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
SUMMARY

JANUARY 2000

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO
TOKYO ENGINEERING CONSULTANTS, TOKYO

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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,

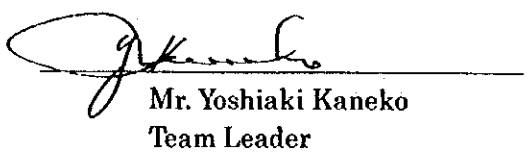
We are pleased to submit to you the final report entitled " The Feasibility Study on Sewerage Facilities in Western District of Abidjan City in the Republic of Côte d'Ivoire ". This report has been prepared by the Study Team in accordance with the contract signed on 11 March 1999 between the Japan International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

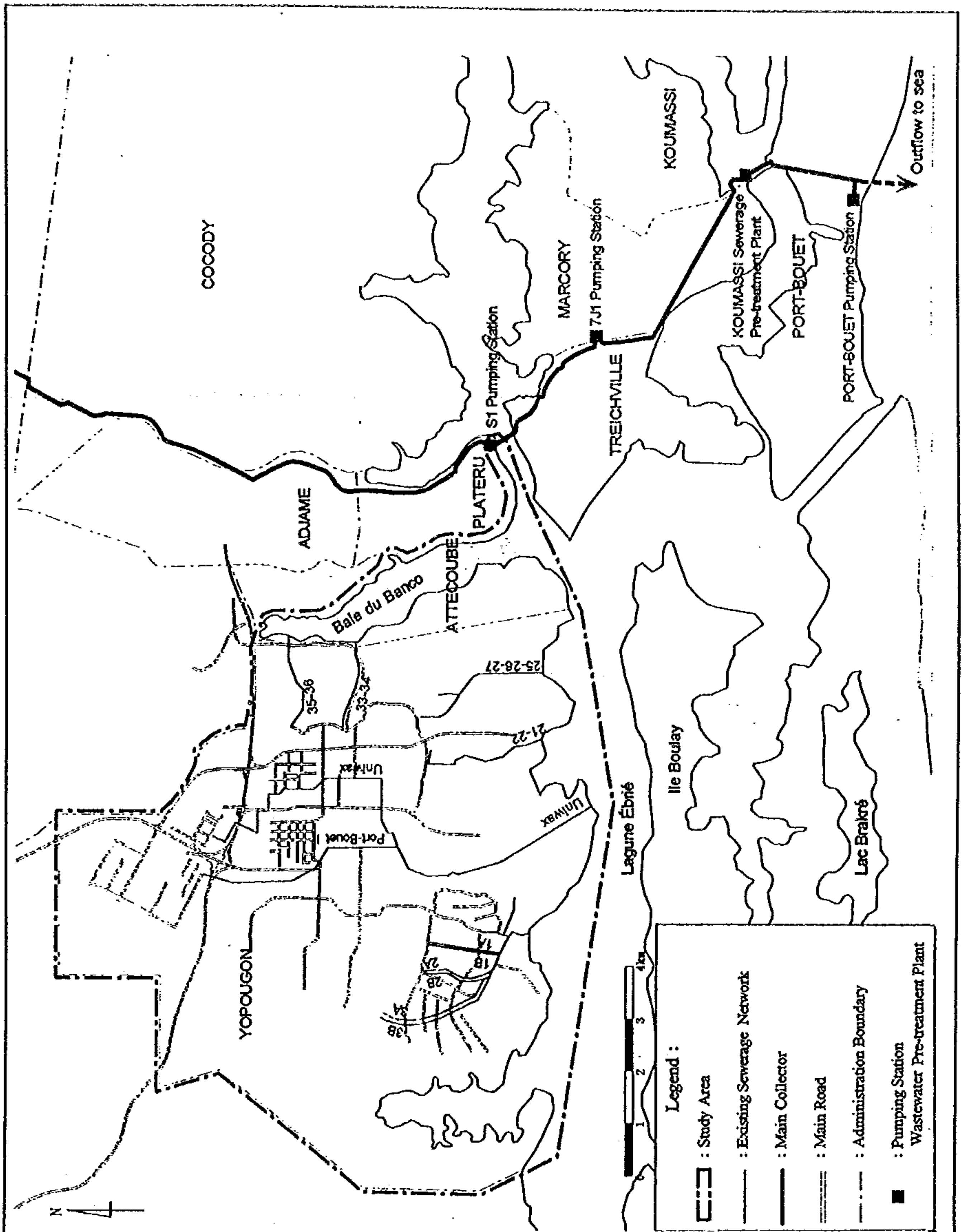
The report consists of the Executive Summary, Main Report, and Supporting Report. The Executive Summary summarizes the results of all studies. The Main Report contains background conditions, results of the feasibility studies, and conclusions and recommendations. The Supporting Report includes technical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



STUDY AREA

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

JICA

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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 its independence. 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 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 thousand)
Yopougon	7,200	756
Attécoubé (west)	610	147
Study Area Total	7,810	904

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 Logement 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:

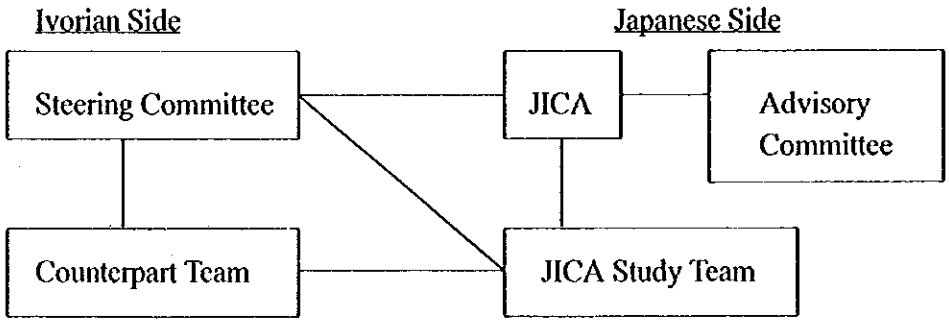

Fig. 1.1 Study Organization

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 was completed in Japan one month after the Study Team recieved comments made by the Ivorian Side to the Draft Final Report.

