JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PEOPLE'S COMMITTEE OF HO CHI MINH CITY (PCHCMC)
MINISTRY OF PLANNING AND INVESTMENT (MPI)
THE SOCIALIST REPUBLIC OF VIET NAM

THE STUDY ON URBAN DRAINAGE AND SEWERAGE SYSTEM FOR HO CHI MINH CITY IN THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

SUMMARY

DECEMBER 1999

PACIFIC CONSULTANTS INTERNATIONAL

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Foreign Currency Exchange Rate Applied in this Report

Currency	Exchange Rate/US$
Vietnamese Dong (VND)	13,956
Japanese Yen (JPY)	113.39

(As of July, 1999)

PREFACE

In response to a request from the Government of the Socialist Republic of Viet Nam, the Government of Japan decided to conduct a master plan and a feasibility study on Urban Drainage and Sewerage System for Ho Chi Minh City in the Socialist Republic of Viet Nam and entrusted the study to Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Ryuji Yanai, Pacific Consultants International (PCI) to Viet Nam, three times between July 1998 and December 1999. In addition, JICA set up an advisory committee headed by Mr. Kenji Tomizawa, Managing Director of Japan Sewer Collection System Maintenance Association, between July 1998 and December 1999, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Viet Nam and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Viet Nam for their close cooperation extended to the team.

December, 1999

Kimio Fujita
President
Japan International Cooperation Agency

THE STUDY ON URBAN DRAINAGE AND SEWEARGE SYSTEM
FOR
HO CHI MINH CITY
IN
THE SOCIALIST REPUBLIC OF VIET NAM

December, 1999

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "The Study on Urban Drainage and Sewerage System for Ho Chi Minh City in the Socialist Republic of Viet Nam". This report has been prepared by the Study Team in accordance with the contracts signed on 3 July 1998 and 13 May 1999 between the Japan International Cooperation Agency and the Pacific Consultants International.

The report examines the existing conditions of urban drainage and wastewater disposal in about 650 km^2 of Ho Chi Minh City and presents the results of master plan of urban drainage and sewerage system and feasibility study for priority projects concluded in the master plan.

The report consists of the Summary, Main Report, Supporting Report and Data Book. The Summary summarizes the results of all studies. The Main Report contains the existing conditions, the master plan, the feasibility study, and conclusions and recommendations. The Supporting Report includes technical details of contents of the Main Report. In addition, Data Book has been prepared and is submitted herewith.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction and Embassy of Japan in Viet Nam, and also to officials and individuals of the Socialist Republic of Viet Nam for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the improvement of urban drainage and sewerage system in the Socialist Republic of Viet Nam and that friendly relations of both countries be promoted further by this occasion.

Yours faithfully,

柳内 隆二

Ryuji YANAI
Team Leader

ABSTRACT

1. Introduction

The objectives of this study are to establish the master plan on urban drainage improvement and sewerage development covering the urbanized area of about 650 km^2 in Ho Chi Minh City and to conduct the feasibility study of priority project selected from the master plan.

The study, which commenced on July 1998, was conducted in co-operation with People's Committee of Ho Chi Minh City (PCHCMC), the executing agency of the Government of Viet Nam.

2. Master Plan

An outline of the master plan on the urban drainage improvement and sewerage development with the target year of 2020 is summarized below.

Urban Drainage Improvement

Both structural and non-structural measures are proposed according to the land development condition.

(I) Structural Measures

(1) Canal Improvement

Canal improvement of 27 drainage systems with a total length of 307.3 km is proposed. The canal improvement includes dredging/excavation, slop protection works, and construction of operation and maintenance roads, box culverts and bridges.

(2) Natural Retarding Basin

Provide the low-lying paddy field for the natural retarding basin to regulate the flood run-off and to minimize the cost of channel improvement. Three (3) areas of Ben Da-Ba Hong of 1.1 km^2, Rach Dai Ham of 3.7 km^2 and R. Cua Nuoc Len of 5.0 km^2 are proposed.

(3) Pump Drainage Improvement

Pump drainage system with retarding pond for three (3) relatively low-lying areas located in the fringe of C drainage zone is proposed as follows.

Location	Thanh Da	Ben Me Coc (1)	Ben Me Coc (2)
Drainage Area (km^2)	0.154	0.709	0.460
Pump Capacity (m^3/min.)	21.0	90.0	27.6
Retarding Pond (m^3)	22,900	33,000	21,400

(4) Drainage Pipe/Channel Development

Proposed drainage pipe/channel development by drainage zone is summarized below.

(unit : km)

Drainage Zone	C	N	W	S	NE	SE	Total
Area (ha)	10,641	13,620	7,291	8,174	6,491	11,936	58,153
Existing Sewer Rehabilitation	15.2	-	-	-	-	-	15.2
Main Combined Sewer	375.8	265.2	53.3	149.1	255.9	294.3	1,446.8
Secondary/Tertiary sewer	162.5	114.7	23.0	64.5	110.6	127.2	625.6
Storm sewer	11.8	59.7	19.5	33.8	35.4	47.1	207.4
Open Channel	214.4	1,085.4	355.2	615.2	642.8	857.2	3,770.2
Total	779.7	1,524.9	451.1	862.6	1,044.6	1,325.9	6,065.1

(II) Non-structural Measures

Following non-structural measures are proposed.

- Identification and publication of flood area
- Preservation of low-lying area for natural retarding basin
- Preservation of future land requirement for canal improvement
- Introduction of flood proofing measures by residents
- Flood control regulation for new development in high land area
- Improvement of existing hydrological monitoring system

Sewerage Development

Both sewerage system and on-site sanitation system are proposed for wastewater disposal in Ho Chi Minh City.

Based on the comparative study of unit project cost of on-site sanitation system and sewerage system, the following treatment system is proposed.

Sewerage system is proposed for the area with population density of more than 200 person/ha. Remaining area is covered by on-site sanitation system.
Sewerage development area and population in 2020 are as follows:

Sewerage Development Area : 189.78 km^2 or 30 % of the Study Area
Population in 2020 : 5,774,748 or 78 % of the Study Area

On-site sanitation development area and population in 2020 are as follows:

On-site sanitation Development Area : 445.96 km^2 or 70 % of the Study Area
Population in 2020 : 1,653,867 or 22 % of the Study Area

The sewerage development area is divided into nine (9) individual sewerage zones as shown below.

Sewerage Zone	Area (ha)	Population	
		Existing (1997)	Future (2020)
Tham Luong – Ben Cat	1,495	185,696	354,857
Nhieu Loc – Thi Nghe	3,935	1,217,258	1,359,569
Tan Hoa – Lo Gom	2,447	542,108	655,540
Tau Hu – Ben Nghe, Doi – Te	3,065	1,468,703	1,390,282
Saigon West	1,315	97,782	398,000
Saigon South	1,555	80,960	320,000
Saigon North – I	2,324	171,165	500,000
Saigon North – II	1,152	63,410	196,500
Saigon East	1,690	68,100	600,000
Total	18,978	3,895,182	5,774,748

The total project cost for the Master Plan of Urban Drainage Improvement and Sewerage Development in HCMC is estimated at 40,381 billion VND (16,423 billion VND for Urban Drainage Improvement and 23,958 billion VND for Sewerage Development). Annual total operation and maintenance (O/M) cost is estimated at 156.9 billion VND (33.8 billion VND for Urban Drainage and 123.1 billion VND for Sewerage Development).

As a result of economic analysis, the Urban Drainage Project would have the EIRR of 10.97%. The recommendable sewerage tariff described below assumed from the willingness and the affordability of people to pay for the sewerage services was examined covering O/M cost including replacement cost with about 10 % of surplus.

Recommended Sewerage Tariff Covering All Nine (9) Sewerage Zones

For Residence	:	15,000 VND/HH/month
For Commercial	:	61,320 VND/shop/month
For Industry	:	27,350 VND/factory/month

3. *Priority Project*

Project	Content	Project Cost (Billion VND)		
		Foreign	Local	Total
Urban Drainage Improvement				
(1) Canal Improvement	Tau Hu – Ben Nghe Canal Improvement with a length of 12.2 km	148.6	346.8	495.4
(2) Pump Drainage Improvement	Thanh Da area of 0.154 km^2 (Pump capacity of 21 m^3/min.) Ben Me Coc (I) of 0.709 km^2 (Pump capacity of 90 m^3/min.) Ben Me Coc (II) of 0.46 km^2 (Pump capacity of 27.6 m^3/min.)	43.1	100.6	143.7
(3) Drainage Pipe System Improvement	Rehabilitation : Additional pipe = 10,272m Replacement = 1,320 m New drainage pipe = 52.4 km	76.9	179.4	256.3
(4) Cleaning/Dredging Equipment	High compressor car, Vacuum car, Bucket-type sewer cleaning car, Van, Set of checking and repairing tool for each district	27.7	64.5	92.2
Total of Urban Drainage Improvement [(1) to (4)]		296.3	691.3	987.6

Sewerage Development				
(5) Interceptor Sewer	Left bank area of Tau Hu-Ben Nghe : 5,480 m with a diameter ranging from ϕ 700 mm to ϕ 1,500 mm Isolated areas by Tau Hu-Ben Nghe, Doi-Te canals : 18,469 m with a diameter ranging from ϕ 400 mm to ϕ 1,200 mm	285.4	233.5	518.9
(6) Diversion Chamber	103 units of diversion chamber	8.6	7.0	15.6
(7) Intermediate Sewage Pumping Station	Pump capacity of 444.5 m^3/min.	113.4	92.8	206.2
(8) Conveyance Sewer	ϕ 2,500 mm : 5,400 m ϕ 2,000 mm : 500 m ϕ 1,500 mm : 500 m	225.2	184.2	409.4
(9) Separate Sewer	Right bank area (537 ha) of Doi-Te canal : Total length of sewer of 60,844 m (ϕ 300mm～ ϕ 600mm) with 151,838 numbers of house connection	51.8	42.4	94.2
(10) Wastewater Treatment Plant	Modified activated sludge system with a capacity of 469,000 m^3/day	1,339.4	1,095.9	2,435.3
Total of Sewerage Development [(5) to (10)]		2,023.8	1,655.8	3,679.6
(11) Administration Cost		0	154.5	154.5
(12) Engineering Cost		228.7	98.0	326.7
(13) Land Acquisition and Compensation		0	483.6	483.6
(14) Physical Contingency		213.6	253.1	466.7
Sub-total of (11) to (14)		442.3	989.2	1431.5
(15) Price Escalation		398.2	660.3	1058.5
Grand Total		3,160.6	3,996.6	7,157.2

The total cost of the priority project is estimated at 7,157.2 billion VND (512.8 million USD) with an annual O/M cost of 73.4 billion VND (7.4 billion VND for Urban Drainage and 66.0 billion VND for Sewerage system).

As a result of economical and financial analysis, the Urban Drainage Improvement project would have the EIRR of 18.77%, and the Sewerage Development project would have the FIRR of 1.20% with the monthly sewerage tariff of 12,500 VND/HH for residence, 51,100 VND/shop for commercial and 22,800 VND/factory for industry. This sewerage charge system recovers 26.6% of the total loan repayment including the interest.

While in the case of monthly sewerage tariff can be increased to 27,400 VND/HH for residence, 111,800 VND/shop for commercial and 49,900 VND/factory for industry, the revenue from the sewerage charge can cover the all repayment of loan with its interest and O/M cost. And this tariff system is still lower than the affordability of people to pay the sewerage services.

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SUMMARY

I. INTRODUCTION

The Government of the Socialist Republic of Viet Nam (hereinafter referred to as "GOV") approved the "Viet Nam National Plan for Environmental and Sustainable Development" in 1992. The Plan emphasizes the necessity of preparation and execution of environmental protection and improvement measures for the major cities in Viet Nam. Ho Chi Minh City (hereinafter referred to as "HCMC"), that is the largest city of the nation as well as the socio-economic center in the southern region of the country, was also nominated on the Plan with the highest priority. The Plan indicated the current environmental deterioration problem, particularly urban drainage and sewerage problems, which affects the health of a huge number of people. The improvement of existing environmental condition in HCMC is required very urgently.

In response to the request of GOV, the Government of Japan (hereinafter referred to as "GOJ") decided to implement the Study on Urban Drainage and Sewerage System for Ho Chi Minh City in the Socialist Republic of Vietnam (hereinafter referred to as " the Study"). Japan International Cooperation Agency (hereinafter referred to as " JICA"), the official agency responsible for the execution of technical cooperation program of GOJ, is conducting the Study in close cooperation with the authorities concerned of GOV.

This is the Summary of Final Report covering the Master Plan and the Feasibility Study on Urban Drainage and Sewerage System for Ho Chi Minh City.

II. MASTER PLAN

1. The Study Area

The Study area of about 650 km^2 located in the central part of HCMC covers the existing urbanized area (the inner city area) of about 140 km^2 and the surrounding area of about 510 km^2 (refer to Fig. 1). According to the Adjustment Master Plan prepared by UPI in 1998, the population of the Study area of about 4.4 million in 1997 is projected at about 7.6 million in the year 2020. Due to the rapid population growth, the present built-up area of about 174 km^2 will be expanded to about 430 km^2 (almost 70% of the Study area).

Infrastructure services of the central part of HCMC were considered to be fairly good within the country. Due to the current remarkable economic development and population increase of the city, the urbanized area was rapidly expanded without a development of infrastructure, especially urban drainage and sewerage system. The Study area is prone to flooding due to its geographic feature with low ground elevation, high precipitation and high tide. The original urban drainage and sewerage system (combined system) constructed in 1870s has been improved from 1950s to 1975. However, these old facilities have been

designed for a population of 1.5 million. Therefore, during the monsoon season, floods have been occurred several times in the existing urbanized area of about 35 km^2 and agricultural land of about 230 km^2. Annual flood losses are estimated at about 845 billion VND/year. In addition, the domestic and industrial wastewater of 729,000 m^3 with a pollution load of more than 193,000 kg in terms of BOD_5 is discharged daily to rivers and canals in the Study Area without any treatment. This pollution load deteriorates the water quality of rivers and canals to an unacceptable level. Water quality of main canals in the inner city area of Nhieu Loc – Thi Nghe, Tan Hoa – Lo Gom, Tau Hu – Ben Nghe and Doi – Te is aggravated more than 100 mg/l in terms of BOD_5. And some portion of Tan Hoa – Lo Gom canal, water quality is worse than 400 mg/l in terms of BOD_5. Furthermore, domestic solid waste dumped to the canal from the illegal houses along the waterway, unsatisfactory dredging of the drainage canals, and insufficient maintenance works for these canals aggravate remarkably the water pollution with an untolerable smell. This deteriorated water condition much affects the people's sanitary environment. Considering the continuous rapid urbanization of the city, the water environment will be getting worse, if any countermeasures for environmental improvement will not be properly implemented.

2. Planning Concept

Planning concepts in formulating a Master Plan of Urban Drainage Improvement and Sewerage Development are as follows:

- The target completion year of the Plan is set at 2020 on the premise that the proposed stepwise project implementation will be taken up at least 20 years.
- Existing urban drainage and sewerage facilities are to be fully utilized to minimize the investment cost and allocate the budget effectively.
- The integrated urban drainage measures, which consist of structural and non-structural measures are proposed to limit the flood damage to an acceptable level in all the basins, to minimize the project cost and to facilitate the smooth implementation of the project.
- The urban drainage improvement plan is formulated to meet the appropriate design scale between 2 and 10-year return period for each drainage facility and the projected land use in the year 2020.
- Both On-site Sanitation Improvement and Sewerage Development are proposed for wastewater management
- In principle, the industrial wastewater is to be treated individually by each corresponding factory itself.
- The Plan should be compatible and coordinated with the on-going environmental improvement projects in the region assisted by World Bank, Belgium Government, Asian Development Bank, etc.

3. Urban Drainage Improvement

3.1 Outline of the Proposed Optimum Urban Drainage Improvement

(1) Zoning

The Study area is divided into six (6) drainage zones (C, N, W, S, NE, and SE zones) as shown in Fig. 2. Each zone has different physical, social and living environmental conditions, such as topography, geology, land use, urbanization, urban drainage system, flood situation, etc. Firstly, these conditions and flood mechanism have been analyzed by zone, then it has found out that serious inundation area will be expanded to surrounding area due to urbanization and urban drainage condition will be more deteriorated, if no countermeasure are implemented.

(2) Integrated Urban Drainage Improvement Plan

Considering the rapid urbanization and serious flood situation of each drainage zone, the integrated urban drainage measures consisting of structural and non-structural measures are proposed. Basic concept for selecting adequate measures is as follows:

(a) For existing urbanized area	:	Storm water is to be drained out as soon as possible by applicable structural measures and intensive O/M works to decrease flood losses
(b) For future urbanized area	:	Flood losses are to be minimized by combination of structural and non-structural measures.
(c) For non-urbanized area	:	Rainwater storage potential to be preserved by non-structural measures. In principle, no structural measures are proposed.

The optimum urban drainage improvement plan consisting of short, mid. and long term programs is proposed for each drainage zone as shown in Fig. 3.

3.2 Structural Measures

The proposed structural measures consist of (i) canal improvement, (ii) natural retarding basin, (iii) pump drainage application, (iv) on-site detention pond, and (v) drainage pipe/channel development. These are shown in Fig. 4 and summarized below.

(1) Canal Improvement

Canal improvement is the main structural measures to improve urban drainage and city environmental condition including city landscape. Channel improvements of 27 canal systems with a total length of 307.3 km are proposed. The channel improvement includes dredging/excavation, slope protection works, and construction of operation

and maintenance roads, box culverts and road bridges. Five (5) types cross section are proposed to be able to apply easily under the different site conditions. Improvement of the canal with its catchment area of more than 30 km^2 located out of the inner city is to be implemented on 5-year return period as a short or mid-term plan and to be graded up to 10-year return period as long-term plan. Canal improvement by drainage zone is as follows:

CANAL IMPROVEMENT WORKS BY ZONE

Item	C	N	W	S	NE	SE	Total
Channel Improvement (km)	55.3	57.4	46.2	58.5	40.7	49.3	307.3
Box Culvert (place)	0	4	0	0	0	0	4
Bridge (place)	4	7	3	0	5	0	19

Proposed canal improvement in C drainage zone is shown in Fig. 4.

(2) Natural Retarding Basin

Preservation of low-lying agricultural land having a potential of rainwater storage is essential to control the peak discharge of storm run-off. It was proposed that some low-lying paddy fields in N and W zones utilize as a natural retarding basin with an allowable inundation (depth: max. 0.3 m, duration: within one day) to regulate the flood run-off and to minimize the cost of downstream channel improvement. Location and area of the proposed natural retarding basin are as follows:

PROPOSED NATURAL RETARDING BASIN

No.	Location		Dimension	
	Drainage Zone	Name of Canal	Area (km^2)	Capacity ($x10^3$ m^3)
1	N	Ben Da-Ba Hong	1.1	220
2	N	Rach Dai Han	3.7	1,110
3	W	R. Cua-Nuoc Len	5.0	3,000

(3) Pump Drainage Application

The application of pump drainage system was proposed to three (3) relatively low-lying areas situated on the fringe of C-zone in inner city, which has being developed but annually threatened by seasonal inundations, due to the difficulty of relocation to carry out land filling up. In order to minimize the pump drainage cost, it has planned to make small pump capacity in association with a retarding pond. The proposed pump drainage plan is shown below:

PROPOSED PUMPING DRAINAGE PLAN

Location / Item	Thanh Da	Ben Me Coc (1)	Ben Me Coc (2)
Drainage Area (km^2)	0.495	0.709	0.460
Pump Capacity (m^3/s)	1.0	1.5	1.0
Retarding Pond (m^3)	22,900	33,000	21,400

(4) On-site Detention Pond

New developments in high land, such as Hoc Mon in N zone and Thu Duc in NE zone, will increase a flood risk for downstream low lands and a necessity of canal improvement. So, it was proposed to establish the regulation that the developers should construct the on-site detention pond, of which specific storage requirement is estimated at 17,000 – 19,000 m^3/km^2. In case of small new development, the developer can select the alternative to pay a part of the future canal improvement cost as a compensation fee. PCHCMC shall start to have a study of its legal aspect, technical development of the said pond, investigation and inspection of the documents from the developer, etc.

(5) Drainage Pipe/Channel Development

Drainage pipe/channel development plan has been formulated taking into the following considerations:

- to utilize the existing combined sewers with intensive O/M to minimize investment costs
- to apply the existing combined sewer pipe network system for the inner city area and the separate system with pipe/ open channel network in drainage for newly developed areas
- to utilize the existing natural drainage system in undeveloped areas
- to harmonize the drainage pipe/channel installation with sewerage development in newly developed area

The proposed drainage pipe/channel development by zone is summarized below.

PROPOSED DRAINAGE PIPE/CHANNEL DEVELOPMENT

(Unit : km)

Item / Zone	C	N	W	S	NE	SE	Total
Area (ha)	10,641	13,620	7,291	8,174	6,491	11,936	58,153
Rehabilitation of Existing Sewer	15.2	-	-	-	-	-	15.2
Main Combined Sewer	375.8	265.2	53.3	149.1	255.9	294.3	1,446.8
Second/Tertiary Combined Sewer	162.5	114.7	23.0	64.5	110.6	127.2	625.6
Storm Sewer	11.8	59.7	19.5	33.8	35.4	47.1	207.4
Open Channel	214.4	1,085.4	355.2	615.2	642.8	857.2	3,770.2
Total	779.7	1,524.9	451.1	862.6	1,044.6	1,325.9	6,065.1

3.3 Non-structural Measures

In order to complement the structural measures, of which implementation will take much investment and time, to minimize the project cost and to facilitate the smooth implementation of the project, the following non-structural measures have been proposed.

- Identification and publication of flood area for the residents
- Preservation of low-lying area for utilization of the natural retarding basin
- Preservation of future land requirement of canal improvement
- Flood proofing measures by residents in flood plain
- Flood control regulation for new development in high land
- Improvement of the existing hydrological monitoring system

In addition to these non-structural measures, the introduction of a new O/M framework with sophisticated equipment and mutual cooperation among concerned organizations (UDC, District Public Service Enterprises and local communities), the strengthening of the Steering Committee of Flood and Storm Prevention in PCHCMC were proposed accordingly, defining the corresponding functional organizations and responsibilities for the preparation of an efficiency in total management, a sufficient regulation/law for the environmental conservation at local basis.

