JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF HYDRAULICS

THE REPUBLIC OF SENEGAL

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

SUPPORTING REPORT

OCTOBER 1994

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO

in association with

TOKYO ENGINEERING CONSULTANTS CO. LTD., TOKYO

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LIST OF SUPPORTING REPORTS

SUPPORTING REPORT - A GENERAL

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The city of Dakar, the Capital of Senegal, has the highest concentration of population in the nation and also the center of industry and commerce. The population of Dakar and the adjacent urban center Pikine was about 700,000 and 600,000 in 1988, respectively, and is expected to increase to about 1,400,000 each in 2010.

The progressing rapid urbanization in the suburban areas exacerbates the social and environmental problems. The sanitary conditions in the area is one of the most important problems to be addressed and the improvement of drainage and wastewater disposal systems is indispensable to maintain a favorable living environment.

In the old town area in the city of Dakar, the drainage and sewerage systems were constructed about 50 years ago and are comparatively functioning well at present. However in the other areas, the drainage and sewerage facilities are very poor and moreover they are not functioning properly. Thus, during the rainy season, rain water stagnates in many places causing serious flood damage, as well as traffic problems.

At present, most of the wastewater collected by the existing sewerage system is directly discharged into the sea without any treatment. In some areas, sewer pipes were improperly connected to drains and this causes stagnation of polluted water in open drains.

There still exist many traditional villages that virtually have no drainage or sewerage/sanitation system. Thus, lack of appropriate drainage and sewerage system causes water quality deterioration of surface and groundwater and coastal water resources, aggravating urban and marine environmental conditions.

Furthermore, the population in the areas is expected to increase two-fold between 1988 and 2010. Such a rapid increase will cause a higher density of population and further expansion of urban areas, resulting in deterioration of sanitary conditions and water quality and increase of flood prone areas. Thus, deterioration of living conditions could become more serious, if rapid and appropriate countermeasures are not implemented.

To resolve the problems, the "Plan Strategique d'Assainissement de la Communaute Urbaine de Dakar" (hereinafter referred to as "the Strategy Plan"), which included studies on present and future conditions in Dakar and its adjacent areas, and strategy to improve existing urban drainage and wastewater systems in the areas, was prepared by UNDP and the World Bank in 1991.

Under these circumstances, the Government of Senegal requested technical assistance from the Japanese Government in the formulation of a master plan for development of urban drainage and wastewater systems and a feasibility study of a high priority project from the master plan. In response to the request, a preparatory study team was sent to Senegal in December 1992 and both countries agreed to conduct the Study on Urban Drainage and Wastewater Systems in Dakar and its Surroundings. The Scope of Work for the Study was signed on December 17, 1992.

1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are;

i) to draw up a master plan for development of the urban drainage and wastewater systems in the study area in 2010, including its phased implementation program, and

ii) to conduct a feasibility study on urban drainage and/or wastewater system(s) for a high priority project selected from the master plan.

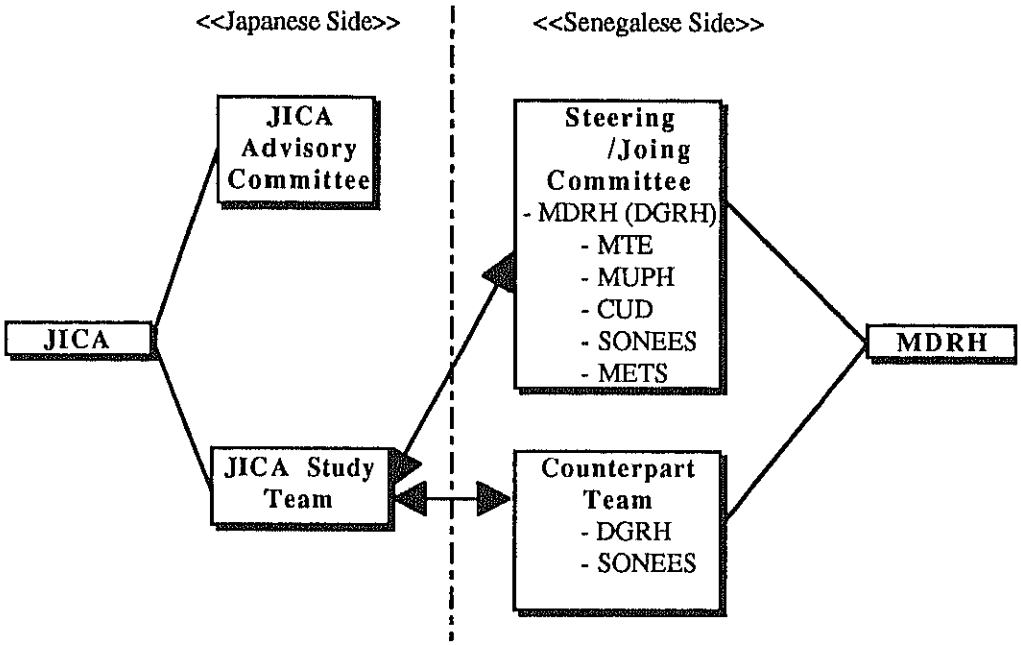
1.3 STUDY AREA

As shown in *Figure A.1.1*, the study area covers the city of Dakar and its surrounding areas with an area of about 175 km^2, consisting of the Department of Dakar and the Department of Pikine.

1.4 STUDY ORGANIZATION

1.4.1 General Organization

A general organization for the study can be depicted as follows:



Note : JICA : Japan International Cooperation Agency
DGRH : Directorate of Rural Works and Hydraulics, MDRH
MDRH : Ministry of Rural Development and Hydraulics
MTE : Ministry of Tourism and Environment
MUPH : Ministry of Urban Planning and Habitat
CUD : Dakar Urban Community
METS : Ministry of Equipment, Transport and Sea
SONEES : Societe Nationale d'Exploitation des Eaux du Senegal

1.4.2 Japanese Organization

The official agency of the Japanese side to execute the study is Japan International Cooperation Agency (JICA). JICA has organized an advisory committee to ensure smooth and appropriate execution of the study.

The JICA Study Team consists of twelve members and the Advisory Committee consists of two members as shown below.

JICA STUDY TEAM

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

JICA ADVISORY COMMITTEE

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

1.4.3 Senegalese Organization

The executing organization of the Study of the Senegalese side is the Ministry of Rural Development and Hydraulics (MDRH). The MDRH coordinates with representatives of government offices which are concerned, as well as act as a primary counterpart to the Study Team.

A Steering / Joint Committee, which consists of representatives of organizations concerned to the Study to discuss with the Japanese side on progress and results of the Study and which is chaired by the MDRH, has been organized.

Members of the Counterpart Team, shown below, were sent from the Directorate of Rural Works and Hydraulics (DGRH), SONEES of MDRH and other concerned organizations.

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

1.5 REPORTS

The study reports prepared are as follows:

i) Main Report: English version and French version

ii) Supporting Report: English version and French version

iii) Summary Report: English version and French version

iv) Data Book: English version and French version

This supporting report comprises of three appendices to the contents of the Main Report. Appendix A corresponds to Part I of the Main Report, which explains contents of the Study and background information on the study area. Appendix B and Appendix C contain details of the Master plan and Feasibility studies on the Sewerage System and Urban Drainage System, respectively. Appendix D is the study report on the initial environment examination of impacts by the proposed projects.

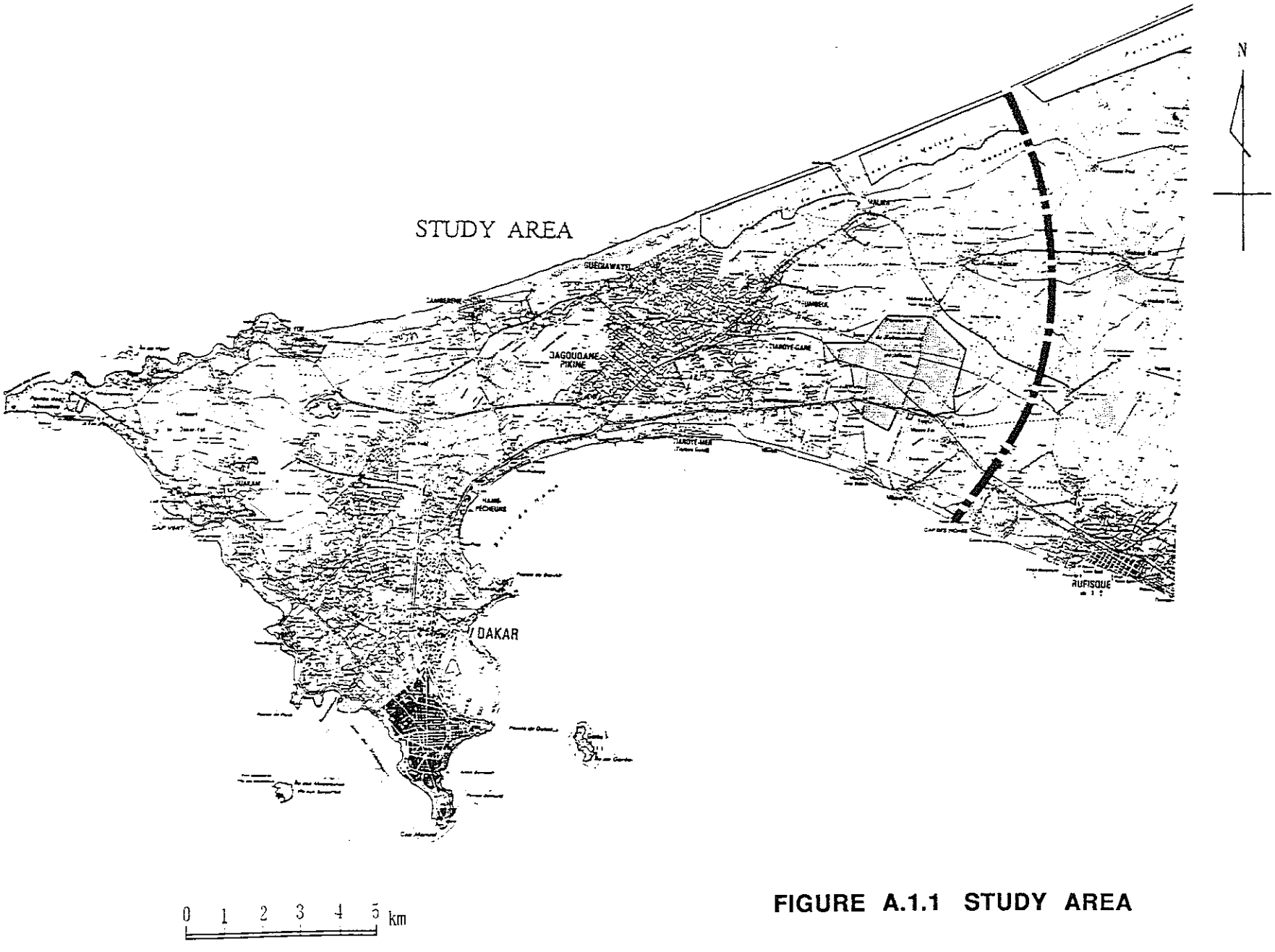


FIGURE A.1.1 STUDY AREA

CHAPTER 2 BACKGROUND OF THE STUDY AREA

2.1 NATURAL CONDITIONS

2.1.1 Location

The Republic of Senegal is situated in the most western part of the African Continent, spreading in latitude from 12 to 16 degrees north and in longitude from 11 to 17 degrees west. The study area covers the western half of Cap Vert, the peninsula that stretches sharply out into the Atlantic Ocean. The study area is surrounded by the coast, except at the eastern end, and extends 18 km from east to west and between 5 to 10 km from north to south.

2.1.2 Topography and Geology

The topography of the study area is generally low with the highest elevation of 105 m at Les Mamelles. The western edge, the Dakar-Yoff Airport area, and southern parts, the Dakar urban area, of the study area have relatively high elevation between 10 to 20 m, forming cliffs along the shoreline. Most of the eastern parts of the study area, Pikine, is low in elevation and is at a level of 0 m MSL in several places.

One of the remarkable topographic characteristics of the study area are closed basins that do not have outlets to other basins or to the sea. Such basins exist both in higher and lower areas. In the higher area, the basins are surrounded by hilly area with the lowest elevation of 10 m MSL. In the lower areas, these basins are known as "Niaye" that means low lands between sand dunes running parallel to each other. Among them, the Grand Niaye is a large low land, spreading out between Pikine and Dakar. Small Niayes, which are strips of low lands are very common in Pikine, most of which are enclosed by long sand dunes developed along the shoreline. Some of these basins along the northern coast are filled with the permeating from the sea, forming high salinity lakes.

2.1.3 Climate

The climate of the study area is arid, having two distinct seasons; the rainy and the dry seasons. Average annual rainfall ranges from 325 mm to 596 mm. Average monthly rainfall from 1947 to 1989 is shown in *Figure A.2.1*. About 90% of the rains fall in three months from July to September.

Monthly mean temperatures are shown in *Table A.2.1*. Annual average temperature between 1955 and 1989 is about 24°C. The maximum temperature (31.8°C) and minimum temperature (15.3°C) have been recorded in October and January, respectively.

Monthly mean relative humidities are shown in *Table A.2.2*. The maximum and minimum humidities have been recorded in September and December, respectively. The relative humidity is rather higher for an arid climate, as the area is surrounded by the ocean.

Monthly solar radiation and monthly mean daily evaporation rate are shown in *Tables A.2.3* and *A.2.4*

2.2 ECONOMIC CONDITIONS

The gross domestic product (GDP) of the Republic of Senegal was 1,691.8 billion FCFA at market prices in 1992, according to the Ministry of Economy, Finance and Planning. The national population in the same year is estimated at 7,703,826 by the afore-mentioned ministry. Thus, the estimated per capita GDP of the nation for 1992 works out at 219,605 FCFA. Assuming an exchange rate of 275 FCFA to the US dollar, the per capita GDP corresponds to US$ 799. This economic level is among the highest in the sub-Sahara African countries.

Turning to the economic structure, the primary, secondary and tertiary (including non-mercantile services) sectors account for 19.8%, 18.8% and 61.4%, respectively. The comparatively small share of the primary sector can be noticed. When the primary sector is broken down, it can be further noticed that agriculture accounts for only 9.1% of the national economy. The secondary sector is given an important position, having a share approaching that of the primary sector. "Other industries" in *Table A.2.5* include food, chemical and machinery industries, accounting for a substantial 12.5% of the

economy. Commerce occupies the top place in the tertiary sector (including non-mercantile services) with the 24.6% share followed by transport with 10.0% and administration with 8.6%.

Looking back over the time span of the past ten years, it is seen that the primary sector is shrinking, the secondary sector is expanding and the tertiary sector is maintaining the afore-mentioned level; in essence, healthy economic development.

