

THE STUDY ON URBAN DRAINAGE  
AND  
WASTEWATER SYSTEMS  
IN  
DAKAR CITY AND ITS SURROUNDINGS

SUMMARY REPORT

OCTOBER 1994

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO

in association with

TOKYO ENGINEERING CONSULTANTS CO. LTD., TOKYO

THE STUDY ON URBAN DRAINAGE AND WASTEWATER SYSTEMS IN DAKAR CITY AND ITS SURROUNDINGS SUMMARY REPORT

526  
618  
555

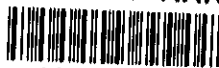
SSS  
JR  
84-118

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF HYDRAULICS  
THE REPUBLIC OF SENEGAL

**THE STUDY ON URBAN DRAINAGE  
AND  
WASTEWATER SYSTEMS  
IN  
DAKAR CITY AND ITS SURROUNDINGS**

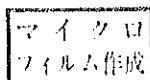
JICA LIBRARY



1118927(11)

27417

**SUMMARY REPORT**



OCTOBER 1994

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO

in association with

TOKYO ENGINEERING CONSULTANTS CO. LTD., TOKYO

国際協力事業団

27417

In this report, project costs are estimated based on March 1994 prices with an exchange rate of FF 1=FCFA 100 (FF 1=¥18.64).

## Preface

In response to a request from the Government of the Republic of Senegal, the Government of Japan decided to conduct a master plan and feasibility study on Urban Drainage and Wastewater Systems in Dakar City and Its Surroundings and entrusted the study of Japan International Cooperation Agency (JICA).

JICA sent to Senegal a study team headed by Mr. Akira Takechi, Pacific Consultants International (PCI) and composed of staff members of PCI and Tokyo Engineering Consultants Co., Ltd. four times between June 1993 and August 1994.

The team held discussions with the officials concerned of the Government of Senegal, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Senegal for their close cooperation extended to the team.

October 1994



---

Kimio Fujita  
President  
Japan International Cooperation Agency



**THE STUDY ON URBAN DRAINAGE AND WASTEWATER SYSTEMS  
IN DAKAR AND ITS SURROUNDINGS**

October 1994

Mr. Kimio Fujita  
President  
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit you the final report entitled "THE STUDY ON URBAN DRAINAGE AND WASTEWATER SYSTEMS IN DAKAR AND ITS SURROUNDINGS". This report has been prepared by the Study Team in accordance with the contracts signed on 13 May 1993, 28 January 1994 and 2 May 1994 between Japan International Cooperation Agency and Pacific Consultants International.

The report examines the existing conditions concerning urban drainage and wastewater systems in Dakar and its surrounding areas, and presents a master plan for development of urban drainage and wastewater systems and the results of a feasibility study on a priority project selected from 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 presents the results of the whole study including background conditions, formulation of the master plan, selection of the priority project and the feasibility study on the priority project. The Supporting Report describes in detail the same contents in the Main Report. The Data Book contains raw data uses in the Study.

All members of the Study Team wish to express grateful acknowledgment to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Senegal, and also to officials and individuals of the Government of Senegal for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study contribute to the improvement of the urban drainage and wastewater systems and the social and economic development in Dakar.

Yours faithfully,



---

Akira Takechi  
Team Leader









# THE STUDY ON URBAN DRAINAGE AND WASTEWATER SYSTEMS IN DAKAR AND ITS SURROUNDINGS

## ABSTRACTS

### I. WASTEWATER SYSTEM

1. Target year: 2010

2. Area and population covered by the Master Plan:

Area: 3480 ha (20% of the Study Area)

Population: 1,041,328 (35.8% of the total population of the Area)

3. Components of the Wastewater Master Plan

3.1 Structural components

Construction of sewer networks: 1,302ha

Construction of trunk sewers: 34.3 km

Expansion of wastewater treatment plant: 90,000 m<sup>3</sup>/day

Improvement of existing collector system in Ouakam Area

3.2 Non-structural components

Industrial wastewater: Individual treatment in each factory

On-site system: Encouragement of improvement of toilet facilities

4. Project Cost of the Wastewater Master Plan

Direct Construction Cost	83,500 FCFA million
Land Acquisition	827 FCFA million
Engineering Service	8,350 FCFA million
Government Administration	1,252 FCFA million
<u>Physical Contingency</u>	<u>8,350 FCFA million</u>
Total	102,279 FCFA million

5. Financial Feasibility

The project is judged to be financially feasible under following conditions:

- The government subsidies 100 % of the construction cost.
- Sewerage charges is increased to 8 % of water charge to cover operation and maintenance costs.

6. Priority Project

6.1 Area: Parcels Assainies and its surrounding areas (810 ha).

6.2 Population: 167,000

6.3 Proposed facilities

Pumping stations:	Construction or reconstruction of 12 pumping stations.
Secondary collectors:	Construction of secondary collectors for service area of 20 ha
Wastewater treatment plant:	Expansion of Camberene wastewater treatment plant to 30,000 m <sup>3</sup> /day by two additional trains, including reconstruction of the treated water ocean outfall.

6.4 Project Cost

Direct Construction Cost	13,963 FCFA million
Sewer Cleansing Equipment	455 FCFA million
Engineering Service	1,396 FCFA million
Government Administration	210 FCFA million
<u>Physical Contingency</u>	<u>1,396 FCFA million</u>
Total	17,410 FCFA million

## II. URBAN DRAINAGE SYSTEM

1. Target year: 2010

2. Area: 160.4 km<sup>2</sup>

3. Components of Urban Drainage Master Plan

3.1 Structural components

Construction of drainage channels, pumping stations and infiltration/retention ponds in the areas which have been already urbanized and do not an outlets to the sea or lakes.

3.2 Non-structural components

Encouragement of infiltration and storage of stormwater.

4. Project Cost of the Urban Drainage Master Plan

Direct Construction Cost	18,985 FCFA million
Pumping cars	500 FCFA million
Land Acquisition	881 FCFA million
Engineering Service	1,329 FCFA million
Government Administration	298 FCFA million
<u>Physical Contingency</u>	<u>2,149 FCFA million</u>
Total	24,143 FCFA million

5. Economic Feasibility

EIRR is calculated to be 8.7 % and the Project is judged to be economically feasible considering its public nature.

## 6. Priority Project

6.1 Area: Central Pikine (11.3 km<sup>2</sup>)

### 6.2 Proposed facilities

Storm sewer/transmission pipe:	total 7.0 km
Open channel:	total 3.3 km
Pumping stations:	8 places
Retention pond:	5.1 ha

### 6.3 Project Cost

Direct Construction Cost	8,686 FCFA million
Land Acquisition	250 FCFA million
Engineering Service	608 FCFA million
Government Administration	134 FCFA million
<u>Physical Contingency</u>	<u>968 FCFA million</u>
Total	10,647 FCFA million

### 6.4 Evaluation

Net Present Value (NPV):	430 FCFA million
Benefit Cost Ratio (B/C):	1.07
Economic Internal Return Rate (EIRR):	10.8%