4. Sewerage Development

4.1 Delineation of On-site Sanitation and Sewerage Development Areas

(1) General

For treatment of domestic, commercial and institutional wastewater consisting of both toilet wastewater and gray water, the following three (3) systems are considered to be appropriate.

- Septic tank with anaerobic up-flow filter (On-site treatment system)
- Package treatment plant with extended aeration tank (On-site treatment system)

- Sewerage system with treatment plant

(2) Required Wastewater Treatment Level

The Vietnamese standard of TCVN5942-1995 stipulates the water quality of rivers and canals based on its respective water uses. The water quality of rivers and canals in the Study Area are specified as follows:

Water Supply Source (Upper Stream of Dong Nai River)	:	BOD_5 less than 4 mg/l
Other Water Uses (Other Rivers and Canals)	:	BOD_5 less than 25 mg/l

Vietnamese Government also regulates the effluent industrial water quality by the industrial wastewater discharge standard (TCVN5945-1995). All industrial wastewater should be treated to the appropriate level before discharging to the public water bodies. The required effluent industrial water quality is stipulated based on the respective water use of the receiving water bodies.

Effluent water quality to rivers and canals in the Study Area are as follows:

Water Supply Source (Upper Stream of Dong Nai River)	:	BOD_5 less than 20 mg/l
Other Water Uses (Other Rivers and Canals)	:	BOD_5 less than 50 mg/l

The effluent water quality of the wastewater treatment plant is regards as the industrial wastewater discharge standard. Then, the required wastewater treatment level is proposed to be less than 50 mg/l for the Urgent Stage. While, for the Master Plan Stage of year 2020, the required treatment level is proposed at 20 mg/l in terms of BOD_5.

(3) Wastewater Treatment System

Based on the required treatment level in Urgent Stage and Master Plan Stage, unit project cost consisting of construction cost and operation and maintenance cost per capita of both On-site Sanitation system and Sewerage system are compared. Unit cost of the Sewerage system varies according to magnitude of service area and its population density. While unit cost of the On-site Sanitation system is relatively constant.

As evidence from the comparative study of unit project cost of On-site Sanitation system and Sewerage system, the following treatment system is proposed for the Master Plan.

Sewerage system is proposed to treat both toilet waste and gray water for the area with population density of more than 200 person/ha. Remaining area will be covered by on-site sanitation system of septic tank with anaerobic up-flow filter.

(4) Zoning

Sewerage development area is delineated on the following criteria.

- Wards with a population density of more than 200 person/ha
- Wards surrounded by or located in the vicinity of other high population density area and Wards in which the combined sewer developed area even where population density of less than 200 person/ha

Proposed sewerage development area and population in the year 2020 are as follows:

Sewerage Development Area	:	**189.78 km^2 or 30% of the Study Area**
Population in 2020	:	**5,774,748 or 78% of the Study Area**

On-site Sanitation development area and population in the year 2020 are as follows:

On-site Sanitation Development Area	:	**445.96 km^2 or 70% of the Study Area**
Population in 2020	:	**1,653,867 or 22% of the Study Area**

Delineation of proposed sewerage Development area and on-site sanitation development area is shown in Fig. 5.

4.2 Short Term Sanitation Improvement Plan

Following structural and non-structural measures are proposed to improve the existing sanitary condition as the short term solution.

- Promotion of industrial wastewater treatment and on-site sanitation improvement
- Public campaign for environment protection
- Construction of public toilet
- River and canal environment improvement by dredging and aeration

4.3 Proposed Sewerage Development

Proposed sewerage development area of 18,978 ha is divided into nine (9) individual sewerage zones. Area and population of respective sewerage zones are as shown below.

Sewerage Zone	Area (ha)	Population	
		Existing (1997)	Future (2020)
1. Tham Luong – Ben Cat (TLBC)	1,495	185,696	354,857
2. Nhieu Loc – Thi Nghe (NLTN)	3,935	1,217,258	1,359,569
3. Tan Hoa – Lo Gom (THLG)	2,447	542,108	655,540
4. Tau Hu – Ben Nghe – Doi – Te (THBNDT)	3,065	1,468,703	1,390,282
5. Saigon West (SW)	1,315	97,782	398,000
6. Saigon South (SS)	1,555	80,960	320,000
7. Saigon North – I (SN-I)	2,324	171,165	500,000
8. Saigon North – II (SN-II)	1,152	63,410	196,500
9. Saigon East (SE)	1,690	68,100	600,000
Total	18,978	3,895,182	5,774,748

Proposed sewerage system of the nine (9) respective sewerage zones along with its treatment plant site are shown in Fig. 6 and outline of each sewerage system is described as below.

(1) Tham Luong – Ben Cat Zone

This zone covers D. Go Vap and D. Binh Thanh. Combined sewer system with interceptor sewer is proposed for collection of wastewater. Conventional activated sludge treatment plant with an ultimate capacity of 131,000 m^3/day is proposed in Ward 17 of D.12.

(2) Nhieu Loc – Thi Nghe Zone

This zone covers whole or part of seven (7) districts of D. 1, 3, 10, Binh Thanh, Go Vap, Phu Nhuan and Tan Binh. Combined sewer system with interceptor sewer is proposed. Wastewater treatment plant with an ultimate capacity of 501,000 m^3/day is proposed in Ward Phuoc Loc in D. Nha Be.

(3) Tan Hoa – Lo Gom Zone

This zone covers 32 wards in five (5) districts of D. 6, 8, 11, Tan Binh and Binh Chanh. Combined sewer system with interceptor sewer along Tan Hoa – Lo Gom canal is proposed. Wastewater treatment plant with an ultimate capacity of 242,000 m^3/day is proposed in ward Tan Kien in D. Binh Chanh.

(4) Tau Hu – Ben Nghe – Doi – Te Zone

This zone covers the central part of the inner city area consisting of nine (9) districts of D. 1,3,4,5,6,8,10,11 and Tan Binh with totally 88 wards. 80% of this sewerage zone is covered by the existing combined sewer system. Interceptor sewer is proposed along Ham Nghi, Tran Hung Doa Rds and roads along Tau Hu, Ben Nghe Doi and Te canals. Treatment plant with an ultimate capacity of 512,000 m^3/day is proposed in ward Phuoc Loc in D. Nha Be.

(5) Saigon West Zone

This zone covers seven (7) wards in D. 12. Separate system is proposed to collect wastewater in this zone. Wastewater treatment with an ultimate capacity of 111,000

m3/day is proposed nearby May 19 canal.

(6) Saigon South Zone
This zone covers D. 7 consisting 11 wards. Separate system is proposed. Conventional activated sludge treatment plant with an ultimate capacity of 89,000 m^3/day is proposed in ward Phuoc Kien in D. Nha Be.

(7) Saigon North – I Zone
This zone covers 12 wards in D. Thu Duc. Separate system is proposed to collect wastewater in this zone. Treatment plant with an ultimate capacity of 139,000 m^3/day is proposed in ward Truong Tho in D. Thu Duc.

(8) Saigon North -- II Zone
This zone covers eight (8) wards in D. 2. Separate system is proposed for wastewater collection. Wastewater treatment plant with an ultimate capacity of 55,000 m^3/day is proposed in Ward Binh Khanh in D. 2.

(9) Saigon East Zone
This zone covers 12 wards in D. 9. Separate system is proposed. Wastewater treatment plant with an ultimate capacity of 167,000 m^3/day is proposed in Ward Tang Nhon Phu in D. 9.

5. Master Plan Project Cost

The total project cost for the Master Plan of Urban Drainage Improvement and Sewerage Development in HCMC is estimated at 40,381 billion VND (16,423 billion VND for Urban Drainage Improvement, 23,958 billion VND for Sewerage Development) in February 1999 price. Breakdown of the Master Plan project cost is shown in Table 1.

6. Evaluation of Master Plan Project

For the economic evaluation of the part of the urban drainage improvement for six (6) drainage zones, existing and future annual direct and indirect economic benefits of respective drainage zones are summarized as shown below:

Drainage Zone	Annual Average Benefit (Billion VND)			
	Direct Benefit		Indirect Benefit	
	1998	2020	1998	2020
C Zone	366.5	439.9	107.7	120.0
N Zone	218.1	273.4	8.2	22.1
W Zone	40.9	117.5	6.7	14.6
S Zone	39.1	117.9	4.0	13.6
NE Zone	3.7	64.7	3.7	12.5
SE Zone	39.4	127.5	6.7	34.7
Whole Area	707.7	1,140.9	137.0	217.5

Based on the above-mentioned economical benefits, economical evaluation is conducted with project costs of construction cost and 50 year's O/M costs including replacement cost of 20 years interval. The EIRR of each drainage zone ranges from 13.07% of C Zone to 2.19% of NE Zone with an average of 10.97%. The B/C ranges from 1.25 of C zone to 0.23 of NE Zone with an average of 1.08. The EIRR and B/C of respective drainage zones are shown below.

Indicator	C Zone	N Zone	W Zone	S Zone	NE Zone	SE Zone	Study Area
EIRR	13.07	10.63	6.83	8.70	2.19	9.28	10.97
B/C	1.25	1.05	0.66	0.85	0.23	0.91	1.08

Sewerage charge was assumed based on the willingness of people to pay and the affordability of people to pay for sewerage development. Based on the assumed sewerage charge, availability to cover the construction cost and O/M cost by sewerage charge was discussed. It is quite obvious that the sewerage development project is not viable by the expected sewerage charge only and it is required the Governmental support for the capital investment. The recommended sewerage tariff system described below was examined covering only O/M cost including replacement cost with about 10% of surplus.

RECOMMENDED SEWERAGE TARIFF

For Residence	:	15,000 VND/HH/ month
For Commercial	:	61,320 VND/shop/ month
For Industry	:	27,350 VND/factory/ month

7. Selection of the Priority Project

Priority sequences for implementation of urban drainage and sewerage development project were determined from the aspects of (1) demands /benefits, (2) adverse effects and (3) constraints of the respective development zones. Major evaluation indexes for the proposed projects are as follows.

(Demands/Benefits)
- Population density
- Present flood condition
- Pollution load generation
- Damage to commercial and institutional activities
- Waterborne disease contraction rate
- Public land use

(Adverse Effects)
- Required construction cost and O/M cost

(Constraints)
- Required land acquisition and availability of wastewater treatment plant site

Drainage **Zone C** and **Tau Hu, Ben Nghe -- Doi, Te zone** were selected as the priority project of urban drainage improvement and sewerage development for the subsequent feasibility study respectively.

III. PRIORITY PROJECT

1. Priority Project Area

The Project Area covers the central portion of Ho Chi Minh City with an area of 3,065 ha, defined as Tau Hu, Ben Nghe -- Doi, Te Basin. The Project Area also covers the isolated area of Thanh Da area of 15.4 ha, Ben Me Coc (1) of 70.9 ha and Ben Me Coc (2) of 46.0 ha for pump drainage development areas (refer to Fig. 7). The Project Area encompasses 10 Districts with a total existing and future population of 1,468,703 in 1997, 1,421,778 in 2010 and 1,390,282 in 2020.

2 Urban Drainage Improvement Plan

The priority urban drainage improvement project consists of the following three (3) project components; 1) Tau Hu, Ben Nghe canal improvement, 2) Pump drainage improvement, and 3) Existing drainage pipe improvement.

2.1 Tau Hu - Ben Nghe Canal Improvement

Tau Hu - Ben Nghe canals situated along southern edge of the central business area of HCMC with a total length of the canal is about 12.2 km. The canals have three functions, urban drainage for 8 Districts of about 61.7 km^2, waterway transportation between Mekong Delta and HCMC and water open space including landscape for the city life. However, much sedimentation of garbage, waste disposal and soil deposit, encroachment of illegal houses and buildings along the canals, and direct inflow of domestic wastewater from their basins have promoted the necessity of the canal improvement to create primary functions.

Design scale of the canal improvement is applied 10-year frequency flood for urban drainage and 100 - 300 tonnage boat navigation for waterway transportation.

Alignment of the courses of Tau Hu - Ben Nghe is proposed to coincide with the existing channel alignment as much as possible, to consider the navigation requirements, and to harmonize with the road alignment proposed in Ben Chung Duong – Ben Ham Tu – Tran Van Kieu Road Improvement Project. Fig. 8 shows the proposed alignment of Ta Hu - Ben Nghe canals.

The canal bed is designed principally to meet the requirement of waterway transport. As shown in Fig. 9, canal bed slope is planned at 1/20,000 to be gentler hydraulic gradient of design high water level not to create drainage problem inside the embankment.

Main features of the canal improvement are as follows:

Name of Canal	Length (m)	Top Width (m)	Depth (m)	Slope Protection
Ben Nghe	3,140	60 – 120	5.30 – 5.48	Stone masonry
Tau Hu (Downstream)	4,220	40 – 60	5.30 – 5.48	Stone masonry, concrete pile revetment
Tau Hu (Upstream)	4,810	45 – 50	6.30 – 6.54	Stone masonry
Ngang No.1 to 3	1,210	45 - 60	6.38 - 6.54	Stone masonry

2.2 Pump Drainage Improvement

Pump drainage improvement is proposed to three low-lying areas situated on the fringe of inner city, Thanh Da of 15.4 ha, Ben Me Coc (1) of 70.9 ha and Ben Me Coc (2) of 46.0 ha. The proposed improvement works consist of the construction of dike, pumping station with retarding pond and sewer network. Fig. 10 shows the proposed drainage system in combination with these facilities. The salient features of respective pump drainage improvements are shown as below:

Location / Item	Thanh Da	Ben Me Coc (1)	Ben Me Coc (2)
Drainage Area (km^2)	0.154	0.709	0.460
Pump Capacity (m^3/s)	0.35	1.5	1.0
Retarding Pond Capacity (m^3)	22,900	33,000	21,400
Dike construction & rehabilitation	74 m	2,590 m + 1,360 m	1,760 m + 1,350 m
Construction & Rehabilitation of Drainage Pipe (km^2)	ϕ 800～ϕ 1,200 655 m	ϕ 900～ϕ 1,800 4,607 m	ϕ 800～ϕ 1,800 4,206 m

2.3 Drainage Pipe System Improvement

To economize on an investment in sewer construction and achieve immediate results, existing combined sewer improvement is proposed to the central area of HCMC, consisting of 5 sewer catchments, which are C, D, Rach Ong, Pham The Hien and Binh Dang catchments as shown in Fig. 11. According to an evaluation of discharge capacity by using a hydrodynamic model, the proposed drainage pipe improvement in 2 catchments of C and D are summarized as below:

Zone	Area (ha)	Condition	Sewer Type/Size	Length
C	442	Additional	ϕ 1,000 to ϕ 2,500mm	1,912 m
			Box : 2.4m x 2.4m - 2.4m x 3.0m	3,620 m
		Sub Total		5,532 m
		Replace	ϕ 2,000 to ϕ 2,500mm	1,320 m
D	619	Additional	Box : 2.4m x 2.4m - 2.4m x 3.0m	4,740 m

However, combined sewer system has been partially developed to the remaining 3 catchments of Rach Ong, Pham The Hien and Binh Dang. Thus separate system is proposed to these catchments with new drainage main pipes of about 52.4 km length with a

diameter ranging from 600 mm to 3,000 mm.

3. Sewerage Development Project

The proposed sewerage development system covers entire project area other than rivers, canals, parks and other open spaces. Accordingly, the area covered by sewerage development system becomes at 2,791.6 ha. The proposed sewerage development area is divided into three (3) independent zones as (1) left bank area of Tau Hu, Ben Nghe canal (1,693.4 ha), (2) isolated area by Tau Hu, Ben Nghe, Doi, Te canals (561.4 ha), and (3) right bank area of Doi, Te canals (536.8 ha). These three (3) independent zones are further divided into 24 sub-zones by existing drainage system and canals as shown in Fig. 12

Proposed sewerage development project consists of (1) Interceptor sewer including diversion chamber, (2) intermediate sewage pumping station, (3) conveyance sewer and (4) treatment plant.

3.1 Interceptor Sewer

(1) Interceptor Sewer of Left Bank Area of Tau Hu, Ben Nghe Canals

The interceptor sewer is proposed at the south end of each combined sewer along river and canals just before discharging wastewater into them. While, Ben Chuong Duong road along Ben Nghe canal will be reconstructed by the future road expansion plan and tunnel construction plan crossing Saigon River to Thu Thiem area. To avoid the adverse affect of the future road reconstruction, the interceptor sewer is proposed along Ton Duc Thang – Ham Nghi – Tran Hung Dao roads instead of along Ben Nghe canal for the eastern portion of the area. This section is expected to construct in the first phase. Interceptor sewers with a total length of 5,480 m are proposed with the diameter ranging from 700 mm to 1,500 mm. While, the interceptor sewer for the western portion of left bank area of Tau Hu, Ben Nghe canals is proposed along Tau Hu canal under future expansion road. This section is expected to construct simultaneously with the road expansion project. The total length of proposed interceptor sewer for the western portion is 4,990 m with a diameter of ranging from 900 mm to 1,500 mm. The proposed interceptor sewer route and its longitudinal profile are shown in Fig. 13 and Fig. 14 respectively.

(2) Interceptor Sewer for Isolated Areas by Tau Hu, Ben Nghe – Doi, Te Canals

These isolated areas are divided into four (4) sub-zones as Khanh Hoi sub-zone, Hung Phu sub-zone, Tung Thien Vuong sub-zone and Binh Dong sub-zone by canals. The interceptor sewers are proposed both sides of these isolated areas along Tau Hu, Ben Nghe -- Doi, Te canals as shown in Fig. 15.

The main features of the interceptor sewers of respective sub-zones are as follow.

Sub-zone	Service Area (ha)	Length of Sewer (m)	Diameter of Sewer (mm)
Khanh Hoi	350.2	6,513	ϕ 450 ~ ϕ 1,200
Hung Phu	76.7	4,543	ϕ 400 ~ ϕ 500
Tung Thien Vuong	82.0	4,870	ϕ 400 ~ ϕ 700
Binh Dong	48.6	2,543	ϕ 400 ~ ϕ 450

All wastewater discharged from these isolated areas are collected by the interceptor sewers and transferred to the intermediate pumping station located at Ward 4 in District 8.

(3) Diversion Chamber

To intercept wastewater from the existing combined sewers, diversion chamber is required nearby their outlets. 103 units of the outlet exist in the project area. All outlets are affected by tide. Hence designing diversion chamber, high water level of the rivers and canals should be taken into consideration.

The proposed typical diversion chamber is shown in Fig. 16. The orifice is proposed to divert the wastewater to the interceptor sewer. The weir with orifice and flap gate is installed at the center of the diversion chamber to avoid the river and canal water intrusion in the interceptor sewer at high tide.

From the maintenance reason, typical plane internal dimension of 2.0 m x 2.2 m is proposed.

3.2 Intermediate Sewage Pumping Station

Intermediate sewage pumping station is proposed at Ward 4 in District 8. The area of about 0.6 ha is located in the swampy area enclosed by Dong Dien road and Ong Nho canal.

Design capacity of intermediate sewage pumping station is 640,000 m^3/day (445.0 m^3/min.). Five (5) units of axial flow vertical type pump with a design capacity of 133.3 m^3/min./unit (2 units) and 105.0 m^3/min./unit (3 units) are installed. Grit chamber and screen are proposed after pumping up.

The proposed location and layout of intermediate sewage pumping station is shown in Fig. 13 and Fig. 17.

3.3 Conveyance Sewer

The proposed site of wastewater treatment plant is located about 5 km far from the project area in Phuoc Loc Ward in Nha Be District. To transfer the wastewater to the treatment plant site, conveyance sewer is required. The conveyance sewer is proposed under the road, which is planed to construct leading to the new prison in the same Ward as the treatment

plant. The conveyance sewer with a diameter of between ϕ 1,500 and ϕ 2,500 mm is proposed to construct in the first phase. The alignment and longitudinal profile of the proposed conveyance sewer are shown in Fig. 13 and Fig. 14 respectively.

3.4 Wastewater and Sludge Treatment Plant

The proposed treatment plant site is located in Phuoc Loc Ward in Nha Be District. The area of about 50 ha is allocated as the treatment plant site by PCHCM. The area is enclosed by Can Kho canal to the east and Go Nai canal to the west.

Modified activated sludge treatment consisting of (1) inflow pump, (2) primary sedimentation basin, (3) aeration tank, (4) secondary sedimentation basin, and (5) disinfection tank is proposed for the wastewater treatment. Sludge treatment consisting (1) gravity thickener, (2) centrifugal thickener, (3) belt filter press, and (4) composting plant is proposed. The proposed location and layout of wastewater and sludge treatment plant are shown in Fig. 13 and Fig 18. Required treatment capacity is decided to meet the wastewater discharge of 469,000 m^3/day in the year 2010.

Design inflow wastewater quality is 180 mg/l in terms of BOD_5 and 200 mg/l of SS. Design effluent water quality is proposed at 50 mg/l in terms of BOD_5.

The main features of the proposed facilities are shown below.

Wastewater Treatment Plant

Facilities	Main Features
Inflow Pump	Capacity : 445.0 m^3/min.
Primary Sedimentation Basin	Dimension: 7 m(W) x 51 m (L) x 4.5 m (D) x 36 units Flight chain type sludge collector : 36 units Sludge drawing pump : 0.2 m^3/min. x 13 units
Aeration Tank	Dimension: 7 m(W) x 63 m(L) x 6 m(D) x 36 units Blower: 580 m^3/min. x 6.3 mAq x 800 kw x 3 units
Secondary Sedimentation Basin	Dimension: 7 m(W) x 76.5 m(L) x 5.25 m(D) x 36 units Flight chain type sludge collector : 36 units Sludge drawing pump: 15m^3/min. x 18 units
Disinfection Tank	25 m(W) x 56 m(L) x 4.5m(D) x 1 unit

Sludge Treatment Plant

Facilities	Main Features
Gravity Thickener	Dimension : Storage tank 5 m x 5 m x 5 m x 1 unit Thickener ϕ 24 m x 4 m(D) x 2 units
Centrifugal Thickener	Decanter type thickener Capacity: 1,067 kg/hr/unit x 2 units
Dewatering	Belt filter type Capacity : 157 m^3/day/unit x 12 units
Composting Plant	Rotary kiln type dewatering: 1st fermentation tank : 18 m x 72 m x 2 units 2nd fermentation yard : 150 m x 40 m x 2 units

4. Proposed O/M Framework

4.1 Proposed Institutional Organization

Concerning the O/M aspect, two (2) parts are subject to be organized: 1) the overall management organization for O/M, and 2) the O/M for specific facilities at field level envisaged in the Project.