The economy of Senegal grew at the average annual rate of 2.2% for the ten years from 1982 to 1992. During the same period the national population is estimated to have increased from 6,038,000 to 7,703,826 at the average annual rate of 2.5%.

Over the above-mentioned ten years, the GDP deflator grew at the average annual rate of 4.9%. However, so far as the latest five years from 1987 to 1992 are concerned, the average annual growth rate of the deflator dwindled to 1.8%.

In January, 1994 the Senegalese currency was devaluated form 50 FCFA to 100 FCFA to one French franc. It will work to pull down the per capita GDP of the country to something like one half in a short term.

However, the real objective of the devaluation is to develop import substitute industries and thereby invigorate the national economy. If the objective is attained, Senegal may in the future have an economic growth more than she used to have before the devaluation.

A certain extent of price escalation is inevitable accompanying devaluation of a currency. It is forecast in the governmental sources that the inflation rate by the end of 1994 will be 30% to 40%. The key to the successful devaluation lies in the containment of inflation within a reasonable limit. It is hoped that the prices will stabilize after a short period of irregular rises.

2.3 POPULATION AND LANDUSE

2.3.1 Population

The population of the study area is shown in *Table A.2.6*, which are the estimates made by the Direction de la Prevision et de la Statistique and the Strategy Plan.

According to the Direction de la Prevision et de la Statistique, the population of the area in 1993 is about 1,580,000 and 2,908,000 in 2010. However, the Strategy Plan estimated the 2010 year population as 3, 009,000.

The ratio of the population of the study area to the national population is estimated to increase from 16.7 % in 1980 to 23.8 or 24.6 % in 2010, indicating further urbanization of the study area.

Since both estimates are similar and the estimates of the Strategy Plan are based on population projections on a unit basis obtained by dividing the study area according to landuse and housing types, the population estimated by the Strategy Plan will be adopted as the population for the Master Plan along with minor adjustments that would reflect new development plans proposed after the Strategy Plan was prepared.

2.3.2 Landuse

The landuse in the study area prepared in 1989 is shown in *Figure A.2.2* and outlined as follows:

- Urbanized area in the southern half of Dakar
- Airport area, with small towns/villages scattering in the northern half of Dakar
- Industrial area in the strip along the coastal line from Hann to Mbaw.
- Farm land, swamps and ponds in and around the Grand Niaye.
- Residential area in the strip along the north coastal line from Yoff to Camberene.

- Conservation area along the northern coastal line from Camberene to Malika.
- Urbanized area in Pikine
- Undeveloped area (farm land, small villages, forestation) in the east of Pikine.

In addition, the aerial photographs taken in 1992, shows that urbanization is rapidly progressing in the north end of Dakar urban area and Pikine, the north edge of the Dakar urban area is expanding towards Ouakam and Grand Yoff and Pikine area has been fully developed except for some small low lying areas.

In the Master Plan study, the future landuse pattern adopted basically follows the one proposed in the Strategy Plan, after making the following modifications:

- Addition of development plans of which detailed information has become available.
- Changing landuse with respect to newly proposed plan.

The modified landuse pattern is shown in *Figure A.2.3*.

2.4 ENVIRONMENTAL CONDITIONS

2.4.1 Water Pollution

In the study area, there are few natural streams that have any base flow during the dry season. Most streams in the area are drainage water in the rainy season. Fresh water bodies of which water quality should be discussed, hardly exist in the area. Two or three artificial drainage channels have water flow throughout year even in the dry season. This means the such water flow consists of mainly sewage that is intentionally and/or mistakenly released into the channel. Consequently, the water quality of these channels are considered to be same as sewage.

The water quality of the ocean seems to be rather important in this area, since the area is surrounded by the ocean and both treated and untreated wastewaters are directly discharged to the ocean. There is little water quality data available for the ocean in previous studies. The only available information is found in the Strategy Plan, which presents the distribution of BOD and Dissolved Oxygen in the Hann Bay. Some extracts from the Strategy Plan are shown in *Figure A.2.4*. These distribution patterns indicate diffusion of contaminants to the Bay from the outlets of factories and deterioration of the water quality in the harbor area by stagnation.

2.4.2 Groundwater

As mentioned in the following section, groundwater is the major source of water supply for the Study area. SONEES is withdrawing about 26,700 m^3/day of water (13.5% of the total production) from 93 wells located in the Study area. In addition, many people who have difficulty to access to the water supply services of SONEES rely on private wells. Therefore, the water quality of groundwater is important from a view point of health of residents.

Table below shows major chemical characteristics of groundwater obtained from the SONEES water supply wells located in Mamelles and Thiaroye. The parameters that are mainly related to taste and operationability in water treatment such as chloride, bicarbonate, calcium, magnesium and sodium are considered to be within normal range of drinking water. However an existence of ammonium and nitrite indicates the possibility of fecal contamination also in most of the wells in Thiaroye. Furthermore, high concentrations of the nitrate are also observed in every well, particularly in the wells of Thiaroye.

Although there is no evidence of direct fecal contamination since no bacteriological data is available, it is natural to suspect direct fecal contamination from the observed concentration of the ammonium and the nitrate. This would be more probable in the private wells where on-site sanitation facilities are located nearby. The level of the nitrates, which is apparently exceeding the limit prescribed in the WHO's drinking water guidelines may cause methemoglobinemia. These facts suggest that the

groundwater in the area may be affected by seepage from on-site sanitation facilities, which are common in the area.

Major Chemical Characteristics of Well Water

(date) (unit : mg/l)

Parameters	Thiaroye*						Mamelles*			
	F15	F17	F18	F19	F21	F22	Camp pénal	Terme Nord	Point M	Terme Sud
Chloride	25	25	29.6	30	30	25	14	20	10.2	16.6
Bicarbonate	48.8	48.8	109.8	48.8	48.8	48.8	195.2	195.2	122	195.2
Nitrate	143.9	175.2	285.6	174.9	266	268.3	11.7	13.3	15.8	21.25
Nitrite	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0
Ammonium	0.3	0.3	1.2	0.5	0	0.3	0.1	0	0.15	0.15
Calcium	56	48	68	56	48	64	32	40	16	48
Magnesium	29.1	38.8	26.7	38.8	43.7	38.8	24.3	24.3	14.6	34.02
Sodium	130	126		148	139	127				

* : For locations, refer to *Figure A.2.5.*
SOURCE = SONEES

2.5 RELEVANT PLANS AND PROJECTS

There are two main plans that are closely related to this study; Water Supply and Sanitation Master Plan, 1973, and Strategy Plan of Sanitation, 1991. (Contents of each plan are reviewed in later sections.) However, there is no higher, broader level plan such as a regional development plan, comprehensive town planning plan etc. in the study area.

There are several plans or projects that concern improvement of sewerage or drainage systems for some parts of the study area. These are mentioned below:

- Drainage improvement project in Ouakam Area
- Drainage improvement project in Grand Yoff area
- Installation project of City Faycal (PROJECT DE RACCORDEMENT DE LA CITE FAYCAL)
- Project for sewage and stormwater sanitation at low point in HLM Las Parmas of Guediawaye (ASSAINISSEMENT DU POINT BAS DES HLM LAS PALMAS DE GUEDIAWAYE EAUX USEES ET PLUVIALS, DOCUMENTS D'APPEL D'OFFERES)
- Project for modification of the sewerage system in Parcelles Assainies (MEMORUNDAM SUR LE FONCTIONNEMENT DU SYSTEME D'ASSAINISSEMENT DES PARCELLES ASSAINIES)

Among the above, the first two projects are for construction of drainage facilities, which are considered to be parts of the Urgent Projects proposed in the Strategy Plan. Financing of main parts of each project has been committed by the French Agency.

The latter three projects have been proposed by SONEES to improve the existing conditions of their sewerage system. While the project of City Faycal is expected to start shortly, there is no concrete implementation plan for the other two projects.

Several housing development projects in the study area, which may affect the future population, have been identified as follows:

- Redevelopment of the military camp in the south of the Pikine railway station.
- Development of area located between Reboisement de Mbaw and Rufisque.
- Development in Malika.
- Other small developments.

In addition to the above, a conceptual plan for redevelopment of the Pikine Irregular area has been obtained. The plan includes a proposed road network and rearrangement of residential areas. While the plan has not been approved by any authority, a project that is considered to follow the concept, which includes regulating the land ownership and physical rearrangement, has been initiated in an area in the Pikine Irregular area under technical assistance of GTZ, Germany.

2.6 WATER SUPPLY SYSTEMS

2.6.1 Coverage of Services

The water supply system of SONEES covers the entire study area and thus coverage is considered to be 100 % of the area.

There are two types of water distribution system; house connections and standpipes. Presently, about 60 % of the population in the study area are covered by house connections and the remaining 40 % are covered by standpipes. In the standpipe type, access to water highly depends on the distance to a nearest standpipe and there are some people who have particular difficulty in receiving standpipe service due to their being long distance from the standpipes. Three to four (3 to 4) % of the population are estimated to obtain their potable water from private wells because of the difficulty in access to the standpipes or other reasons.

The service coverage in term of population is considered to be about 95 %, though there is a large difference in per capita consumption rates between house connection users and standpipe users.

2.6.2 Facilities

The water supply system in the study area is shown in *Figure A.2.6*. The water sources of the system consist of "Local water source" and "Remote water source".

The Local water source include three groundwater sources located in the area. They are Mamelles, Thiaroye and Point B.

The Remote water source include the A.L.G. system and the Bonna system. The A.L.G. system consists of water conveyed from the Lake Guiers (Lac de Guiers) with supplementary supply from underground water sources along the conveyance lines. That conveyance provides not only Dakar, but also cities such as Louga, Tivaouane, Pire Mekhe and villages a long the force main.

The major portion of water is distributed through four water reservoirs as shown in *Figure A.2.7*. The study area is covered by four water distribution networks, each of which corresponds to the above-mentioned four reservoirs, and other networks receive water directly from the A.L.G. system, as shown in *Figure A.2.6*.

Water output of each water source is summarized below:

System	Water Sources		Output (m^3/day)
Local	Mamelles		12,000
	Point B		7,000
	Tiaroye		7,700
	Sub-total		26,700
Remote	A.L.G.*	Lake Guiers**	38,300
		Pout Nord, Pout Direne Kelle, Kebemer	91,000
	Bonna	Pout Sud	15,800
		Sebikotane	25,000
	Sub-total		170,100
Grand Total			196,800

*: About 20,000 m^3/day are used by towns and villages along the conveyance line.
**: Surface water, others are groundwater.
NB (Main Report PP2-7)

2.6.3 Future Development Plan

The future development plan for the water supply system in the study area was proposed in the Study on Reinforcement of the Water Supply in the Dakar Area (REINFORCEMENT DE L'APPROVISIONNEMENT EN EAU DE LA REGION DAKAR, 1988). The construction of the Cayor Canal is recognized to be only way to balance the future demands of the area. Therefore, the plan proposed the utilization of the water from the Cayor Canal by phased construction of water treatment plants as a medium-long term plan. In addition, the plan also proposed the following short term plans to supplement the shortage before water through the Cayor Canal is available:

- Urgent phase: Increase of 41,000 m^3/day by construction of 10 wells.
- Intermediate phase: Construction of new wells in Thies and the northern coastal areas, doubling of the main between Geoul and Dakar, and extension of the N'gnith water treatment plant. The Project has already been realized since 1991.

The demand projection and proposed production capacity are shown in *Figure A.2.8*.

Based on the proposed plan, projects have been implemented since 1988 according to the time schedule shown in *Figure A.2.9*. Although there is no concrete plan for projects in the Cayor Canal phase yet, it should be noted that the water supply to the study area will increase more than twice of the present one, once the first stage of the Cayor Caral phase is implemented. This could cause an increase of per capita water consumption rate, which is presently held at lower consumption rate due to absolute shortage of the supply.

2.7 ORGANIZATIONS AND INSTITUTIONS

2.7.1 Administrative Organizations

1) Introduction

At the initial stages of the field study, new decrees were issued prescribing reform of the administrative structure. The Ministry in charge of urban drainage and wastewater systems was reorganized as the Ministry of Hydraulics and the structure of the Ministry is under consideration.

The study was conducted by collecting additional data and information and discussing with persons and parties concerned.

2) Administrative Structure

(1) Present Administrative Structure

The Central Government is composed of 28 Ministries and among them, the Ministries relating to this study are;

Ministere de l'Hydraulique,
Ministere de l'Economie, des Finances et du Plan
Ministere de l'Environnement et de la Protection de la Nature
Ministere de l'Intéreur
Ministere de l'Urbanisme et de l'Habitat
Ministere de l'Energie, des Mines et de l'Industrie
Ministere de la Sante Publique et de l'Action Sociale
Ministere de l'Equipement et des Transports Terrestres
Ministere de la Ville.

(2) Historical Changes in Administrative Organizations in Recent Years

The administrative structure was reorganized in June, 1993, and Ministere du Developpement Rural et de l'Hydraulique(MDRH) was divided into two Ministries, namely, the Ministere de l'Agriculture and the Ministere de l'Hydraulique(MH). Since 1990 MDRH used to be the competent authority of wastewater systems, however, in the reorganized structure Ministere de l'Hydraulique took over the role.

Before the reorganization, MDRH had one direction and five (5) divisions described as below;

- Direction of Urban Hydraulics and Sanitation (DHUA)
- Division de l'Hydraulique Urbaine et de l'Assainissement (DHUA)
- Division de l'Hydraulique Rurale (DHR)
- Division de l'Entretien et de la Maintenance(DEM)
- Division des Ressources en Eau(DRE)
- Division du Genie Rural(DGR)

In the recent structure of the Ministere de l'Hydraulique, the original scheme was to establish two directions by combining former divisions. But this original scheme is still under consideration and may be modified. Consequently, DHUA is still in charge of sewerage projects.

3) Present Status of Local Government

The republic is divided into ten local governments named "Region". Each Region is composed of three Departments and organizations under the Departement of the Municipality (Municipalite).

The head of "Region", "Departement" and "Municipalite" is known as "Gouverneur", "Prefet" and "Maire", respectively. Gouverneurs and Prefets are chosen by authorities, while Maires are elected by the people.

Communaute Urbaine de Dakar (CUD), which is the executive agency of urban drainage in the study area, is the same organization with Region de Dakar.

4) Organizations Relating to Urban Drainage and Sewerage System

Organizations in charge of Urban drainage and sewerage system are Division du Hydraulique Urbaine et de l'Assairissement (DHUA), Communaute Urbaine de Dakar (CUD) and Societe Nationale d'Exploitation des Esaux de Senegal (SONEES).

DHUA is responsible for the planning and execution of sanitation projects. SONEES is in charge of the operation and maintenance of sanitation facilities excluding open drainage channels, which are operated and maintained by CUD. For the organizational structures of SONEES, refer to *Figures A.2.10* and *A.2.11*.