CHAPTER 2 REVIEW OF EXISTING SEWERAGE PLAN IN THE WESTERN DISTRICT

2.1 Studies and Investigations

For the Feasibility Study of the sewerage system of the Western District the following investigations and studies were carried out:

(1) Projection of future population in 2003 and esimation of design wastewater.
(2) Identification of existing conditions of the sewerage system in the Study Area.
(3) Comparison of alternative interceptor routes and selection of optimun route.
(4) Site investigation for design of sewerage faciliies; topographic survey, soil survey.
(5) Wastewater flow and water quality survey for sewerage planning.
(6) Site reconnaissance and proposal of rehabilitaiton plan of damaged trunk sewers.
(7) Site reconnaissance and proposal of rehabilitation/improvement guideline of the existing drainage canals.
(8) Preparation of facility plan of interceptor for the year of 2003.
(9) Selection of urgent works of sewerage facilities of the interceptor.

2.2 Population and Land Use

2.2.1 Population Projection

The future population of Abidjan City was projected by BNETD up to the year 2015 based on the general census realized in 1988. These projections were made on the basis of the rhythm of densification that is done with the increase of the number of persons in a room, the number of rooms in a parcel, the number of parcels or houses which are inhabited and the number of parcels per ha.

Table 2.1 Present and Projected Future Populations in the Study Area and Abidjan

District	1998	2003	2015
Yopougon	596,500	756,600	1,265,300
Attécoubé West	258,100	328,200	551,500
Total	854,600 (31.7%)	1,084,800 (33.8%)	1,816,800 (38.9%)
Abidjan	2,695,000	3,208,000	4,673,000

2.2.2 Land Use

For Abidjan City, there exists only Land Use (MOS) in 1989. The actualization of the Urban

Master Plan started in 1993 has not yet been achieved. The districts of Yopougon and Attécoubé have a surface area of 6,667 ha and 4,029 ha, respectively. According to the Land Use Map in 1989, the land use of Yopougon and Attécoubé are as follows:

Table 2.2 Land Use of Yopougon and Attécoubé in 1989

Land Use	Yopougon Area (ha) and Percentage	Attécoubé Area (ha) and Percentage
Natural spaces	3,803 (57.0%)	3,522 (87.4%)
Urban land	842 (12.6%)	91 (2.3%)
Housing	1,207 (18.1%)	337 (8.4%)
Activities	390 (5.9%)	29 (0.7%)
Equipment	425 (6.4%)	50 (1.2%)
Total	6,667 (100%)	4,029 (100%)

Besides the MOS of 1989, the last land use map for the Study Area is given in Fig.2.1.

2.2.3 Acutual Situation of related Development Projects

Urban Road, where the interceptor will be installed, is ranked in the mid-term and long term of Abidjan Master Scheme. This road will be constructed by the year 2001 because the Harbor is due to open by the year 2002. The study will commence shortly by BNETD.

2.3 Existing Sanitary Conditions

The public dumping ground receives all domestic, industrial, and hospital wastes which contain potential harmful components for the environment. There are many illegal open dumping grounds in the area causing odors and other offensive problem.

Regarding individual sanitation facilities in the Study area, the population uses the following different types of disposal sysytem:

Table 2.3 Individual Sanitation Facilities

Ditrict	Sewerage / Septic tanks (%: population)	Courtyard latrine (%: population)	External latrine (%: population)	Others (no facility) (%: population)
Yopougon	39.11	25.94	7.42	25.74
Attécoubé	4.12	32.81	22.78	40.28

According to the health records, 25% of patients in Cote 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.

