JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF HOUSING AND CITY PLANNING
REPUBLIC OF COTE D'IVOIRE

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

FINAL REPORT
MAIN REPORT

JANUARY 2000

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO
TOKYO ENGINEERING CONSULTANTS, TOKYO

The cost estimate is made based on the average market rate between March and August, 1999. The rate of local currency, FCFA to Jp Yen is as follows:

1 FCFA = 0.195 Jp Yen

FCFA is fixed rate to French Franc, FF as follows:

100 FCFA = 1 FF

PREFACE

In response to a request from the Government of the Republic of Côte d'Ivoire, the Government of Japan decided to conduct the Feasibility Study on Sewerage Facilities in Western District of Abidjan City in the Republic of Côte d'Ivoire and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Yoshiaki Kaneko, Pacific Consultants International (PCI) and composed of staff members of PCI and Tokyo Engineering Consultants Co., Ltd. to the Republic of Côte d'Ivoire, two times between March 1999 and December 1999. In addition, JICA set up an advisory committee headed by Mr. Ichiro SETO, Japan Sewer Optical Fiber Technological Association, between March 1999 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 the Republic of Côte d'Ivoire, 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 the Republic of Côte d'Ivoire for their close cooperation extended to the team.

January 2000

Kimio Fujita
President
Japan International Cooperation Agency

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

January 2000

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

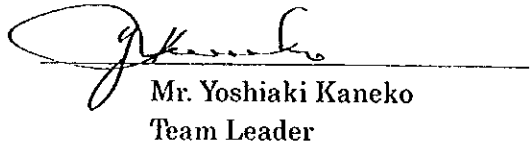
We are pleased to submit to you the final report entitled " The Feasibility Study on Sewerage Facilities in Western District of Abidjan City in the Republic of Côte d'Ivoire ". This report has been prepared by the Study Team in accordance with the contract signed on 11 March 1999 between the Japan International Cooperation Agency and the Joint Study Team of Pacific Consultants International and Tokyo Engineering Consultants.

The report examines the existing conditions of sewerage and urban drainage in the area of Yopougon, reviews a master plan of sewerage plan and presents the results of a feasibility study on sewerage facilities for the priority areas.

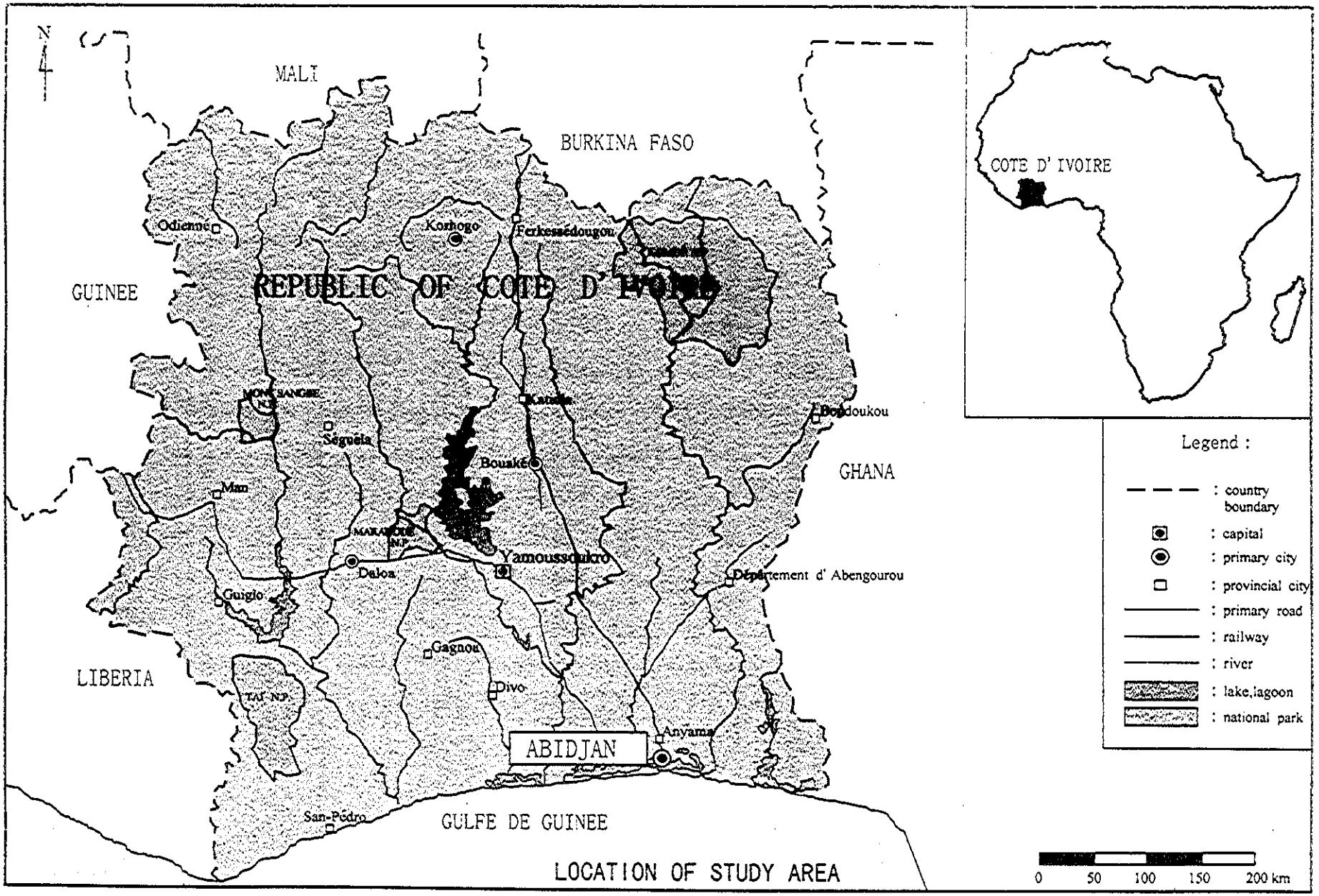
The report consists of the Executive Summary, Main Report, and Supporting Report. The Executive Summary summarizes the results of all studies. The Main Report contains background conditions, results of the feasibility studies, and conclusions and recommendations. The Supporting Report includes technical details of contents of the Main Report.

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 Côte d'Ivoire, and also to Ivorian officials and individuals for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the implementation of sewerage facilities in Abidjan, and that friendly relations of both countries will be promoted further by this occasion.

Yours faithfully,



Mr. Yoshiaki Kaneko
Team Leader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Bouaké
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Divo
Anyama
ABIDJAN
San-Pédro
Département d' Abengourou
TAI N.P.
COTE D' IVOIRE
Legend :
: country boundary
: capital
: primary city
: provincial city
: primary road
: railway
: river
: lake,lagoon
: national park
0 50 100 150 200 km
LOCATION OF STUDY AREA

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ABREVIATION

ADB	African Development Bank (BAD en Français)
ANDE	National Agency for Environment Agence Nationale de l'Environnement
BAD	Banque Africaine de Développement (ADB in English)
BCEAO	Banque Centrale des Etats de l'Afrique de l'Ouest
BIRD	Banque Internationale pour la Reconstruction et le Développement (IBRD in English)
BM	Banque Mondiale (WB in Englich)
BNETD	Bureau National d'Etudes Techniques et de Developpement
BOD_5	Biochemical Oxygen Demand (DBO_5 en Français)
BOT	Build-Operate-Transfer (COT en Français)
COT	Construire-Opérer-Transférer (BOT in English)
CARENA	Compagnie Abidjanaise de Réparation Navale et de Travaux
CEDEAO	Communauté Economique d'Etats de l'Afrique de l'Ouest Economic Community of the Western African Countries
CEE	Communauté Economique Européene (EEC in English)
CFA	Communauté Financière Africaine
CIAPOL	Centre Ivoirien d'Anti-Pollution
COD	Chemical Oxygen Demand (DCO en Français)
CRO	Centre de Recherches Océanologiques
DAUC	Département Aménagement Urbain et Construction
DBO_5	Demande en Oxygène Biochimique (BOD in English)

DCI	Ductile Cast-Iron
	Une Fonte Nodulaire
DCO	Demande en Oxygène Chimique
	(COD in English)
DDT	Dichlorodiphenyltrichloroethane
	Dichloro-Diphényl Trichloroéthane
DSR	Debt Service Ratio
	Ratio de Service de la Dette
DTT	Département Transports et Télécommunications
	Transport and Telecommunication Department
EEC	European Economic Community
	(CEE en Français)
EIA	Environmental Impact Assessment
	Evaluation de l'Impact sur l'Environnement
EU	European Union
	(UE en Français)
F/S	Feasibility Study
	Etude de Faisabilité
FCD	Ferrum Casting Ductile
	Fonte Nodulaire Ferreuse
FIRR	Financial Internal Rate of Return
	Taux de Rentabilité Interne Financier
FMI	Fonds Mpnétaire International
	(IMF in English)
FNE	Fonds National de l'Eau
FOB	Free-on-Board
	Livré à Bord
GDP	Gross Domestic Product
	(PIB en Français)
HHWL	Higher High Water Level
	Niveau d'Eau plus Elevé
IBRD	International Bank for Reconstruction and Development - World Bank
	(BIRD en Français)

IMF	International Monetary Fund
	(FMI en Français)
INS	Institut National de Statistique
JICA	Japan International Cooperation Agency
	Agence Japonaise de Coopération Internationale
LANEMA	Laboratoire National d'Essais de Qualité, de Métrologie et d'Analyses
M/P	Master Plan
	(P/D en Français)
MACA	Maison d'Arrêt et de Correction d'Abidjan
M&E	Machine and Electric
	Machine et Electricité
MINEF	Ministère de l'Environnement et de la Forêt
MES	Matières en suspension
	(SS in English)
MIE	Ministère des Infrastructures Economiques
MLU	Ministère du Logement et de l'Urbanisme
MOS	Mode d'Occupation de Sol
NPV	Net Present Value
	Valeur Actuelle Nette
OMS	Oraganisation Mondiale de la Santé
P/D	Plan Directeur
	(M/P in English)
PAA	Port Autonone d'Abidjan
PCB	Polychlorobiphenyl
	Polychlorobiphényle
PDA	Perspectives Décennales d'Abidjan
PIB	Produit Intérieur Brut
	(GDP in English)
PNUD	Programme des Nations Unie pour le Développement
PLAD	Pipe Line Arch-Drilling
	Perçage en arc pour la Canalisation
P/S	Pumping Station
	Station de Pompage

PVC	Polyvinyl Chloride
	Chlorure de Polyvinyle
RC	Reinforced Concrete
	Béton Armé
S/W	Scope of Work
	Etendue des Travaux
SETU	Société d'Equipement des Terrains Urbains
SIIC	Service de l'Inspection des Installations Classées
SODECI	Société de Distribution d'Eau de la Côte d'Ivoire
SODEXAM	Société d'Exploitation et de Développement Aeroportuaire Aéronautique et Météorologique
SPT	Standard Penetration Test
	Test de Pénétration Standard
SS	Suspended Solids
	(MES en Français)
SSPL	Supported Seabed Pipe-Laying
	Pose de Tuyaux Soutenus sur le Fond Marin
T/S	Trunk Sewer
	Collecteur Primaire
T-N	Total Nitrogen
	Azote Total
T.O.R.	Terms of References
	Termes de Référence
T-P	Total Phosphorus
	Phosphore Total
UEMOA	Union Economique et Monetaire de l'Afrique de l'Ouest
	West African Economic and Monetary Union
UE	Union Européenne
	(EU in English)
UNDP	United Nations Development Program
	(PNUD en Français)
UNIDO	United Nations Industrial Development Organization
	Organisation des Nations Unies pour le Développement Industriel

USEPA	United States Environmental Protection Agency
	Agence Américaine pour la Protection de l'Environnement
WB	World Bank
	(BM in French)
WHO	World Health Organization
	(OMS en Français)

UNIT

FCFA:	Currency unit in Côte d'Ivoire
	1 FCFA ≈ 0.195 Jpn Yen, average between March and August, 1999
	100 FCFA = 1 FF (French Franc); Fix rate

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background

Abidjan City, the center of economic and political activities in Cote d'Ivoire, has been undergoing remarkable development since independence of the country. Population of the City has increased from 120 thousand in 1955 to 3.5 million at present.

However, infrastructure has not been properly developed to cope with the problems caused by rapid industrialization and urbanization, and most of the domestic and industrial wastewater has been directly discharged into the lagoons without treatment.

As a result, the lagoon of closed water area is affected resulting in serious environmental problems such as sedimentation of organic mud in the Lagoon, degradation of water quality and odor nuisance.

In order to cope with these problems, the Sewerage Master Plan of Abidjan City was formulated by WHO in 1971 and a Feasibility Study was carried out by UNDP in 1974.

Based on these studies, trunk sewers of 18 km length in the central part of the City were constructed from 1975 as Phase I by World Bank finance, followed by sewers of 69 km length in 1985 as Phase II, based on the reviewed Sewerage Master Plan. In 1995, the Phase III project was executed including the construction of a wastewater pre-treatment plant and the installation of ocean outfall pipes in the sea for a service population of three million. Under these projects, wastewater discharged from the north, central and south districts of the City is collected by a central trunk sewer and discharged into the Sea after pre-treatment.

While, wastewater discharged from the western district having a newly developed housing area and industrial zone is directly discharged into the Ebrie lagoon through the existing sewers and storm water drains.

The population of this district has rapidly increased from about 450 thousand in 1988 to

about 700 thousand in 1998 and the degradation of water quality of the lagoon has become more and more serious.

Under such a situation, the Government of Cote d'Ivoire made an official request to conduct a sewerage development study for the Western area of the City.

Responding to the request, the Government of Japan dispatched the Preparatory Study Team in October 1998 to discuss the Scope of Work for the full-scale Study. Both sides reached an agreement for this Study to be conducted by Japanese consultants.

1.2 Purpose of Feasibility Study

The Study is targeted at the following components to improve the environmental and hygienic conditions of the area of Yopougon and Attécoubé:

(1) To conduct a Feasibility Study for sewerage facilities in the area of Yopougon and Attécoubé, and

(2) To conduct a technical transfer to the Ivorian counterpart personnel in the course of the Study.

The wastewater to be targeted at will be domestic wastewater, nightsoil and industrial wastewater.

The existing sewerage plan will be reviewed taking into account all the aspects related to the Study such as urban and industrial developments up to the target year 2003.

1.3 Study Area

The Study Area will be divided to six (6) major sewerage districts; 1-2-3 A/B, UNIWAX, 21-22, 25-26-27, 33-34, and 35-36 sewerage basins.

The population growth rate is as high as 5.4 %, and is considered to be by and large at this

level in the near future.

Based on this projection, the total population of the Study Area will be about 904 thousand in the target year 2003.
The total Study Area is estimated to be about 78 km^2, with a total population of about 904 thousand, resulting in an average population density of 116 persons per ha.

The area and population is summarized as follows:

TABLE 1.1 AREA AND POPULATION OF THE STUDY AREA IN 2003

Study Area	Area (ha)	Population (in thousands)	Remarks
Yopougon	7,200	756	study area
Attécoubé (west)	610	147	study area
Study Area Total	7,810	904	
Attécoubé (east)	250	180	remaining area of Attécoubé

1.4 Study Organization

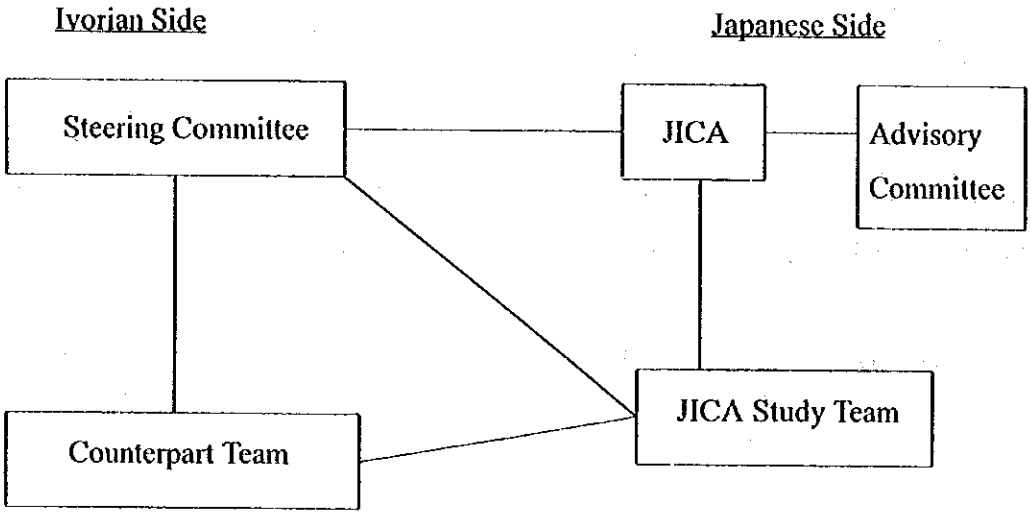
The preliminary Study Team reached the agreement of S/W to conduct the Study in November 1998. The full-scale Study Team was selected in March 1999 by JICA. The counterpart organization of the Ivorian Government is Ministère du Longement et de l'Urbanisme (MLU).

The Japan International Cooperation Agency (JICA) has the overall responsibility for the Study, assisted by the Advisory Committee. The Committee is basically responsible for the technical aspects and is to give advice to JICA as required.

