CHAPTER 3 PROPOSED WASTEWATER SYSTEM

3.1 SEWERAGE ZONES

The Sewerage planning area determined in Section 2.2 is divided into 14 sewerage zones for system design, taking into account the topographic conditions and the existing sewerage system. *Figure* B.3.1 shows the sewerage zones. Units included in each sewerage zone are shown in *Table* B.3.1.

Units which should be provided with small bore sewer system were identified according to the criteria mentioned in Sections 2.2 and 2.4. These units are also shown in *Table* B.3.1.

3.2 WASTEWATER FLOW AND CHARACTERISTICS FOR FACILITY DESIGN

3.2.1 Wastewater Flow

Two sets of wastewater flow were calculated for sewerage facilities design, viz. complete flow and actual flow. The former is the total wastewater flow generated in each unit in 2010. The latter is the flow expected to be actually collected by the sewerage system in 2010, calculated by taking into account the connection ratios. For the design of sewer pipes including trunk sewers (diameter 300 mm or more), the complete wastewater flow is used because the useful life time of sewer pipes is, in general, much longer than the 17-year period to 2010, and replacement or installation of new pipes to increase the capacity will require unnecessarily high cost.

On the other hand, treatment plant is usually extended by stages to meet the increasing wastewater flow. Pumping stations, at least their mechanical and electrical equipment, are also installed to keep pace with the increase of wastewater flow. Therefore, for the design of these facilities, the actual flow which is likely to flow in the sewerage system in 2010 is used.

Factors discussed in Section 2.4, such as discharge ratio and infiltration, are taken into account in calculating the wastewater flow. Two wastewater flows in sewerage zones are presented in *Tables* B.3.2 and B.3.3.

In 2010, a total wastewater flow of 426,449 m^3/day (daily average) will be generated in the entire sewerage planning area, out of which 335,917 m^3/day or 78.8 % of the total will be collected by the sewerage system.

3.2.2 Wastewater Characteristics

The BOD load collected by the sewerage system in 2010 amounted to 143,837 kg/day. Out of the total BOD load collected, 118,316 kg/day or 82.2 % is domestic in origin. Among the 14 sewerage zones, wastewater in 10 zones except for. Dakar Port, (No.2). Pikine Industrial (No.8) and. Thiaroye Industrial (No.9), is domestic in nature. BOD load collected by the sewerage system in 2010 and BOD concentrations are calculated as shown in *Table* B.3.4. The average BOD concentration of raw wastewater of the 10 zones is 382 mg/l.

The SS concentration of the raw wastewater was estimated based on its ratio to BOD obtained from the water quality analysis at the Camberene WWTP. Consequently, concentrations for the design of treatment plant for the 10 zones were determined as shown below.

Raw Wastewater Characteristics for Design
BOD : 380 (mg/l)
SS : 410 (mg/l)

For the three sewerage zones where industrial wastewater is dominant, BOD concentration are calculated as shown in *Table* B.3.5. The average BOD and SS concentrations are calculated in the same manner as shown below.

Raw Wastewater Characteristics for Design
BOD : 970 (mg/l)
SS : 1,100 (mg/l)

3.3 COMPARISON OF ALTERNATIVE SEWERAGE SYSTEMS

3.3.1 Sewer Networks

1) Dakar Zone

This zone was already provided with sewer networks and the connection rate of most of the units is 100 %. Therefore, the extension of the sewerage network is not necessary, except for minor extension and replacement of damaged pipes.

The most important issue for the sewer network in this zone is the capacity of the main trunk sewers. The total wastewater flow in the zone is estimated to increase from 49,461 m^3/day (daily average) in 1993 to 115,327 m^3/day in 2010. Therefore, the capacity of main trunk sewers should be investigated to ascertain if it can accommodate the increased wastewater flow.

The capacity of the largest Hann-Fann collector was examined with the design flow rates in 2010. Based on the drawings and information obtained from SONEES, their capacities were estimated and bottleneck sections located. The size and the capacity of the bottleneck culvert at the most downstream section are as follows.

Hann-Fann Collector Bottleneck Section
Size: Culvert W 0.90 m x H 1.06 m (oval)
Gradient: 1.0 per mill (estimated)
Capacity: 1.06 m^3/sec

The capacity of the culvert is insufficient to accommodate the design flow from the catchment sewerage area. In order to resolve the problem, the following two alternative measures can be considered.

Alternative A: To install an additional collector in parallel with the existing collector

Alternative B: To convert the upstream catchment area to the Camberene WWTP to keep the wastewater flow within the capacity of the existing culvert

The two alternatives are shown in *Figure* B.3.2. The construction costs of the two alternatives are shown in *Table* B.3.6.

The construction cost for Alternative B is lower than that for Alternative A. In addition, there are many advantages with Alternative B. The wastewater flow of the upstream catchment area, i.e. about 30,000 m^3/day on daily average basis, will be treated at the Camberene WWTP. Extension of the Cambrene plant is likely to be realized earlier than the future treatment plant in Ouakam. Thus, this decreases the pollutant load which will otherwise be discharged from Pointe de Fann.

Construction of a pumping station and force mains to the Camberene WWTP is much easier than that of a new collector in parallel with the existing Hann-Fann collector. In case of the new collector, installation of large pipes along the main roads in the bustling urban center will cause much more disturbance to the inhabitants as well as to traffic. Conversion of the secondary mains to the new collector will require additional costs and increase disturbances.

For the reasons mentioned above, Alternative B, i.e. conversion of the upstream catchment area of the Hann-Fann collector to the Camberene WWTP, is proposed.

Improvements of the Madeleines sewer system including the three small ocean outfalls in the zone were investigated. Integration of the three outfalls to the main collectors were planned to prevent discharge of wastewater at the coast, together with examination of capacities of the existing main collectors.

There are two methods to integrate the existing three outfalls theoretically, viz. pumping and bypassing by means of additional collectors. The two alternatives are compared for each of the three outfalls, taking into account the wastewater flow in 2010.

Consequently, construction of three new pumping stations, two at the sites of the existing outfalls and one at Soumbedioune and new collectors from southern part of Madeleines to Soumbedioune are proposed as shown schematically in *Figure* B.3.3. All collectors are proposed to be installed newly, and construction costs are estimated. However, the possibility of using certain sections of the existing collectors, especially from the proposed No. 2 pumping station to the existing Soumbedioune pumping station, should be investigated at the later stage of planning.

2) Parcelles Assainies and Its Surroundings Zone

Most of the small units included in this sewerage zone were already provided with sewer networks and the wastewater is sent to the Camberene WWTP for treatment. Wastewater from new housing developments can be sent to the Camberene WWTP without difficulty. The main problem for the zone is low sewerage connection rate in the large Parcelles Assainies area. Installation of sewer networks should be accelerated. Improvements of the existing pumping stations in this area should be considered in accordance with the concept of the current sewerage planning.

In the preliminary design of the trunk sewers for the zone, two collectors separately flowing into the Camberene WWTP are proposed. One network pumping station is necessary for the west collector because of the topography of the zone. The location of the new pumping station is in the vicinity of the existing Djily Mbaye pumping station. The capacities of the existing and new pumping stations are as follows.

Capacity of the Pumping Stations	
Dsily Mbaye (existing):	35 l/s
West (proposed):	55 l/s

Design flow of the new pumping station is larger than the existing one. However, there is a possibility of increasing the pump capacity by replacement of pumps and attached equipment while utilizing the structure of the existing pumping station.

Two new network pumping stations are proposed for the east collector. The first station (E-1) is to be constructed at exactly the same location of the existing Unite 2 pumping station. The capacities of the existing and the new pumping stations are as follows.

Capacity of the Pumping Stations	
Unite 2 (existing):	29 l/s
E-1 (proposed):	9 l/s

The existing Unite 2 pumping station can be used for the future sewerage system as far as the capacity is concerned. If the pumping station is continued to be used, a new force main to change the direction of the wastewater flow is required, because the existing force main is connected to the Guediawaye pumping station.

The other pumping station is proposed at a different site, and it cannot be replaced by any of the existing pumping stations.

The other seven (7) existing pumping stations will not be used once the two proposed collectors and secondary trunk sewers are constructed. However, advantages and disadvantages of pumping stations and secondary trunk sewers should be further investigated at a later stage, and, therefore, the proposal of SONEES to improve the existing pumping stations should also be reviewed.

3) Grand Yoff Zone

Small housing units recently developed in the zone have been provided with sewer networks. Two large housing units, viz. Unit 43b (SCAT-URBAM) and Unit 45 (Grand Yoff/Khar Yalla), are not sewered at present. However, a part of Unit 43b, which is under construction, is provided with a sewer network, and wastewater from this unit will be collected by the AK3 collector. It is, therefore, expected that the new housing areas to be developed in the zone will have sewer networks. The sections of the existing Hann-Fann collector in the zone will have sufficient capacity to accommodate wastewater generated in the zone if the conversion of the upstream of the collector to the Camberene WWTP proposed in the current plan is realized.

Provision of a sewer network in Unit 45 is considered to be difficult because of the present conditions of the houses. Many houses were constructed at levels below the surface of the roads, and in many cases more than 1 m. There are depressions where flooding occurs during the rainy season. Special considerations are required for the design of sewer networks. Construction costs for sewer networks is expected to be higher than those for other units.

4) Hann Zone

Units in this zone are generally small and residential areas have been developed with adequate road networks. Yet all residential units, except for Unit 94 (Cite Faycal), do not have sewer networks. The early provision of sewer networks is, therefore, recommended for the zone. The proximity of this zone to the Camberene WWTP is an advantage.

The construction of a small pumping station at Cite Faycal proposed by SONEES was reviewed, as presented below. Wastewater from the unit can be collected by the proposed Guediawaye-Pikine collector. However, taking into account the urgency to stop the current raw sewage disposal to Niaye and completion of the new collector, this proposal should be realized as soon as possible.

Design Wastewater Flow of Unit 94 (Cite Faycal)

	1993	2010
Daily Average (m^3/day)	73	221
Peak Flow (l / s)	1.4	4.8

Design of the pumping station with two minimum capacity pumps, (one for standby), and force mains, (PVC, diameter 110 mm, length 671 m), was reviewed with the design wastewater flow. It was confirmed that they have sufficient capacities to send the wastewater even in 2010. A pump well with enough capacity should be provided to prevent frequent on-off operation of the pumps, since intermittent operation due to small quantity of wastewater can not be avoided.