UDC representatives are recommended to work at district level for conducting the proper schedule of maintenance of the sewer network in each district. On this basis, the schedules of sewer cleaning, dredging and rehabilitation works are to be controlled by the overall management organization for proceeding works with the same tariff system and same technical work specifications.

4.2 Introduction of Sophisticated Equipment for the Project

For the maintenance works, the introduction of sophisticated maintenance equipment at each district is proposed. The maintenance team to be set up with an UDC representative at each district shall be equipped with a High Compressor car, a Vacuum car, a Bucket-type Sewer Cleaning Car, a Van, and a Set of Checking and Repairing Tools. The invested equipment cost is estimated at about 4.1 billion VND/ district.

With the introduction of new maintenance equipment, a team of about 5 persons can effectively perform the cleaning of 500 m of sewers per day. At present, a group of about 10 workers can do about 100 m per day only by manual cleaning.

5. Proposed Organizations

Integration of Water Supply Company (WSC) and Urban Drainage Company (UDC), and assign the management of water supply, sewerage and drainage services to the integrated company. This institutional alignment seems theoretically ideal. In actuality, however, historical remoteness and very difficult organizational climates of two companies would be the immediate hazard against the integration in the near future.

Single management for the sewerage and drainage services, therefore, would be a practical option. The existing UDC should be reorganized to build a sewerage and srainage corporation that should be the management center of the city's sector service. This new institution should provide with and consist of the following functional organization.

Organization	Management	Division	Functional Unit
Sewerage Drainage Corporation (SDC)	Top Management	Technical Operation	Operation
			Maintenance & repair
			Procurement & storehouse
			Laboratory
			Design & construction management
		Planning	Planning
		Administration Support	Public & customer relation
			Human resources administration & development
			Supply & asset administration
			General administration
		Financial Control	Financial administration & cost control
			Accounting
		Commercial Operation	Customer registration
			Billing & collection
			Marketing

6. Relocation and Resettlement

Total number of the houses to be relocated in case of implementation of the Priority Project is estimated at 1,754 as shown in table below.

Location	No. of Houses
Drainage Pumping Station Site	
1. Thanh Da Area (Binh Thanh District)	96
2. Ben Me Coc 1 and 2	21
Wastewater Treatment Plant Site (Nha Be District)	60
Wastewater Pumping Station Site (District 8/Dong Dieu)	20
Tau Hu-Ben Nghe Canal Improvement Site	
1. District 4	755
2. District 8	802
Total	1,754

Based on the governmental decree No. 22/1998/ND-CP, compensation for relocation is estimated at VND 79.8 billion.

There are 11 housing construction projects with total unit of 15,234 are proposed in District 4, 7, 8 and Binh Thanh as shown in Fig. 19. In case of implementation of the Project, about 70% of the total households to be relocated require new houses in the resettlement site. Therefore, it is not difficult for PCHCMC to provide dwellings for the inhabitants to be resettled. The detailed allocation for relocatees to each proposed housing construction site and the implementation schedule will be decided by the Land and Housing Department of PCHCMC harmonizing with the implementation schedule of the Priority Project.

7. Project Cost for the Priority Project

The priority project cost for urban drainage improvement and sewerage development is estimated at 7,157.2 billion VND under the economic condition in July 1999. Its breakdown is shown below.

BREAKDOWN OF PRIORITY PROJECT

Item	Cost (Billion VND)		
	Foreign Portion	Local Portion	Total Cost
A. Construction Cost			
(1) Improvement of Existing Combined Sewer	40.3	94.1	134.4
(2) New drainage system	36.6	85.3	121.9
(3) Drainage Pumping Station	43.1	100.6	143.7
(4) Canal Improvement	148.6	346.8	495.4
(5) Cleaning/Dredging Equipment	27.7	64.5	92.2
(6) Interceptor Sewer	285.4	233.5	518.9
(7) Conveyance Sewer	225.2	184.2	409.4
(8) Diversion Chamber	8.6	7.0	15.6
(9) Separate Sewer	51.8	42.4	94.2
(10) Sewage Pumping Station	113.4	92.8	206.2
(11) Sewage Treatment Plant	1,339.4	1,095.9	2,435.3
Sub-total of (A)	2,320.1	2,347.1	4,667.2
B. Land Acquisition & Compensation	0	483.6	483.6
C. Engineering Service	228.7	98.0	326.7
D. Administration Cost	0	154.5	154.5
E. Physical Contingency	213.6	253.1	466.7
Sub-total of (B) to (E)	442.3	989.2	1,431.5
F. Price Escalation	398.2	660.3	1,058.5
Grand Total	3,160.6	3,996.6	7,157.2

Note : Exchange rate : US$ 1 = VND 13,956 = ¥ 113.39 (¥ 1 = VND 123.08)
Engineering service : 7% of construction cost
Administration cost : 3% of construction cost and land acquisition & compensation cost
Physical contingency : 10% of construction cost
Price escalation : Foreign portion = 2 % per annum, Local portion = 3% per annum

Annual operation and maintenance cost in the year of 2010 is estimated about 73.4 billion VND consisting of 7.4 billion VND for urban drainage and 66.0 billion VND for sewerage management.

Annual disbursement schedule of the Priority Project is shown in Table 2.

8. Project Evaluation

8.1 Economic Evaluation of Urban Drainage Improvement

Following table shows a summary of economic benefit for the Urban Drainage System Improvement Works as a priority Project in HCMC.

Average Annual Benefit of Targeted Zone of Priority Project

(Billion VND)

Direct benefit			Indirect benefit		
Benefit items	Base year	2020	Benefit items	Base year	2020
Buildings/movables	118.06	185.80	Business suspension losses	17.90	17.34
Public facilities	1.14	2.19	Income losses of workers	0.63	1.22
Agricultural crops	0.51	0.26	Saving amount of medical cost	0.64	1.28
			Navigation benefit	10.79	18.16
Total	119.71	188.25	Total	29.96	38.00

The estimated annual economic costs for construction is summarized as below:

Economic Cost for Urban Drainage System Improvement Works

(Billion VND)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
Economic cost										
1st phase	165.9	131.8	178.4	178.4	178.4	54.3				887.2
2nd phase						40.7	160.9	157.4	85.8	444.8
Total										1,332.0

The evaluation is made using cash flows based on the above benefit and cost, and results are summarized below:

Results of Economic Evaluation for Urban Drainage System Improvement

Zone	Net present value(VND10^9)	EIRR(%)	B/C
Targeted Zone of Priority Project	557.0	18.77	1.66

The EIRR resulted at 18.77 % as shown in the above Table has cleared the level of 10 % of discount rate applied in this study with enough allowance, so it may say that the priority Project has a viability to be executed from an economical viewpoint.

Therefore, a sensitivity analysis is made for 16 combined cases including base case under the benefit of --5 %, -10 % and --15 %, and the cost of +5 %, +10 % and +15 % taking into account of fluctuation of the benefit and the cost.

Under the most critical case of the benefit of 15 % decrease and the cost of 15 % increase, the EIRR is calculated as 12.89 %.

8.2 Economic and Financial Evaluations for Sewerage System Development

From the socio-economic point of view, the benefit of this sewerage development project is expected to be tremendous, but it is rather difficult to quantify them while it is sure and visible. Some of them are identified as follows:

- To improve water environments of Tau Hu, Ben Nghe and Doi, Te canals
- To improve water quality of Saigon River
- To contribute reduction of waterborne diseases contraction ratio

For the financial evaluation of the sewerage system development by the revenue of following sewerage tariff system under a condition of its annual increasing rate of 2.5%, the FIRR of 1.20% was obtained.

i) For residence : 12,500 VND/HH· month
ii) For commercial : 51,100 VND/shop· month
iii) For industry : 22,800 VND/factory· month

This tariff system is recommended based on the existing water supply charge, and willingness and affordability of people to pay the sewerage service.

The most optimistic case in benefit of 10% increase and cost of 10% decrease, the FIRR is still low of 2.33%.

This sewerage charge for residence is equivalent to 0.6% of the average monthly income of VND 1,950,000/HH. This charge is considered bearable, compared to 3.0% of water supply charge.

Under the above mentioned tariff condition, the revenue from sewerage charge can cover the O/M cost including replacement cost with B/C rate of 1.81. However, the initial investment cost should be born by the subsidy of the government.

8.3 Repayability of Loan Amount Including Its Interest

In a case under the condition as:

i) An interest rate of 1.3 % is assumed for repayment of loan amount, and
ii) Total repayment period of the loan is assumed at 30 years including 10 years grace period

If the following sewerage tariff system can be established, the revenue only from the sewerage charge can cover all expenditure consisting of repayment of loan including its interest and O/M cost with replacement cost.

iv) For residence : 27,400 VND/HH· month
v) For commercial : 111,800 VND/shop· month

vi) For industry : 49,900 VND/factory·month

This tariff system for residence is still lower than the affordability of people to pay for the sewerage service of VND 30,000/HH.month.

9. Implementation Program for Phase I Project

9.1 Project Phasing

Due to the large number of envisaged works to be carried out in a large area of the Priority Project are (more than 3,000 ha), the Priority Project is made to be implemented through two (2) phases, Phase I and Phase II, as shown below.

In Phase I (2000 - 2005), along with the detailed design works of the basic structures relating to this Phase to be started firstly, the subjected construction works and the related institutional programs will be orderly carried out in the Phase I part of the Priority Project area..

In Phase II (2006 - 2010), all the rest of the Priority Project, the expanded works in the Phase II part of the Priority Project area and the prolonged institutional programs, will be carried out to achieve completely all components envisaged in the Priority Project by the end of 2010.

9.2 Implementation Program for Phase I Project

The Phase I Project consisting of detailed design and construction of Phase I Project will be implemented within 70 months from March, 2000 to December 2005. The detailed design will be accomplished within 13 months between March, 2000 and March, 2001. The prequalification and tendering of contractor will be done within 6 months from April, 2001 to September, 2001. The construction works will be conducted within 51 months from October, 2001 to December, 2005.

The Phase I project consists of:

- Existing combined sewer improvement
- Pump drainage improvement
- Canal improvement
- Interceptor sewer and conveyance sewer construction
- Intermediate sewage pumping station and
- Wastewater treatment plant construction

The salient features of Phase I Project are summarized as follows.

Project Area	914.7 ha (refer to Fig. 20)
Existing combined sewer improvement	**Additional** 10,272 m (ϕ 1,000 – □2,400 x 3,000 mm) **Replace** 1,320 m (ϕ 2,000 – ϕ 2,500 mm)
Pump drainage improvement	**Thanh Da area** : 15.4 ha Pump capacity = 21 m^3/min. Concrete pile revetment = 74 m Retarding pond = 7,600 m^3 Drainage pipe = 655m (ϕ 800 – ϕ 1,200 mm) **Ben Me Coc (I) area** : 70.9 ha Pump capacity = 42 m^3/min. Temporary earth dike = 3,950 m Retarding pond = 16,700 m^3 Control Gate Drainage pipe = 4,607m (ϕ 900 – ϕ 1,800 mm) **Ben Me Coc (II) area** : 46.0 ha Temporary earth dike = 3,290 m Drainage pipe = 4,206 m (ϕ 800 – ϕ 2,000 mm)
Canal improvement	**Ben Nghe canal** Type A : 3,140 m **Tau Hu canal** Type A : 2,490 m Type B : 1,205 m Type C : 525 m
Interceptor sewer	Interceptor sewer : Main : 870m (ϕ 700 mm) : 1,970m (ϕ 1,000 mm) : 1,070m (ϕ 1,200 mm) : 1,570m (ϕ 1,500 mm) Secondary : 6,050 m (ϕ 300 – ϕ 700 mm) Diversion chamber Type I : 32 units
Intermediate sewage pumping station	Pump capacity : 133.3 m^3/min. x 1 unit (+1 unit as stand by)
Conveyance sewer	Conveyance sewer : 500m (ϕ 1,500 mm) 500m (ϕ 2,000 mm) 5,400m (ϕ 2,500 mm)
Wastewater treatment plant	**Wastewater treatment** – Inflow pump : 133.3 m^3/min. x 20 m x 40 0kw x 1 unit (+1 unit as stand by) – Primary sedimentation basin : 7 m(W) x 51 m(L) x 4.5 m(D) x 8 units with flight chain type sludge collector – Aeration tank : 7 m(W) x 63 m(L) x 6 m(D) x 8units with blower of 580 m^3/min. x 6.3 mAq x 800 kw x 1 units (+ 1 unit as stand by) – Secondary sedimentation basin : 7 m(W) x 76.5 m(L) x 5.25 m (D) x 8 units with flight chain type sludge collector – Disinfection tank : 25 m(W) x 56 m(L) x 4.5 m(D), dosing chlorine of 450 kg/day **Sludge treatment** – Gravity thickener : 24 m x 4 m(H) x 1 unit – Dewatering : Belt filter press with a capacity of 157 m^3/day/unit x 6 units

Wastewater treatment plant	– Composting plant : Rotary kiln type dewatering, 1st fermentation tank of 18 m x 36 m and 2nd fermentation yard of 40 m x 75 m

9.3 Cost Estimation of Phase I Project

The Phase I Project cost for Urban Drainage Improvement and Sewerage Development is estimated at 3,162 billion VND under the economic condition in July, 1999. Its breakdown is shown below.

BREAKDOWN OF PHASE I PROJECT COST

Item	Cost (Billion VND)		
	Foreign Portion	Local Portion	Total
A. Construction Cost			
1) Improvement of Combined Sewer	40.3	94.1	134.4
2) Drainage Pumping Station	27.0	63.0	90.0
3) Canal Improvement	89.2	208.2	297.4
4) Cleaning/Dredging Equipment	11.1	25.8	36.9
5) Interceptor Sewer	88.6	72.6	161.2
6) Conveyance Sewer	225.2	184.2	409.4
7) Diversion Chamber	2.3	1.8	4.1
8) Intermediate Sewage Pumping Station	58.1	47.5	105.6
9) Wastewater Treatment Plant	430.5	352.2	782.7
Sub-total of (A)	972.3	1,049.4	2,021.7
B. Land Acquisition & Compensation	0	433.9	433.9
C. Engineering Cost	99.1	42.5	141.6
D. Administration Cost	0	73.7	73.7
E. Physical Contingency	89.9	112.3	202.2
Sub-total of (B) to (E)	189.0	662.4	851.4
F. Price Escalation	96.9	192.3	289.2
Grand Total	1,258.2	1,904.1	3,162.3

Note : Exchange rate : US$ 1 = VND 13,956 = ¥ 113.39 (¥ 1 = VND 123.08)
Engineering service : 7% of construction cost
Administration cost : 3% of construction cost and land acquisition & compensation cost
Physical contingency : 10% of construction cost
Price escalation : Foreign portion = 2 % per annum, Local portion = 3% per annum

Annual operation and maintenance cost in the year of 2005 is estimated about 27.0 billion VND consisting of 7.1 billion VND for urban drainage and 19.9 billion VND for sewerage management.

10. Recommendations

(1) Immediate Project Implementation

It is concluded that the Priority Project is technically and economically feasible. Besides, financial viability and positive social and environmental impacts are observed from the integrated project evaluation results. So, it is justified that implementation of the Priority Project, especially Phase I Project shall be commenced as soon as possible to improve the deteriorating environmental conditions in the central part of Ho Chi Minh City.

(2) Harmonization with Closely Related Project

Rehabilitation and widening project of Ben Chuong Duong - Ben Ham Tu - Tran Van Kieu Road is on-going by the assistance of JBIC. Engineering Service (Detailed Design) of the project is appraised by JBIC in October 1999. This project is closely related with the canal improvement of Tau Hu - Ben Nghe. So, it is recommended that the detailed design of both projects is to be undertaken in parallel as same timing as.

(3) New Organization

To operate sufficiently the urban drainage and sewerage service, it is recommended to establish a new organization, which provisional name is Sewerage and Drainage Company (SDC). This new company should have a strong leadership and delegated power to exercise the professional service.

(4) Strengthening of Project Management Unit (PMU)

For a smooth implementation of the Project, the existing PMU should be strengthened. The PMU should be made directly under the PCHCMC to avoid any idling time required for consultation with other related authorities in PCHCMC. The PMU should have the right to report directly the vice chairman of PCHCMC.

(5) Minimization of Relocation

The number of the relocated houses on canal and half canal/half land should be minimized as far as the project implementation is not disturbed. Also, since the moving too many people in a short time to large sites is likely to have serious social consequences, a whole of small community or some divided groups of community are considered to avoid breakup of the existing community.

In addition to the mentioned-above, the following items shall be considered.

(6) Strengthening of Existing Hydrological Monitoring System
(7) Establish of Environmental Monitoring System
(8) Introduction of Sophisticated Maintenance Equipment
(9) Introduction of Environmental Education Program
(10) Establish of Environmental Sanitation Center
(11) Pilot Project of Wastewater Treatment Plant

TABLE 1 PROJECT COST

Urban Drainage Development

(Unit: Billion VND)

Cost / Zone	C	N	W	S	NE	SE	Total
1. Construction	3,856.4	2,649.1	1,243.7	883.4	1,559.6	1,031.2	11,223.4
(1) Canal Imp.	(894.0)	(786.1)	(540.1)	(272.4)	(648.8)	(179.8)	(3,321.2)
(2) Pump Drainage	(262.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(262.1)
(3) Onsite Re-Pond	(0.0)	(0.0)	(0.0)	(0.0)	(272.4)	(0.0)	(272.4)
(4) Existing Sewer Imp	(118.4)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(118.4)
(5) Combined Sewer	(2,369.0)	(785.0)	(350.8)	(0.0)	(0.0)	(0.0)	(3,504.8)
(6) Storm Sewer	(212.9)	(1,078.1)	(352.8)	(611.0)	(638.4)	(851.4)	(3,744.5)
2. Land Acquisition and House Compensation	1,386.2	631.3	250.5	183.6	235.6	181.7	2,868.9
3. Administration	157.3	98.4	44.8	32.0	53.9	36.4	422.8
4. Engineering Service	269.9	185.4	87.2	61.8	109.2	72.2	785.9
5. Contingency	385.7	264.9	124.3	88.3	156.0	103.1	1,122.3
Total	6,055.5	3,829.3	1,750.5	1,249.1	2,114.3	1,424.6	16,423.3

Note : 1. Cost: Cost as of February 1999.

2. Exchange Rate : 10,000 VND = 90 Yen, 120 Yen/US$

3. Engineering cost and physical contingency is assumed at 7 and 10 % of the construction cost.

4. Administration cost is assumed at 3 % of a total cost of construction and land acquisition and house compensation.

5. Breakdown of the construction costs is shown in Tables J.1.2 to J.1.5.

6. Breakdown of the land acquisition costs is shown in Table J.1.2.

Sewerage Development

(Unit: Billion VND)

Cost / Zone	TLBC	NLTN	THLG	THBNDT	SS	SE	SN-I	SN-II	SW	Total
1. Construction	1,051.3	3,226.0	1,887.1	3,156.0	1,932.3	2,570.0	2,708.5	1,445.5	1,939.4	19,916.1
2. Land Acquisition and House Compensation	2.2	13.7	8.1	14.6	2.2	2.4	2.0	1.4	10.9	57.5
3. Administration	31.6	97.2	56.9	95.2	58.0	77.2	81.3	43.4	58.5	599.3
4. Engineering Service	73.6	225.8	132.1	220.9	135.3	179.9	189.6	101.2	135.8	1,394.2
5. Physical Contingency	105.1	322.6	188.7	315.6	193.2	257.0	270.9	144.6	193.9	1,991.6
Total	1,263.8	3,885.3	2,272.9	3,802.3	2,321.0	3,086.5	3,252.3	1,736.1	2,338.5	23,958.7

Note : 1. Cost: Cost as of February 1999.

