คพ. / PCD 07-02-36

POLLUTION CONTROL DEPARTMENT

FINAL REPORT

PRELIMINARY STUDY AND DESIGN OF DRAINAGE, WASTEWATER TREATMENT AND SOLID WASTE MANAGEMENT SYSTEMS FOR KHAO PHRA SANITARY DISTRICT

VOLUME 3 EXECUTIVE SUMMARY

PREPARED BY

THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH

กพ.
PCD 07-02-36

POLLUTION CONTROL DEPARTMENT

FINAL REPORT

PRELIMINARY STUDY AND DESIGN OF DRAINAGE, WASTEWATER TREATMENT AND SOLID WASTE MANAGEMENT SYSTEMS FOR KHAO PHRA SANITARY DISTRICT

VOLUME 3 EXECUTIVE SUMMARY

PREPARED BY

THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH

สถาบันวิจัยวิทยาศาสตร์และเทคโนโลยีแห่งประเทศไทย

THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH

ที่ วว 5101/ 0167 **บันทึกข้อความ** Memorandum

เรื่อง Subject : ส่งรายงานฉบับสมบูรณ์การศึกษาออกแบบขั้นต้นระบบระบายและบำบัดน้ำเสียและระบบการจัดการขยะมูลฝอยของสุขาภิบาลเขาพระและสุขาภิบาลสามชุก

เรียน To : อคพ.

จาก From : ผวท. วันที่ Date 10 กุมภาพันธ์ 2536

ตามหนังสือ คพ. ที่ วว 0302/0125 ลงวันที่ 11 มกราคม 2536 คพ. ได้พิจารณาร่างรายงานผลการศึกษาออกแบบขั้นต้นระบบระบายและบำบัดน้ำเสีย และระบบการจัดการขยะมูลฝอยของสุขาภิบาลเขาพระและสุขาภิบาลสามชุก ที่ วท. ได้ทำการปรับปรุงแก้ไขอีกครั้งหนึ่ง แล้วเห็นชอบในรายงานฯ ดังกล่าว และขอให้ วท. จัดทำรายงานฉบับสมบูรณ์เพื่อส่งมอบให้ คพ. ต่อไป ความละเอียดแจ้งแล้ว นั้น

วท. ได้จัดทำรายงานฉบับสมบูรณ์เสร็จเรียบร้อยแล้ว ดังปรากฏในเอกสารที่แนบมาพร้อมนี้ ซึ่งประกอบด้วย รายงานฉบับสมบูรณ์เป็นภาษาไทย 50 ชุด พร้อมบทคัดย่อเป็นภาษาไทยและภาษาอังกฤษ จำนวน 50 ชุด และรายงานสรุปเป็นภาษาไทยและภาษาอังกฤษ จำนวนอย่างละ 50 ชุด

จึงเรียนมาเพื่อโปรดพิจารณา

(นายสันทัด โรจนสุนทร)
ผู้ว่าการ

สาขาวิจัยสิ่งแวดล้อมและทรัพยากร
โทร. 5791121 - 30 ต่อ 2312
โทรสาร 5614771

FINAL REPORT

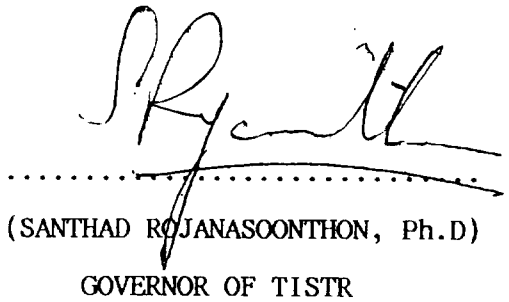
PRELIMINARY STUDY AND DESIGN OF DRAINAGE, WASTEWATER TREATMENT AND SOLID WASTE MANAGEMENT SYSTEMS FOR KHAO PHRA SANITARY DISTRICT

VOLUME 3 EXECUTIVE SUMMARY

SUBMITTED TO

POLLUTION CONTROL DEPARTMENT

APPROVED BY



(SANTHAD ROJANASOONTHON, Ph.D)
GOVERNOR OF TISTR

PREPARED BY

ENVIRONMENTAL AND RESOURCES
MANAGEMENT DEPARTMENT
THAILAND INSTITUTE OF SCIENTIFIC
AND TECHNOLOGICAL RESEARCH

/C FEBRUARY 1993

PREFACE

The final report of the preliminary study and design of drainage, wastewater treatment and solid waste management systems for Khao Phra Sanitary District consists of three volumes.

Volume 1 the main report presents all the study results consisting of 9 chapters. Chapter 1 is the introduction. Chapter 2 is the details of physical characteristics and landuse in the study area. Chapter 3 presents the basic data on socio-economic and environmental hygiene. Chapter 4 provides the study results on water pollution situation in the project area including problem conditions and guidelines for solution. Chapter 5 is the details on existing solid waste and cesspool sludge management of Khao Phra Sanitary District and summation of the problem conditions and guidelines for solution. Chapter 6 is the preliminary engineering design of several projects aiming at to solve wastewater and solid waste problems. Chapter 7 presents the economic and financial analysis of the proposed projects. Chapter 8 is the presentation of basic data and the analysis of the administrative organization, law and regulation including suggestions on the improvement of organization and law to serve the implementation of wastewater treatment and solid waste management projects. Chapter 9 is summarized of the measures and projects to be implementedd as well as the steps and the implementation plan for a period of 20 years.

Volume 2 is the executive summary (in Thai).

Volume 3 is the executive summary (in English).

ACKNOWLEDGEMENTS

Thailand Institute of Scientific and Technological Research (TISTR) wishes to express its gratitude toward the Pollution Control Department (PCD) (formerly the Office of the National Environment Board) for entrusting TISTR with the opportunity to conduct the preliminary study and design of drainage, wastewater treatment and solid waste management systems for Khao Phra Sanitary District (Sukhaphiban Khao Phra). The studied results are presented herein this report.

Whilst preparing this report the TISTR study team received full cooperation from numerous central and provincial organizations including personnel from Khao Phra Sanitary District. These provided useful basic informations, opinions and valuable recommendations essential for the preliminary study and design of wastewater treatment and solid waste management systems and the study team wish to express its sincere thanks to them all.

Finally, TISTR also wishes to thank the Secretary-General of PCD (Mr. Pakit Kiravanich), the Deputy Director-General of PCD (Mr. Pornchai Taranatham), the Director of Water Quality Management Division (Mrs. Nisakorn Kositrat), the Task Appraisal Committee and other PCD personnel involved for their kind assistance throughout the duration of the study.

The Study Team
February 1993

STUDY TEAM

Advisor	Dr. Santhad Rojanasoonthon Mr. Chalermchai Honak
Project Manager	Mr. Chaiyuth Klinsukont
Project Engineer	Mr. Preecha Ploypatarapinyo
Project Coordinator	Miss Jirawon Chetthadomdecha
Physical Study	Mr. Watchara Sunthornsarn Mr. Sabong Tha.Chieng Thong Mr. Khiri Krutthanom Mr. Pichit Phoungphoti Mr. Supoj Ngaosanam
Landuse Study	Mr. Pramuk Kaeonium Mr. Winit Buachum Mrs. Lamom Intharakamhaeng Mrs. Thawin Phrampunt
Socio-economic Study	Mr. Cherdchai Narktipawan Mrs. Siriwan Issaree Miss Jirawon Chetthadomdecha
Environmental Sanitation Study	Miss Pornsawan Disayabutr
Water Pollution and Solid Waste Management Study	Mr. Suchart Teekakul Miss Pornsawan Dissayabutr Mr. Tavee Sappinant Mr. Chatree Suchakarn Mr. Unnop Jatamara
Preliminary Engineering Design	Mr. Chaiyuth Klinsukont Mr. Preecha Ploypatarapinyo Mr. Suchart Teekakul
Economic and Financial Analysis	Mr. Cherdchai Narktipawan
Organization and Legal Aspects Study	Mr. Suchart Sailamai
Report Publishing Work	Miss Jirawon Chetthadomdecha Mrs. Ramphai Yoocharoen Mrs. Sukumarn Krutthanom Mrs. Tasana Khunakornjitirak Mrs. Lamom Intharakamhaeng Mrs. Thawin Phrarmpunt Mr. Khiri Krutthanom Mr. Krisorn Prigthung

SPECIFIC WORDINGS

ACT	พระราชบัญญัติ (พ.ร.บ.)
- Building Control Act	พ.ร.บ. ควบคุมอาคาร
- Enhancement and Conservation of the National Environment Quality Act.	พ.ร.บ. ส่งเสริมและรักษาคุณภาพสิ่งแวดล้อมแห่งชาติ
- Factory Act.	พ.ร.บ. โรงงาน
- Notification of the Revolutionary Party Issue No. 286 on Land Allottment Control	ประกาศคณะปฏิวัติฉบับที่ 286 เรื่อง การควบคุมการจัดสรรที่ดิน
- Public Cleansing and Neatness Act.	พ.ร.บ. รักษาความสะอาดและความเป็นระเบียบเรียบร้อยของบ้านเมือง
- Public Health Act.	พ.ร.บ. การสาธารณสุข
- Sanitation Act.	พ.ร.บ. สุขาภิบาล
Local Finance Division, Department of Local Administration	กองคลังส่วนท้องถิ่น, กรมการปกครอง
Ban Kam Ma Chian	บ้านกำมะเชียร
Ban Tha Chang	บ้านท่าช้าง
Building Effluent Standard of type A	มาตรฐานคุณภาพน้ำทิ้งจากอาคาร ประเภท ก.
District (= Amphoe)	อำเภอ
- Dan Chang District	อำเภอด่านช้าง
- Doembang Nangbuat District	อำเภอเดิมบางนางบวช
- Hankha District	อำเภอหันคา
- Nakhon Chai Si District	อำเภอนครชัยศรี
Doembang Nangbuat Provincial Waterworks Authority	การประปาภูมิภาคเดิมบางนางบวช
Domestic Effluent Standard	มาตรฐานคุณภาพน้ำทิ้งชุมชน
Khao (=Hill)	เขา, ภูเขาขนาดเล็ก
Khao Kam Ma Chian	เขากำมะเชียร
Khao Moonlek	เขามูลเหล็ก

Khao Nomnang	เขานมนาง
Khao Phra	เขาพระ
Khao Sinont	เขาสินนท์
Office of the National Environment Board (ONEB)	สำนักงานคณะกรรมการสิ่งแวดล้อมแห่งชาติ (วล.)
Pollution Control Department (PCD)	กรมควบคุมมลพิษ (คพ.)
Province, Chai Nat	จังหวัดชัยนาท
Province, Suphan Buri	จังหวัดสุพรรณบุรี
Samut Sakhon Municipality	เทศบาลเมืองสมุทรสาคร
Sanitary District (=Sukhaphiban)	สุขาภิบาล
- Khao Phra Sanitary District, (KPS-District)	สุขาภิบาลเขาพระ
- Nangbuat Sanitory District	สุขาภิบาลนางบวช
- Sam Chuk Sanitary District	สุขาภิบาลสามชุก
Suphan Buri Municipality	เทศบาลเมืองสุพรรณบุรี
Talad Tha Chang	ตลาดท่าช้าง
Tambon (=sub-district)	ตำบล
Tambon Doembang	ตำบลเดิมบาง
Tambon Hao Khao	ตำบลหัวเขา
Tambon Khao Phra	ตำบลเขาพระ
Tambon Khokchang	ตำบลโคกช้าง
Tambon Nangbuat	ตำบลนางบวช
Tambon Paknam	ตำบลปากน้ำ
Tha Chang Road	ถนนท่าช้าง
Tha Chin River	แม่น้ำท่าจีน
Thaboit Watergate	ประตูน้ำท่าโบสถ์
Thailand Institute of Scientific and Technological Research (TISTR)	สถาบันวิจัยวิทยาศาสตร์และเทคโนโลยีแห่งประเทศไทย (วท.)
Thamma Chot School	โรงเรียนธรรมโชติ

FINAL REPORT

PRELIMINARY STUDY AND DESIGN OF DRAINAGE,
WASTEWATER TREATMENT AND SOLID WASTE MANAGEMENT SYSTEMS
FOR KHAO PHRA SANITARY DISTRICT

VOLUME 3 : EXECUTIVE SUMMARY

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Project Title : Preliminary Study and Design of Drainage, Wastewater Treatment and Solid Waste Management Systems for Khao Phra Sanitary District
Project Duration : July 1991 - July 1992

Khao Phra Sanitary District (hereinafter referred to as the "KPS-District") is a sanitary district (Sukhaphiban) located on the west bank of the Tha Chin River in Doembang Nangbuat District, Suphan Buri Province. It occupies an area of 11.12 sq km and its population in B.E. 2534 (1991) is 9,147 persons. The topographic land is a plain area with some small hills located on the western side, i.e., Khao Nom Nang, Khao Kam Machian and Khao Phra. The main community which is on the river's bank is called Talad Tha Chang Community in which Thanon Tha Chang, the main road is passing through. Another small community, the Ban Kam Machian Community, is located at the foot-hill of Khao Kam Machian on the road-way from Talad Tha Chang to Dan Chang District. Besides these two communities which the population reside in a high density, in general there will be houses or office buildings scattering along both sides of the roads in the community.

From the study on wastewater problem of the KPS-District, it was found that both communities discharged wastewater into the public recieving water, i.e., the Tha Chin River and the Ban Kam Machian Reservoir. Especially those houses tresspassing on the Tha Chin River have discharged household wastewater directly into the river. For houses and buildings outside the communities the septic tank and seepage pit are used to treat the toilet waste. For sullage or other types of wastewater, it is drained on to the ground and eventually seeping away. Moreover, the KPS-District does not provide any service on cesspool sludge disposal. The people have to rely on the service of private truck or do it by themselves. They normally dispose of the sludge on the ground outside and far away from the community. This is not the proper and correct method for treatment of such a cesspool sludge.

For solid waste management the KPS-District has only one solid waste collecting truck with a volume of 10 cubic metre and one pulling cart of 2 cubic metre capacity. The total collection capacity was 2.226 tons/day of fresh solid waste which was equivalent to 55% of the total solid waste produced. The collected solid waste was dumped into the earth trench on the public land at the foot-hill of Khao Nom Nang, and was incinerated occasionally. It still had the problems of rats, insects, bas smell and smoke nuisance.

In order to solve the problems of community wastewater and solid waste disposal for KPS-District, some measures and projects are proposed to be implemented as follows :-

Measure for Solving Wastewater Problem

- To campaign the publics to realize the important of environmental conservation and convincing them to stop disposing of sewage and solid wastes into the Tha Chin River.

- To cooperate with the authority concerned, such as provincial industry official, in controlling the discharge of wastewater and fly-ash rice mills into the Tha Chin River.

- In the long term goal, relocation of those households trespassing on the Tha Chin River is needed in order to stop direct discharge of sewage and solid wastes into the river.

- To support and promote the on-site treatment such as septic tank and seepage pit system for individual house in the KPS-District, this is to reduce total waste loads discharged into the river at present and to ensure a better sanitation of the community.

- To provide cesspool sludge service facilities, including a proper disposal site, this can be run by the KPS-District or by leasing to private sector with under supervision of the KPS-District.

Project for Solving Community Wastewater Problem

- Master Plan of Central Wastewater Collection and Treatment Systems for KPS-District. This project covers an area of 7.5 sq km. It is the long term project laying emphasis on the acquisition of land area for the central treatment plant which should not be less than 35 rai and should be on the southern part of the KPS-District. The feasible treatment system is an oxidation pond.

- Construction of Wastewater Collection and Treatment System for Talad Tha Chang Community. This covers a specific Talad Tha Chang Community with the population of 5,000. The construction cost excluding land cost is Bt 15.58 million and the operating cost is Bt 0.55 million/year. The feasible treatment system is an oxidation ditch which requires an area of 1.5 rai.

- Construction of Wastewater Collection and Treatment System of Ban Kam Machian Community. This covers the present area of Ban Kam Machian Community with the population of 1,000. The construction cost excluding land cost is Bt 4.48 million and operating cost is Bt 0.05 million/year. The feasible treatment system is an oxidation pond which requires an area of 3.5 rai.

Measure on Solid Waste Management

- To provide more service on solid waste collection by increasing service area or length of the existing route, without any increasing number of collecting truck and man power.

- To increase efficiency in collecting fee in order to earn more revenue to be sufficiently used for providing more service on solid waste collection.

- At present, the rate of collecting fee is relatively low only Bt 5/household/month. This should be increased under responsibility and authority provided by the Sanitation Act.

- Emphasis on public relation to the people in the KPS-District and seeking cooperation in keeping the community clean.

Project on Solid Waste Management

- Project on Solid Waste Collecting Service. Request for annual budget to cope with all expenses in solid wastes collecting service including budget for purchasing new garbage truck to replace the old and expired ones according to the details proposed by the study team.

- Project on Solid Waste Disposal by Using Incinerator and Ash-landfill. The feasible solid waste disposal method for the KPS-District is the high temperature incinerator followed by ash-landfill. The site for installation of the systems is the public land at the foot-hill of Khao Nom Nang where existing solid waste is being dumped on. This will require a construction cost of Bt 9.0 million (price in 1991) with an operating and maintenance cost of Bt 1.1 million/year.

FINAL REPORT
PRELIMINARY STUDY AND DESIGN OF DRAINAGE, WASTEWATER TREATMENT AND SOLID WASTE MANAGEMENT SYSTEMS FOR KHAO PHRA SANITARY DISTRICT
VOLUME 3 : EXECUTIVE SUMMARY

---

1. INTRODUCTION

1.1 BACKGROUND.

Tha Chin is one of the rivers which is very important to the socio-economic system of Thailand since it is a main water resource for agriculture, industry and consumption of 20 municipalities and sanitary districts along the river. Wastewater from the communities is unavoidably drained down into this river. In the past, there were less population and activities. Wastewater drainage and garbage dumped into the river were relatively less. The river could naturally assimilate all those wastes. Later, the number of population has increased. Activities causing water contamination inversely increase too. The quantity of the wastewater and garbage has accumulated too much for the river to assimilate. The river water is, therefore, contaminated or polluted.

During 1980-1983, the Office of the National Environment Board (which later became the Pollution Control Department, PCD) assigned Thailand Institute of Scientific and Technological Research (TISTR) to undertake a study on water quality in the Tha Chin river so that a master plan for controlling and managing its water quality can be made.[1/] It was found that the water quality was quite low especially in the lower part of the river from Nakhon Chaisi District downward. And in the dry season, less volume of water flew down. The water pollution became worse.

From the result of the study mentioned above, PCD has launched a project to study the water quality in the Tha Chin river. The objective of the project was to provide a master plan for the municipalities, the sanitary districts and the related agencies to use for solving the problems of wastewater and solid waste in the 20 communities along the river. PCD had assigned TISTR to undertake a study and preliminary design of a drainage, wastewater treatment and solid waste management systems for the communities located along the Tha Chin river according to their priority. The first community to be studied was Suphan Buri Municipality in fiscal year 1989 and in the following year in Samut Sakhon Municipality.

1/ Report on the Provision of a Master Plan for Controlling the Water Quality in Tha Chin River Phase 1, 2 and 3 by the Office of the National Environment Board, NEB. PUB. 1981-006, 1983-002, and 1983-010.