MLU has organized the Steering Committee including MLU as the prime counterpart organization, Ministère de l'Environment et de la Forêt, Bureau National d'Etudes

Techniques et de Developpement (BNETD), Société de Distribution d'Eau de la Côte d'Ivoire (SODECI), Ministère des Infrastructures Economiques, Ministère de l'Interieur et de la Decentralisation, Ministère de la Santé, Commune de Yopougon and Commune d'Attécoubé. The Steering Committee is the major committee of the Ivorian Government, in which the Study's major findings are to be reported and the decisions are to be made for essential matters like land acquisition.

The Study has been jointly conducted by both the JICA Study Team and the Ivorian counterpart team in close consultation with the Steering Committee as well as with the JICA Advisory Committee. The study organization is shown below:



In Japan the Advisory Committee is held at the essential timing as departure and return of the Study Team to be reported to and give guidance through JICA.

1.5 Study Reports

All the reports to be produced in the course of the Study are as follows:

- Inception Report to be submitted in April 1999
- Interim Report to be submitted in July 1999
- Draft Final Report to be submitted in October 1999
- Final Report to be submitted January 2000

The Final Report will be completed in Japan one month after the Study Team receives comments made by the Ivorian Side concerning the Draft Final Report.

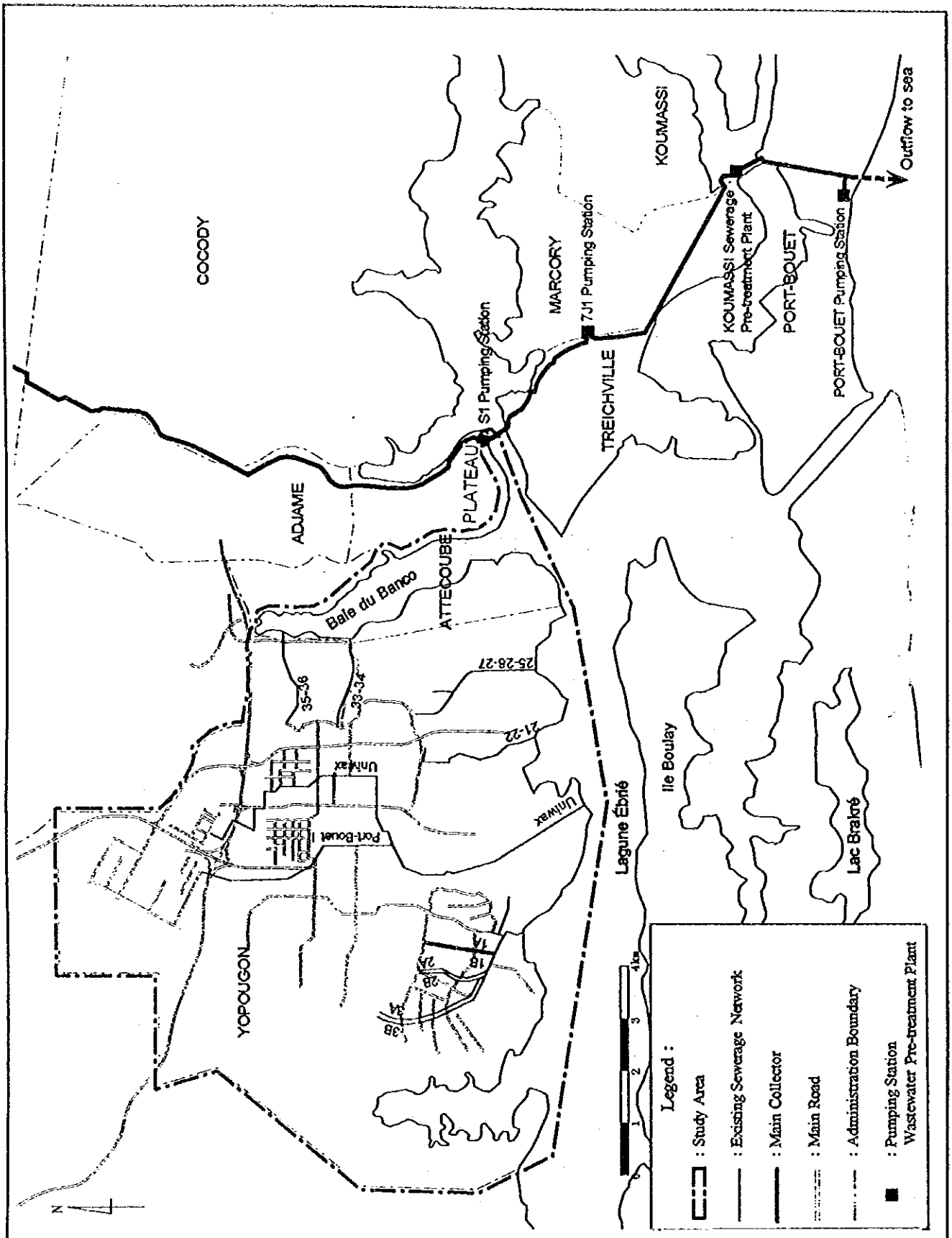


FIG. 1.1 STUDY AREA

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

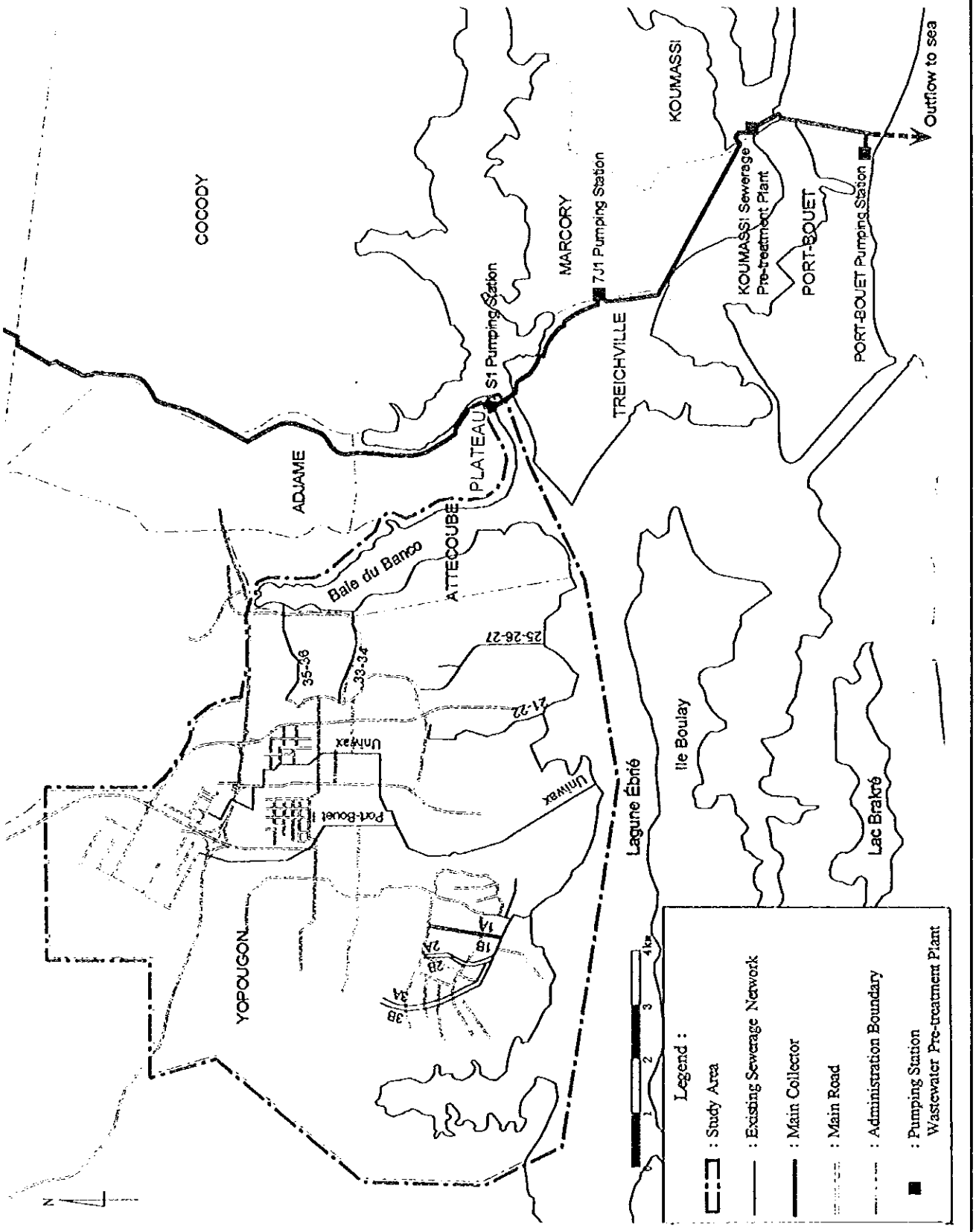


FIG. 1.1 STUDY AREA

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

CHAPTER 2

EXISTING CONDITIONS

CHAPTER 2 EXISTING CONDITIONS

2.1 Natural Conditions

2.1.1 Topography and Geology

Topography of Abidjan City is generally divided into three types as follows:
First, the flat land called "Le Cordon Littoral" which spreads out along the southern coast of West Africa for hundreds of kilometers. This land is composed of marine sand and alluvial deposits from a continental source.

Second, the islands which are scattered in the Ebrié Lagoon. This lagoon is over 120 km long in the east and west sides of Abidjan City.

Third, the Continental Plateaus, which lie on the northern side of the lagoon. These plateaus are sometimes cut by the bays which penetrate deep into the inner land of the plateaus.

In Abidjan, there is the Plateau of Banco, the Plateau of Cocody and the Plateau of the Riviera. The elevation of these plateaus is about 40 m to 50 m.

These plateaus are divided by rivers or valleys and have very gentle slopes to the south. The southern ends of the plateaus are sometimes bluff and cut by a steep slope valley.

The Study Area comprises Commune de Yopougon and a part of Commune de Attécoubé. The Area is surrounded by the Park of Banco and the Forest of Langeudedou in the north, and the Ebrié lagoon in the south. Banco Bay and the Gbangbo River are located in the east and west.

The Area is mostly flat terrain having high plateaus with elevations of 20 m to 50 m except in the area near the bay and lagoon.

The basement of the Area is composed of schist of the Pre-Cambrian Period. The upper stratum is composed of Cretaceous, Tertiary and Quaternary deposits. Surface soils of the

Area consist mainly of sandy soils. The stratigraphy and geological profile of Abidjan are shown in Fig. 2.1.

Soils of the high plateau consists mainly of compacted sandy soils (Ib2-IIb). Loose sandy soils are observed in low ground (Ib2-Ia2).

The bottom of the lagoon is composed of loose sand and poor cohesive soils up to a depth of 30 m – 40 m (Ia2). The bottom is covered with 5 m depth of plastic mud.

2.1.2 Meteorology

1) Climate

The Study Area of Abidjan is governed by an equatorial climate characterized as follows:

- Rainy season from April to July
- Small dry season, generally from July to September
- Second rainy season, from September to November, very irregular and less important than first rainy season
- Grand dry season from December to March

Daily rainfall corresponds to stormy downpours at the beginning of the rainy season. During the rainy season and especially the second rainy season, rainfall becomes more continuous.

The variations of the temperature are very limited by the yearly oceanic influence.

2) Temperature

Annual and monthly average climate data in Abidjan are shown in Fig. 2.2. Average temperature from 1969 to 1998 is 26.5℃. Annual average temperature shows a gentle upward trend recently.

Monthly average yearly temperature between 24.0 and 28.1℃. The highest temperatures are observed in April and the lowest in August.

3) Precipitation

Annual and monthly average rainfall data are shown in Fig. 2.2. Annual rainfall varies between 1,100 mm and 2,500 mm. Annual average rainfall from 1969 to 1998 is 1,750 mm. Drought years appear almost every 10 years; 1977, 1990, 1998.

Annual rainfall seems to show a trend of decreasing recently. In a monthly range, rainy and dry seasons are clearly separated. In June, precipitation reaches more than 500 mm.

2.2 Socio-economic Conditions and Financial Environments

2.2.1 Socio-economic Conditions

Here, the Study Team takes up the present socio-economic condition, especially the GDP and the international balance of payments of the Republic of Côte d'Ivoire.
This country belongs to the CFA franc region since its independence and occupies a central position within the region. While, in addition to this country, the western Africa countries such as Senegal, Mali, Burkina Faso, Niger, Benin, Togo, Guinea and Guinea-Bissau (participation in 1997) are participating in the CFA franc region. This country occupies 38% of the GDP in this region and has a leading status.

There is a huge positive aspect of a fixed currency exchange rate with the French franc in order to be integrated with international economy. The free exchange with the French franc is guaranteed, too. But from now on, EU currency integration might cause a big problem to such systems. By EU currency integration, in 2001 the CFA franc will interlock with the unified currency Euro. There is a possibility that it will destroy the base of the structure adjustment in progress because of the overvaluation of the CFA franc. The World Bank has shown anxiety on this issue in their report.

This country had been taking pro-Western Europe and moderate policy lines after its independence among the Western Africa countries. It has already achieved the level of USD 1000 per capita GDP in 1977. The country is known as "miracle ivory ".

But after that, the industrialization became worse. The 1980's was the lost decade and the economy stagnated because of an increase of the debt from foreign countries and the deterioration of the terms of trade in primary commodities.
The devaluation of the CFA franc in January, 1994 brought about an epoch-making effect to reconstruct the economy of this country. Exportation increased by the devaluation and the international balance of payments has been improved. Along with the CFA franc devaluation the structure adjustments by the International Monetary Fund and the World Bank are promoted in all aspects of government activities.

1) Structure of the International Trade and the International Balance of Payments

(1) Structure of the exportation

The composition of the major item in the exportation is shown in Table 2.1. This country is the world's top producer of cacao beans, as biggest export item. Also, coffee is a main product. The cacao beans and coffee occupies 36% of exportation. In the long run, it is necessary to increase the exports of other than cacao beans and coffee. Also, the country must attempt to export these farm products after processing. The exportation of petroleum and natural gas is highly expected as petroleum has recently been discovered offshore.

The destination of the exportation is shown in Table 2.3. Most customers are overwhelmingly European. The top is France and the second is the Netherlands.

(2) Structure of the importation

The composition of the import of the items is shown in Table 2.2. There are many general consumer goods imported, such as machine product and capital goods, as is usual in developing countries. While the exportation is mainly from Europe, the importation is even from America, Asia in addition to Europe. Also the importation from France is protruding among importation from Europe.

(3) Structure of the international balance of payments (Table 2.4)

This country has a constant positive balance in merchandise trade. This trend is considered to continue. However, there is a substantial deficit in both the invisible trade balance, and in transfer payments. Interest payments is the largest item in the invisible trade balance. Royalty, and technical and business fees will be also large. The major part of transfer payments will be the remittance of profits to parent companies and the payment of the dividends. As a whole, the overall balance has always shown a deficit trend.

2) The composition of the GDP (Table 2.5 and Table 2.6)

After the GDP of this country reached 1000 USD per capita in year 1977, the economy has continued to stagnate due to the deterioration in terms of trade in primary export commodities. Although the GDP per capita in terms of USD was decreased radically by the devaluation of the CFA franc in January, 1994, the economy of this country has shown the remarkable recovery after that. The economy has begun to expand smoothly. At present the industrial composition of the GDP is shown in Table 2.5. The expansion of the industry centering around agricultural product processing is expected. The devaluation of the CFA franc in January, 1994 brought about an epoch-making effect on the reconstruction of the economy of this country. Exportation increased as the result of the devaluation and the international balance of payments improved.

2.2.2 Business and Financial Environment

In discussing the economic structure of this country, a fundamental problem is in the employment structure of this country (Table 2.7). First of all, half of the population is located in farm villages and is engaged in traditional agriculture. In the country only 230,000 people of the labor force belong to a formal sector. Most of the labor force remaining belongs to the so-called informal sector. None the less, the prosperity of this country is attracting foreign laborers and among these 230,000 formal sector employees. 30000 are foreigners mainly coming from neighboring African countries. It is the present condition that there are an overwhelming number of employees who apply for the minimum wage regulation program, although minimum wages are postulated in terms of job categories. There are public officers other than private enterprise employees. Of these, about 100,000 are teachers. The World Bank is requesting the recruitment control of the public officers except for teachers. The job to applicant ratio is several dozens time that of the labor market in this country.

It will be impossible even for the public utilities charges and tax payments to be shared widely.

In order to stabilize the income of the people, the expansion of employment is the fundamental problem that must be solved in the long term.

2.3 Institution and Structural Reform

2.3.1 Administrative Organizations

The administrative function on the sewerage service in this country is divided into three organizations.

1) Department of Construction and Sewerage, MLU

Department of Construction and Sewerage, MLU takes charge of the sewerage administration overall as the part of the government. It represents the country and supervises BNETD and SODECI. It prepares the laws, regulations and budget for the national sewerage service.

However, the water supply service belongs to not MLU but the Ministère des Infrastractures Economiques. Because the water supply service is the major business of SODECI, it is actually supervised by the later ministry.

While the trend toward outsourcing and privatization will proceed further, the authority that decides the border between the government and related agencies and private companies resides within the government. Agencies and private companies only operate within the scope decided by the government.

Because this study is the feasible study on the western district of Abidjan, further discussion about the central organizational issue will be out of scope.

2) BNETD

It is the technical center of the country which recently becomes an independent body from the division of the government. Although BNETD is trying to be financially independent from the government but this target is not yet achieved. The main portion of the work comes from the contract with the government. BNETD is now soliciting the contract from private sectors but this portion other than from the government is still relatively

small.

As for the sewerage service in this country, BNETD is the major organization that has substantial sewerage technology. Even the authority to make a plan and prepare the budget for the sewerage service is belonging to the ministry, the assistance is provided by BNETD. The coverage of BNETD is the planning and supervising of the works of newly construction and large scale rehabilitation of sewerage service.