5) Pikine Regular and Guediawaye Zones

These are two large residential areas, and the presently already large population inhabiting the areas will further increase up to 2010 and farther.

Development of the Pikine Regular zone was, in general, more recent than that of the Pikine Irregular area, but older than the Guediawaye zone. Most of the Pikine Regular zone, except for Units 112b (Cite SOTIBA), and 114 (Cite ICOTAF), have been developed without sewerage planning. The sewerage connection rate in this zone is, therefore, very low.

Another difficulty encountered in sewerage planning is the topography of the zone. The zone is located on sand dunes and depressions, both of which run in the northeast-southwest direction. Therefore, several long secondary sewers along the depressions will be required to collect wastewater. Road networks in some areas are not adequately provided.

Sewer networks in the Technopole (Unit 94b) should be designed and constructed by the development authority as one of the necessary utilities. For the sewerage planning purpose, it is assumed that the first phase of the development project will be completed by 2000 and the second phase by 2010. Wastewater flow generated in the Technopole is taken into account the planning of main sewerage facilities, such as trunk sewers and the Camberene WWTP. However, it is likely that the completion of the first phase will come ahead of the construction of trunk sewers. In this case, a pumping station and a force main which will transfer the wastewater to the Camberene WWTP should be provided.

Wastewater generated in the Technopole is considered to be two different kinds in nature, viz. domestic wastewater and wastewater generated from various institutions and factories. Characteristics of the latter wastewater vary significantly, like industrial wastewater, depending on the kinds of institutions and factories. The development authority should investigate the characteristics of wastewater of an institution or a factory in selecting them. Institutions or factories which may produce hazardous wastewater should not be allowed, or these can be allowed if their wastewater is treated individually by themselves to the allowable level and not to be discharged to the sewerage system.

The Guediawaye zone is composed of small- to medium-sized housing areas that have developed in recent years. Two of them, viz. Units 107 (Lotissement Golf Nord) and 109b (HLM Guediawaye), have been provided with sewer networks constructed by the developers. The other units do not have sewer networks. Provision of sewer networks in these units is not difficult because of orderly road networks.

Difficulty for the Guediawaye zone in planning the sewerage system is its remote location from the Camberene WWTP. The zone is located at the opposite side of Grand Niaye from the Camberene WWTP. To collect wastewater in the zone and send to the Camberene WWTP, pumping stations and long collectors are required. Two alternatives are considered for the collector system. One is to send wastewater through the neighboring Pikine Regular zone, and another through the neighboring Parcelles Assainies zone.

Two alternatives were compared based on the topographic conditions of these zones. Consequently, total pumping head in case of combination with the Pikine Regular is found to be less than in case of combination with the Parcelles Assainies. Therefore, a collector from the Guediawaye zone to the Camberene WWTP through the Pikine Regular is proposed.

In preliminary designing the trunk sewer system for the Guediawaye zone, a network pumping station (W-1) is proposed at exactly the same location as the existing Guediawaye pumping station. SONEES has prepared an improvement plan for the station, which includes a new pumping station exclusively for wastewater and conversion of the existing pumping station for stormwater drainage purposes. The capacity of the three pumping stations, viz. the existing, that proposed by SONEES and a new pumping station proposed in the current planning, are as follows.

Capacity of the Pumping Stations	
Guediawaye (existing):	16 l/s
SONEES (proposed):	43 l/s
W-1 (proposed):	54 l/s

The design of the new pumping station proposed by SONEES should be reviewed according to the proposed trunk sewer system, and at least the design flow should be increased to 54 l/s.

A pumping station for storm water drainage will not be necessary, when the drainage system proposed in Chapter 3 of the Appendix C is constructed. Therefore, early implementation of the proposed drainage system is recommended instead of the conversion of the existing pumping station.

6) Malika and Mbao Housing Development Zones

These are two large housing development areas. Housing development in a part of the Malika area has been initiated recently. Most of the development area is, however, still an open area at present. There is no construction of any kind in the Mbao development area, and the area is left untouched at present.

Taking into account the present conditions in the zones and future sanitary and environmental conditions of the entire Study Area, these two zones are proposed to be included in the sewerage planning area. Construction of the sewerage facilities along with the development of the area is much easier and requires less time and money.

Individual sewerage systems for the two zones and a combined system with one treatment plant can be considered which are discussed in Section 3.3.3.

7) Almadies Zone

The sewerage planning area surrounds the northern and western sides of the Dakar Airport. The topography of the northern part of the zone becomes lower towards the west, and that of the western part becomes lower towards the north. Therefore, wastewater in the zone is taken to the northwestern part of the zone near Ngor. In case of individual treatment, a treatment plant will be located at the side of the existing stormwater drain near Ngor. Advantages and disadvantages of the two alternatives, viz. individual treatment and combination with the Ouakam zone will be discussed in the next Section 3.3.3.

On-site sanitation systems are the other possibility for the zone. There are large hotel and holiday resort complexes in the zone. Also, houses in the western part are large detached types. The buildings and houses have some kind of on-site sanitation systems. Although the soil conditions of the zone is not suitable for disposal of wastewater by infiltration, discharge to the sea by individual outfalls or to a nearby drain after sufficient treatment by an on-site system can be considered for the zone. Individual on-site treatment systems are discussed in Section 3.4.3.

8) Ouakam Zone

Most of the newly developed units in the zone have been provided with sewer networks. There is one traditional village called Village de Ouakam, and one spontaneous irregular area called Quartir de Ouakam. It is difficult to construct sewer networks in these areas unless they are redeveloped. However, these areas are surrounded by already sewered areas, and construction of a small bore sewer system can be considered. Therefore, sewerage systems in the units are planned on the basis of small bore sewer system instead of the conventional sewer system.

9) Dakar Port, Pikine Industrial and Tiaroye Industrial Zones

These are port and industrial zones. The characteristics of wastewater in the zones are quite different from those of the domestic wastewater generated in the zones previously mentioned.

It is advisable to separate the wastewater of these zones from that of other zones from view points of wastewater treatment and reuse of the effluent. Industrial wastewater sometimes contains hazardous materials, such as heavy metals, which have a serious effect on the operation of the plant or can not be reduced by the conventional wastewater treatment, making the reuse of the effluent for the agricultural purposes impossible.

Individual treatment by each factory is another desirable alternative for industrial waste treatment. If industrial waste contains only inorganics or non-biodegradable organics, the wastewater should be excluded from the sewerage system which depends on the biological treatment. Otherwise, inclusion of these kinds of industrial wastewater into the sewerage system increases the construction cost needlessly.

For the reasons mentioned above, three industrial zones were separated from residential zones. A sewerage system is planned as one of the alternatives for the wastewater treatment, which is explained in Section 3.3.3.

10) Pikine Irregular

This sewerage zone consists of the units which are classified as spontaneous irregular housing type. Road networks are disorderly arranged and construction of sewer networks is very difficult at present. A sewerage system should be provided after or in keeping pace with redevelopment of the area. Therefore, main sewerage facilities, such as trunk sewers, pumping stations and a treatment plant are planned based on the redevelopment plan. A commercial and administrative center planned at the existing military camp is taken into account the calculation of wastewater flow and facility design.

3.3.2 Wastewater Treatment Process

Three representative wastewater treatment processes selected in the previous Chapter 2 were evaluated in order to find the most suitable process for the sewerage system in the Study Area. Three processes are as follows.

(1) Conventional Activated Sludge
(2) Oxidation Ditch
(3) Oxidation Pond

Treatment process using aquatic weeds is not selected because this process requires larger unit pond areas than the oxidation pond system and the configuration of the ponds is not suitable for a large scale treatment plant. This process, however, has many advantages and can be applied for small scale plants.

Design of the wastewater treatment plants based on the three processes were carried out under the same conditions mentioned below, and construction cost functions are developed based on the actual construction costs for the Camberene WWTP. General plans of the plants were drawn to investigate land area required for each process.

Design Basis	
Daily Average Flow:	10,000 m^3/day
Raw Sewage	
BOD Concentration:	380 mg/l
SS Concentration:	410 mg/l
Effluent	
BOD Concentration:	30 mg/l (60 mg/l for oxidation pond)
SS Concentration:	30 mg/l (60 mg/l for oxidation pond)

For the conventional activated sludge process, facilities are designed on the same basis as for the existing Camberene WWTP. The sizes of each component facility were examined, and it was confirmed that the existing facilities designed for 9,600 m^3/day flow and 625 mg/l BOD concentration satisfy the above mentioned conditions.

The arrangement of the facilities are modified to investigate the necessary land area. The general plan of the conventional activated sludge process is shown in *Figure* B.3.4. As shown in the figure, the necessary land area including green spaces as a buffer zone to the surrounding areas is 3.91 ha.

The oxidation ditch treatment plant was designed on the basis of the design criteria used in Japan which are suitable for the conditions mentioned above. The same sludge treatment as that used for the conventional activated sludge process, i.e. sludge digestion and sludge drying beds, is adopted. The general plan of the plant is shown in *Figure* B.3.5. The land area for the plant is 5.13 ha on the same basis as applied for the conventional activated sludge process. It is 1.3 times that required for the conventional activated sludge process.

The effluent standards for the oxidation pond system are established at a lower level than the former two processes taking into account the nature of the treatment and the characteristics of the effluent. Effluent BOD and SS concentrations of 60/60 mg/l are considered to be satisfactory for the process.

Important factors for the design of the plant are the various organic loads for the ponds, viz. volumetric load for the anaerobic pond and surface load for the facultative pond. Coliform die-off coefficient is important to size the maturation pond.

All the factors for the pond design are highly temperature dependent. The temperature for the design was determined to be 20.6 C, which is the mean temperature in the coldest month in Dakar. The general plan is shown in *Figure* B.3.6. The land area required for the plant is 17.82 ha, which is 4.6 times that for the conventional activated sludge process.

Cost functions for the three processes were worked out by modifying those developed in Japan. The construction cost for the Camberene WWTP at 1987 price level was converted to 1993 price level and then to March 1994 price level as shown below, and used for the modification.

Camberene WWTP Construction Cost
2,630 (million FCFA, 1987) x 1.114 = 2,930 (million FCFA, 1993)
1,172 x 1.40 + 1,758 x 2.00 = 5,157 (million FCFA, 1994)

Consequently, the following formulas were obtained.