## TABLE OF CONTENTS

PREFACE

LETTER OF TRANSMITTAL

ABSTRACTS

1.	INTRODUCTION.....	1
2.	WASTEWATER SYSTEM .....	3
2.1	Present Conditions of Wastewater System .....	3
2.1.1	Existing Wastewater System .....	3
2.1.2	Coverage of Sewerage System.....	3
2.1.3	Sewerage Facilities .....	3
2.2	Planning Conditions.....	4
2.2.1	Population and Land Use.....	4
2.2.3	Selection of Sewered Area.....	4
2.2.2	Wastewater Flow and Pollutant Loads.....	4
2.3	Sewerage Master Plan.....	4
2.3.1	Wastewater Systems for Entire Study Area.....	5
2.3.2	Proposed Wastewater Master Plan.....	6
2.3.3	Project Evaluation.....	7
2.4	Feasibility Study on the Priority Project .....	8
2.4.1	Proposed Priority Project.....	8
2.4.2	Project Cost and Implementation Schedule .....	9
2.4.3	Project Evaluation.....	9
3.	URBAN DRAINAGE SYSTEM.....	10
3.1	Present Conditions of Study Area .....	10
3.1.1	Existing Urban Drainage System .....	10
3.1.2	Flood Conditions .....	10
3.2	Planning Conditions.....	11
3.2.1	Landuse .....	11
3.2.2	Design Return Period of Rainfall .....	11
3.3	Urban Drainage Master Plan.....	11
3.3.1	General.....	11
3.3.2	Proposed Master Plan .....	12
3.3.3	Project Evaluation.....	13
3.4	Feasibility Study on the Priority Project .....	13
3.4.1	Proposed Priority Project.....	13
3.4.2	Project Cost and Implementation Schedule .....	14
3.4.3	Project Evaluation.....	15
4.	RECOMMENDATION .....	16
4.1	Recommendation related to Wastewater System .....	16
4.2	Recommendation related to Urban Drainage System .....	17

# 1 INTRODUCTION

The City of Dakar, the Capital of Senegal, has the highest concentration of population in the nation and also the center of industry and commerce. The progressing rapid urbanization in the suburban areas exacerbates social and environmental problems. The sanitary conditions in the area is one of the most important problems to be addressed and the improvement of drainage and wastewater disposal systems is indispensable to maintain a favorable living environment.

This study on development of urban drainage and wastewater systems in Dakar and its surroundings was conducted by the Study Team of the Japan International Cooperation Agency (JICA) in cooperation with the Ministry of Hydraulics, SONEES and other related government agencies from June 1993 to August 1994.

The objectives of the Study are;

- i) to draw up a master plan for development of urban drainage and wastewater systems in the study area in 2010, including its phased implementation program, and
- ii) to conduct a feasibility study on urban drainage and/or wastewater system(s) for a high priority project selected from the master plan.

The study area covers the City of Dakar and its surrounding areas with an area of about 160 km<sup>2</sup>, consisting of the Department of Dakar and the Department of Pikine, as shown in *Figure 1.1*.

The study was carried out in cooperation with the Japanese and Senegalese organizations shown in figure below.

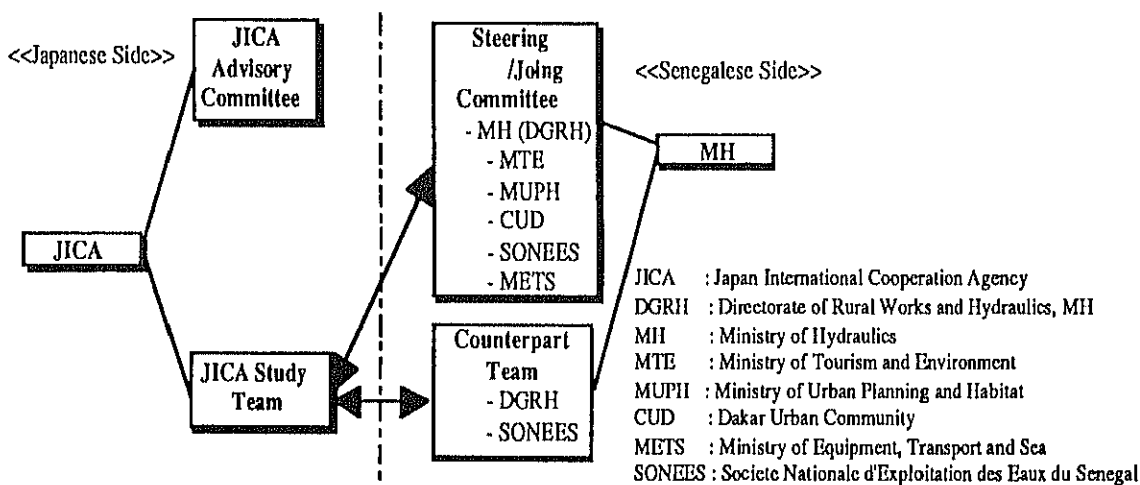


Figure Study Organization

**JICA STUDY TEAM**

Name	Field in Charge
Akira Takechi	Team Leader / Sewerage Planning
Hiroyuki Shiraiwa	Urban Drainage Planning
Masafumi Miyamoto	Facilities Planning and Designing (Sewerage)
Ryo Matsumaru	Facilities Planning and Designing (Urban Drainage)
Jyudo Hagiwara	Facilities Planning and Designing (Treatment Plant)
Masahiro Kawachi	Water Quality / Industrial Wastewater Treatment
Arun Kumar Viswanath	Environment
Ryuji Yanai	Organization / Implementation Planning
Placide Meirsman	Urban Planning
Noboru Narushima	Construction Planning / Cost Estimation
Naomichi Ishibashi	Economic and Financial Analysis
Osamu Nogoshi	Survey and Soil Investigation

**JICA ADVISORY COMMITTEE**

Name	Field in Charge	Present Post
Yoshio Tano	Chairman / Sewerage Planning	Counselor, Japan Regional Development Corporation
Osamu Fujiki	Urban Drainage Planning	Chief, Research & Technology Development Dept., Japan Sewage Works Agency

**Senegalese Counterpart Team**

Name	Field in Charge	Organization
Birama NDIAYE	General	DGRH/DHUA
M. Alioune BA	Sewerage	DGRH/DHUA
Cheikh FALL	Sewerage	SONEES
Ousmane CAMARA	Urban Drainage	SONEES
Ibrahima SOW	Urban Drainage	DGRH/DHUA
Fatoumata NIANG	Water Quality Analysis	SONEES
Papa Ibrahima DIONE	Water Quality Analysis	SONEES
Chikh SYLLA	Water Quality Analysis Environment	MTE
Alioune BAKHOUM	Organization	DGRH/DHUA
Baba COULIBALY	Organization	SONEES
Mame Pierre CAMARA	Economic/Finance	DCET/MEFP
Souleymane DIOP	Survey	DGRH/DHUA

## **2. WASTEWATER SYSTEM**

### **2.1 PRESENT CONDITIONS OF WASTEWATER SYSTEM**

#### **2.1.1 Existing Wastewater System**

Urbanized areas in the Study Area are provided with sanitary systems which can be classified broadly into two categories, viz. off-site system and on-site system. The off-site system is the conventional sewerage system collecting sewage from households and various kinds of buildings. A sewerage system currently existing in the Study Area has been designed and constructed as a separate system which collect sewage and storm water runoff separately. The collected sewage is finally discharged to the sea either after or without treatment.

The on-site system is an individual sanitary system which deals with wastewater at site of its origin.

#### **2.1.2 Coverage of Sewerage System**

The current sewered population is estimated to be 453,958, which accounts for 30 % of the total population of 1,517,400 in the Study Area. In aerial wise, sewered area covers 34 % of the total Study area.

Based on the above population and considering unit wastewater and pollutant loads, wastewater amount and pollutant loads generated and collected are estimated.

#### **2.1.3 Sewerage Facilities**

The present sewerage facilities comprise of i) sewer networks provided in the sewered area, ii) trunk sewers that send collected wastewater to wastewater treatment plant and ocean outfalls, iii) 25 pumping stations, iv) two wastewater treatment plants (one of two is not functioning as designed) and ocean outfalls.

The wastewater collected from sewer networks in Dakar zone is discharged mainly from Fann without treatment. The Camberene Wastewater Treatment Plant treats wastewater mainly from Parcelles Assaineis area.



## 2.2 PLANNING CONDITIONS

### 2.2.1 Population and Land Use

Ten new developments that were not included in the Strategy Plan were identified through the Study .