BNETD also has the contract to support the ministry's works on an annual basis. An individual contract comes from the ministry separately. Direct contact with SODECI must be approved by the ministry in advance. But at informal and technical levels, communications between BNETD and SODECI seem to be frequent.

3) SODECI

SODECI is a privately owned company that takes charge of the water supply and sewerage services of this country. It is under the supervision of the government extensively in the way of business, tariff system etc. in the exchange for the monopoly of the business. Until recently the performance of the company did not necessarily stabilize. The main cause for this is nonpayment by large-scale users, especially government and municipalities. At the end of the fiscal year, the settlement was reached by receiving part of charge and abandoning the remainder. Recently the financial performance improved more than before.

2.3.2 Structural Reform, Privatization and Regulatory Reform

The main pillars of the structure adjustment are the privatization and the disengagement of government business and the reduction of the financial deficit. Privatization usually has two objectives. One is to improve the efficiency of the operation and the other is to increase the governmental revenue by selling the government holding stock of privatized companies to public.

Concerning SODECI's taking charge of the sewerage service in Abidjan, the privatization

has been already completed, and even the government share holding ratio is very low. SODECI's stock is listed in the Abidjan security market is showing moderate performance. It is widely considered to be a success example of the government's privatization plan.

2.4 Sanitation Conditions

In 1998, the city of Abidjan had about 2.7 million in population, about 18% of the total population of Côte d'Ivoire. The present population of Abidjan is estimated at about 2.8 million with an annual growth rate of 4%. On the other hand, the present population of the Study Area is about 850,000 (about 30% of the population of Abidjan), which is expected to grow about 1,080,000 in year 2003 (about 21% increase over the present population). The strong population growth and inadequate infrastructure services have been causing extensive and serious environmental problems. Although progresses have been made on improving the water supply services and road facilities.

1) Solid Waste Conditions

Inefficient solid waste collection and disposal facilities are contributing to environmental degradation such as blocking of street drains, flooding, odor and spread of disease. Accumulation of eroded soils, plants, garbage etc in the drainage canals without any maintenance is contributing to breeding ground for flies and vermin, blocking of flow, foul odors and visual offense. Illegal housings, traditional villages and scattered inhabitants are deprived of roads for disposal of waste. Pre-collectors with little means of transport called "pousse-pousse" in the local language, evacuate wastes indiscriminately into accessible areas. The public dumping ground (such as Attécoubé dumping ground) receives, without any consideration, all the domestic, industrial, and hospital wastes. They contain potential harmful components for the environment, such as organic matters, metals, plastics, broken glass, oils, pathogen microorganisms and toxic substances. The natural drainage of the dumping ground is towards the lagoon creating the risks from the leachate. The dumping grounds are not well developed, not controlled and not covered by the environmental standards. In addition, there are many illegal open dumping grounds in the area causing odors and other offensive problems.

2) Sewerage and Drainage Conditions

In spite of efforts to improve the sewerage and drainage system in the Study Area, the situation remains serious. Improvement of the drainage system by the construction of concrete lined drainage canals was started, but remains unfinished in the downstream land area. This has exacerbated the erosion of the downstream land. Moreover, the existing

sewerage system project, which consists of six trunk sewers, was not completed. Therefore, the wastewater of the Study Area could not be disposed of to the Gulf of Guinea as per the Master Plan. The trunk sewers, which are in the state of deterioration, are discharging wastewater into the lagoon, resulting in high pollution of the lagoon water, and posing a serious threat to the environment and the sanitary condition of the communities.

About 1 million people of Abidjan (35% of the total 3 million population) are connected to the sewer network. The rest of the pollution (about 2 million) is not connected to any sewer system. The existing regulation requires land developers to install the reticulation system and connection to the existing sewerage system, therefore, the area developed by the land developers are serviced by the existing sewerage system. Illegal housings, traditional villages and scattered inhabitants are not served by the sewerage system. On the other hand, illegal housing are situated on the existing sewers. Therefore, the maintenance of the sewerage system in this area has become a major problem.

3) Individual Sanitation Facilities

Table 2.8 shows the distribution of population using the different types of disposal systems. An average 39.11% of the population in Yopougon district have access to the sewerage system and septic tanks whereas only 4.12 % in Attécoubé district have access to septic tanks, as there is no sewerage system there. Many households dispose of sullage (kitchen and bathroom wastewater) directly onto the ground, drains, ditches or public roads.

In the absence of maintenance, most of the septic tanks overflow and discharge the wastewater into drains and ditches. It costs about 6000-11000 FCFA to desludge the septic tanks by private desludging companies. The desludging trucks are required to dump their sludge at designated locations in the sewerage system where sludge-dumping facility is provided. To avoid payment of the sludge disposal fee to the municipality, and the distance and waiting time, the sludge of the Study Area is sometimes dumped near the shore or into the lagoon.

An average 27.54% of the population in Yopougon district and 40.28% in the Attécoubé district do not have access to any sanitary waste disposal facilities. As a result, these populations comprise by bushes, open area, lagoon, tall grass, or drainage canals thus

creating the risk of epidemics. During rainfall, faeces is carried away by the surface water flow through the area or drainage canals to the lagoon. The same water is used downstream for irrigation and also for drinking. Therefore, to improve the sanitation condition it is important that this waste disposal system be declared illegal and punishable.

An average 33.36% of the population in Yopougon district and 55.59% in Attécoubé district have access to courtyard latrines. Each courtyard latrine, which is some form of pit latrine, is shared by 5 or more families. When the tank is full, the pit is covered and another tank is dug in the area until it eventually become saturated. To avoid this type of situation, deeper pits are dug, about 8 to 20 meters, eventually contaminating the groundwater. The latrines, which are located far away from the inhabitants, are public and private latrines located in the center or in the entrance of markets in addition to backwater latrines etc. Pathogens from the night soil in pit latrines cause the spread by flies and other insects. These latrines emit bad odors. There is great concern about groundwater contamination and the public health hazard if this practice is allowed to continue. It should be noted that groundwater is the main source of drinking water in Abidjan.

To improve sanitation conditions, appropriate control measures should be introduced in the construction of latrines, such as the control of flies, odor and contamination of groundwater. With proper ventilation and light, this can be achieved if:

i) Air contact between excreta storage and latrine compartment is blocked;
ii) Excreta storage is isolated from external atmosphere;
iii) Ventilation of the latrine compartment and the excreta storage is accelerated; and
iv) Over-flow is discharged properly.

Moreover, the improved latrines should be inexpensive and much simpler, and adaptable to the conditions and needs of the area. The improved latrines should also:

i) be convenient for use;
ii) be acceptable to users without contradiction to their beliefs and custom;
iii) have privacy;
iv) have cleaner surroundings;
v) use local materials and know-how to reduce costs and get the interest of beneficiaries;
vi) be easy to maintain;

vii) be flexible i.e., able to be modified to meet various requirements; and

viii) be inexpensive, and correspond to the economic situations of the population.

Proper ventilation system will reduce bad odors, and the installation of screen at the end of the vent pipe will keep away flies. Latrines with flushes can be installed indoors, because of the hydraulic siphon separating the tank from the basin or the pavement. Flushing with 1-2 liters of water after each use is sufficient to flush down the excrements is sufficient. The siphon prevents bad odors and insects from penetrating the latrine through the flush.

4) Health Conditions

Based on health records, 25% of patients in Côte d'Ivoire are suffering from waterborne related diseases and over 60% of the population carry in their digestive system eggs and various worms harmful to human life (a report of Water Directorate). Proper disposal of waste is therefore very necessary.

2.5 Major Infrastructures

2.5.1 Roads and Harbor

The Ministère des Infrastructures Economiques (MIE) is responsible for everything related to roads, bridges, airports and harbors in Côte d'Ivoire.

Fig. 2.3 shows the Master Scheme of Great Abidjan executed in October 1998. In this figure, the gray lines represent the existing roads, the black ones represent roads that will be built in the mid-term future (target year: 2003) and the red one represent roads that will be built in the long-term future.

This Master scheme is the first phase of a general study and it deals with major infrastructures such as harbors, airports, roads and bridges. The second phase will be given in detail in the next City Planning Master Plan.

The existing major infrastructures in the Study Area are as follows:

- Azito Power Plant
- Autoroute du Nord
- La Paix Boulevard
- Road alongside Banco Bay in the Yopougon area
- Road going from the MACA prison to the SAGUIDIBA movie theater
- Road going from Autoroute du Nord Highway to Fire Station

Projects in the Study Area are given as follows:

- Extension of the existing PAA harbor (Port Autonone d'Abidjan) to Locodjoro;
- Road V1: This road will connect Niangon Nord to Niangon Sud;
- Road V6: This road will connect Niangon Sud to the road in the direction of Dabou City;
- Road V28: This road will connect Yopougon hospital to Niangon Sud SIDECI;
- Road (WE1): This road will connect the harbor to the projected Sud Banco bridge. This road has not yet been studied and it is the route chosen for the interceptor that is

the object of this Feasibility Study.

- Sud Banco Bridge: This bridge will cross the Banco bay in the southern part to connect Yopougon with Plateau.

Major infrastructures in the Study Area that are objects of the present study are shown in Fig. 2.4.

1) Existing Major Roads

a) Autoroute du Nord Highway

The Autoroute du Nord Highway runs east to west. This large road (2 x 3-lane road) is located in the north of Banco Plateau. Its characteristics are given as follows:

- width: 43 m
- road: 26 m
- 2 sidewalks: 4 m each
- total length: 5.6 km

b) La Paix Boulevard

This existing (2 x 2-lane) road is located in Attécoubé Commune. Its characteristics are given as follows:

- width: 25 m
- road: 17 m
- 2 sidewalks: 3 m each
- total length: 6.0 km

c) Road WB : Road alongside Banco Bay in the Yopougon area

This existing (2 x 1-lane) road is located along the west side of Banco Bay. Its characteristics are given as follows:

- width: 12 m
- road: 7 m

- 2 sidewalks: 2.5 m each
- total length: 5.6 km

2) Projected Major Roads and Harbor

a) Extension of the PAA (Abidjan Harbor Authority) harbor to Locodjoro

The extension of this harbor to Locodjoro will be, in fact, used for the transshipment of large container vessels; those ships will discharge their containers that will be transshipped to other countries in the western part of Africa. This type of harbor will be built in the five regions of the African Continent and Abidjan has been chosen as the one in West Africa.

After bidding, a private group from UK, ITC Corporation Ltd., was selected and this project will be financed by the type of BOT (Build-Operate-Transfer). This harbor is due to start by the year 2002 and from the convention between the Government of Côte d'Ivoire and the ITC Corporation Ltd. is specified as follows:

- The Government of Côte d'Ivoire is responsible for the basic infrastructures (road, electricity, water, etc.) that will be completed by the year 2001;
- The construction of the harbor and everything within the area will be done by the ITC Corporation Ltd.

At this stage, BNETD only has the scheme of this area. The total surface area of the harbor upon the completion of the project will be 200 hectares. However, the first phase of construction will occupy 100 hectares and will be built in the direction from Banco Bay to the Azito Power Plant.

The village of Yopougon-Sante will be resettled in an area provided accordingly.

b) Road V1: Niangon Nord / Niangon Sud

This road is located in the western part of Yopougon and connects the northern part to the road in the direction of Adzopé City near Yopougon. It is near the highway "Autoroute du Nord" and is a better access to all the southern and western parts of Yopougon that are presently difficult to reach. At the end in the South, this project is

connected to a secondary road in Niangon Sud, opposite to the street going to Niangon Lokao village. This road will reach the village in the future.
This road will be as follows:

- width: 35 m
- road (for urban train): 7 m
- 2 sidewalks: 2 m each
- total length: 5.75 km with 1.60 km already realized.
- estimated cost: 1,955,900,000 F CFA (value 1994)

c) Road V2-V6 Yopougon Koute / Niangon Sud / Road to Dabou City

This projected road is the southwest of Yopougon to a connected to the existing primary road of the Banco Plateau. This road connects to a road in the direction of Dabou City to the west near Niangon-Adjamé village. The last portion of the road (V6), which has a length of 1300 meters, consists of a temporary build-up (amenagement) on the route of the future bypass (rocade) to the south of Yopougon.
This road will be as follows:

- width: 35 m
- road (for urban train): 7 m
- 2 sidewalks: 2 m each
- total length: 7.3 km with several culverts that have to be realized.
- estimated cost: 1,581,800,000 F CFA (value 1994)

d) Road V28

This projected road will be built in Yopougon Commune in a north/south direction. It will be linked in the south to Road V1-V6 and eventually to Road WE1. Its characteristics are given as follows:

- width: 35 m

- road (for urban train): 7 m
- 2 sidewalks: 2 m each
- total length: 7.3 km with several culverts that have to be realized.
- estimated cost: 1,581,800,000 F CFA (value 1994)

e) Road (EW1)

There is no study on this projected road that will be used as the route of the interceptor. However, from the convention between the Government of Cote d'Ivoire and ITC Corporation Ltd., this road must be built by the year 2001 because the harbor is due to open by the year 2002.

From aerial photographs dating back to 1997, around 500 houses have been built in the northern part of the area reserved for the extension of the PAA harbor right on a 50 m wide section reserved for the road. Questioned to know if the present situation will change the route of the projected road, the DTT (Transport and Telecommunication Department) manager of BNETD replied that these houses will be demolished and resettled, and the landlords will be compensated accordingly.

f) Sud Banco Bridge

Concerning the projected bridge over Banco Bay (one of the 12 projects of "Les 12 chantiers de l'elephant d'Afrique") at an estimated cost of 50 billion (50,000,000,000) FCFA, the Government of Côte d'Ivoire is planning to finance in the type of BOT and is asking a private group from UK to finance the project but an agreement has yet to be reached.

The schemes of the drawings have been completed but they have not been public because no decision has been made concerning the type of the bridge (fixed, open or pivoting). The scheme for the pivoting option is as follows:

- Length: 550 m
- Width: 30 m
- Clearance from HHWL to the bridge: 12 m
- Length of the pivoting portion: 120 m

3) Traffic in the Banco bay

a) The dockyard (shipyard)

The yearly traffic in the Banco bay for ships going to the dockyard is around 200. The following is some information about Banco bay:

- Size of the ships: 10,000 to 15,000 ton
- Length and draught of the ships: 150 m and 9 m, respectively
- Dredging is done only in the neighboring area of quays;
- The latest dredging was done 1.5 years ago and the volume of the sediment (sludge or silt) was around 40 m^3;
- Dockyard CARENA is in its maximum area and this area can not go beyond the ex-SEBROKO Hotel.

b) Transportation

There are two (2) private companies operating small ferryboats in the Banco bay between Plateau and Locodjoro with two (2) stations to each bank of the bay; the CARENA side and the Locodjoro side. There is in average departure every five (5) minutes carrying an average of 50 passengers.

2.5.2 Water Supply System

1) Service Area

A big effort by the Government to improve the water supply in Cote d'Ivoire has been made. In 1988, it was estimated that 85 to 100% of the urban population and 75% of the rural population had access to potable water. The Government annually invests about 200 million FCFA on the expansion and maintenance of the distribution network.

In Côte d'Ivoire, water consumption changes from city to city. The water consumption in the city of Abidjan, which is the center of political, economic and cultural activities of the country, is estimated to be 80 to 100 L/person/day (Lpcd) compared to only about 25 Lpcd

in other cities. The country's average is about 55 Lpcd.

The coverage of water supply services and sources of potable water in the Study Area are shown in Table 2.9. An average area of 61.70% and 33.1% of the Yopougon and Attécoubé districts, respectively are served by the water supply system compared to 75% for the whole of Abidjan. In Yopougon, 6.91% of total potable water consumed is from wells and 11.37% from other sources (such as lagoon water directly) whereas in Attécoubé 3.54% from wells and 19.49% from other sources. Of course, this water (wells and other sources) is consumed by a section of population that cannot afford to have the services of a potable water supply.

2) Water Supply Facilities

The Ministry of Infrastructure and Economics through the Water Directorate, is in charge of the development, exploitation and conservation of water resources in the country. However, the operation of the water supply services (from point of abstraction to disinfection), the maintenance of the distribution network and management of the customers (connection, subscription, invoicing, payment and repair) is done by SODECI under a contract with the Government.

The whole of Abidjan is supplied with groundwater whereas other cities are supplied from other sources also such as about 73% from surface water. The water quality data of groundwater and treated water from the Adjamé pumping station in Abidjan is shown in Table 2.10. WHO guidelines for pH range from 6.5-8.5. The treated water is out of range. It is necessary to manage water treatment carefully. The low pH is the result of a high concentration of free carbon dioxide, which commonly occurs in little-mineralized and aggressive groundwater. The pH in the water supplied through the distribution network is adjusted after pumping from the source to prevent the corrosion of the distribution network. The physical, chemical and bacteriological parameters of tap water at different locations in the distribution network are shown in APPENDIX C.

There are nine pumping stations, which consist of 73 deep wells, and neutralization, storage and disinfection units, serve the city of Abidjan. The total capacity of the existing pumping stations is 115 million m^3 per year. The water leakage ratio in the entire

distribution network is roughly at 20-15%. To reduce the water leakage further, old pipes

of the water supply system are steadily being replaced with new pipes. The pipes, which are 40 years or older, are the top priority in the pipe replacement program. The material of the pipes used is FCD for 800-300 mm diameter pipes and PVC for 300 mm or less.