For fiscal year 1991, PCD has assigned TISTR to undertake another project on the preliminary study and design of drainage, wastewater treatment and solid waste management systems for Khao Phra Sanitary District and Sam Chuk Sanitary District located in Suphan Buri Province. The contract was signed on July 17, 1991. The duration of the study was 12 months.

This report is the executive summary which summarize the main report of the preliminary study and design of the drainage, wastewater treatment and solid waste management systems for Khao Phra Sanitary District only. The Sam Chuk Sanitary District study is separated in another report.

1.2 GOAL AND OBJECTIVES.

The project goal was to study the preliminary design of drainage, wastewater treatment and solid waste management systems for Khao Phra Sanitary District (hereinafter referred to as the "KPS-District") which may be used as a master plan for the KPS-District or related organizations to solve the problems.

The objectives of the project as specified in the Term of Reference (TOR) were as follows :-

(1) Wastewater.

1) To study the wastewater problem in KPS-District communities in terms of characteristics and quantity.

2) To impose the type and the network of the wastewater drainage for the whole area of KPS-District. The network will be linked with the wastewater treatment system to be constructed in the future.

3) To design the preliminary wastewater treatment system by proposing alternatives of the treatment in terms of appropriate methods, size and location or site.

4) To study the feasibility in managing and constructing drainage and wastewater treatment systems.

5) To obtain the information of the wastewater treatment system in terms of both financial and technical aspects.

6) To evaluate the outcome gained from the proposed alternatives.

7) To survey the people's attitude and cooperation in paying tax or service fee for their use of the drainage and wastewater treatment facilities.

8) To seek an appropriate type of drainage and wastewater treatment system to be used in small community like sanitary district where they have to be responsible for its own project on this matter.

9) To proper guidelines, measure and action plan in both short term and long term as well as steps of operating the work to solve the community's wastewater problem in accordance with the local condition and the proposed alternatives.

(2) Solid Waste.

1) To study the solid waste problem in KPS-District both in terms of characteristics and quantity.

2) To impose solid waste collection and disposal system for KPS-District. This primary design is proposed with the alternatives in terms of method, location and size.

3) To study the feasibility in solid waste management in KPS-District to meet the need to reduce water pollution in the Tha Chin river where garbage is thrown.

4) To obtain information from each alternative of solid waste diposal system in terms of financial and technical aspects.

5) To evaluate the outcome obtained from the implementation of the solid waste disposal alternative. The impact on the water quality in the Tha Chin river is emphasized.

6) To survey the people's attitude and possibility of cooperation in solving the solid waste problem.

7) To propose guidelines, measure and action plan in both short term and long term as well as steps of implementation in solving solid waste problem in accordance with the local condition and the proposed alternatives

1.3 OUTPUT OF THE STUDY.

Output of the study was expected as follows :-

(1) The possibility to construct wastewater treatment and solid waste disposal systems for KPS-District.

(2) Primary design of the drainage, wastewater treatment and solid waste disposal systems for KPS-District.

(3) Clear guidelines, measure in solving the problem as well as short term and long term action plan to manage the drainage, wastewater treatment and solid waste disposal systems in KPS-District.

(4) Suggestions on appropriate type of drainage and wastewater treatment systems in terms of type of treatment and construction site, cost for detailed design, cost estimation for construction and maintenance, personnel in charge of the system, responsible organization, socio-economic trends as well as financial sources.

(5) Suggestions on the improvement of solid waste collection and disposal.

(6) Rehabilitation efficiency of the Tha Chin river in case that the solution of wastewater and solid waste problem is possible, correct and appropriate.

(7) Manual for small community like sanitary district in finding lands for wastewater treatment and solid waste disposal and primary principle in the management of drainage and wastewater treatment. This manuals will be distributed to the other sanitary districts.

2. PHYSICAL CONDITION AND LANDUSE

2.1 PHYSICAL CONDITION

KPS-District is located in Doembang Nangbuat District, Suphan Buri Province (Figure 2.1). Its area is 11.12 sq km consisting of 8 villages, seven of which belong to Tambon Khao Phra and another one belongs to Tambon Doembang. To the north of KPS-District is Tambon Paknam, to the east is Tambon Khokchang, to the south is Tambon Nangbuat and to the west is Tambon Hao Khao.

Most of the area is plain suitable for agriculture. Some small hills appear in the west such as Khao Nom Nang, Khao Kam Machian, Khao Phra, etc. (Figure 2.2). The community area is located on the west bank of the Tha Chin river. Tha Chang, the main road, runs parallel to the Tha Chin river through the community in the north-south direction. Talad Tha Chang (Tha Chang market) is the center of the community. From Tha Chang market, there is a road branching off to the west passing Ban Kam Machian community, a small community near Khao Kam Machian which is the end of the sanitary district area, to Dan Chang District. Apart from these two communities where people live in group, there are residential houses and office buildings scattered alongside of the road.

There is a network of drainage pipes only in Talad Tha Chang community. The size of the pipe is ϕ 0.60 m and the drainage gutter is 0.30-0.50 m wide. The network collects the wastewater from the community and drain it down into the Tha Chin river at 4 main points (Figure 2.3). According to the survey, the houses along the river discharge wastewater and toilet waste into the Tha Chin river. For houses outside the community, most of them have septic tank and seepage pit to treat the toilet wastewater. The effluent overflow from seepage pit and other wastewater are eventually drained down onto the ground or the earth ditch to be assimilated away.

The climatic condition of KPS-District is under the influence of northeast and southwest monsoons. There are 3 season; hot, rainy and cold season. The annual mean rainfall for the period of 30 year was 1,177.8 mm/year, the monthly mean temperature was in the range of 23.7 - 31.2°C.

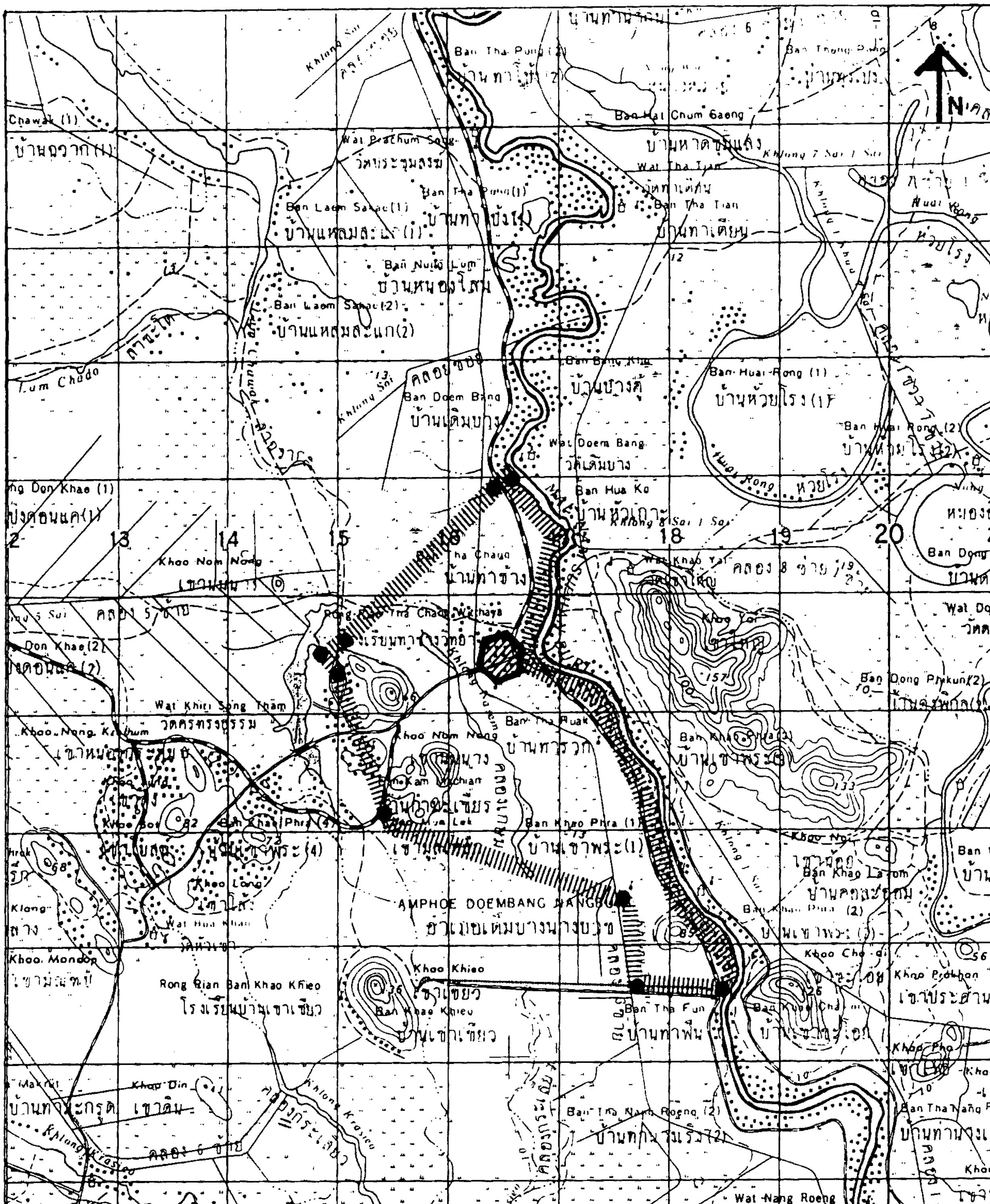


Figure 2.1 Boundary Area of Khao Phra Sanitary District (KPS- District), Doembang Nangbuat District, Suphan Buri Province.

Talad Thachang Community	0 0.5 1 Km.
KPS-District Boundary	Scale 1 : 50,000

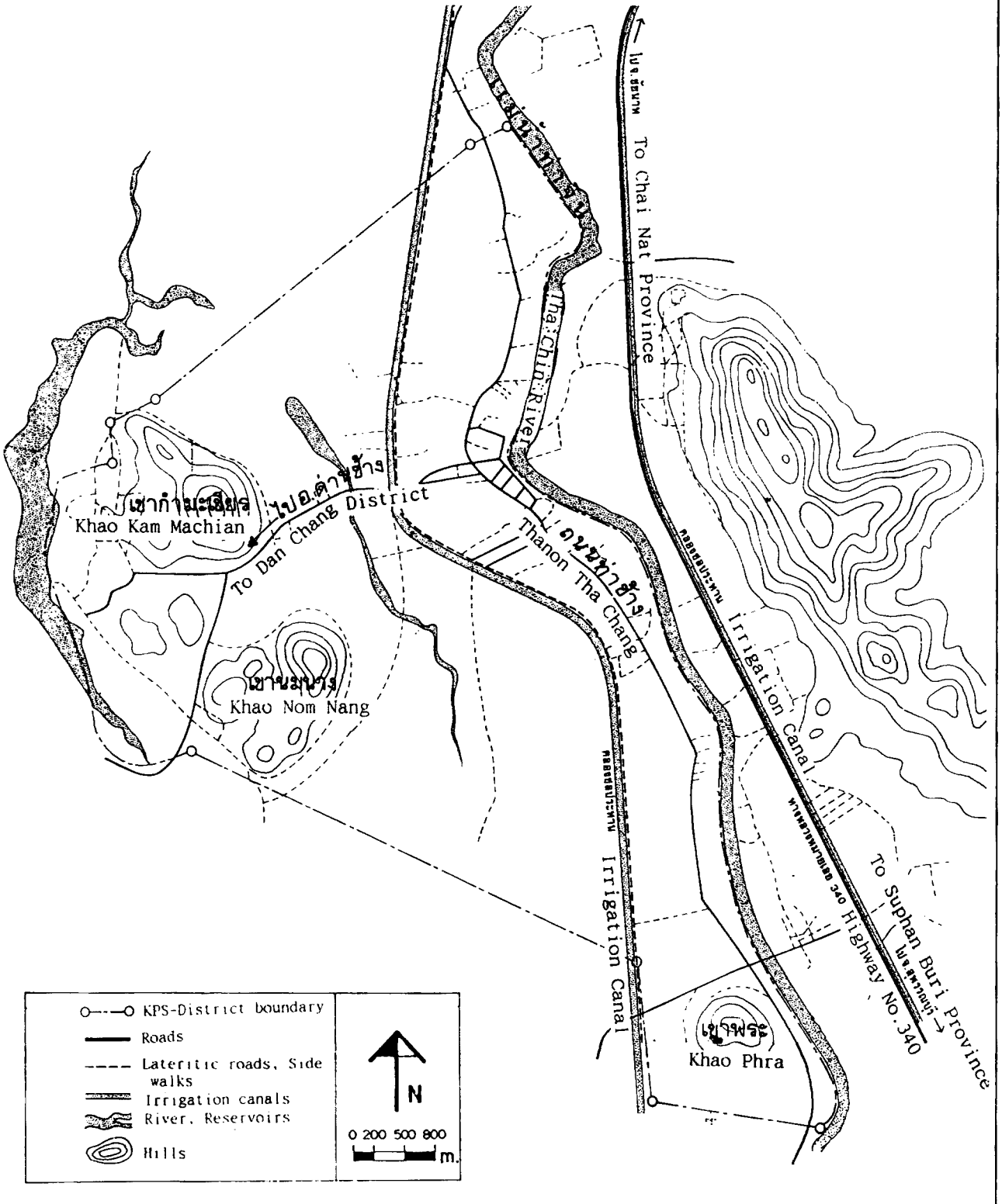


Figure 2.2 Road Networks in the KPS-District.

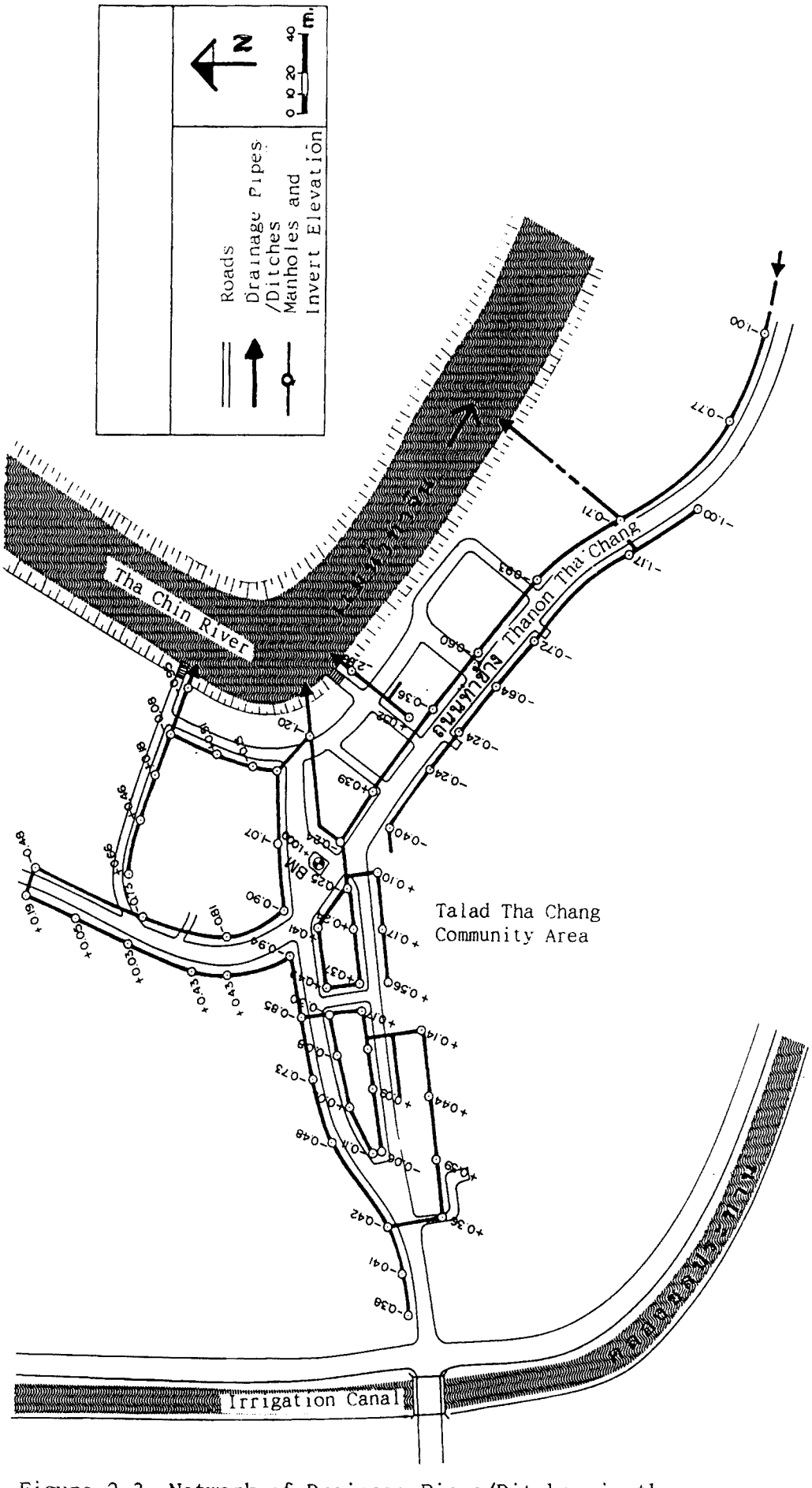


Figure 2.3 Network of Drainage Pipes/Ditches in the Talad Tha Chang Community Area.

2.2 LANDUSE

2.2.1 Present Landuse.

Landuse in KPS-District can be summarized as follows :- (Figure 2.4 and Table 2.1)

(1) Landuse for Agriculture is accounted for most part of the area. It is quite fertile with its own water resource and irrigation system. The total area for this purpose is 5,632 rai or 81.03% of the whole sanitary area. It consists of paddy fields, fruit and perennial orchards and forest area described as follows :-

1) Paddy fields take up most of the whole agriculture land scattered along the irrigation canal. Its area is about 4,500 rai or 64.75%.

2) Fruit and perennial orchards takes up the second large area. Most of the orchards are of the mixed type scattered along the west bank of the river. Coconut, mango, pomelo trees and others are grown. The area for this purpose is about 438 rai or 6.30% of the whole area.

3) Forest area is composed of small bamboo and scrubs scattered in the mountainous area such as Khao Nom Nang, Khao Moonlek, Khao Kam Machian and Khao Phra (Khao is a hill or mountain) taking up 694 rai or 9.98%.

(2) Mixed orchard/Residential area is characterized as a rural community scattered in 2 main communities; Ban Tha Chang and Ban Kam Machian, taking up about 850 rai or 12.23%.

1) Ban Tha Chang community. Houses are scattered around the Tha Chang market, which is the center of the area, along Tha Chang road and the west bank of the Tha Chin river. To the south is the district office and to the north is the end of the sanitary area. The density of the residential area is between low to moderate, accompanied by mixed fruit orchard and perennial especially along the river bank.

2) Ban Kam Machian community is located near Khao Nom Nang alongside the road to Dan Chang, 2 km from the Tha Chang market. It is a community of farmers. The population is about 230 households which tends to create wastewater problem by discharging wastewater into Kam Machian reservoir which will be developed to be a recreation place and for irrigation purpose.

(3) Commercial, service and dense residential area centering in Tha Chang market consists of shops, market, bus station and residential blocks. Its total area is 125 rai or 1.80%.