With inclusion of the new development, projected population in the Study area in 2010 is changed from 2,915,459 (Strategy Plan) to 2,908,871.

### 2.2.3 Selection of Sewered Area

The area to be sewered by the sewerage system were selected by considering following factors:

- Water supply service level (per capita water consumption rate)
- Population density
- Physical and economical suitability of on-site treatment

A total of 2,135,435 inhabitants or 73.4 % of the total population of the Study Area in 2010 will be covered by sewerage system.

### 2.2.2 Wastewater flow and Pollutant Loads

Total wastewater flow in 2010 is estimated at 511,007 m<sup>3</sup>/day, of which, 484,197 m<sup>3</sup>/day originates from domestic sources and 26,814 m<sup>3</sup>/day from industrial sources. The pollutant load in 2010 is estimated at 202.9 BOD ton/day, of which 178.5 BOD ton/day originates from domestic sources and 24.4 BOD ton/day from industrial sources.

## 2.3 SEWERAGE MASTER PLAN

### General

Sewerage planning was carried out for the entire area that was selected to be sewered as mentioned above (ref. 2.2.1). However, the sewerage plan was judged to be difficult to be completed by the year 2010 from view points of financial feasibility and work volume, as such it was agreed that several areas would not be included in the Master Plan to be proposed so as to make the Master Plan feasible.

Therefore, it should be noted that although the Study has prepared sewerage plan covering the whole area to be sewered, only some parts of it will be proposed as a Master Plan.

### 2.3.1 Wastewater Systems for Entire Study Area

#### (1) Sewerage system

The area to be seweraged was divided into 14 sewerage zones, considering topographic conditions and the existing sewerage system. The proposed sewerage system will have 7 wastewater treatment plants to cover 14 sewerage zones as shown in Figure 2.1. The total of the project costs (prices after the devaluation) are estimated as below:

Items	1000 FCFA	
Direct Construction Cost (DCC)	255,116,953	
Sewer networks	60,211,067	
Trunk sewers	34,560,549	
Force mains	5,702,463	
Pumping Stations	32,071,099	
Treatment plants	121,862,715	
Ocean outfalls	709,060	
Land Acquisition	1,162,450	
Engineering Service	25,516,695	(10 % of DCC)
Government Administration	3,826,754	(1.5 % of DCC)
Physical Contingency	25,516,695	(10 % of DCC)
<b>Total</b>	<b>311,129,548</b>	

#### (2) Industrial Wastewater Treatment

While one wastewater treatment plant for the industrial zone was included in the sewerage system proposed above, individual treatment by each factory was proposed as an alternative of industrial wastewater treatment. The proposal includes proper treatment process by industry types and cost estimates. A total construction cost in 2010 is estimated at 20,160 million FCFA.

#### (3) On-site System

On-site system was studied from view points of improvement of their sanitation conditions and control of groundwater contamination.

For improvement of sanitation conditions, improvement of toilet facilities are proposed.

For groundwater contamination control, excreta collection, treatment and disposal system was investigated. However, the system was judged not to be feasible because of its large costs estimated at 310,000 million FCFA.

#### (4) Re-use of Treated Wastewater

Reuse of treated wastewater was investigated based on the assumption that the wastewater treated by conventional treatment without any advanced treatments will be used for irrigation and watering.

Two facilities, one is irrigation of farmlands around the Grand Niaye and another is watering of trees along the National highway and in the Mbaou reforestation were proposed. Estimated construction costs are 1,372 million FCFA and 680 million FCFA, respectively.

### 2.3.2 Proposed Wastewater Master Plan

In order to make the sewerage plan (mentioned in (1) of section 2.3.1) sizable to be able to be completed by 2010, several sewerage systems were shifted out based on cost efficiency, progress of development of the area and grade of the existing sewerage system.

Finally, the Camberene sewerage system was proposed as a system for the Master Plan. The proposed Master Plan is illustrated in Figure 2.2 and its components are summarized as below:

Components of the Project	Zones to be done
Construction of sewer networks	Parcelles Assainies, Dakar-Yoff, Hann, Guediawaye, Pikine regular
Construction of trunk sewers	Parcelles Assainies, Dakar-Yoff, Guediawaye, Pikine regular
Expansion of wastewater treatment plant	Camberene wastewater treatment plant
Improvement of collector system	Ouakam

The project cost is estimated as below:

Items	1000 FCFA
Direct Construction Cost (DCC)	83,499,556
Land Acquisition	826,650
Engineering Service	8,349,955 (10 % of DCC)
Government Administration	1,252,497 (1.5 % of DCC)
Physical Contingency	8,349,955 (10 % of DCC)
Total	102,278,613

The priority was identified base on a comparison of their cost effectiveness as below and an implementation schedule is proposed based on project priority:

- Priority 1: Parcelles Assainies zone
- Priority 2: Grand Yoff and Hann zones  
Improvement collector system in Ouakam zone
- Priority 3: Guediawaye and Pikine Regular zones

### 2.3.3 Project Evaluation

The proposed sewerage projects will cover an area of 3,480 ha, which is 20 % of the total study area. The proposed system will collect wastewater for a population of 1,041,328, which is 35.8 % of the total population in 2010 of the study area, and treat 97,200 m<sup>3</sup>/day of wastewater that is equivalent to that for a population of 635,466. This will increase the sewerage coverage rate from 29.9 % to 35.8 % and the treatment rate from 4.2 % to 21.8 %.

Though some extents of negative impacts related to noise and smell conditions near wastewater treatment plants and pumping stations are expected during operation phase, these impacts are considered to be minor compared to prevailing positive impacts by the project.

Following three cases of financial conditions were assumed for the finance projections:

Case 1: 100 % of the initial costs; Governmental subsidy

Case 2: 100 % of the initial costs; Government loan

Case 3: 70 % of the initial costs; Government loan  
30 % of the initial costs; Governmental subsidy

Note: In each case, the operation and maintenance costs are paid by beneficiaries.

From view points of comparison of willingness to pay (24.7% of water charge) and the proposed sewerage charges, and the FIRR's calculated at 6.8% to 7.4%, any of cases is considered to be feasible. However, if possible, it is recommended to apply case 1 for implementation of the projects. Sewerage projects benefit more general public than people who are connected to system by its effects to environmental sanitation improvement. In this context, nature of sewerage projects are, some how, similar to drainage projects. Furthermore, although the proposed sewerage charge is within the people's willingness to pay surveyed, it would be still hard for beneficiaries.

Proposed Average Sewerage Charges

Period	Sewerage Charge
up to 2000	6.1 % of water charge (21.01 FCFA/m <sup>3</sup> )
2001 to 2010	14 % of water charge (48.23 FCFA/m <sup>3</sup> )
2011 on	28 % of water charge (96.46 FCFA/m <sup>3</sup> )

## 2.4 FEASIBILITY STUDY ON THE PRIORITY PROJECT

### 2.4.1 Proposed Priority Project

#### (1) Project Area

The feasibility study area for the wastewater priority project was selected under the Master Plan. The study area is one of the sewerage zones of the Camberene sewerage system.

The zone is divided into 14 subzones taking into account the service areas of the existing pumping stations and development conditions.

#### (2) Population and Wastewater Flow

Population and wastewater flow of the study area at present (1993) and in 2010 projected under the Master Plan are as follows.

Year:	1993	2010
Population:	159,618	260,696
Sewered Population:	51,306	167,237
Connection Ratio (%):	32.1	64.1
Wastewater Flow (m <sup>3</sup> /day):		
Actual (Collected by sewerage):	3,169	23,946
Total (Generated):	11,360	39,383
Peak Flow (Generated):	22,720	78,762

#### (3) Proposed Facility

The proposed facility plan is shown in Figure 2.3. The plan comprises of construction of following components.