5) The present procedure to implement sewerage project

(1) Types of Executive Agency

Sewerage projects in Senegal are implemented by DHUA, SONEES, public corporations such as SICAP and private development companies. The above mentioned organizations with the exception of SONEES participate in projects at the planning and the construction stages. SONEES participates only in the operation and maintenance stages of the project.

(2) Procedure of Implementation

The procedures of implementation of sewerage projects differ depending on the executive agencies. In case of DHUA, SONEES is involved from the planning stage of the project. But still responsibility lies with DHUA. In case public corporations, such as SICAP take part in the sewerage project, they are generally restricted to such projects only up to residential complex development stage. These organizations are requested to get approval from the competent authorities and usually, DHUA is consulted as the competent authority concerning sewerage projects. Sometimes DHUA dispatches engineer(s) to the project sites also. SONEES is also involved in the technical aspects of the project. SONEES's involvement is not prescribed legally.

In case private developers are going to construct a sewerage system as a part of their development, they consult SONEES to ensure continuity and ease of transfer of the facilities at the time of completion. The situation where procedures are not prescribed legally, conflicts between private developers and SONEES may occur.

2.7.2 Laws

1) General

Senegal has reacted with a relative promptness to an increase of the pollutions and industrial nuisances in an industrialized society particularly in the West. This reaction resulted in the formulation of the following fundamental documents:

- Bill of the Sanitation Law (Projet de Loi portant Code de l'Assainissement)
- Bill of the Environment Law (Projet de Loi portant Code de l'Environnement)
- Water Law (Loi portant Code de l'Eau)
- Hygiene Law (Loi portant Code de l'Hygiene)
- Town Planning Law (Loi portant Code de l'Urbanisme)

In addition, there are two following decrees concerned:

- Decree concerning the Power of the Minister of Hydraulics (Decret relatif aux Attributions du Ministre de l'Hydraulique)
- Decree concerning the Power of the Minister of Environment and Protection of Nature (Decret relatif aux Attributions du Ministre de l'Environnement et de la Protection de la Nature)

The regulations governing SONEES are as follows:

- Note on the General Clauses and Conditions of the Public Water and Sanitation Service and its Annexes (Cahier des Clauses et des Conditions Generales du Service Public de l'Eau et de l'Assainissement et ses Annexes)
- Second Contract and Plan between the State and SONEES (Deuxieme Contrat-Plan Etat-SONEES)

2) General Laws and Regulations

The Bill of the Sanitation Law concerns with domestic and industrial wastewater, rain water and solid wastes. It contains provisions regarding the definition of domestic wastewater, the system of wastewater discharge, obligation and conditions of connection to the public sewerage, the definition of rain water, collection and drainage of rain water, characteristics of industrial wastewater, obligations of the factory owners, taxes and duties, utilization of treated water for industrial and agricultural purposes, etc.

The Bill of the Environment Law deals with classification and authorization of establishments, regulations related to water pollution, noise pollution, air pollution and bad smell. Under these regulations, discharging, dumping or depositing of any material, which is likely to alter the quality of surface, ground and sea, is prohibited. This bill is now under an intensive examination by the Ministries concerned so that it can be reinforced and made more suitable to the existing circumstances. The major point of concern is the effluent quality standards of industrial wastewater.

The Water Law applies to non-maritime water and hydraulic works. It concerns with the authorization for ground, mineral and surface water discharge, protection of water quality, different uses of water, order of priority of utilization etc. It has provisions applicable to the discharging, running, dumping and depositing of materials and more generally all that are likely to provoke or increase the degradation of surface and ground water, provisions applicable to each kind of water use, and regulations and authorization regarding activities susceptible of water pollution.

The Hygiene Law concerns with public hygiene. It includes hygienic rules of water, housing, streets, beaches, industrial facilities, food, drinks and restaurants. Also, it explains the power of the national hygienic service agents. The hygienic rules of water deal with the protection, disinfection and precautions regarding water supply networks, wells and tanks. The hygienic rules of housing deals with domestic wastes disposal, wastewater discharge and various forbiddings.

The Town Planning Law includes provisions related to the norms of the density of buildings, town planning schemes, green squares, the town development, land reserves, executive organizations, authorization to build, and checking and penalties.

These documents were released (or revised) in 1981 to 1988. They seem to encompass every facet of sanitation. In this respect Senegal can be said to be provided with abundant and sufficient laws/regulations concerned. It is hoped that they will be duly applied and will be brushed up in the course of actual applications.

In addition the two decrees can be implemented in June 1993.

Under the Decree concerning the Power of the Minister of Hydraulics, the Minister, is in charge of the great works of hydraulics realized under the authority of the government and also in collaboration with foreign countries, makes sure that the population is correctly supplied with urban and agricultural water, is in charge of the construction and maintenance of sanitation facilities, makes sure that water quality is in accordance with the official standards, etc.

Under the Decree concerning the Power of the Minister of Environment and Protection of Nature, the Minister is in charge of, the struggle against any type of pollution, the struggle against the turning into a desert, the protection of the soil, the protection of forests, animals and plants, etc.

These decrees show the importance and weight the government gives to the matters related to sanitation.

3) Regulations governing SONEES

The Note on the General Clauses and Conditions of the Public Water and Sanitation Service and its Annexes which was put into force in 1984 for SONEES stipulates its objective, work, obligations, etc.

In connection with sanitation it explains that:

- the state confers on SONEES the exclusive right to construct, realize and operate the facilities concerning the collection and treatment of wastewater;

- the state also can confer on SONEES by means of particular contracts the right to assure the collection and discharge of rain water; the facilities necessary for public service are composed of buildings, treatment plants, pumping stations, collection sewers, connections, etc.;

- all of these goods are the property of SONEES with the exception of those belonging to the public domain;

- SONEES is obliged to acquire, construct and operate all the above facilities; SONEES is obliged to prepare long and middle term investment plans for the public water service and have them approved by the state;

- the enforcement period of the note is 50 years.

The note continues that:

- the connection to the public sewerage receiving domestic wastewater is obligatory for the user and shall have access to it within two years starting from the sewerage service;

- the charge related to the connection of wastewater and rainwater will be borne by the user.

- the sanitation charges for the ordinary discharges are in principle included in the water charge per cubic meter.

- the tariff for sanitation, for a transitory period, covers only the costs of operation and little maintenance, etc.

The Second Contract and Plan between the State and SONEES is based on the above-mentioned note and constitutes an expansion or addition on its certain aspects. It is valid for the five year period 1990 to 1994 and renewable. In connection with sanitation it provides that SONEES is in charge of the operation and maintenance of all the installations and the renewal of electro- mechanical equipment and is obliged to assure the good functioning of the collection, treatment and discharge facilities for wastewater and rain water.

Regarding financial and management aspects it explains that:

- SONEES will generate at least 2% profit on the fixed assets employed and will make the annual evaluation of financial performance by comparing the achievement with the budget;

- the obligations for direct taxes and duties are suspended;

- SONEES will embark on the study of tariff revision to satisfy its engagements;

- the state will officially change the statute so that the financial management of stand pipes may be transferred from the Communes to the private persons.

2.8 PRESENT STATUS OF REUSE OF WASTEWATER

Since the study area is situated in an arid zone, treated wastewater or even untreated wastewater is recognized as an important potential water source. There are several studies to investigate possibilities of re-use of treated wastewater mainly for agriculture use. While these studies cover necessary additional treatments, nutrition effects, yield effects, etc., demands of such treated water and methods of distribution have not been investigated.

There is no actual application of the re-use in the area, though two wastewater treatment plants are presently under operation. Instead, it is observed that raw wastewater is used for irrigation in some areas. While such raw wastewater may be an only available water source for such people who are not affordable for obtaining SONNES water or have difficulty in accessing to underground water, this could

be a great concern in terms of hygienic problems for themselves and bacteriological/pathological contamination of their crops.

There is one example that re-use of treated water was tried in a small housing development project operated by a private developer in the Parcelles Assainies area. In the project, a small wastewater treatment plant with an activated sludge method was constructed to treat wastewater from developed houses and it was intended to use its treated water for gardening of the houses. For this purpose, a transmission pump was installed in the plant and treated water distribution pipe were installed to send water to each house. However, people in the area never used the treated water probably because of their mental hesitation to the treated wastewater. This fact may suggest one of difficulties in utilization of treated wastewater.

TABLE A.2.1 MONTHLY MEAN TEMPERATURE (DEGREES C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Maximum	24.2	24.1	24.8	24.8	25.8	28.3	29.7	29.9	30.1	30.4	28.8	26.5
Daily Minimum	17.1	17.1	17.6	18.6	20.4	23.2	24.8	24.8	24.6	24.6	22.4	19.7
Average	20.6	20.6	21.2	21.7	23.1	25.7	27.2	27.3	27.3	27.5	25.6	23.1

Data Source: Strategy Plan

TABLE A.2.2 MONTHLY MEAN RELATIVE HUMIDITY (%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Maximum	88.8	92.3	92.5	92.8	92	90.8	89.4	91.2	93.8	92.8	91	86.8
Daily Minimum	47.9	55.9	56.9	64.5	66.6	67.1	67.5	71	71.5	65.6	54.5	44
Average	68.3	74.1	74.7	78.6	79.3	78.9	78.5	81.1	82.7	79.2	72.8	65.4

Data Source: Strategy Plan

TABLE A.2.3 AVERAGE MONTHLY RADIATION (10cal/sqcm/day)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly radiation	82	86	94	99	96	86	75	69	73	83	84	77

Data Source: Strategy Plan

TABLE A.2.4 MONTHLY AVERAGE DAILY EVAPORATION (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Evaporation	3.4	2.9	3	2.6	2.4	2.6	2.8	2.3	1.9	2.5	3.3	4.2

Data Source: Strategy Plan

TABLE A.2.5 GROSS DOMESTIC PRODUCT (GDP) OF SENEGAL AT CURRENT PRICE IN 1992

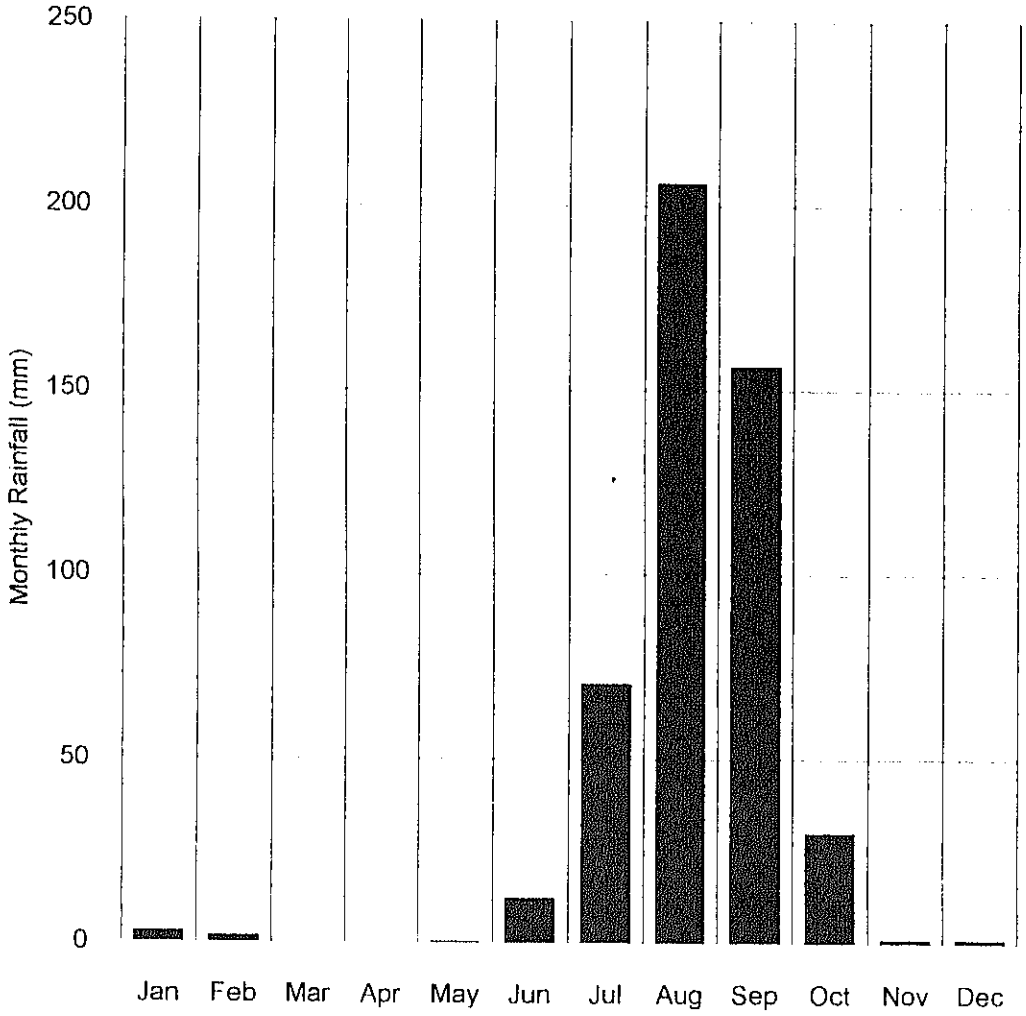
Item	Amount (billion FCFA)	Annual Rate of Growth (%)	Share (%)
Primary	334.3	6.4	19.8
Agriculture	154.6	6.5	9.1
Stock Raising	120.7	6.8	7.1
Fisheries	39.9	4.8	2.4
Forestry	19.2	6.1	1.1
Secondary	317.3	3.9	18.8
Mining	11.2	5.6	0.7
Oil	14.8	20.1	0.9
Energy	31.6	2.9	1.9
Construction	48.4	3.6	2.9
Other Industries	211.2	3.0	12.5
Tertiary	867.5	5.2	51.3
Transports	169.5	3.4	10.0
Commerce	415.8	6.3	24.6
Other Services	282.2	4.6	16.7
Non-Mercantile Services	172.7	0.3	10.2
Households	27.1	3.0	1.6
Administration	145.6	-4.6	8.6
Gross Domestic Product	1,691.8	4.6	100.0

Source: Direction de la Prevision et de la Statistique

TABLE A.2.6 POPULATION OF THE STUDY AREA

Year	Senegal	Dakar		Pikine		Study Area	
	DPS	DPS	SP	DPS	SP	DPS	SP
1980	5,734,000	566,000	566,000	420,000	420,000	986,000	986,000
1988	6,896,808	687,362	687,000	622,397	622,000	1,309,759	1,309,000
1983	7,913,090	767,194	-	812,344	-	1,579,538	-
1998	9,037,906	860,113	867,000	1,044,814	1,018,000	1,904,927	1,885,000
2001	9,774,093	919,683	931,000	1,206,540	1,179,000	2,126,223	2,110,000
2010	12,209,985	1,109,485	1,173,000	1,798,398	1,836,000	2,907,883	3,009,000