(4) Industry and warehouses. Most of them are rice mills and rice silos. There are 5 places taking up 31 rai or 0.45% of the whole area. They scatter along the Tha Chin river bank. Some rice mills dispose of fly-ash and rice husks into the

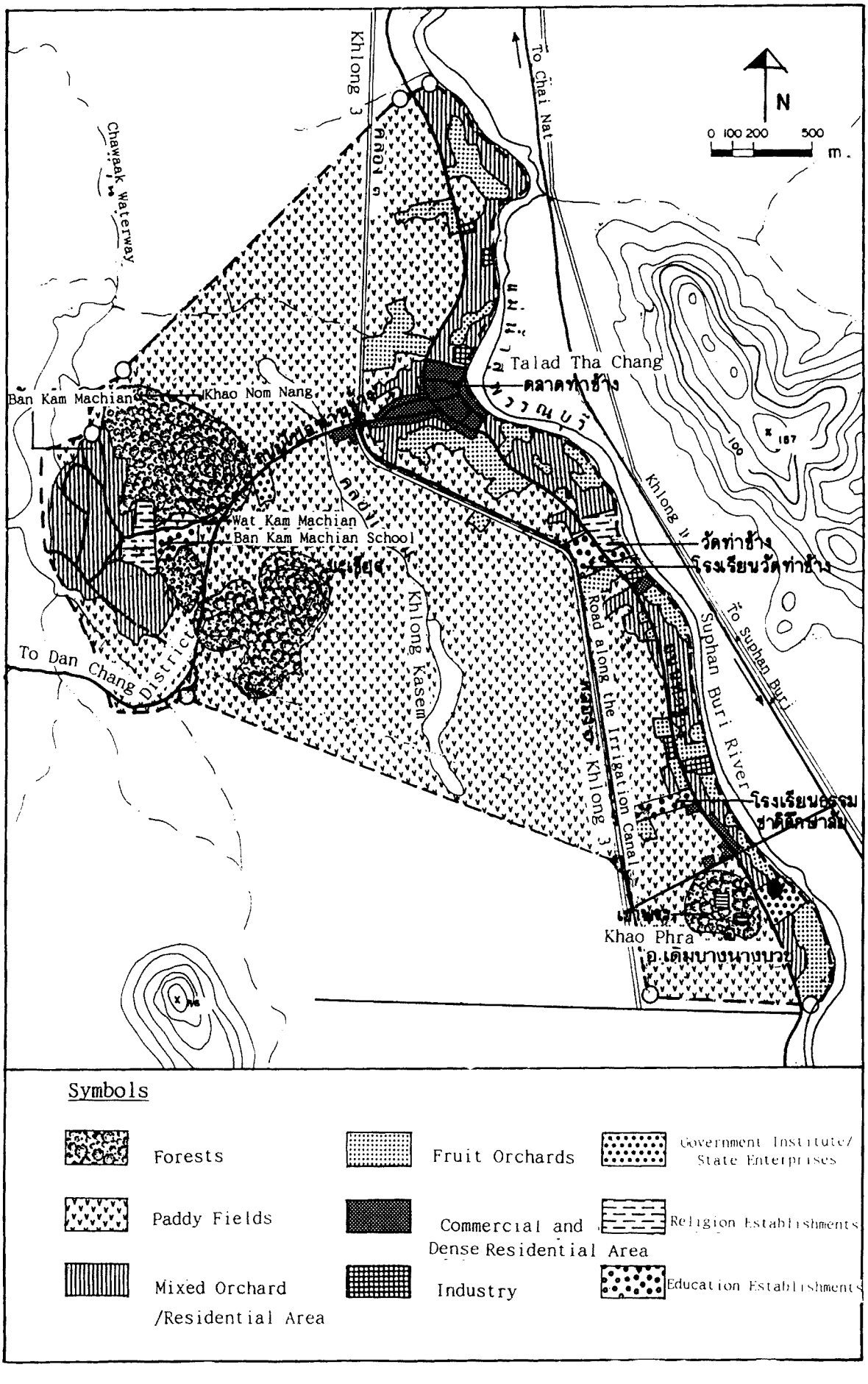


Figure 2.4 Existing Landuse Patterns of the KPS-District.

Table 2.1 Existing Landuse in KPS-District

Type of Landuse	sq km	rai	percentage, %
1. Agriculture	9.01	5,632	81.03
- Paddy fields	(7.20)	(4,500)	(64.75)
- Fruit and perennial orchards	(0.70)	(438)	(6.30)
- Forests	(1.11)	(694)	(9.98)
2. Mixed orchard/Residential area	1.36	850	12.23
3. Commercial service and dense residential area	0.20	125	1.80
4. Industry and warehouses	0.05	31	0.45
5. Government institutes and state enterprises	0.04	25	0.36
6. Education, religion and recreation establishments	0.17	106	1.53
7. Water resources	0.29	181	2.60
Total	11.12	6,950	100.00

Source : Interpreting from aerial photographs and the additional field surveys in B.E. 2534

river causing water pollution. The local government has some limitations in solving this problem.

(5) Government institutes and state enterprises is centering near Khao Phra at the bank of the river and to the south of Ban Tha Chang. The total area is 25 rai or 0.36%.

(6) Education, religion and recreation establishments are scattered in Ban Tha Chang and Ban Kam Machian communities. The recreation place is a fitness park around Khao Phra. At present parks around Khao Nom Nang and Kam Machian reservoir are being developed as recreation areas taking up 106 rai or 1.53% of the whole land.

(7) Water resources include the Tha Chin river, ponds, reservoirs and canals taking up about 181 rai or 2.60% of the whole area.

According to the landuse, it can be seen that KPS-District is a rural community which is expanding in terms of residential houses, commercial area and service.

2.2.2 Future Landuse Trend.

(1) On the west bank of the river especially in the sanitary area, future landuse tends to expand along the road from Tha Chang market to Dan Chang District connected to Ban Kam Machian community; and along the irrigation canal southward to reach Khao Phra junction near the present Doembang Nangbuat District office. It is a kind of gradual expansion. It is expected that this area will be able to cope with the expansion for more than 10 years.

(2) On the east bank of the river especially along the sides of the Suphan Buri - Chai Nat road opposite the sanitary boundary area, at present situates a hospital, a temple, and residentials houses, scattered along the river. It tends to expand more because there is a housing and commercial center scheme which will connect Nangbuat Sanitary District more conveniently. Some government offices are expected to move here.

3. PRIMARY INFORMATION ON SOCIO-ECONOMIC AND ENVIRONMENTAL HYGIENE.

3.1 SOCIO-ECONOMIC CONDITION

The study on socio-economic condition of KPS-District was undertaken using random sampling technique. 5% of households was randomly chosen to respond the questionnaire. The result of the study can be summarized as follows :-

(1) Occupation. The people's major occupation is trading taking up the proportion of 1 : 3 of the overall households. The other occupations ranking from the second top are employee, government service, agriculture and private business respectively. Average income of all occupation is 6,664 baht/house/month.

(2) Family characteristics. Most of them are single family (67.0%) and are old settlers (62.0%). Average members really living in the family is 3.7 but registered number is 5.3 persons/house.

(3) Population structure and education. Population of working age, 15-59 years old is 62.67% . Dependent rate is 59.57% i.e., 1 person of working age has to take care of 0.6 dependent. More than 80% of the population completed compulsory education.

(4) Housing characteristics. Most people own their lands (78.0%). Their houses are permanent residents. (86.0%)

(5) Water usage. Main water resource for use is tap water from the Doembang Nangbuat Provincial Waterworks Authority supplying 66.1% of the families. Houses outside the community beyond the reach of the tap water and houses along the rivers have to rely on natural water resources like the Tha Chin river, ponds, canals and rainfall, etc. It was estimated that in 1991 water used in KPS-Distirct would reach 270,228 cu m.

(6) Wastewater drainage and disposal. There are 2 ways of draining wastewater from laundry washing, kitchen and bathing. Houses located in the community where drainage pipes are available release those wastewater to the pipes leading to the Tha Chin river. Only Talad Tha Chang community has drainage pipes. Houses having no drainage pipes release those wastewater onto the ground to be assimilated away. In managing toilet waste, most houses have septic tanks and seepage pits or only septic tanks to do so except the houses tresspassing on the river which release their waste directly into the river. When the septic tanks are full up, the people have to hire the private suction truck to take out the cesspool sludge or do it by themselves since the KPS-District does not provide the service. They normally dispose of the sludge on the ground outside and far away from the community. This is not the proper and collect method for treatment of such a cesspool sludge.

(7) Solid waste management. It was found from the questionnaire that only 47.0% of the households that KPS-Distrcit provided the service on solid waste collection. The rest of them had to manage by themselves. Most of the latter (84.6%) dumped it on the ground near their houses and burned it later. There was no problem in self-disposal. For the service by KPS-District, 82.4% of the houses was collected daily. The solid waste collection fee was 5 baht/house/month and only 39.0% of households paid.

(8) Environmental problems in the community. General problems found were sound nuisance, dust, water trapped near the houses, bad smell and water pollution.

(9) Illness caused by bad environment. Illness suffering from respiratory system diseases was mostly found (60.0%) and followed by skin diseases, sore eyes, gastro intestinal system diseases and sore feet respectively.

(10) People's attitude toward the construction of wastewater treatment and solid waste management systems. It was found that most of them realized the necessity of these systems which would help solving environment problem in their community. They thought they would get more benefit and were willing to pay for the treatment fees. But the amount of fee that they were willing to pay was obviously small, only 10 baht/house/month. This was so because they compared the price with those of the solid waste collecting fee which was only 5 baht/house/month.

3.2 POPULATION.

The total population of Suphan Buri Province at the end of 1991 was 833,616. Average population density was 155.8 persons/sq km. The population of Doembang Nangbuat District was 77,090; average 137.2 persons/sq km.

The population of KPS-District at the end of 1991 was 9,147; average 822.6 persons/sq km. Number of households was 1,730; average 5.3 persons per house. The number of the population was increased from 6,540 in 1971 to 9,147 in 1991. It was noticeable that the change of the population number was uncertain, i.e., during 1971-1976 highly increased and during 1977-1983 decreased and stayed about the same. According to the population registar, during that period, the people migrated to work in Dan Chang District which is closed to Doembang Nangbuat District and its economy was rapidly expanded causing the establishments of factory, business and service places. Some of the migrating people still lived in the KPS-District since it is on the way to Dan Chang District. During 1985-1991 the population has increased thoroughly.

To forecast the future population of KPS-District, the population record in the past 20 years was used to predict the future tendency. The exponential model is the most reliable equation for the prediction at the increasing rate of 0.62% per year. The population of 9,147 in 1991 was used as a base year for the calculation of future population.

3.3 PUBLIC HEALTH, SANITARY AND ENVIRONMENTAL HYGIENE.

The results of the study in Doembang Nangbuat District were as follows :-

(1) Public health service. There were 1 community hospital, 17 health care stations, 5 medical doctors, 1 dentist, 1 pharmacist and 34 nurses.

(2) Illness suffering. Food and water born diseases and respiratory system diseases were found. The disease ranking the first was diarrhea with the number of 2,243 cases per 100,000 population. The other diseases ranking respectively were dysentery, food poisoning, pneumonia and hepatitis rating in the range of 95-42 cases.

(3) Primary health care has covered 100% of the villages in the district. However, there were only 72.94% of public health newsmen and 84.03% of public health volunteers left (PHN/PHV) because most people wanted to do their own job and earn more money.

(4) Sanitary and environmental hygiene. What had already been done were training the lavatory technicians, promoting the water-sealed toilet, sufficient drinking water supply and house garbage bins. Most of works achieved the goal.

(5) Suphan Buri Project. At present, there were 100 developed villages out of 111.

4. STUDY ON WATER POLLUTION PROBLEMS.

4.1 RESULTS OF THE STUDY.

4.1.1 Community Wastewater.

The survey of quantity and characteristics of the community wastewater drained into the Tha Chin river in KPS-District was undertaken twice; on October 8, 1991 and on February 4, 1992. Sample of wastewater was collected from the drainage pipe in Talad Tha Chang community where the wastewater was drained into the river at 4 points; pipe S1-S4 as shown in Figure 4.1. The survey result could be summarized as follows :-

(1) The quantity of wastewater in KPS-District drained through 4 pipes to the Tha Chin river was 661 cu m/day in the rainy season and 548 cu m/day in the dry season.

(2) No difference was found in measuring the pH value at each point. pH was almost neutral at 6.3-6.9.

(3) The BOD concentration of the wastewater in the drainage pipes surveyed twice was at 9-290 mg/l with the average of 47 mg/l. This average BOD value is higher than the value proposed by the Domestic Efflent Standard of not more than 20 mg/l. (Domestic Effluent Standard is based on the Building Effluent Standard of type A)

(4) The BOD of the wastewater from every point was statistically calculated using Frequency Analysis as shown in Figure 4.2. It was found that BOD at 50% probability was 74 and 55 mg/l in October and February respectively.

(5) The SS of the wastewater in the drainage pipe was around 15-141 mg/l with the average of 68 mg/l which exceeded the Domestic Effluent Standard of not more than 30 mg/l.

(6) The total Kjeldahl Nitrogen (TKN) of the wastewater from every drainage pipes was less than 40 mg/l in both surveys.

(7) Faecal Coliform Bacteria (FCB) was found in every pipe in both surveys. The quantity of FCB was more than 24×10^6 MPN/100 ml except pipe S1 in the first survey which 0.11×10^6 MPN/100 ml of FCB was found. However, the FCB in wastewater was rather high.

4.1.2 Wastewater from Buildings having Specific Activities.

The quantity and characteristics of the wastewater from the buidings having specific activities such as school, market, slaughterhouse and rice mill were examined. The results were summarized as follows :-

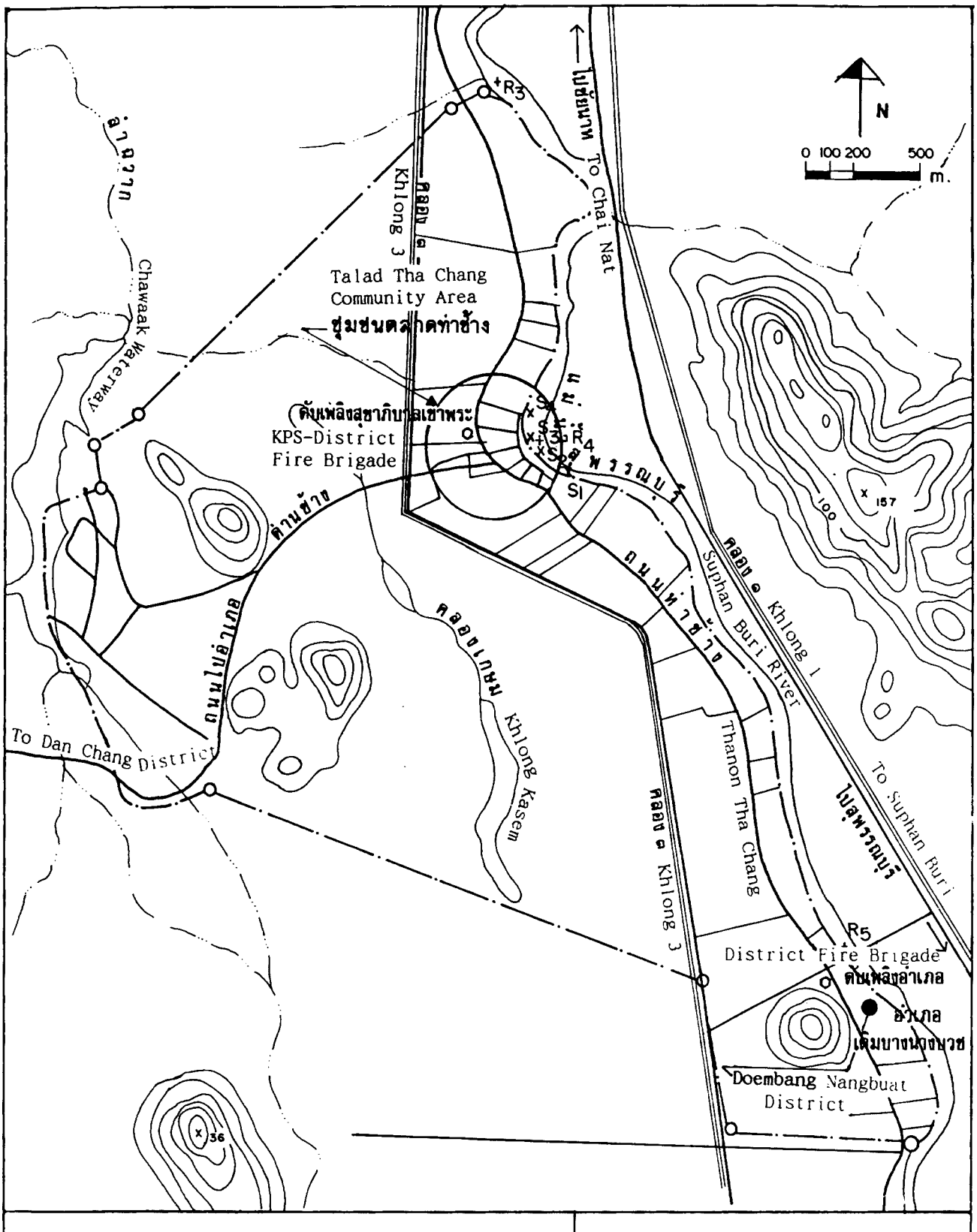


Figure 4.1 Community Wastewater Drainage Pipes that Discharge Wastewater into the Tha Chin River.

+R = Sampling Points of Water in the Tha Chin River.
xS = Sampling Points of Wastewater at the End of the Drainage Pipes.