In Abidjan within the next 10 years, the annual household demand is projected to be 113 million m^3. With 15% projected as industrial demand and considering the leakage at 15%, the total water demand will be 153 million m^3 per year. This annual water demand is expected to reach to about 170 million m^3 if the Government plan to improve the living conditions of illegal habitants is realized. However, the current total water production is only about 70% of the total demand. In Abidjan, the annual rate of increase in water consumption is estimated at 6%.

Apart from the above water consumers, factories have their own private deep wells. To have their own private deep well, factories are required to notify to the Water Directorate of the Ministry of Infrastructure and Economics. Upon installation of the deep well, SODECI installs a water meter, bills and collects groundwater extraction fees monthly based on the amount of water consumed.

In the Yopougon district, the existing pumping station, which is located in the northwest was installed in 1980. The capacity of the pumping station is 40,800 m^3 per day. Currently, the rate of operation of the pumping station is 100%. A second pumping station with a capacity of 60,000 m^3/day is under construction and is being financed by a loan from the French Development Agency.

The network of Yopougon is 420 km in which 5% of the pipes have a diameter of larger than 200 mm. On the other hand, 8.5% of the network in the whole of Abidjan, which is 2,800 km, have a diameter of larger than 200 mm. The existing pumping station in Yopougon includes:

i) Deep Wells

A total of 10 wells with an average depth of 70 meters are installed in the lowland area

with an altitude between IGN +20 level and IGN +40 level. In this area, the static groundwater level is at IGN+7. Each well equipped with a submersible pump that discharges into the raw water collector of the pumping station. The distance between the station and deep wells site is 3,000 meters.

ii) Treatment (pH Control)

The low pH in raw water is controlled by the addition of lime as limewater. Saturators, which consist of a lime bed, produce limewater. The water to be saturated is passed through the lime bed. The saturated water (limewater) is then mixed with the raw water to produce water of pH within the acceptable limit. The pumping station has 2 saturators, which need a periodical reloading of lime. Saturator cleaning time is 2 hours/day and the reloading of lime takes 2 hours/day. Therefore, the continuous operation of each saturator is limited to 20 hours/day.

iii) Reservoir

The treated water (after pH control) is sent to a reservoir (capacity 10,000 m^3), which is adjacent to the station. From the reservoir, water after dosing with chlorine from a feeder is supplied by gravity into the distribution network.

3) Future Plan

To satisfy the water demand within the next 10 years, additional water sources must be investigated.

A plan to construct 2 new pumping stations using groundwater sources is under negotiation with the African Development Bank. It is assumed that the pumping stations at the Abobo Baoulé and Palmeraie sites supply water within the next five years, and have the capacity of 12,096 m^3/day and 17,280 m^3/day, respectively.

However, the danger of groundwater contamination by seawater intrusion might be possible if abstraction is not controlled. According to the SOGREAH study, the maximum volume of groundwater to be abstracted is to be limited to 4.2 m^3/s (about 130 million m^3/year). Therefore, from the forecasted total water demand of about 170 million m^3/year, the remaining balance of about 40 million m^3/year should be supplied from

sources other than groundwater.

Water from the Potou and Aghien lagoons, which presently show high concentrations of chloride, can be used. However appropriate measures are necessary to keep the chloride content at an acceptable level that include building of an anti-salt dike and setting up protection perimeters around the lagoons to protect them from human pollution.

2.5.3 Sewerage System

1) Sewerage System

The development of the water supply and sanitation sector from 1974 to 1983 benefited from the investments of which 85% were financed by external and internal loans. Sewerage services were made for about 35% of Abidjan's population. However, the expansion of the sanitation sector was halted after 1984 due to conflicts arising among various governmental agencies that have technical differences of opinion about the section concerning the solution for the final discharge of wastewater. As a result, interceptor of the sewerage system in the Study Area to dispose of the wastewater into the ocean could not be completed. The incomplete / damaged sewers discharge the wastewater into the Lagoon. To restore the ecological conditions of the Lagoon, the completion of the sewerage system is critical.

SETU (SOCIETE D'EQUIPMENT DES TERRAINS URBANS) was set up in 1971 at the Ministry of Public Works to prepare M/P of Abidjan with assistance from WHO. In addition, SETU conducted the F/S in 1974 with the assistance of UNDP and had implemented installations of reticulation system, sewerage facilities and ocean outfall in three phases since 1975.

Work Profile of SETU:

1971:	M/P with WHO assistance
1974:	F/S with UNDP assistance
1975-1980:	First stage of WB project: construction of sewers of 18 km
1978-1985:	Second stage of WB project: construction of sewers of 69 km

1981.1982:	Review of M/P by the Government
1986:	Review of F/S by the Government
1990-1995:	Third stage of WB project: construction of reticulation system, pumping station, sewage pre-treatment plant and ocean outfall

2) Outline of Sewerage System

The Master Plan of 1971 proposed the sewage of the Central, western and eastern area of Abidjan to be sent to the sewage pre-treatment plant and then disposed of into the Gulf of Guinea through the ocean outfall.

In 1981-1982, the Government reviewed the Master Plan of 1971. It was proposed that the sewage from the western area of Abidjan be through the S1 Pumping Station instead of sending it to the Koumassi Pre-Treatment Plant directly. However, the design capacity of the central trunk sewer on the downstream side of the S1 pumping station, which was installed before the completion of the third stage of the WB project, is supposed to be insufficient to accommodate the sewage flow of the western area. The present situation of the sewerage facilities in the western area is examined in the following paragraphs. The outline of the existing sewerage system is as shown in Fig. 2.5.

3) Trunk Sewers

There are six trunk sewers in the Study Area. Four trunk sewers discharge sewage into the Lagoon and two trunk sewers discharge sewage into the Banco Bay. The present conditions of the six trunk sewers are as follows:

(1) 3A・3B; 2A・2B & 1A・1B Trunk Sewers

i) 3A (φ300, L=2500m)・3B (φ300, L=2500m)

In the upstream area, the trunk sewers are installed on both sides of the concrete drainage canal. There is no sewage flow in the 3B Trunk. Due to inadequate maintenance over the years, the manholes and sewer have been choked with garbage, litter, solids, etc. On the other hand, the 3A Trunk Sewer has only partial flow. Judging from the inspection of the manholes, the maintenance of this sewer seems to be possible in order to recover its function. The downstream is broken and the sewage flows into the natural drain which discharges into the Lagoon.

ii) 2A (ϕ 500, L=1500m) · 2B (ϕ 300, L=1500m)

The natural drain passes through this area and both sides of its bank are covered with bushes. The upstream of the 2B Trunk Sewer is abandoned and choked with garbage, litter, solids etc. On the other hand, the maintenance of the 2A Trunk Sewer, which is comparatively new, is well done. The flow in this sewer is smooth. The 3A · 3B-trunk sewer in the downstream is joined by the 2A · 2B Trunk Sewer. Therefore, the diameter of the sewer in the downstream side of the joint increases to ϕ 800. Further, after about 400 m downstream, the sewer is joined by the 1A · 1B Trunk Sewers.

iii) 1A (ϕ 300, L=1300m) · 1B (ϕ 500, L=1300m)

The 1A- and 1B- trunk sewers are installed parallel on both side of the natural drain covered with bushes. The sewers are partially choked and the flow is not normal. After joining the 1A and1B-trunk sewer, the diameter of the sewer increases to 1000mm. At about 900 m downstream from the joint, the sewer discharges into the Lagoon.

(2) Port-Bouet II and UNIWAX Trunk Sewers

i) Port-Bouet II (ϕ 400, L=1800m, ϕ 600, L=2400m)

The Trunk Sewer is laid on the left side of the concrete drainage canal. The maintenance of the sewer is good and the flow is smooth. However, the downstream sewer is broken and the sewage flows out to the natural drain.

ii) UNIWAX (ϕ 250, L=1000m, ϕ 500, L=600m, ϕ 600, L=3600m, ϕ 800, L=3500m)

In the upstream area, the Trunk Sewer is installed in the right side of the concrete drainage canal. The sewer is maintained up to the concrete drainage canal. However, the sewer of Port-Bouet II is lost at the crossing point with the drainage canal before joining with the UNIWAX Trunk Sewer. The sewage flows out into the natural drain.

The flow is again smooth in the middle part of the sewer. About 1600 m downstream of the middle part, the sewer pipes cross the natural drain supported by

steel pipes. However, a part of the sewer that is supported on the piers is broken and the sewage flows out into the natural drain. The steel pipes seem to be in good condition.

(3) 21-22 Trunk Sewer (ϕ250, L=250m, ϕ300, L=600m, ϕ400, L=1700m)

The flow is comparatively smooth in this trunk sewer. A part of the sewer near the middle part of the sewer pipe line crossing the drain is made of PVC. The original sewer was washed away due to an insufficient foundation, heavy soil erosion and drainage water.

(4) 25-26-27 Trunk Sewer (ϕ400, L=200m, ϕ500, L=1500m)

The Trunk Sewer starts from the premise of the Yopougon Student Dormitory. The sewer is maintained up to the concrete drainage canal. The sewer pipe after crossing the concrete drainage canal has washed away and the sewage flows out into the natural drain.

(5) 33-34 Trunk Sewer (ϕ300, L=1500m)

The construction of new housing in the upstream part of the Trunk Sewer has been controlled from the beginning. As a result, the sewer is well maintained in the upstream part. However, illegal houses are scattered along the middle and downstream section of the sewer. In the vicinity of the discharging point to the Lagoon, the flow in the sewer is not fluent due to being partially choked.

(6) 35-36 Trunk Sewer (ϕ200, L=2000m)

Using the geographical feature of the ground, a sewer 200 mm in diameter was installed on the left side of the concrete drainage canal under the housing development plan. The plan was later abandoned because of a large amount of storm water run-off through the area. The area is now occupied with scattered houses. The manholes and sewer have become completely choked with garbage, litter, solids, etc. It seems almost an impossibility to clean and use it again.

4) Pumping Stations

In Abidjan, SODECI is operating forty-nine pumping stations. In addition, there are five pumping stations in the French Military camp and three pumping stations in the Ivory Electric Power Company. Among the forty-nine pumping stations operated by SODECI, the record of thirty-seven pumping stations is shown in Table 2.11.

Two pumping stations and one sewage pre-treatment plant were reviewed in this Study. They are S1 pumping station (S1 Pont de Gaulle), 7J1 pumping station and sewage pre-treatment plant (Koumassi). These were constructed in 1993-1994 based on the master plan and send wastewater coming from the central and southern area of Abidjan to the Gulf of Guinea through the ocean outfall. The existing capacity of these pumping stations is not sufficient to serve the population of 3,000,000 in Abidjan. However, each pumping station has enough space to install additional facilities, such as pumps, screens and so on. The wastewater coming from the Study Area will be conveyed using these pumping stations.

Outline of facilities at S1 and 7J1 pumping stations is as follows:

(1) S1 Pumping Station (Pont De Gaulle Pumping Station)

The S1 pumping station is composed of facilities, such as wall gate, screen with mechanized rake, grit chamber, pumps, etc. The detailed descriptions of these facilities are shown in Table 2.12.

As shown in Table 2.12, only one pump is available to convey wastewater. In 1998, the amount of pumped up wastewater was only 0.57 m^3/s and the rate of operation was very low. The rate of operation averaged less than 15%.

(2) 7J1 Pumping Station

The structure of 7J1 Pumping Station is almost the same as the S1 Pumping Station except for the number of pumps, the pump capacity and generator. Detailed descriptions of the facilities are shown in Table 2.13.

The 7J1 Pumping Station has a capacity of 1.59 m^3/s and the monthly rate of operation is the same as S1 Pumping Station.

5) Sewage Pre-Treatment Plant

Near the Pre-Treatment Plant, there is another pumping station which lifts up and discharges the pre-treated wastewater into the ocean. This pumping station is located at the most downstream part of the Abidjan sewerage system, and lifts up and discharges the wastewater into the ocean. The Pre-Treatment Plant is constructed to remove mainly sand, oil and grease. The sewage flows into the division box where the applicable flow for screw pumps is allowed. The division box has an overflow-wall to discharge the surplus sewage.

There are only two screw pumps among the proposed four pumps. The pumped up sewage is passed through the screen followed by the grit chamber. The sand collected in the grit chamber is removed by the sand extraction pump and sent to the stockyard. The sewage after passing through the oil separation facility is pumped to a surging tank, which is installed to prevent water hammer, to be discharged to the ocean outfall through the 1200 mm pipe. On the other hand, parallel to the surging tank an 800 mm by-pass pipe is installed for emergency purposes. Detailed descriptions of facilities are shown in Table 2.14.

2.5.4 Storm Water Drainage System

In the Study area, there exist six (6) major trunk main systems similar to the sewerage system. The total length of these drainage trunk mains is about 25.8 km and most parts of them have been constructed from 1976 to 1984. These artificial canals having concrete linings are constructed mainly in the upstream basin (northern part of the Area). Only natural watercourses exist in the downstream basin. The population of Yopougon has increased from 400,000 to 600,000 between 1988 and 1998 and is mostly concentrated in the northern part of the catchment. However, land development has been going on in the southern part recently and run-off from the catchment has increased.

The existing drainage master plan was formulated based on 1981 land use conditions.

In the Area, most parts of the trunk sewers are installed along the drainage canal and

sometimes across the canal. Some of them are seriously affected by damaged or eroded canals especially downstream where drainage canals without any bank protection are easily eroded.

The condition of the damaged drainage canals are described in more detail in Section 9.2 in Chapter 9.

Fig. 2.6 shows the existing stormwater drainage system in the Study Area.

2.6 Operation and Maintenance

SODECI, a private company, operates the urban water piped system, maintains the sewerage and drainage system of Abidjan under a contract with the Government. In fiscal year 1996, SODECI received 1,095 million FCFA for the operation and maintenance work from the Government, which was 3.93% of SODECI's total income.

SODECI operates the sewerage facility of Abidjan through its Pipe Section, Development Section and Facility Section. SODECI maintains the following existing sewerage and drainage facilities in Abidjan:

- 868 km of sewers including 158 km of trunk sewers
- Forty-nine pumping stations including the sewage pre-treatment plant
- One ocean outfall pipe
- 602 km drainage canals

2.6.1 Sewer Pipes

The Government used to request SODECI to supply manpower in the case of trouble with the sewerage system. At present, the operation and management of the sewerage system is done by SODECI. The cleaning of sewers is done using high-pressure pumps. SODECI has nine high-pressure pump trucks for cleaning the sewers. Starting from July 1999, SODECI will be using closed circuit television cameras to determine the actual conditions in the sewers. TV inspection is an effective method of detecting exact locations of leaks, corrosion, intrusions, failures and partial blockages.

2.6.2 Pumping Stations and Sewage Pre-Treatment Plant

Forty-nine pumping stations located at different places in Abidjan under the management of SODECI are divided into North and South zones and are controlled by its Facility Section. In the North zone, there are two teams; each team consists of one technician and one unskilled labor. In the South zone, there are three teams, which are similar in

composition to the North zone groups. These teams carry out the following routine maintenance of the pumping stations.

- Cleaning of screens
- Checking of pumps, motors, and dynamos
- Checking of pump operation records
- Diagnosis of the breakdown of pumps
- Minor repairs

Large variations in the flow coming to the pumping stations causes the frequent starting and stopping of the pumps and is one of the major causes of pump breakdowns even though all of the pumps have automatic operation.

A technical expert controls the management of the sewage pre-treatment plant, which also consists of a pumping station. One technician and 4 laborers per shift are assigned to the sewage pre-treatment plant.

2.6.3 Current Operation Status of Pumping Stations and Sewage Pre-Treatment Plant

The monthly record of operation by respectively summing up the daily operation hours and the daily pumped up quantity exists. The operation records for the year 1998 of S1 pumping station, 7J1 pumping station and sewage pre-treatment plant are explained in the following paragraphs.

1) S1 Pumping Station

The S1 pumping station is located in the middle of the central trunk sewer. The operation record for the year 1998 is given in the Table 2.6.1. The amount of pumping was 2,603 m^3/d based on the average monthly operation time of 94 hours, which turned out to be only 1% of the pumping station's capacity.

2) 7J1 Pumping Station

According to the 1998 records of the 7J1 Pumping Station, the amount of pumping was

2,603 m^3/d based on the average monthly operation time of 94 hours. Table 2.6.2 shows the record of operation of this pumping station.

3) Sewage Pre-Treatment Plant

The wastewater lifted at the $7J_1$ Pumping Station is sent to the sewage pre-treatment plant. The wastewater coming to plant first flows into the division box where the applicable flow for screw pumps is allowed. The division box has an overflow-wall to discharge the surplus wastewater into the Lagoon. However, as shown in Table 2.6.3, the pumping station at the plant operated only during the month of June. In the remaining months the wastewater was made to overflow the wall of the division box to discharge the wastewater into the Lagoon.

4) Operation Cost for Pumping Stations and Sewage Pre-Treatment Plant

The operation cost of a pumping station and treatment plant includes only the electricity charge to operate the pumps. The electric charge is based on the fixed premium plus charge for consumption depending on the category of the voltage used (medium or low). The electricity charge per month for each pumping station and the pre-treatment plant is given in the Table 2.6.4.

2.7 Water Quality

2.7.1 Water Quality of Lagoon

The Ebrié lagoon (523 km^2, 120 km long, 1 to 7 km wide with an average depth of 4.8 m (maximum depth 28 m) stretches parallel to the shoreline. Several bays (half-closed or opened perpendicular to the main axis) and secondary basins (Aghien and Potou Lagoons, 43 km^2) complete a system characterized by a complex morphology. The Ebrié lagoon constitutes the major coastal ecosystem in West Africa. It is connected to the Atlantic ocean through the Virdi canal and the Bassam inlet and fed by the Comoé, the Agneby and the Mé rivers. The Ebrié lagoon is also connected with the Aby and the Grand Lahou lagoons by artificial canals: Asagny Canal links Grand Lahou and Ebrié lagoons, while Assinie Canal links Ebrié and Aby lagoons. Narrow and shallow, these waterways once used for transportation are no longer maintained. The Ebrié lagoon is connected to the sea so the water is brackish. The lagoon is seasonally subjected to marked salinity variations (0-28 psu).