- Pumping stations:  
Twelve pumping stations are to be newly constructed or reconstructed.
- Secondary collectors:  
Secondary collectors are defined for preliminary design purpose as those which have contributing service areas of more than 20 ha.
- Wastewater Treatment Plant:  
The capacity of Camberene Wastewater treatment plant is expanded to 30,000 m<sup>3</sup>/day by construction of two additional trains.

### 2.4.2 Project Cost and Implementation Schedule

The construction costs are estimated at 17,410 million FCFA with a break-down as shown below and operation and maintenance costs are estimated at 392 million FCFA annually.

Items	Total FCFA (1000 FCFA)	Local Currency Portion (1000FCFA)	Foreign Currency Portion (1000FCFA)
Direct Construction Cost (DCC)	13,962,706	3,644,865	10,317,841
Sewer Cleasing Equipment	445,000	0	445,000
Land Acquisition	350	350	0
Engineering Service	1,396,271	418,882	977,389
Government Administration	209,441	209,441	0
Physical Contingency	1,396,271	1,396,271	0
<b>Total</b>	<b>17,410,039</b>	<b>5,669,809</b>	<b>11,740,230</b>

Implementation schedule up to the year 2000 has been developed taking into consideration a period required for the necessary preparatory works, such as survey, design and contract process. Yearly project cost is as shown below:

	(1000FCFA)						
	1995	1996	1997	1998	1999	2000	Total
Local Currency Portion	176,739	176,989	934,171	988,102	1,539,939	1,853,869	5,669,809
Foreign Currency Portion	343,252	343,252	2,033,579	2,097,388	2,746,662	4,176,097	11,740,230
<b>Total</b>	<b>519,991</b>	<b>520,241</b>	<b>2,967,750</b>	<b>3,085,490</b>	<b>4,286,601</b>	<b>6,029,966</b>	<b>17,410,039</b>

### 2.4.3 Project Evaluation

The priority project consists of:

- i) Improvement of the present sewerage facilities, such as pumping station system, sewer networks and collectors in Parcelles Assainies areas (414 ha).
- ii) Installation of sewer networks in the unsewered areas (306 ha).
- iii) Expansion of the Camberene WWTP.
- iv) Reconstruction of ocean outfall of the treated water from Camberene WWTP.

Environmental impacts by the project is considered to be negligible compared to the present conditions because most of the facilities will be constructed as replacement or expansion of the existing ones. While some extent of impacts during construction are unavoidable, they would be within limited time and area and can be mitigated by applying proper methods.

From a financial view point, the project will be feasible by increasing sewerage charge within a range of people's willingness to pay.

### **3. URBAN DRAINAGE SYSTEM**

#### **3.1 PRESENT CONDITIONS OF STUDY AREA**

##### **3.1.1 Existing Urban Drainage System**

The study area having a total area of 160.4 sq. km was divided into the following seven sub-drainage areas based on natural conditions.

- A-1: Dakar Urban Area (27.9 km<sup>2</sup>)
- A-2: Grand Yoff and Ouakam Area (6.93 km<sup>2</sup>)
- A-3: Dakar-Yoff Airport and Its Surrounding Area (17.6 km<sup>2</sup>)
- A-4: Yoff-Guediawaye Coastal Area (18.5 km<sup>2</sup>)
- A-5: Grand Niaye Area (15.0 km<sup>2</sup>)
- A-6: Pikine Area (21.0 km<sup>2</sup>)
- A-7: Eastern Pikine Area (53.5 km<sup>2</sup>)

Drainage network in the study area is provided for Dakar urban area, Dakar-Yoff Airport area and a small part of Pikine. Most of the stormwater in Dakar is drained by gravity to the sea except the areas where drainage system is not established or areas drained to Grand Niaye.

In Pikine, stormwater drainage system has maintained its natural shape although runoff characteristics have been changed by urbanization. Most of the stormwater is drained to Grand Niaye, other Niayes, Lacs and the sandy ground. Only small areas along the coast are drained to the sea.

##### **3.1.2 Flood Conditions**

Floods in the study area have been occurring in the rainy season of July, August and September. The recorded largest flood occurred in August 1989. The daily rainfall amount of this storm is recorded to be 113.7 mm and it is estimated to be in a scale of a storm once in 10 years' frequency. The storm caused flood at many places in Dakar and Pikine. Possible causes of these floods have been identified as follows:

- Urbanization took place in low land areas, where stormwater gathered in the rainy season.

- Urbanization increased storm run-off and decreased stormwater infiltration capacity of ground.
- In some areas, drainage systems were not completed.

### 3.2 PLANNING CONDITIONS

#### 3.2.1 Landuse

The land use plan for the year 2010 was applied for urban drainage planning. Planned land use composition of the Study Area is as follows:

Land Use Category	Area (sq. km)
Housing (Village, Spontaneous-irregular)	24.2
Housing (Spontaneous-regular, Planned)	41.3
Housing (Detached house, Flat)	12.1
Equipment (Public Facility)	15.0
Park, Cemetery, Military (Camp)	14.4
Industrial	14.6
Agricultural	24.3
Open Space	3.4
Reforestation	11.1
<b>Total</b>	<b>160.4</b>

Most of the Study Area is expected to be urbanized by 2010 except a part of Grand Niaye, Lacs, reforestation areas, and some part of eastern Pikine.

#### 3.2.2 Design Return Period of Rainfall

The design return period of rainfall for the drainage facilities were applied as follows:

- Five years return period for drainage channels.
- Ten years return period of 24 hours rainfall for pumping stations and retention/infiltration ponds.

### 3.3 URBAN DRAINAGE MASTER PLAN

#### 3.3.1 General

Stormwater drainage system of the study area is proposed based on the following concepts:

- Target year of this proposed drainage improvement plan is 2010.
- Drainage sub-areas shall be decided mainly based on natural topography, in order to save cost of construction and operation/maintenance.



- Stormwater shall be infiltrated as much as possible as a groundwater source.
- Natural gravity flow drainage shall be applied to the maximum extent and pumping drainage shall be minimized.
- Each drainage sub-area shall have an outlet. Existing wet lands such as Niayes, Lacs, inland depressed areas and the Marigot will be used as the receiving bodies.
- Drainage channel crossing large roads should be avoided in principle.
- The concrete facility plans are considered as structural measures for the areas which had inundation problem in 1989 flood. For sandy areas with high ground elevation (say more than 5m), non-structural measures such as infiltration, land use regulation of depressed areas, etc. should be applied.

### 3.3.2 Proposed Master Plan

The proposed master plan is shown in Figure 3.1 and consists of sub-projects in the areas of Dakar IV-3, Ouakam Basin, Grand Yoff, Dakar-Yoff Airport, Yoff Channel, Central Pikine and Lac 1 catchment areas. The stormwater drainage facilities to be provided in the master plan stage are the drainage channels, pumping stations and infiltration/retention ponds.

In addition to the facility plan shown in the figure, Master Plan proposes non-structural measures that facilitates infiltration and storage of stormwater.

The project costs were estimated at 24,143 million as shown below:

Items	1000 FCFA	
Direct Construction Cost (DCC)	18,985,922	
Pumping Cars	500,000	
Land Acquisition	881,100	
Engineering Service	1,329,015	(7 % of DCC)
Government Administration	298,005	(1.5 % of DCC)
Physical Contingency	2,149,404	(10 % of DCC)
<b>Total</b>	<b>24,143,447</b>	

Priority of the sub-projects was proposed taking the following factors into account:

- Present severeness of flooding
- Anticipated flood problems in the future due to urbanization
- Required cost of drainage and efficiency of the sub-project
- Difficulty of solution if the sub-project is not conducted
- Progress of the sub-project such as study, design, etc.

### 3.3.3 Project Evaluation

The proposed urban drainage Master Plan covers entire study area either by structural measures or by non-structural measures. Under this plan, all the flood areas, flooded by the 1989 August flood, will be protected from inundation against the same level of rainfall.

