1188.	336.	96.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2936.

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YEAR	(1)	(2) - (EMERGENCY)			(2) - (1ST)			(2) - (2ND)			(2) - (3RD)			(3)
		A	B	C	A	B	C	A	B	C	A	B	C	
2004	1188.	336.	0.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2840.
2005	1188.	336.	0.	0.	452.	865.	0.	0.	0.	0.	0.	0.	0.	2840.
2006	1188.	336.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1975.
2007	1188.	336.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1975.
2008	1188.	336.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1975.
2009	1188.	336.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1975.
2010	1188.	336.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1975.
2011	1188.	336.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1975.
2012	1188.	336.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1975.
2013	1188.	336.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1975.
2014	1188.	0.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1639.
2015	1188.	0.	0.	0.	452.	0.	0.	0.	0.	0.	0.	0.	0.	1639.
2016	1188.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1188.

P.C.K.K. ELECT. COMP. DEPT. AMORTIZATION SCHEDULE JOB BANGKOK SEPARATE SYSTEM

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************************************       INTEREST   (1)  (2)
*                 WATER RATE       *   (A) :   6.00   :   5   35  :     (1) = THE TERM OF LOAN
*  CASE - 3 :        3.0           *   (B) :   3.25   :   5   25  :
*            (CHARGE / M**3)       *   (C) :   0.     :   0    0  :     (2) = THE TERM OF PAYMENT
************************************        (PERCENT)     (YEAR)
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(UNIT : 1000)

YEAR	(A)	BORROWING (B)	(C)	INCOME WATER CHARGE	EXPENDITURE MANAGEMENT	AMORTIZATION	TOTAL	BALANCE PER YEAR	ACCUMULATION
1974	4866.	1630.	0.	0.	0.	345.	345.	-345.	-345.
1975	0.	0.	0.	1232.	705.	345.	1050.	182.	-163.
1976	6549.	14650.	0.	1372.	726.	1214.	1940.	-568.	-730.
1977	0.	0.	0.	1516.	936.	1214.	2150.	-634.	-1365.
1978	0.	0.	0.	1664.	959.	1214.	2173.	508.	-1873.
1979	0.	0.	0.	1817.	982.	1301.	2282.	-406.	-2339.
1980	0.	0.	0.	1973.	1005.	1301.	2306.	-333.	-2672.
1981	0.	0.	0.	2134.	1029.	1748.	2778.	-644.	-3315.
1982	0.	0.	0.	2299.	1054.	1748.	2802.	-503.	-3819.
1983	0.	0.	0.	2468.	1079.	1748.	2828.	-360.	-4179.
1984	0.	0.	0.	2642.	1105.	1748.	2854.	-212.	-4390.
1985	0.	0.	0.	2820.	1132.	1748.	2881.	-61.	-4451.
1986	0.	0.	0.	3002.	1159.	1748.	2908.	95.	-4356.
1987	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-4103.
1988	0.	0.	0.	3190.	1188.	1748.	2936	254.	-3849.
1989	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-3596.
1990	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-3342.
1991	0.	0.	0.	3190.	1188.	1748	2936.	254.	-3088.
1992	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-2835.
1993	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-2581.
1994	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-2327.
1995	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-2074.
1996	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-1820.
1997	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-1567.
1998	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-1313.
1999	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-1059.
2000	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-806.
2001	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-552.
2002	0.	0.	0.	3190.	1188.	1748.	2936.	254.	299.
2003	0.	0.	0.	3190.	1188.	1748.	2936.	254.	-45.
2004	0.	0.	0.	3190.	1188.	1652.	2840.	350.	305.
2005	0.	0.	0.	3190.	1188.	1652.	2840.	350.	655.
2006	0.	0.	0.	3190.	1188.	787.	1975.	1215.	1869.
2007	0.	0.	0.	3190.	1188.	787.	1975.	1215.	3084.
2008	0.	0.	0.	3190.	1188.	787.	1975.	1215.	4299.
2009	0.	0.	0.	3190.	1188.	787.	1975.	1215.	5514.
2010	0.	0.	0.	3190.	1188.	787.	1975.	1215.	6728.
2011	0.	0.	0.	3190.	1188.	787.	1975.	1215.	7943.
2012	0.	0.	0.	3190.	1188.	787.	1975.	1215.	9158.
2013	0.	0.	0.	3190.	1188.	787.	1975.	1215.	10373.
2014	0.	0.	0.	3190.	1188.	452.	1639.	1550.	11923.
2015	0.	0.	0.	3190.	1188.	452.	1639.	1550.	13473.