The Ebrié lagoon is an important element in the socio-economic environment of Côte d'Ivoire. Three to four thousand fisherman carry on their activities in this coastal environment. Forty thousand people receive their income from fishery related activities such as ship building, manufacturing of fishing gear, fish packaging, transport and marketing. Other activities such as sand extraction, aquaculture and public transportation occur in the Ebrié lagoon.

Abidjan with an estimated population of 3 million is built on the Ebrié lagoon shores. The wide range of land-based activities have introduced fertilizers, pesticides, garbage, sewage, excreta and industrial effluents into the Ebrié lagoon and its adjacent environment. The effects of these discharges are particularly evident in the region of Abidjan, where several still backwaters are badly polluted leading to anaerobic conditions and accumulations of sediments rich in hydrogen sulfides. Mass fish mortality near urban areas are frequent.

According to an expert of CRO (Center de Recherches Océanologiques), the bacterial count (*E. coli*, *Enterococcus* and *C. perfringens*) was found to be always high in the Ebrié lagoon:

E. coli and *Enterococcus* was on the average, respectively, 500 and 70 times higher than that observed in a rural estuarine. The bacterial count was found to increase during the rainy season. The *E.coli*, *Enterococcus* and *C. perfringens* count rose significantly, respectively, to 6, 2 and 1.85 times. The stormwater drainage/surface run-off is responsible for this increase. According to WHO guidelines, the Ebrié lagoon water is not suitable for swimming.

The Me, Agneby and Comoe rivers constitute an important pathway by which pollutants from agricultural sources enter the Ebrié ecosystem. The runoff of fertilizers and pesticides from farmlands into the rivers, then into the lagoon is adding to the problems of eutrophication (due to nitrogen and phosphorus) and chemical contamination of water and fish. Sediment in the Ebrié lagoon is contaminated with DDT and metabolites, lindane and PCB. The highest concentrations of the compounds are found in the bays. The metal concentrations in sediments of the Ebrié lagoon is in excess of background levels; this was attributed to the disposal of untreated sewage and industrial effluents.

Epidemiological data presage the possible implication of the Ebrié lagoon and its hydroclimatical variations in the endemic support of some diseases: an outbreak of typhoid among children and prevalence of *salmonella* during the rainy season, and *vibrio* spp., which principally is implicated in the outbreak of cholera since 1970.

CIAPOL (Centre Ivoirien d'Anti-Pollution), which is under the authority of the Ministry of Environment and Forest, investigates the water quality of the lagoon once a month at nine different locations (Fig. 2.8 and APPENDIX C). At each location surface water is sampled from 50 cm below the water surface, and bottom water is sampled from 50 cm above the water-sludge interface. The bacterial count, salinity, pH and temperature, SS and DO are investigated. BOD_5 and COD, indicators of organic pollution, are not analyzed. BOD_5 and COD are very important factor for analysis of wastewater quality. Therefore, the determination of BOD and COD is strongly recommended.

The CIAPOL is assigned to:

- Follow up and investigate the quality of continental, sea and lagoon waters
- Analytical support to SIIC

- Control of accidental toxic and hydrocarbons pollution in sea, lagoon and coastal areas
- Environmental data exchange
- Warning
- Surveillance and control of pollution in sea and lagoon
- Training, information, sensibilization and campaign for environment protection

In Côte d'Ivoire, there are no water quality standards for raw water used for drinking, standards for protection of aquatic ecosystem in fresh water, standards for protection of aquatic ecosystem in marine waters, and standards for recreation and aesthetic values. Because of these lack of standards, waterbodies in the country have not been classified as to their most beneficial or intended use. There is no basis therefore to evaluate if the ocean has already exceeded its acceptable limits for its intended use. The WHO guidelines or standards of other countries may be adopted to classify the waters.

2.7.2 Sewage Quantity and Quality Survey

The JICA Study Team investigated the sewage quantity and quality in the months of June and July 1999 by 24 hour monitoring and sampling in the existing trunk sewers, pumping stations (S1 and 7J1 pumping stations), and sewage pre-treatment plant in order to assess the current situation (Fig. 2.9).

As a result, 1,2,3 AB, Port-Bouet II, UNIWAX, 21-22 are relatively higher BOD than general domestic wastewater. It is strongly said that untreated industrial wastewater flows the T/S. Among them, UNIWAX is the most polluted.

Location of sampling and the details of the result is described in APPENDIX C. Data is used in the design of interceptor, pumping stations and related facilities.

TABLE 2.1 COMPOSITION OF EXPORTS IN 1995

Product	Amount (millions FCFA)	Percentage
Primary Products		
Raw Coffee	169,541	9.1%
Cacao Beans	530,155	28.5%
Banana	40,103	2.2%
Pineapple	21,403	1.2%
Cotton mass	68,970	3.7%
Bark	25,801	1.4%
Palm Oil	44,139	2.4%
Gum	56,325	3.0%
Nut	516	0.0%
Grain	2,444	0.1%
Sub-Total	959,397	**51.6%**
Transformed Products		
Transformed Cocoa	96,089	5.2%
Transformed Coffee	39,628	2.1%
Canned Fish	106,858	5.7%
Canned Pineapple	59	0.0%
Sugar	5,462	0.3%
Cloths	16,384	0.9%
Timber	176,724	9.5%
Cement	16,320	0.9%
Sub-Total	457,524	**24.6%**
Petroleum Products	181,962	**9.8%**
Other Products	272,038	**14.6%**
Exportation Totale	1,860,920	100.0%

TABLE 2.2 COMPOSITION OF IMPORTS IN 1995

Item	Amount (Billions FCFA)	Percentage
Food, Drinks and Tobacco	**260.6**	**19.0%**
Fishies & Fresh Shellfish	72.1	5.2%
Cereal	96.4	7.0%
Rice	52.6	3.8%
Wheat	29.2	2.1%
Other	92.1	6.7%
Other consumption Goods	**331.7**	**24.2%**
	61.9	4.5%
	65.1	4.7%
Other consumption Goods	204.8	14.9%
Raw Material & Semi-finished Good	**434.1**	**31.6%**
Petroleum Products	234.5	17.1%
Crude Oil	185.5	13.5%
Paper & Cartoons	52.2	3.8%
Other	147.3	10.7%
Capital Equipment	**347**	**25.3%**
Machines	116.1	8.5%
Material of Transport	127.4	9.3%
Steel	30.7	2.2%
Other	72.9	5.3%
At Custom	**1373.4**	**100.0%**
Import (FOB)	1167.4	

TABLE 2.3 GEOGRAPHICAL DISTRIBUTION OF EXPORTS AND IMPORTS IN 1994

Country	Export		Import	
	Amount (Billions FCFA)	Percentage	Amount (Billions FCFA)	Percentage
Europe	**985.16**	**64.9%**	**589.5**	**56.1%**
EEC	**939.1**	**61.9%**	**537.3**	**51.1%**
Germany	110.7	7.3%	39.8	3.8%
Denmark	4.9	0.3%	1.8	0.2%
France	276.8	18.2%	326.6	31.1%
Spain	62	4.1%	36.6	3.5%
Greece	15.7	1.0%	3.8	0.4%
Ireland	6.6	0.4%	4.8	0.5%
Italy	116.3	7.7%	33.6	3.2%
Netherlands	224.5	14.8%	32.4	3.1%
Portugal	11.6	0.8%	4	0.4%
United Kingdon	43.7	2.9%	22.3	2.1%
Belgium/ Luxemburg	66.3	4.4%	31.6	3.0%
	939.1	61.9%	537.3	51.1%
Africa	**369.2**	**24.3%**	**222.6**	**21.2%**
CEDEAO*	330.9	21.8%	185.9	17.7%
Other	38.3	2.5%	36.7	3.5%
America	**71.9**	**4.7%**	**110.1**	**10.5%**
Asia	**88.5**	**5.8%**	**125.7**	**12.0%**
Oceania	**2.6**	**0.2%**	**3.8**	**0.4%**
Total	1517.36	100.0%	1051.7	100.0%

Note
*: Economical Community of the Western African Countries

TABLE 2.4 TRADE BALANCE AND INTERNATIONAL PAYMENT

Item	Unit	Year																						
		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Trade balance	Bill. FCFA	208.0	700.0	671.5	776.8	795.2	857.9	942.9	1076.1	1171.7	1253.5	1354.6	1431.9	1521.1	1614.9	1719.2	1828.1	1946.7	2080.8	2235.1	2402.8	2589.7	2797.6	3034.6	3301.5
Exports (FOB)	Bill. FCFA	713.2	1592.8	1906.6	2190.2	2378.9	2480.5	2675.6	2907.3	3119.7	3311.6	3544.6	3805.0	4085.2	4385.9	4713.9	5067.4	5451.5	5870.6	6329.0	6829.2	7376.6	7975.7	8634.7	9359.8
Of which	Bill. FCFA																								
Cocoa	Bill. FCFA	267.5	527.9	619.8	816.0	820.8	902.2	946.1	1008.9	1060.2	1099.3	1154.1	1210.5	1266.3	1320.2	1377.6	1432.6	1488.0	1544.7	1603.4	1663.7	1725.5	1788.4	1854.9	1925.2
Coffee	Bill. FCFA	68.9	138.5	212.1	151.8	208.4	196.0	205.5	217.3	224.8	230.3	238.1	251.0	264.6	278.9	293.1	308.1	323.8	340.4	357.9	375.1	393.2	412.2	432.3	453.4
Cocoa & coffee	Bill. FCFA	336.4	666.4	831.9	967.8	1029.2	1098.2	1151.6	1226.2	1285.0	1329.6	1392.2	1461.5	1530.9	1599.1	1670.5	1740.7	1811.8	1885.1	1961.3	2038.8	2118.7	2200.6	2287.2	2378.6
% of Cocoa & coffee in export	%	47.2%	41.8%	43.6%	44.2%	43.3%	44.3%	43.0%	42.2%	41.2%	40.1%	39.3%	38.4%	37.5%	36.5%	35.4%	34.4%	33.2%	32.1%	31.0%	29.9%	28.7%	27.6%	26.5%	25.4%
Imports (FOB)	Bill. FCFA	505.2	892.8	1235.1	1413.4	1583.7	1622.6	1732.7	1831.2	1948.0	2058.1	2190.0	2373.1	2564.1	2771.0	2994.7	3239.3	3504.8	3789.8	4093.9	4426.4	4786.9	5178.1	5600.1	6058.3
Services	Bill. FCFA	-486.4	-612.0	-772.0	-823.0	-846.7	-907.4	-941.5	-973.6	-999.7	-1023.1	-1057.7	-1103.1	-1158.1	-1215.8	-1288.4	-1378.2	-1464.5	-1592.2	-1751.4	-1883.8	-2039.1	-2194.6	-2362.4	-2544.4
Receipts	Bill. FCFA	219.0	297.6	405.6	396.0	432.7	485.1	523.8	558.9	603.4	650.5	700.0	752.7	808.8	868.9	932.6	1001.4	1075.6	1120.9	1168.2	1228.7	1292.4	1359.6	1430.5	1505.3
Payments	Bill. FCFA	703.4	909.6	1177.6	1219.0	1279.4	1392.5	1465.3	1532.5	1603.1	1673.6	1757.7	1855.8	1966.9	2084.7	2221.0	2379.6	2540.1	2713.1	2919.6	3112.5	3331.5	3554.2	3792.9	4049.7
Transfers	Bill. FCFA	-46.6	-131.2	-197.7	-214.1	-216.3	-237.7	-260.0	-283.0	-312.2	-343.8	-376.7	-411.2	-447.6	-481.3	-522.0	-560.5	-602.0	-646.9	-695.3	-747.6	-804.2	-865.4	-931.5	-1003.1
Current account	Bill. FCFA	-322.8	-43.2	-298.2	-260.3	-267.8	-287.2	-258.6	-180.5	-140.2	-113.4	-79.8	-82.4	-84.6	-82.2	-91.2	-110.6	-119.8	-158.3	-211.6	-228.6	-253.6	-262.4	-259.3	-246.0
% of GDP	%	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Memorandum items:																									
Nominal GDP	Bill. FCFA	2946.0	4256.0	4987.7	5473.6	5983.4	6529.8	7100.2	7690.7	8306.1	8962.5	9647.8	10374.5	11148.2	11977.2	12854.8	13801.8	14823.9	15927.6	17119.9	18408.1	19800.7	21306.6	22935.5	24693.3
Nominal exchange rate	Bill. FCFA	283.2	555.2	499.1	511.6	582.4	594.5	591.6	588.3	585	574	570	570	570	570	570	570	570	570	570	570	570	570	570	570

TABLE 2.5 COMPOSITION OF GDP

Item	Unit	Year							
		1993	1994	1995	1996	1997	1998	1999	2000
Gross domestic product	%	100.0	100.0	100.0	100.0	100.0	100.1	100.0	100.0
Agriculture	%	34.9	27.7	28.8	27.6	27.3	27.0	26.6	26.2
Industry	%	20.7	18.5	20.0	21.2	21.8	22.5	23.2	23.9
Service	%	44.4	53.8	51.2	51.2	50.9	50.6	50.2	49.9
Consumption (private & govt)	%	90.3	77.6	79.7	80.0	76.7	72.8	72.4	72.7
Investment (incl. stock inv.)	%	7.4	10.8	12.8	14.4	18.6	21.6	21.3	20.3
Of which									
Government	%	3.4	3.8	4.1	4.5	5.6	5.7	5.7	5.7
Private	%	4.0	7.0	8.7	9.9	13.0	15.9	15.6	14.6
Exports	%	31.3	42.9	41.1	44.6	45.3	46.6	46.9	47.0
Imports	%	27.5	33.1	35.7	38.3	40.5	41.1	40.6	40.0
Net Exports	%	3.8	9.8	5.4	6.3	4.8	5.5	6.3	7.0
Consump+Invest+Net Export	%	101.5	98.2	97.9	100.7	100.1	99.9	100.0	100.0
GDP per capita (FCFA)	FCFA	10406	7666	9992	10685	10476	11309	12235	13208
GDP per capita (USD)	USD	720	640	640	640	640	690	700	730
Growth rate									
GDP %	%	-0.3	2.1	7.1	6.8	6.3	6.0	6.0	5.9
GDP per capita %	%	-3.7	-1.4	3.4	3.1	3.2	2.6	2.6	2.5

TABLE 2.6 COMPOSIOTN OF INTERNATIONAL FINANCIAL AIDS

Funder	Year								
	1990	1991	1992	1993	1994	1995	1996	Total	
	FCFA	FCFA	FCFA	FCFA	FCFA	FCFA	FCFA	FCFA	%
World Bank	51.5	44.5	34.9	0.0	249.0	107.2	102.4	589.5	
IMF	41.2	12.7	0.0	0.0	94.6	89.5	72.5	310.5	
ADB	22.9	23.3	16.7	13.8	46.4	0.0	6.4	129.5	
EEC	33.4	21.2	20.8	19.8	62.2	35.5	25.7	218.6	
Total	149.0	101.7	72.4	33.6	452.2	232.2	207.0	1,248.1	
France	57.5	43.0	77.0	113.7	12.0	120.0	50.0	473.2	86%
Japan	8.7	5.3	0.0	5.1	8.6	3.7	0.0	31.4	6%
Germany	0.0	5.4	0.0	5.1	0.0	10.0	0.0	20.5	4%
United State	5.1	2.8	0.8	2.8	4.7	0.0	2.1	18.3	3%
Other	0.0	0.0	0.4	0.0	2.0	1.3	0.0	3.7	1%
Total	71.3	56.5	78.2	126.7	27.3	135.0	52.1	547.1	100%

TABLE 2.7 LABOR MARKET CONDITION

(1) The Composition of Labor Force (1995)

Administration publique	Public Administration	105,000	2.0%
Secteur prive moderne	Modern Private Sector	125,000	2.3%
Secteur informel (tout statuts)	Informal Sector (Any Statutes)	1,698,300	31.9%
Secteur traditionnel agricole	Traditional Agricultural Sector	3,400,000	63.8%
Total	Total	5,328,300	100.0%

(1) The Trend of Public Servants

		1980	1985	1987	1990	1992	1995
Administration publique	Public Administration	73,847	107,460	110,200	116,000	103,160	105,000

Recruitments	Recruitment	1993	1994	1995	Total	
Non enseignments	No Education	849	1503	1586	3,938	36%
Enseignments	Education	2,675	1529	2920	7,124	64%
Total	Total	3,524	3,032	4,506	11,062	100%