2. Exchange Rate : 10,000 VND = 90 Yen, 120 Yen/US$

3. Engineering cost and physical contingency is assumed at 7 and 10 % of the construction cost.

4. Administration cost is assumed at 3 % of a total cost of construction and land acquisition and house compensation.

Table 2 Annual Disbursement of Construction Cost
(Urban Drainage and Sewerage Development)

1. Phase I

Cost Component	Project Cost (Mil. VND) Total	2000 FC	2000 LC	2000 Sb-total	2001 FC	2001 LC	2001 Sb-total	2002 FC	2002 LC	2002 Sb-total	2003 FC	2003 LC	2003 Sb-total	2004 FC	2004 LC	2004 Sb-total	2005 FC	2005 LC	2005 Sb-total
1. Direct construction cost																			
(1) Drainage	558,836	0	0	0	25,148	58,678	83,825	41,913	97,796	139,709	41,913	97,796	139,709	41,913	97,796	139,709	16,765	39,119	55,884
(2) Sewerage	1,463,072	0	0	0	80,469	65,839	146,308	144,844	118,509	263,353	217,266	177,763	395,029	217,266	177,763	395,029	144,844	118,509	263,353
Sub total	2,021,908	0	0	0	105,617	124,517	230,133	186,757	216,305	403,062	259,179	275,559	534,738	259,179	275,559	534,738	161,609	157,628	319,237
2. Land acquisition & Comp.	433,907	0	217,241	217,241	0	54,167	54,167	0	54,167	54,167	0	54,167	54,167	0	54,167	54,167	0	0	0
3. Engineering cost	141,534	49,538	21,230	70,768	9,907	4,247	14,154	9,907	4,247	14,154	9,907	4,247	14,154	9,907	4,247	14,154	9,907	4,247	14,154
4. Administration cost	73,674	0	14,735	14,735	0	11,788	11,788	0	11,788	11,788	0	11,788	11,788	0	11,788	11,788	0	11,788	11,788
5. Physical contingency	202,191	0	0	0	17,146	20,499	37,644	18,822	24,411	43,232	18,822	24,411	43,232	18,822	24,411	43,232	16,307	18,543	34,849
Sub total	2,873,214	49,538	253,206	302,744	132,670	215,218	347,886	215,486	310,918	526,403	287,908	370,172	658,079	287,908	370,172	658,079	187,823	192,206	380,028
Price Contingency	289,185	991	7,596	8,587	5,360	13,107	18,467	13,189	28,830	42,020	23,733	46,460	70,193	29,966	58,959	88,924	23,696	37,298	60,994
Total	3,162,399	50,529	260,802	311,331	138,030	228,325	366,355	228,675	339,748	568,424	311,641	416,632	728,273	317,874	429,131	747,004	211,519	229,504	441,023

2. Phase II

Cost Component	Project Cost (Mil. VND) Total	2005 FC	2005 LC	2005 Sb-total	2006 FC	2006 LC	2006 Sb-total	2007 FC	2007 LC	2007 Sb-total	2008 FC	2008 LC	2008 Sb-total	2009 FC	2009 LC	2009 Sb-total	2010 FC	2010 LC	2010 Sb-total
1. Direct construction cost																			
(1) Drainage	428,729	0	0	0	51,448	120,044	171,492	51,448	120,044	171,492	25,724	60,022	85,746	0	0	0	0	0	0
(2) Sewerage	2,216,505	0	0	0	182,862	149,614	332,476	304,769	249,357	554,126	304,769	249,357	554,126	304,769	249,357	554,126	121,908	99,743	221,651
Sub total	2,645,234	0	0	0	234,310	269,658	503,968	356,217	369,401	725,618	330,493	309,379	639,872	304,769	249,357	554,126	121,908	99,743	221,651
2. Land acquisition & Comp.	49,696	0	24,848	24,848	0	9,939	9,939	0	7,454	7,454	0	7,454	7,454	0	0	0	0	0	0
3. Engineering cost	185,166	64,809	27,775	92,584	12,662	8,856	21,518	12,212	7,806	20,018	12,212	7,806	20,018	10,861	4,655	15,516	10,861	4,655	15,516
4. Administration cost	80,848	0	16,887	16,887	0	14,227	14,227	0	14,227	14,227	0	14,227	14,227	0	10,639	10,639	0	10,639	10,639
5. Physical contingency	264,524	0	0	0	27,310	34,169	61,479	27,310	34,169	61,479	24,738	28,168	52,905	22,165	22,165	44,330	22,165	22,165	44,330
Sub total	3,225,468	64,809	69,510	134,319	274,282	336,849	611,131	395,739	433,057	828,796	367,443	367,034	734,476	337,795	286,816	624,611	154,934	137,202	292,136
Price contingency	769,927	8,176	13,489	21,665	40,782	77,433	118,215	67,932	115,527	183,459	71,685	111,862	183,548	73,975	98,641	172,616	37,707	52,718	90,425
Total	3,995,395	72,985	82,999	155,984	315,064	414,282	729,346	463,671	548,584	1,012,255	439,128	478,896	918,025	411,770	385,457	797,227	192,641	189,920	382,561

(Note) Price Escalation : LC : 3% annum.
FC : 2% annum.

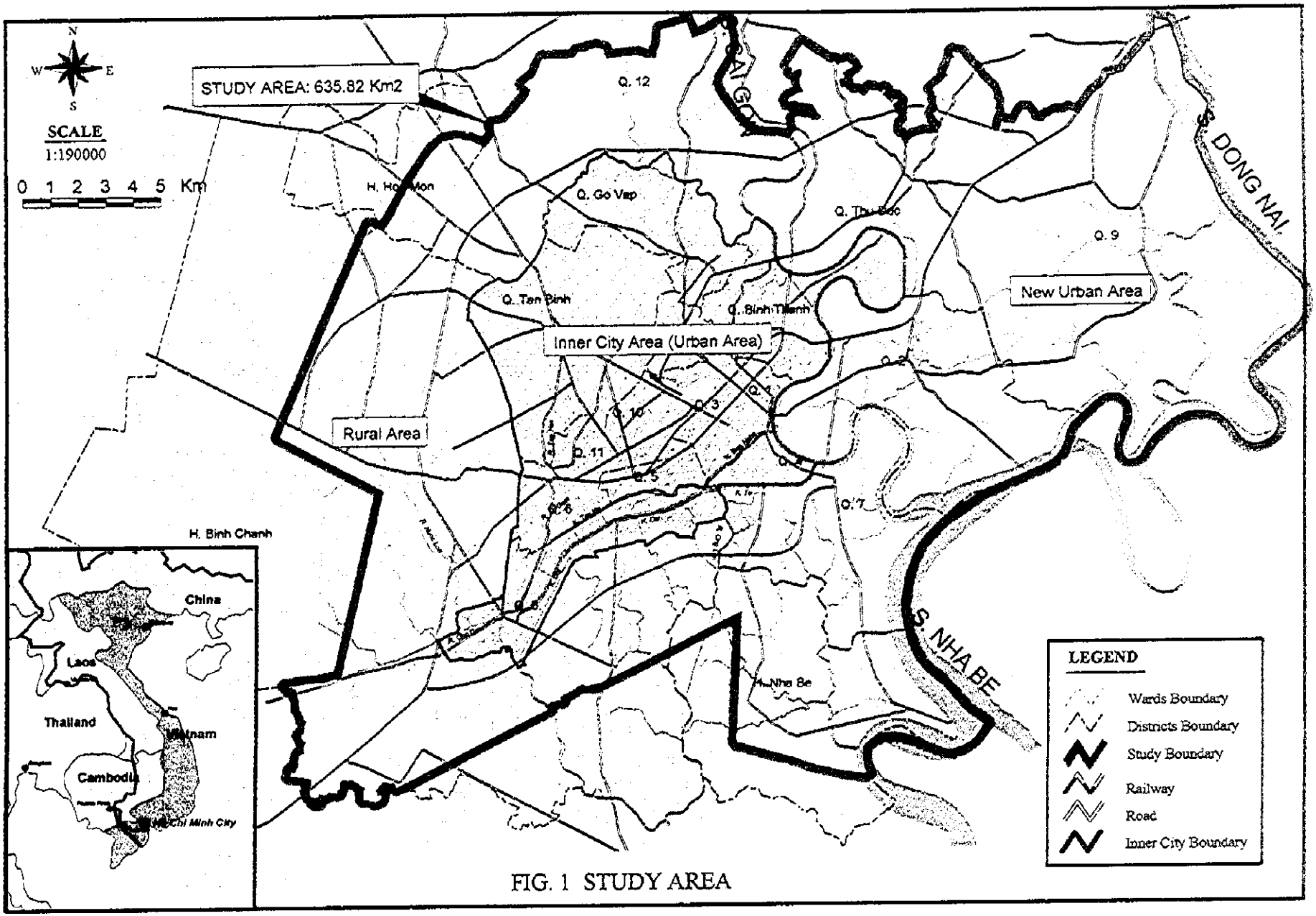


FIG. 1 STUDY AREA

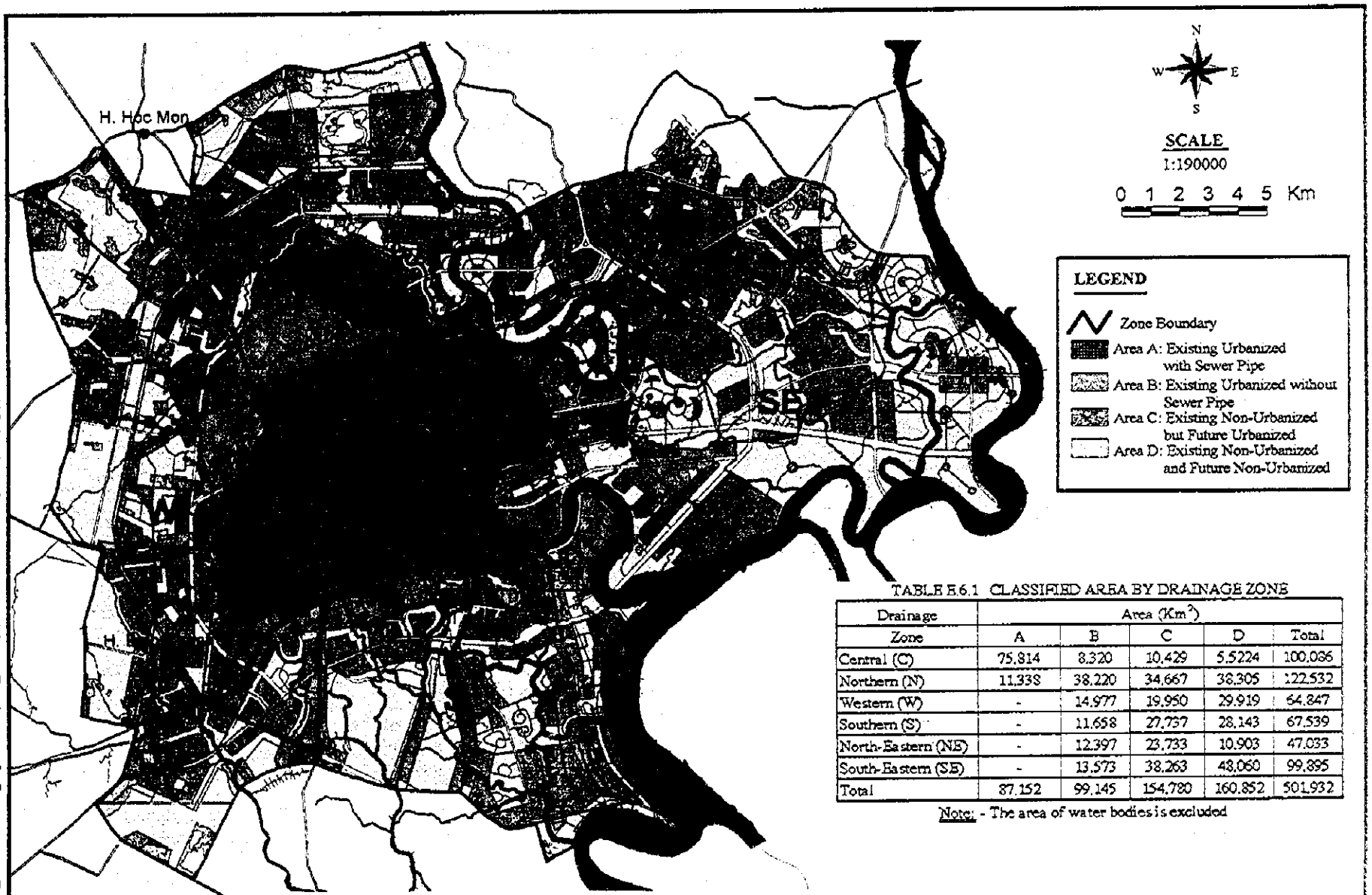


TABLE E.6.1 CLASSIFIED AREA BY DRAINAGE ZONE

Drainage	Area (Km^2)				
Zone	A	B	C	D	Total
Central (C)	75,814	8,320	10,429	5,5224	100,086
Northern (N)	11,338	38,220	34,667	38,305	122,532
Western (W)	-	14,977	19,950	29,919	64,847
Southern (S)	-	11,658	27,737	28,143	67,539
North-Eastern (NE)	-	12,397	23,733	10,903	47,033
South-Eastern (SE)	-	13,573	38,263	48,060	99,895
Total	87,152	99,145	154,780	160,852	501,932

Note: - The area of water bodies is excluded

FIG. 2 DIVISION OF DRAINAGE AREA

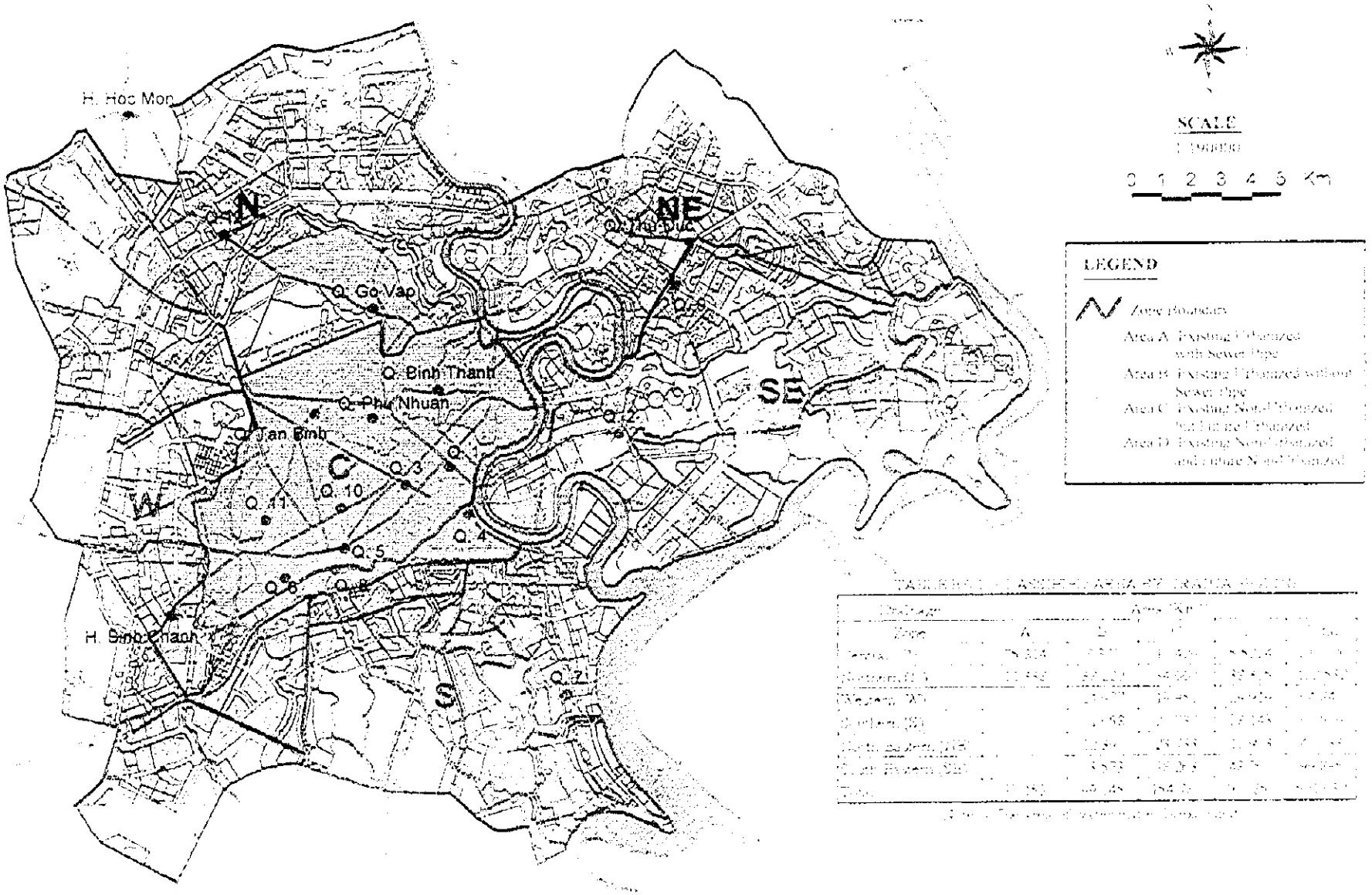


FIG 2 DIVISION OF DRAINAGE AREA

W-Zone (72.91 km2)

1. Topography: Relatively high land, partly flood-prone
2. Land Use : Mostly agricultural, partly residential
3. Urbanization:
   [P]: 175,500 (4%) - 628,900 (9%)
   [B]: 14.4 km2 (0.8%) - 33.6 km2 (1.0%)
4. Flood: Serious condition
   [B]: 2.7 km2 (8%) - 17.7 km2 (11%)
   [A]: 31.9 km2 (14%) - 17.0 km2 (15%)
   [V]: 74,000 (6%) - 289,000 (12%)
5. Existing drainage system: Canal, channel drainage system
6. Measures: Structural/Non-structural Measures
   (a) Land use regulation for low land and utilization of natural retarding basin (S.T.)
   (b) Rehabilitation of existing drainage channel/drain (S.T.)
   (c) Canal Improvement of R. Cua-R.Nhuoc Len (M.T.)
   (d) Construction of drainage channel/drain for new built-up area (M.T.)

N-Zone (136.19 km2)

1. Topography: Relatively high land, partly flood-prone
2. Land Use Mostly agricultural, partly residential
3. Urbanization: Residential and agricultural land
   [P]: 421,900 (10%) - 1,127,400 (16%)
   [B]: 46.6 km2 (27%) - 80.3 km2 (24%)
4. Flood: Serious condition
   [B]: 7.5 km2 (22%) - 26.49 km2 (17%)
   [A]: 31.1 km2 (14%) - 12.0 km2 (11%)
   [V]: 137,000 (12%) - 409,000 (17%)
5. Existing drainage system: Mainly canal, channel drainage system, partly drainage pipe system (inner city area)
6. Measures: Structural/Non-structural Measures
   (a) Land use regulation for low land and utilization of natural retarding basin (S.T.)
   (b) Rehabilitation/construction of drainage pipes (S.T.)
   (c) Canal Imp. : Tham Luong-Ben Cat, Ben Da- Ba Hong (M.T.)
   (d) Rehabilitation/construction drainage channel/drain (M.T.)

NE-Zone (64.91 km2)

1. Topography: Mostly high land, partly flood-prone
2. Land Use Mostly agricultural, partly residential
3. Urbanization: Urbanizing
   [P]: 174,400 (4%) - 536,700 (8%)
   [B]: 12.4 km2 (7%) - 44.57 km2 (13%)
4. Flood: Not so serious condition
   [B]: 0 km2 (0%) - 11.8 km2 (8%)
   [A]: 16.4 km2 (7%) - 4.6 km2 (4%)
   [V]: 43,000 (4%) - 151,000 (6%)
5. Existing drainage system: Canal, channel drainage system
6. Measures: Structural/Non-structural Measures
   (a) Land use & flood control regulation for land developer : Onsite detention pond (S.T.)
   (b) Preservation of land along canals (S.T.)
   (c) Rehabilitation of existing drainage channel/drain (S.T.)
   (d) Canal improvement adjusting urbanization (M.T., L.T.)
   (e) Const. of drainage channel for new built-up area (M.T., L.T.)

S-Zone (81.74 km2)

1. Topography: Mostly low land
2. Land Use Mostly agricultural, partly residential
3. Urbanization: Rapidly urbanizing
   [P]: 127,500 (3%) - 475,400 (9%)
   [B]: 11.4 km2 (7%) - 39.5 km2 (12%)
4. Flood: Serious external flood
   [B]: 1.8 km2 (5%) - 33.5 km2 (22%)
   [A]: 58.7 km2 (25%) - 27.0 km2 (24%)
   [V]: 79,000 (7%) - 318,000 (13%)
5. Existing drainage system: Canal, channel drainage system
6. Measures: Structural/Non-structural Measures
   (a) Land use regulation and preservation of land along the canal (S.T.)
   (b) Rehabilitation of existing drainage channel/drain (S.T.)
   (c) Partial main canal improvement (M.T., L.T)
   (d) Construction of drainage pipe/channel for new built-up area (M.T., L.T.)

C-Zone (106.41 km2)

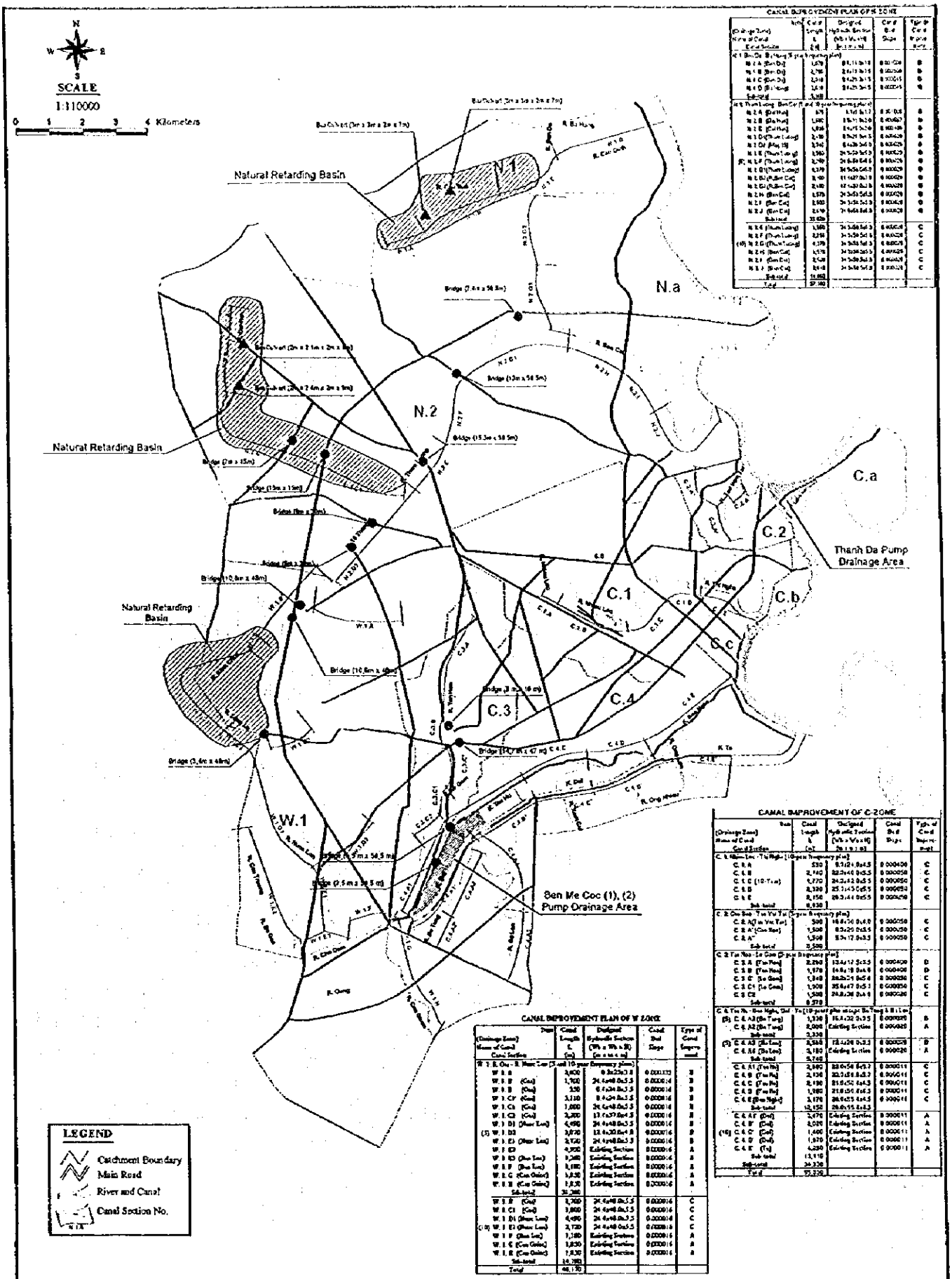
1. Topography: High land
2. Land Use Residential, commercial, small industry
3. Urbanization: Overcrowded, few open space & green area
   [P]: 3,185,400 (75%) - 3,421,900 (49%)
   [B]: 75.4 km2 (43%) - 87.6 km2 (28%)
4. Flood: Very serious condition
   [B]: 21.1 km2 (61%) - 27.9 km2 (18%)
   [A]: 9.2 km2 (4%) - 2.5 km2 (2%)
   [V]: 767,000 (65%) - 846,000 (34%)
5. Existing drainage system: Combined sewerage system
6. Measures: Structural Measures
   (a) Canal improvement of Nhieu Loc-Thi Nghe, Tan Hoa-Lo Gom, Tau Hu-Ben Nghe canals (S.T.)
   (b) Rehabilitation/construction of drainage pipes (S.T.)
   (c) Pump drainage improvement for low land (S.T.) : Than Da, Ben Me Coc (1) & (2)

SE-Zone (119.37 km2)

1. Topography: Low land (Flood -prone area)
2. Land Use Agricultural land, partly residential
3. Urbanization: Rapidly urbanizing
   [P]: 160,200 (4%) - 844,300 (12%)
   [B]: 13.5 km2 (8%) - 54.25 km2 (16%)
4. Flood: Serious external flood
   [B]: 1.4 km2 (4%) - 37.44 km2 (24%)
   [A]: 83.4 km2 (36%) - 47.4 km2 (43%)
   [V]: 84,000 (7%) - 468,000 (19%)
5. Existing drainage system: Canal, channel drainage system
6. Measures: Structural/Non-structural Measures
   (a) Land use regulation and preservation of land along the canal (S.T.)
   (b) Rehabilitation of existing drainage channel/drain (S.T.)
   (c) Canal improvement adjusting urbanization (M.T., L.T.)
   (d) Construction of drainage channel for new built-up area (M.T., L.T.)