Construction Cost Function

(1) Conventional Activated Sludge: $C = 989\ Q^{0.73}$
(2) Oxidation Ditch: $C = 912\ Q^{0.79}$
(3) Oxidation Pond: $C = 472\ Q^{0.86}$

Where C: Construction Cost (million FCFA)
Q: Design Flow (1,000 m^3/day)

Three cost functions are shown in *Figure* B.3.7. As shown in the figure, for the range of the design flow between 5,000 m^3/day to 200,000 m^3/day, the construction cost for the oxidation ditch process is the highest, followed by that for the conventional activated sludge process. The construction cost for the oxidation pond process is the lowest among the three. For the smaller design flow, less than 5,000 m^3/day, the construction cost for the oxidation ditch process is lower than that for the conventional activated sludge process.

The oxidation pond system is the most advantageous from a construction cost view point. Moreover, if the operation and maintenance costs are taken into account, this process becomes more advantageous than the other two processes. However, the fatal defect which prohibit the process from being adopted for the sewerage system in Dakar is the requirement of large land area for the construction.

Approximately 18 ha is required for a plant with 10,000 m^3/day capacity. If design flow increases to 100,000 m^3/day, almost 180 ha of the land is required, because economy of scale cannot be expected for the land requirement of the process. If all wastewater is to be treated by the oxidation pond process, a total of over 500 ha land area is necessary for the construction of the treatment plants. This magnitude of land area cannot be obtained in the Study Area. Therefore, the oxidation pond process is sifted out from the current sewerage planning.

The remaining two processes can be used for the current sewerage planning depending upon the design flow of each treatment plant, i.e. the conventional activated sludge process for a plant with a design flow larger than 5,000 m^3/day, and the oxidation ditch process for smaller plants.

3.3.3 Possible Wastewater Treatment Plant Sites

Nine (9) possible wastewater treatment plant sites were marked on the map and the Study Team visited each site. These are shown in *Figure* B.3.8 and described below.

No.	Location of the Site
1	Around the Camberene WWTP and the Patte d'Oie WWTPs
2	Around the existing ocean outfall at Pointe de Fann
3	Around the Niaye WWTP
4	North of Pikine, near Lac Warouwaye
5	East of Malika, near Khereub Keur
6	Around the Mbao Industrial WWTP
7	South of the National Road No.1, between the Reboisement de Mbao and Rufisque
8	Ouakam, near the old aerodome
9	Ngor, near the downstream of storm water drain

Firstly, the present WWTP sites were selected since extension of a treatment plant is, in general, easier than constructing a new treatment plant at a different site. Sizable land is available at the site, and land, as needed, can be purchased easily in the vicinity of the existing WWTP. Therefore, Nos. 1, 3, and 6 were selected.

Among the three sites, the extension of the Camberene WWTP is most desirable because of the topographic advantage of the location and existence of the only one properly functioning WWTP. The existing plant is located in the center of the eastern half of the sewerage planning area including Parcelles Assainies and Its Surroundings, Grand Yoff, Hann, Guediawaye and Pikine Regular sewerage zones. Urban development in the Niaye area surrounding the Camberene WWTP is prohibited by law, and procurement of the land for the extension is not difficult.

The existing Niaye WWTP is also located in the Niaye area, at the eastern part, near Pikine Regular sewerage zone. The location is convenient for a treatment plant for the same five sewerage zones mentioned above. However, it is less advantageous than that of the Camberene WWTP. The existing treatment plant cannot be used for secondary treatment of larger wastewater flow. Significant modifications or even demolition is required for the new treatment plant construction.

Also modifications and extension of the existing trunk sewers to the Camberene WWTP is required if the wastewater is to be centrally collected at the new plant. It is not advisable to leave the plant as it is and treat a small quantity of wastewater matching the plant capacity from economic and operation and maintenance point of view. Conversion of the plant with some minor modification, such as a treatment plant for the sludge from the on-site systems, should be considered.

No.2, the site at Pointe de Fann was selected for wastewater treatment before discharging to the sea. This point is most suitable since all wastewater from the already sewered Dakar sewerage zone is collected here. This is government land, and no cost needs to be incurred in obtaining this land. However, the area is limited to about 3 ha and a conventional secondary treatment plant of any kind can not be accommodated unless the area is expanded by land reclamation, which is prohibitively costly. Therefore, this place is left out as a possible site for a treatment plant.

No. 8, the site in Ouakam near the old aerodome is, therefore, selected as the alternative site for treatment of the same wastewater. The site is farmland at present. Taking into account the magnitude of the wastewater from Dakar and Ouakam sewerage zones in 2010, which is nearly 100,000 m^3/day, approximately 30 ha of land is needed for the new treatment plant if the same design criteria as for the Camberene WWTP is adopted.

It is considered difficult to obtain 30 ha of land in the vicinity of the old aerodome. It is, therefore, recommended that the compact design of the conventional activated sludge process and sludge treatment by mechanical dewatering instead of sludge drying beds should be applied for the new treatment plant.

A sample of the general plan of such a design, which is commonly used for treatment plants in Japan, is shown in *Figure* B.3.9. In this case, the required land area is less than 10 ha. Although the construction cost as well as the operation and maintenance cost for the design is higher than those for the Camberene type treatment plant, this has other advantages. Among others, it enables easier central control of operation and easier prevention of odor emission to the surrounding areas. Therefore, this compact design is recommended unless conditions of the surrounding area do not permit the adoption of the Camberene type design.

Nos. 4, 5 and 7 were selected as possible treatment sites for Pikine Irregular, Malika and Mbao housing development sewerage zones.

Sites No.5 and No.7 are open spaces and have convenient topographic conditions to collect wastewater from these areas. No. 7 site was selected so as not to have an adverse effect on the old village located near the Cap des Biches.

Individual or a combined treatment plant may be possible to service these zones. When one treatment plant for both zones is considered, site No. 5 is recommended for the following reasons. Firstly, Malika is expected to be developed earlier than Mbao, and construction of the treatment plant is also expected earlier. Secondly, the effluent from the plant can be discharged from the north coast of the Cap Vert peninsula instead of the Hann bay, which is more vulnerable to pollutant loads.

Alternative A : Individual Treatment

Alternative B : Combined treatment at Malika WWTP

Two alternatives are shown in *Figure* B.3.10. The construction costs for the components which differ for the two alternatives are compared, as shown in *Table* B.3.7.

Construction cost of Alternative A is less expensive than that of Alternative B. In addition, greater flexibility of the construction program to expand the treatment plants by stages is expected for Alternative A. Thus, Alternative A, individual sewerage systems for two zones, are proposed.

Site No. 7, near the existing industrial wastewater treatment plant was selected for a possible new industrial wastewater treatment plant for sewerage zones of Dakar Port, Pikine Industrial and Tiaroye Industrial. The total wastewater from these three zones, mostly industrial wastewater, is about 26,000 m^3/day in 2010. Approximately 15 ha of land is needed for the treatment plant. This area cannot be obtained in the Dakar Port zone, because the zone has been fully developed and various port facilities and factories have been established.

Two old villages, viz. Hann Pecheurs and Tiaroye Mer, are located between these three sewerage zones. Construction of a new treatment plant in the vicinity of the villages should be avoided as much as possible to protect the villages. Consequently, in case of the treatment of the industrial wastewater by a sewerage system, possible site for the plant is limited to the area near the existing plant.

Site No. 9 in Ngor was selected for a possible treatment plant for the Almadies sewerage zone. The total volume of the wastewater in the zone in 2010 is about 4,100 m^3/day. The following two alternatives can be considered to dispose off the wastewater.

Alternative A:	Individual treatment by oxidation ditch process
Alternative B:	Combined treatment with the Ouakam sewerage zone. Treatment plant is located at site No.8. A pumping station and a force main from site No. 9 to site No.8 is necessary.

Two alternatives are shown schematically in *Figure* B.3.11. Construction costs for two alternatives are compared as shown in *Table* B.3.8. Construction costs which are common to both alternatives, such as costs for sewer networks are not included in the comparison.

The construction costs, including that for the new treatment plant in Ouakam, for two alternatives are almost same, 1.8 % higher for Alternative A. Selection of alternatives cannot be based on this small difference.

One of the advantages of Alternative A, individual treatment, is the flexibility of construction of the treatment plant No. 9 for Almadies zone. The treatment plant can be constructed independently of the treatment plant in Ouakam. In case of combined treatment, wastewater of the zone cannot be treated until the treatment plant in Ouakam becomes operational. Thus, individual treatment is proposed for the zone.

3.4 PROPOSED WASTEWATER SYSTEM

3.4.1 Sewerage System

Based on the considerations mentioned in the previous Section 3.3.3, the sewerage system for the Study Area is proposed as described below.

Seven (7) wastewater treatment plants are proposed to be constructed to treat the wastewater collected by the sewerage system. Therefore, the entire sewerage planning area is divided into seven independent sewerage systems. Name of the treatment plants, which are virtually the name of the sewerage systems, and their corresponding sewerage zones are as shown in *Table* B.3.9.

Systems of the trunk sewers and large pumping stations attached to them to collect wastewater from corresponding sewerage zones and to send to each treatment plant were designed.

Sizes and lengths of trunk sewers in each sewerage system are shown in *Table* B.3.10. A total of 61,810 m of trunk sewers with diameter from 350 mm to 1,650 mm is proposed to be constructed. For trunk sewers which should be laid deeper than 4.0 m from the ground level, driving method is proposed for construction. The total length of sewers for the driving method is approximately 3,600 m. Centrifugally reinforced concrete pipes are recommended for trunk sewers.

Force mains were designed together with pumping stations and trunk sewers. The total length of force mains is approximately 19,170 m with diameters from 150 mm to 1,350 mm. Ductile cast iron is recommended as the pipe material.

A total of eleven (11) large pumping stations are proposed. Design capacities of the pumping stations are shown in *Table* B.3.11. All pumping stations are proposed to be constructed as dry pit type, in which pumps are to be installed in a dry pit separated from a pump well. Electrical equipment including generators for emergencies is to be provided adequately.

All wastewater treatment plants are proposed to adopt biological secondary treatment processes. Six treatment plants, except for the Almadies WWTP, are conventional activated sludge plants. The Almadies WWTP is proposed to be an oxidation ditch plant. The design capacities of the seven treatment plants are shown in *Table* B.3.12.

Ocean outfalls which discharge the effluents sufficiently far from the coast are proposed for four treatment plants, viz. Ouakam, Camberene, Lac Warouwaya and Malika WWTPs.

The major components of the sewerage system are shown in *Figure* B.3.12.