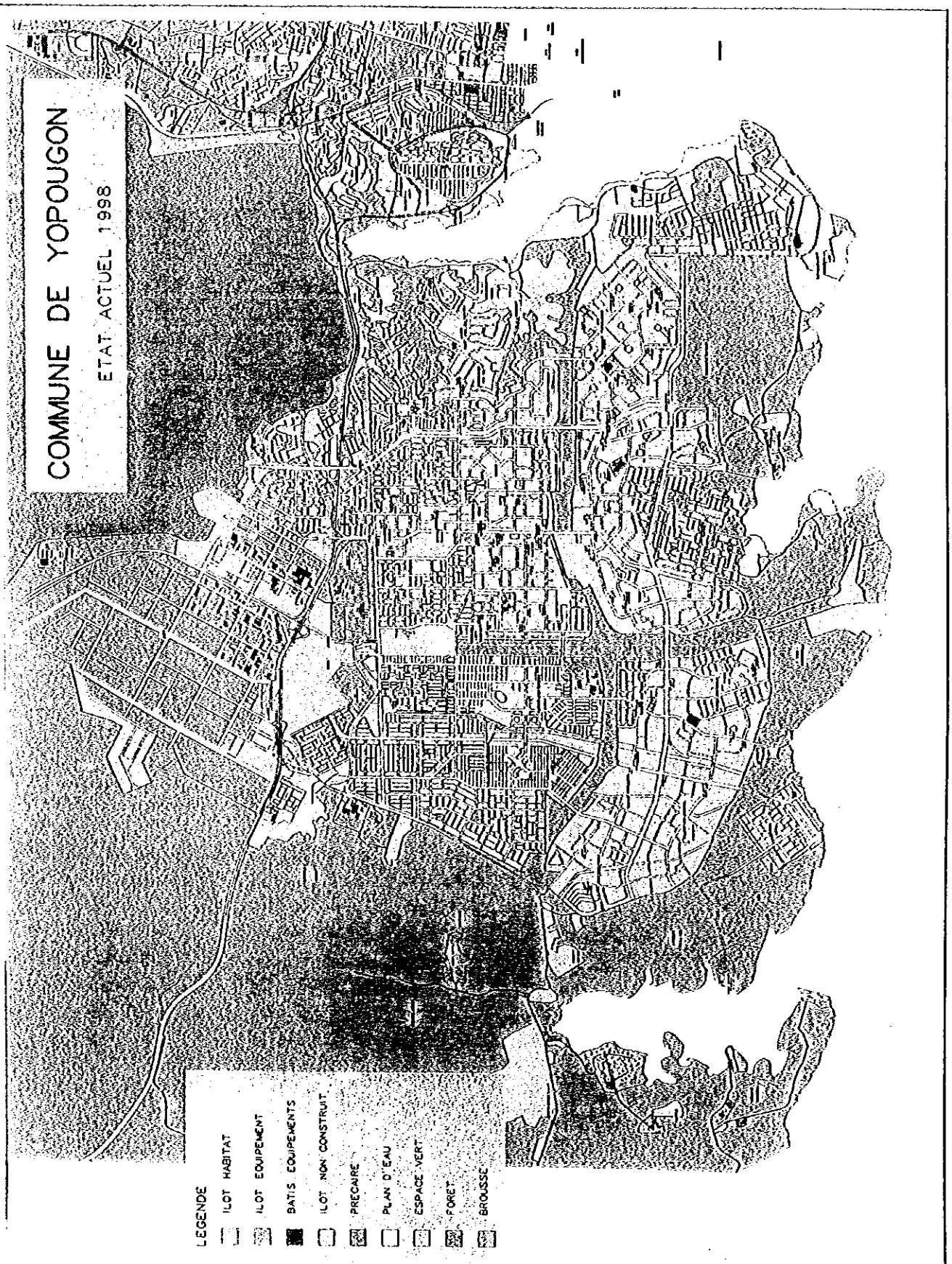

FIG. 2.1 LAND USE IN STUDY AREA IN 1998

2.4 Existing Water Supply System

The water supply system of Abidjan has been rapidly developed after gaining independence. At present, the water supply system serves about a 75% area of Abidjan. The Government has been spending annually 200 million FCFA on the installation and maintenance of the reticulation system to develop services.

The major water resources of Abidjan is groundwater which is drawn by drilling deep wells (aquifer of 80~125 m). The total amount of water supply in Abidjan is about 315,000 m^3/day and water leakage ratio is roughly at 15~20 %.

Water sources in Yopougon and Attecoube are composed of 80.7 % of water supply, 5.6 % of well and 13.7 % of other sources.

The per capita water consumption is classified according to the following dwelling types:

A-Level: 402L/day/habitant	high& middle class residential habitant
B-Level: 81L/day/habitant	economical/very economical residential habitant
C-Level: 78L/day/habitant	habitant by old progressive housing development
D-Level: 65L/day/habitant	habitant by actual progressive housing development
E-Level: 26L/day/habitant	spontaneous brick-constructed habitant

2.5 Existing Sewerage System

The sewerage system of Abidjan City has been constructed as Phase-I and Phase-II projects since 1975 based on the Master Plan formulated in 1971. In 1981, this Master Plan was revised and the Phase-III project, including costruction of wastewater pre-treratment plant and installation of ocean outfall pipes, was executed based on this revised master plan.

In the Study Area, there exist six trunk sewers which collect wastewater from each basin and carry it to the lagoon. The features of these trunk sewers are as follows (Table 2.4).

Four existing trunk sewers, except for 1-2-3 A/B T/S and 33-34 T/S, are heavily damaged especially in its downstream section. Therefore, most of the wastewater discharges into storm water drainage canals causing serious environmental problems even though they are separate systems.

Table 2.4 Existing Trunk Sewers in the Study Area

Name of Trunk Sewer	Diameter (mm)	Length (km)
1-2-3-A/B	300 - 500	10.60
UNIWAX	250 - 800	12.90
21-22	250 - 400	2.55
25-26-27	400 - 500	1.70
33-34	300	1.50
35-36	200	1.50
Total		30.75

2.6 Existing Storm Water Drainage System

In the Study area there are six (6) major trunk mains. The total length of these trunk mains is about 25.8 km and most parts have been constructed from 1976 to 1984. The trunk mains are of concrete lining in the upperstream and natural watercourses in the downstream basin.

Drianage canals without any bank protection have been seriously eroded resulting in heavy damage for sewerage facilities which are installed across or along the canal.

2.7 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.

SODECI maintains the following existing sewerage and drainage facilities of Abidajn:

- 868 km of sewers including 158 km of trunk sewers
- Forty-nine (49) pumping stations including the sewerage pre-treatment plant
- One ocean outfall pipe
- 602 km drainage canals

Operation and maintenance work generally seems to be properly done in the urban area. However, in the Western District, trunk sewers are heavily damaged or lost without any proper maintenance and rehabilitaiton.

2.8 Basic Considerations for Sewerage Planning

2.8.1 Division for Sewerage Basin

The Study Area was divided into seven (7) sewerage basins; Western Edge, 1-2-3 A/B, UNIWAX, 21-22, 25-26-27, 33-34 and 35-36, based on the topographical features and existing sewerage systems. Among these seven basins, only six basins, except Western Edge, have trunk sewers. Total area of seven basins is 7,810 ha.

The UNIWAX basin is the largest one ,and has an area of 2,520 ha and 40 % of the total population of the Study Area.

2.8.2 Design Sewage Flow and Design Pollution Load

Design sewage flow and design pollution load for each basin in the target year 2003 are as follows:

Table 2.5 Sewage Flow and Pollution Load in Each Sewerage District

Basin Name	Area (ha)	Served Population	Daily Averaged Sewage Flow (m^3/day)	Design Maximum Sewage Flow (m^3/sec)	Design Pollution Load (kg/day)
1-2-3 A/B	3,510	129,695	13,398	0.233	3,721
UNIWAX	2,520	436,961	30,900	0.537	11,722
21-22	390	77,445	6,784	0.118	2,241
25-26-27	790	143,251	6,008	0.104	3,384
33-34	240	39,822	1,552	0.027	921
35-36	360	76,642	2,908	0.051	1,737
Total	7,810	903,876	61,550	1.07	23,726

Total sewage flow from six basins (the basin of Western Edge id inclthe basin of Western Edge id included in 1-2-3 A/B) will be 1.07 m^3/s and the pollution load be 23,726 kg/day.