Legend: [P]: Population in 1997 and 2020, [B]: Built-up area in 1997 and 2020, [A]: Agricultural land in 1997 and 2020, [V]: Flood vulnerable population in 1997 and 2020
(S.T.): Short Term, (M.T.): Mid. Term, (L.T.): Long Term

FIG. 3 OUTLINE OF PROPOSED URBAN DRAINAGE IMPROVEMENT PLAN BY ZONE



CANAL IMPROVEMENT PLAN OF N ZONE

(Drainage Zone) Name of Canal Canal Section	Year	Canal Length L (m)	Designed Hydraulic Section (Wb x Wa x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
N.1 B-Ou (B-Hung Sub-Drainage plan)					
N.1 A (Bin Ou)		1,570	8.0x1.0x1.5	0.001/250	B
N.1 B (Bin Ou)		2,740	8.0x1.0x1.5	0.000/500	B
N.1 C (Bin Ou)		2,210	8.0x1.0x1.5	0.000/315	B
N.1 D (B-Hung)		2,610	8.0x1.0x1.5	0.000/315	B
Sub-total		9,140			
N.2 Thanh Long Ben Cuc (Tuan and Bi-year frequency plan)					
N.2 A (Bin Hung)		1,570	3.5x1.0x1.5	0.001/315	B
N.2 B (Bin Hung)		1,890	3.5x1.0x1.5	0.000/567	B
N.2 E (Bin Hung)		1,930	3.5x1.0x1.5	0.000/189	B
N.2 D (Thanh Long)		2,130	3.5x1.0x1.5	0.000/420	B
N.2 D2 (B-Hung)		3,340	3.5x1.0x1.5	0.000/420	B
N.2 E (Thanh Long)		3,980	3.5x1.0x1.5	0.000/420	B
(R) N.2 F (Thanh Long)		3,240	3.5x1.0x1.5	0.000/420	B
N.2 G (Thanh Long)		4,370	3.5x1.0x1.5	0.000/420	B
N.2 G1 (B-Bin Cuc)		3,400	3.5x1.0x1.5	0.000/420	B
N.2 G2 (B-Bin Cuc)		2,400	3.5x1.0x1.5	0.000/420	B
N.2 H (Bin Cuc)		1,570	3.5x1.0x1.5	0.000/420	B
N.2 I (Bin Cuc)		1,900	3.5x1.0x1.5	0.000/420	B
N.2 J (Bin Cuc)		2,140	3.5x1.0x1.5	0.000/420	B
Sub-total		33,020			
N.2 E (Thanh Long)		1,380	3.5x1.0x1.5	0.000/420	C
N.2 F (Thanh Long)		2,230	3.5x1.0x1.5	0.000/420	C
(R) N.2 G (Thanh Long)		4,370	3.5x1.0x1.5	0.000/420	C
N.2 H (Bin Cuc)		1,570	3.5x1.0x1.5	0.000/420	C
N.2 I (Bin Cuc)		2,140	3.5x1.0x1.5	0.000/420	C
N.2 J (Bin Cuc)		2,140	3.5x1.0x1.5	0.000/420	C
Sub-total		13,830			
Total		57,190			

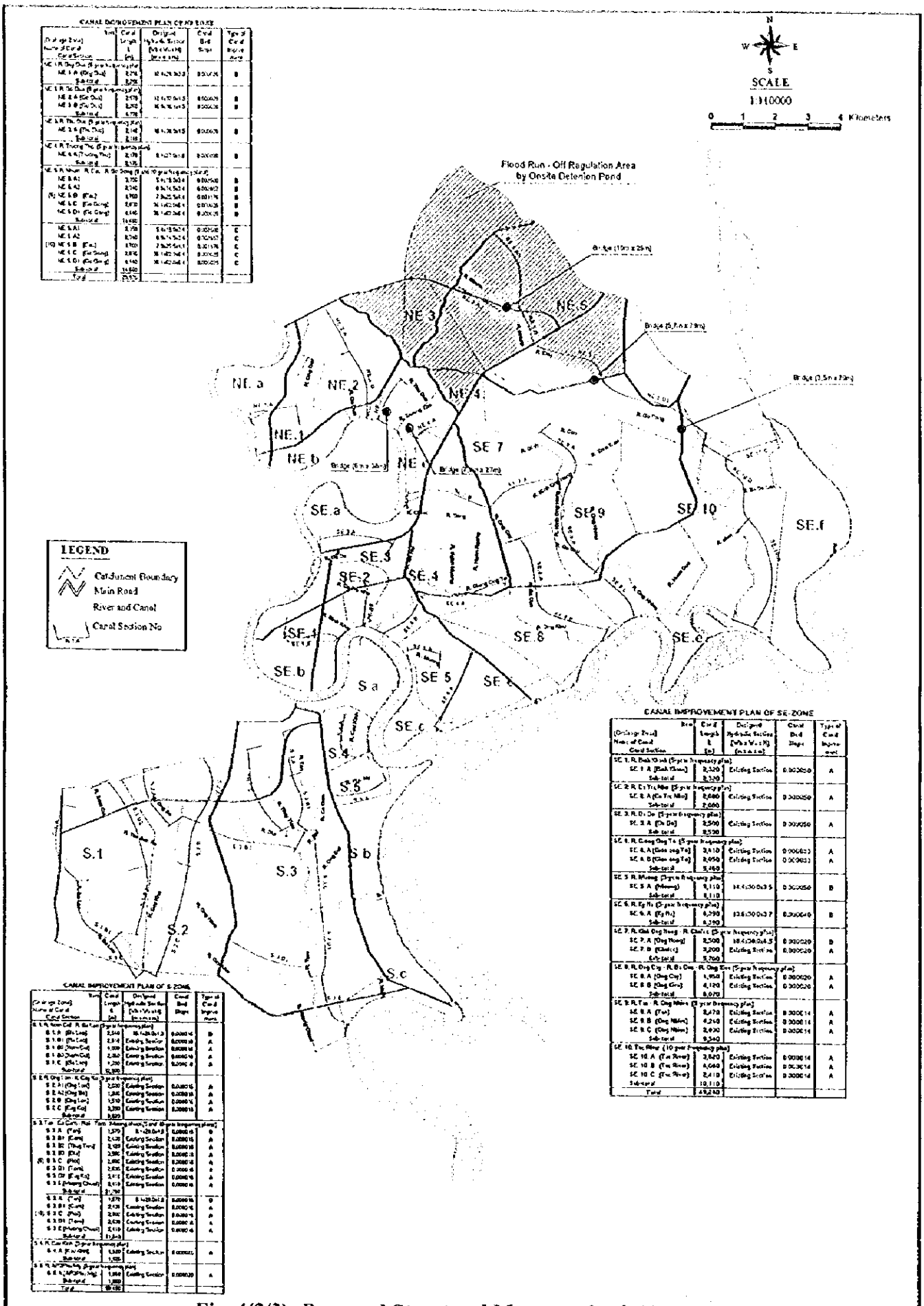
CANAL IMPROVEMENT OF C-ZONE

(Drainage Zone) Name of Canal Canal Section	Year	Canal Length L (m)	Designed Hydraulic Section (Wb x Wa x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
C. 1. Nam Ton - Tu Nghi - (10-year frequency plan)					
C. 1. A		530	8.0x2.0x1.5	0.000/400	C
C. 1. B		2,140	22.0x4.0x5.5	0.000/050	C
C. 1. C (10-Tuan)		1,770	24.0x4.0x5.5	0.000/050	C
C. 1. D		3,380	25.0x4.0x5.5	0.000/050	C
C. 1. E		2,150	26.0x4.0x5.5	0.000/050	C
Sub-total		9,930			
C. 2. Cho Moi - Tu Vu Tu (5-year frequency plan)					
C. 2. A (Tu Vu Tu)		500	16.0x3.0x4.0	0.000/050	C
C. 2. A' (Cho Moi)		1,500	8.0x2.0x3.5	0.000/050	C
C. 2. A''		1,500	8.0x1.0x3.5	0.000/050	C
Sub-total		3,500			
C. 3. Tu Nhu - Le Coc (5-year frequency plan)					
C. 3. A (Tu Nhu)		2,290	13.0x1.0x3.5	0.000/400	D
C. 3. B (Tu Nhu)		1,970	16.0x1.0x4.0	0.000/400	D
C. 3. C (Le Coc)		1,840	26.0x2.0x5.5	0.000/050	C
C. 3. C1 (Le Coc)		1,900	35.0x2.0x5.5	0.000/050	C
C. 3. C2		1,500	24.0x2.0x5.5	0.000/050	C
Sub-total		9,570			
C. 4. Tu Nhu - Ben Nghe, Dai Tu (10-year plan except Ba Tung & Bi Lien)					
(R) C. 4. A2 (Ba Tung)		1,330	15.0x3.0x3.5	0.000/025	B
C. 4. A2 (Ba Tung)		2,000	Existing Section	0.000/025	A
Sub-total		3,330			
(R) C. 4. A3 (Ba Lien)		2,560	15.0x3.0x3.5	0.000/025	B
C. 4. A4 (Ba Lien)		3,180	Existing Section	0.000/025	A
Sub-total		5,740			
C. 4. A1 (Tu Nhu)		2,890	22.0x5.0x5.5	0.000/011	C
C. 4. B (Tu Nhu)		2,104	22.5x5.0x5.5	0.000/011	C
C. 4. C (Tu Nhu)		2,190	21.0x5.0x5.5	0.000/011	C
C. 4. D (Tu Nhu)		1,980	21.0x5.0x5.5	0.000/011	C
C. 4. E (Ben Nghe)		3,170	20.0x5.0x5.5	0.000/011	C
Sub-total		12,130	20.0x5.0x5.5		
C. 4. A' (Dai)		2,070	Existing Section	0.000/011	A
C. 4. B' (Dai)		2,020	Existing Section	0.000/011	A
(R) C. 4. C' (Dai)		1,400	Existing Section	0.000/011	A
C. 4. D' (Dai)		1,870	Existing Section	0.000/011	A
C. 4. E' (Tu)		4,280	Existing Section	0.000/011	A
Sub-total		13,110			
Sub-total		34,330			
Total		57,230			

CANAL IMPROVEMENT PLAN OF W ZONE

(Drainage Zone) Name of Canal Canal Section	Year	Canal Length L (m)	Designed Hydraulic Section (Wb x Wa x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
W. 1. E. Ou - E. Nam Con (5-and 10-year frequency plans)					
W. 1. A		3,600	9.0x2.0x3.5	0.000/133	B
W. 1. B (Cau)		1,700	24.0x4.0x5.5	0.000/014	B
W. 1. B (Cau)		350	6.0x2.0x3.5	0.000/014	B
W. 1. C2 (Cau)		3,110	8.0x2.0x3.5	0.000/016	B
W. 1. C3 (Cau)		1,000	24.0x4.0x5.5	0.000/014	B
W. 1. C4 (Cau)		2,200	13.0x3.0x4.5	0.000/016	B
W. 1. D1 (Nam Lon)		4,490	24.0x4.0x5.5	0.000/014	B
(S) W. 1. D2		3,870	13.0x3.0x4.5	0.000/016	B
W. 1. D3 (Nam Lon)		2,720	24.0x4.0x5.5	0.000/014	B
W. 1. E2		4,900	Existing Section	0.000/016	A
W. 1. E3 (Nam Lon)		1,240	Existing Section	0.000/016	A
W. 1. E7 (Nam Lon)		1,180	Existing Section	0.000/016	A
W. 1. E4 (Cau Gieng)		1,850	Existing Section	0.000/016	A
W. 1. E5 (Cau Gieng)		1,830	Existing Section	0.000/016	A
Sub-total		31,240			
W. 1. E6 (Cau)		3,700	24.0x4.0x5.5	0.000/016	C
W. 1. C1 (Cau)		1,800	24.0x4.0x5.5	0.000/016	C
W. 1. D4 (Nam Lon)		4,490	24.0x4.0x5.5	0.000/014	C
(S) W. 1. E3 (Nam Lon)		2,720	24.0x4.0x5.5	0.000/016	C
W. 1. F (Nam Lon)		1,180	Existing Section	0.000/016	A
W. 1. E (Cau Gieng)		1,850	Existing Section	0.000/016	A
W. 1. E (Cau Gieng)		1,830	Existing Section	0.000/016	A
Sub-total		14,760			
Total		46,170			

Fig. 4(1/2) Proposed Structural Measures for C, N and W - Zone



CANAL IMPROVEMENT PLAN OF NE-ZONE

Drainage Zone / Name of Canal / Canal Section	Canal Length L (m)	Designed Hydraulic Section (Wb x Wt x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
NE.1 R. Dog Dae (5-year frequency plan)				
NE.1 A (Dog Dae)	2,270	10.0x2.0x2.5	0.00035	B
Sub-total	2,270			
NE.2 R. Ta Dae (5-year frequency plan)				
NE.2 A (Ta Dae)	2,170	12.0x2.0x2.5	0.00035	B
NE.2 B (Ta Dae)	2,170	10.0x2.0x2.5	0.00035	B
Sub-total	4,340			
NE.3 R. Ta Dae (5-year frequency plan)				
NE.3 A (Ta Dae)	2,140	10.0x2.0x2.5	0.00035	B
Sub-total	2,140			
NE.4 R. Thong Ta (5-year frequency plan)				
NE.4 A (Thong Ta)	2,170	8.0x2.0x2.5	0.00035	B
Sub-total	2,170			
NE.5 R. Nam R. Ca. R. Ba Seng (5 and 10-year frequency plan)				
NE.5 A1	2,750	5.0x1.5x2.4	0.00560	B
NE.5 A2	2,740	6.0x1.5x2.4	0.00560	B
(10) NE.5 B (Ca.)	2,700	7.0x2.5x2.4	0.00178	B
NE.5 C (Ca Seng)	2,870	10.0x2.0x2.4	0.00035	B
NE.5 D1 (Ca Seng)	4,140	10.0x2.0x2.4	0.00035	B
Sub-total	14,600			
NE.5 A1	2,750	5.0x1.5x2.4	0.00560	C
NE.5 A2	2,740	6.0x1.5x2.4	0.00560	C
(10) NE.5 B (Ca.)	2,700	7.0x2.5x2.4	0.00178	C
NE.5 C (Ca Seng)	2,870	10.0x2.0x2.4	0.00035	C
NE.5 D1 (Ca Seng)	4,140	10.0x2.0x2.4	0.00035	C
Sub-total	14,600			
Total	35,570			

CANAL IMPROVEMENT PLAN OF SE-ZONE

Drainage Zone / Name of Canal / Canal Section	Canal Length L (m)	Designed Hydraulic Section (Wb x Wt x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
SE.1 R. Bak Kiak (5-year frequency plan)				
SE.1 A (Bak Kiak)	2,320	Existing Section	0.000050	A
Sub-total	2,320			
SE.2 R. Ca Tra Nao (5-year frequency plan)				
SE.2 A (Ca Tra Nao)	2,080	Existing Section	0.000050	A
Sub-total	2,080			
SE.3 R. Da Dae (5-year frequency plan)				
SE.3 A (Da Dae)	2,590	Existing Section	0.000050	A
Sub-total	2,590			
SE.4 R. Gong Ong Ta (5-year frequency plan)				
SE.4 A (Gong Ong Ta)	2,410	Existing Section	0.000033	A
SE.4 B (Gong Ong Ta)	2,050	Existing Section	0.000033	A
Sub-total	4,460			
SE.5 R. Nhong (5-year frequency plan)				
SE.5 A (Nhong)	2,110	14.0x0.5x0.5	0.000050	B
Sub-total	2,110			
SE.6 R. Eg Ni (5-year frequency plan)				
SE.6 A (Eg Ni)	2,390	13.0x0.5x0.7	0.000040	B
Sub-total	2,390			
SE.7 R. Gia Ong Nong - R. Ca Ca (5-year frequency plan)				
SE.7 A (Ong Nong)	2,500	18.0x0.5x0.5	0.000020	B
SE.7 B (Ca Ca)	3,200	Existing Section	0.000020	A
Sub-total	5,700			
SE.8 R. Ong Cay - R. Ba Dae - R. Ong Ren (5-year frequency plan)				
SE.8 A (Ong Cay)	1,950	Existing Section	0.000020	A
SE.8 B (Ong Ren)	4,120	Existing Section	0.000020	A
Sub-total	6,070			
SE.9 R. Ta - R. Ong Nhien (5-year frequency plan)				
SE.9 A (Ta)	2,470	Existing Section	0.000014	A
SE.9 B (Ong Nhien)	4,240	Existing Section	0.000014	A
SE.9 C (Ong Nhien)	2,830	Existing Section	0.000014	A
Sub-total	9,540			
SE.10 R. Tra Nhay (10-year frequency plan)				
SE.10 A (Tra Nhay)	3,820	Existing Section	0.000014	A
SE.10 B (Tra Nhay)	4,040	Existing Section	0.000014	A
SE.10 C (Tra Nhay)	2,410	Existing Section	0.000014	A
Sub-total	10,110			
Total	49,240			

CANAL IMPROVEMENT PLAN OF S-ZONE

Drainage Zone / Name of Canal / Canal Section	Canal Length L (m)	Designed Hydraulic Section (Wb x Wt x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
S.1 R. Nam Cal - R. Ba Lan (5-year frequency plan)				
S.1 A (Ba Lan)	2,540	18.0x0.5x1.3	0.000014	B
S.1 B1 (Ba Lan)	2,540	Existing Section	0.000014	A
S.1 B2 (Nam Cal)	1,000	Existing Section	0.000014	A
S.1 B3 (Nam Cal)	2,360	Existing Section	0.000014	A
S.1 C (Ba Lan)	1,290	Existing Section	0.000014	A
Sub-total	9,890			
S.2 R. Ong Lon - R. Cay Ka (5-year frequency plan)				
S.2 A1 (Ong Lon)	2,000	Existing Section	0.000014	A
S.2 A2 (Ong Ba)	1,840	Existing Section	0.000014	A
S.2 B (Ong Lon)	1,510	Existing Section	0.000014	A
S.2 C (Eg Ka)	3,200	Existing Section	0.000014	A
Sub-total	8,550			
S.3 R. Ta - R. Ca Ca - R. Ba Tam - R. Nhong (5 and 10-year frequency plan)				
S.3 A (Ta)	1,970	8.0x0.5x1.3	0.000014	B
S.3 B1 (Ca)	2,120	Existing Section	0.000014	A
S.3 B2 (Tha Ta)	2,120	Existing Section	0.000014	A
S.3 B3 (Ba)	2,380	Existing Section	0.000014	A
(10) S.3 C (Ba)	2,860	Existing Section	0.000014	A
S.3 D1 (Tam)	2,830	Existing Section	0.000014	A
S.3 D2 (Eg Ka)	2,410	Existing Section	0.000014	A
S.3 E (Nhong Chuoi)	2,410	Existing Section	0.000014	A
Sub-total	21,300			
S.3 A (Ta)	1,970	8.0x0.5x1.3	0.000014	B
S.3 B1 (Ca)	2,120	Existing Section	0.000014	A
S.3 B2 (Tha Ta)	2,120	Existing Section	0.000014	A
(10) S.3 C (Ba)	2,860	Existing Section	0.000014	A
S.3 D1 (Tam)	2,830	Existing Section	0.000014	A
S.3 E (Nhong Chuoi)	2,410	Existing Section	0.000014	A
Sub-total	12,310			
S.4 R. Cau Kon (5-year frequency plan)				
S.4 A (Kon Ong)	1,320	Existing Section	0.000020	A
Sub-total	1,320			
S.5 R. Ba Ch Ha (5-year frequency plan)				
S.5 A (Ba Ch Ha)	1,800	Existing Section	0.000020	A
Sub-total	1,800			
Total	55,490			