DPS: DIRECTON DE LA PREVISION ET DE LA STATISTIQUE
SP: STRATEGY PLAN



Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Rainfall (mm)	2.9	1.7			0.3	12	70	206	157	30	1.1	1.1

FIGURE A.2.1 MONTHLY AVERAGE RAINFALL (1947-1989)

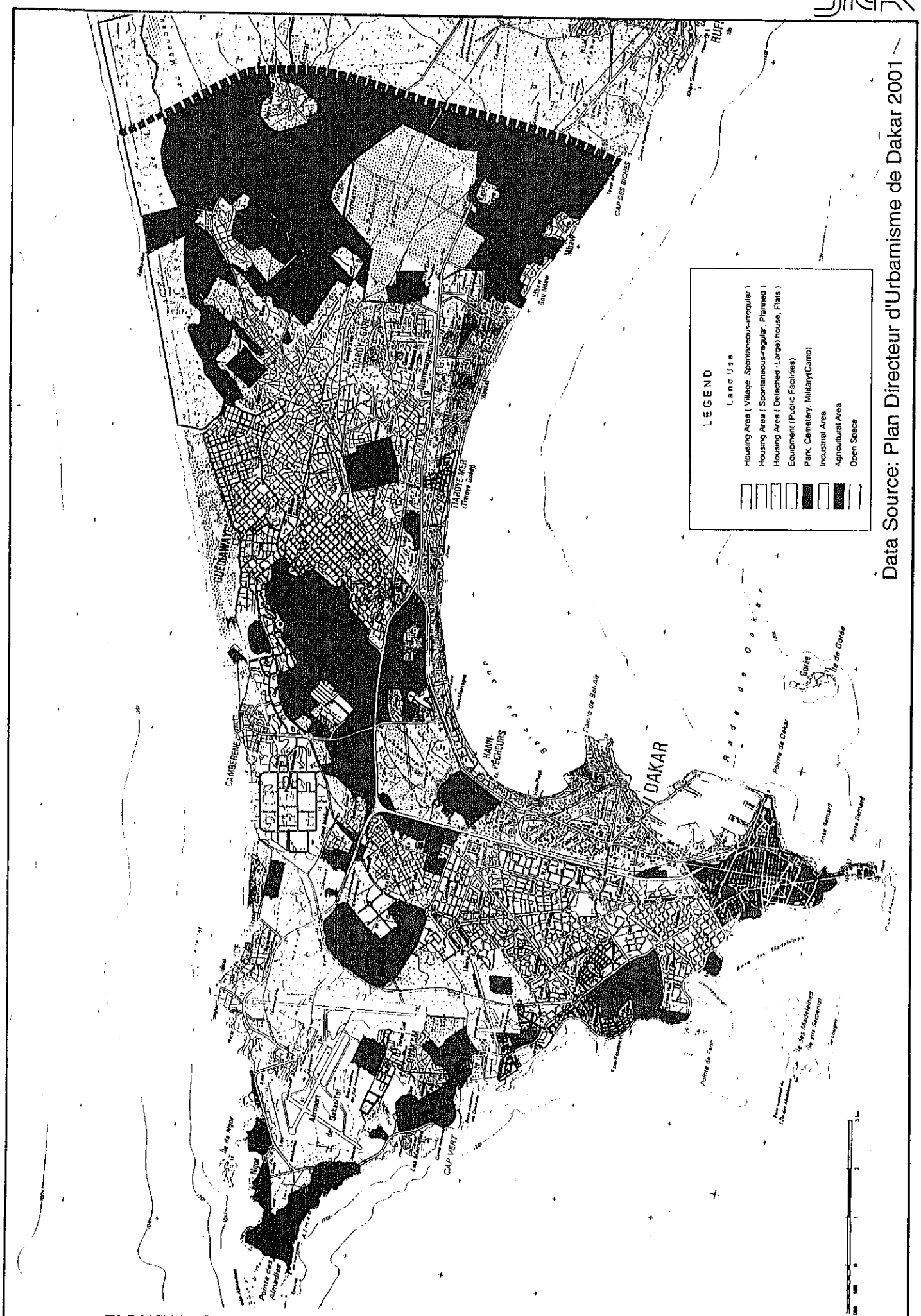


FIGURE A.2.2 PRESENT LAND USE OF THE STUDY AREA

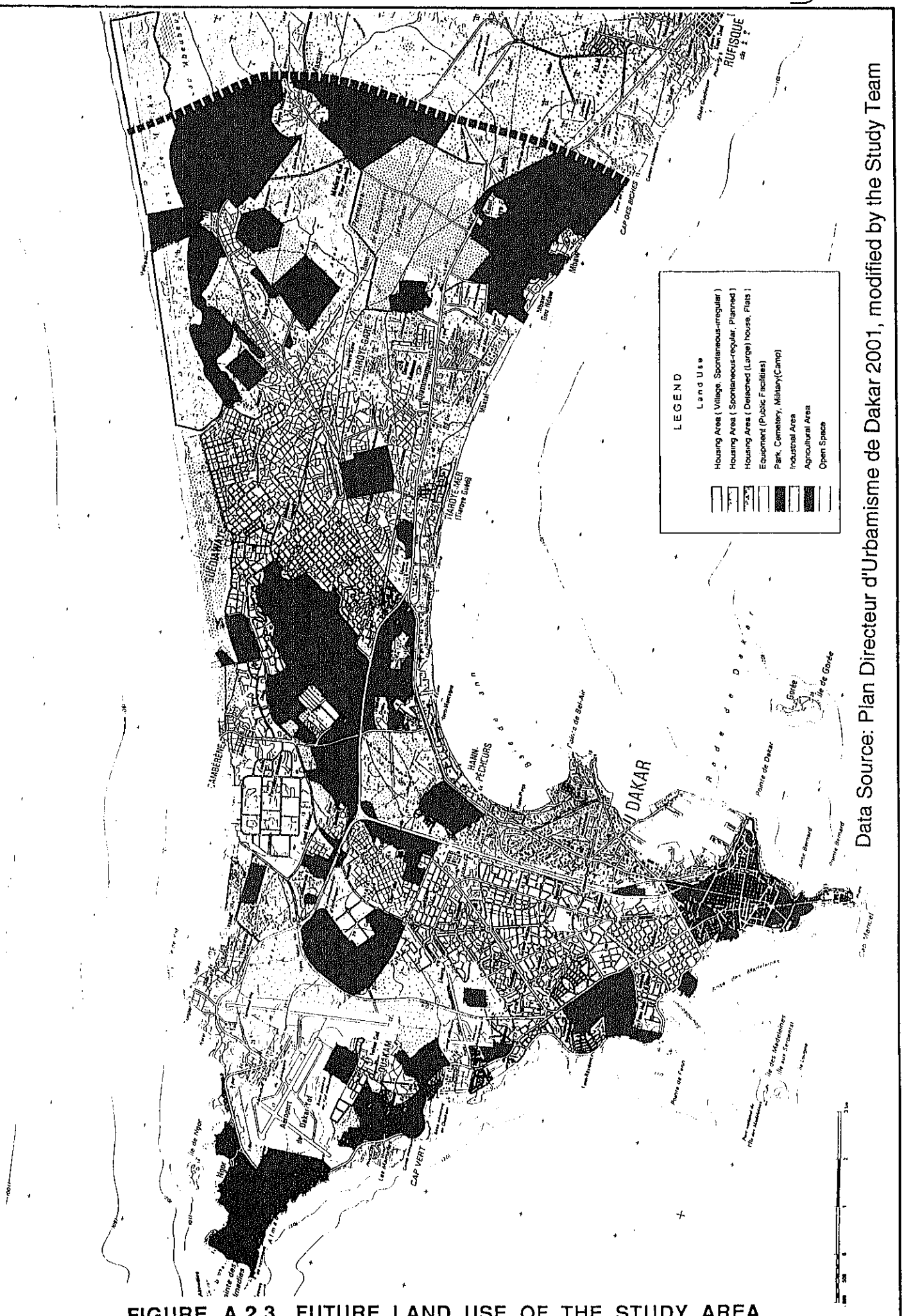
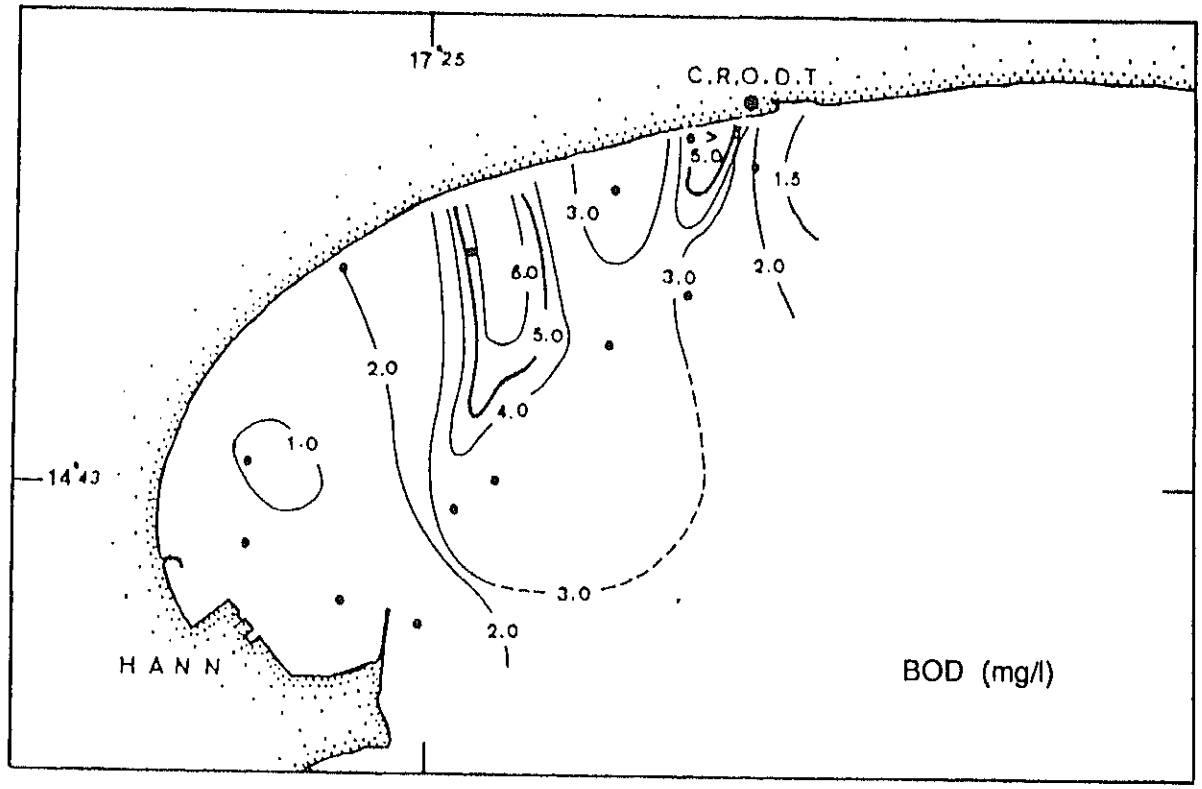