2.9 Alternative Interceptor Planning

2.9.1 Alternative Interceptor Routes

The following three alternative interceptor routes were selected for comparison by considering the location of existing sewerage facilities, present and future land use, and related development plan (refer to Fig. 2.2):

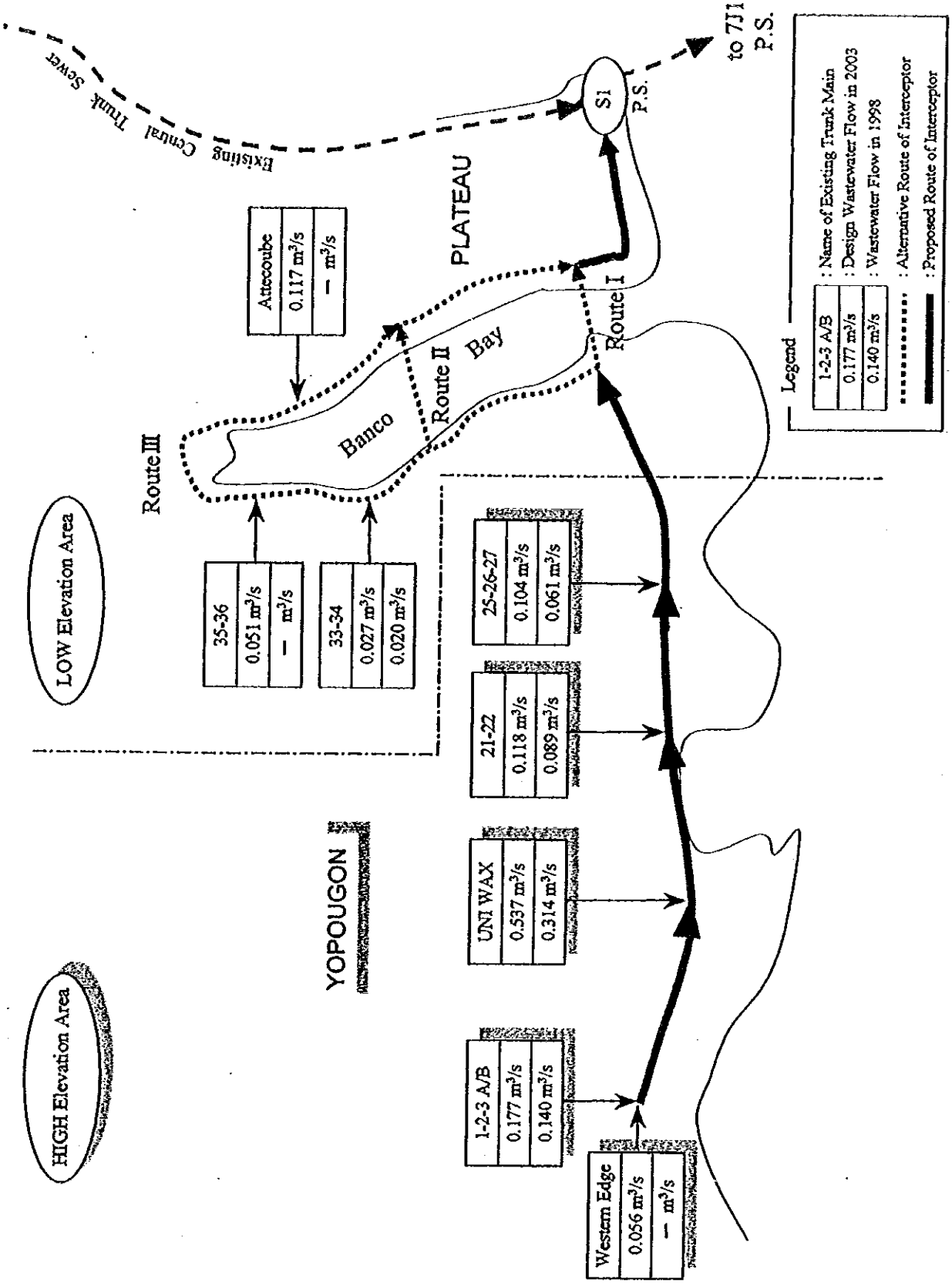

FIG. 2.2	ALTERNATIVE INTERCEPTOR ROUTE AND DESIGN MAXIMUM HOURLY WASTEWATER

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

Alternative Interceptor Route-I:

South Interceptor and West Interceptor join near the Banco Bay mouth and cross the Bay for connection to S1 Pumping Station.

Alternative Interceptor Route-II:

South Interceptor and West Interceptor join at the inner side of the Bay and cross the Bay under water then reach the S1 Pumping Station through the East Interceptor.

Alternative Interceptor Route-III:

Wastewater from the Area will be carried through the South, West and East Interceptors detouring the Banco Bay and received by the S1 Pumping Station.

2.9.2 Flow System

The route of the interceptor generally have undulation but ups and downs for crossing several valleys. The interceptor must also cross the bottom of the Banco Bay.

Total length of the inteceptor in Alternative -II is about 14 km and the total head is only 10 m. The gravity flow method is generally adopted for sewerage planning. However, under these conditions, gravity flow, pressurized flow and combined systems were compared. Finaly the combined system was selected as an optimum flow system considering few maintenance problems and ease of construction.

2.9.3 Selection of Optimum Interceptor Route

Three alternatives were compared and comprehensively evaluated by taking into account the difficulty of construction, land acquisition, environmental issues, operation and maintenance problems and construction cost.

The Alternative Route I was rejected because of the longterm O/M problems of the Banco Bay structures installed at about 50 m deep from water surface.

The Alternative III has about 6 km long section under syphon condition and has a O/M problems. The construction cost will be about 30 % higher comparing to the Alternative II.

The Alternative II was finally selected as an optimum interceptor route because of better cost performance and ease of O/M comparing to the others. The construction cost of the Alternative II was roughly estimated at 14.5 billion FCFA.

2.10 Project Components

The project components of the sewerage system proposed for the target year of 2003 are composed of interceptor sewer pipelines and pumping stations. Most parts of the sewer pipeline is to be installed underground but about a 800 m section crossing the Banco Bay will be installed on the plate supported by piling at the bottom of the Bay.

The proposed facilities are as follows:

Table 2.6 Project Components of Revised Master Plan

Components	Location	Interceptor Length (km)	Interceptor Diameter (mm)	Pump Capacity (m^3/min)
Interceptor	P1 P/S ~ P2 P/S	1.6	500	-
	P2 P/S ~ P3 P/S	2.0	800	-
	P3 P/S ~ P4 P/S	1.6	900	-
	P4 P/S ~ Exist. T/S	4.7	900	-
	Exist.T/S	2.4	1000	-
	Exist.T/S ~ S1 P/S	1.6	1200	-
	P5 P/S ~ JT1	1.0	250	-
	P6P/S ~ P5P/S	1.2	200	-
Pumping Station	P1; 4 pumps, H=38m	-	-	13.98
	P2; 4 pumps, H=27m	-	-	32.22
	P3; 3 pumps, H=20m	-	-	7.08
	P4; 3 pumps, H=11m	-	-	6.24
	P5; 3 pumps, H=28m	-	-	4.68
	P6; 3 pumps, H=25m	-	-	3.06
Total		16.1		

2.11 Rehabilitation of Damaged Sewers

Four existing trunk sewers, except for 1-2-3 A.B T/S and 33-34 T/S, are heavily damaged especially in its downstream section. These damaged or lost trunk sewers should be rehabilitated or reconstructed to connect with the new interceptor. The rehabilitation/recostruction method for these damaged sewers were studied and proposed as a guideline.