Fig. 4(2/2) Proposed Structural Measures for S, NE and AE - Zone

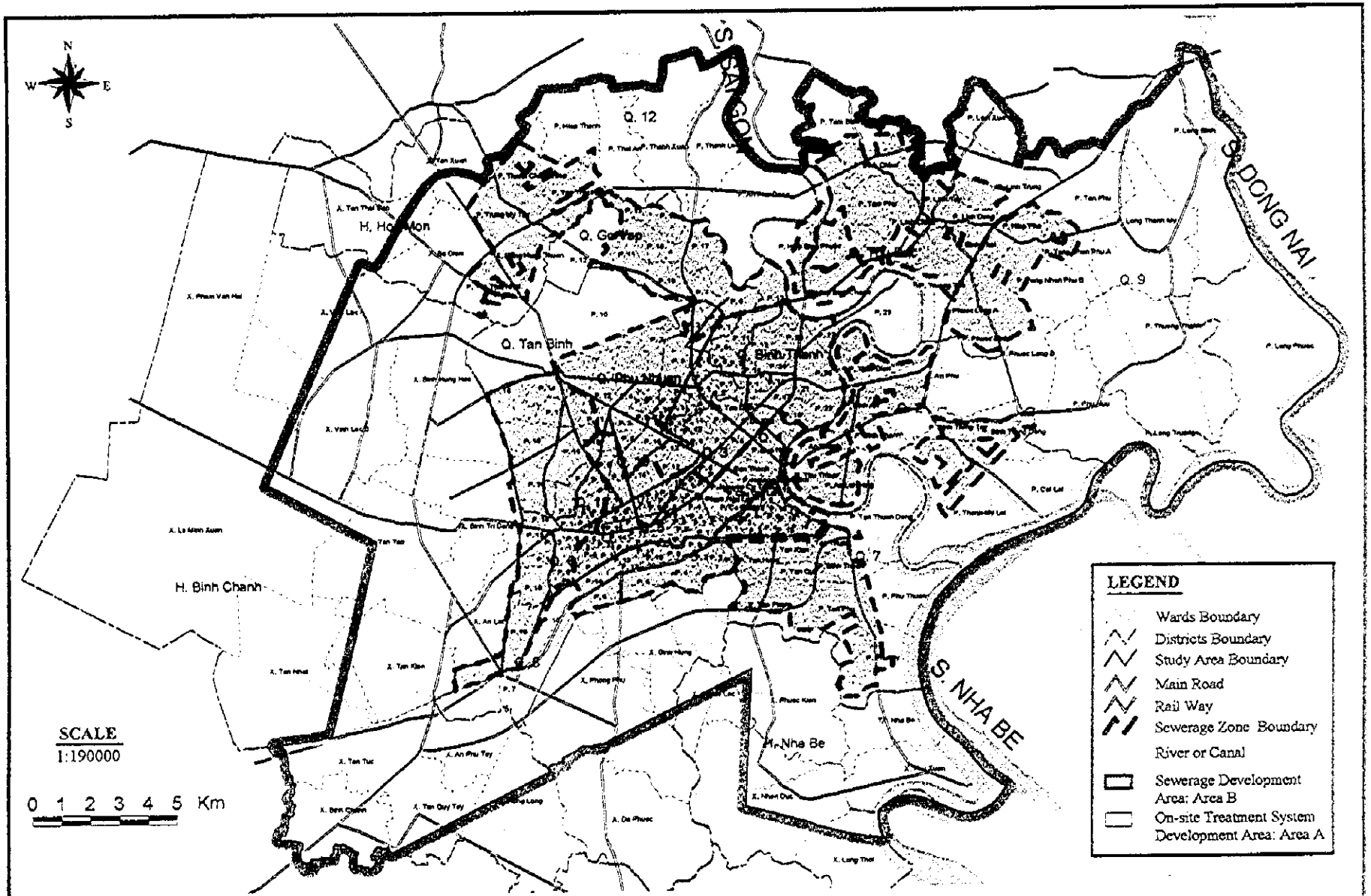


FIG. 5 DIVISION OF PROJECT AREA BY SANITATION SYSTEM

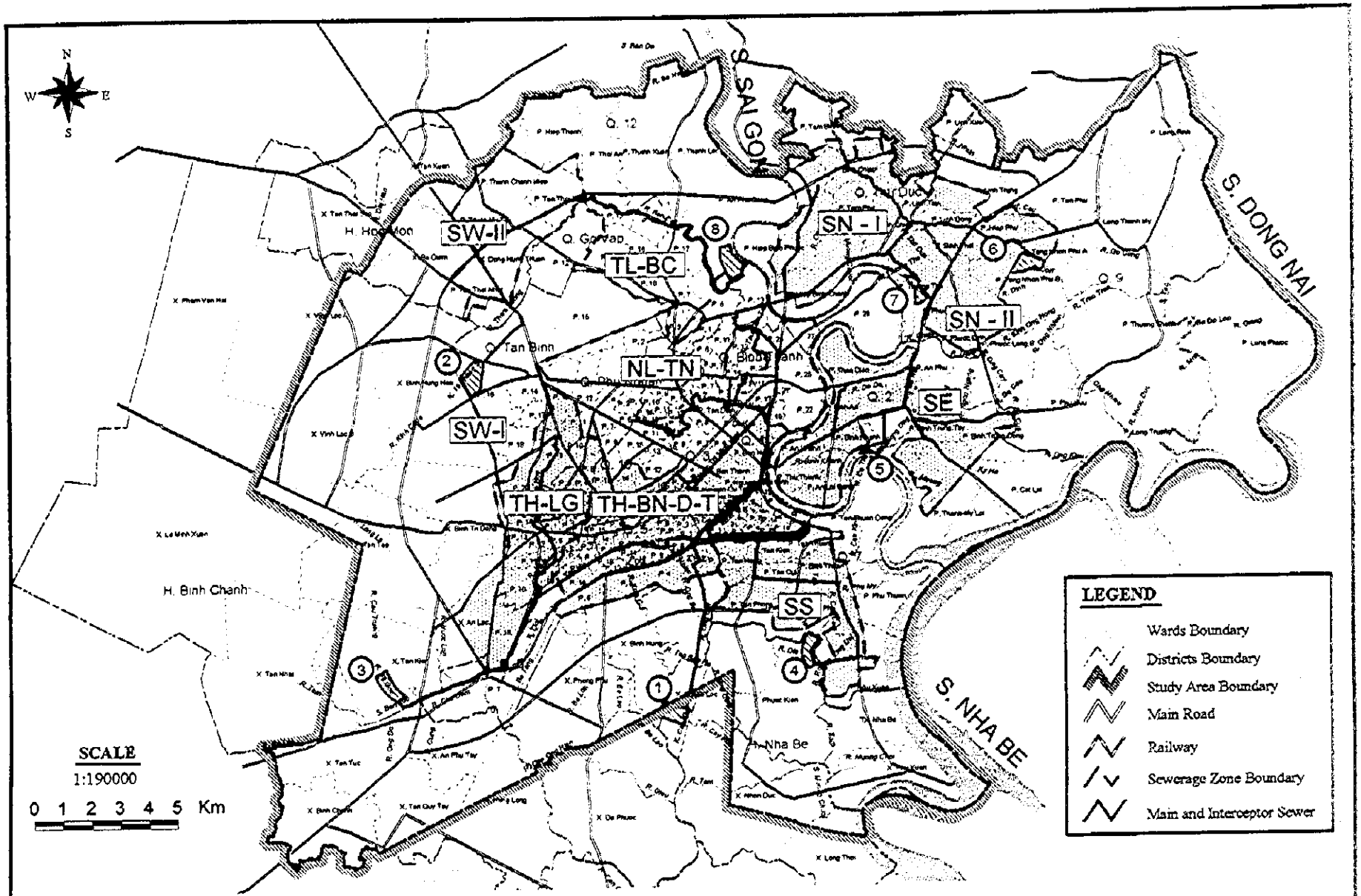


FIG.6 PROPOSED SEWERAGE DEVELOPMENT

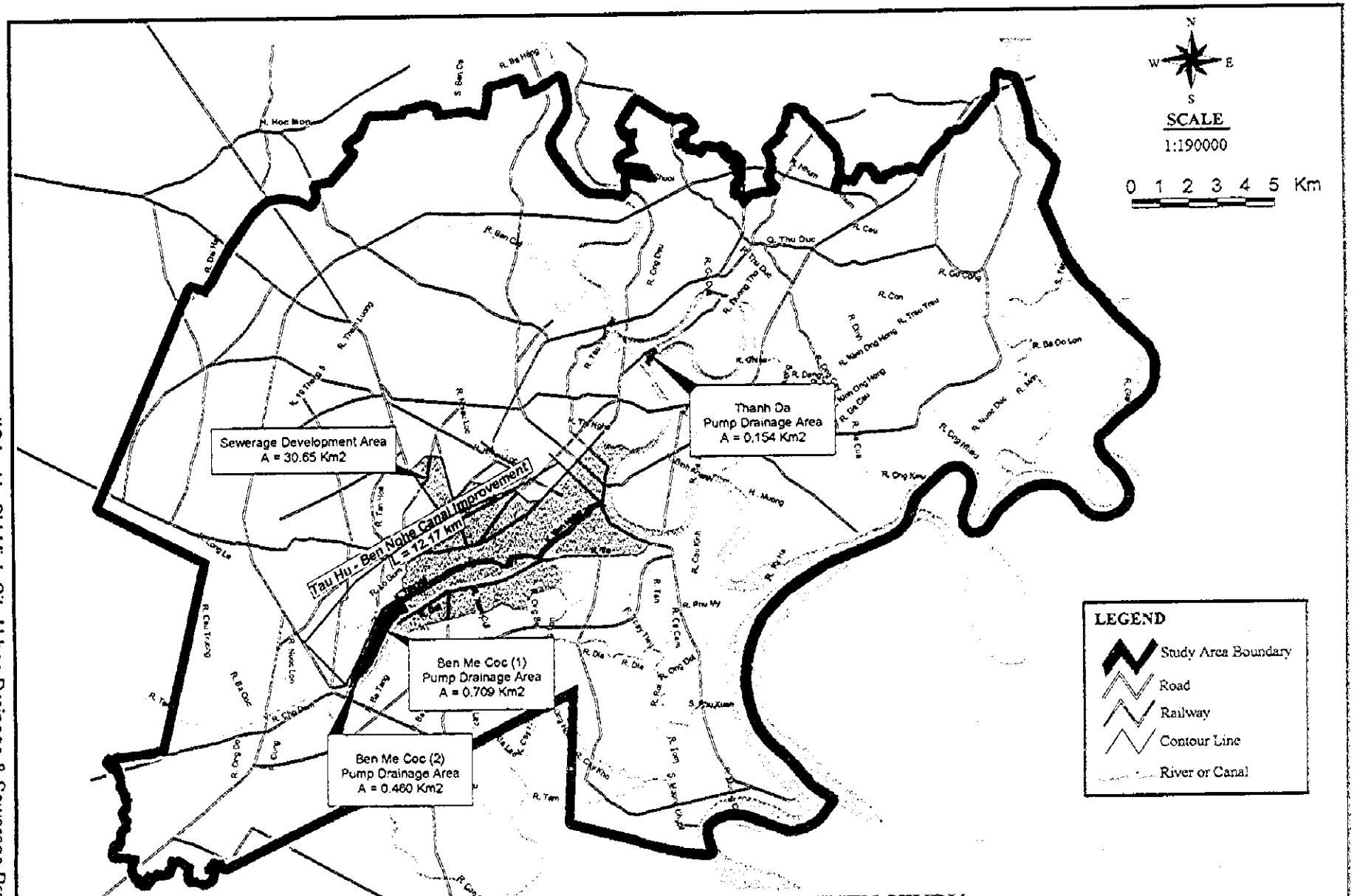


FIG. 7 PRIORITY PROJECT FOR FEASIBILITY STUDY

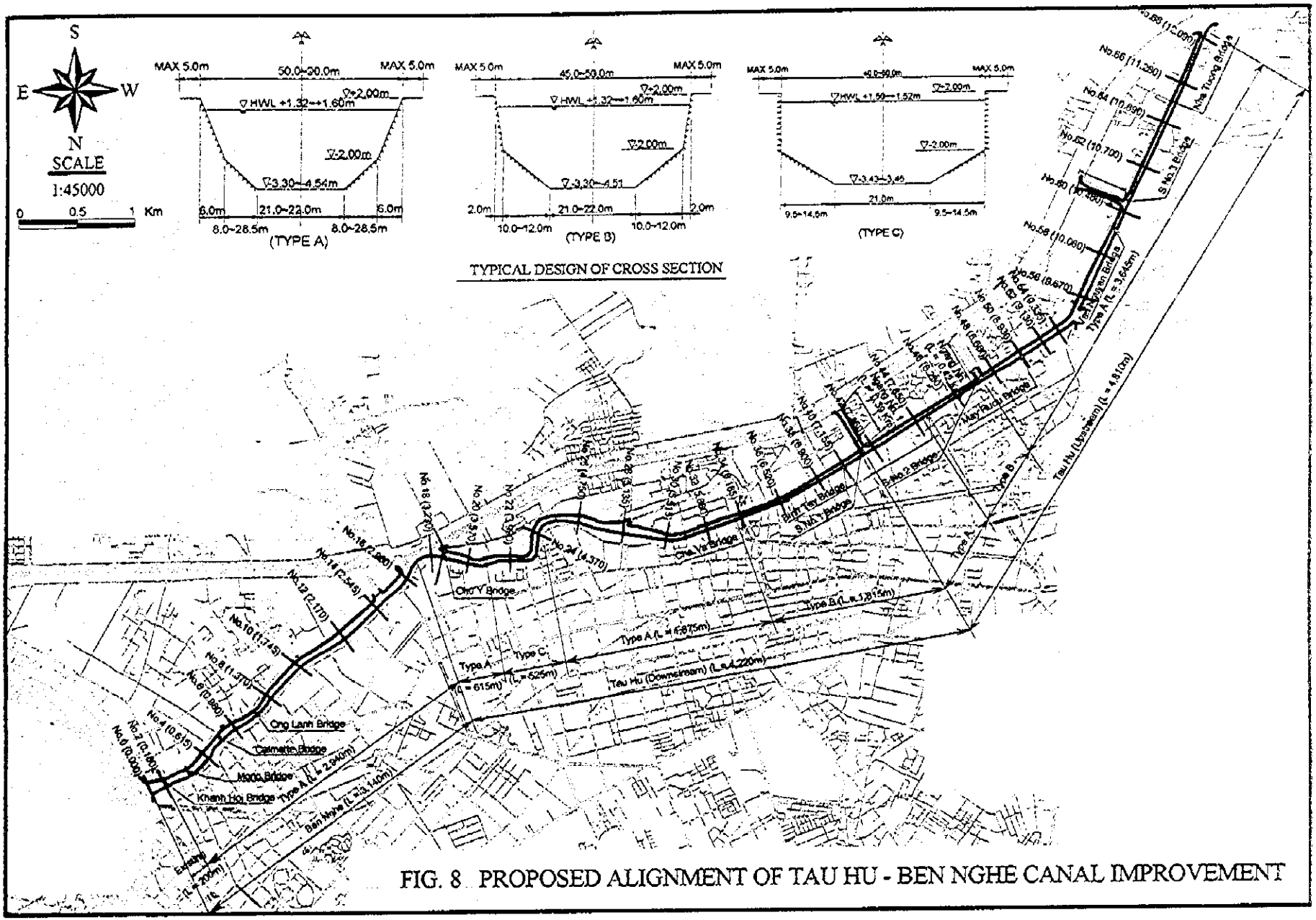


FIG. 8 PROPOSED ALIGNMENT OF TAU HU - BEN NGHE CANAL IMPROVEMENT

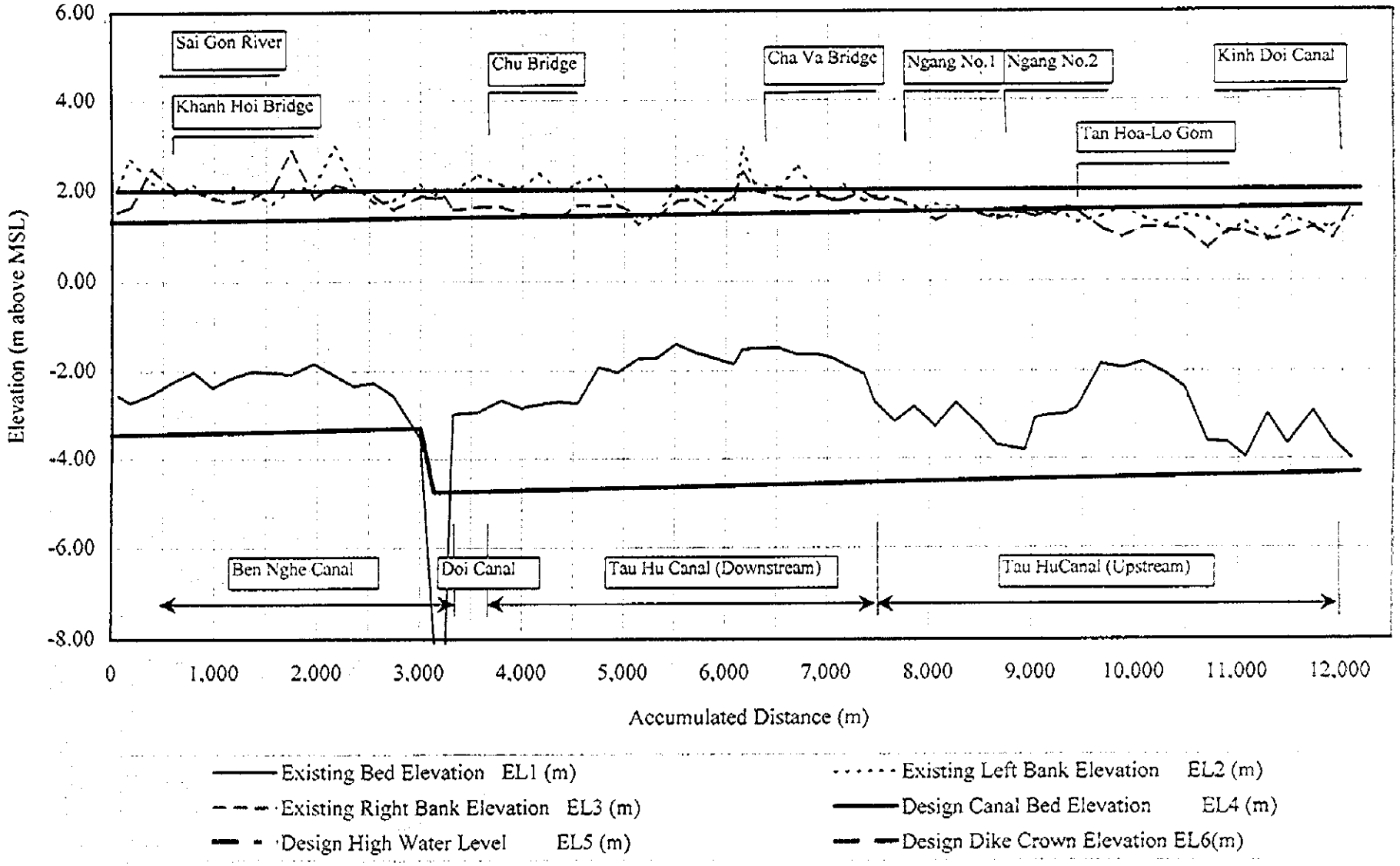


FIG. 9 PROPOSED LONGITUDINAL PROFILE OF TAU HU - BEN NGHE CANAL IMPROVEMENT

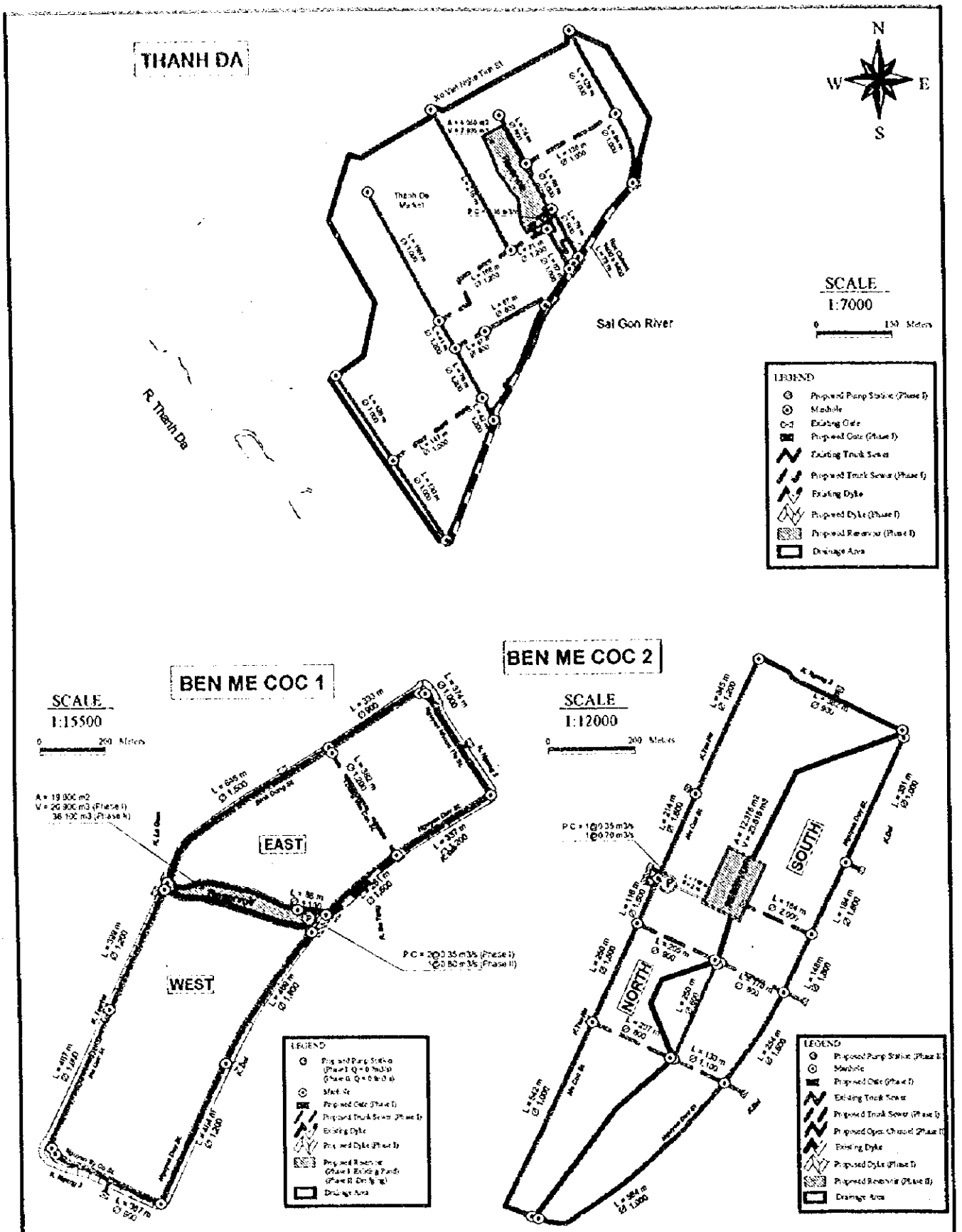
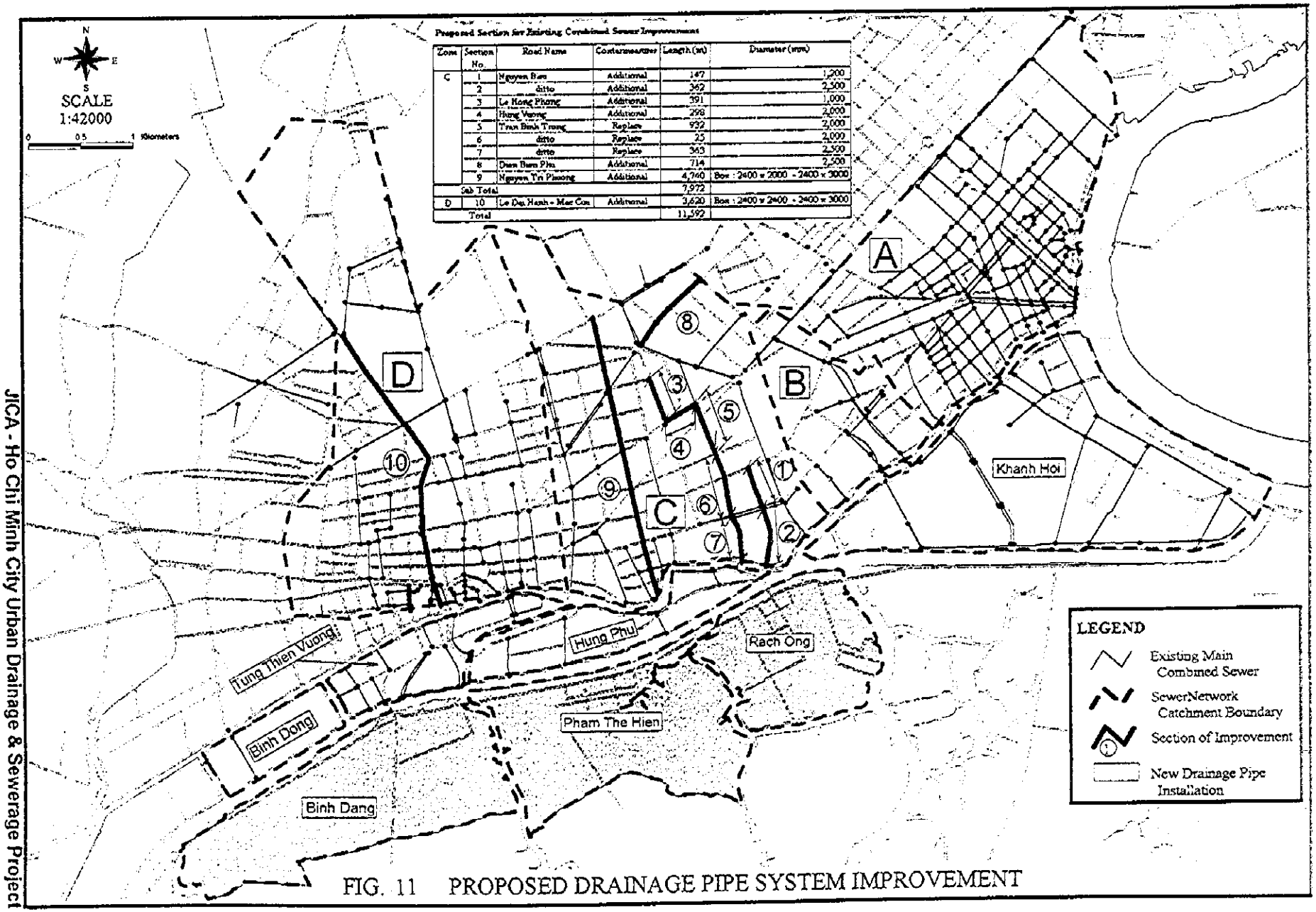


Fig. 10 PROPOSED DRAINAGE SYSTEMS FOR PRIORITY PROJECT AREAS



Proposed Sections for Existing Combined Sewer Improvement

Zone	Section No.	Road Name	Contents/Other	Length (m)	Diameter (mm)
C	1	Nguyen Bieu	Additional	147	1,200
	2	ditto	Additional	362	2,500
	3	Le Hong Phong	Additional	391	1,000
	4	Hung Vuong	Additional	298	2,000
	5	Tran Binh Trong	Replace	932	2,000
	6	ditto	Replace	25	2,000
	7	ditto	Replace	365	2,500
	8	Duan Buon Phu	Additional	714	2,500
	9	Nguyen Tri Phuong	Additional	4,760	Box : 2400 x 2000 - 2400 x 3000
Sub Total				7,972	