FIGURE A.2.3 FUTURE LAND USE OF THE STUDY AREA



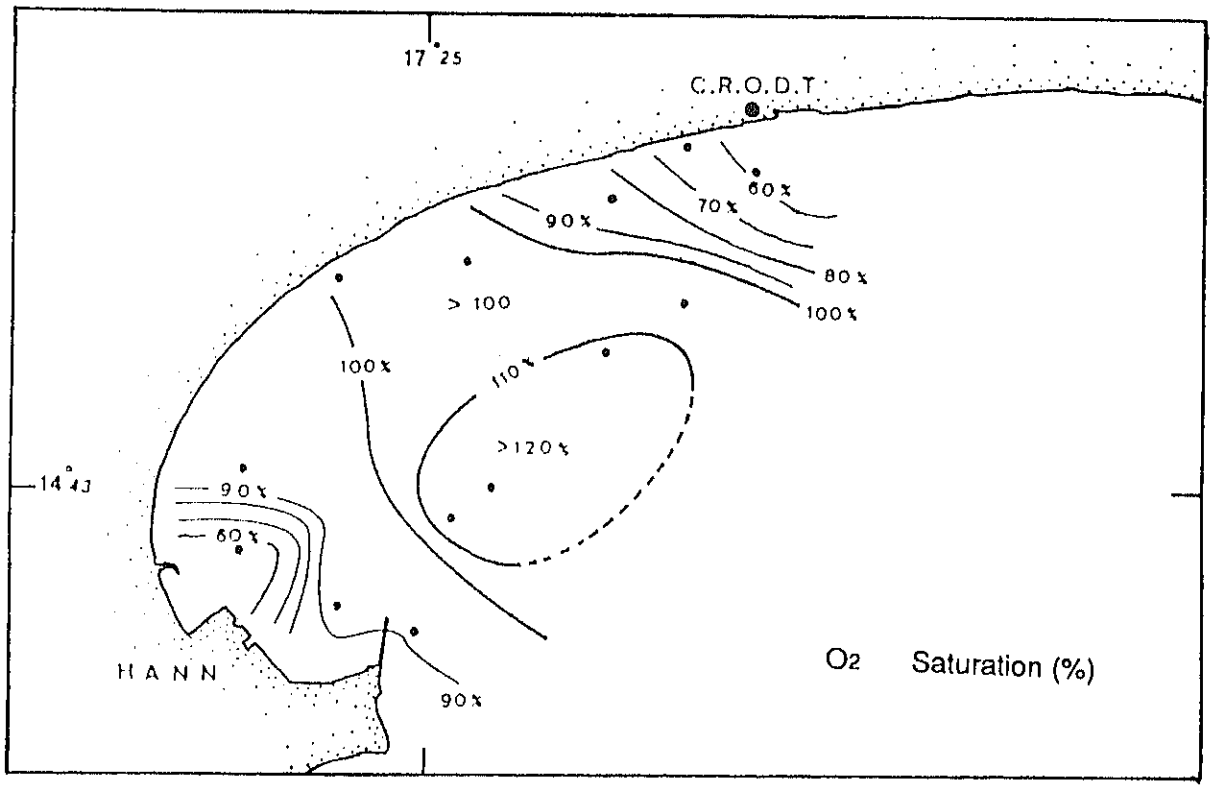


FIGURE A.2.4 DISTRIBUTION OF BOD AND DISSOLVED OXYGEN IN THE HANN BAY

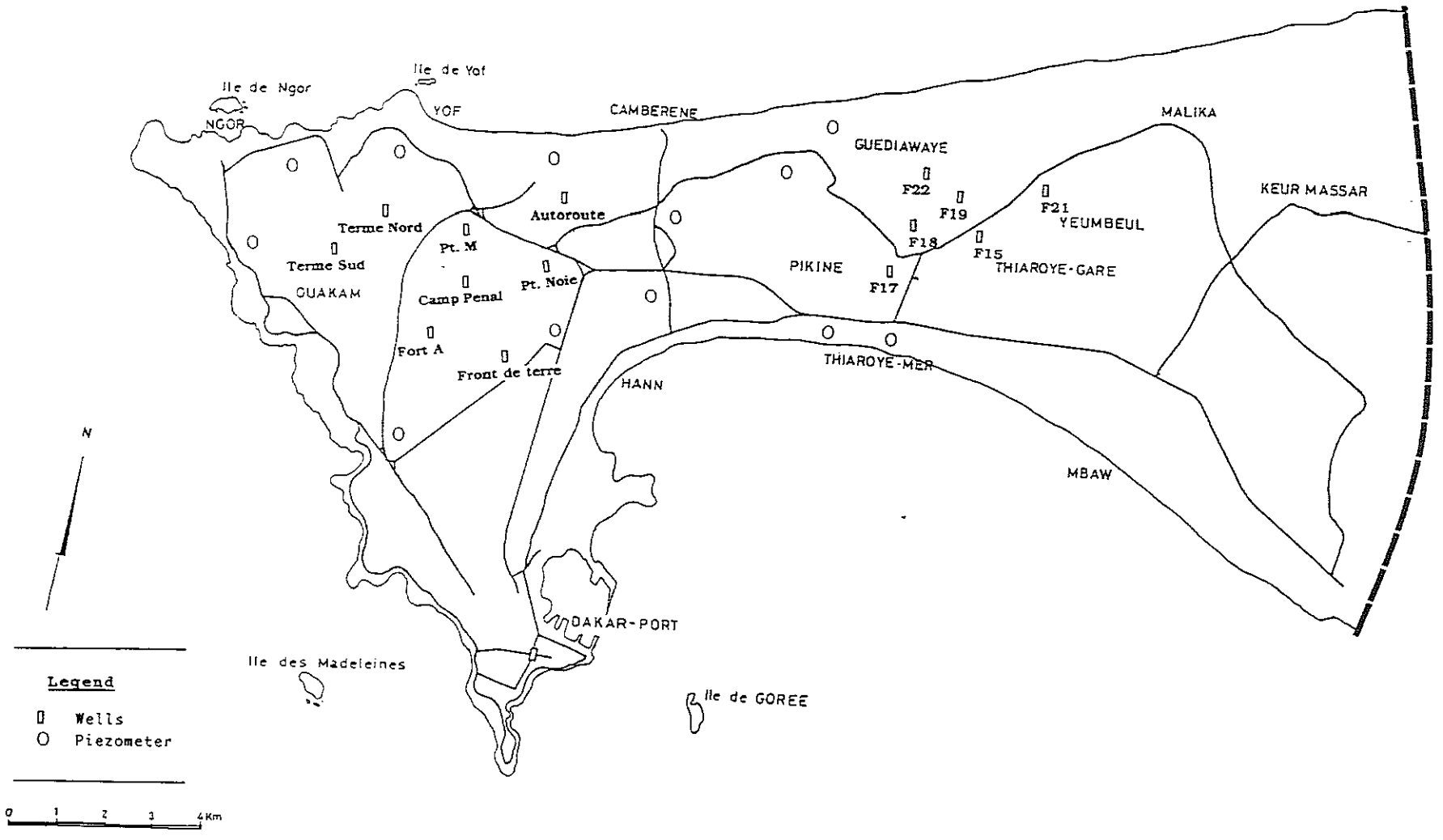
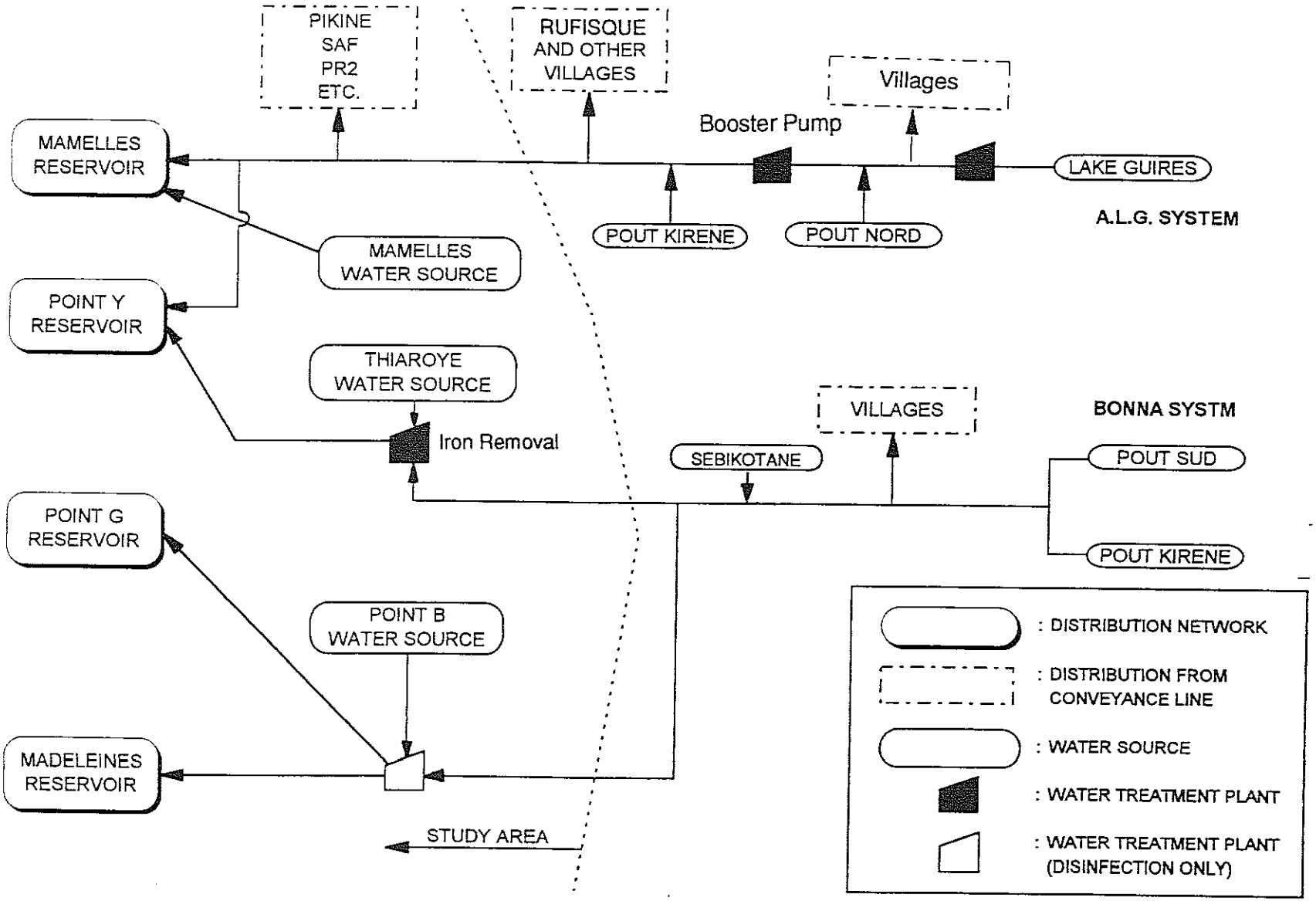


FIGURE A.2.5 LOCATION OF WELLS UTILIZED BY SONEES IN THE STUDY AREA



Source:SONEES 93

FIGURE A.2.6 CONCEPTIONAL EXPLANATION OF WATER SUPPLY SYSTEM IN THE STUDY AREA

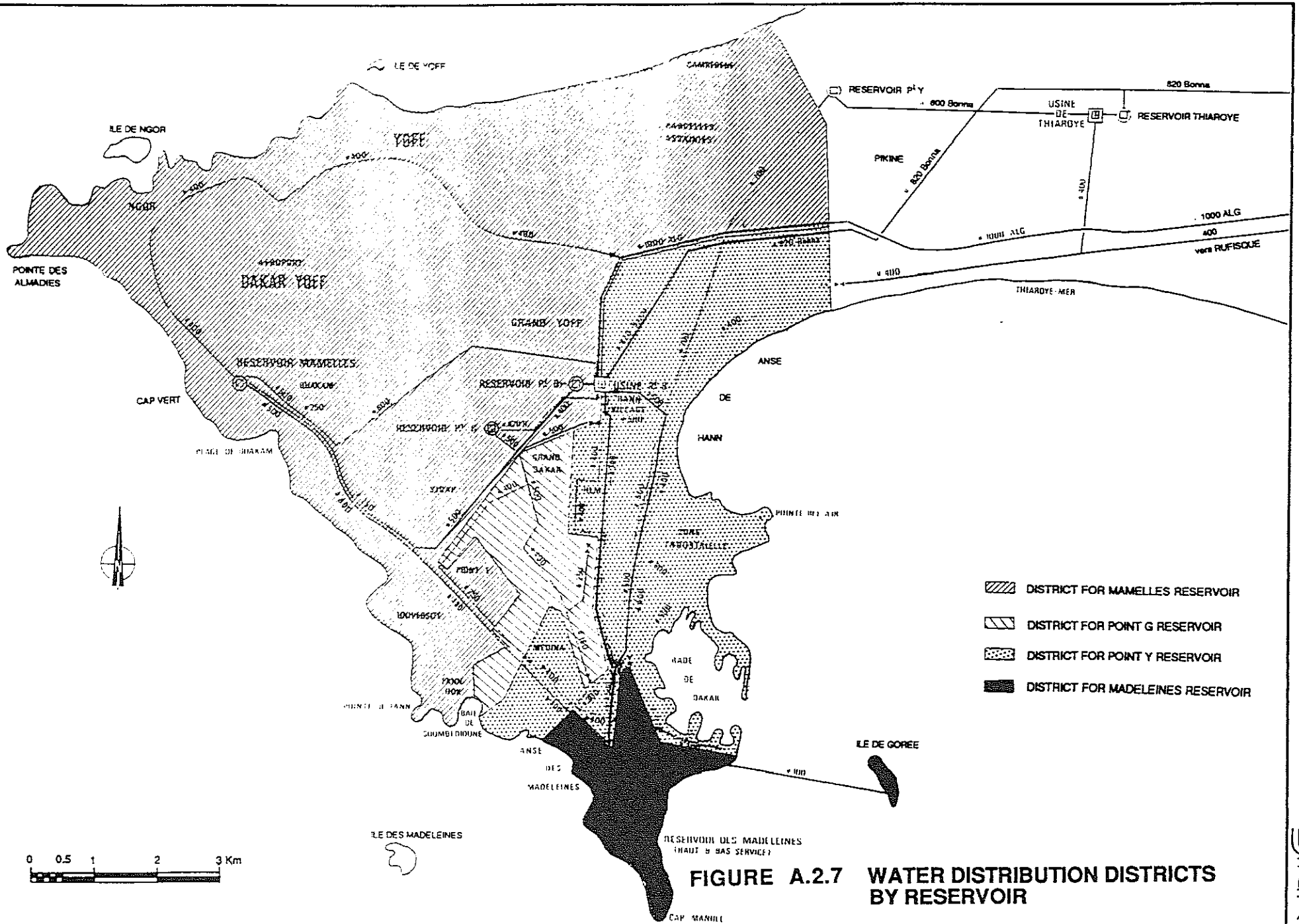
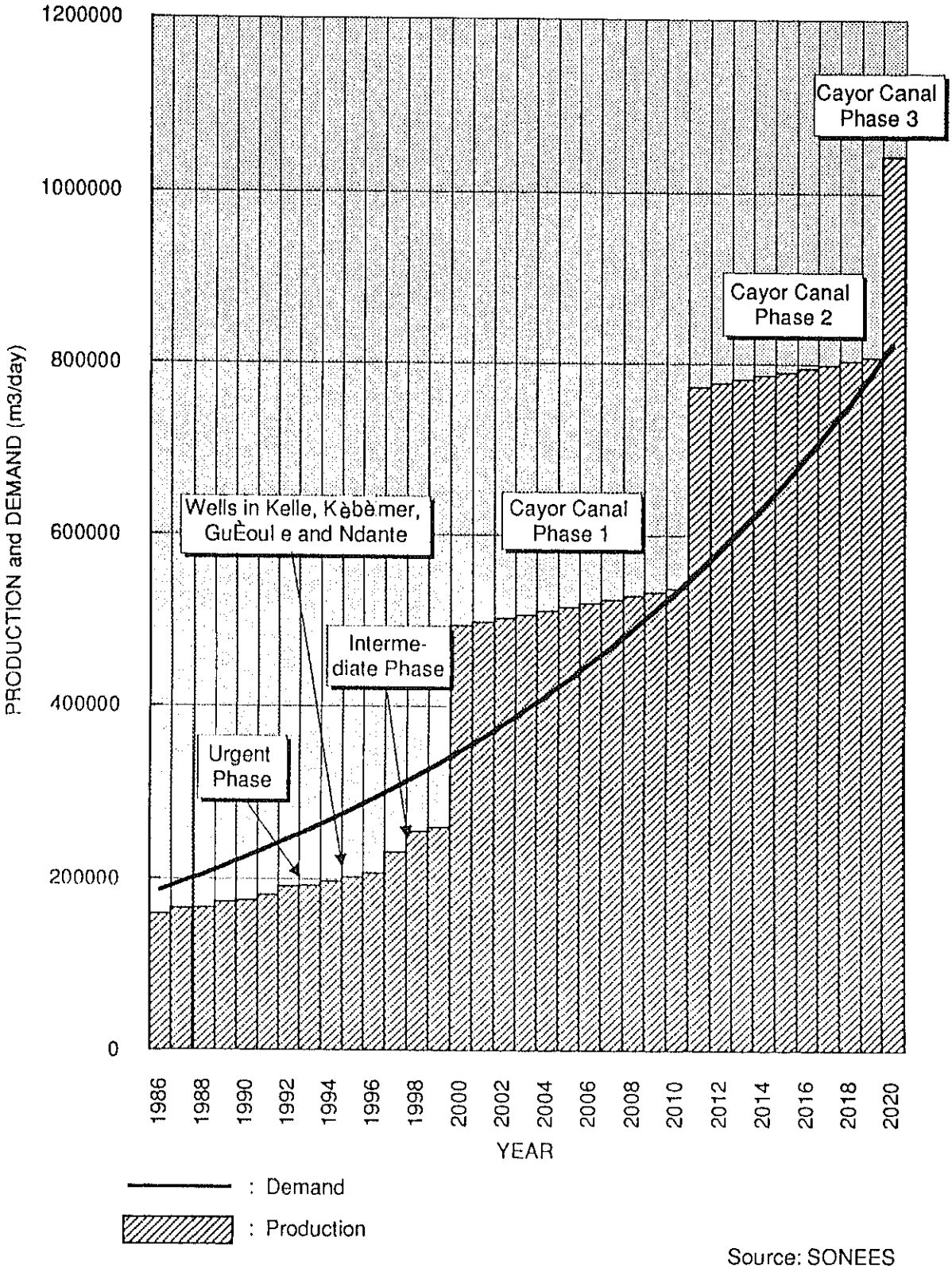
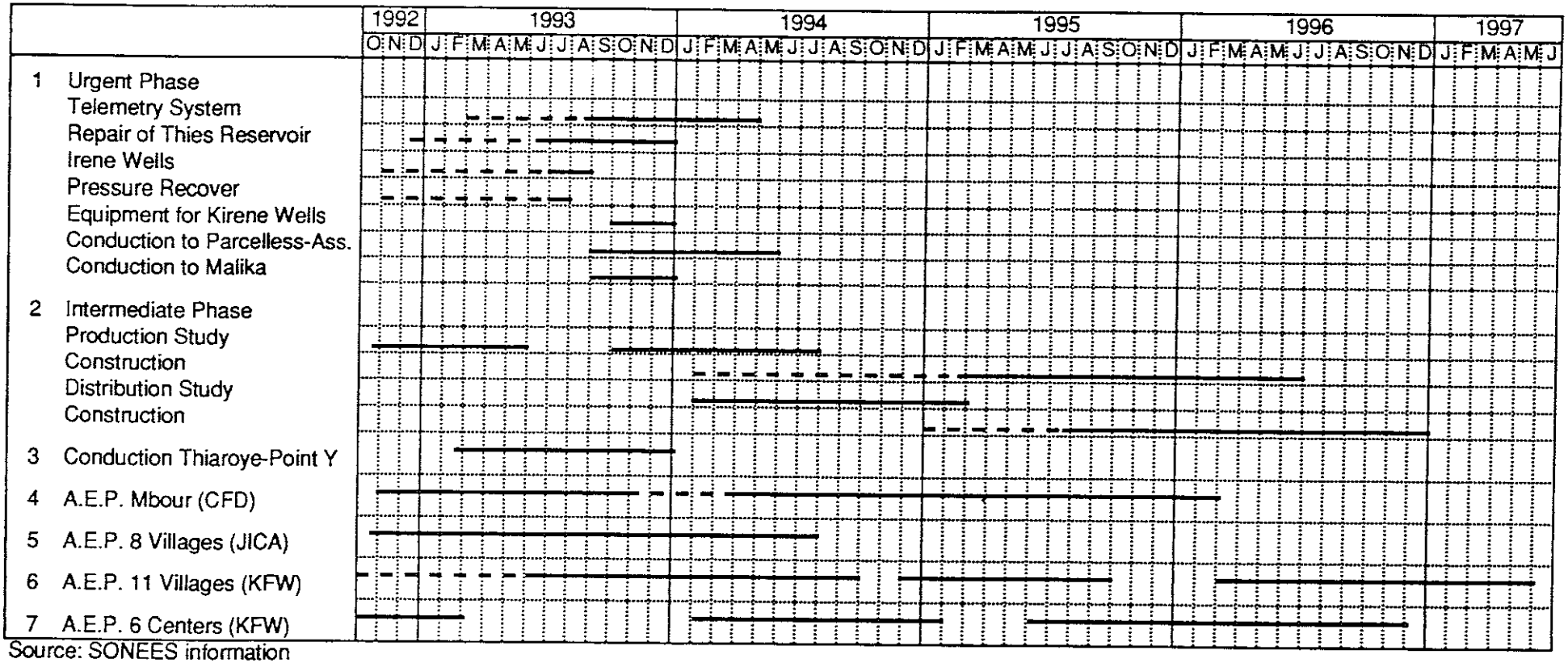