The damaged sewers, due to heavy erosion of the canal, should be reconstructed shifting the route with safety distance against erosion.

2.12 Improvement Plan of Storm Water Drainage Canal

In the Study Area, there are three major drainage canals which are heavily eroded. They are drainage canals along 21-22 T/S, 25-26-27 T/S and UNIWAX T/S. These eroded canals have been causing serious envirnmental prolems such as danger of slope failure to riverine people, damage of the concrete drainage canal, destruction of sewerage facilities and environmental degradation of the Lagoon due to an excessive sediment run-off.

Major proposed countermeasures would be the construction of a check dam, a consolidation dam, drop structures and bank protection

2.13 Review of Capacity of Existing Sewerage System

The capacity of the Central Trunk Sewer to which the new interceptor from the western district will be connected was reviewed. The exisiting Central Trunk Sewer, in principle, has been constructed based on the 1981 Master Plan with the target year of 1995 for serving three (3) million people of Abidjan. Pump facilities, however, were not completed to full size. Most of them have only about half of the proposed capacities.

The review was done for the downstream section of the S1 Pumping Station taking into account the projected future population of the entire Abidjan in the target year of 2003.

The major sewerage facilities and results of evaluation are as follows:

- Trunk Sewer between S1 P/S and Koumassi PT Plant – 7,630 m:
  775 m of them does not have sufficient capacity(more than 85 %) but be able to carry design discharge without any negative backwater effects.

- Trunk Sewer between PT Plant and ocean outfall – 3,800 m:
  All stretches have sufficient capacity.

- S1 P/S with two pumps (2 x 0.576 m^3/s x 8.4 m):
  Four additional pumps (4 x 0.35 m^3/s x 15m) will be required for 2.09 m^3/s

- 7J1 P/S three pumps (3 x 0.53m^3/s x 10.2 m):
  Three additional pumps (3 x 0.47m^3/s x 12 m) will be required for 2.81 m^3/s

- Koumassi PT Plant with two screw pumps (2 x 0.91m^3/s x 4 m):

Two additional pumps (2 x 0.91m^3/s x 4 m) will be required for 3.38 m^3/s

- Koumassi PT Plant with two submerged pumps (4 x 0.45m^3/s x 8 m):

  All existing pumps should be replaced by new ones with higher head for 3.38 m^3/s (4 x 0.91m^3/s x 20 m)

CHAPTER 3 FEASIBILITY STUDY OF SEWERAGE SYSTEM

3.1 Priority Project Component Facilities

The priority project area covers the entire area of the Master Plan except for the 35-36 Sewerage District. However , the interceptor will be implemented with master plan design scale. The number of pumps at each pumping station was decided upon by taking into account the actual sewer connection ratio, estimated future inflow and operation and maintenance needs.

Wastewater flow from 1-2-3 A.B, UNIWAX,21-22 and 25-26-27 sewerage districts will be collected by the South Inteceptor. Wastewater from 33-34 Sewrage District will be collected by the West Interceptor and connected to the South Interceptor before crossing the Banco Bay. After crossing the Bay, wastewater will be carried to the S1 Pumping Station through the East Interceptor.

To carry wastewaster, the multiple pressurized system was adopted. At the starting point of the South Interceptor, wastewater is pumped up to a height to enable it to carry out wastewater to the highest point near the Banco Bay. Then, Trunk Sewers of UNIWAX, 21-22 and 25-26-27 will be connected using pumps to the pressurized South Interceptor.

The priority project components are summarized in the following table and the layout is shown in Fig. 3.1:

Table 3.1 Priority Project Sewerage Components

Components	Location	Interceptor Length (km)	Interceptor Diameter (mm)	Pump Capacity (m3/min)
Interceptor	P1 P/S ~ P2 P/S	1.40	500	-
	P2 P/S ~ P3 P/S	2.14	800	-
	P3 P/S ~ P4 P/S	1.57	900	-
	P4 P/S ~ Exist. T/S	4.95	900	-
	Exist.T/S	2.30	1000	-
	Exist.T/S ~ S1 P/S	1.58	1200	-
	P5 P/S ~ JT1	0.90	250	-
Pumping Station	P1: 3 pumps, H=38m	-	-	9.32
	P2: 3 pumps, H=27m	-	-	21.48
	P3: 3 pumps, H=20m	-	-	7.08
	P4: 3 pumps, H=11m	-	-	6.24
	P5: 2 pumps, H=16m	-	-	1.62
Total		14.84		