The plan has identified developing activities that do not concern topographic conditions as a major cause of inundation problems. Therefore, non-structural measures, such as to reserve low lands for infiltration for development in future, are strongly recommended while structural measures are proposed for the areas where urbanization has already occurred or expected to occur soon.

Negative impacts of the project are expected to occur during construction of the proposed facilities. However, these are expected to be small because the facilities are small in scale.

Economic evaluation is conducted by calculating the economic internal rate of return (EIRR) based on economic costs and the economic benefits of the project.

As a result, EIRR of 8.7 % is obtained. While this value is by 1.3 points lower than OCC of 10 % that is generally accepted in developing countries, the project is judged to be economically feasible because of following reasons:

- Drainage project are of public projects and relates to human basic needs. Thus it is not necessary to stick on the OCC too much, because the drainage project is of a public project.
- Only direct flood damage has been counted in this analysis. Therefore, if indirect flood damage is added to the benefits, EIRR may approach or exceed 10 %.

## 3.4 FEASIBILITY STUDY ON THE PRIORITY PROJECT

### 3.4.1 PROPOSED PRIORITY PROJECT

#### (1) Project area

The feasibility study area covers the Central Pikine (C.P.) recommended by the Master Plan as the first priority area and a part of its surroundings. Total area for the feasibility study covers an area of 11.3 sq. km. Through the discussion between the Senegalese side and the study team, the drainage channel proposed along the National Road, a part

of main channels of the proposed pump drainage system, was included because of on-going development in its catchment area.

## (2) Pump Drainage System

The area to be drained by pump is divided into two areas, Pikine (C.P.1-1 and C.P.1-2) and Thiaroye (C.P.2) and pump drainage system for the two areas are proposed as shown in Figures 3.2 and 3.3, respectively. Its main features are shown in Table 3.1.

## (3) Non-structural Measures

For the areas mentioned above, no particular structural measures are proposed, but the following non-structural measures are recommended from view point of urban drainage:

- Depressed areas in every independent catchment should be kept for infiltration/retention and on-site infiltration should be applied as much as possible.
- There are small scale possible flood areas in Pikine irregular area, having ground elevation of less than 4 m, in the north of the proposed pump drainage area. These areas should be reclaimed for easy infiltration when the areas are redeveloped.
- Wide low laying area is spread along the Rufisque Road and areas lower than 2 m and 1m in north and south of the road respectively are flood prone. These areas should be reclaimed if developed.
- A depressed area located at the northern edge of Central Pikine is an important place for drainage and should not be urbanized.

### 3.4.2 Project Cost and Implementation Schedule

The construction costs are estimated at 10,748 million FCFA with following break down and operation and maintenance costs are estimated at 270 million FCFA.

Item	Total FCFA (1000 FCFA)	Local Currency Portion (1000FCFA)	Foreign Currency Portion (1000FCFA)
Direct Construction Cost (DCC)	8,686,730	3,235,077	5,451,653
Land Acquisition	250,800	250,800	0
Engineering Service	608,071	182,421	425,650
Government Administration	134,063	134,063	0
Physical Contingency	967,966	967,966	0
<b>Total</b>	<b>10,647,630</b>	<b>4,770,327</b>	<b>5,877,303</b>

The project is proposed to be started from 1995 and completed in 2004 with a period of 10 years, while only installation of the secondary networks will be carried out after 2000. Yearly project cost is as shown below:

	Local Currency Portion (1000FCFA)	Foreign Currency Portion (1000FCFA)	Total FCFA (1000 FCFA)
1995	69,494	121,614	191,108
1996	162,833	121,614	284,447
1997	904,917	1,982,306	2,887,223
1998	1,458,636	2,173,964	3,632,600
1999	938,593	475,489	1,414,083
2000	247,171	200,463	447,634
2001	247,171	200,463	447,634
2002	247,171	200,463	447,634
2003	247,171	200,463	447,634
2004	247,171	200,463	447,634
Total	4,770,328	5,877,303	10,647,630

### 3.4.3 Project Evaluation

The proposed urban drainage project for Central Pikine area is evaluated as follows:

The project is technically sound without any difficulty in construction, and no serious problem is expected in drainage function of the facilities and in operation/maintenance.

Negative impacts to noise/vibration conditions and traffic in the vicinity of construction sites would be unavoidable during the construction phase. However, any of such impacts would be limited to short time and to small areas. Although construction of pumping stations and retention ponds may require land acquisition, since sites for these facilities have been selected in wet lands, residential areas discarded due to repeated inundation and vacant place in public facilities, any particular problems are not foreseen.

Economic evaluation is carried out based on the economic costs and economic benefits by applying the same method as the Master Plan Study. The results are as follows:

Net Present Value (NPV):	430 million FCFA
Benefit Cost Ratio (B/C)	1.07
Economic Internal Return Rate (EIRR):	10.8 %

## 4. RECOMMENDATION

### 4.1 RECOMMENDATION RELATED TO WASTEWATER SYSTEM

- The Sewerage Master Plan was proposed by shifting out several project components from the Sewerage Development Plan that covered the whole study area, because of budget constraint. The proposed Sewerage Master Plan is considered to have the essential components to satisfy the minimum requirements to improve the present sewerage conditions of the area and to ensure further development following the shifted out project components. Therefore, it is recommended to implement the projects according to the proposed Master Plan as early as possible. In this regard, political decision to provide special financial supports to the projects are strongly required.
- It is desired to review this master plan when the projects in the plan proceed to some extent to cope with areas not included in this master plan.
- Either by re-organization of SONEES or by creation of a new organization, one organization should take responsibilities for planning and execution of the projects, operation and maintenance of the facilities and management of organization and finance of sewerage system, as SONEES is presently doing in the water supply system. The Ministry of Hydraulics, which is presently responsible for the projects execution, should be involved in the system as an governmental authority to give approval to each activity.
- Efforts to improve present conditions existing in the Study Area, especially to increase wastewater flow to the Camberene WWTP by promoting house connections in the existing sewered areas, should be continued. Provision of installment would help these efforts.
- Though industrial wastewater was recognized as one of major pollutant sources, sewerage system for industrial zones were shifted out from the Master Plan. This is because that industrial wastewater was judged to be treated either by individual treatment or by treatment plant to be constructed and operated by such industries. Therefore, it is recommended that the government apply regulations for wastewater discharges to encourage this direction.
- Improvement of toilet facilities of on-site system should be encouraged to mitigate the sanitary problems of the area, in particular bacteriological contamination of shallow well water.

- Substitution of Thiaroye water supply source by other water sources would be essential to avoid supplying water with high concentrations of nitrate nitrogen. In this regard, earlier implementation of the Cayor Canal project is strongly recommended.
- Reuse of raw sewage from the Niaye WWTP for agricultural purpose should be ceased as soon as possible.
- The coordination and cooperation among the Ministries and other organizations concerned are prerequisites if the sewerage construction project and operation & maintenance of the sewerage facilities are to be successfully conducted. In this connection establishment of the Coordination Committee is recommended.

#### **4.2 RECOMMENDATION RELATED TO URBAN DRAINAGE SYSTEM**

Immediate construction of the facilities is recommended in consideration of serious flood problem.

The following non-structural measures are also recommended to support the proposed structural measures and to achieve successful drainage of the project area.

- Drainage of all areas having elevation of higher than 4 m should be done by infiltration, in principle. The depressed area in each closed catchment area, except the proposed pump drainage areas, should be kept for infiltration/retention, and on-site infiltration should be applied in high areas.
- In relation to the Technopole development, an open channel for drainage of a part of Pikine urban and Technopole project areas into Grand Niaye should be provided. Excavated soils during construction of the channel can be used for reclamation of the Technopole area.
- There have small scale flood prone areas in Pikine irregular area located in the north of the pump drainage area. These areas should be slightly reclaimed for easy infiltration when the areas will be redeveloped.
- Areas with elevation of less than 2 m and 1 m in north and south of Rufisque Road respectively are flood prone. These areas, except the proposed retention pond areas, should be reclaimed if developed.
- A depressed area located at the northern edge of the project area is an important land for drainage and should not be urbanized.