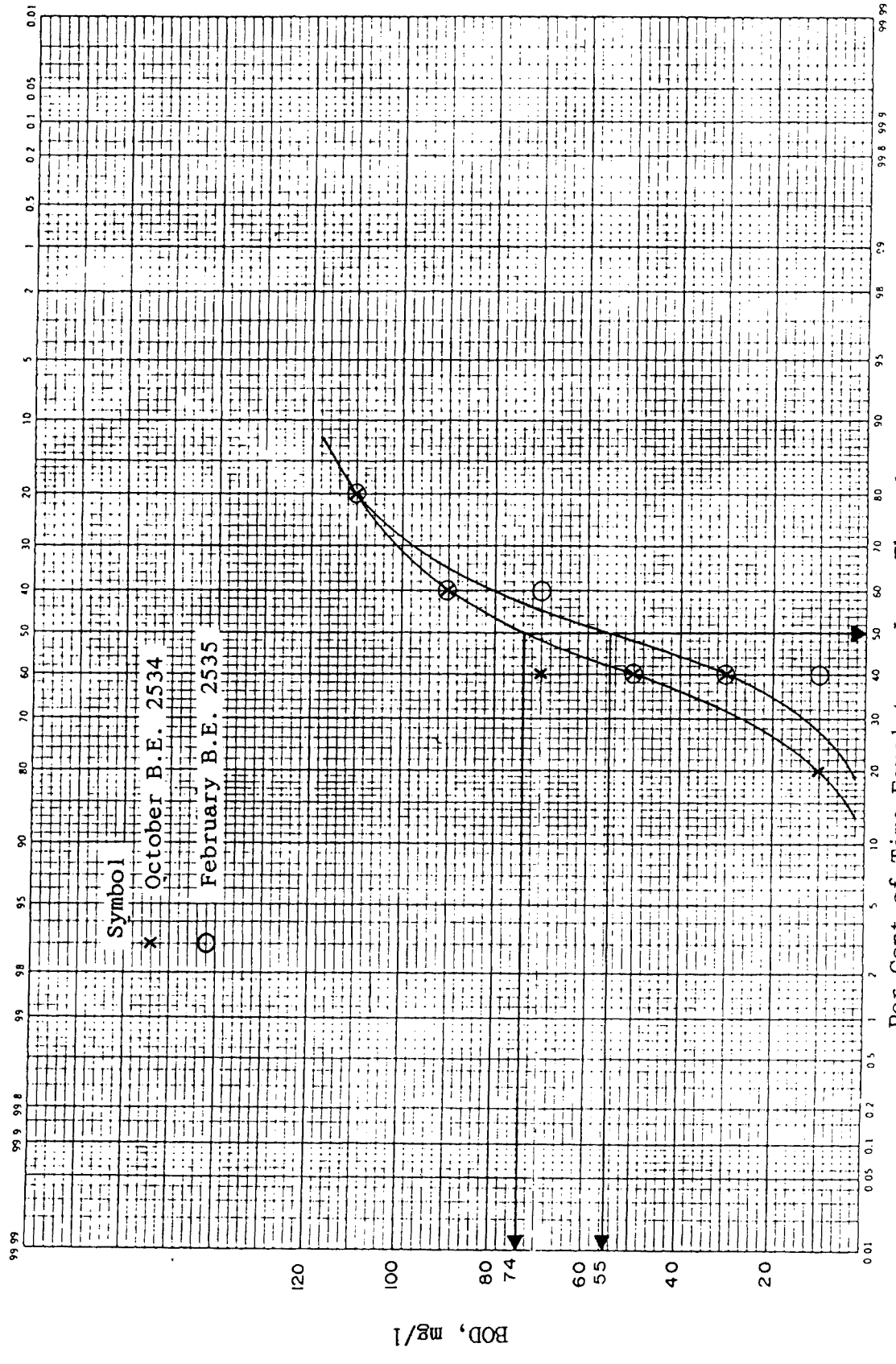


Figure 4.2 Distribution of the BOD Values for the KPS-District Community Wastewater.

(1) School.

Thamma Chot school has a total area of 42 rai of which 6,900 sq m is floor area. There were 80 teachers, 1,300 students and 12 personnel staff, totalling 1,392 persons. Average daily water consumption was 56.7 cu m/day. This could be estimated daily wastewater of 45.36 cu m/day (80% of the daily water consumption) or 33 l/person/day. This wastewater was not drained through the drainage pipe. Most of it was drained onto the ground and eventually vapourized or assimilated. Only the wastewater from the canteen was drained through the pipe. The wastewater BOD was 215 mg/l. Since its quantity could not be measured, the population equivalent of 2.22 gmBOD/person/day of the similar school in Suphan Buri Province studied by TISTR in 1989 was used instead. Consequently, BOD load of Thamma Chot school was estimated at 2.22 x 1.392 = 3.1 kg/day.

(2) Market.

The KPS-District market which its area was 600 sq m discharged the wastewater measured on May 12, 1992 at the rate of 28.5 cu m and BOD value of 3,050 mg/l. This is equivalent to 47.5 l/sq m/day and BOD load of 86.92 kg/day or 0.145 kg/sq m/day.

(3) Slaughterhouse.

The KPS-District slaughterhouse discharge wastewater from a killing of 14 pigs on May 12, 1992 at 5.5 cu m/day with the BOD of 880 mg/l. This is equivalent to the wastewater of 392 l/head/day and BOD load of 4.84 kg/day or 0.345 kg/head/day.

(4) Rice Mill.

There were 3 rice mills in KPS-District. Their milling capability as registered with the Ministry of Industry was 100, 66 and 5 Kwian/day respectively (1 Kwian = 2,000 litres). Wastewater sample from one mill was 5 mg/l of BOD and 965 mg/l of SS. The effluent quantity could not be measured due to lack of cooperation. Therefore, the unit load from the previous study of a rice mill in Suphan Buri Province in 1989 was used to calculate instead as follows :-

Wastewater generated (Fly-ash trapped water + other wastewater)	=	6.13 cu m/ton of unhusked rice
Average BOD load	=	0.025 kg/ton of unhusked rice
Average SS load	=	3.02 kg/ton of unhusked rice

From the above figure, it could be estimated that those 3 rice mills had drained the wastewater into the Tha Chin river during their operation as follows :-

Wastewater quantity	=	148	cu m/day
BOD load	=	4.3	kg/day
SS load	=	547	kg/day

4.1.3 Water in the Tha Chin River.

Five water sampling points in the Tha Chin river of the KPS-District area and connected area were specified as follows :-

- Point R1 : At the Thaboit watergate, Hankha District, Chai Nat Province situated to the north of KPS-District at the distance of 290 km from the river mouth, or about 32.5 km upstream of the KPS-District.

- Point R2 : At the bridge across Tha Chin river of Hankha District, Chai Nat Province situated to the north of KPS-District at the distance of 275 km from the river mouth, or about 17.5 km upstream of the KPS-District.

- Point R3 : In front of the potable water treatment plant at the northern boundary of KPS-District, 257.5 km from the river mouth.

- Point R4 : In front of the rice mill at Talad Tha Chang, 255.5 km from the river mouth.

- Point R5 : At the bridge across Tha Chin river of the KPS-District, 253 km from the river mouth.

Water sample was collected 3 times; on October 10, 1991, February 6, 1992 and May 13, 1992, the analysed water characteristics could be summarized as follows :-

(1) Form Figure 4.3 (A) the DO at point R3, R4 and R5 in October 1991 was 4.7, 4.8 and 5.3 mg/l which was lower than in February and May 1992 whose DO was 6-7 mg/l. It could be seen that DO at point R3, R4 and R5 of each of the surveys were not significantly different.

(2) From Figure 4.3 (B) the BOD at point R3, R4 and R5 in the 3 surveys were almost the same; 1-2 mg/l. The BOD value at point R5, the lower part from the community did not show any increasing tendency.

(3) The analysis of nitrate nitrogen of the river water was between <0.1 - 0.3 mg/l or averaged 0.16 mg/l (average only of the known value).

According to the inspection of nitrate nitrogen from the report on Master Plan for Water Quality Control in Tha Chin River undertaken from January to December 1980 (Figure 4.4 A), it was found that nitrate nitrogen ranged between 0.3-0.5 mg/l in the upper part of the river and was higher at the point from the 100 km from the river mouth downward to the river mouth.

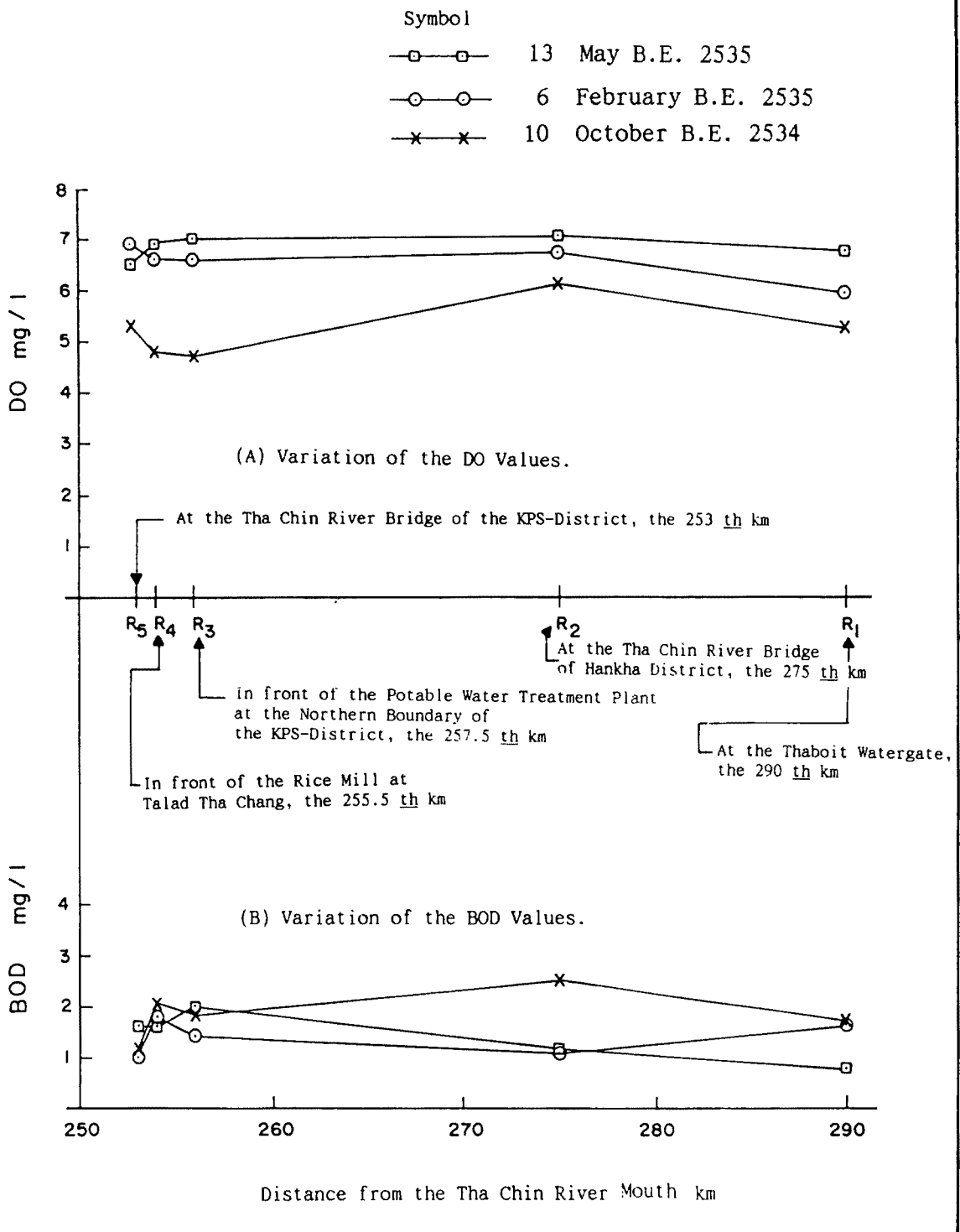


Figure 4.3 Variation of DO and BOD Values of the Tha Chin River Water at the Distance of 253-290 km from the River Mouth.

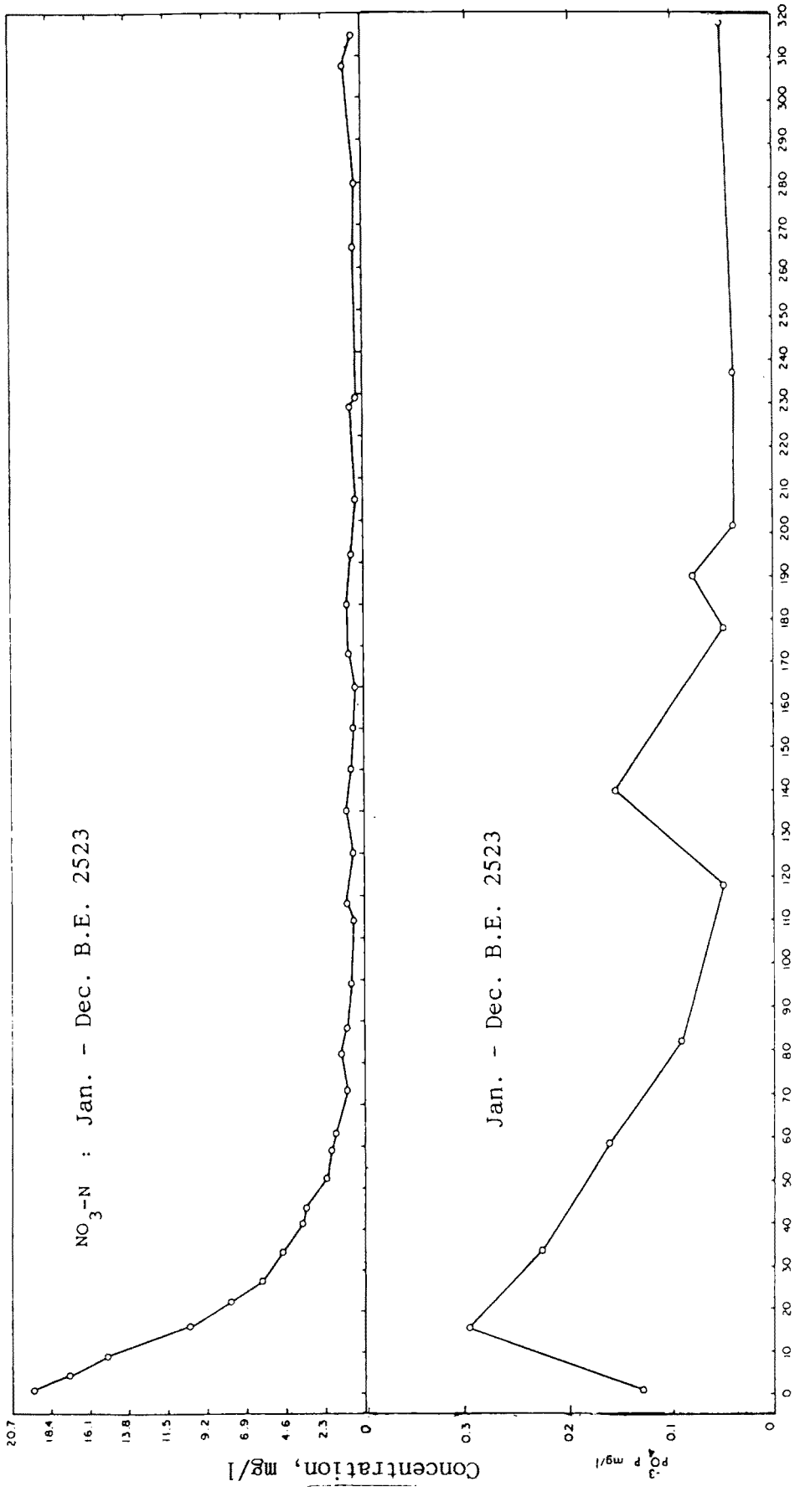


Figure 4.4 Analysis of Nitrate and Phosphate Concentrations of the Tha Chin River Water in B.E. 2523.

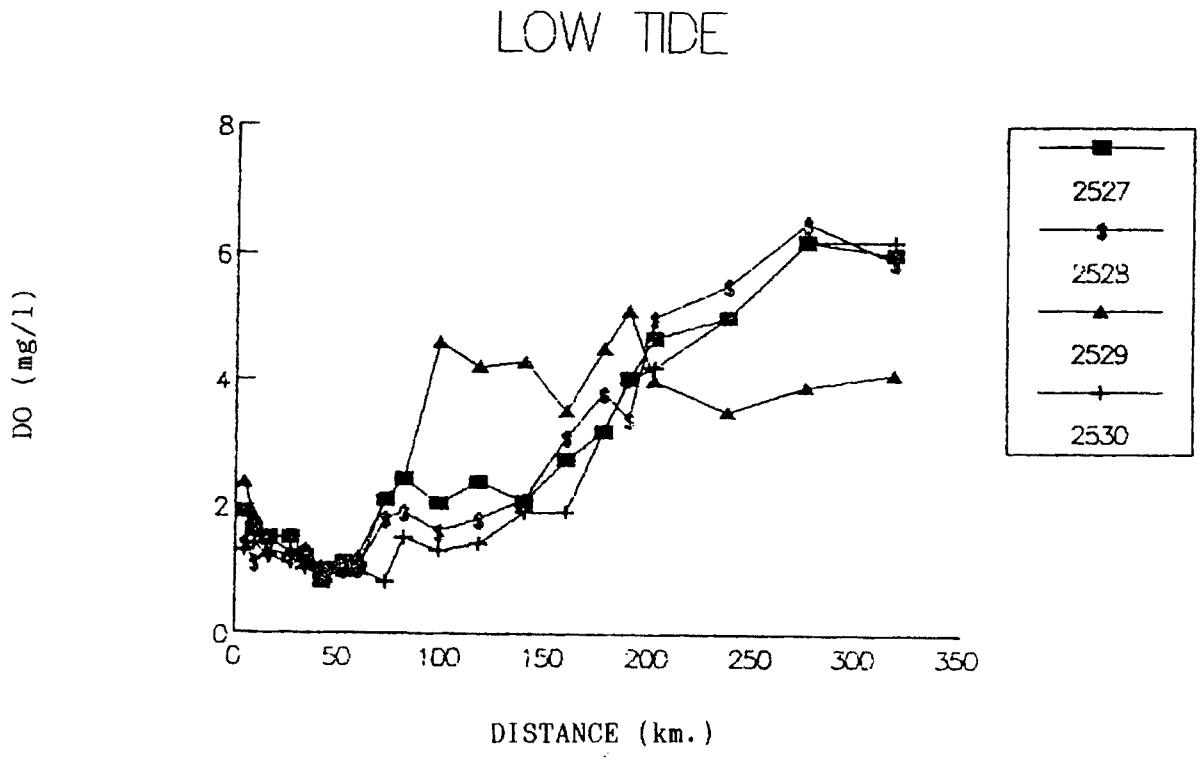
(4) The result of total phosphorus (T-P) analysis showed that T-P in October 1991 ranged from 0.9-2.5 mg/l while in February 1992 was lower ranging from 0.06-0.18 mg/l and in May 1992 was a little bit higher ranging from 0.15-0.25 mg/l. In conclusion the range of T-P found was 0.06-2.5 mg/l or averaged at 0.57 mg/l.

The source of phosphorus in the river was from the detergent dissolved in the community wastewater, and from the phosphase fertilizer and the insecticide containing organo phosphate substance left in the agricultural area. Therefore, that the T-P in October 1991 was higher than in February and May 1992 may be because the rain water had washed the fertilizer and insecticide residues from the agricultural area down to the Tha Chin river. From the Master Plan Report (Figure 4.4 B), it was found that in 1980, the water in the upper part of the river had phosphate value of about 0.05 mg/l. In general, if the concentration of phosphate in the river is more than 0.1 mg/l, it will already cause the eutrophication or the excessive growth of aquatic plants.

(5) The analysis of FCB ranged from 0.04 - 4.3 x 10^6 MPN/100 ml (only certainly known value) or averaged at 1.2 x 10^6 MPN/100 ml. There are five analysis which was less than 0.04 x 10^6 MPN/100 ml.

(6) The analysis of total pesticides indicated that it was much lower than the standard. The standard value of total pesticides is not more than 50 ppb while the analysed value was only in the range of one-thousandth to one-hundredth of the ppb. However, water sample was collected in May 1992 which was beyond the cultivation time, pesticide usage was therefore, less.

(7) The water quality in the Tha Chin river of KPS-District is classified as the Surface Water Quality of class 2, i.e., the DO value is not less than 6 mg/l; BOD not more than 1.5 mg/l and FCB not more than 1,000 MPN/100 ml. However, the water quality during 1991-1992 was not stable; sometimes it was better than class 2 but sometimes was lower. In comparison of water quality in the past at the same area (the 255th - 290th km) during 1984-1987 as shown in Figure 4.5 which the DO valued was about 6 mg/l and BOD about 2 mg/l, it can be seen that the present water quality is almost the same as the past.