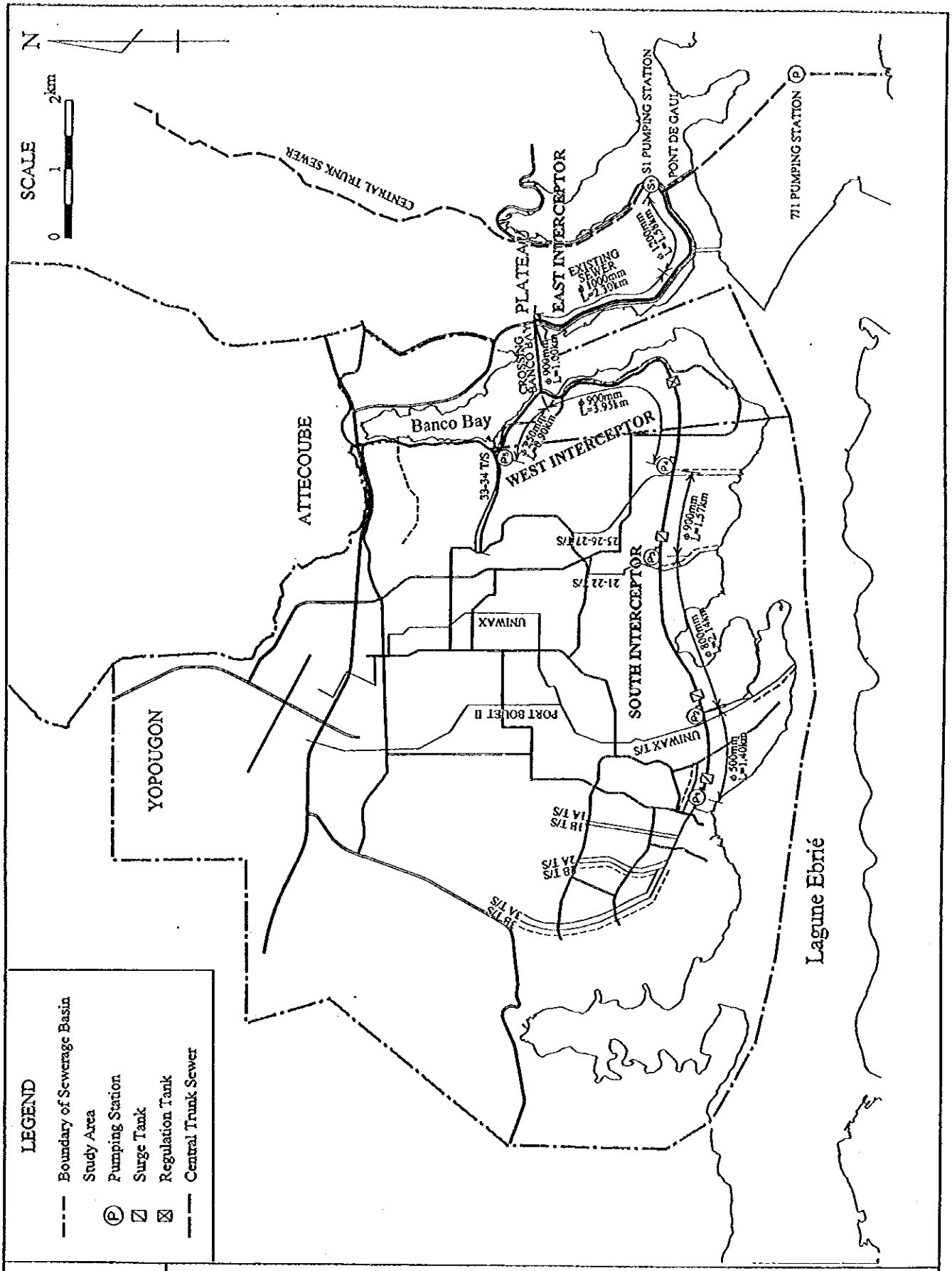

FIG. 3.1 LAYOUT OF PRIORITY PROJECT SEWERAGE COMPONENTS

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

3.2 Sewers and Bay Crossing Structures

The Interceptor cross the Banco Bay, which is about 10 m deep and 800 m wide, from the West Interceptor in Attécoubé to the East Interceptor in Plateau. The sewer pipes will be supported on the foundation piles driven into the bottom of the Bay.

The features of the inteceptor sewer pipes and their supporting structures are as flows:

Length of sewer pipes under sea water:	800 m
Flow system:	Gravity flow
Diameter and materials of pipe:	ϕ 900 mm, steel pipe protected by bitumen Coating outside and by an epoxy resin containing glass fibers inside
Diameter and length of foudation pile:	ϕ 300 mm, max L=45 m
Interval of pile supported platforms:	24 m pitch

3.3 Pumping Stations

In order to connect the trunk sewers to new interceptor, the five pumping stations are required to be installed. The type of pumping stations depends on the amount of sewage flow.

The major facilities of each pumping station are as follows:

Table 3.2 Major Facilities at Each Pumping Station

Name of P/S	Type of P/S	Grit chamber/ Pit	Surge tank/ Regulation tank	
P1	standard	grit chamber	surge tank	90 m^3
P2	standard	grit chamber	surge tank	78 m^3
P3	simplified	sand pit	surge tank	35 m^3
P4	simplified	sand pit	Regulation tank	
P5	manhole	---	---	

Table 3.3 Features of Pump at Each Pumping Station

P/S	Type of pump	Output	Nos. of pump
P1	ϕ 200 horizontal type screw volute pump	55 kW	3
P2	ϕ 300 horizontal type screw volute pump	110 kW	3
P3	ϕ 200 submersible type screw volute pump	22 kW	3
P4	ϕ 200 submersible type screw volute pump	11 kW	3
P5	ϕ 100 submersible type screw volute pump	11 kW	2

3.4 Cost Estimate

The total cost of the prioroty project is estimated at about 1.5 billion FCFA and shown in Table 3.4. The annual operation and maintenance costs are shown in Table 3.5.

Table 3.4 Deatailed Project Cost of Priority Works

	Description	1,000 FCFA	1,000 Yen
Construction Cost	(1)	13,071,918	2,550,331
Engineering Fee	(2)=(1) x 10%	1,307,192	255,033
Physical Contingency	(3)=(1) x 10%	1,307,192	255,033
Land Acquisition	(4)	3,900	761
Total	(1) + (2) + (3) + (4)	15,690,202	3,061,158

Note: Exchange Rate of Currency

(An avearge of the half year from March to August 1999)

1 FF=100 FCFA=19.51Yen、1 USD=120.38Yen

Table 3.5 Annual Operation and Maintenance Costs of Priority Works

No	Year	Sewer Pipeline	Pumping Station	Personnel Expenses	Total O&M Cost
1	2000	0	0	0	0
2	2001	0	0	0	0
3	2002	0	0	0	0
4	2003	0	0	0	0
5	2004	62,205,000	196,000,000	18,000,000	227,205,000

Note: 1. Cost: as of Septemver 1999.

2. Repairing Cost: Direct Construction Cost x 0.5% /Year

CHAPTER 4 EVALUATION OF FEASIBILITY STUDY

4.1 Technical Justification of Proposed System

At present the wastewater from the Western District of Abidjan City is directly discharged into the Lagoon without treatment. The existing sewerage Master Plan of Abidjan proposes that the sewage flow from the Western District should be connected to the Central Trunk Sewer and discharged into the Gulf of Guinea through the ocean outfall after pre-treatment.

The proposed priority sewerage project covers an area of 5,260 ha and serves a population of 791,500 of Yopougon and Attécoubé areas.

After implementation of this project, the sewerage Master Plan Project of Abidjan will be completed serving a population of three million of the City.