FIGURE A.2.7 WATER DISTRIBUTION DISTRICTS BY RESERVOIR



Source: SONEES

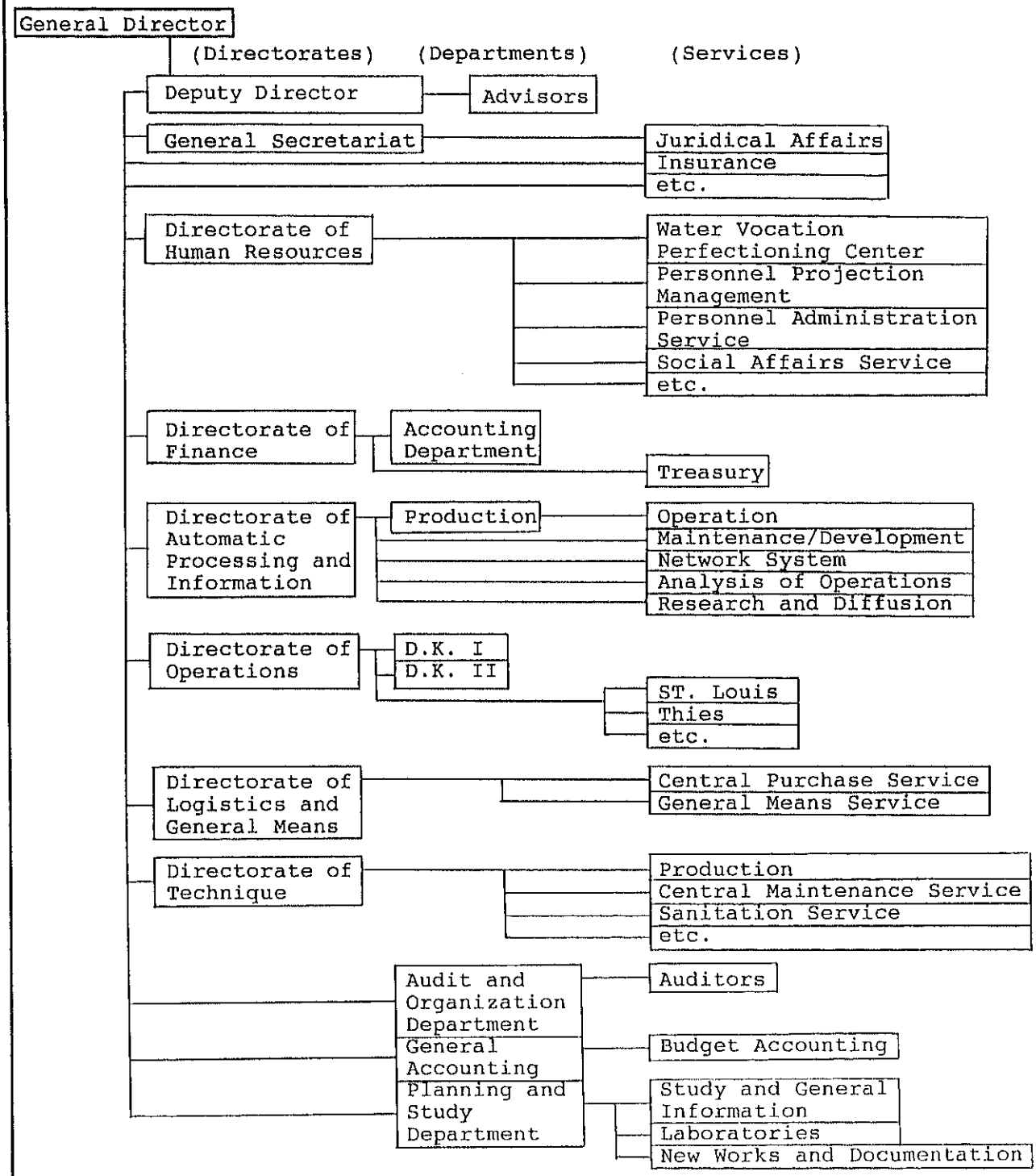
FIGURE A.2.8 WATER DEMAND AND PRODUCTION PROJECTION



Source: SONEES information

FIGURE A.2.9 IMPLEMENTATION SCHEDULE OF CURRENT WATER SUPPLY PROJECTS BY SONEES

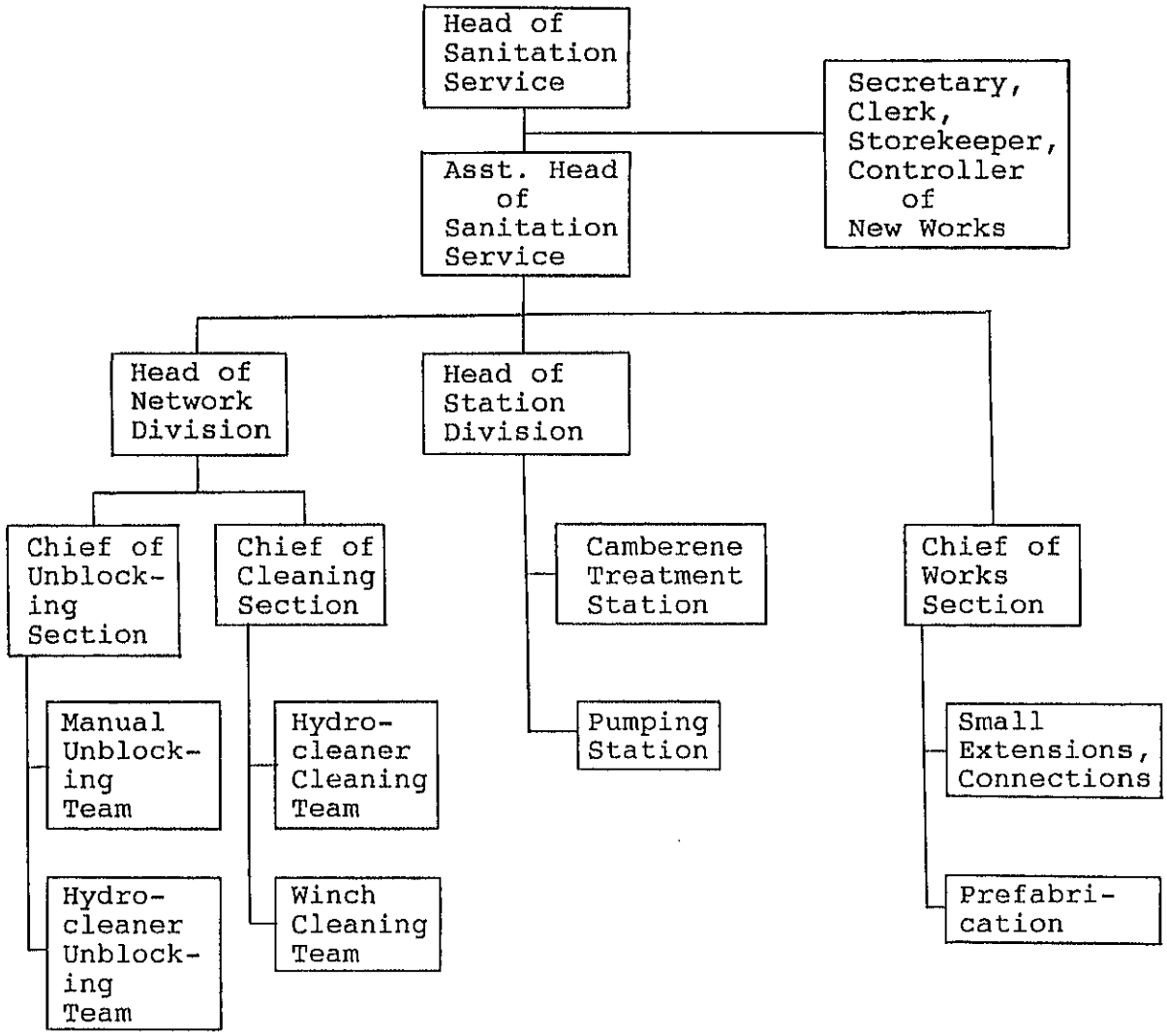
(FIG2-6.XLS, 11/9/1993)



Total Personnel:1,477

Source SONEES 1993

FIGURE A.2.10 ORGANIZATIONAL STRUCTURES OF SONEES



Number of Workers:

about 100

FIGURE A.2.11 ORGANIZATIONAL STRUCTURE OF THE SANITATION SERVICE OF SONEES

SUPPORTING REPORT - B

WASTEWATER SYSTEM

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CHAPTER 1 PRESENT CONDITIONS OF WASTEWATER SYSTEM

1.1 OUTLINE OF THE SEWERAGE SYSTEM

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

The on-site system is an individual sanitary system which deals with wastewater at the site of its origin. Several kinds of systems are found in the Study Area, from simple pit latrines which treat only human excreta to septic tank systems which treat sludge together with toilet wastes. In extreme case, houses which do not have any kind of sanitary system still exist in the Study Area.

Sewerage is essentially a public infrastructure system which should be provided by a public authority. There are, however, several sewer networks constructed by private developers and transferred to SONEES after completion of construction. These are mostly found in the newly developed housing areas. In these areas, houses are not always connected to the public sewers, and have some kind of on-site systems. Even in some areas, houses connected to the sewerage system account for only a small portion of all the houses. In addition, there are houses in the Dakar area, where the sewerage system was constructed a long time ago, which do not have sewer connection, although these are only a few in number. Therefore, the population in sewered areas does not equal the actually sewered population in the Study Area.

Currently SONEES is making efforts to combine the small independent or dispersed sewer networks into two major systems, viz. Hann-Fann and Camberene systems. The former system covers the older urban areas, such as Plateau, Medina, Universite, Grand Dakar and SICAP districts. Sewage from these districts is collected and finally pumped to Pointe de Fann for final disposal by an ocean outfall. Raw sewage is discharged to the sea without any treatment.

The Camberene system collects sewage from the comparatively new developed districts, such as Parcelles Assainies. Patte d'Oie district which was served by Patte d'Oie WWTP has been converted to the Camberene WWTP. A part of Guediawaye whose sewage had been treated at the Niaye WWTP was recently transferred to the Camberene system. Construction of a new force main from Sotiba P/S, which collects sewage from a part of Pikine, to the Camberene WWTP has been initiated. Also upstream area served by the Hann-Fann collector is temporarily converted to the Camberene WWTP in order to increase the sewage flow to the plant which is now being operated in an under-loaded condition. All the sewage collected at the Camberene WWTP is discharged at the Camberene village to the sea after complete secondary treatment by the activated sludge process.

The outline of the existing sewerage system, sewered areas and location of the main facilities, is shown in *Figure* B.1.1.

1.2 EXISTING SEWERAGE SYSTEM

1.2.1 Zones

Among 181 units identified by "Strategy Plan", 79 units are provided sewer networks as of 1993. Area (ha), residential population and served population that are connected to the networks of each unit are shown in *Table* B.1.1. Units other than residential area, such as public institutions, are included in the table, as far as provision of sewer is concerned. Residential areas are classified into six housing types according to the following classification.