TABLE 2.8 DISTRIBUTION OF POPULATION USING DIFFERENT TYPES OF DISPOSAL SYSTEMS

Sector		Sewerage/septic tanks (% population)	Courtyard latrines (% population)	External latrines (% population)	Others (% population)
Yopougon	Yopougon Attié	46.53	28.46	2.81	22.2
	Banco Nord	70.28	8.82	1.05	19.85
	Banco Sud	59.14	33.62	2.03	5.21
	Extension du Port	17.2	31.19	34.32	17.29
	Yopougon Kouté	74.05	18.65	1.64	5.66
	Zone Industrielle	25.38	23.47	1.69	49.46
	Hôpital	21.82	16.49	7.93	53.76
	Niangon Nord	13.87	52.51	1.21	32.41
	Niangon Sud	47.53	31.15	8.34	12.98
	ORSTOM	15.26	15.04	13.14	56.56
	Average	**39.11**	**25.94**	**7.42**	**27.54**
Attécoubé	Adjamé Santé	0.39	7.34	34.25	58.02
	Santé II	11.85	62.06	6.01	20.08
	Santé III	0.52	33.38	10.19	55.91
	Locodjoro	4.33	42.28	18.27	35.12
	Abobo Dumé	10.7	47.02	8.67	33.61
	Attécoubé III	1.08	11.24	21.28	66.4
	Parc National du Banco	0	26.37	60.81	12.82
	Average	**4.12**	**32.81**	**22.78**	**40.28**

Source: Outline of Yopougon and Attécoubé District (BNETD, August 1999)

TABLE 2.9 SOURCES OF POTABLE WATER

Sector		Water Supply Service Area (%)	Source of Potable Water (%)		
			Water Supply System	Well	Others
Yopougon	Yopougon Attié	90.63	93.54	0.96	5.50
	Banco Nord	74.50	94.20	0.00	5.80
	Banco Sud	0.67	96.71	1.40	1.89
	Extension du Port	32.03	44.84	28.24	26.92
	Yopougon Kouté	98.40	99.19	0.16	0.65
	Zone Industrielle	69.91	98.72	0.53	0.75
	Hopital	57.13	95.4	4.08	0.52
	Niangon Nord	99.45	90.77	3.24	5.99
	Niangon Sud	79.9	89.31	1.21	9.48
	ORSTOM	14.39	22.67	21.09	56.24
	Average	**61.70**	**82.54**	**6.91**	**11.37**
Attécoubé	Adjamé Santé	13.47	64.43	4.18	31.39
	Santé II	28.05	77.26	11.5	11.24
	Santé III	2.69	73.99	0.90	25.11
	Locodjoro	83.92	81.68	8.09	10.23
	Abobo Dumé	100.00	98.88	0.02	1.1
	Attécoubé III	5.02	96.35	0.11	3.54
	Parc National du Banco	0.00	46.15	0.00	53.85
	Average	**33.31**	**76.96**	**3.54**	**19.49**

Source: Outline of Yopougon and Attécoubé District (BNETD, August 1999)

TABLE 2.10 GROUNDWATER QUALITY AND ITS TREATED WATER IN ADJAME PUMPING STATION

Water Quality Parameters	Units	Raw Water	Treated Water
Water Temperature	Degree Celsius	27.6	26.7
pH		4.92	6.05
Taste	Unobjectionable		
Odor	Unobjectionable		
Color	mg/l Co. Pt	2	1
Turbidity	NTU	0.262	0.185
Alkalinity as $CaCO_3$	mg/l	0	48.8
Ammonia nitrogen (NH_4^+)	mg/l	0.845	0.048
Zinc	mg/l	0.041	
Iron	mg/l	<0.008	0.08
Copper	mg/l	<0.021	0.01
Sodium	mg/l	6.28	
Aluminum	mg/l	<0.005	<0.005
Manganese	mg/l	0.018	<0.005
Chloride	mg/l	6.39	8.85
Hardness as $CaCO_3$	mg/l	5	54.4
Total Dissolved Solids	mg/l	38.8	74.3
Organic Substances (Potassium Permanganate Consumption Value)	mg/l	0.05	0.02
Nitrate as NO_3^-	mg/l	20	12.32
Nitrite as NO_2^-	mg/l	<0.026	0.0025
Residual Chlorine	mg/l		0.23

TABLE 2.11 DATA ON PUMPING STATIONS

	Pumping St.	Manufacturer	Ot (h)	Np	C (m^3/h)	Q (m^3/d)	H (m)	P (kW)
1	RB1	Flygt	3.6	2	7	25.2	18	1.3
2	Allabra	do.	4	2	160	640	9	5.6
3	RC11	do.	3.12	2	160	499.2	10	5.6
4	RC12	do.	5.53	2	160	884.8	10	5.6
5	RC19	do.	8.72	2	160	1395.2	10	5.6
6	RC20	do.	7.63	2	3.11	23.7293	16	1.5
7	Sideci	do.	4.5	2	18	81	18	1.3
8	S5 Abobo	do.	-	-	-	-	8	9
9	S7 Abobo	Hydrost	1.56	4	364	567.84	8.4	90
10	RAB2	Flygt	-	-	-	-	9	5.6
11	Williamsville	Flygt	3.37	2	44	148.28	3	1.3
12	Aquarium	ETK	1.31	4	1400	1834	5.4	37
13	Pt De Gaulle	Hydrost	1.2	4	576	691.2	8.4	90
14	Biafrais	Flygt	1.87	2	18	33.66	3	1.3
15	7J1	Hydrost	2.67	4	1920	5126.4	10.2	75
16	P. et M.Curie	Flygt	4.81	2	127	610.87	5	3.1
17	Rue des P.	KRTE	Under Rehabilitation	2	160	-	8	5
18	MU7	Flygt	2.03	3	180	365.4	6	-
19	MU8	do.	8.29	2	97	804.13	8.4	2.9
20	Sopin	do.	Under Rehabilitation	2	256	-	6.6	6.35
21	RK10	KRTE	4.35	2	180	783	5	6.9
22	RK11	do.	8.62	2	180	1551.6	5	2.2
23	RK12	Flygt	3.51	2	269	944.19	6	-
24	RK13	KRTE	3.24	2	55	178.2	5.5	2.2
25	RPB1	Flygt	14.5	3	191.65	2778.925	-	-
26	RPB2	do.	6.56	2	137	898.72	4.5	6.34
27	RPB3	do.	10.23	2	137	1401.51	5.5	6.34
28	RPB4	do.	4.14	2	97.6	404.064	10	2.35
29	Vridi	do.	21.63	2	50	1081.5	5.5	1.7
30	RK1	do.	2.6	2	59.4	154.44	4.5	1.3
31	RK2	Flygt	2.62	2	104.4	273.528	4	2
32	RK3	do.	1.3	2	57.6	74.88	10	13.5
33	RK4	do.	0.83	2	57.6	47.808	2	1.3
34	RK5	do.	4.44	2	59.4	263.736	7	2
35	RK6	do.	Not Working	2	59.4	-	4.5	1.3
36	RK7	do.	0.72	2	55.8	40.176	3	1.3
37	RK8	do.	1.6	2	91.8	146.88	5.5	3.1

Note: Ot: Operation Time, Np: Number of Pump, C: Capacity, Q: Quantity, H: Head, P: Power

TABLE 2.12 FACILITIES OF S1 PUMPING STATION

Items	Descriptions	Quantity	Remarks
Manual Sluice Gate	1.0 m × 1.0 m	1	Manual Control
Screen with Mechanized Rake (Year of manufacture 1978)	Width 2.4 m	1	Additional space & structure
Grit Chamber	diameter 5.5 m	1	
Sand Extraction Pump	diameter 50 mm × 10 m × 1 kW	1	
Vertical Axis Pump (Year of manufacture 1978)	diameter 500 mm, nominal discharge 576 L/sec, nominal pump head 8.4 m, rotation speed 980 rpm	4	2 pumps are under repair; one is not connected to engine.
Synchronous Electrical Engine (Year of manufacture 1978)	380 v, 50 Hz, nominal power 75 kW	4	2 engines are under repair.
Effluent Pipe	diameter 800 mm ~ 1200 mm		
Generator	450 KVA × 380 V × 50 Hz	1	
Electrical Panel		6	For generator and pumps
Monorail Hoist		1	

TABLE 2.13 FACILITIES OF 7J1 PUMPING STATION

Items	Descriptions	Quantity	Remarks
Manual Sluice Gate	2.0 m × 1.0 m	1	Manual Control
Screen with Mechanized Rake (Year of manufacture 1981)	Width 1.4 m	2	Additional space & structure
Grit with Manual Rake		1	Manual cleaning
Vertical Axis Pump (Year of manufacture 1980)	diameter 500 mm, nominal discharge 530 L/sec, nominal pump head 10.2 m, rotation speed 960 rpm	3	
Synchronous Electrical Engine (Year of manufacture 1988)	380 v, 50 Hz, nominal power 75 kW	3	
Effluent Pipe	diameter 500 mm ~ 1000 mm		
Generator	700 KVA × 380 V × 50 Hz	1	
Electrical Panel		6	For generator and pumps
Monorail Hoist		1	

TABLE 2.14 FACILITIES OF PRE-TREATMENT PLANT

Items	Descriptions	Quantity	Remarks
Manual Sluice Gate	1.8 m × 1.8 m	1	Stainless steel
Archimedes' Screw Pump of Flygt	Nominal capacity 910 L/sec	2	Additional space & structure for two more
Engines	380 v, 50 Hz, nominal power 75 kW	2	
Electrical Panel		2	
Mechanically Cleaned Screen		1	
Manually Cleaned Screen		1	
Grit & Oil Removing Tank with Rake-Bridge		2	Each tank has two compartment
Aeration Turbine		12	.for air injection/ 3 turbines per compartment
Sand Extraction Pump (WEMCO trademark)		8	2 pumps per compartment
Eccentric Screw Pump (SEEPE trademark)		4	For grease draining/ 1 pump per compartment
Stocking Sandpit		2	
Hydrocyclone		8	4 hydrocyclone per sandpit
Submersible Pumps (KSB trademark)	nominal discharge 455 L/sec, nominal pump head 7.35 m, 38 kW, 50 Hz	4	
Effluent Pipe	diameter 800 mm ~ 1400 mm	1	

TABLE 2.15 OPERATION RECORD OF S1 PUMPING STATION IN 1998

Pump	Capacity (m^3/h)	Jan			Feb			Mar		
		Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)
P1	2073	1.6	3316.8		0.0	0.0		0.0	0.0	
P2	2073	0.2	414.6		0.0	0.0		0.0	0.0	
P3	2073	0.0	0		0.0	0.0		0.0	0.0	
P4	2073	17.5	36277.5		42.7	88517.1		114.9	238187.7	
Total	8292	19.3	40,009	1,334	42.7	88,517	2,951	114.9	238,188	7,940
		Apr			May			Jun		
		Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)
P1	2073	0.8	1658.4		37.8	78359.4		153.6	318412.8	
P2	2073	0.0	0.0		0.0	0.0		0.0	0.0	
P3	2073	0.0	0.0		0.0	0.0		0.0	0.0	
P4	2073	131.0	271563		127.2	263685.6		0.0	0.0	
Total	8292	131.8	273,221	9,107	165	342045	11,402	153.6	318,413	10,614
		Jul			Aug			Sep		
		Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)
P1	2073	0.0	0.0		1.7	3524.1		0.1	207.3	
P2	2073	81.5	168949.5		15.5	32131.5		0.0	0.0	
P3	2073	0.0	0.0		0.0	0.0		0.0	0.0	
P4	2073	9.0	18657		124.9	258917.7		18.6	38557.8	
Total	8292	90.5	187,607	6,254	142.1	294,573	9,819	18.7	38,765	1,292
		Oct			Nov			Dec		
		Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)
P1	2073	0.0	0.0		1.7	3524.1		0.1	207.3	
P2	2073	81.5	168949.5		15.5	32131.5		0.0	0.0	
P3	2073	0.0	0.0		0.0	0.0		0.0	0.0	
P4	2073	9.0	18657		124.9	258917.7		18.6	38557.8	
Total	8292	90.5	187,607	6,254	142.1	294,573	9,819	18.7	38,765	1,292

Note; Ot: Operation Time (hour), Qt: Total Quantity (m^3), Q: Quantity (m^3/d)

TABLE 2.16 OPERATION RECORD OF 7J1 PUMPING STATION IN 1998

Pump	Capacity (m^3/h)	January			February			March		
		Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)
P1	1851	26.4	48866.4		40.9	75705.9		127.2	235447.2	
P2	1993	29.4	58594.2		37.6	74936.8		122.5	244142.5	
P3	1916	56.9	109020.4		74.1	141975.6		249.8	478616.8	
Total	5760	112.7	216,481	7,216	152.6	292,618	9,754	499.5	958,207	31,940
		April			May			June		
		Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)
P1	1851	64.0	118464		57.5	106432.5		40.9	75705.9	
P2	1993	60.7	120975.1		49.5	98653.5		41.3	82310.9	
P3	1916	120.8	231452.8		104.2	199647.2		78.3	150022.8	
Total	5760	245.5	470,892	15,696	211.2	404,733	13,491	160.5	308,040	10,268
		July			August			September		
		Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)
P1	1851	41.1	76076.1		23.6	43683.6		0.0	0.0	
P2	1993	40.9	81513.7		27.0	53811		42.2	84104.6	
P3	1916	77.0	147532		50.3	96374.8		62.0	118792	
Total	5760	159	305,122	10,171	100.9	193,869	6,462	104.2	202,897	6,763
		October			November			December		
		Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)	Ot(h)	Qt(m^3)	Q(m^3/d)
P1	1851	41.1	76076.1		23.6	43683.6		0.0	0.0	
P2	1993	40.9	81513.7		27.0	53811		42.2	84104.6	
P3	1916	77.0	147532		50.3	96374.8		62.0	118792	
Total	5760	159	305,122	10,171	100.9	193,869	6,462	104.2	202,897	6,763

Note; Ot: Operation Time (hour), Qt: Total Quantity (m^3), Q: Quantity (m^3/d)

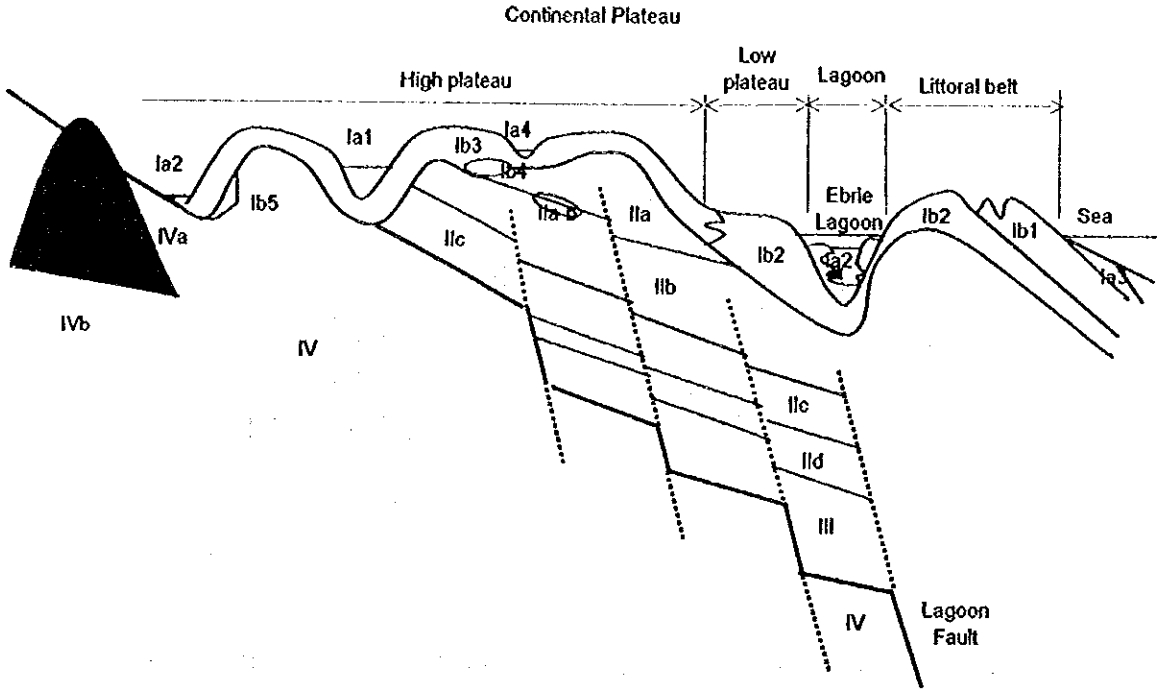
TABLE 2.17 OPERATION RECORD OF SEWAGE PRE-TREATMENT PLANT IN 1998

Pump	Capacity (m^3/h)	January			February			March		
		Ot (h)	Qt (m^3)	Q (m^3/d)	Ot (h)	Qt (m^3)	Q (m^3/d)	Ot (h)	Qt (m^3)	Q(m^3/d)
P1	1620	0.0	0.0		0.0	0.0		0.0	0.0	
P2	1620	0.0	0.0		0.0	0.0		0.0	0.0	
P3	1620	0.0	0.0		0.0	0.0		0.0	0.0	
P4	1620	0.0	0.0		0.0	0.0		0.0	0.0	
Total	6480	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		April			May			June		
		Ot (h)	Qt (m^3)	Q (m^3/d)	O (h)	Qt (m^3)	Q (m^3/d)	Ot (h)	Qt (m^3)	Q(m^3/d)
P1	1620	0.0	0.0		0.0	0.0		66.7	108054	
P2	1620	0.0	0.0		0.0	0.0		97.7	158274	
P3	1620	0.0	0.0		0.0	0.0		32.4	52488	
P4	1620	0.0	0.0		0.0	0.0		30.8	49896	
Total	6480	0.0	0.0	0.0	0.0	0.0	0.0	227.6	368,712	12,290
		July			August			September		
		Ot (h)	Qt (m^3)	Q (m^3/d)	Ot (h)	Qt (m^3)	Q (m^3/d)	Ot (h)	Qt (m^3)	Q(m^3/d)
P1	1620	0.0	0.0		0.0	0.0		0.0	0.0	
P2	1620	0.0	0.0		0.0	0.0		0.0	0.0	
P3	1620	0.0	0.0		0.0	0.0		0.0	0.0	
P4	1620	0.0	0.0		0.0	0.0		0.0	0.0	
Total	6480	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		October			November			December		
		Ot (h)	Qt (m^3)	Q (m^3/d)	Ot (h)	Qt (m^3)	Q (m^3/d)	Ot (h)	Qt (m^3)	Q (m^3/d)
P1	1620	0.0	0.0		0.0	0.0		0.0	0.0	
P2	1620	0.0	0.0		0.0	0.0		0.0	0.0	
P3	1620	0.0	0.0		0.0	0.0		0.0	0.0	
P4	1620	0.0	0.0		0.0	0.0		0.0	0.0	
Total	6480	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note; Ot: Operation Time (hour), Qt: Total Quantity (m^3), Q: Quantity (m^3/d)