- Operation and maintenance of the proposed drainage facilities will be done by the Community of Dakar and SONEES. A part of the work is recommended to be done under participation of the residents in the flood prone areas who are the direct beneficiaries of the project. Such work items are as follows:
  - Maintenance work of the drainage channels in the flood prone areas such as cleaning of the channels before rainy season, preventive activities to keep the channels clean, etc.
  - Management of the retention ponds by the farmers who have agricultural activities in the pond areas.

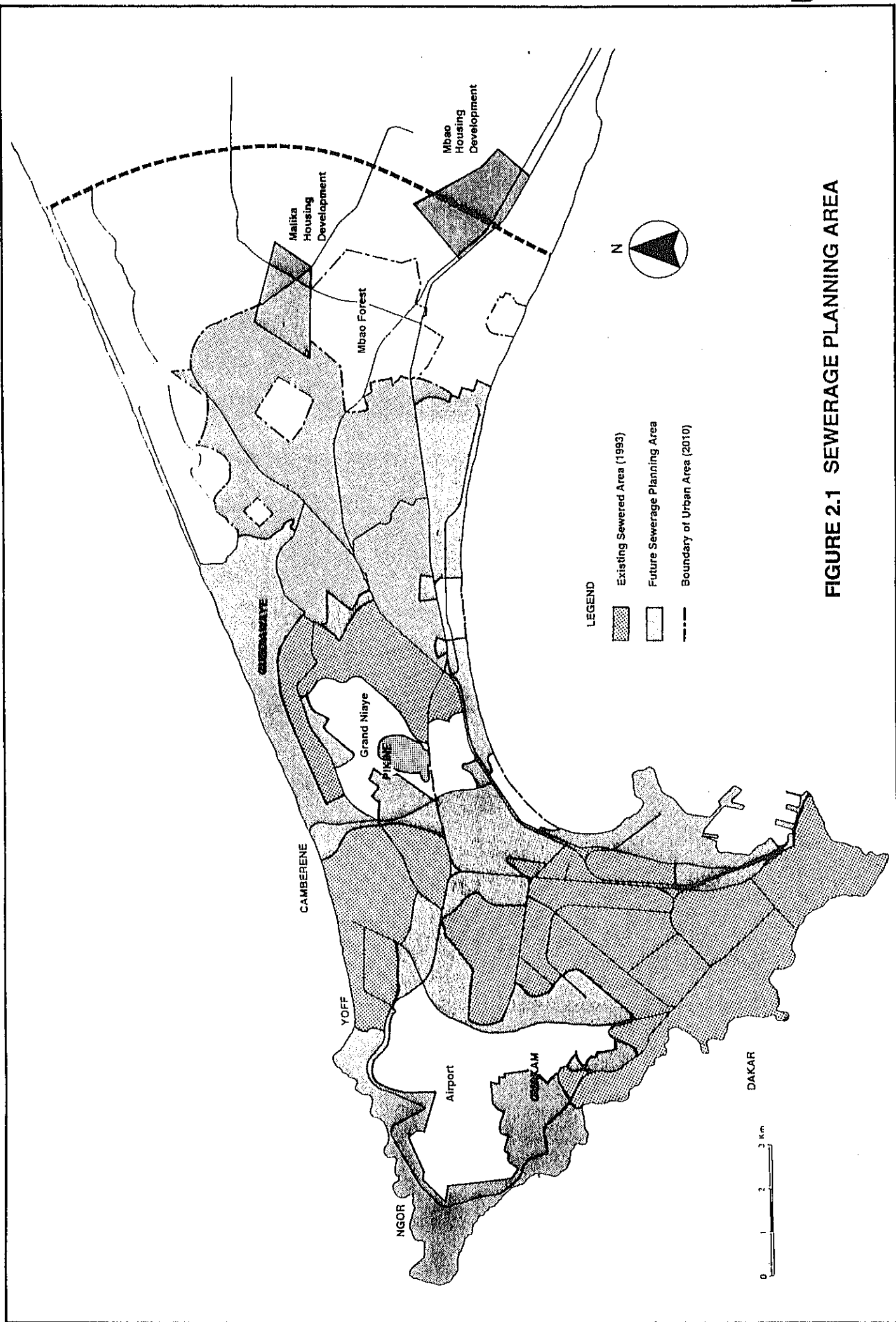
**TABLE 3.1 SUMMARY OF PROPOSED FACILITY**

Area	Proposed Facilities	Total
CP 1	Drain to Grand Nlaye	
	Construction of Storm Sewer	2 Systems Total L= 4,460 m
	C.P.1-1	(L=2,970m)
	d=1,100mm CP	(250m)
	d=1,000mm CP	(1,050m)
	d=900mm CP	(620m)
	d=800mm CP	(1,050m)
	C.P.1-2	(L=1,490m)
	d=1,100mm CP	(260m)
	d=1,000mm CP	(550m)
	d=600mm CP	(680m)
	Construction of poen channel (2m x 0.4 - 0.6m, 1)	2 Systems Total L = 400m
	C.P.1-1	(100 m)
	C.P.1-2	(300 m)
	Stormwater Pumping Station	2 Systems Total 7 pls
	C.P.1-1 (1.0 m <sup>3</sup> /s 2pls, 0.3 m <sup>3</sup> /s 1pls)	3 pls
	C.P.1-2 (1.5 m <sup>3</sup> /s , 1.0 m <sup>3</sup> /s, 0.5m <sup>3</sup> /s, 0.3m <sup>3</sup> /s)	4 pls
	Stormwater Transmission Pipe (Ductile Iron Pipe)	2 Systems Total L= 2,630m
	C.P. 1-1	(L=690m)
	d=600mm DCIP	(420m)
	d=800mm DCIP	(270m)
	C.P. 1-2	(L=1,940m)
	d=600mmDCIP	(570m)
	d=1100mm DCIP	(920m)
	d=801mm DCIP	(450m)
CP 2	Drain to Sea	
	Construction of main Drainage Channel (1-3m x 0.4-1.6m, 1)	L = 2,940 m
	Improvement of Existing Drainage Channel (3m x 0.9m, 1)	L= 770 m
	Stormwater Pumping Station (1.5 m <sup>3</sup> /s)	1 Place
	Retention Pond	Total 5 .1ha