Classification	Housing Type
1	Village
2	Spontaneous, irregular
3	Spontaneous, regular
4	Planned

5	Detached (Large) houses
6	Flats

The current sewered population is estimated to be 453,958, which accounts for 30 % of the total population of 1,517,400 in the Study Area. In the Strategy Plan, the sewered population was estimated to be 416,646, which accounted for 32 % of the total population of 1,296,010 in 1989. The sewered population increased by about 37,000 from 1989 to 1993. However, sewerage service ratio decreased slightly from 32 % to 30 % during the same period. This is an indication that the extension of the sewerage system has not caught up with the recent population growth. As shown in the table, most of the residential units served by the sewerage system belong to classifications 4, 5 and 6, which suggests a close relationship between housing type and sanitary facilities therein.

1.2.2 Facilities

1) House Connections

Wastewater from households flow into the public sewer network through house connections. A typical arrangement of the sewers and house connections is shown in *Figure* B.1.2. A house is provided with one connection pit where all the wastewater is collected. The pit is connected to a manhole by connection pipes made of asbestos cement or PVC. Formerly, asbestos cement pipes of 150 mm in diameter were used, but recently these have been changed to PVC pipes of 160 mm diameter. Installation of house connections, which consists of a pit and pipes, is carried out by SONEES on the request of the house owner. SONEES collects a connection fee from the house owner, which depends on the distance between the pit and the manhole, with 150,000 FCFA being the average (1993 before devaluation of FCFA). Therefore, house connections are private properties, and are not part of public sewerage system.

The cross section of typical house connections, structure of a connection pits and a manhole are shown in *Figures* B.1.3, B.1.4 and B.1.5, respectively.

Four types of connection pits are currently used, depending upon the depths to the invert, from 0.75 to 1.44 m. *Figure* B.1.4 shows Type 1, which is the shallowest.

There are two types of standard structures for manholes, viz. shallow types for depths less than 3.5 m and deep type. *Figure* B.1.5 shows the shallow type.

2) Sewer Networks

The total length of the sewer network is approximately 610 km at present. The diameter of the sewer pipes vary from 150 to 250 mm for branch and lateral sewers, and 300 up to 1,400 mm for secondary mains and collectors.

Asbestos cement and clay pipes were used in old sewered areas, such as Plateau and Medina. However, these materials are not used presently, and broken pipes are replaced by PVC pipes. PVC pipes are widely used currently for smaller diameter pipes up to 300 mm diameter. These pipes are made by a local manufacturer, and are readily available. Reinforced concrete pipes, which are imported or manufactured locally by special orders, are used for larger diameters. Steel pipes and cast iron pipes, also imported, are used in case of force mains. Nevertheless, PVC pipes are also used for force mains.

3) Pumping Stations

There are a total of 25 pumping stations in the Study Area. The name, type, capacity and total head are shown in *Table* B.1.2.

There are two types of pumping stations, viz. submersible and dry pit types. The former type is used for the smaller capacity pumping stations, with the latter for larger capacities. Two pumping stations, Universite and Soumbedione, are dry pit type and the remaining 23 pumping stations are submersible type. Dry pit type pumping stations are equipped with centrifugal pumps. Typical structures of the submersible type pumping station are shown in *Figure* B.1.6.

All pumping stations, except P/S 26 in Pikine, are equipped with FLYT pumps made in Sweden. Generators for emergency use are installed at some pumping stations.

All pumping stations are kept clean and maintained well by SONEES. A few important pumping stations, such as Parcelles Assainenes 13 and Soumbedioune, are attended by SONEES staff round-the-clock, while the remaining stations are supervised intermittently. Automatic on-off devices controlled by water levels are provided at all the stations.

Breakdown of pumping stations caused by power or mechanical failure is not rare, especially in the rainy season, which causes flooding by raw sewage. In case of a serious failure, the breakdown lasts a few weeks. SONEES receives many complaints from nearby inhabitants.

4) Wastewater Treatment Plants (WWTPs)

There are five wastewater treatment plants in the public sewerage system. A few small scale wastewater treatment facilities exist, which were constructed and owned by private developers or contractors. However, these treatment facilities are out of order for various reasons and no treatment is carried out by them. Moreover, among the five wastewater treatment plants in the public sewerage system, only two plants, Camberene and Niaye, are receiving sewage at present. The present condition of the five treatment plants is described below.

(1) Camberene WWTP

Camberene WWTP was commissioned in December 1989. A loan from the African Development Bank was utilized together with the Senegal Government budget for the construction administered by the Ministry of Hydraulics. One process train was constructed as the first phase of the project. Design parameters of the first process train are as follows:

Population equivalence:	100,000 persons
Daily average flow:	9,600 m^3/day
Peak flow:	16,800 m^3/day (1.75 Q)
BOD load:	6,000 kg/day
SS load:	9,000 kg/day
Raw sewage	
BOD concentration:	625 mg/l
SS concentration:	938 mg/l
Treated effluent	
BOD concentration:	20 mg/l
SS concentration:	30 mg/l

The second process train, which has the similar process and parameters, is to be constructed next to the first one. With the expansion, the plant's treatment capacity will be sufficient for population of 200,000. The plan of the existing facilities and the hydraulic profile are shown in *Figures* B.1.7 and B.1.8 respectively.

The plant was designed to have the complete secondary treatment by the activated sludge process. Raw sewage flowing into the plant is lifted by screw pumps. After screening, sewage flow into the aerated grit chamber. A circular primary sedimentation tank is provided before the rectangular shaped aeration tank which is equipped with six mechanical aerators. A circular final sedimentation tank follows the aeration tank. Treated sewage finally flows into the chlorination tank, and from where it is pumped through a force main to the ocean outfall located at the coast in Camberene village. At the time of inspection by the Study Team, all wastewater treatment facilities are functioning properly but chlorination. Chlorinator pumps were out of order, and periodical chlorination is conducted by using calcium-hypochloride solution.

Excess sludge from the final sedimentation tank is returned to the primary sedimentation tank and sent to the sludge digestion tanks together with primary sludge. Two stage anaerobic digestion is conducted before the sludge is sent to sand drying beds. A gas holding tank and a power generator utilizing methane gas from the digester are provided. The generator, however, has been out of order because of mechanical failure since October 1992. Excess gas is burnt by a burner.

Ancillary works, such as various kinds of buildings, are adequately provided for the proper operation of the plant.

(2) Niaye WWTP

Niaye WWTP is located in the eastern part of Grand Niaye near Pikine. The plant is surrounded by swamps and vegetable farms. The plant was constructed based on the proposal in the Water Supply and Sewerage Master Plan, 1973, to treat sewage from the Guediawaye and Sotiba areas. However, the Guediawaye area has recently been converted to the Camberene system, though sewage from Sotiba is sent to the plant at present.

The plant consists of a grit chamber and Imhoff tank, an oxidation pond, three infiltration ponds and sludge drying beds. Design parameters of the plant are as follows:

Population equivalence:	7,600 persons
Daily average flow:	550 m^3/day
Peak flow:	960 m^3/day (1.75Q)
Grit chamber	
Surface loading:	30 m^3/m^2/hr.
Velocity:	30 cm/sec
Inhoff tank	
Sedimentation tank:	550 m^3
Anaerobic digestion tank:	400 m^3
Oxidation pond	
Surface area:	5,000 m^2
Depth of water:	1.2 m
Retention time:	11 days (appr.)
Infiltration pond	
Total surface area:	800 m^2
Sludge drying beds	
Total surface area:	380 m^2

The plant is not functioning as designed. The main reason for this is pilferage of sewage from the oxidation pond by farmers. Holes have been pierced in the concrete wall of the tank to obtain water, which is used for growing vegetables. The infiltration ponds seems never to have received effluent from the oxidation pond up to now. SONEES wants to stop operating the plant as soon as conversion of Sotiba pumping station to the Camberene system is completed. This has recently been initiated.

(3) Mbao WWTP

Mbao WWTP was constructed in 1982 by the Ministry of Industry to treat industrial wastewater from the factories in the industrial zone. However, this treatment plant has never been used until now. SONEES canceled the contract with the Ministry for keeping the mechanical and electrical equipment in working condition, since no payment was made. Although civil works seem to be in fairy good condition, all the mechanical and electrical equipment should be replaced if the rehabilitation of the plant is intended.

The plant was designed as biological secondary treatment based on the activated sludge process. Minor additional facilities, such as an oil separator before primary sedimentation tank, were added. Design parameters are not available. However, judging from the size of the facilities, the plant seems to have a capacity of a few thousand m^3/day.

(4) Patte d'Oie I WWTP

Patte d'Oie I WWTP had been commissioned in 1971, and ceased to function in 1988 when conversion to the Camberene WWTP was completed. The plant was constructed to treat sewage from Patte d'Oie

housing development area. The trickling filter process was adopted, and it served approximately 4,000 inhabitants, with a peak flow capacity of 60 m^3/hr.

Mechanical and electrical equipment are non-existence or totally broken. Possibility of rehabilitating the plant is questionable. SONEES has no intention of rehabilitating the plant.

(5) Patte d'Oie II WWTP

Patte d'Oie II WWTP was constructed in 1984, but has never been put into operation. The plant was designed to treat sewage from the extended Patte d'Oie housing development area. Conventional activated sludge process with mechanical aerators was adopted. Design parameters are as follows:

Daily average flow:	1,800 m^3/day
Peak flow:	3,696 m^3/day (2.05 x Daily average)
BOD load:	1,500 kg/day
SS load:	1,800 kg/day

SONEES declined to take over the plant when the construction was completed, since the construction of the Camberene WWTP was expected shortly at that time. Although most of the civil works seem to still be usable, replacement of the mechanical and electrical equipment is mandatory if the rehabilitation of the plant is intended. SONEES has no intention of using the plant.

5) Ocean Outfalls

There are two main ocean outfalls in the sewerage system, viz. Fann outfall at Pointe de Fann and Camberene WWTP outfall in Camberene village, in addition to three minor outfalls. There are some other wastewater discharges to the sea in the Study Area, such as open drainage channels which receive wastewater, industrial wastewater outfalls from factories in the industrial zone, and outfalls from large hotels. In this section, however, only five outfalls which are directly connected to the sewer network are discussed.

Fann outfall discharges wastewater from the most density populated areas and business center of Dakar. The wastewater is finally pumped at either of two pumping stations, viz. Universite P/S and Soumbedioune P/S, to the receiving well located at Point de Fann. From there the wastewater flows though a pipeline by gravity, and is discharged to the sea 350 m from the coast. No treatment, except screening at pumping stations, is provided and raw sewage is discharged to the sea.

The Hann-Fann collector flows into Universite P/S, and Corniche collector and Fass-Gueule Tapee collector flow into Soumbedione P/S.

There are three old collectors which directly discharge wastewater to the sea. These are Plateau, Rue Mangin and Rue 9 collectors. Invert levels of these collectors are deeper than that of the Corniche collector which was constructed in 1986. Thus, the Corniche collector, which was designed to intercept the old collectors, can not collect these three collectors. Wastewaters collected by them flows into the sea without any treatment.

The quantity of sewage discharged on daily average basis at present is estimated as follows.

i	Fann	49,500 m^3/day
ii	Camberene	3,900 m^3/day
iii	Plateau	4,700 m^3/day
iv	Rue Mangin	2,400 m^3/day
v	Rue 9	1,000 m^3/day

Location of each outfall is shown in *Figure* B.1.1 in the previous section.

1.2.3 Wastewater and Pollutant Load Generated and Collected

Wastewater generated in the Study Area was estimated based on the current population and per capita water consumption rates. Per capita water consumption rates for each unit worked out in the Strategy

Plan were used because no significant changes were observed in the total water consumption. Wastewater produced in non-residential areas such as hospitals, military camps, and the university, was estimated based on population equivalence. Industrial wastewater was estimated based on the unit wastewater flow per area (ha) which was worked out from the results of the survey conducted by the Study Team.

Wastewater flow collected by the sewerage system was estimated by units utilizing the sewerage connection ratio of every unit, which was worked out by the Strategy Plan. Discharging ratios which is the ratio of discharging flow into the sewerage system to the generated wastewater flow, were also used in estimating the collected flow.

The results of the estimation are tabulated in *Table* B.1.3.

As shown in the table, the total domestic wastewater flow including those generated in various kind of non-residential areas is 168,074 m^3/day on a daily average basis. Industrial wastewater is estimated to be 12,914 m^3/day. Thus, the total wastewater is 180,988 m^3/day. Out of the total wastewater flow, 66,210 m^3/day, or about 37 % is being collected by the sewerage system at present.

Pollutant load (BOD) generated in the Study Area and collected by the sewerage system was estimated in the same manner as in the case of wastewater flow. The unit BOD loading rate is worked out to be 47 gpcd (gram per cpita per day) from the results of the field survey conducted by the Study Team, which are shown in *Table* B.1.4.

Characteristics of the industrial wastewater taken from the 19 representative factories were analyzed by the Study Team. The results are shown in *Table* B.1.5. An average BOD concentration of the 18 factories except for the slaughter house (Abattoirs) is 240 mg/l. BOD concentrations are considered too low for the type of industries. BOD concentration of the wastewater generated by the same type of the industry in Japan is, therefore, used to estimate the industrial pollutant load. The average BOD concentration claculated by this is 920 mg/l as shown in *Table* B.1.5. This figure is considered to be more appropriate to estimate the industrial pollutant load.

BOD load generated and collected by the sewerage system is shown in *Table* B.1.6 and *Figure* B.1.9.

A total of 88,559 kg BOD load is generated daily in the Study Area, of which 76,808 kg/day (86.7 %) is domestic in origin. The remaining 11,751 kg/day (13.3 %) is considered to be generated by industries (including the slaughter house). This industrial BOD load is equivalent to about 250,000 persons.

BOD load collected by the sewerage system is either treated or discharged to the sea directly. The balance of BOD load collected is as follows.

Balance of BOD Collected by the Sewerage System

		(kg/day)
Total BOD collected	31,241	
Hann-Fann System	27,044	(86.6%)
Camberene System	4,197	(13.4 %)
Reduction at WWTP	4,029	(12.9%)
Total BOD discharged	27,212	(87.1%)
Hann-Fann System	27,044	
Camberene System	168	

As shown above, a total of 31,241 kg/day BOD load is collected by the sewerage system which accounts for 35.3 % of the total BOD load generated. The Hann-Fann system, including three small collectors which discharge raw sewage, collects the dominant portion of pollutant load collected, i.e. 86.6 %. The remaining 13.4 % is collected by the Camberene system. Out of the total BOD load of 31,241 kg/day collected by the sewerage system, only 4,029 kg/day or 12.9 % is treated. The remaining 27,212 kg/day is discharged to the sea, most of it being raw sewage. However, this calculation does not include BOD load discharged when the Camberene WWTP bypasses raw wastewater. BOD load discharged from the Camberene system is larger than 168 kg/day if bypasses are taken into account.