3.4.2 Industrial Wastewater Treatment

For the industrial wastewater treatment in the study area, the sewerage system collecting wastewater from three industrial areas along the Hann Bay and having a treatment plant in Mbao has been discussed in the previous section. This system has been designed to collect and treat only industrial wastewater, because mixing of industrial wastewater and domestic wastewater may cause unexpected contaminations of the treated water by hazardous materials originated from industrial wastewater, which makes difficult to use the treated water to possible re-uses. Therefore, the discussed system is considered to be the system only for factories but not for public. Thus, factories concerned should take responsibility for such system including its construction and operations. In this section, another alternative for the treatment of the industrial wastewater, that is individual treatment by each factory, is investigated. Therefore, factories concerned will be able to study on two options, namely individual treatment and collective treatment when they are required to treat their wastewater before discharging.

1) Characteristic of Wastewater and Wastewater Quantity for Different Industries

Based on the results of Industrial Wastewater Survey, characteristic of wastewater in each industry and wastewater quantity in 1993 and 2010 are shown in *Table* B.3.13. Assuming that the characteristics of wastewater in the future will not change, wastewater quantity in the future is estimated by the area of industrial zone in the year 2010 and the existing discharge quantity per unit area.

2) Effective Treatment Process

Unit treatment process effective to each water quality parameter are shown in *Table* B.3.14. Overall treatment process by industry type is proposed as a combination of unit processes effective to particular objective parameter in wastewater. Typical processes for each industry type are shown in *Figure* B.3.13.

3) Cost Estimates

Construction cost of wastewater treatment facilities highly depends on the wastewater concentrations, daily wastewater quantity and construction materials of facilities. Designing of treatment facilities for each factory would be necessary to estimate precise construction costs for such industrial wastewater treatment. However, since the necessary information for each factory is not available at present, indicative costs are presented in this study to provide reference information for further studies. In the calculation, construction costs of similar facilities in Japan was converted to unit price of construction in Senegal. Total costs for the estimated wastewater quantity in 2010 are shown in *Table* B.3.15.

3.4.3 On-site System

On-site system was supposed to be proposed aiming the following two improvements:

- Sanitation conditions; fly control, deodorization, protection of bacteriological contamination of well water.
- Groundwater conditions; mitigation of the nitrate contamination of the groundwater.

To improve the sanitation conditions, it is necessary;

i) to cut off the air movement between the excreta storage place and the toilet compartment,
ii) to isolate the excreta storage place from the external atmosphere,
iii) to accelerate the ventilation of the toilet compartments and the excreta storage place, and
iv) to locate the excreta storage place with a certain distance (minimum 10m) away from shallow wells.

An example of the toilet to meet with the above requirements is shown in *Figure* B.3.14.

To improve the groundwater condition, it was considered necessary to stop the disposal of wastewater by infiltration in the area where the groundwater would be affected by the infiltration. Therefore, the system that collects excreta by withdrawal from each house and transferring them by tankers to a treatment facility was investigated. *Table* B.3.16 shows the estimated population in 2010 which relies on the on-site system classified by the housing type and soil type. In the table, the soil types II, III and VI are judged to be not suitable to apply infiltration system because penetrated wastewater would easily reach to the groundwater and affect its water quality. Thus, the excreta generated in these areas has to be disposed through the excreta collection system that is to be newly proposed. The amount of the excreta was calculated as follows:

Total population in these areas in 2010;	1,222,000
Daily quantity of excreta per capita (including excreta itself, anal cleansing water and pour flush water);	5 l/day/capita
Daily excreta generation in these areas;	6,110 m^3/day

Required facilities are considered as follows:

Treatment plants	200m^3/day x 30
Collection vehicle	682 pumping cars (with a suction pump and 3m^3 tank), supposing one car works three times a day.

These requirements seem apparently to be not feasible because it would be difficult to provide such many sites for the treatment plants in the area. It would be possible to reduce the number of plants by increasing the treatment capacity of each plant. However, few treatment plant with a capacity of more than 200m^3/day can be found in Japan(where excreta treatment was most developed in the world) and a larger capacity of the plant may cause other problems such as extreme concentration of excreta transferring vehicles in the vicinity of the plant and necessary time to transfer the excreta from vehicles to the treatment process.

The roughly estimated required costs for the above facilities are as follows:

Treatment plants;	9,200 million/plant x 30 plants =	276,000 million FCFA
Collection vehicles;	50 million/vehicle x 682 vehicles =	34,100 million FCFA
Total;		310,000 million FCFA

The estimated costs exceeds the estimated costs for a conventional sewerage system by several folds.

As such, the excreta collection system that aimed to reduce the infiltration of the wastewater in the area is judged to be not feasible from technical and financial view points. For the on-site system, therefore, it is proposed to improve toilet facilities from view point of local sanitation as shown in *Figure* B.3.14.

In the consideration of the on-site treatment, it has been aimed to reduce the nitrate supply to the groundwater by changing the disposal methods of the wastewater in the area from infiltration to collection system and judged to be not feasible. Furthermore, development of a conventional of sewerage system can not be expected before 2010. However, it is a matter of fact that the groundwater is contaminated by the nitrate nitrogen and people drink it every day. The situation should be improved as soon as possible. Only way to improve the situation seems earlier utilization of the Cayor Canal water. According to the water supply development program mentioned in Section 2.6.3 of Appendix A in this report, water supply to the area is to increase from 276,000 m^3/day to 689,000 m^3/day in 1995. Among 276,000 m^3/day of the present supply, the supply from Thiaroye source, which is the groundwater highly contaminated by the nitrate nitrogen, counts 10,500 m^3/day. At the time when the Cayor canal water becomes available (scheduled in 1995), it will counts only 1.5 % of the total supply, that is 689,000 m^3/day. It would be possible to substitute the water from Thiaroye source by the water from other sources. The water from Thiaroye source may be able to be used to supplement the other uses than drinking, such as agricultural use.

3.4.4 Re-use of Treated Water

Since the study area is situated in an arid zone, where people are suffering from severe shortage of water and some people are using even raw wastewater for irrigation, there could be potential demand of reuse of the treated wastewater.

In this section, possibilities of reuse of the treated wastewater will be studied. A feasibility of the reuse of wastewater highly depends on the types of treatments being required to obtain the water quality that enables the necessary water uses. Theoretically, it is possible to obtain same of quality as that of pure water after treatments. The feasibility of the reuse could be determined based on comparison of required costs to achieve reusable wastewater, with the cost of other alternative sources. Thus, the reuse of the treated wastewater should be considered in water consuming projects.

Therefore, the study will indicate rough estimates of costs necessary for the reuse of treated water after conventional wastewater treatments, for the reference of further studies.

1) Possible Uses of Treated Wastewater

The potential uses of the treated wastewater in the area are considered as follows:

- Irrigation
- Watering of road side trees and reforestation
- Industrial/domestic use
- Recharging of groundwater

Among the above, the industrial/domestic uses and the recharging are judged to be not practical because of the following reasons:

- It is difficult to eliminate any possibilities of contamination of groundwater. It is theoretically impossible to assure 100% safety, even if any advanced treatment is applied.

- Industrial/domestic uses could require further advanced treatment in addition to conventional treatment to obtain water quality for such uses and another water supply network to distribute water to users. This would increase the project cost. The main objective of wastewater treatment system development is to extend wastewater collection and increase the amount of wastewater to be treated. Therefore, this should be studied as an alternative water source for water supply, if necessary.

Therefore, the reuse of the treated wastewater in this area is considered to be possible for the irrigation and watering uses.

2) Irrigation

(1) Demands for irrigation use

Potential water demands for irrigation in the study area are estimated based on cultivated area and irrigation rates by crop. Also cultivation schedule in the area, shown in *Figure* B.3.16 is considered to estimate the daily irrigation rates by month.

The irrigation area, irrigation rates and daily irrigation rates are given in *Table* B.3.17. Monthly fluctuation of water demand for irrigation is calculated as shown *Figure* B.3.17. The maximum demands is estimated at approximately 40,000 m^3/day. As several crops, such as kidney beans, onion and potato, are not cultivated from April to October, demand decreases during that period. In the above calculation, it is assumed that irrigation water is not required during the rainy season (July to September). In addition, required irrigation water for crops not eaten raw is considered, since the required water quality would be different for the crops eaten raw and not eaten raw. The demand for the crops not eaten raw, which is approximately 50 % of those for all crops, has been also indicated in the *Figure* B.3.17.

The above estimation is based on information for 1991 - 1992. A general trend of the agricultural production in the area, however, is expected to decrease, according to the information from ISRA. The vegetable production in Dakar and Pikine was about 30 to 36 % of the national production in 1970 - 1980 and the recent production has decreased to 10 % of the national production. Therefore, the estimated irrigation demands would further decrease in the future.

(2) System Considerations

a. Treatment

Table B.3.18 shows the required water quality for various uses. As can be seen in the Table, if the use of the treated water is limited to the irrigation for only crops not eaten raw, the treated water by the present treatment in Camberene plant can be used without any additional treatment. It is not recommendable to expand the use to the irrigation for the freshly eatable crops because that could considerably increase both construction and operational costs, due to necessary additional treatments , such as sand filtration and sterilization.

However, there is possibility that treated wastewater is used by mistake for the crops eaten raw. Special care should be taken in this regard. In case of mistake, possibility of contamination is not so serious as secondary treatment includes chlorination, which reduces bacteria effectively.

b. Distribution

To enable the reuse of treated water, it is necessary to distribute the water to the users. Thus the facilities for the reuse would include pumping stations, water transmission pipelines and distribution net work. To design the distribution facilities, it is necessary to know the actual service area of the reuse, required amount of the water and those in the year 2010.

However, since above data is not available now, distribution system will be designed based on the following assumptions:

- The service area is limited to the cultivated land near Grand Niaye, excluding the captivated land in the East Pikine. (The area in the Grand Niaye is about 50% of the total)
- Required amount of the irrigation water in the Grand Niaye is 10,000 m^3/day.
- The water is transmitted by pumps that is installed in the Camberene plant.
- The water is transmitted through a pipeline that is installed around the Grand Niaye and users will take water from a connection point on the pipeline.

Schematic drawing of the facilities is shown in *Figure* B.3.18.

3) Watering of trees

Presently drinking water produced by SONEES is used for watering trees along streets and trees in the reforestation. There is no need to say that such watering never require such high quality water. It could be replaced by the treated wastewater . Such reuse would be more preferable than that for irrigation use as possibility of mistake is reduced.