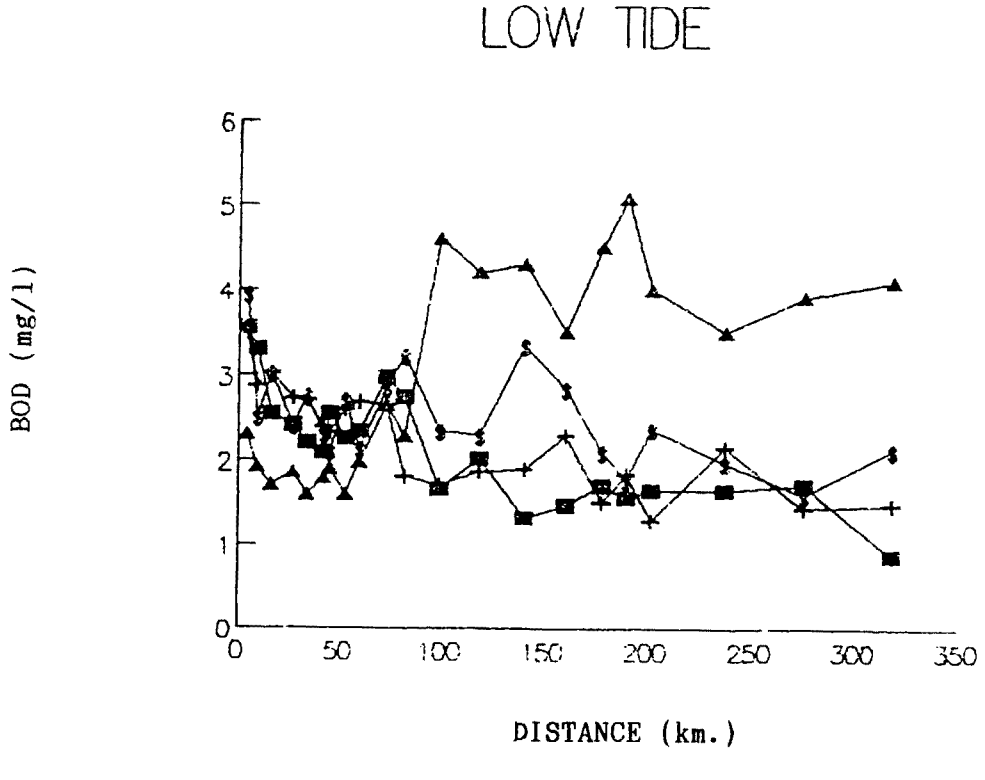


Figure 4.5 Variation of DO and BOD values of the Tha Chin River Water in the Year B.E. 2527-2530.

4.2 SUMMARY OF PROBLEM AND GUIDELINES FOR SOLUTION.

(1) Problem situation.

1) No any treatment of wastewater from the community where drainage pipes were available before being discharged into the Tha Chin river.

2) Houses alongside the river discharged the wastewater directly into the river. Some trespassing houses discharged toilet waste directly into the river.

3) The rice mills discharged the wastewater directly into the river which contained fly-ash, rice husks and waste oil.

4) The KPS-District did not provide any cesspool sludge disposal service. The people had to hire the private suction truck or disposed of it by themselves which could not be controlled the proper treatment of the cesspool sludge.

(2) Guidelines for solution.

1) Provide a long term master plan on central wastewater collection and treatment systems to cover the whole KPS-District area, laying emphasis on acquisition of land area for constructing the central wastewater treatment system and the reservation of land for laying drainage pipes.

2) Construct the temporary wastewater treatment system in the dense populated area such as Talad Tha Chang, and Ban Kam Machian communities (expected for in operation of not less than 10 years).

3) Provide the cesspool sludge disposal service and proper treatment of it by using the land area of the existing solid waste dumping site.

4) Impose a measure to move away the houses encroached the river.

5) Encourage the people to realize the necessity of environment conservation which can be achieved by not draining wastewater or dumping solid waste into the river. This can be done in terms of the cooperation between the KPS-District office and the non-government organization (NGO).

5. SOLID WASTE MANAGEMENT SYSTEM

5.1 EXISTING SOLID WASTE MANAGEMENT SYSTEM.

The information of solid waste management system of KPS-District is as follows :-

(1) The personnel involved in the solid waste management system excluding administrative staff are 7, i.e., 1 driver 4 collectors and 2 sweepers. There are one solid waste collecting truck of openside and rear dump type with the capacity of 10 cu m and one pulling cart with a capacity of 2 cu m. There are approximately 40 garbage bins with the capacity of 100 litres each.

(2) For collecting system, the collecting truck provides service only for dense populated area, i.e., in Talad Tha Chang and Ban Kam Machian communities and alongside of the main route where the collecting truck passes by. The collecting frequency is mostly once a day or twice if there is more waste. Figure 5.1 shows the route map of the solid waste collection and the disposal site.

(3) Average amount of the solid waste collected by KPS-District is 2.226 ton/day (8.35 cu m). Its moisture content is 51-58% of wet weight and the heating value is 3,640-3,970 kilocalories/kg of dry weight. The compositions of solid waste are mostly food residue, plastic, paper and wood pieces which is a typical composition of community garbage.

(4) It was estimated that the KPS-District could collect about 55% of the total solid waste generated. For the remaining amount, the people have to dispose of it by themselves. And in general most of it was piled up near the houses and burned down occasionally. According to the amount of solid waste collected as mentioned above, the average solid waste generation is estimated at 0.44 kg/person/day or 1.66 l/person/day.

(5) The expenditure for solid waste management of KPS-District including staff salary is approximately 1,112 Bt/day or 505 Bt/ton. Meanwhile, the KPS-District can collect the service fee of 20,000 Bt/year or 24.6 Bt/ton. It can be seen that the amount of the collected fee is 20 times lower than the expenditure.

(6) The KPS-District has a place for solid waste disposal site. It is public land area located at the foot-hill of Khao Nom Nang about 4 km from the KPS-District office along with the Tha Chang - Dan Chang District highway. The solid waste was dumped into the earth trench surrounded by the earth bund. The trench is 2.5 m deep, 60 m wide and 90 m long. There is a slopeway down to the bottom of the trench for the truck to dump the waste and another slopeway of 1.5 m wide for draining rainwater. Beside the bund is an earth ditch to hold the

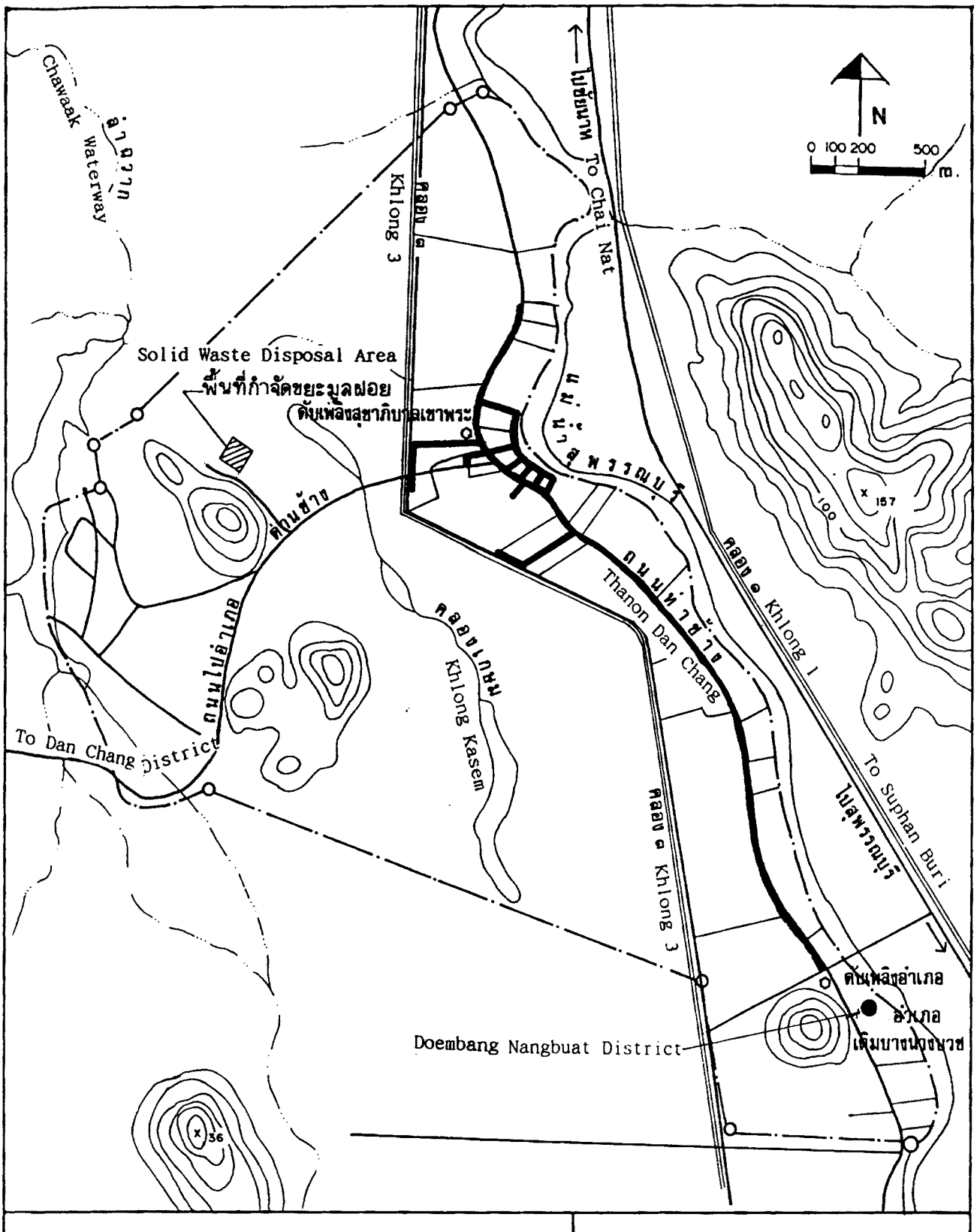


Figure 5.1 Solid Waste Collection Route for the KPS-District.

Solid Waste Collection Route

Solid Waste Disposal Area

leachate. The solid waste in the trench is compacted and covered by soil for every 2 months.

(7) The impact of the solid waste on the Tha Chin river is that from 90 houses or approximate 476 people living along the river dispose of the solid waste directly into the river. This waste was equivalent to BOD load of 10 kg/day.

(8) Cesspool sludge disposal . The KPS-District does not provide any cesspool sludge disposal service. Therefore, when the septic tank is full up, the people have to rely on the service of the private truck or do it by themselves. The disposal method is not correct. They normally dispose it onto the ground outside and far away from the community. Some of them dispose it into the river, especially from those 90 households along the river can do it easily.

5.2 SUMMARY OF PROBLEMS AND GUIDELINES FOR SOLUTION.

5.2.1 Problem Situation.

(1) A present, it is estimated that the KPS-District can collect about 55% of the total solid waste generated which is rather low. The remaining uncollected amount is disposed by the residents themselves because they live outside the service area. Therefore, the KPS-District should increase its collecting capacity to more than 55%.

(2) Eventhough the present solid waste disposal method is dumping into the earth trench but it is not covered by soil for everyday as of the correct method for sanitary landfill. Therefore, they still have the problems of insect and bad smell to the nearby area. Meanwhile, in the future this nearby area will be developed as a public park. Consequently, it is necessary to dispose of the solid waste by a more proper and better method.

(3) The proportion of the solid wase disposal expenditure to the income from the collecting fee is quite high.

(4) The cesspool sludge disposal method is not hygienically proper and correct. It is still disposed onto the ground and water resources which may cause the disgusting condition and the spreading over of the diseases.

5.2.2 Guidelines for solution.

(1) Increase the capacity of solid waste collection by extending the service route. It is not necessary to increase the collecting truck and personnel involved because at present they collect only once a day and for each trip the volume of solid waste collected is about 65-70% of the truck capacity. Anyway, the extention of the collecting route will require more fuel expense.

(2) The existing solid waste disposal method by dumping into the earth trench and covering it by soil for every 2 months is still not appropriate. It should be done daily or at least weekly so as to reduce the problems of insects and bad smell. If done weekly, the insecticide spraying is suggested to control the insects.

(3) Service fee must be collected throughout the service area.

(4) Provide the cesspool sludge disposal service and control the proper treatment of it before disposal.

(5) Consider to install an solid waste incinerator system accompanied with the ash-landfill method. This will lengthen the use of the limited disposal site area. The principle of the system will be mentioned later in chapter 6.

6. PRELIMINARY ENGINEERING DESIGN.

In determining guidelines to solve the wastewater and solid waste problems of the KPS-District, TISTR has undertaken the preliminary design for totally 6 projects, i.e., 4 projects on wastewater treatment and 2 projects on solid waste management and disposal. The details of all projects including construction cost, operating and maintenance cost and land area requirement are presented in Table 6.1. This preliminary design will be used for the further study on economic and financial aspects.

The design calculation for the 6 projects can be summarized as follows :-

6.1 MASTER PALN OF CENTRAL WASTEWATER COLLECTION AND TREATMENT SYSTEMS OF KHAO PHRA SANITARY DISTRICT.

6.1.1 Wastewater Collection System.

(1) Design principle.

1) Since KPS-District has drainage pipes only in Talad Tha Chang community, the future collection system should be a separated system by laying 2 main drainage pipes in the north-south direction as shown in Figure 6.1. That is, line 1 along Tha Chang road (pipe ① - ⑬), and line 2 along the road on the west side of the irrigation canal (Khlong 3) to collect the wastewater from the community on the west side of Khlong 3 (pipe ⑭ - ⑲). All wastewater will be collected and transferred to the treatment site at the southern area of the KPS-District behind Khao Phra. The wastewater collection area of the 2 main lines is about 7.5 sq km or 750 hectares (1 sq km = 100 hectares) or equivalent to 67% of the KPS-District area. The remaining area is composed of mountains, hills, parks and agricultural area which the chance to become a dense populated community is less. Consequently, it is not taken into account.

2) Along the main drainage pipe, there will be a manhole at every interval of 100 m provided for the branching pipes to be connected which will carry the wastewater from the community to the mainline. The design of branching pipes are not included in this preliminary design.

(2) Design criteria for wastewater collection system.

1) The quantity of wastewater flowing in the drainage pipe is estimated from the future population density of 100 person/hectare and the wastewater generated by people is 200 l/person/day. The water infiltrating into the pipe is estimated at 20 % of the wastewater quantity and the peak factor value is 2.0. Consequently, the maximum amount of wastewater flowing in pipes is calculated at $0.2 \times 100 \times 1.2 \times 2.0 = 48$ cu m/hectare/day.

Table 6.1 Summation of the Preliminary Designed Projects

Item	Construction cost, Bt million	Operating cost, Bt million/year	Area required, rai
1. Master plan of central wastewater collection and treatment system for KPS-District			
1.1 Main wastewater collection system	313	7.0	-
1.2 Wastewater treatment system having 3 alternatives :-			
- Alternative 1 : Oxidation pond	5.25	0.04	17.4
- Alternative 2 : Aerated lagoon	5.22	0.48	6.0
- Alternative 3 : Oxidation ditch	14.9	0.55	2.2
2. Project on the construction of wastewater colection and treatment system for Talad Tha Chang community.			
2.1 Wastewater collection system	5.08	0.15	-
2.2 Wastewater treatment system	10.5	0.40	1.5
Total	(15.58)	(0.55)	
3. Project on the construction of wastewater collection and treatment system for Ban Kam Machian community			
3.1 Wastewater collection system	3.44	0.04	-
3.2 Wastewater treatment system	1.04	0.01	3.5
Total	(4.48)	(0.05)	
4. Project on the construction of the on-site treatment for houses by using the septic tank and seepage pit	(7,000 Bt/unit)	(140 Bt/year/unit)	

.../to be cont'd

Table 6.1 (Continued)

Item	Construction cost, Bt million	Operating cost, Bt million/year	Area required, rai
5. Project on solid waste collecting system (procurement of collecting truck and sweeping instrument to be replaced).	0.74	0.02	-
6. Project on solid waste disposal system : 2 alternatives :-			
6.1 Alternative 1 : Sanitary landfill of the solid waste (compaction density of 1,200 kg/cu m).	11.4	1.78	6.0
6.2 Alternative 2 : Incineration of solid waste and ash-landfilling.	9.0	1.10	1.0

Remark : 1) Cost estimation based on price in B.E. 2534.
2) Land cost is excluded.

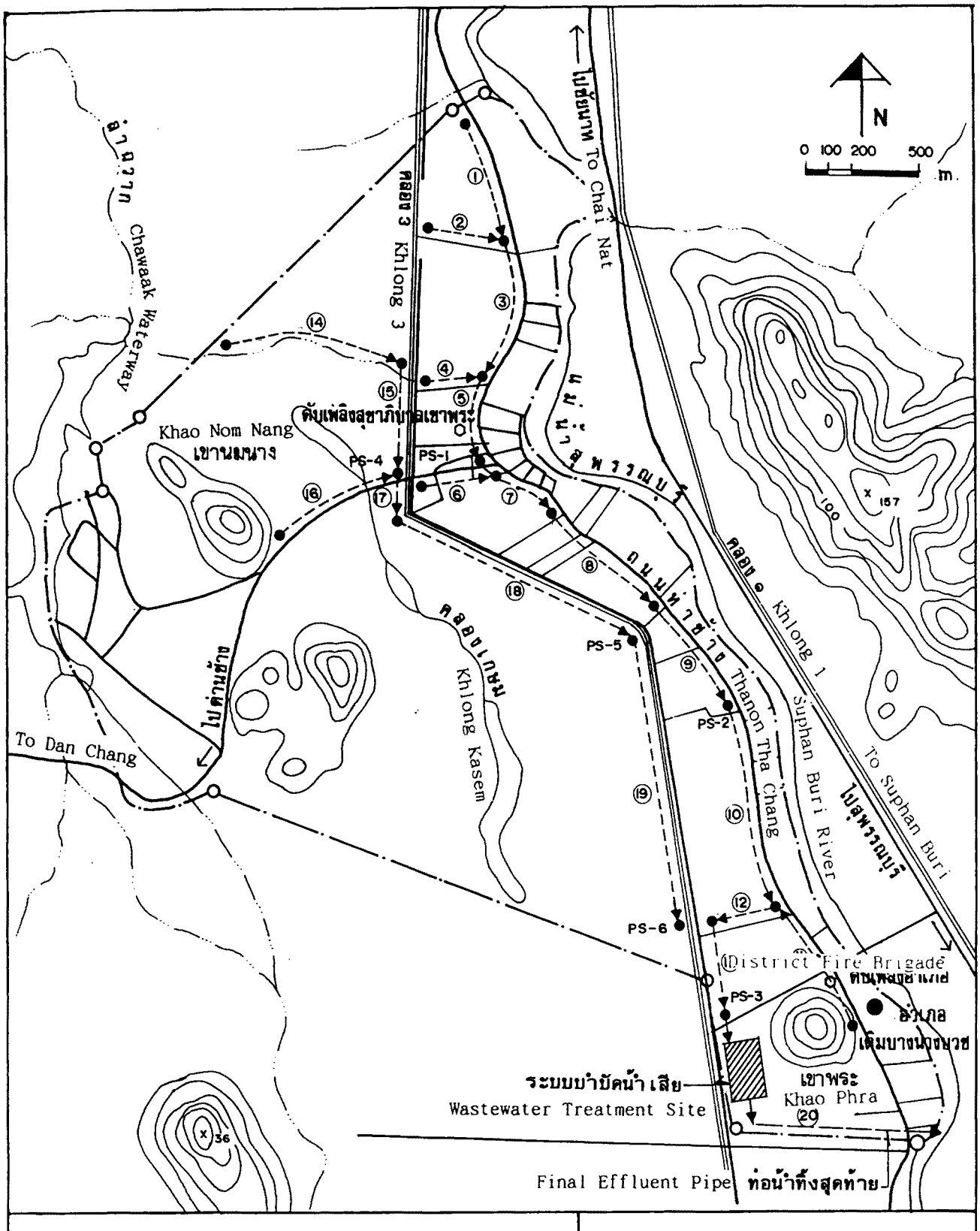


Figure 6.1 Main Interceptors and Wastewater Drainage Pipes for the KPS-District.