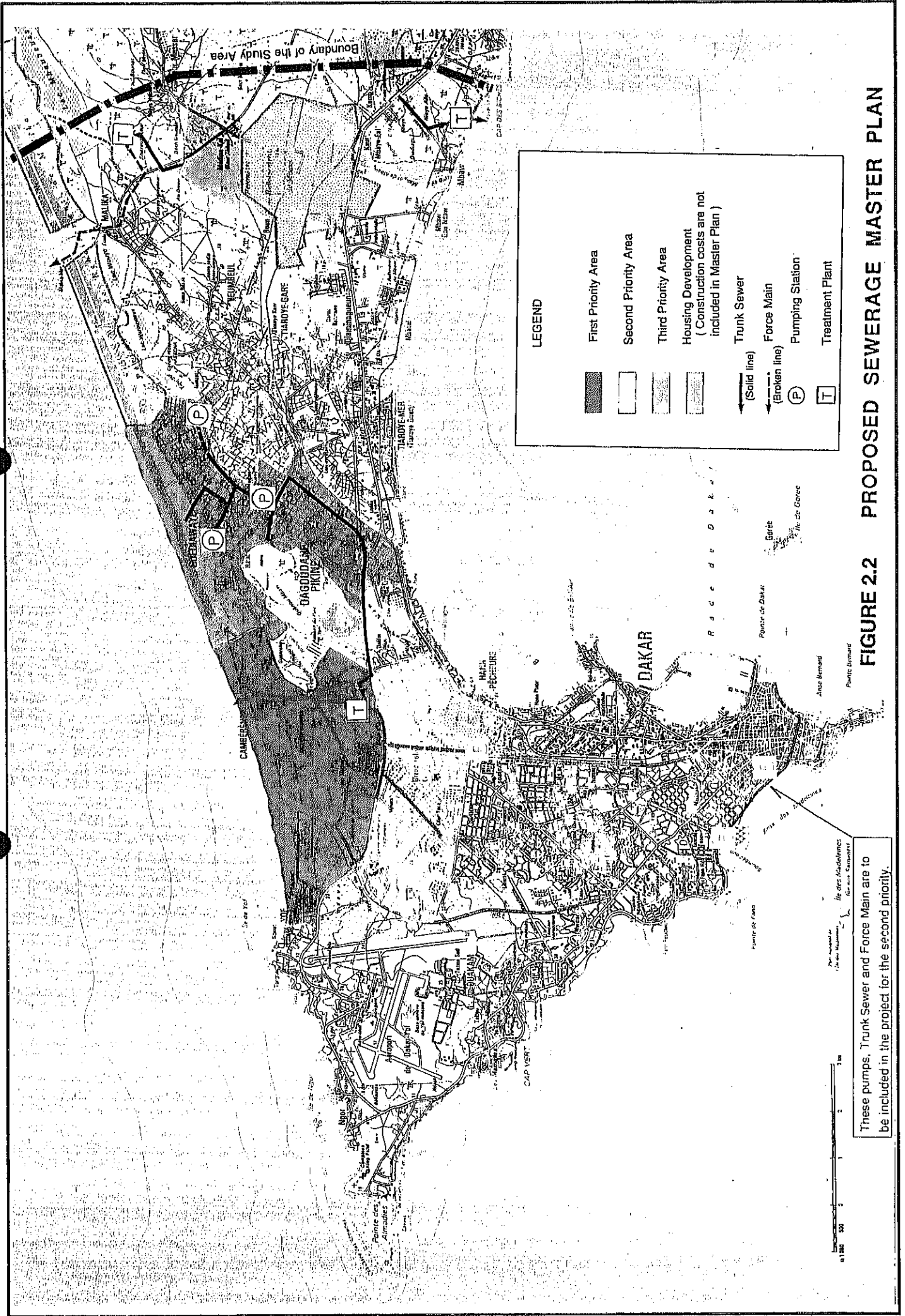




FIGURE 1.1 STUDY AREA



**FIGURE 2.1 SEWERAGE PLANNING AREA**



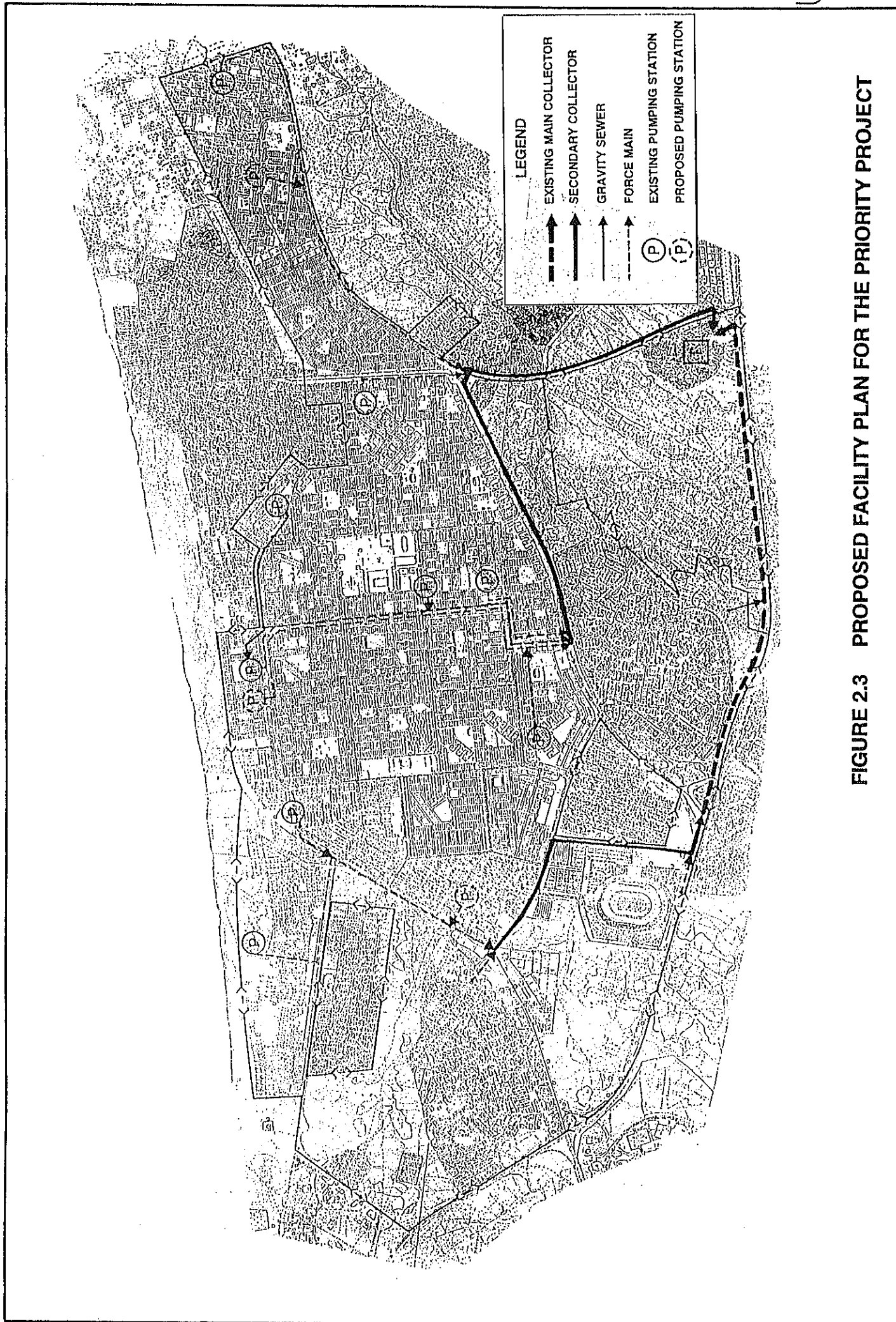


FIGURE 2.3 PROPOSED FACILITY PLAN FOR THE PRIORITY PROJECT



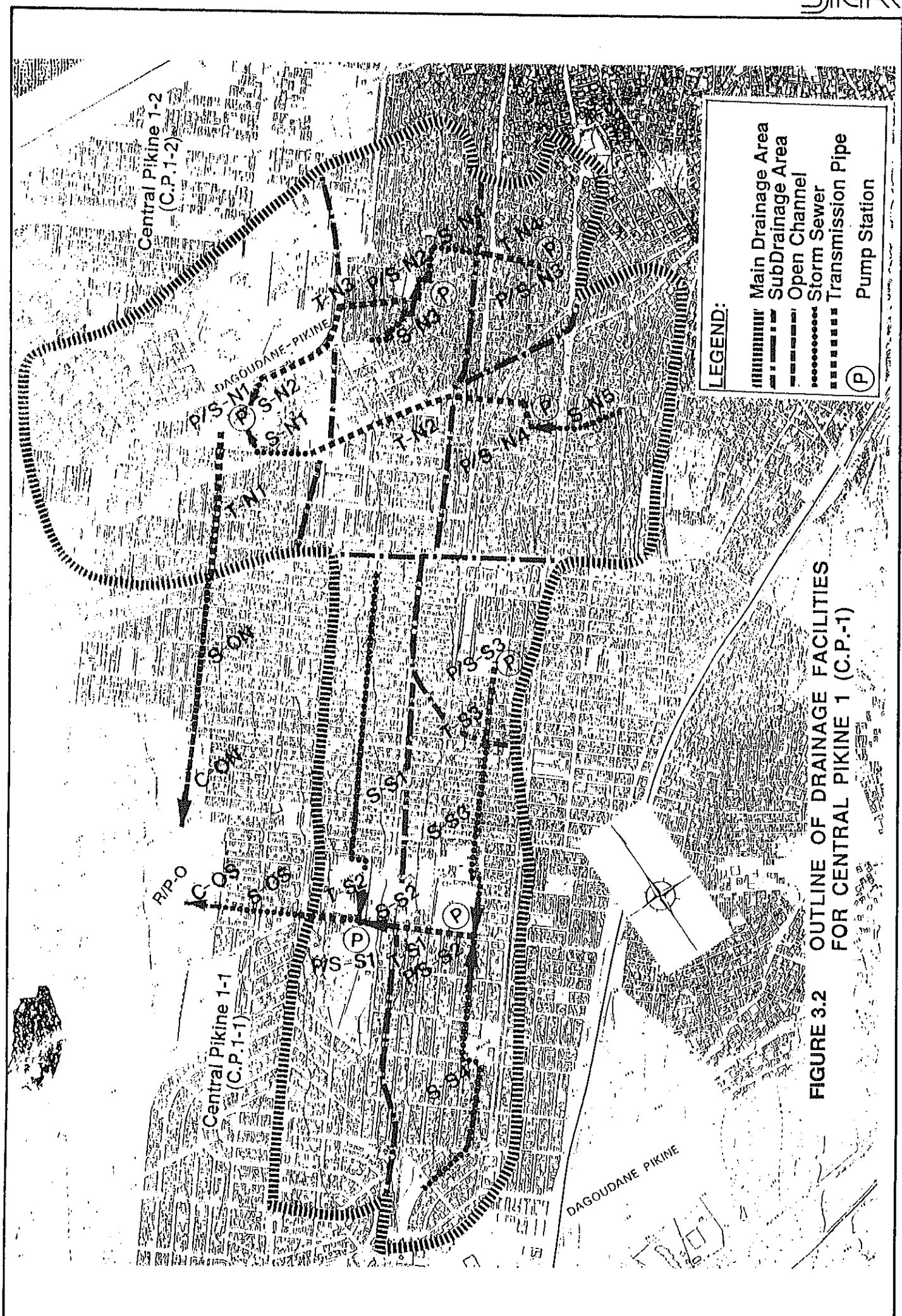
This drawing presents the structural measures proposed in the drainage master plan. The master plan also proposes non-structural measures that facilitate the infiltration and storage of stormwater, such as:

- i) to protect Grand Niaye from further urbanization,
- ii) to secure lands for the infiltration/storage of stormwater in future development plans,
- iii) to encourage the infiltration of stormwater inside private and public premises.