1.2.4 Operation and Maintenance

Operation and maintenance of the sewerage system together with storm water drain pipes is being carried out by SONEES. According to the annual report prepared by SONEES, at the beginning of 1993, SONEES' two departments, viz. Network and Station Departments, maintain the following facilities.

- 610 km sanitary sewer pipes
- 157 km storm water pipes
- 40,000 house connections
- 27 pumping stations (including 2 for storm water drainage)
- 2 treatment plants (Camberene and Niaye)

SONEES prepares an annual operation and maintenance program every year, which includes minor improvement and expansion works, such as installation of sewer pipes and improvements of pumping stations.

Cleaning of the sewer pipes is the responsibility of the Network Department. In general, the performance of the department in 1992 was satisfactory. Cleaning work is carried out by its permanent and temporary workers. In 1992, a total of about 108 department staff, including 13 technicians, 45 permanent workers and about 50 temporary workers, under two section chiefs carried out 4,438 cleaning jobs against a planned workload of 4,000 jobs. Each cleaning work took 1.04 days on an average against 1.0 day planned.

The department estimated the average pipe cloggings per unit length of pipe to be 3.3 points/km. However, actual cloggings occurred reached 4.2 points/km in 1992. Cloggings did not occur uniformly over the service area. These are concentrated in four sewerage districts out of the 19 districts, viz. Rue 10, Malick Sy, Rue 31 and Rue 9. They are parts of the older service area. The major causes for the cloggings in these districts are, 1) low quality of cleaning work, 2) stoppage of treatment plant by power failure, 3) corrosion of pipes, 4) intrusion of solid materials, and 5) shallow gradients of pipes. Greater number of working days per point were also required for unblocking works for the four districts.

The Station Department takes care of the 25 sewerage pumping stations and two treatment plants. Operation records of the 22 operating pumping stations in 1991 and 1992, viz. annual operation hours, total power consumption and volume of wastewater pumped, are shown in *Table* B.1.7. As shown in the table, a total of 8,121,565 m^3 (22,300 m^3/day on average) wastewater was pumped with total power consumption of 530,272 kWH (1,450 kWH/day on average) in 1991. These figures increased to 8,299,160 m^3 (22,700 m^3/day) and 550,995 kWH (1,500 kWH/day) respectively in 1992. Unit power consumption rates were 0.07 kWH/m^3 in both 1991 and 1992.

The records of the treatment plant operation for the recent four years, 1990 to 1993 (partly), were obtained from SONEES. Daily wastewater flows to the plant were shown in *Figure* B.1.10 and summarized in *Table* B.1.8. Daily average wastewater flows did not change significantly for the four years, i.e. 3,875 m^3/day in 1990, 3,395 m^3/day in 1991, 3,717 m^3/day in 1992 and 3,934 m^3/day in 1993. Extraordinarily large flows (1.5 to 2 times the daily average) were recorded mostly in the rainy season from July to September. Obviously, increased flows resulted from the ingress of the storm water into the sewer networks through misconnection of storm water drains to sanitary sewers or other faulty arrangements. A few extraordinarily large flows were recorded in the dry season and these may have resulted from the failure of the measuring device.

In order to eliminate effects of these extraordinarily large flows and to obtain the average dry weather wastewater flow, medians or the value that 50 % of the daily flows do not exceed were worked out. Medians were 2,691 m^3/day in 1990, 3,112 m^3/day in 1991, 3,700 m^3/day in 1992, and 3,953 m^3/day in 1993. These can be taken as representative dry weather daily average wastewater flows. Thus, the daily average wastewater flow has gradually increased over the four recent years.

A bypass pipe to the discharging pump pit attached to the chlorination tank was provided from all wastewater treatment unit after the main pump for emergency purposes. Therefore, in case of power failure or other emergencies, bypass flows occur and raw sewage discharged to the sea. During the four year period, bypass flows were recorded 115 times, although the percentages to the total flow were relatively small, i.e. 2.6 % in 1990, 3.0 % in 1991, 3.1 % in 1992, and 1.0 % in 1993. Intentional bypassings to keep wastewater treatment processes functioning properly in case of extraordinarily large flow, may be included. However, dates of the extraordinarily large flows do not necessarily coincide with those of bypassings. It seems, therefore, that most of the bypassings occurred because of power or other kinds of failures.

Several water quality parameters are analyzed regularly at the laboratory attached to the plant. The results of the analysis of the three parameters, viz. BOD, COD and SS, of raw sewage, primary and secondary effluents in 1992 are shown in *Table* B.1.9, and summarized as shown in *Table* B.1.10. Two other parameters, total nitrogen and phosphorus (PO_4-P) are added in *Table* B.1.10. Average concentrations of BOD of the raw sewage and the secondary effluent were 600 mg/l and 20 mg/l respectively. Those of SS were 654 mg/l and 14 mg/l. Reduction ratios calculated with those figures are 96 % for BOD and 98 % for SS. Concentrations and reduction ratios are quite satisfactory for the secondary process.

From the operation records and the results of water quality analysis, several important operating indicators for the main facilities are worked out, as shown in *Table* B.1.11. Most of the indicators are within the normal range or on the lower side, e.g. surface loading and detention time of the primary sedimentation tank, and MLSS concentration in the aeration tank. These indicators suggest the obvious under-loaded operational condition because of the lower wastewater flow compared the plant capacity. This is one of the reasons for low concentrations of the secondary effluent and good reduction ratios.

The annual operation and maintenance cost of the plant for 1992 was obtained from SONEES which is shown in *Table* B.1.12. Operation and maintenance cost is divided into two categories, viz. fixed costs and variable charges. Fixed costs include employers' salary, temporary workers' salary, maintenance of vehicles and so on. Variable charges include charges for electricity and various oils and chemicals. In 1992, the fixed costs and variable charges amounted to 47,269,281 FCFA and 66,923,058 FCFA, respectively. The total operation and maintenance cost amounted to 114,192,339 FCFA. In the same year, a total of 1,374,951 m^3, or 3,767 m^3/day on an average, of wastewater was treated at the plant. Thus, the average operation and maintenance cost per volume of wastewater was 83 FCFA/m^3.

1.2.5 Financial Conditions

1) Public Investment for Water Supply and Sanitation

In the 6th Four-Year Plan of Economic and Social Development the public investment amounting to 447,404 million FCFA was budgeted for the period from 1981/1982 to 1984/1985. Out of it, 14,973 million FCFA or 3.3% was earmarked for urban hydraulics and sanitation. (Refer to *Table* B.1.13.) Out of 14,973 million FCFA, 6,222 million FCFA or 41.6% went to sanitation. That is to say, 1.4% of the total public investment was appropriated to sanitation projects.

Regarding the area-wise distribution of this 6,222 million FCFA, 3,662 million FCFA or 58.9% was for Dakar and its vicinities, 2,000 million FCFA or 32.1% for Saint-Louis and 560 million FCFA or 9% for other areas. The amount for Dakar and its vicinities which occupied 0.8% of the total public investment budget was to be used for sanitation works for Dakar and its surroundings, construction of Gueule Tapee canal, Front de Terre and individual sewer connections.

Of the total amount of public investment, 98,485 million FCFA or 22.0% was to be financed from the local sources and the balance of 348,919 million FCFA or 78.0% was to come from the external sources. With regard to the amount of public investment for urban hydraulics and sanitation, 2,391 million FCFA or 16.0% was to be locally financed and the remaining 12,582 million FCFA or 84.0% was to be externally derived.

In the 7th Four-Year Economic and Social Development Plan covering 1985/1986 to 1988/1989 546,700 million FCFA was budgeted for investment in the public sector. Out of it, 34,000 million FCFA or 6.2% was allocated to urban hydraulics and sanitation. (Refer to *Table* B.1.13.) Out of 34,000 million FCFA, 15,000 million FCFA or 44.1% went to sanitation. That is to say, 2.7% of the total public investment was allocated to sanitation projects.

Regarding the area-wise distribution of this 15,000 million FCFA, something like 7,900 million FCFA or 52.7% was for Dakar and its vicinities and the balance of 7,100 million FCFA or 47.3% for Saint-Louis and other areas. The amount for Dakar and its vicinities which occupied 1.4% of the total public investment budget was to be used for sanitation works for Dakar and its surroundings, construction of Gueule Tapee canal, Front de Terre and individual sewer connections.

Of the total amount of public investment, something like 22.0% was to be financed from the local sources and the balance of 78.0% was to come from the external sources. With regard to the amount of public investment for urban hydraulics and sanitation, something like 1,400 million FCFA or 4.1% was to be locally financed and the remaining 32,600 million FCFA or 96.9% was to be externally derived.

In the course of the implementation of the 7th development plan the actual amount appropriated for public investment is estimated to have been something like 455,200 million FCFA, which corresponds to 83.3% of the budgeted amount. Regarding urban hydraulics and sanitation, the estimated 26,500 million FCFA was actually appropriated, the ratio of attainment coming to 77.9%.

From 1989/1990 onward the Economic and Social Development Plan of Senegal underwent a conceptual transformation, in which the unit planning length of four years was abolished and the Six Year Orientation Plan for Economic and Social Development was introduced in its stead. Also, the fiscal year which spanned from July 1 of a particular year to June 30 of the following year was changed to the calendar year from 1992 onward. This 8th plan, therefore, covers the period 1989/1990 to 1995.

The Six Year Orientation Plan in which macro-economic framework is formulated is cut into two programs. The program which is called the Three Year Public Investment Program (le Programme Triennal d'Investissements Publics or PTIP) constitutes the implementation instrument of the Plan.

In the PTIP covering 1989/1990 to 1992, 392,960 million FCFA was invested in the public sector, out of which 10,817 million FCFA or 2.8% was spent for urban hydraulics and sanitation. In the PTIP covering 1993 to 1995, 483,670 million FCFA was budgeted, of which 50,320 million FCFA or 10.4% was allocated to urban hydraulics and sanitation. (Refer to *Table* B.1.14.) Throughout the six year plan period 876,630 million FCFA will be invested in the public sector, of which 61,137 million FCFA or 7.0% will be spent for urban hydraulics and sanitation.

2) Financial Statements of SONEES

SONEES provided the study team with the documents which are necessary for the team to analyze the corporation's financial conditions such as income statement, balance sheet and the analysis report on its financial position.

The impression of the JICA Study Team after examining all the documents concerned is that SONEES is trying hard to maintain its financial health and as a result it is managerially doing well as a public organization. (Refer to *Tables* B.1.15 and B.1.16.)

The Team noticed that the income statement of the past twelve years shows that SONEES was lightly in the red only in three years during that period. However, one thing that is noticeable in *Table* B.1.15 is that there are a few items where anything can be put and where the sum is very much irregular from year to year. Looking at *Table* B.1.16, one is convinced that SONEES is essentially in a good health in financial/managerial terms. One negative point is that the average period of credit to clients in 1992 is 4.4, which exceeds the border-line value of 3.

Looking into the structures of the income statement in *Table* B.1.15, it is observed that the revenues from water supply charge (water bill) amounted to 14,305 million FCFA in 1991. They are the regular and central revenues which can be constantly counted upon. In addition to them, there are various revenues most of which appear to be of an irregular nature, totaling 5,877 million FCFA. The ultimate revenues thus come to 20,182 million FCFA. The regular revenues accounted for 70.9% of the total revenues. It would be better if the ratio were greater.

Costs of operation totaled 14,782 million FCFA, which slightly exceeded the revenues from water bill. Materials and supply costs were 5,736 million FCFA, accounting for 38.8% of costs of operation. Personnel costs were 3,955 million FCFA, accounting for 26.8%. These two regular cost items accounted for 65.6% or about two thirds of the costs of operation.

Payment of interest was 2,039 million FCFA, occupying 13.8% of costs of operation. The ratio seems to be not too big.

Depreciation amounted to 3,895 million FCFA, which corresponded to 26.3% of costs of operation. This seems to be big. Net profits worked out at 107 million FCFA in 1991. The JICA Study Team's overall observation is that SONEES succeeds in financial management, but it would be better if there were more revenues from water bill.

3) Water Tariffs of SONEES

In January, 1994 the Senegalese currency was devaluated from 50 FCFA to 100 FCFA to one French franc. This precipitated the rises of various domestic prices induced by the one hundred percent increase of import prices. The government of Senegal is vigilant so that price escalation may be contained within a reasonable limit.

The government announced the official rates of price increases for various goods and services belonging to the public sector. Regarding the water supply charges, they were raised by 30%.

At the present moment new water tariffs after the devaluation are not yet available. The following description, therefore, deals with the water tariffs of SONEES that were effective immediately before the devaluation.

Broadly speaking, the water tariffs of SONEES were classified into three types, i.e. the tariff for urban consumers with connections, public stand tariff and the tariff for gardening crops growers. The first tariff consisted of three sections. They were social, normal and dissuasive sections. The third tariff was also comprised of three sections. (Refer to *Table* B.1.17.) Those sections were distinguished based on the levels of water consumption.

Regarding the tariff for urban consumers with connections, the social section was applied for a consumer with the bimonthly water consumption of 0 to X1 m^3. The normal section was applied to the bimonthly water consumption of X1 to X2 m^3. And the dissuasive section was applied to the bimonthly water consumption of over X2 m^3. There were 18 categories of consumers. For a general household with the gauge 15, X1 and X2 equaled 20 and 100 respectively.

Regarding the tariff for gardening crops growers, the first section applied for a grower with the bimonthly water consumption of 0 to 3,000 m^3. The second section applied to the bimonthly water consumption of 3,000 to 20,000 m^3. And the third section was applied to the bimonthly water consumption of over 20,000 m^3.

There were two tariff systems based on the areas. One system was applied to the consumers in the sewered area and the other to the consumers in the unsewered area.

In the sewered area the normal section tariff for urban consumers ,for instance, was 389.15 FCFA per m^3. The public stand tariff was 166.20 FCFA per m^3. And the 2nd section tariff for gardening crops growers was 70.42 FCFA per m^3.

In the unsewered area the normal section tariff for urban consumers was 366.92 FCFA per m^3. The public stand tariff was 141.45 FCFA per m^3. The 2nd section tariff for gardening crops growers was the same as in the sewered area.

In the case of the normal section tariff for urban consumers there was a difference of 22.23 FCFA per m^3 between the sewered and unsewered areas. Likewise, in the public stand tariff there was a difference of 24.75 FCFA per m^3 between the two areas. they were accounted for by the sewerage charge.

Water tariff was made up of various components. For example, the normal section tariff of 366.92 FCFA per m^3 in the unsewered area was the summing up of the operation component of 179.56 FCFA, debt component of 56.21 FCFA, renewal component of 57.94 FCFA, expansion component of 45.47 FCFA, value added tax of 23.74 FCFA, rural hydraulics surtax of 1.50 FCFA and municipality surtax of 2.50 FCFA. In the sewered area the sewerage charge was added. The sewerage charge in this