⑲ Main Drainage Pipes

PS- Pumping Station

Proposed Construction Site for Wastewater Treatment System

2) The flowing velocity in the pipe at the peak factor is not less than 0.6 m/second.

3) Minimum pipe diameter is 0.6 m.

4) The type of the pipe must be durable to erosion. Hence, the glassfiber reinforced pipe (GRP) class PN 2.5 is specified to use.

(3) Results of the design and cost estimation.

1) The main wastewater drainage pipe network consists of GRP pipe 12,450 m long and the final effluent pipe of 900 m long or totally 13,350 m.

2) The total number of manholes is 161 manholes.

3) There are 6 pumping stations.

4) The construction cost of main wastewater drainage pipes and the pumping stations is Bt 313 million and the operating cost is Bt 7.0 million/year.

6.1.2 Wastewater Treatment System.

(1) Design principle of wastewater treatment system.

1) The BOD load to be treated is calculated from the number of population in the next 20 years as follows :-

Population at the end of 1991	=	9,147 persons
Average increasing rate	=	0.62 %/year
Population by the end of 2011	=	10,425 persons
Estimated population in the wastewater collection area	=	90 %
	=	9,382 persons
Design population	=	10,000 persons
BOD value in term of population equivalent	=	32 gm/person/day
BOD load to be treated	=	320 kg/day

2) Oxidation pond system is designed as the wastewater treatment system by the reason that the community is in the rural area where land cost is still low. Another reason is that in the future if the population increases more than the estimation and the land area is limited, the oxidation pond can be modified to be aerated lagoon system or oxidation ditch system.

(2) Design criteria of wastewater treatment system.

The oxidation pond consists of 2 ponds, i.e., the first pond is a facultative pond responsible for stabilizing BOD value of wastewater and the second pond is a maturation pond responsible for decreasing coliform bacteria. The design criterias and calculations are as follows :-

- Aerial BOD loading of facultative pond = 0.035 kg/sq m/day
- Effective depth = 2.5 m
- The dimension of muturation pond is designed to be equal to facultative pond.
- Effective depth 2.0 m.

- Giving an extra area for pond embankmment and road around the pond to be 50% of the pond area.
- Calculated area requirement = 87 sq m/kg BOD
- Construction cost estimated = 16,400 Bt/kg BOD
- Operating cost estimate = 0.33 Bt/kg BOD/day

(3) Results of the design calculation.

1) The central wastewater treatment system using the oxidation pond of KPS-District requires an area of 17.4 rai. But for the procurement of land area, it is recommended to acquire for doubling the required area. Consequently, the total land area to be acquired is 35 rai.

2) The total construction cost of the oxidation pond system is Bt 5.248 million. The operation cost is 40,000 Bt/year (cost estimation at the end of 1991). For future budgetary estimation an increasing rate of 10% is recommended for annual inflation.

6.2 CONSTRUCTION OF WASTEWATER COLLECTION AND TREATMENT SYSTEM FOR TALAD THA CHANG COMMUNITY.

6.2.1 Wastewater Collection System.

(1) Principles.

1) Talad Tha Chang community is located on the bank of the Tha Chin river. Its drainage system is the combined system which recieves both wastewater and rainwater and then, being drained into the river at 4 points (point S1-S4). As the wastewater is directly drained into the river, it is suggested that the wastewater treatment system should be urgently constructed as a temporary measure until the master plan of wastewater collection and treatment system has already been implemented. Then, the wastewater in this community area will be connected to the main collection pipeline.

2) According to the survey the pipes S1 and S3 recieve a large wastewater flowrate at about 200-400 cu m/day, while the pipe S2 and S4 receive less at about 4-12 cu m/day only. The total volume of wastewater in the 4 pipes is 550-660 cu m/day with the average of 600 cu m/day.

3) The collection system should be done as follows :- (see Figure 6.2)

- Close the end of pipe S4 in order that the wastewater in it will be drained to the pipe S3.
- Close the end of pipe S2 and construct a new pipeline (pipe ①) to drain the wastewater into pipe S3.
- Construct an interceptor (I-1) at the end of pipe S3 to intercept only the wastewater from the combined wastewater.
- Construct a pipe line (pipe ②) from S3 to the pumping station, PS.
- Construct an interceptor (I-2) at the end of pipe S1.

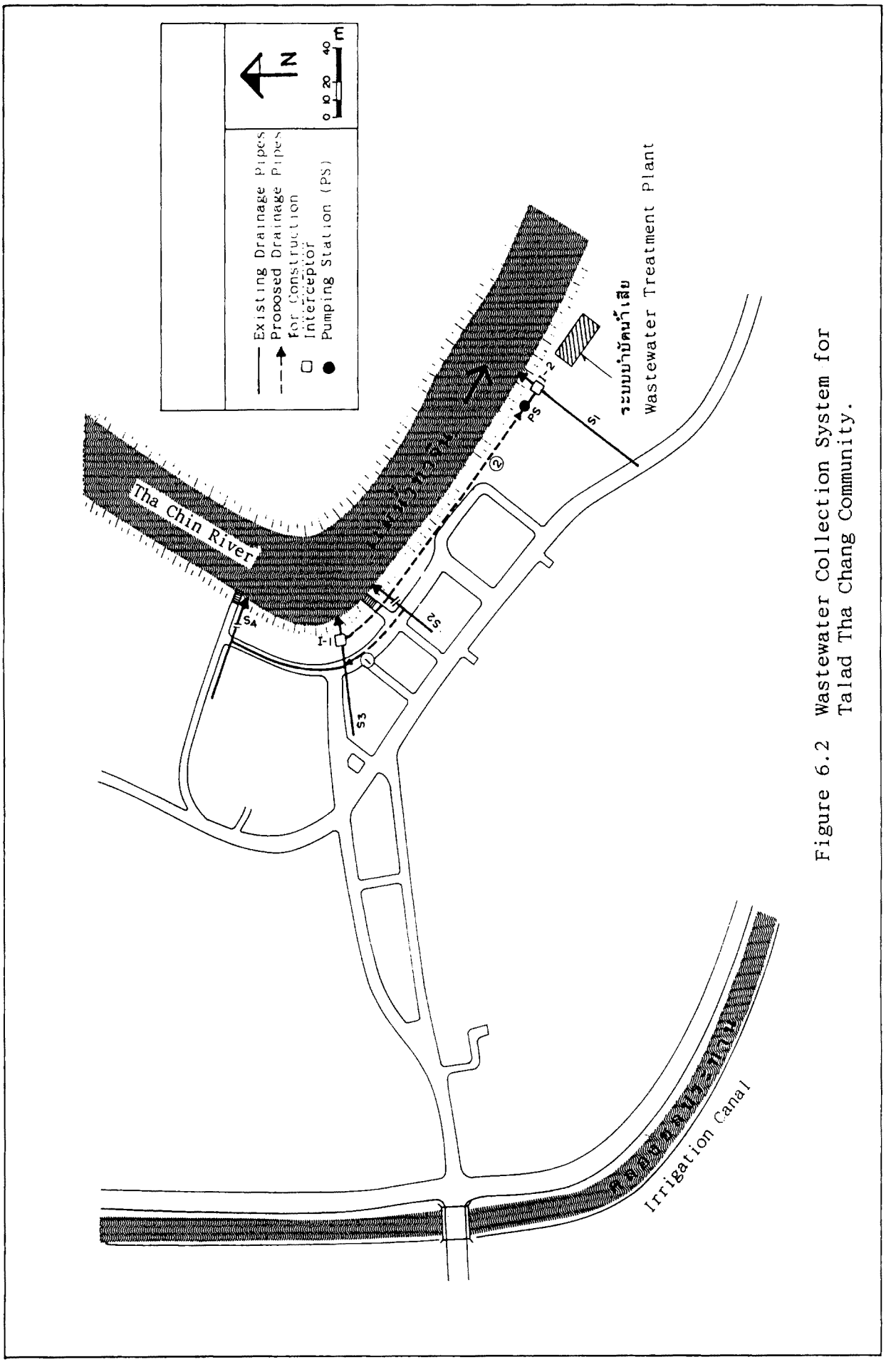


Figure 6.2 Wastewater Collection System for Talad Tha Chang Community.

- Construct a pumping station (PS) to collect and transfer the wastewater from the interceptors I-1 and I-2 to the nearby treatment site.

(2) Design criterias.

Safety factor of about 1.5 times is used in design of the wastewater flowrate, as follows :-

Interceptor I-1, average wastewater	=	600 cu m/day
Interceptor I-2, average wastewater	=	400 cu m/day
Total designed flowrate	=	1,000 cu m/day

(3) Result of the design calculation.

The total construction cost of wastewater collection system for Talad Tha Chang community is estimated at Bt 5.08 million and the operating cost is Bt 0.15 million/year.

6.2.2 Wastewater Treatment System.

(1) Principles

1) The wastewater treatment system should be of the type that require small area so that the on-site treatment system can be constructed near the wastewater pumping station. This land area may be procured or rented for implementation.

2) The oxidation ditch is designed for the treatment system in order to reduce burden on sludge handling and disposal.

(2) Design criterias.

1) Wastewater influent is 1,000 cu m/day.

2) The BOD concentration is estimated from the survey result which ranges from 10-150 mg/l or averages at 82 mg/l. So the BOD concentration of wastewater is designed at a maximum value of 150 mg/l or equivalent to the BOD load of 150 kg/day.

(3) Results of the design calcultion.

The wastewater treatment system using the oxdiation ditch for Talad Tha Chang community requires the area of 1.5 rai. The total construction cost is estimated at Bt 10.5 million and the operating cost is Bt 0.4 million/year.

6.3 CONSTRUCTION OF WASTEWATER COLLECTION AND TREATMENT SYSTEM FOR BAN KAM MACHIAN COMMUNITY.

6.3.1 Wastewater Collection System.

(1) Principle.

1) Ban Kam Machian community is located in the west side of KPS-District. Its land area is stretching between the foot-hill of Khao Kam Machian and Khao Sinont and Kam Machian reservoir. At present there are about 250 houses in this community. The people use water from rain, shallow wells and Kam Machian reservoir for their consumption. Animals such as pig are raised. No wastewater treatment system is available. The wastewater is drained onto the ground and seeping away. Some of the wastewater flows into Kam Machian reservoir. It is suggested that the proper management of wastewater in this community should be provided.

2) In taking into account the road leading to the village which is the laterite one, the wastewater collection system should be the combined system, i.e., to drain the rainwater too. The trapezoidal concrete gutter along the lateritic road is constructed to receive both wastewater and rainwater. The drainage pipes is laid across or down under the road if necessary (Figure 6.3). The wastewater is separated at the interceptor and treated before being drained into the reservoir.

(2) Design Criteria.

1) Wastewater flowrate is calculated from the number of population. Since it is the rural community, some of the wastewater will seep away. Therefore, the collected wastewater is estimated at 150 l/person/day. From the average population size 5.3 persons/house and the number of houses of 250, it is caculated that the wastewater flowrate is 200 cu m/day (0.0023 cu m/second).

2) The rainfall quantity is calculated from the water shed area as follow :-

- Water shed area, app.90 rai = 144,000 sq m
- Rainfall intensity = 100 mm/hr
- Runoff coefficient = 0.3

Calculated runoff = 144,000 x 0.1 x 0.3/3,600
= 1.2 cu m/sec

3) Average flow velocity in the gutter 0.6 m/sec

(3) Design calculation and cost estimation.

1) Trapezoidal concrete gutter.

Runoff quantity = 1.2 cu m/sec
Average velocity = 0.6 m/sec
Required cross sectional area = 2 sq m
Since the gutter is along with the foot-hill with a sharp slope, there is no problem in design the gutter slope.

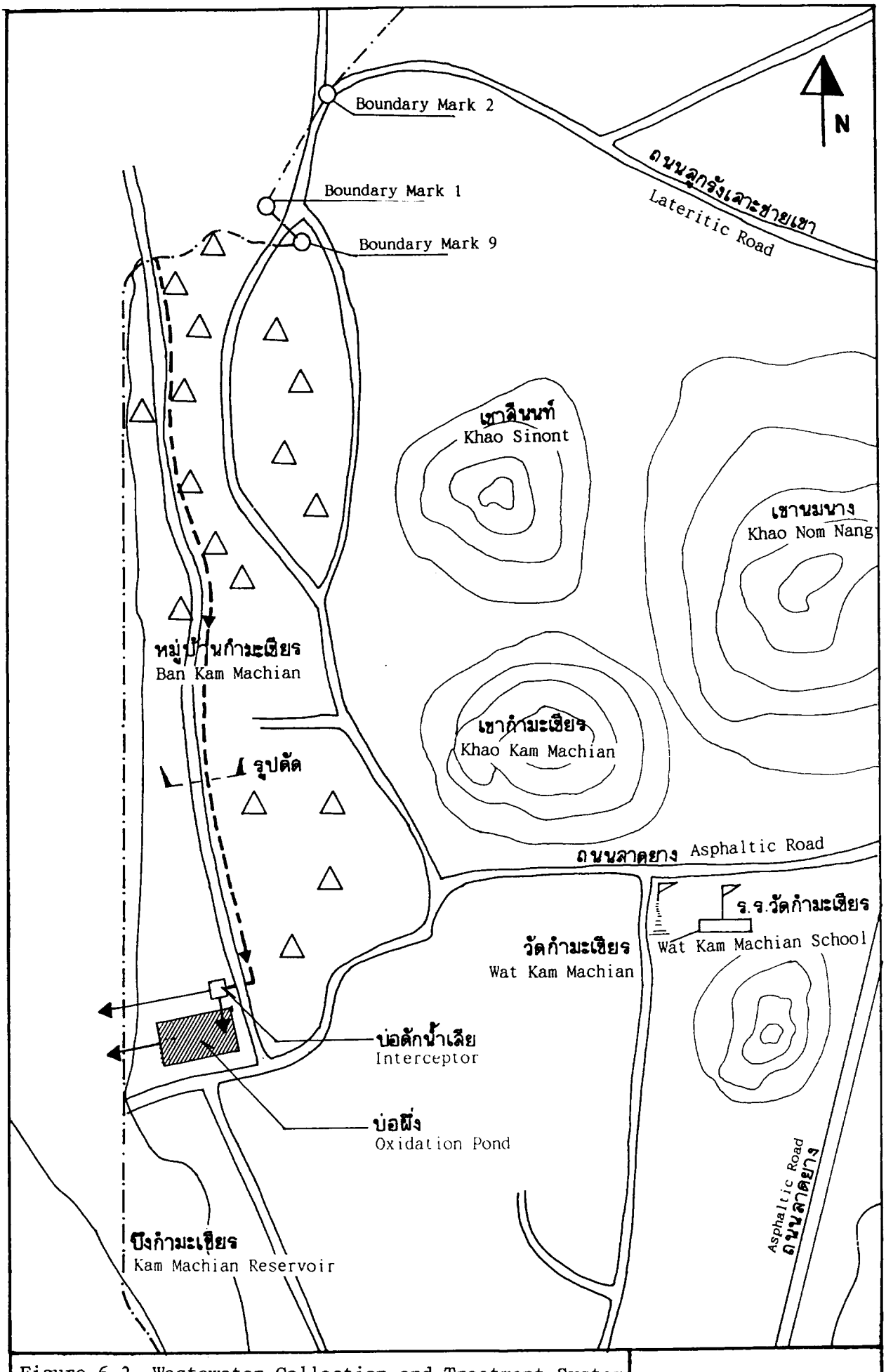


Figure 6.3 Wastewater Collection and Treatment System of Ban Kam Machian Community.

Concrete Ditch Road Community

Scale 1 : 5,000

Design the dimension of the trapezoidal concrete gutter as follow :-

Depth	=	1.0 m
Bottom width	=	1.0 m
Upper edge width	=	4.0 m
Wall slope	=	1 : 1.5

Spare more depth of 0.5 m for the difference between the road and the original ground surface.

2) Wastewater interceptor.

It is made of reinforced concrete with the capacity to handle wastewater and rainwater of 1.2 cu m/sec.

The drainage of wastewater to the treatment system is gravitational flow.

3) Cost estimation.

The total construction cost of wastewater collection system for Ban Kam Machian community is estimated at Bt 3.44 million. The operating and maintenance cost is 40,000 Bt/year.

6.3.2 Wastewater Treatment System.

(1) Principle and design criteria.

1) Ban Kam Machian is a small community. The population is scattered in about 250 houses with the average population of 5.3 persons/house. The wastewater treatment system should be natural system therefore, the oxidation pond is designed.

2) The BOD load is estimated from the number of population as done in the wastewater estimation by using the population equivalent of 32 gmBOD/person/day. The total BOD load is 250 x 5.3 x 0.032 = 42.4 kg/day.

(2) Design calculation and cost estimation.

The oxidation pond system for Ban Kam Machian community requires an area of 3.5 rai. The total construction cost is Bt 1.04 million and the operating cost is 10,000 Bt/year (for cutting the grass around the pond once a month)

6.4 DESIGN OF THE ON-SITE WASTEWATER TREATMENT SYSTEM FOR RESIDENTIAL HOUSES.

(1) Principles.

1) The on-site wastewater treatment system is to construct the treatment system at the place where the wastewater is generated in order to treat the wastewater to meet the quality standard before being discharged into the drainage pipe, the public stream or seeping away. This is different from the central treatment system which the wastewater is collected and transferred to be treated at the central plant. The on-site system is suitable for houses or buildings scattered away which

the construction of the wastewater collection system will be too costly.

2) There are 2 types of on-site treatment system, i.e., aerobic and anaerobic system. Most aerobic system (oxygen adding) is ready made and commercially available. Its size can be selected to suit the number of people living in the house. The advantage of this type is that it can treat the wastewater to meet the Effluent Quality Standard from building of type A, i.e., the BOD value is not more than 20 mg/l. The disadvantage is that it is rather costly (about 21,000 Bt for the family size of not more than 10 persons, excluding installation cost). Other expenses are energy consumption cost during its operation, and maintenance cost of the aeration instrument. Besides, the final effluent still contains more faecal coliform bacteria (FCB).

The anaerobic system is based on the principle of anaerobic disgestion. An ordinary septic tank or an anaerobic filter system can be used. The advantage of this system is that FCB and parasites are destroyed in the tank. The longer the hydraulic retention time (HRT), the higher the killing rate. General septic tank has HRT value of about 10 days. The killing FCB rate is up to 98%. This means that it can reduce the amount of bacteria from 10^7 to 10^5 MPN/100 ml. Another advantages are that it can be constructed by the general skilled workers and the construction materials are easily available. The construction cost is cheaper than the ready made aerobic system. However, its disadvantage is that the BOD value of the final effluent is more than 20 mg/l but still within the Effluent Quality Standard from Building of type D, i.e., the BOD value is not more than 90 mg/l. Therefore, it is necessary to have the final effluent disposal process by using a seepage tank to let the effluent assimilate into the ground.