(1) Demands for watering of trees

Two applications are considered as watering of trees; trees along roads and trees in the reforestation.

a. Trees along roads

Two roads, the high way and the National road No.1, are considered to be watered by the treated water. Trees are supposed to be planted every 10 m pitch along the road with cross sections below:

Determining the sections to be watered as shown in *Figure* B.3.19, the necessary amount for the watering is calculated as follows (assuming the watering rate is 70 l/day/tree):

The National Road No.1 (13,500 m):	(13500/10+1)*2*0.07=	189.1. m^3
The High Way (6,500m)	(6500/10+1)*3*0.07=	136.7 m^3
	Total	325.8 m^3

b. Reforestation

Assuming 90 trees per hector as the planting density and 70 l/tree/day of the watering rate, a total watering amount for the Mbaw reforestation zone is calculated as follows:

A total watering rate: 654 ha * 90 * 0.07 = 4,120 m^3

(2) System Considerations

a. Trees along roads

Watering amount for trees along roads is as low as 325 m^3/day. Distribution by water tankers is considered to be more practical than by pipeline that will be very long with small diameter.

b. Reforestation

It is necessary to send water from the plant to the reforestation zone by a pump and pipeline (11km), as shown in Figure B.3.19. Also it is necessary to install distribution network in the zone to spread water to each tree.

4) Construction Cost

Construction costs for the facilities proposed in the previous section were estimated based on the following preliminary design. Facilities are limited to those which may be constructed by the sewerage authority. The other facilities, such as pipes or open channels for distribution, are not included because the most suitable distribution system is to be selected and construction costs are to be borne by the beneficiaries.

(1) Facilities for Cost Estimation

a. Irrigation

Facilities	Type, Size, Capacity etc.
Pumping Station:	Submersible, Dia. 200 mm,(at Camberene WWTP) 3 units (including pumps for reforestation)
Force Main:	DCIP, Dia. 300 mm, L 3.8 km
Reservoir:	RC, Capacity 2,500 m3

b. Reforestation

Facilities	
Force Main:	DCIP, Dia. 300 mm, L 9.0 km
Elevated Tank:	RC, Capacity 130 m3 (at Mbaw reforestation)

(2) Construction Costs

Direct construction cost for each facility is as follows.

a. Irrigation

Facilities	Construction Cost
Pumping Station (at Camberene WWTP):	1,100 million FCFA
Force Main:	535
Reservoir:	830

b. Reforestation

Facilities		
Force Main:	1,269	million FCFA
Elevated Tank (at Mbaw reforestation):	9	
Total:	5,786	

The total construction cost for irrigation and reforestation is 5,786 million FCFA.

3.5 PROJECT COST

3.5.1 Basis for Cost Estimates

Project costs required for the construction of the sewerage facilities planned, as proposed in Section 3.4, were estimated in this section.

The latest information regarding the construction of similar facilities as the sewerage facilities was collected from the authorities concerned, including the Department of Hydraulics and SONEES, and utilized for the estimation. For construction costs for the facilities or methods which have not available in Dakar, standardized costs used in Japan were modified and applied.

All costs are indicated at March, 1994 price level taking price escalation effects by devaluation of FCFA of January, 1994 into account.

The project cost is composed of the following components.

Project Cost Components
1. Direct Construction Cost
2. Land Acquisition Cost
3. Engineering Cost
4. Government Administration Cost
5. Physical Contingency

Direct construction cost was estimated for each sewerage facility as described later in this section.

Land acquisition cost was estimated based on the land areas necessary for the construction of facilities and unit land price. Sizable land areas are necessary for construction of large pumping stations and treatment plants. Unit land prices at various locations were collected from the Department of Cadastral, the Ministry of Finance.

Two indirect cost components, viz. engineering cost and government administration cost, were estimated as ratios of the direct construction cost. 10 % and 1.5 % of the direct construction cost were applied for the engineering and government administration costs, respectively.

The physical contingency cost was also estimated as a ratio of direct construction cost. A commonly used ratio of 10 % of the direct construction cost was applied.

Direct construction costs for component sewerage facilities are described below.

1) House Connection

Although the cost for installation of house connections is paid for by the beneficiaries and is not a part of the project cost, it was also estimated so as to get an idea of the magnitude of expenses borne by the beneficiaries.

A unit cost for installation of a house connection of 150,000 FCFA, which was obtained from SONEES in 1993 was converted to 264,000 FCFA at 1994 price level. An average number of house connections per unit area was worked out from the calculation for the following three representative areas.

Average Number of House Connections per Area

		Plot	Area(ha)	Nos./ha
a.	Pacelles Assainies (existing)	10,458	387	27
b.	Malika Housing Development (plan)	13,000	418	31
c.	Mbao Housing Development (plan)	27,000	647	42
	Total (average)	50,458	1,452	35

Therefore, a unit cost per area of 9.24 million FCFA/ha was obtained by using an average number of house connections per area of 35 nos./ha.

264,000 x 35 = 9,240,000 FCFA/ha

2) Sewer Network

The construction costs for providing sewer networks, consisting of branch and lateral sewers and small pumping stations called network pumping stations, were estimated based on the cost estimation prepared by SONEES and preliminary design of sewer network for a sample area.

Representative costs for component facilities were worked out from a few cost estimates of SONEES as follows.

Unit Cost for Component Facility

a.	Sewer (dia. 250 mm, PVC):	40,000 FCFA/m
b.	Manhole:	282,000 FCFA/unit
c.	Network Pumping Station:	54,000,000 FCFA/unit

An area of 72.4 ha in Parcelles Assainies was selected for the preliminary design to work out average length of sewer pipes and number of manholes. These are as shown below.

Average Length of Sewer Pipes and Number of Manholes

		Total	Average
a.	Sewer:	20,382 m	20,382 / 72.4 = 282 m/ha
b.	Manhole:	635 unit	635 / 72.4 = 8.77 unit/ha

An average number of network pumping stations was worked out to be 0.018 unit/ha, based on the number of the existing pumping stations (7 units) in and the total area of Parcelles Assainies (387 ha).

Average Number of Network Pumping Stations
7 / 387 = 0.018 unit/ha

The unit construction cost for sewer network of 14,725 million FCFA was obtained by using the figures presented above.

Unit Construction Cost for Sewer Network

		Average Length or Number		Unit Cost	Cost
a.	Sewer:	282	x	40,000 =	11,280,000
b.	Manhole:	8.77	x	282,000 =	2,473,140
c.	P/S:	0.018	x	54,000,000 =	972,000
	Total				14,725,140 (FCFA)

Sewer networks in the industrial sewerage zones are differently arranged from those in residential zones because of different plot sizes and road arrangement. Preliminary design of a sewer network was conducted for the same industrial area as selected for the calculation of wastewater flow in Section 2.3.2.

A total sewer length of 8,320 m was obtained for an area of 61.6 ha. Thus, a unit sewer length per area was calculated to be 135 m/ha as shown below.

Average Length of Sewer Pipes in the Industrial Area
8,320 / 61.6 = 135 (m/ha)

For the planning purposes, an average length of 150 m/ha is used, and the unit sewer network construction cost was proportionally reduced to 7,832 million FCFA/ha.

3) Trunk Sewer and Force Main

Construction costs for trunk sewers (diameter 300 mm or more) and force mains were estimated, based on the preliminary design.

Construction of shallow pipes (depth of excavation 4.0 m or less) is to be carried out by the open-cut method. Driving method is proposed for the construction of deep (depth of excavation more than 4.0 m) sewers. Centrifugally reinforced concrete pipes are recommended for pipe material. All force mains are to be constructed by the open-cut method. Pipe material recommended is ductile cast iron.

Representative unit construction costs for trunk sewers and force mains are shown in *Tables* B.3.19 and B.3.20 respectively.

4) Pumping Stations

Construction costs for the major pumping stations (capacity 50 l/sec or more) were estimated based on the capacities obtained from the preliminary design and the cost function shown in *Figure* B.3.20.

5) Treatment Plants

Construction costs for the treatment plants were estimated in the same manner as for pumping stations. The oxidation ditch process is proposed for the Almadies WWTP. The other six treatment plants are proposed to be conventional activated sludge plants. The following cost functions described in Section 3.3 were used.

A compact design of wastewater treatment and sludge treatment by mechanical dewatering is proposed for the Ouakam WWTP to reduce land area required. An additional cost for the adoption of these was estimated taking into consideration construction practices in Japan.

Cost Function for Treatment Plants

a. Conventional Activated Sludge Process: $C = 989\ Q^{0.73}$

b. Oxidation Ditch Process: $C = 912\ Q^{0.79}$

where C: Construction Cost (million FCFA)
Q: Design Flow (1,000 m^3/day)

3.5.2 Project Cost

1) House Connection

Costs for the house connection to be borne by the beneficiaries are shown in *Table* B.3.21. As shown in the table, a total of 50,794 million FCFA will be necessary to provide house connections in the entire sewerage planning area. Three industrial sewerage zones are excluded from the total cost.

2) Sewerage System

The project cost for the seven sewerage systems is shown in *Table* B.3.22, with breakdowns for component facilities. The total project cost amounts to approximately 311 billion FCFA at 1994 price level.

3.6 IMPLEMENTATION SCHEDULE FOR SEWERAGE SYSTEM

3.6.1 Priority for Implementation

In order to develop an implementation program up to 2010, priorities of the component works of the project were evaluated. Component works of the sewerage system should not be implemented independently of each other. Expansion of the treatment plant should keep pace with installation of sewer networks at the upstream end and with construction of collectors and pumping stations to connect them. Therefore, priority of each sewerage system was evaluated firstly, and then those of component zones or facilities.

The total project cost for the six (6) sewerage systems, excluding the sewerage system for the industrial zones, amounted to approximately 289 billion FCFA. It is considered very difficult to complete all these project by 2010. As discussed later, financial analysis revealed that approximately 100 billion FCFA would be a realistic amount of the project cost up to 2010. Selection of the sewerage zones or component works is necessary in this regard.

A unit direct construction cost per unit wastewater was calculated for each sewerage system as a factor which indicates the cost efficiency. These are as follows.

Unit Direct Cost

Sewerage System	Total Direct Cost (1,000 FCFA)	Wastewater Flow (m^3/day)	Unit Cost (1,000 FCFA/m^3/day)
Ouakam	56,521,431	90,558	624
Camberene	76,217,622	99,528	766
Malika	20,195,795	22,472	899
Mbao	29,012,655	44,604	650
Almadies	12,997,403	4,111	3,161
Pikine Irregular	41,911,222	48,290	867

The lowest figure, which means the highest efficiency, was obtained for Ouakam sewerage system. This system services the Dakar and the Ouakam sewerage zones where sewer networks in most areas have already been provided. Therefore, no construction cost for provision of sewer networks is required. This is a main reason for the lower unit cost than the other sewerage systems for which sewer networks are to be newly provided.