The proposed project is expected to contribute an environment improvement in the Area and its vicinity as discribed below:

(1) Total sewage flow of the Project area in 2003 is estimated to be about 61,500 m^3/day which is about one third of the total sewage flow of the entire Abidjan City. The pollution load in the total sewage flow from the Project area is calculated as 23,700 kg/day and is expected to be reduced in the Lagoon.

(2) The existing damaged/lost trunk sewers in the Study Area cause the serious environmental problem to the riverine people and the Lagoon water quality. These trunk sewers will be rehabilitated to connect to the new interceptor. This will contribute to improvement of sanitary conditions especially in the downstream area.

(3) In connection with this sewerage project, rehabilitation and improvement of the storm water draiange canals, which cause serious soil erosion and bank failures, will be excuted. This related works will improve the conditions of danger of slope failure and degradation of the Lagoon water quality due to excessive sediment run-off.

(4) At present, the existing sewerage facilities of the Central Trunk Sewer does not efficiently function because of insuffcient sewage flow due to sewer low connection ratio in the other districts of the City. As a sewer connection ratio in the Western Area is relatively high (about 60 %), an efficient operation of these sewerage facilities is expected after connection of the new interceptor from the Project Area.

Overall, the proposed priority project is justified to be technically sound and will contribute to a large extent to the improvement of the currently deteriorated public sanitation and environment in the Western District.

4.2 Project Execution

The Department of Construction and Sewerage, MLU will be the Executing Agency for the Project, in association with Yopougon and Attécoubé cities, and will assume resposibility for the project implementation. BNETD, the major organization which has substantial sewerage technology, may assist with the planning and supervision of new construction work and the large scale rehabilitation of sewerage services under contract with the government.

4.3 Procurement

The civil works contract is to be awarded through competitive bidding for the construction of interceptor sewers, pumping stations and small pumping units. This includes mechanical and electrical contracts for plants and equipment.

4.4 Consulting Services

Consulting services will be required in one tender package for assistance in project implementation, construction supervision, and to undertake training courses for local staff involved in the Project. Detailed design work for the Project will be undertaken by consultants appointed and funded under a budget allocation from the international cooperation agency.

4.5 Implementation Schedule

It is envisaged that implementation of the Project will proceed rapidly together with rehabilitation of existing trunk sewers, improvement of the drainage canal and construction of urban road.

It is planned that urgent work will be implemented over a period of three years by the end of 2002. Implementation Schedule is illustrated in Table 4.1.

Table 4.1 Implementation Schedule

Year	2000				2001				2002				2003			
Work Items / Month	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12
0. Financial Arrangement																
1. Survey and Design Works		B/D			D/D					Rainy Season				Rainy Season		
2. Prequalification / Tender																
3. Contract and Mobilization																
4. Construction / Supervision																

4.6 Operation and Maintenance

Operation and maintenance work of the urban water piped system, sewerage and storm water drainage system of Abidjan are executed by SODECI under a contract with the Government. SODECI has enough capability and experience in these services and is expected to undertake operation and maintenance work in the western district of Abidjan. Operation and maintenance work in the western district will be similar in the other districts of Abidjan.

Rehabilitation of the existing trunk sewers, which is absolutely required to be connected with the new interceptor, is to be executed by SODECI using part of loan which SODECI borrows from the France Development Agency.

4.7 Land Acquisition and Rights

Most part of new interceptor sewers will be constructed within proposed or existing road reserves. However, most of the pumping stations and one part of the new interceptor sewer will need to be constructed on privately owened land, which will be purchased as part of the Project.

A total of two (2) large pumping stations and three (3) small manhole type pumping units are proposed to be constructed. Pumping station sites have been selected so that no resettlement will be required.

4.8 Economic and Finacial Evaluation

The sewerage service in the Western District of Abidjan will be remarkably improved with this project in addition to the accompanying rehabilitation program and new sewerage tariff system.

4.8.1 Socio-Economic Evaluation of Project

From the Socio-Economic point of view, the benefit of this project is tremendous but it is very hard to quantify them while it is surely and visible. Some of them are as follows.

- The improvement of sanitary condition
- The increase of land value
- Industrial promotion
- Amenity
- Tourism
- Fishery in lagoon

Using available data, we have estimated the economic benefits in the land value increase the fishery in Lagoon and Tourism.

(1) The increase of Land value

The industrial district in the study area (47 ha) as a whole is paying property tax 29.572 M FCFA twice annually according to individual lot sizes. Annual property tax is assumed to be two percent of land value. If this project increase the land value of the industrial district by ten percent, the economic benefit in 2004 will be 296 M FCFA.

(2) Fishery in Lagoon

The output of fishery in Lagoon was 8,372 M FCFA in 1990 (La Cote d'Ivoire en Chifferes, edition 96-97). After 1990, the output in Lagoon has been disappeared from the official statistics for some reason while other fishery such as ocean and inland fishery has been increasing in output. If we assume five percent of the output in 1990 is increased by this project and the net economic benefit is twenty percent of the output, the net increase of economic benefit in Lagoon fishery is estimated as 84 M FCFA annually.

(3) Tourism

In 1995, the whole output in tourism in this country amounted to 100,112 M FCFA. Among them, Vacation tourism and Family tourism made up 56,505 M FCFA (La Cote d'Ivoire en Chifferes, edition 96-97). If we assume five percent of the output in Vacation and Family tourism (1995) is increased by this project and the net economic

benefit is twenty percent of the output, the net increase of economic benefit in tourism is estimated as 565 M FCFA annually.
For example, in case of the cruising service (about one hour, 2000 FCFA per person) in Lagoon, if five ships travel five times a day, five passengers for every trip, 150 days operation annually will make 37.5 M FCFA (1875 passengers). In addition, the opening of the bay bridge will increase visitors.

Only above three economic benefits contribute 944 M FCFA in 2004 and 649 M FCFA (after 2005). Under these very conservative assumption EIRR (economic internal rate of return) will be 39.42 % (Table 14.7) based on the same assumption as financial evaluation. Even if fifty percent or one hundred percent of the investment is shared by the project, EIRR is still 9.41% (Table 14.8) or 3.78 % (Table 14.9). Actually the increase of land value is not confined in the industrial district but is surely extended to whole study area. The whole net economic benefit will exceed the above estimate and EIRR in Table 14.9 (Case 3) will be far higher than 3.78 %. It means this project is surely justified from socio-economic point of view too.