3) In conclusion, the septic and seepage tanks are designed for on-site wastewater treatment system of the houses. The septic tank is responsible for treating the toilet wastewater while the seepage tank is responsible for eliminating the effluent overflow from the septic tank as well as the other wastewater from washing up and bathing by means of assimilation.

(2) Details of the design.

Figure 6.4 shows the detailed drawing of the septic and seepage tank system designed for on-site treatment of wastewater from houses in KPS-District. Its treatment capacity is up to 6 persons.

(3) Cost estimation.

The total construction cost is estimated at 7,000 Bt. The operating cost accounts for only the maintenance cost is 2%/year or 140 Bt/year.

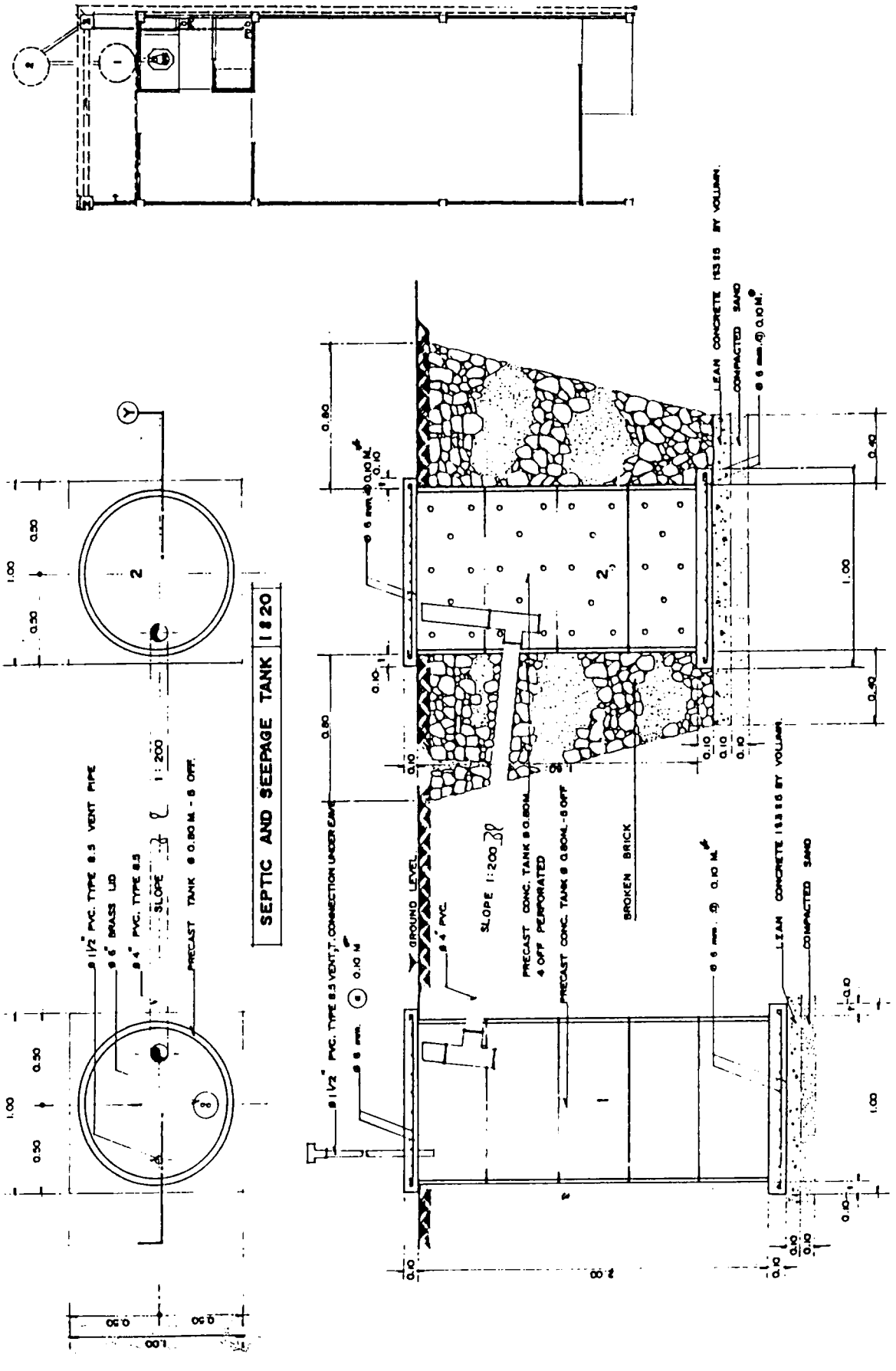


Figure 6.4 Detailed Drawing of the Septic Tank and Seepage Pit for Residential Housing.

6.5 DESIGN OF THE SOLID WASTE COLLECTION SYSTEM.

(1) Principles

1) To preliminarily design of the module and instruments used for collecting solid waste in KPS-District in the next 20 years.

(2) Estimation of the generated and collected solid waste quantity.

1) The quantity of daily solid waste generated can be estimated by using the solid waste generation rate of 0.44 kg/person/day. This figure is obtained from the survey.

2) The amount of solid waste expected to be collected daily by the collecting truck is :-

During the period of 1992-2001 = 55 % of the total amount generated.

During the period of 2002-2011 = Increasing to be 65 % of the total amount by extending the collecting route and efficiency in accordance with the expansion of the community.

(3) Design criteria.

1) The working life-duration of the solid waste collecting truck is 15 years.

2) The collecting truck is of open side and rear dump type with the capacity of 10 cu m (12 cu yard).

3) The collecting truck is to provide the maximum collection services of twice daily.

4) The collecting truck is to provide the maximum amount of solid waste collected at 90% of its full capacity.

5) A sufficient number of solid waste bins is to be provided to receive 40% of the total solid waste volume generated daily.

6) The bulk density of the collected solid waste is 0.265 kg/cu m.

(4) Design calculation.

1) At present, KPS-District has 2 solid waste collecting trucks. One is an open side and rear dump with the capacity of 10 cu m. It was bought in 1983 and will be expired in 1998. Therefore, it should be replaced by a new one in 1999. Another collecting truck is a pulling cart with the capacity of 2 cu m, bought in 1991 and will be expired in 2006, thus, should be replaced in 2007.

2) According to the design criteria, the number of solid waste bins and the collecting trucks has been calculated to handle the solid waste in the period of 1992-2011 as follows :-

- Number of solid waste bins with the capacity of 100 l needed each year is 45. They must be purchased every year due to its end of working life-duration.

- One solid waste collecting truck and a cart are enough to be used until 2011. No need to buy more but the replacement is necessary when its working life-duration is ended.

(5) Cost estimation.

1) A solid waste collecting truck, open sides and rear dump type with the capacity of 10 cu m is to be procured in 2009 as a replacement. The price at the end of 1991 was 700,000 Bt.

2) A pulling cart of 2 cu m capacity is to be procured as a replacement in 2007. The price at the end of 1991 was 40,000 Bt.

3) The solid waste bins and sweeping instruments are estimated at 20,000 Bt/year.

4) The operating cost including fuel, truck maintenance, wages and salary and miscellaneous is to be taken from the annual budget for which the KPS-District office is to propose every year. No estimation of this cost is undertaken at this step.

6.6 DESIGN OF THE SOLID WASTE DISPOSAL SYSTEM.

6.6.1 The Design of Sanitary Landfill System.

(1) Principles.

The sanitary landfill is one of the solid waste disposal method that require not so much operating cost therefore, it is suitable for the community whose land cost is not too high. The general principle of this method is that an earth trench is dug, the solid waste is disposed into the trench and then, compacted and covered by the dug soil. It should be done daily to prevent the insects and other animals from living and seeking food. Preventive system against leachate is also to be provided.

(2) Design Criteria.

Using the same criteria as item 6.5 of that for the collecting system design. Moreover, the depth of the trench is 2.5 m. The design is taking into account of 2 cases as follows:-

Case 1 Use the compaction density of 550 kg/cu m in the operation. This density is equivalent to the compaction of solid waste by the tractor.

Case 2 Use the compaction density of 1,200 kg/cu m which is the density of the compacted solid waste after having been compacted for more than 2 year upward.

(3) Preliminary design calculation.

1) Calculation of the required landfill area.

Case 1 If the compaction density is 550 kg/cu m, the area requirement for the period of 20 years is 13 rai.

Case 2 If the compaction density is 1,200 kg/cu m. The area requirement for the period of 20 years is 6 rai.

2) Disposal Site.

It is the public land at the foot-hill of Khao Nom Nang situated about 500 m apart from the Talad Tha Chang - Dan Chang District highway. It is still in the KPS-District area about 4 km from the KPS-District office. Its area is the foot-hill slope in which the nearby area is paddy field. An earth trench of 60 m wide, 90 m long and 2.5 m deep was dug. The bottom area is leaning along the mountain slope. The lower side of the trench, 1.5 m wide, is open to drain out the leachate from the trench and discharge into an earth ditch around the trench. It is recommended to use this area for disposal site which should consist of :-

- A road and a drainage ditch (some parts have been constructed).
- Leachate treatment pond. (some parts have been done but not completed yet).
- Area for buildings construction, trucks parking and equipment storage.
- Area for planting trees as wind breaker.

3) Machinery and equipment.

- One multi-purpose tractor, 120 horse power.
- One six-wheeled soil dumping truck.
- One pick-up truck (for the foreman).
- A truck parking area, an accommodation and the road improvement.

4) Cost estimation.

- The total construction and installation cost excluding land cost for the sanitary landfill system of KPS-District is estimated at Bt 11.4 million and the operating cost is Bt 1.78 million/year (estimated cost as for the end of 1991).
- The land area requirement is different between the compaction density of 550 kg/cu m which requires 13 rai, and the density of 1,200 kg/cu m which requires 6 rai. For the construction and operating cost, the 2 cases is considered to be the same. This means that for case 2 the landfill area is reused again after more than two years of landfilling because the first solid waste compaction is decomposted and can be compacted down further more.

6.6.2 Design of the Incinerator Accompanied with the Ash Landfill.

(1) Design principles and criteria.

1) As KPS-District is a small community which its average collected solid waste is 2.2-3.0 tons/day (estimated during 1992-2011). If the sanitary landfill method is used, it will be too costly for the construction, equipment procurement and the daily operating cost. The machinery procured such as tractor and trucks can finish the daily work within 1-2 hours in operation because of the less solid waste. But if the solid waste is not buried daily, the problems of bad smell, insects and

animals will still be occured. TISTR has therefore, studied and proposed another alternative, the incineration method accompanied with ash landfill.

2) The completed combustion of solid waste of moisture content more than 50% will require the outside supplementary energy source such as oil burner needed to supplement the incinerator.

3) Type of the incinerator should be the high thermal incinerator so that it can burn plastics. There are 2 heating chambers in the incinerator, the first one is for burning solid waste and the second one is for the completed combustion of smokes into vapoar and carbon dioxide.

4) Dust elemination system is needed before releasing flue gases from the incinerator.

5) The height of smoke stack should be enough for releasing the gas not to disturb the residential area located nearby. The recommended height should not less than 12 m.

6) Equipment and system control of the incinerator such as burner, measuring device and temperature control gauge should be automatically operated to lessen the working load of the employee.

7) The incinerator's installing house must be appropriate to its size.

8) Solid waste storage house should have at least a receiving capacity of 7 day waste.

(2) The design calculation.

The incinerator with the capacity of 500 kg/hr is designed for the solid waste of 2.2-3.0 tons/day, with a daily working period 4.4-6.0 hours/day.

(3) Cost estimation.

The total consruction cost of solid waste disposal system using incinerator and ash landfill for KPS-District is about Bt 9.0 million and the operating and maintenance cost is Bt 1.1 million/year.

7. ECONOMIC AND FINANCIAL ANALYSIS

7.1 ECONOMIC ANALYSIS OF THE PROJECT.

The objective of analysing economic aspect of the project is to find out the most appropriate alternative to be employed in the project on wastewater treatment and solid waste management in KPS-District. There are many alternative each of which has different investment and operating costs while its effectiveness is the same. Since this project is environmental oriented, the least cost alternative will be taken into account.

7.1.1 Assumptions Used in Economic Analysis.

(1) The projects to be analysed are the master plan of central wastewater collection and treatment system and the KPS-District which has 3 alternatives for the wastewater treatment plant, i.e., oxidation pond, aerated lagoon and oxidation ditch systems; and the solid waste disposal system which has 2 alternative, i.e., the sanitary landfill with the compaction density of 1,200 kg/cu m and the incineration accompanied with ash-landfill.

(2) The project duration is 20 years (1992-2011) which is divided into 2 years for construction (1992-1993) and 18 years for the operation peiord (1994-2011).

(3) The total project cost consists of land cost estimated at Bt 400,000/rai, the construction cost and the operating cost as estimated in the preliminary design in chapter 6.

(4) The standard converting factors for converting expenditure into economic value are : for land = 1.00, construction work = 0.88 and others = 0.92.

7.1.2 Least Cost Alternative.

(1) Wastewater treatment system.

According to the analysis, oxidation ponds system is the least cost alternative. Its economic value expenditure is Bt 12.287 million, equivalent to 1.17 Bt/1 cu m of wastewater (according to the constant price in 1992). Other subsequent least cost alternative is the aerated lagoon system with 1.51 Bt/cu m and the oxidation ditch system is 2.30 Bt/cu m.

(2) Solid waste disposal system.

According to the analysis, the incinerator accompanied with the ash-landfill is economically feasible since its economic expenditure is Bt 26.54 million or equivalent to 1,396.55 Bt/ton wet garbage while the sanitary landfill method costs Bt 41.91 million or equivalent to 2,205.33 Bt/ton wet garbage.

7.2 FINANCIAL ANALYSIS OF THE PROJECT.

7.2.1 Assumptions Used in the Analysis.

There are some additional assumptions to those of economical analysis as follows :-

(1) Financial Resource. Possible financial support may be obtained from 4 sources, i.e., the central budget channelled through the Public Works Department, the environmental fund administered by the Office of the Environmental Policy and Planning, annual budget of KPS-District and the service fee collected from the people in the service area after which the system is operated.

(2) Depreciation is considered at a constant rate of 5% per year for the whole project period.

(3) The opportunity lost for investment is considered at 4% per year. This is because the low interest loan can be sought for environmental concerning project.

7.2.2 Result of Financial Analysis.

The result of the break-even point analysis for 3 projects on wastewater collection and treatment system and 1 project on solid waste management of KPS-District at the opportunity lost of 4% in 8 cases was summarized in Table 7.1.

7.2.3 Financial Status.

In the fiscal year 1990, KPS-District had a revenue of 3,922,698 Bt and an expenditure of 2,917,137 Bt. The revenue was 1,005,561 Bt higher than the expenditure as shown in Table 7.2. Apart from this, KPS-District also had a provident fund of 1,573,580 Bt (on July 12, 1989) for necessary or urgent expense. This amount of money can be used in the operation of the wastewater treatment system and solid waste management system.

In considering the financial status of KPS-District and the capital of the wastewater collection and treatment system according to the master plan (cases 1, 2 and 3), it is found that KPS-District cannot afford it because much more capital is needed than its capability. The project may be feasible if the investment is supported by the central budget while the KPS-District is responsible for the operation cost. There are 4 cases that the KPS-District can self-implement, i.e., cases 4, 5, 6 and 7 whose systems are for the 2 main communities; Talad Tha Chang and Ban Kam Machian communities. The investment on the construction and the operating cost is not too high for the KPS-Districts to handle, i.e., the capital of Bt 0.58-1.50 million per year from 1994 to 2011 for Talad Tha Chang community and Bt 0.05-0.13 million per year for Ban Kam Machian community.

Table 7.1 Summation of the Break-even Point at the Opportunity Lost for Capital of 4% of the KPS-District's Projects

Project/Analysis cases	Present worth of the project, Bt million	Break-even point, Bt/cu m
1. Master plan of central wastewater collection and treatment system for KPS-District		
Case 1 Cover the total investment cost of the wastewater collection and treatment system	764.49	72.73
Case 2 Cover only the operating cost of the wastewater treatment system	16.71	1.59
Case 3 Cover only the operating cost of the wastewater collection and treatment system	229.01	21.79
2. Project on the construction of wastewater collection and treatment system for Talad Tha Chang community		
Case 4 Cover the total investment cost of the wastewater collection and treatment system	44.05	6.70
Case 5 Cover only the operating cost of the wastewater collection and treatment system	17.57	2.67

.../to be cont'd

Table 7.1 (Continued)

Project/Analysis cases	Present worth of the project, Bt million	Break-even point, Bt/cu m
3. Project on the construction of wastewater collection and treatment system for Ban Kam Machian community		
Case 6 Cover the total investment cost of the wastewater collection and treatment system	10.37	7.89
Case 7 Cover only the operating cost of the wastewater collection and treatment system	1.54	1.17
4. Project on solid waste management system		Bt/ton Solid Waste
Case 8 Cover the total investment of solid waste collecting system, the incinerator and ash-landfill system	53.10	2,794

In case 8 for solid waste management project, the result of the analysis indicates that the present worth of the collecting and the incinerator systems is Bt 53.10 million with the break-even point of 2,794 baht/ton wet garbage. Its average circulating capital for the operating cost from 1994-2011 is Bt 1.64-3.39 million/year. This money can be collected from the people using the service. The KPS-District may take a loan of Bt 9 million for the construction cost from the financial source charging low interest and return it within the period of the project.

Table 7.2 Revenue and Expenditure Budgetary of KPS-District during the Fiscal Year of B.E. 2527-2533.

Unit : Bt

Fiscal Year	Revenue	Expenditure	Revenue higher than expenditure	Annual Provident Fund
2527	2,037,118	1,936,866	100,252	-
2528	2,233,466	2,144,892	88,574	99,860
2529	2,247,704	2,127,146	120,558	71,000
2530	2,441,835	1,779,279	662,556	120,557
2531	2,534,929	1,775,643	759,286	-
2532	3,052,698	1,891,705	1,160,993	-
2533	3,922,698	2,917,137	1,005,561	400,000

Remark : The total Provident Fund of KPS-District = Bt 1,573,580 (As for July 12, B.E. 2532)

Source : Local Finance Division, Department of Local Administration.

8. ADMINISTRATIVE AND LEGAL ASPECTS

8.1 ADMINISTRATIVE BODY

8.1.1 The Organization of the Sanitary District Administration

The administration of KPS-District is within the framework imposed by the Sanitation Act, B.E. 2495 and is administered by the Sanitary District Board consisting of :

(1) 1 sheriff or assistant sheriff of the district where the Sanitary District is located.

(2) 1 assistant sheriff of the District, where Sanitary District is located, appointed by the governor.

(3) Kamnan of the Tambon (Sub-district head) whose part or whole of the area is in the Sanitary District area.

(4) 9 members of the municipality council elected by the people in the Sanitary District.

The Sanitary District will be upgraded to have its own fincncial administration when its financial condition is appropriate. At that stage, the sheriff or assistant sheriff's committeeship or chairmanship will be finished. He will be appointed as a consultant to the Sanitary District committee instead. As KPS-District's revenue is only Bt 2.5 million. it has not been upgraded yet.