The entire population inhabiting Dakar and Ouakam in the existing service area is enjoying sewerage service, and the increasing population in the future will enjoy it regardless of the implementation of the proposed project. The main purpose for the construction of the proposed facilities, i.e. new collectors, pumping stations, force mains and the treatment plant, is treatment of wastewater. It will contribute greatly to the reduction of pollutant load to the sea. However, it will not enhance the service level of the already sewered area.

Taking into consideration the fact that there are many areas where sewerage service is not available and inhabitants are living under inferior conditions, priority should be given to these areas. Major facilities for the Ouakam sewerage system, therefore, have been sifted out from the priority project. The construction of a few collectors to increase the capacities and to stop the raw sewage disposal from three small ocean outfalls are to be implemented by 2010.

The highest unit cost which means the lowest efficiency was obtained for the Almadies sewerage system. The total wastewater collected by the sewerage system is small, i.e. approximately 4,100 m^3/day. Unit construction cost for the treatment is higher than the other sewerage systems because of the smaller design flow. In addition, a long collector and a pumping station is required to collect the wastewater. This is also one of the reasons for the highest unit construction cost.

The sewerage planning area of the system consists of large hotel and holiday resort complexes, high class residential area and a traditional village. Population densities of the first two areas are relatively low, and enough space for an on-site treatment system is available in each plot. A small bore sewer system is proposed for the village and connection ratio to the system is considered to be low even in 2010 when the proposed sewerage system is completed.

Under the circumstances mentioned above, the priority of the Almadies sewerage system is considered to be lower than the other four systems.

Three remaining sewerage systems, viz. the Camberene, the Malika, and the Mbao sewerage systems, have medium unit costs. Although the unit cost for the Mbao system is lower than that for the Camberene system, it should be noted that the level of the preliminary design on which the cost estimation is based is different for the system. The same can be said to the Malika sewerage system. Therefore, priority among the three systems cannot be compared merely by unit costs.

A different financial arrangement can be considered for the Malika and the Mbao sewerage systems rather than that for the Camberene system because these two systems are to be constructed for the new housing developments. Therefore, priority of the two sewerage systems for the implementation by the authority is considered to be lower than that of the Camberene system.

Unit cost for the Pikine Irregular sewerage system is moderate. However, as mentioned previously, the sewerage system can not be constructed before the zones are not redeveloped. Main facilities of the sewerage system such as trunk sewers and pumping stations are proposed based on the redevelopment plan. Therefore, priority of the system can not be compared with the other systems on the unit cost basis.

Taking into account the discussions mentioned above, the highest priority is given to the Camberene system.

The Camberene sewerage system is broadly divided into three subsystems with the main collector systems, viz. the northern subsystem consisting of a part of the Parcelles Assainies and Its Surroundings sewerage zone, the southwestern subsystem consisting of parts of Dakar and Parcelles Assainies and the entire Hann and Grand Yoff sewerage zones, and the eastern subsystem consisting of Guediawaye and Pikine Regular sewerage zones.

In order to evaluate the priorities of the three subsystems, unit construction costs for sewerage zones were calculated with the same method used for the sewerage systems. In this case, unit construction costs were calculated based on the direct construction costs for sewer networks and collector systems. Costs for the treatment plant were excluded from the comparison since all three subsystems flow into the same treatment plant. Unit construction costs are as follows.

Unit Direct Cost

Sewerage Zones	Direct Construction Cost (1,000 FCFA)	Wastewater Flow (m^3/day)	Unit Cost (1,000 FCFA/m^3/day)
Parcelles Assainies and Its Surroundings	11,640,365	23,946	486
Grand Yoff	4,266,954	17,037	250
Dakar (part)	2,933,104	30,000	98
Hann	9,025,602	8,807	1,025
Guediawaye	11,569,157	8,890	1,301
Pikine Regular	7,298,302	10,848	672

Among the three subsystems, the unit costs of the sewerage zones connected to the southwestern subsystem, viz. Dakar and Grand Yoff sewerage zones, are lower than the others. Most of the newly developed areas in Dakar and Grand Yoff sewerage zones have been provided with sewer networks, and wastewater is collected by the existing Hann-Fann collector. This is the main reason for the lower unit construction costs. However, priority of the sewerage project for these areas is low for the same reason as mentioned for the Ouakam sewerage system. Therefore, the lowest priority among the zones of the Camberene system is given to the works to convert the upstream area of the existing Hann-Fann collector.

On the other hand, there remains relatively large unsewered areas in Grand Yoff and Hann sewerage zones. Although provision of sewer network for Grand Yoff/Khar Yalla is difficult and takes longer period, priority for the sewerage project for these unsewered areas is high. Therefore, Grand Yoff and Hann sewerage zones are given the second highest priority next to the Parcelles Assainies and Its Surroundings zone.

Unit construction cost for the Parcelles Assainies and Its Surroundings zone is second to those of the three zones mentioned above. Sewerage connection ratio in the zone is low although sewer networks have been provided in some areas, e.g. Unit 101 (Parcelles Assainies) where connection ratio was estimated to be 25 % at present. Therefore, potential to increase the wastewater flow to the Camberene WWTP is high. In the current planning, the connection ratio in Unit 101 was conservatively assumed to be 55 % in 2010. If connection ratio is higher than 55 %, which can be realized with sufficient effort, the unit construction cost is lower than the figure shown above.

Improvements of the existing pumping stations are proposed by SONEES for the zone. The system of small pumping stations should be significantly changed if the currently proposed collector system is constructed. Since improvements to the pumping stations are urgently required, early implementation of the proposed sewerage system is desirable.

For the reasons mentioned above, the highest priority is given to the Parcelles Assainies and Its Surroundings zone.

The primary reasons for the higher unit construction costs for the Guediawaye and the Pikine Regular zones are their relatively remote locations from the Camberene WWTP and topography. Three large pumping stations and long and large diameter collectors are necessary to collect the wastewater. Also, the sewerage connection ratio in 2010 was estimated to be low, except a few small residential areas recently developed, because of the development conditions in the past. Therefore, priority of the zones is considered to follow those of the Grand Yoff and Hann.

Technopole is included in the Pikine regular sewerage zone of the Camberene system. Priority of the Pikine Regular zone is low and construction of the trunk sewer into which the wastewater from the Technopole is discharged is not expected to be completed until 2000. Therefore, a pumping station and force mains should be constructed by the developer to send the wastewater to the Camberene WWTP as soon as the wastewater is generated.

Based on the discussions mentioned above, priority of the sewerage project is classified into the following four ranks. The Pikine Irregular, the Malika and the Mbao sewerage systems are excluded from the classification for the reasons mentioned previously and it was revealed that the inclusion of these systems exceed the limit of approximately 100 billion FCFA.

Priority	Sewerage System	Zone or Works
1	Camberene	Parcelles Assainies Zone
2	Camberene	Grand Yoff and Hann
	Ouakam	Improvement of Collector system (collectors, pumping stations and ocean outfalls)
3	Camberene	Guediawaye and Pikine Regular Zones
4	Ouakam and Almadies	

With a limit of approximately 100 billion FCFA, sewerage systems under priorities 1,2 and 3 were confirmed to be implemented until 2010. Therefore, the Ouakam and the Almadies sewerage systems are not included in the implementation schedule.

3.6.2 Implementation Schedule

The implementation schedule for the sewerage master plan has been developed to complete all the works identified in the previous section by 2010. Implementation of the sewerage project depends upon the availability of funding in Senegal, since it involves a heavy investment including a sizable foreign currency component.

The project is expected be initiated from the beginning of 1995. Priorities of the sewerage systems and component works are major factors to distribute the components over a 16 year period up to 2010. The duration needed for the necessary preparatory works, such as survey, design, contract process and land acquisition, has been reasonably assumed for each component work.

Construction periods of each work are assumed, taking into account the work load and the construction cost. It has been intended as much as possible that the work load and the investment be distributed evenly throughout the period. However, work loads for five years from 2001 to 2005 are relatively high because balanced construction program for the extension of the wastewater treatment plant and collection systems are intended.

The implementation schedule of the proposed sewerage project is shown in *Figure* B.3.21.

3.6.3 Project Cost and Operation and Maintenance Cost by Phase

1) Project Cost

Project cost over a 16 year period from 1995 to 2010 was estimated based on the implementation schedule developed in the previous section. Indirect cost items, such as engineering service, government administration and physical contingency, are included in the project cost.

Project cost is divided into two currency portions, viz. local and foreign currency portions. Percentages of the two portions in each cost items are as follows.

Percentage of Local and Foreign Currency Portions

Cost Item	Work Item	L/C	F/C
Direct Construction	Sewer (1)	30 %	70 %
	Sewer (2)	15 %	85 %
	Pumping Station	25 %	75 %
	Treatment Plant	30 %	70 %
Land Acquisition		100 %	0 %
Engineering Service		30 %	70 %
Government Administration		100 %	0 %
Physical Contingency		100 %	0 %

Breakdowns of the project cost by year are shown in *Table* B.3.23. Project cost distribution up to 2010 is shown in *Figure* B.3.22.

The total project cost amounts to approximately 102,279 million FCFA at 1994 price level, of which 29,828 million FCFA or 29 % is local currency portion and 72,451 million FCFA or 71 % foreign currency portion.

2) Operation and Maintenance Cost

Operation and maintenance cost required for all sewerage facilities completed by 2010 was estimated based on the extents and numbers of the facilities.

Additional annual operation and maintenance cost which is required for the operation and maintenance of the sewerage facilities proposed under the Master Plan is 1,516 million FCFA, and its breakdown in Table B.3.24.

3 7 FINANCIAL ANALYSIS

3.7.1 Financial Sources

In January, 1994 the Senegalese currency was devaluated from 50 FCFA to 100 FCFA to one French franc. It forced a complete recalculation of the costs and revenues concerned that had been estimated by the JICA Study Team before the devaluation. The following are the final results of such new estimations.

1) Financial Sources of Initial Cost

(1) Foreign Components

The initial cost of the project proposed in the master plan study is estimated to amount to 102,279 million FCFA. Out of it, the foreign components are estimated at 72,451 million FCFA, accounting for 70.8%. The balance of 29,828 million FCFA or 29.2% can be met by local currency.