4.8.2 The Financial Evaluation of Project

The financial plan assumed full coverage of public fund (domestic or internatinal) for initial investiment. But from the conservative point of view, as any aid program requires some portion of internal burden, the Team assumed ten percent of initial investiment must be covered by the hypothetical entity.

The Team developed the pro forma financial statements (fund flow table, income statement and balance sheet) until 2060. Interest rate is assumed to be 1.5% and annual inflation rate is assumed to be 3% (same as 1996-1997 level).

According to the analysis, it is required to prepare some working capital until 2003. The effect of assumed tariff increase at 2011 to 40% level of water charge is tremendous. If this assumption is realized, this hypothetical entity is financially feasible.

Under several assumptions, FIRR (Financial Internal Rate of Return) is about 8% in long run, which support the Project positively from the financial point of view.

4.8.3 Sensitivity Analysis

The Team examined the sensitivity analysis in both initial cost overrun and O&M cost

overrun.

(1) Investiment cost overrun

If the investment cost exceeds the initial plan by 10 %, FIRR of the hypothetical entity will be reduced to 3 %. In the case the sharing of the hypothetical entity of initial investment is changed to 11 % without any overrun of investment cost, FIRR will be reduced to 3 % too. This means the hypothetical entity hardly is able to accommodate any further increase of initial investment cost beyond 10 % level and the investment cost overrun should be provided from outside of the entity.

(2) O&M cost overrun

Three cases were examined: 10%, 20% and 30% O&M cost overrun. The FIRR is 7%, 5% and 4% respectively. The entity has same degree of robustness in the area of O&M cost but every effort should be made to keep O&M cost under control.

Table 4.2 Sensitivity Analysis of FIRR

Cost	Base Case	+10%	+20%	+30%
Benefit (%)	8.58	7.29	5.93	4.45

4.9 Institutional Evaluation

Institutionally, the whole system is working pretty well but the following points are significantly important also and continous effort is required:

(1) The approval of current sewerage tariff proposal.
(2) The increase of sewerage tariff up to 40% of water charge until 2011.
(3) The organizational action to improve both connection rate and collection rate.
(4) To maintain the internal subsidy from Central Business District and international hotels.
(5) The capital budgeting area to be transferred to SODECI gradually in order to strengthen the organizational capability of SODECI.
(6) The effective regulatory framework to be developed.

4.10 Environmental Impact Assessment (EIA)

EIA was conducted to study, forecast and evaluate the environmental impacts of this project.

The EIA study items were defined through IEE conducted during the stage of review of the existing plan. The study items were evaluated not only in the project area but also in any area that might be directly or indirectly affected during the construction.

As result of IEE, major study items evaluated to study are followings; 1)resettelement of inhabitants land acquisition for pumping station and sewer, 2) water pollution of the Banco Bay, 3) surplus excavated materials disposal, 4) odors and screenings/grit disposal, 5) effect of industrial wastewater on the material of the sewer, 6) pollution from wastewater disposal in the Gulf of Guinea.

Among these study items, the following are due to impacts during construction and were evaluated as follows:

1) Resettelement of inhabitants and land acquisition

The major resettelment problem occurs due to the Urban Road Project and will be solved by that project. For the proposed sewerage facilities such as the pumping station and sewer, the sites were selected avoiding residential area. Land acquisition will not cause problem as most part of the land is public land.

2) Water Pollution of the Banco Bay

Water pollution of the Banco Bay during the construction of the Bay crossing structures, the construction does not cause pollution problem beacause the pile supported pipe laying method, which will minimizes the diffusion of silts in the waterway, will be adopted.

3) Surplus excavated material disposal

The most surplus excavated materials will be of natural soil without any harmful material and disposal sites will be easly obtained nearby.

4) Odors and screenings/grit disposal

Odor problem is expected mainly at the pumping station. To cope with the odor problem, the land for construction of pumping stations should be obtained larger to plan a buffer zone between the pumping station and the surroundings.

The quantity of grit and screenings generated in the pumping stations is expected to be approximately 0.3 m^3 and 0.06m^3 per day repectively, and these can be disposed of in the sanitary landfill since the amount is not much to cause any extra problem to the landfill.

5) Effect of industrial wastewater on the material of the sewer

In Abidjan, the prevailing practices of most of the industries are direct discharge to the sewerage system almost without any effective treatment. The untreated industrial wastewater may be containing some harmful compounds to cause corrosion of the sewer.

The new regulations and legislation under formation is expected to be enforced strictly to prevent discharge of industrial wastewater unacceptable to the sewerage system in the future.

As for pollution of the Gulf of Guinea, the Team prepared the TOR. for EIA to evaluate environmental impacts on the Gulf of Guinea due to ocean outfall which discharges the increased wastewater in the stage of operation of the Project. This EIA study will be made by Ivorian side.

CHAPTER 5 RECOMMENDATIONS

The success of a short term strategy for sanitation improvement and environment protection of the western district of Abijan City and its surrounding areas (the Study area) require the implementation of a range of actions. Recommendations include:

(1) Rehabilitation of the existing damaged trunk sewers to connect them to a new interceptor.

(2) Improvement and rehabilitation of the existing drainage canal for erosion and sediment run-off cointrol, protection of river bank and the securing the safety of riverine people.

(3) Early Implementation of a proposed urban road where the new interceptor will be installed.

(4) Early onset of procedures for resident relocation in the proposed urban road area.

(5) Increase in the connection ratio to the trunk sewers in the northern, eastern and central districts of Abijan City for environment protection and effective use of sewerage facilities.

(6) Connection of the Interceptor from the Western District to the Central Trunk Sewer and also the increase of the connection ratio in the other districts of Abidjan City imply the increase of the pollution load to be discharged through the Ocean Outfall. To cope with this problem, the construction of the Primary/secondary Treatment Plant, instead of the present Pre-treatment Plant, should be necessary in the future.

(7) Implementation of sediment run-off control works especially in the 35-36 Trunk Sewer basin for protection of sewerage and drainage facilities.

(8) Introduction of public education programs to promote community participation and understanding of the importance and benefits of public sanitation works;

(9) Training of personnel in project management, finacial management, and the operation and maintenance of wastewater and drainage facilities.