Figure 8.1 presents the organization chart of the Sanitary Disrict administration consisting of the chairman, a committee and the head of the Sanitary District and the action body consisting of 3 sections; finance, technical, public health care and miscellaneous.

8.1.2 Authority

According to the Sanitation Act, B.E. 2495 section 25, the Sanitary District is authorized to undertake the following activities:-

(1) Provide and maintain waterways and roads.

(2) Provide and maintain drainage ditches.

(3) Keep the walkways, roads and public places clean.

(4) Dispose of the solid waste and cesspool sludge.

(5) Prevent and stop contagious diseases.

(6) Provide clean water or water supply.

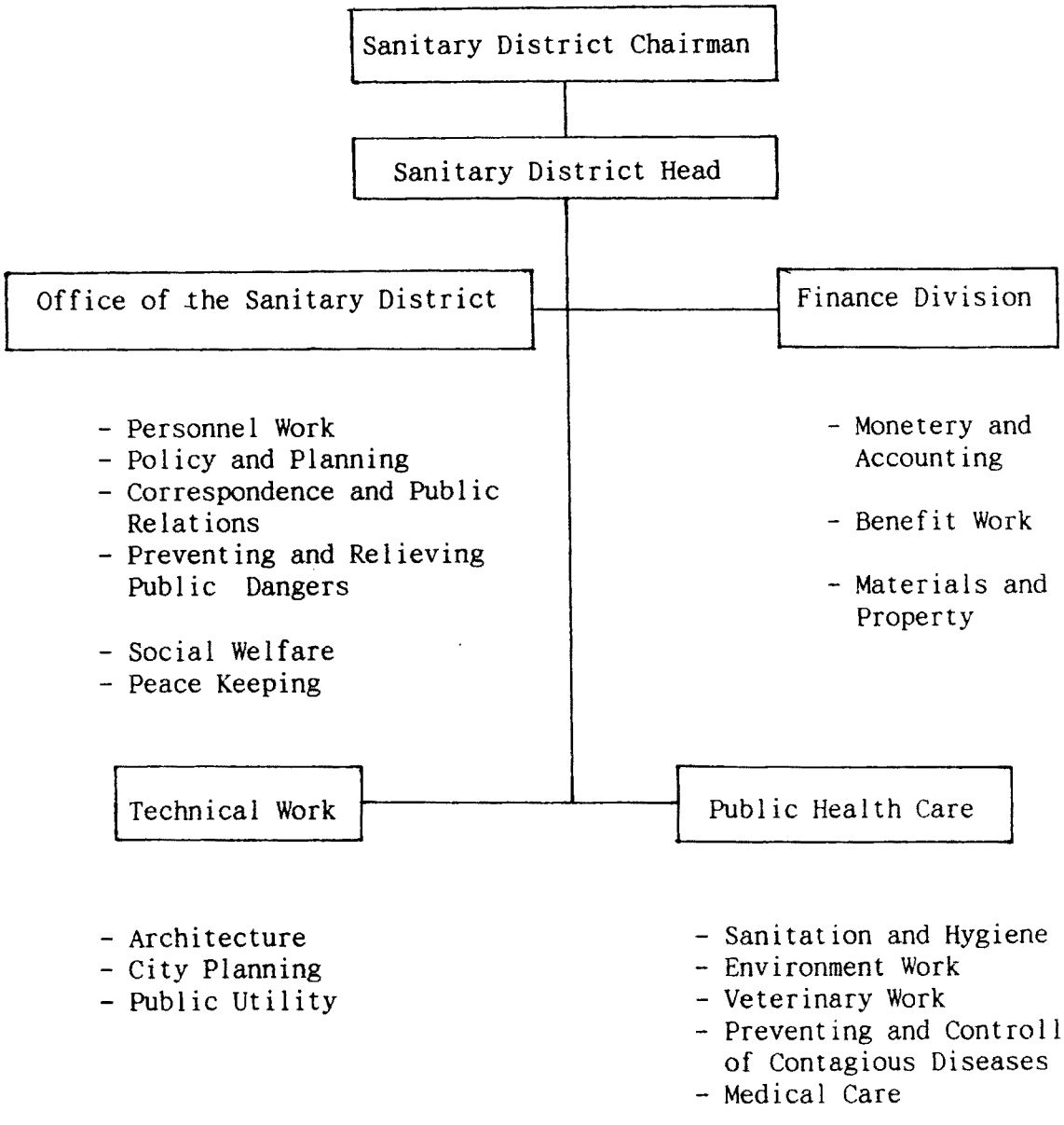


Figure 8.1 Organization Chart of Khao Phra Sanitary District Administration

(7) Provide an slaughterhouse.

(8) Provide markets, ship landings and piers.

(9) Provide a cemetery and a crematorium.

(10) Provide and maintain electricity supply or lighting by any means.

(11) Prevent and stop public dangers.

(12) Provide fire extinguishing equipment.

(13) Provide a health care station.

(14) Foster the people's education.

(15) Improve and promote the people's career.

(16) Provide and maintain places for sport and recreation, park, zoo as well as meeting hall.

(17) Foster religions, culture and morality.

(18) Provide public utility.

(19) Foster commerce.

(20) Foster any activities beneficial to the people in the Sanitary Disrict or activities legally belonging to the sanitary District authority.

According to the legalized authority, it is clear that the Sanitary District administration is to be responsible for solid waste management but not for the wastewater treatment. However, since the wastewater treatment is also related with the public health care and a public utility, the Sanitary District can, therefore, manage this. A local law on wastewater treatment fee collection must be imposed.

8.1.3 Personnel.

There are 24 personnel operating KPS-District. They are divided according to the employment; 2 officers, 12 permanent employees and 10 temporary employees. Eight of the personnel are responsible for solid waste management. There is no personnel having experience in wastewater treatment. The average age of the personnel is 30.9 years. Most of them obtain primary education. Their average income is 3,897.9 Bt/month.

From the information above, it can be seen that there is a shortage of personnel in wastewater treatment. Most of the personnel need some improvement and development in many aspects.

8.2 LAW

8.2.1 State Law.

Most state laws related to wastewater treatment and solid waste management were amended in 1992. They are as follows :-

(1) The Enhancement and Conservation of the National Environmental Quality Act, B.E. 2535 imposes the establishment of 3 organizations directly responsible for environment activities under the Ministry of Science, Technology and Environment, i.e., the Office of the Environmental Policy and Planning, the Pollution Control Department, and the Department of Environmental Quality Promotion. Environmental Fund is also stipulated by this Act to establish for investing and operating the wastewater treatment and waste disposal.

(2) The Public Health Act, B.E. 2535 is the amendment of the old one. It authorizes the local government to issue its own law for public health care management. The chairman of the Sanitary District committee is appointed as the local officer. Penalty on those who disobey the law is increased.

(3) The Public Cleansing and Neatness Act, B.E. 2535 is also the amendment of the old one. It emphasizes the increase of penalty to those who disobey the law by not keeping places clean or disposing of the solid waste or cesspool sludge in the public places.

(4) ONEB's Regulation on Effluent Quality Standard from Building specifies the characteristics of 12 types of building whose large amount of wastewater is discharged. The action agencies can use this regulation as criteria to design the wastewater treatment system for buildings.

(5) Notification of the Revolutionary Party Issue No. 286 (B.E. 2515) on Land Allottment Control specifies that there must be a land allottment committee to issue licences on land allottment taking into account the details of drainage and wastewater treatment in the land to be allotted.

(6) Building Control Act, B.E. 2522, (Issue NO.2) B.E. 2535 emphasizes on wastewater control in high and large buildings. These buildings have to be equipped with drainage and wastewater treatment systems as specified.

(7) Factory Act, B.E. 2535 is an amendment of the old one. This act is for controlling the wastewater discharged from industrial factories.

8.2.2 Local Regulations.

Authorized by the state laws of the Sanitation Act and the Public Health Act, KPS-District has issued 8 local regulations concerning the following issues :-

(1) Disposal of solid waste, cesspool sludge and dirt.

(2) Vendor control

(3) Private market

(4) Public market

(5) Stall control

(6) Barber control

(7) Disgusting or health hazardous trade control

(8) Building trade and ice trade in private place control

Some comments on those local regulations are summarized as follows :-

(1) All local regulations were issued before the amendment of the Public Health Act, B.E. 2535. So the details of the contents are not in accordance with each other.

(2) The local regulatons include the solid waste management and the control of disgusting trade issues but not the community wastewater treatment.

(3) The state laws of the Public Cleansing and Neatness Act and the Building Control Act are directly applied locally. But no local regulation on this matter is issued.

(4) In the past, the responsibility on community wastewater treatment was not clear in term of that who will be the responsible authority between the central government and the local one. This has caused no response in solving problems since the beginning.

(5) In the past, the solution of wastewater problem was emphasized on the law enforcement. No economic measure such as pollution charge was initiated.

8.3 SUGGESTIONS ON THE IMPROVEMENT OF ORGANIZATION ADMINISTRATIONS AND LEGAL ASPECTS.

8.3.1 Organization Administration.

(1) The administrative bodies can be improved by appointing a member of the sub-committee representing Suphan Buri Province to join in the operation plan on controlling the water quality in the Tha Chin river. At the same time, the chairman of KPS-Districts should be appointed in the committee for preventing and solving wastewater problems in Suphan Buri Province.

(2) The master plan to control the water quality in the Tha Chin river should be implemented by the related organizations.

(3) The Sanitary District's administrative body on wastewater should be established as follows :-

1) Establish the Sanitary District's own organization responsible for wastewater treatment under the Sanitary District head. Technicians holding technical certificate are to take care of this matter. Since those technicians have no experience in wastewater treatment before, they should be trained by the designer or the manufacturer of the wastewater treatment machinery as well as by the Public Works Department so as to keep pace with the technology.

2) Recruit the personnel holding higher technical certificate in sanitation. Their duties are to provide academic service on solid waste management and to help the Sanitary District head with the wastewater treatment matter.

8.3.2 Legal Aspects.

(1) Encourage the people to obey the law. For the state laws that do not authorize the local government to issue its own regulation, there should be a close cooperation between the local and central governments so that those laws can enforce locally.

Those laws are :-

- The Enhancement and Conservation of the National Environmental Quality Act, B.E. 2535
- Notification of the Revolutionary Party Issue No. 286 on Land Allottment Control.
- Building Control Act, B.E. 2522, (Issue No.2) B.E. 2535.
- Factory Act, B.E. 2535

In the long term, these laws should be amended to authorized the Sanitary District to issue its own regulation or apply them locally.

(2) Issue local regulation on wastewater treatment basing on the Sanitation Act, the Public Health Act and the Enhancement and Conservation of the National Environmental Quality Act.

Since the community wastewater treatment project is proposed by the central government, its success depends very much on the local agreement. Local regulations is, therefore, necessary to be issued. There are many factors that affect the implementation of the project such as local political situation, local financial capability and people's cooperation. So in authorizing the local government to issue its own community wastewater regulation, the central government has to closely cooperate in granting budget support, increasing financial capability by expanding tax base to assure the local government to run the project.

(3) The Sanitary District should utilize the Ministerial Regulation Issue No. 33 (B.E.2535) on the Availability of Wastewater Treatment and Drainage System in the Buildings to issue a sanitation regulation for controlling and managing wastewater by using central system.

(4) Public relation. The Sanitary District should inform the people of the master plan to solve the wastewater problem and of the need of their cooperation in controlling the effluent quality, paying the service fee and installing wastewater drainage pipes.

(5) Making Plan. The Sanitary District should make a development plan on community wastewater treatment in order that the work can continue even when the administrators are changed.

9. SUMMARY OF THE MEASURES AND THE PROJECTS FOR SOLVING COMMUNITY WASTEWATER AND SOLID WASTE PROBLEMS

9.1 SOLUTIONS TO WASTEWATER PROBLEM

It can be summarized from the study results as follows :-

(1) Measures for Solving Wastewater Problem.

1) To compaign the publics to realize the important of environmental conservation and convincing them to stop disposing of sewage and solid wastes into the Tha Chin river.

2) To Cooperate with the authority concerned, such as provincial industry official, in controlling the discharge of wastewater and fly-ash from rice mills into the Tha Chin river.

3) In the long term goal, relocation of those households trespassing on the Tha Chin river is needed in order to stop direct discharge of sewage and solid wastes into the river.

4) To support and promote the on-site treatment such as septic tank and seepage pit system for individual house in the KPS-District, this is to reduce total waste loads discharged into the river at present and to ensure a better sanitation of the community.

5) To provide cesspool sludge service facilities, including a proper disposal site, this can be run by the KPS-District, or by leasing to private sector with under supervision of the KPS-District.

(2) Projects for Solving Community Wastewater Problem.

The projects for solving wastewater problem in KPS-District are as follows :-

1) Master plan of central wastewater collection and treatment systems for KPS-District.

The collecting of wastewater in this project has been planned to cover the area of 7.5 sq km. The construction cost excluding land cost is Bt 318.3 million (price in 1991) and the operating cost is Bt 7.04 million/year.

As the current population density in the wastewater collecting area is rather low about 1,300 persons/sq km, the central collection and treatment system may not be feasible. (Generally, this system is suitable for the population density of 10,000 persons/sq km upward). Consequently, the emphasis is put, in this master plan project, on the land acquisition for the construction site of the system. The most appropriate wastewater treatment system for KPS-District is oxidation ponds system which needs 17.4 rai of land area. However, it is recommended that the land of not less than 35 rai should be procured and it should be in the south of KPS-District.

2) Project on the construction of wastewater collection and treatment system for Talad Tha Chang community.

The design of wastewater collection and treatment system for Talad Tha Chang community was undertaken in this project. The existing network of drainage pipes is utilized. The system is to cover the population of 5,000. The construction cost is Bt 15.58 million (excluding land cost) and the operating cost is Bt 0.55 million/year.

From the study, it is summarized that this project is appropriate to be implemented because it emphasizes on constructing the system for the dense community area and the existing network of drainage pipes can be used. So the construction cost is not too high. Financial support can be sought from the government or the Environmental Fund while the operating cost can be collected as the wastewater treatment fee from the people taking the service. However, the KPS-District has to provide land for the system construction. The land needed is 1.5 rai. Oxidation ditch is the most appropriate system for this area.

3) Project on the construction of wastewater collection and treatment for Ban Kam Machian community.

The design of the wastewater collection and treatment system for Ban Kam Machian community was undertaken in this project to cover the population of 1,000 people. The construction cost is Bt 4.48 million and the operation cost is Bt 0.05 million/year.

According to the study, this project priority is placed the second. It should be implemented after the wastewater treatment project of Talad Tha Chang community because Ban Kam Machian is a smaller community and households located are not so dense. But, it is necessary to provide the drainage gutters to help draining rainwater too. The financial source can be sought from the same place as that of Talad Tha Chang community project. The land requirement is 3.5 rai. Oxidation ponds system is proposed to be employed.

9.2 SOLUTIONS TO SOLID WASTE PROBLEMS

It can be concluded that the measures and the projects for solving solid waste management problems are as follows :-

(1) Measures on solid waste management.

1) To provide more service on solid waste collection by increasing service area or length of the existing route, without any increasing number of collecting truck and man power.

2) To increase efficiency in collecting fee in order to earn more revenue to be sufficiently used for providing more service on solid waste collection.

3) At present, the rate of collecting fee is relatively low only Bt 5/household/month. This should be increased under responsibility and authority provided by the Sanitation Act.

4) Emphasis on public relation to the people in the KPS-District and seeking cooperation in keeping the community clean.

(2) Project on solid waste management.

1) Project on solid waste collecting service.

KPS-District is to request for annual budget to cope with all expenses in solid wastes collecting service including budget for purchasing new garbage truck to replace the old and expired ones according to the details proposed by the study team.

2) Project on solid waste disposal by using incinerator and ash-landfill.

The feasible solid waste disposal method for the KPS-District is the high thermal incinerator followed by ash-landfill. The site for installation of the systems is the public land at the foot-hill of Khao Nom Nang where existing solid waste is being dumped on. This will require a construction cost of Bt 9.0 million (price in 1991) with an operating and maintenance cost of Bt 1.1 million/year.

9.3 STEPS AND THE DURATION OF THE IMPLEMENTATION

The budget of 5 projects on solving wastewater and solid waste problems is presented in Table 9.1. Table 9.2 shows the details of the steps and the duration of the implementation plan of the 5 projects for the period of 20 years.

Table 9.1 Summation of Construction Cost and Operating Cost for the Implementation of the 5 Projects

Project	Construction cost, Bt million	Operating cost, Bt million/year
1. Master plan of central wastewater collection and treatment system for KPS-District	318.3	7.04
1.1 Wastewater collection system	(313)	(7.0)
1.2 Wastewater treatment system	(5.3)	(0.04)
2. Project on the construction of wastewater collection and treatment system for Talad Tha Chang community	15.58	0.55
2.1 Wastewater collection system	(5.08)	(0.15)
2.2 Wastewater treatment system	(10.5)	(0.40)
3. Project on the construction of wastewater collection and treatment system for Ban Kam Machian community	4.48	0.05
3.1 Wastewater collection system	(3.44)	(0.04)
3.2 Wastewater treatment system	(1.04)	(0.01)
4. Project on solid waste collecting system	0.74	0.02
5. Project on solid waste disposal by using incinerator and ash-landfill	9.0	1.1
Total	348	8.74

Remark : 1) Budget is excluding land cost
2) Price in 1991

Table 9.2 Steps and Duration of the Project Implementation Plan for 20 year

Activity	Budget in B.E. 2534 (1991) Bt million	Year, in B.E. 35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
1. Master plan of central wastewater collection and treatment system for KPS-District	318.3																				
1.1 Land acquisition	-																				
1.2 Feasibility study and detailed design	46.2																				
1.3 Construction	272.1																				
1.4 Operating the system*	(7.04)																				
2. Project on the construction of waste-water collection and treatment system for Talad Tha Chang community	15.8																				
2.1 Land acquisition	-																				
2.2 Feasibility study and detailed design	2.26																				
2.3 Construction	13.32																				
2.4 Operating the system*	(0.55)																				
3. Project on the construction of waste-water collection and Treatment system for Ban Kam Machian community	4.48																				
3.1 Land acquisition	-																				
3.2 Feasibility study and detailed design	0.65																				
3.3 Construction	3.83																				
3.4 Operating the system*	(0.05)																				
4. Project on solid waste collecting system	0.74																				
4.1 Procurement of the collecting truck to be replaced	0.74																				
4.2 Cost for sweeping instrument *	(0.02)																				
5. Project on solid waste disposal by using incinerator and ash-landfill	9.0																				
5.1 Land acquisition	-																				
5.2 Detailed design	0.5																				
5.3 Construction	8.5																				
5.4 Operating the system*	(1.1)																				

Remark : 1. For Project implementation, it is assumed that the land acquisition and the seeking of financial source should be finalized within B.E. 2536. Therefore, each project can be started in B.E. 2537 onward.

2. Budget is estimated at the end of B.E. 2534. To request for the budgetary in advance it is recommended to increase the budget at the rate of 10% per year

* Annual Budget is in Bt million/year (figure in the parenthesis)

THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH. ENVIRONMENTAL AND RESOURCES MANAGEMENT DEPARTMENT.

PRELIMINARY STUDY AND DESIGN OF DRAINAGE, WASTEWATER TREATMENT AND SOLID WASTE MANAGEMENT SYSTEMS FOR KHAO PHRA SANITARY DISTRICT.