D	10	Le Dai Hanh - Mac Cuu	Additional	3,620	Box : 2400 x 2400 - 2400 x 3000
Total				11,592	

FIG. 11 PROPOSED DRAINAGE PIPE SYSTEM IMPROVEMENT

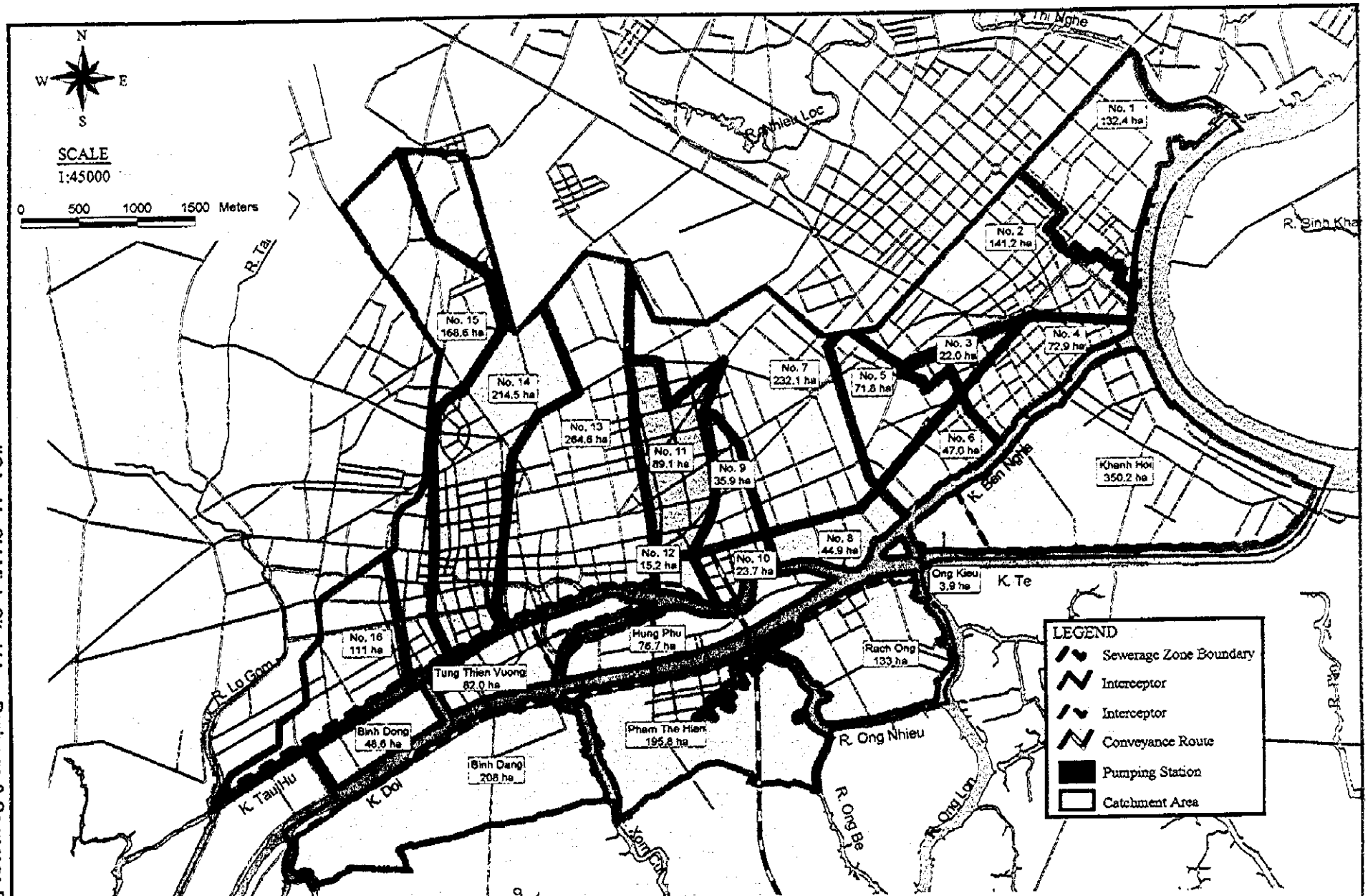


FIG. 12 SUB-ZONES AND INTERCEPTOR ROUTE

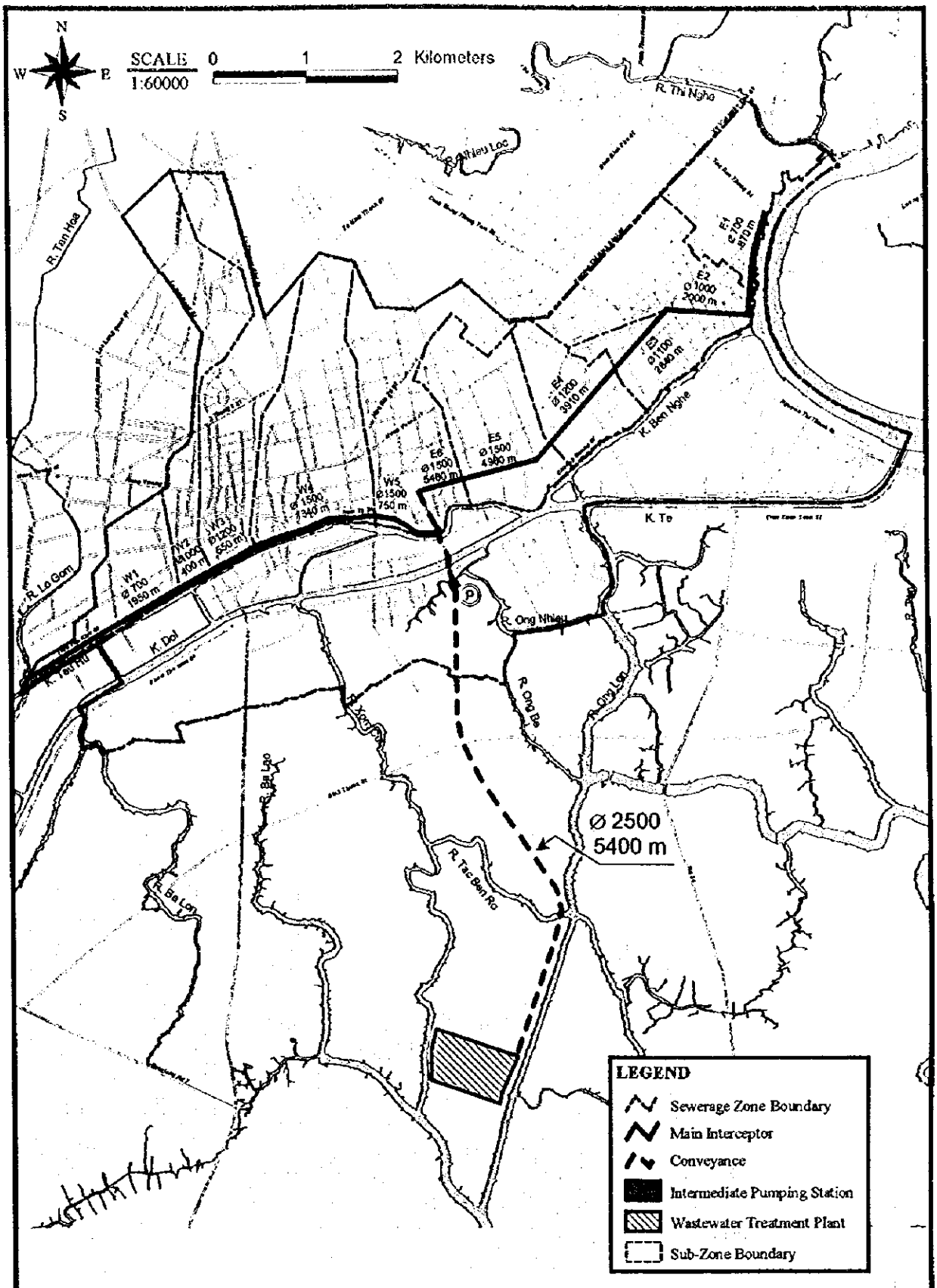
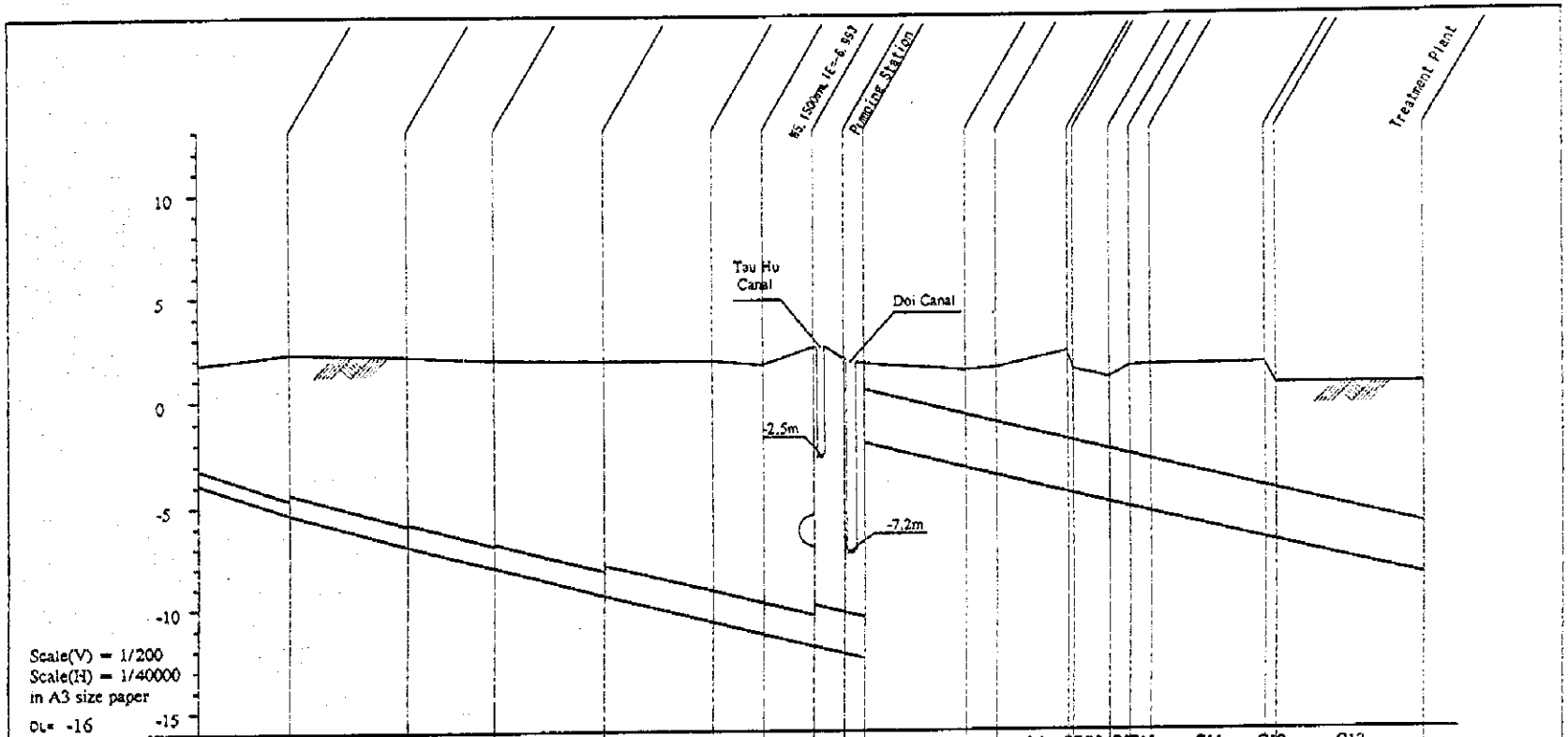


FIG. 13 PROPOSED ALIGNMENTS OF INTERCEPTOR AND CONVEYANCE SEWERS



Line Number	E1	E2	E3	E4	E5	E6	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
Diameter (mm)	700	1000	1100	1200	1500	1500	1500	2000	2000	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Gradient (o/oo)	1.7	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Length (m)	870	1130	840	1070	1070	500	500	300	200	1000	300	700	50	350	200	200	1100	100	1400
Ground Elevation (m)	1.76	2.28	2.12	1.92	1.85	1.84	1.64	1.61	1.92	1.68	1.34	1.45	1.33	1.33	0.93	1.48	1.52	1.58	0.57
Earth Covering (m)	4.88	6.88	8.00	8.82	10.02	10.99	11.39	11.48	12.13	12.13	1.20	2.06	2.53	3.33	3.33	4.40	4.40	5.28	4.89	8.60
Invert Elevation (m)	-3.87	-5.35	-6.53	-8.03	-9.42	-10.29	-11.30	-11.90	-12.26	-12.50	2.07	-3.37	-3.63	-4.47	-4.63	-5.19	-5.43	-5.75	-6.87	-8.55
Total Length (m)	0	870	2000	2840	3910	4980	5480	5980	6280	6480	7480	7780	8180	8530	8880	9080	9280	10380	10480	11880