One way of financing the project is that the foreign components will be met by external resources, while the local components will be covered by the domestic resources.

Another way is that all the initial cost will be externally derived.

Any way, the ratio of the external financing will be determined by consultation between the government of Senegal and the foreign party concerned.

(2) Terms of External Loans

At this stage one cannot determine the terms of loans of external resources because one is not sure about the country or the financing organ from which they will be derived and also because such terms will depend on the negotiations by the parties concerned before the project starts.

Whichever is the financing country or organ and whatever are the results of the negotiations, one is certain that the lending terms will be not hard in view of the social nature of the project and also in consideration of the budgetary situation of the country.

Supposing the urgent project is financed by Japan, it is probable that it will be in the form of grant.

Supposing the ensuing Phase II project is also financed by Japan, it is possible that it will be in the form of soft loan. In that case the terms of the loan will be something like the annual interest rate of 2.5%, the repayment period of 30 years and the grace period of 10 years.

(3) Relending Terms

The financial resources for construction works will be provided by the government to SONEES or a new sewerage organization which will be the executing body of the project.

The terms under which the government provides the financial resources to SONEES or a new sewerage organization may differ depending on the conditions under which external resources will be obtained.

As a result of the interviews and discussions with the key persons in the Directorate of Debt and Investment, Ministry of Economy, Finance and Planning (Direction de la Dette et de l'Envetissement, Ministere de l'Economie, des Finances et du Plan) and the Directorate of Finance, SONEES (Direction Financiere, SONEES) and also based on the knowledge and experience of the JICA Study Team it is proposed that the financial resources of the initial cost be provided by the government to SONEES or its equivalent on the following terms:

a. 70% of initial cost: Loan
   30% of initial cost: Subsidy

b. Terms of loan
   a) Annual rate of interest : 5%
   b) Repayment period : 25 years
   c) Grace period : 5 years

2) Financial Sources of Operation & Maintenance Cost

It is estimated that 2,350 million FCFA will be annually required to operate & maintain the sewerage facilities to be constructed by the project as well as the existing sewerage facilities.

This amount does not include such cost as depreciation, replacement cost and the repayment of loan (principal plus interest).

It is proposed that the new sewerage tariff be introduced from the year 2001 onward so that the revenue from sewerage service may cover all the above-mentioned cost.

(1) Willingness to Pay for Sewerage Service

The average water supply charge for the clients who were located in the sewered areas excluding gardening crops growers were before the devaluation estimated at 279.5 FCFA per m3. This charge included the charge for sewerage service, which was estimated to be 14.5 FCFA per m3. The net water supply charge thus worked out at 265 FCFA per m3. That is to say, the sewerage charge as percentage of the water supply charge was on average estimated at 5.5%. (These are not the results of theoretical calculation, but are based on the actual amount collected by SONEES.)

The revenue from this sewerage tariff was estimated to be about 830 million FCFA for the whole area under SONEES's control in 1993. This amount was enough only for the operation and minor maintenance of the sewerage facilities.

After the devaluation, it was announced by the government that the water supply charge would be raised by 30%. In accordance with the official bulletin the JICA Study Team estimates the average water supply charge in 1994 at 344.5 FCFA (265 FCFA x 1.3) per m3.

In the master plan study the JICA Study Team proposes that the sewerage charge be elevated to such a level where SONEES can cover the repayment and replacement cost as well as the operation & maintenance cost as in the case of the water supply charge.

However, that level must not be much beyond the financial capacity of the beneficiaries.

In this connection the JICA Study Team conducted the sampling questionnaire survey to know the amount beneficiaries are willing to pay for sewerage service. The number of samples was 137 for households and 100 for commerce/institutions/industry. The team tried so that samples might encompass all types or classifications of housing, commerce, institutions and industry.

It is to be noted that the survey was carried out before the devaluation.

The results are shown in *Table* B.3.25. As it shows, the amount a household was on average willing to pay for sewerage service as percentage of water supply charge was 24.7%. And the amount itself worked out at 896 FCFA per month as the average monthly water supply charge was estimated at 3,632 FCFA. In case of commerce/institutions/industry the amount a client was on average willing to pay for sewerage service as percentage of water supply charge was 18.7%.

It is noticed as a general trend that richer households and bigger enterprises were less willing to pay for sewerage service in terms of the ratio to water supply charge.

It turned out that the amount households were on average willing to pay for sewerage service was estimated to constitute 1.3% of their income. (Refer to *Table* B.3.26.)

(2) Proposed Sewerage Tariff

Based on the results of the questionnaire survey it is proposed that a new sewerage tariff be established. Under the new tariff the average sewerage charge will be 12% of the average water supply charge from 2001 to 2010 and the percentage will go up to 22% from 2011 onward. It means that the sewerage charge per m3 will be on average 41.34 FCFA (344.5 FCFA x 12%) from 2001 to 2010 and 75.79 FCFA (344.5 FCFA x 22%) from 2011 on at the 1994 prices. It means also that the sewerage charge per household will be on average 567 FCFA (3,632 FCFA x 1.3 x 12%) from 2001 to 2010 and 1,039 FCFA (3,632 FCFA x 1.3 x 22%) from 2011 on. Under the bimonthly paying system a household will pay 1,134 FCFA (2001 to 2010) and 2,078 FCFA (from 2011) on average every two months.

Up to 2000 the existing sewerage charge will continue to be enforced. That is to say, the average sewerage charge will be around 6.1% of the average water supply charge. It means that the sewerage charge per m3 will be on average 21.01 FCFA (344.5 FCFA x 6.1%). It means also that the sewerage charge per household will be on average 288 FCFA (3,632 FCFA x 1.3 x 6.1%). Under the bimonthly paying system a household will pay 576 FCFA on average every two months.

The collection efficiency of the sewerage charge taking into consideration such things as social tariff is assumed to be 90%.

Under the pre-devaluation tariff households on average paid 0.31% of their income as sewerage charge and along with water supply charge the payment totaled 5.44% of their income.

Supposing household income will increase in parallel with the raising of the water supply tariff, under the new tariff to be introduced from 2001 households will on average pay 0.62% of their income for sewerage service and the combined payment of households for water supply and sewerage service will come to 5.74% of their income. From 2011 on sewerage charge will on average occupy 1.13% of household income and the combined sewerage and water supply charge will share 6.25% of household income.

(3) Estimated Sewerage Revenue

The annual sewerage revenue for the master plan study area to be derived from the above-mentioned new tariff is estimated to come to 3,340 million FCFA in 2001 and 10,020 million FCFA in 2011 at 1994 prices at the charge collection efficiency of 90%, if the project proposed in the master plan study is implemented. (For the revenue in other years refer to *Table* B.3.27.) This revenue is intended to cover the repayment and replacement cost and the operation & maintenance cost of the project as well as the operation & maintenance cost of the existing facilities.

3.7.2 Financial Projections

1) Projection of Financial Statements

(1) Preconditions/Assumptions

In preparing projected financial statements including the income statement and funds statement the following conditions/ assumptions were established:

a. Depreciation period
   Sewerage facilities : 50 years
   Electro-mechanical equipment : 15 years

b. Period of projection: 30 years

c. Annual rate of inflation: 2%

d. Rate of tax on corporate income: 30%

e. Sources of initial cost
   Government loan : 70%
   Government subsidy : 30%

f. Terms of government loan
   Annual interest rate of 5%, repayment period of 25 years, grace period of 5 years

g. Source of operation & maintenance cost
   Revenue from sewerage charge

h. Average sewerage charge
   Up to 2000:
   6.1% of water supply charge or 21.01 FCFA/m3
   From to 2001 to 2010:
   12% of water supply charge or 41.34 FCFA/m3
   From 2011 on:
   22% of water supply charge or 75.79 FCFA/m3
   Note: The per cubic meter charge is based on the actually collected water supply charge.

i. Sewerage charge collection efficiency: 90%

(taking social tariff into account)

j. Source of replacement cost
Revenue from sewerage charge

(2) Projected Financial Statements

Upon the above-listed preconditions and assumptions the projection of financial statements was performed for the sanitation organization of SONEES or a new sewerage organization under the circumstances where the master plan sewerage project is implemented. The service area concerned is the master plan study area. It was revealed as *Table* B.3.28 shows that the organization will be financially sound and stable in terms of earnings as well as solvency during the projection period of 30 years.

2) Estimation of Financial Internal Rate of Return

The cost benefit streams was prepared for 40 years for financial analysis of the project as shown in *Table* B.3.29. Using the table the financial internal rate of return (FIRR) was estimated. It worked out at 7.4%, which, after setting aside 5% for the repayment of interest of the loan, leaves the surplus of 2.4%, which is a little higher than 2%, i.e. the minimum rate of profit on the fixed assets employed as provided in the Second Contract and Plan between the State and SONEES (Deuxieme Contrat-Plan Etat-SONEES). Thus, the value of FIRR is judged to be a reasonable one.

3) Alternative Proposal

(1) Alternative I
Here is a proposal taking into account the way the state usually adopts in providing financial resources of initial cost to SONEES in the realm of water supply. The idea as well as the practice of subsidy has not been evident in such a case.

<u>Preconditions/Assumptions</u>

a. Source of initial cost
100% government loan

b. Average sewerage charge
Up to 2000:
6.1% of water supply charge or 21.01 FCFA/m3
From to 2001 to 2010:
14% of water supply charge or 48.23 FCFA/m3
From 2011 on:
28% of water supply charge or 96.46 FCFA/m3

Regarding other preconditions/assumptions they are the same as those shown in 1) of this section.

As one can see above, under this alternative the government of Senegal provides the financial resources of initial cost entirely as loan to SONEES. The sewerage tariff will be harder than the initial proposal, but can be judged to be not very much beyond people's willingness to pay. The average charge from 2001 to 2010 will be 14% of water supply charge instead of 12% and from 2011 on it will go up to 28% instead of 22%.

The revenue from the sewerage charge will cover the operation, maintenance, replacement and repayment cost.

<u>Financial Projections</u>

The projection of financial statements was done under the above conditions. As shown in *Table* B.3.30, SONEES is projected to have a healthy financial performance with regard to the master plan study area during the period of 30 years. Also, the FIRR was estimated using *Table* B.3.31. It worked out at 6.8%, which after subtracting 5% for repayment of interest leaves a surplus of 1.8%. The value of FIRR is thus judged to be a reasonable one for a public organization like SONEES.

(2) Alternative II

Here is another proposal taking into consideration the delicate political implications of the sewerage tariff issue.