TABLE 2.18 MONTHLY OPERATION COST OF EXISTING PUMPING STATIONS

Medium Voltage					Low Voltage				
	Name of PS	Q (m^3/d)	Q (m^3/mon)	Total Cost (FCFA)		Name of PS	Q (m^3/d)	Q (m^3/mon)	Total Cost (FCFA)
1	RK12	944.19	28,326	135,210	1	RPB1	2778.925	83,368	314,223
2	Allabra	640	19,200	264,313	2	RC11	499.2	14,976	79,450
3	Aquarium	1834	55,020	456,340	3	RC12	884.8	26,526	72,718
4	MU7	365.4	10,962	80,870	4	MU8	804.13	24,124	28,475
5	RK3	74.88	2,246	104,569	5	RPB2	898.72	898	73,524
					6	RPB3	1401.51	42,045	112,778
					7	RPB4	404.064	12,122	20,513
					8	Vridi	1081.5	32,445	130,015
					9	RK	47.808	1,434	37,338
					10	RK5	263.736	7,912	29,427
					11	RK7	40.176	1,205	30,379
					12	RK8	146.88	4,406	85,683

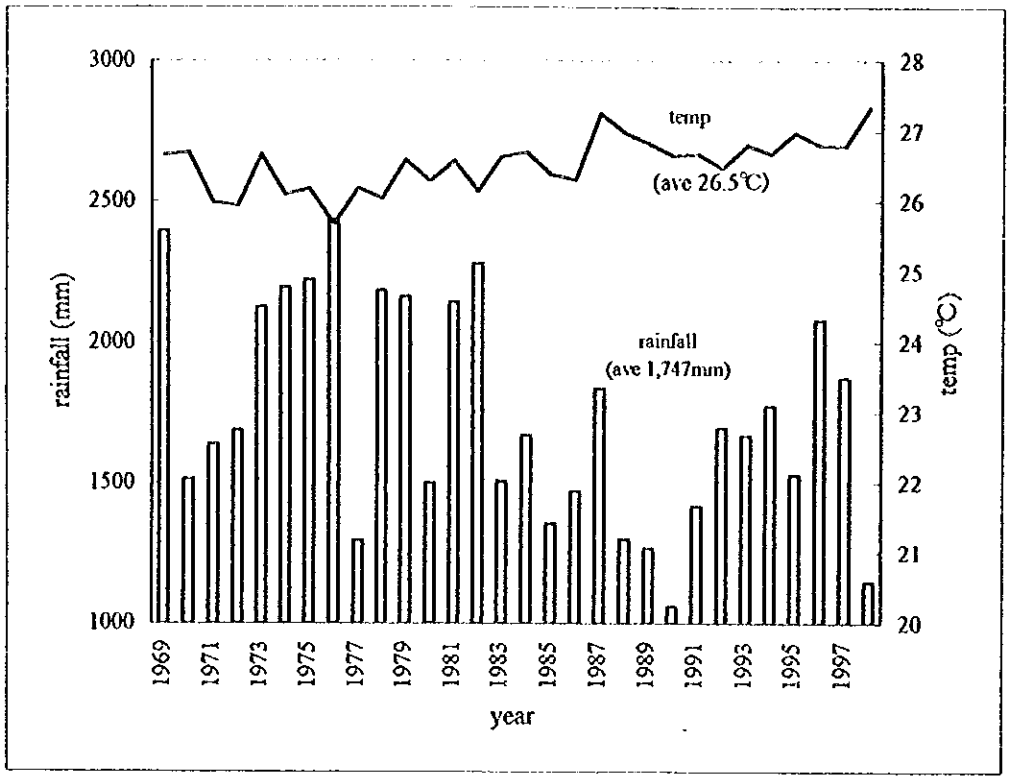


LITHOLOGICAL STRATIGRAPHY OF ABIDJAN

Period	Mark	Formation
Quaternary (Alluvium)	Ia1	Depression deposit; Clayey sand
	Ia2	River and lagoon deposit; Sand, Clay
	Ia3	Marine deposit; Sand, Clay
Quaternary (Deluvium)	Ib1	Coastal deposit; Sand
	Ib2	Low plateau deposit; Clayey sand
	Ib3	High plateau deposit; Clayey sand
	Ib4,5	Gravel
Tertiary	IIa	Coarse sand
	IIa-b	Stiff soil containing much iron
	IIb	White, Black and Complex colored sand, and intercalation sandy and silty soil
	IIc	Medium and coarse sand
	IId	Sand, Clay and Peat
Cretaceous	III	Sandstone, Shale, Conglomerate and Limestone
Pre-Cambrian	IVa	Schist, Cristalline schist
	IVb	Granite

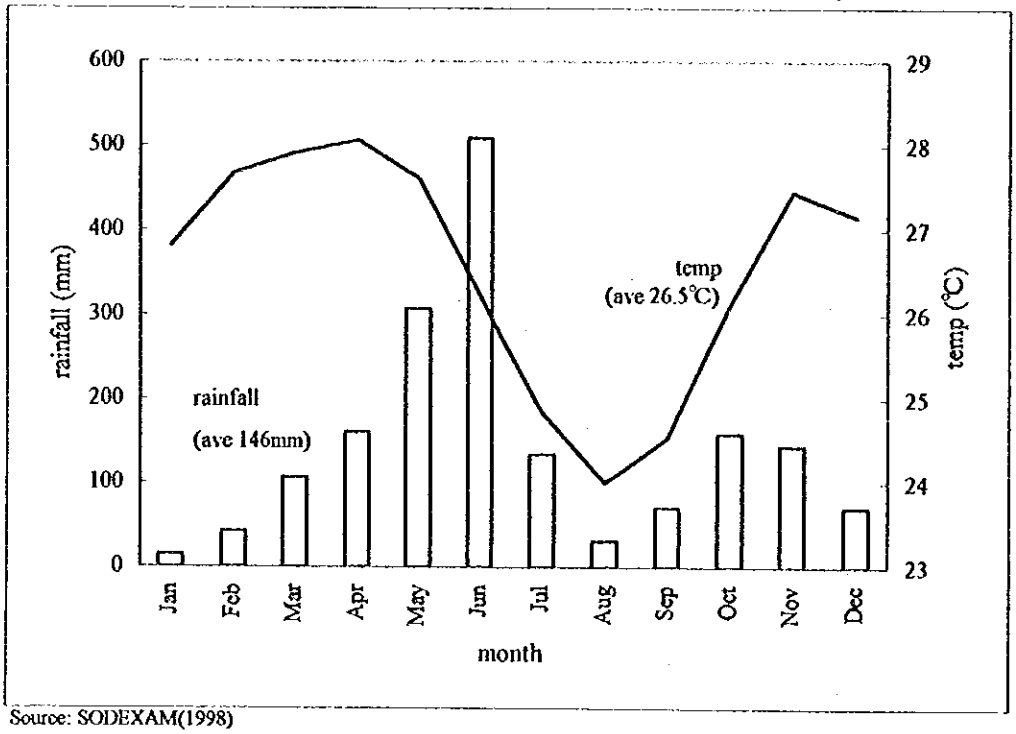
Source: LBTP 1986

FIG 2.1 SHEMATIC GEOLOGICAL PROFILE OF ABIDJAN



Source: SODEXAM(1998)

ANNUAL RAINFALL AND ANNUAL AVERAGE TEMPERATURE



Source: SODEXAM(1998)