FIG. 14 PROPOSED LONGITUDINAL PROFILE OF INTERCEPTOR AND CONVEYANCE SEWERS

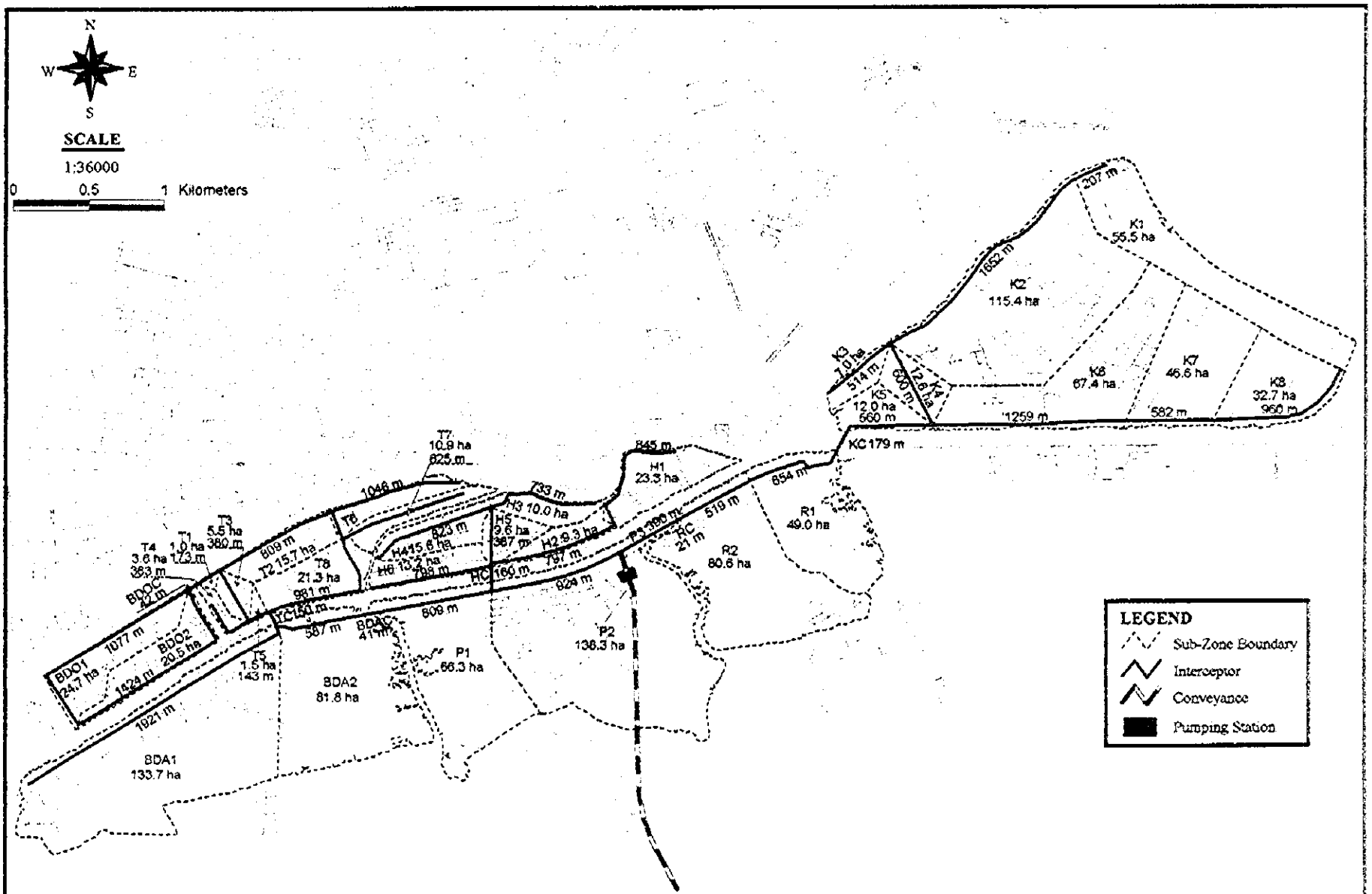


FIG. 15 SUB-ZONE AND INTERCEPTOR ROUTE FOR ISLANDS AND SOUTHERN AREAS

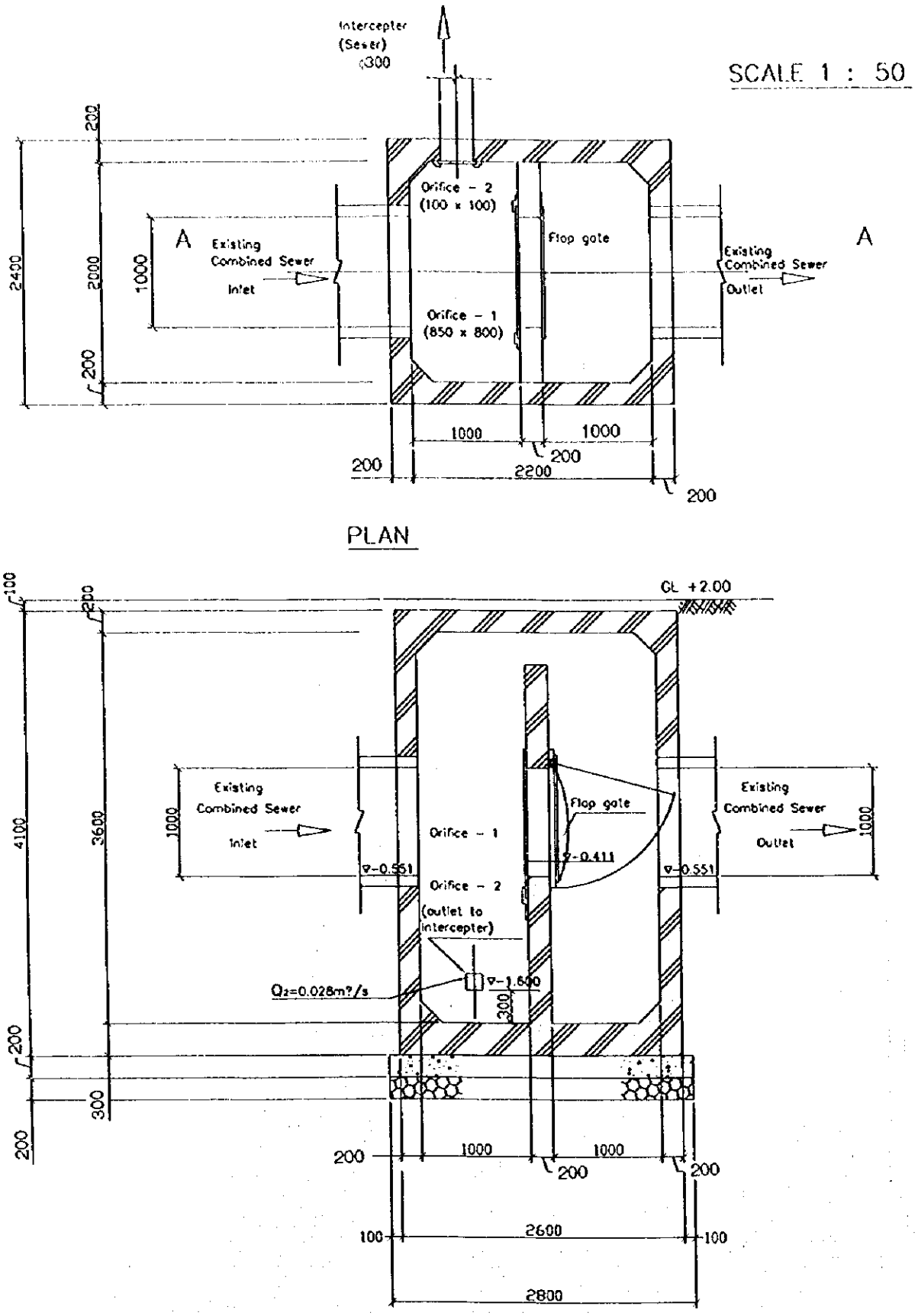
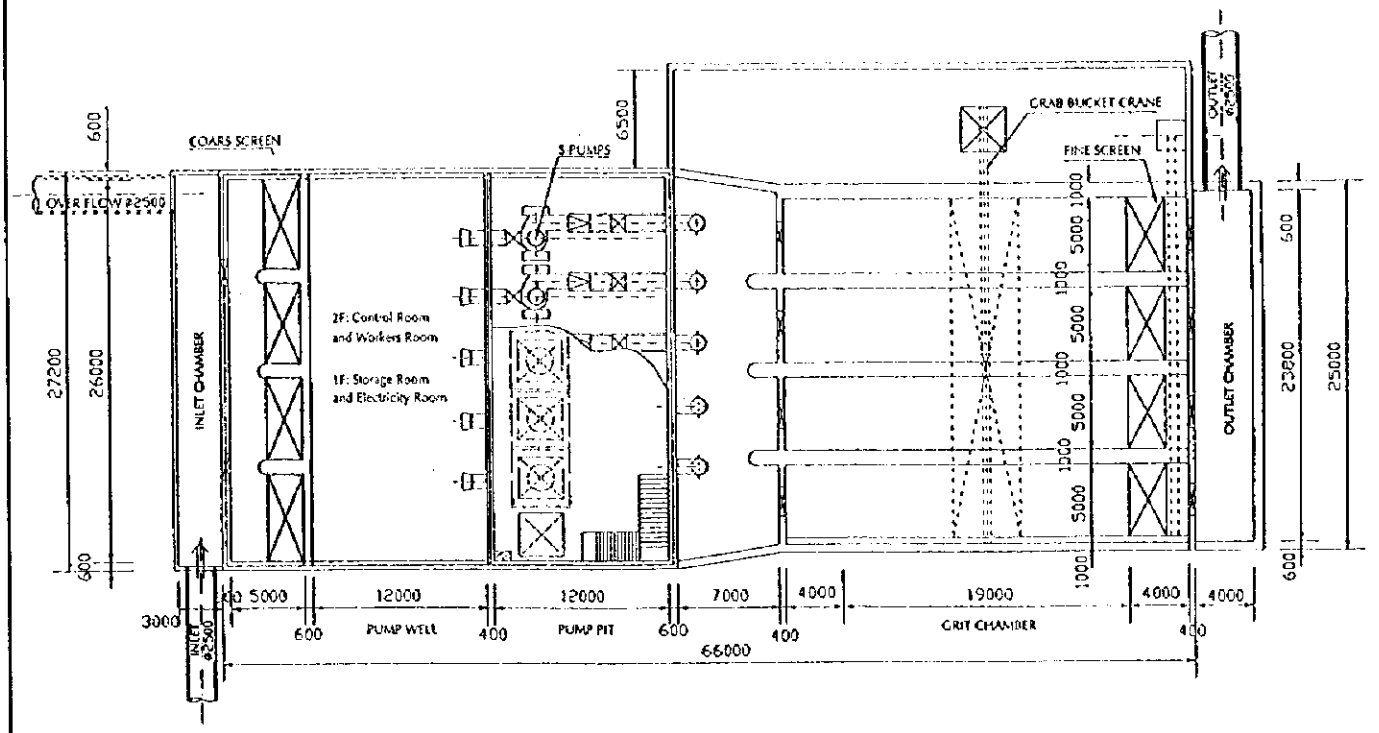


FIG. 16 PROPOSED TYPICAL SECTION DIVERSION CHAMBER

SCALE 1:500



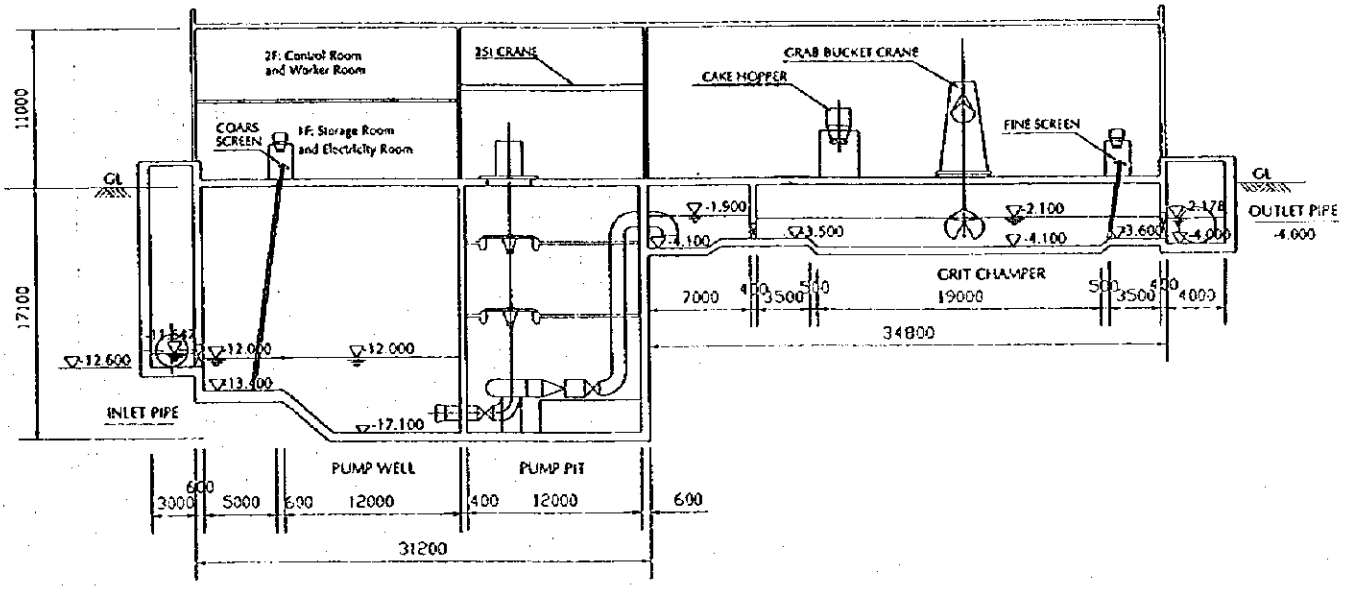


FIG. 17 LAYOUT OF INTERMEDIATE SEWERAGE PUMPING STATION

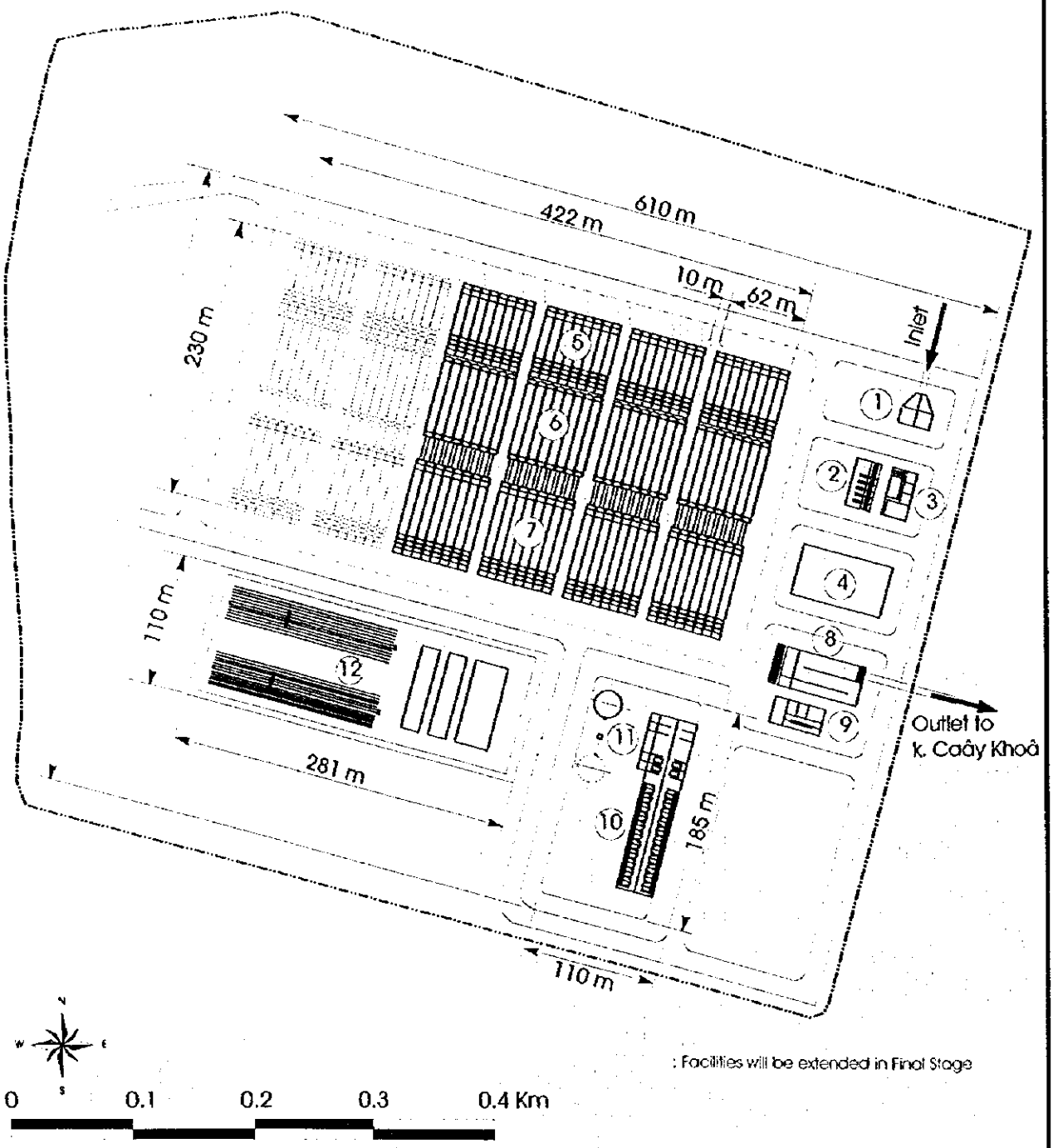
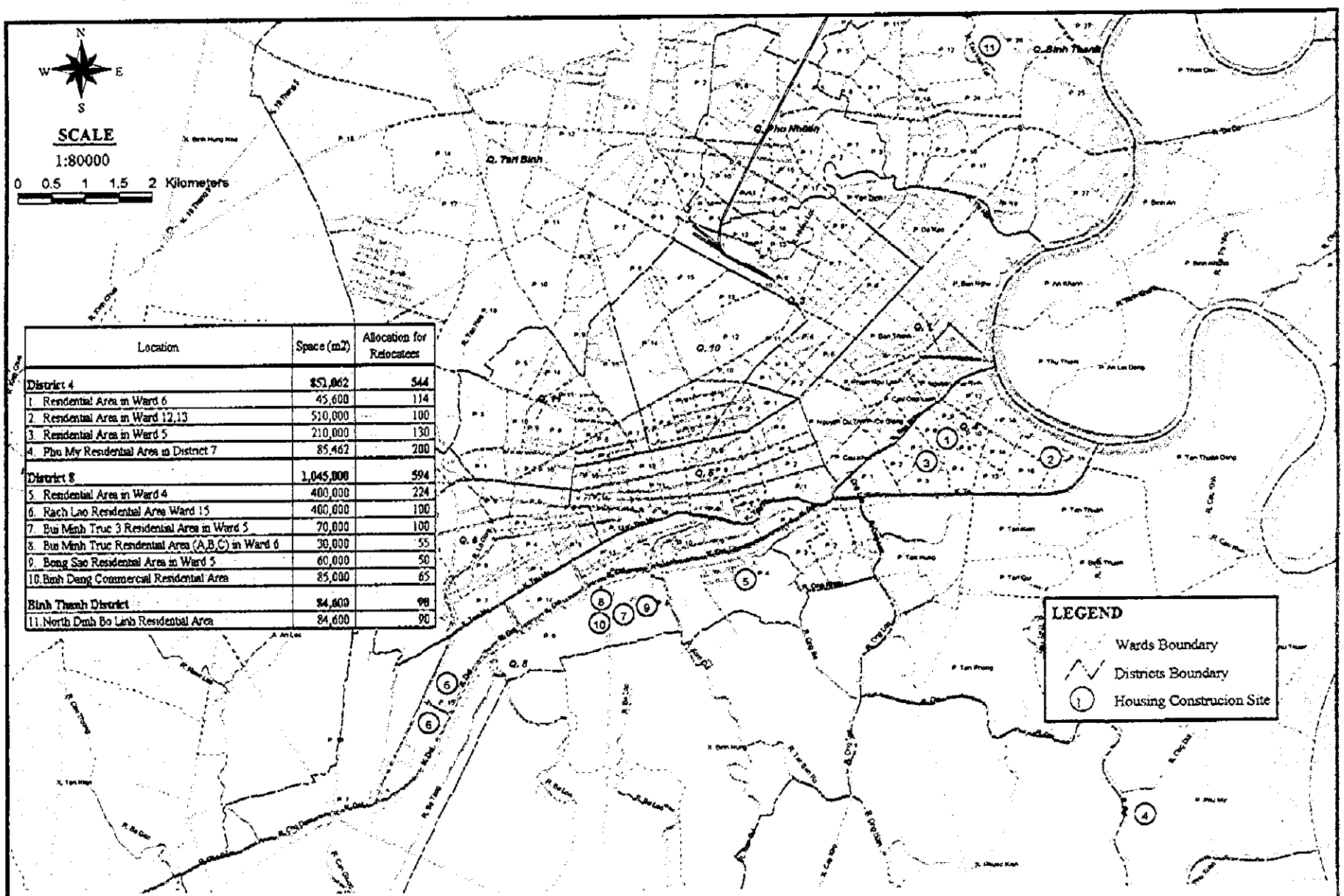


FIG. 18 PROPOSED LAYOUT OF WASTEWATER TREATMENT PLANT



Location	Space (m2)	Allocation for Relocatees
District 4	851,062	544
1. Residential Area in Ward 6	45,600	114
2. Residential Area in Ward 12,13	510,000	100
3. Residential Area in Ward 5	210,000	130
4. Phu My Residential Area in District 7	85,462	200
District 8	1,045,000	594
5. Residential Area in Ward 4	400,000	224
6. Rach Lao Residential Area Ward 15	400,000	100
7. Bui Minh Truc 3 Residential Area in Ward 5	70,000	100
8. Bui Minh Truc Residential Area (A,B,C) in Ward 6	30,000	55
9. Bong Sao Residential Area in Ward 5	60,000	50
10. Binh Dang Commercial Residential Area	85,000	65
Binh Thanh District	84,600	90
11. North Dinh Bo Linh Residential Area	84,600	90

FIG. 19 LOCATION OF PROPOSED HOUSING CONSTRUCTION FOR RESETTLEMENT

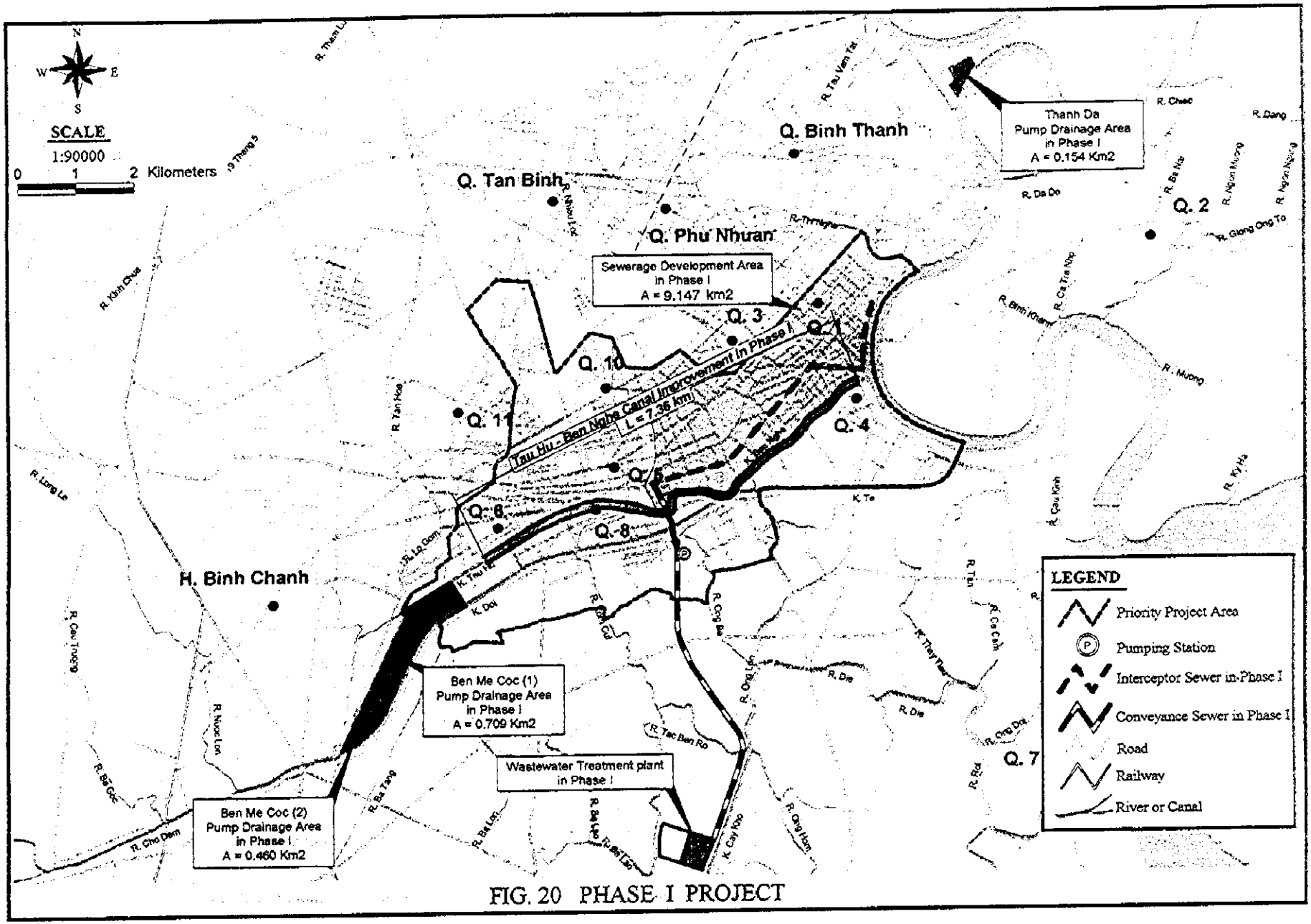


FIG. 20 PHASE I PROJECT

JICA