**LEGEND**

<b>1st Priority</b>	— : Drainage Channel / Storm Sewer
	(P) : Stormwater Pumping Station
	(S) : Infiltration / Retention Pond
<b>2nd Priority</b>	— : Drainage Channel
	(S) : Infiltration Pond
<b>3rd Priority</b>	--- : Drainage Channel
	(S) : Infiltration Pond

**FIGURE 3.1 PROPOSED DRAINAGE MASTER PLAN**



**LEGEND:**

- Main Drainage Area
- Sub Drainage Area
- Open Channel
- Storm Sewer
- Transmission Pipe
- Pump Station

**FIGURE 3.2 OUTLINE OF DRAINAGE FACILITIES FOR CENTRAL PIKINE 1 (C.P.-1)**



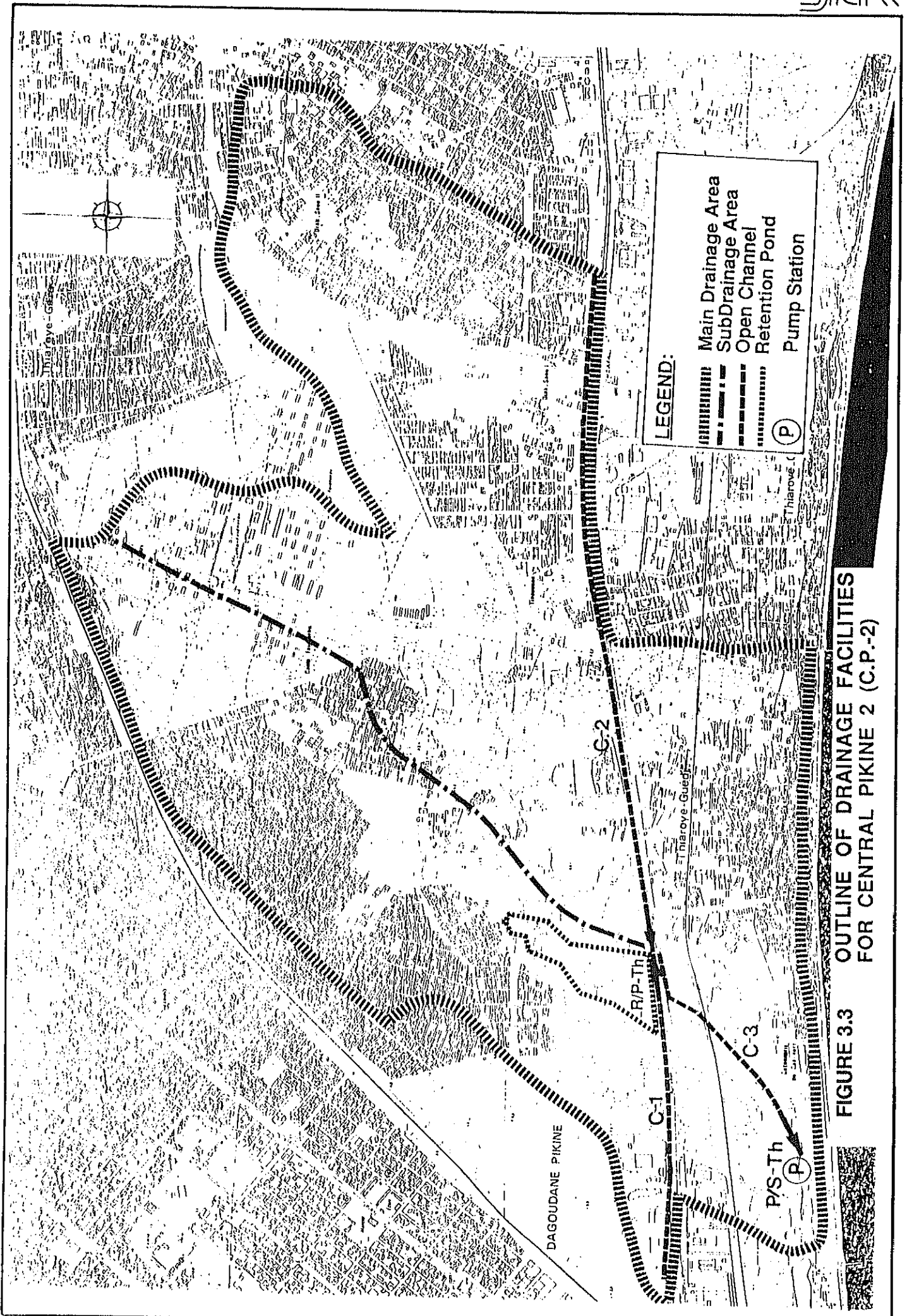


FIGURE 3.3 OUTLINE OF DRAINAGE FACILITIES FOR CENTRAL PIKINE 2 (C.P.-2)





JICA