MONTHLY AVERAGE RAINFALL AND TEMPERATURE

FIG 2.2	METEOROLOGICAL CONDITION FROM 1969 TO 19998 IN ABIDJAN

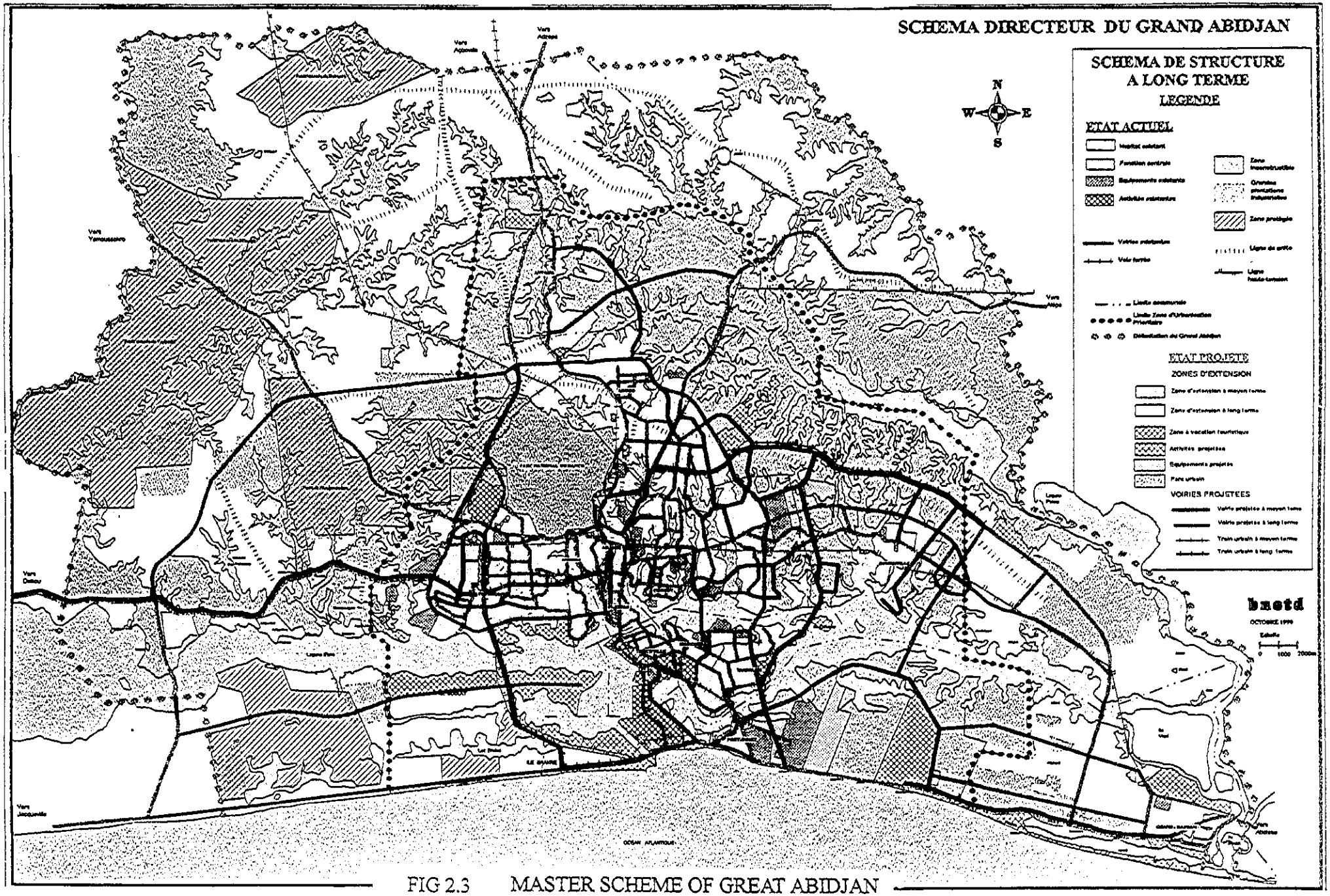


FIG 2.3 MASTER SCHEME OF GREAT ABIDJAN

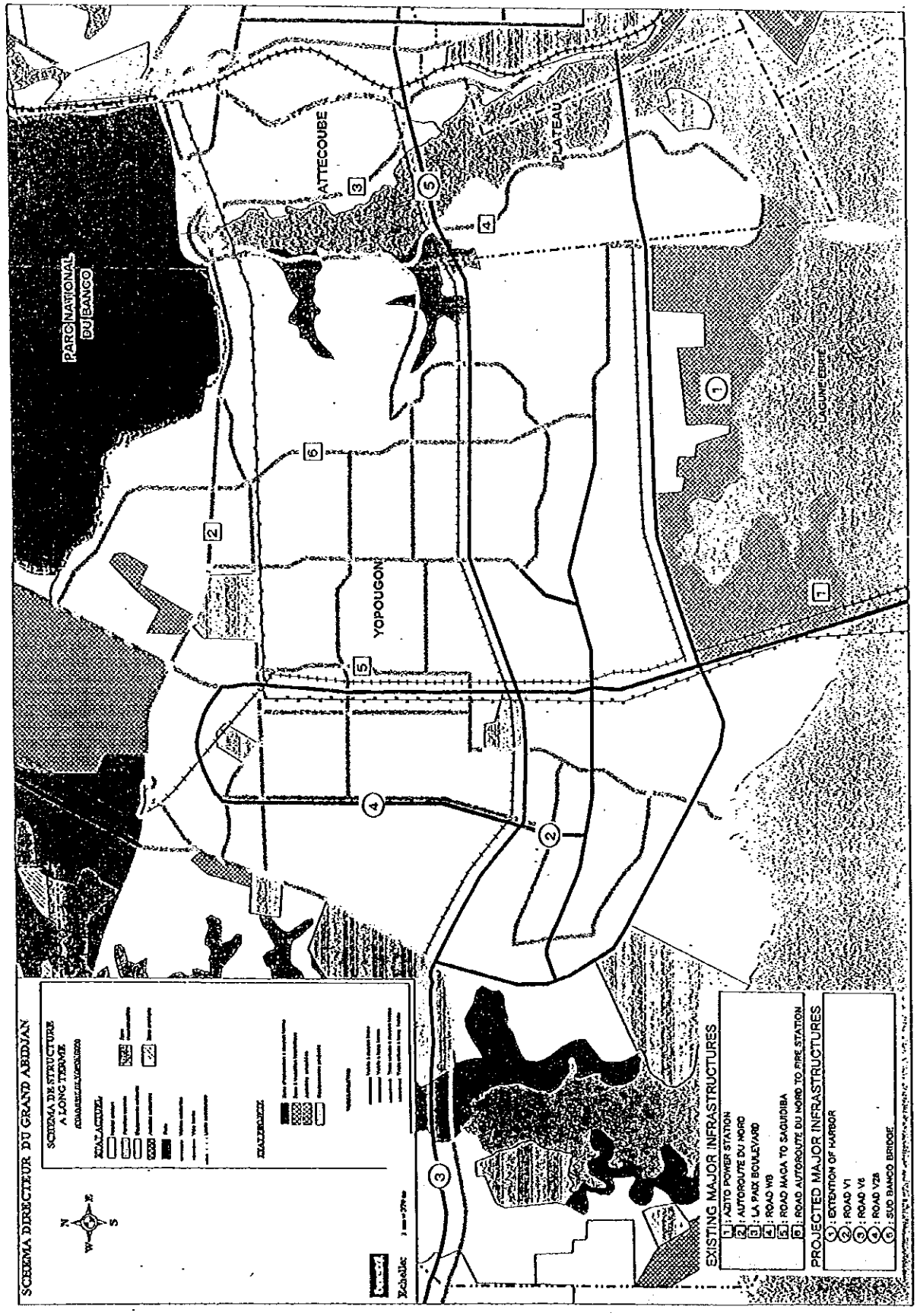


FIG 2.4 MAJOR INFRASTRUCTURES IN STUDY AREA

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

JICA

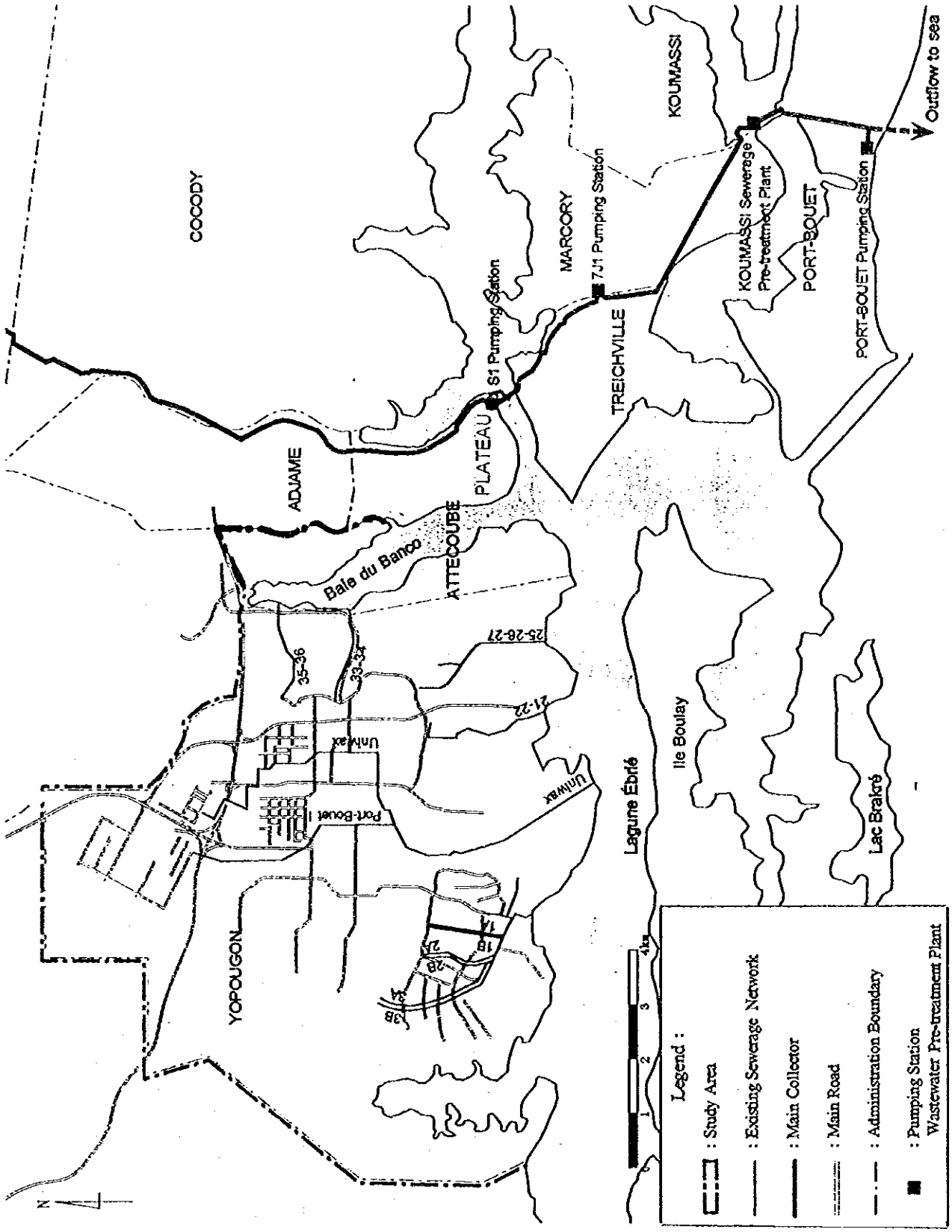


FIG 2.5	EXISTING SEWERAGE SYSTEM

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

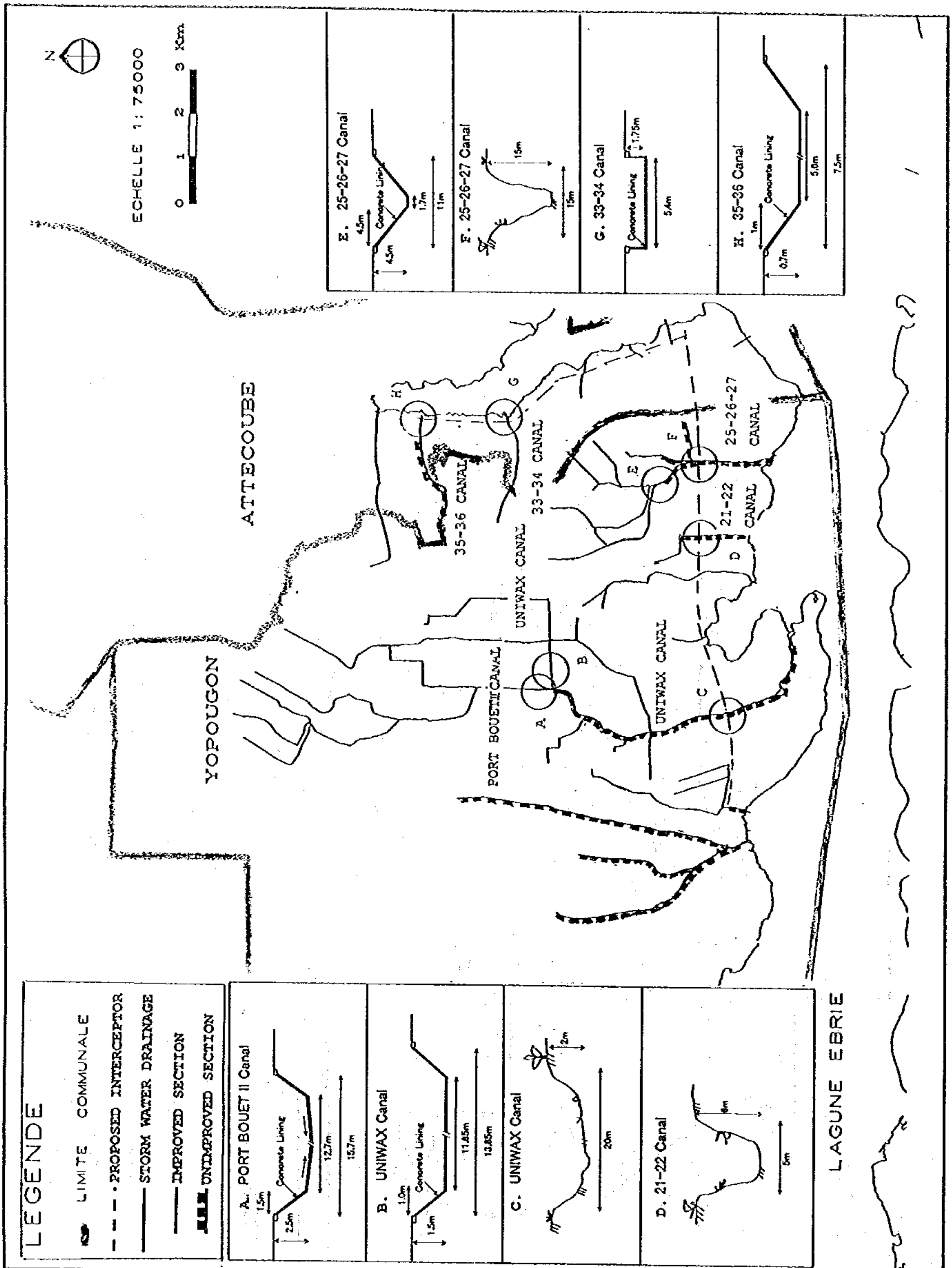


FIG 2.6 EXISTING STORM WATER DRAINAGE SYSTEM

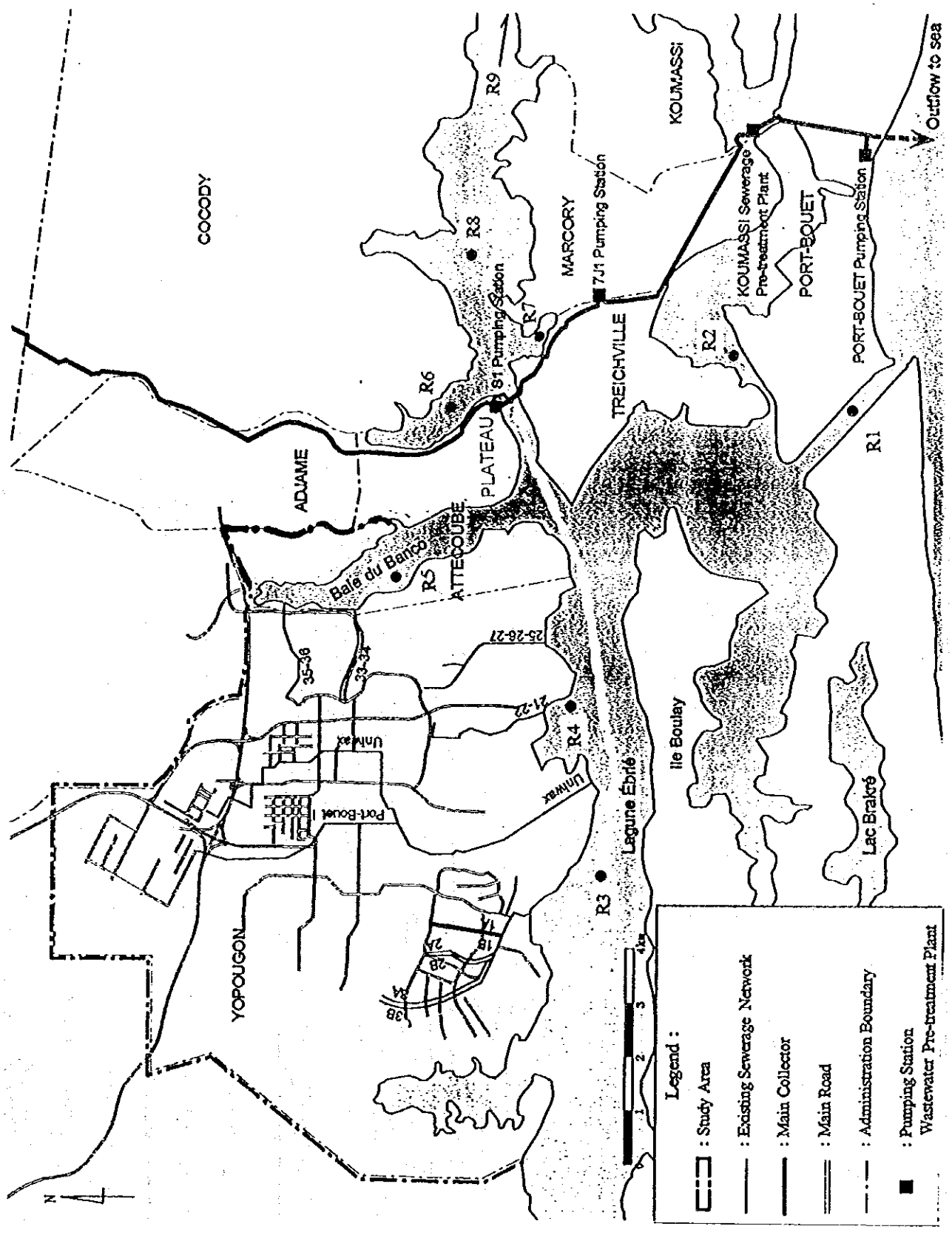


FIG 2.7 LOCATION OF WATER QUALITY SAMPLING IN LAGOON

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

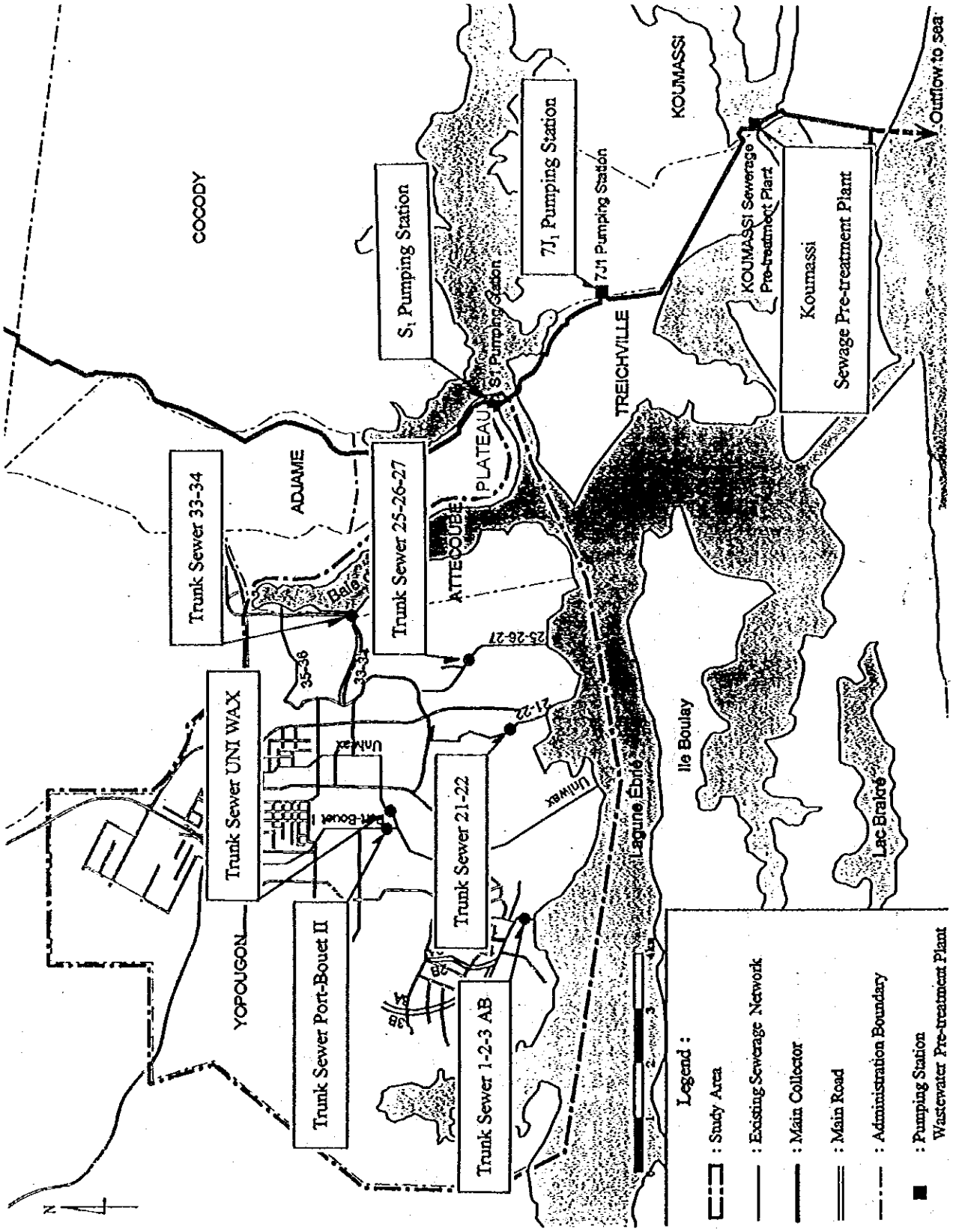


FIG 2.8 LOCATION FOR SEWAGE QUANTITY AND QUALITY SURVEY

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

JICA

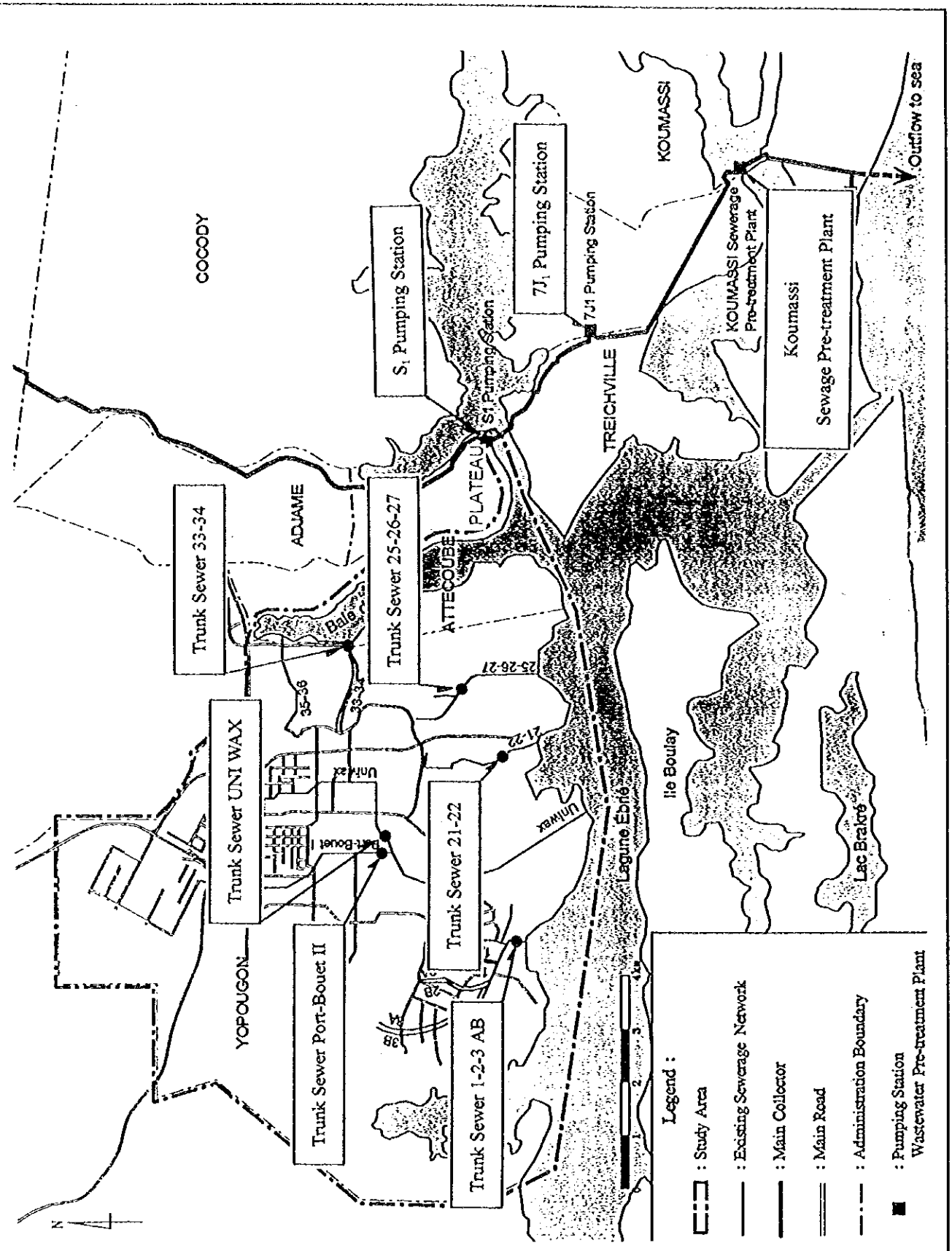


FIG 2.8 LOCATION FOR SEWAGE QUANTITY AND QUALITY SURVEY

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