Preconditions/Assumptions

a. Source of initial cost
100% government subsidy

b. Average sewerage charge
Up to 2000:
6.1% of water supply charge or 21.01 FCFA/m3
From 2001 to 2010:
7% of water supply charge or 24.12 FCFA/m3
From 2011 on:
8% of water supply charge or 27.56 FCFA/m3

c. There will be no depreciation, nor repayment.

Regarding other preconditions/assumptions they are the same as those shown in 3.7.2.

As shown above, under this alternative the government of Senegal provides all the initial cost as subsidy to SONEES. The sewerage tariff will revised in 2001, under which the average charge will be 7% of water supply charge. In 2011 it will be revised again so that the average charge will be 8% of water supply charge. The revenue from the sewerage charge will cover the operation, maintenance and replacement cost.

Financial Projections

Projected financial statements were prepared under the above conditions. *Table* B.3.32 shows that SONEES will be financially in a good shape during the period of 30 years.

3.8 ORGANIZATIONS AND MANAGEMENT

3.8.1 Important Organizational/Institutional Issues

Based on the interviews with the important officials concerned, the examination of the Strategic Plan and the past experience and knowledge in other countries the JICA Study Team lists the following as important issues relative to sanitation from the organizational/institutional viewpoint.

a. Low rate of connection to sewerage
b. Low sewerage charge
c. Limited power of SONEES vis-a-vis the state in sanitation
d. Low status given to sanitation functions in the organizational set-up of SONEES
e. Lack of coordination between the ministries concerned regarding the planning and implementation of sanitation works
f. Needs for the control of industrial wastewater discharge
g. Reuse of wastewater

Each item in the above will be explained hereunder:

1) Low Rate of Connection to Sewerage

It is estimated that out of the population of 1,517,400 in the study area 453,958 people are sewered in 1993. That is to say, 29.9% of the population are connected to the sewerage. On the other hand, the population in the sewered areas are estimated at 733,000. It means that only 61.9% of the households in the sewered areas are connected to the sewerage, although some households which are not connected to the sewerage in the sewered areas utilize public stand pipes.

What this state of affairs represents is that much of the initial capital invested in the sewerage facilities is left un-utilized. It is a big economic loss to the government of Senegal.

Because of the under-utilization of the sewerage network, especially in Pikine and Parcelles Assainies, the Camberene WWTP is forced to function at 40% of its normal capacity.

2) Low Sewerage Charge

Under the pre-devaluation sewerage tariff beneficiaries, excepting those who only consumed the basic volume of water and gardening crops growers, paid 22.23 to 25.57 FCFA per cubic meter of consumed water depending on the volume or type of water consumption. It is said that under the tariff SONEES could cover only the costs of operation and a part of maintenance.

After the devaluation of the Senegalese currency in January, 1994 it was officially decided that the water supply charge would be raised by 30%. According to the decision, beneficiaries now pay 28.90 to 33.24 FCFA per cubic meter.

Until today sanitation was not given a full-fledged status as in the case of water supply in reality as well as in the government's perception. It is reflected in the above charge. From the long term standpoint covering the period up to 2010, during which population in the study area will grow by 91.7% from the present 1,517,400 to 2,908,871, sooner or later sanitation will have to be given a parallel position with water supply.

According to the analysis of the JICA Study Team the average sewerage charge per cubic meter of used water shall be 41.34 to 75.79 FCFA if the projects proposed in this master plan study are to be financially successfully implemented. (The above average sewerage charge is not a theoretical one based on the sewerage tariff, but a practical one on the actual collection basis.) The charge will meet not only the operation and maintenance cost, but also the replacement cost and a major part of the initial cost.

3) Limited Power of SONEES vis-a-vis the State in Sanitation

In the Second Contract and Plan between the State and SONEES (Deuxieme Contrat-Plan Etat-SONEES) it is written as the missions of SONEES that in the realm of water supply SONEES shall manage all the existing and future facilities, supervise all the investment projects, operate & maintain all the installations and repay external debts on one hand, and in the realm of sanitation it shall be in charge of the operation & maintenance and renewal of electro-mechanical equipment on the other.

What signifies above is that the state endows SONEES with an independent status in managerial and financial terms so far as the water supply sector is concerned. Indeed, the Society is equipped with every aspect as an independent enterprise, performing all the "plan-do-see" activities by itself. Only in light of the public nature of the Society's activities governmental approval is required in important decision-makings.

However, in the case of the sanitation sector SONEES cannot manage the facilities, nor supervise investment projects, nor have obligations to pay back capital costs. In short, sanitation is not regarded as important as water supply by the state.

4) Low Status given to Sanitation Functions in the Organizational Set-up of SONEES

Under the present circumstances a majority of the study area, especially the Pikine area, is still left unsewered, a multitude of the population in the sewered area remain unconnected to the sewerage network and a majority of the wastewater collected in the sewers is discharged into the sea without any treatment.

This state of affairs testifies to the stand of the state and the people toward sanitation. However, it will be too late to wait until the catastrophe surfaces as the sufferings and costs will be enormous in such an event.

Reflecting such a stand, the organizational set-up related to sanitation in SONEES is small and not very significant. The Sanitation Service (Service Assainissement) under the Directorate of Technique is only one of 33 services. This service performs unblocking, dredging, operation of the Camberene WWTP and pumping stations, and small-scale extension, connection and prefabrication works. It is manned by about 100 permanent employees out of the total manpower of 1,477. (Refer to Fig. A.2.10 and A.2.11.) Indeed, it can be said that sanitation is organizationally given the importance of around 6.8%.

5) Lack of Coordination between the Ministries Concerned regarding the Planning and Implementation of Sanitation Works

It will be unwise economically to construct sanitation network where not much population is envisaged in the future. It will cost more if the construction plan of sanitation is not coordinated with that of road. It would not work properly if sanitation works were planned and executed without due regard to financial capacity of the state and the people. Due care must be taken so that environment and people' well beings may not be affected by the implementation of the sanitation project especially in the domain of the locations of the treatment plants and relocation/compensation for the evacuated people. It will be not sensible for the sake of the economy to burden industries with too much financial sacrifices in order to control the discharge of industrial wastewater.

Because of all of this the coordination and cooperation between the Ministries in charge of the urban development, transportation, finance, economy, planning, environment, public health, industry, etc. are indispensable for the proper and correct functioning of the sanitation sector.

6) Needs for the Control of Industrial Wastewater Discharge

The JICA Study Team estimates that pollution load that is daily discharged by the industry in the study area corresponds to that of 250,000 people. It warns that because of the discharge of untreated industrial wastewater for years the Bay of Hann is now progressively being polluted.

It seems that now is the time for the state to take measures in order to preserve the environment by institutionally preparing the physical, chemical and biological standards of industrial wastewater that is allowed to be discharged. To facilitate such action it is advised that the state institutionally support the industry by exempting duties regarding the acquisition of anti-pollution equipment.

7) Reuse of Wastewater

In conjunction with the treatment of domestic and industrial wastewater it is advised to recycle the wastewater for agricultural and industrial use. It will contribute to reducing the cost and price of agricultural and industrial products.

3.8.2 Recommendations

Based on the important institutional/organizational issues explained above the JICA Study Team would like to come up with the following recommendations. They are founded upon the strong perception that the sanitation sector must be given the important position comparable to that of the water supply sector because of its inseparable connections with the environment and people's health.

1) Institutional Support for Connection to Sewerage

After the devaluation everything related to the FCFA is thrown into turmoils. One is not very sure about the outcome of price escalation. But, for the sole purpose of convenience it was assumed that the cost of connection and the monthly household income in 1994 be by 30% higher than the pre-devaluation levels.

Many houses and other installations in the sewered areas are not connected to the sewerage due to the expensive cost of connection. The cost of connection ranges from 83,200 to 195,000 FCFA depending on the executioner, materials, transport and other factors, averaging around 156,000 FCFA. On the other hand, according to the results of the questionnaire survey conducted by the JICA Study Team the average monthly household income in the study area is 92,125 FCFA.

This fact coupled with people's lack of proper knowledge about the importance of sanitation tends to limit their willingness to have their houses connected to sewerage. It results in a tremendous loss to the economy as mentioned above.

To rectify this situation it is recommended that the state institutionally make it possible for the households to pay the connection charge on installment. Supposing the period of installment on the original cost of 156,000 FCFA is 36 months at the annual interest rate of 2%, then the monthly payment will be 4,467 FCFA. It occupies 4.8% of the average monthly household income. Supposing the period of installment is 60 months at the annual interest rate of 2%, then the monthly payment will be 2,733 FCFA, occupying 3.0% of the average monthly household income. It is recommended that the interest rate be not higher that the inflation rate.

2) Raising of Sewerage Charge

It is estimated that currently the sewerage charge of 28.90 to 33.24 FCFA per cubic meter is applied depending on the volume or type of water consumption. In terms of the ratio of sewerage charge to the water supply charge it is 6.1% for the water consumption to which the Normal or Dissuasive Section (Tranche Normale or Disuasive) applies and it is 17.5% for the public stand pipe. For the water consumption to which the Social Section (Tranche Sociale) applies as well as for the gardening crops growers sewerage charge is not imposed.

The average sewerage charge as percentage of the water supply charge for the clients other than the Social Section consumers and gardening crops growers is estimated at 6.1% on the actual collection basis.

It is recommended that the ratio be raised to 12 to 22 % if the sewerage projects envisaged in the master plan are to be financially successfully implemented. This level is warranted to be proper by the results of the questionnaire survey conducted by the JICA Study Team. According to the survey the average amount of sewerage charge households are willing to pay is 24.7% of the water supply charge. In case of commerce, institutions and industry they are willing to pay the sewerage charge corresponding to 18.7% of the water supply charge on average.

3) Raising the Power of SONEES vis-a-vis the State in Sanitation

The underlying conception of the state regarding the sanitation sector is that it is essentially a social sector and in this sense not profitable. However, so far as the sewerage project is concerned, the trend in the world is increasingly to treat it as an income generating business like the water supply project. As regard the rain water drainage project, it is considered a social project because the whole society concerned benefits from it and one cannot specify the beneficiaries.

Therefore, it is recommended that the state institutionally provides SONEES with the power in the sewerage sector essentially the same as in the water supply sector.

The power will include:

To prepare the long and medium term development plan subject to the government's approval;

To execute the construction project under its supervision;

To manage the whole existing and future facilities;

To renew the facilities;

To operate & maintain the installations;

To revise the tariff subject to the government's approval;

To pay back a majority of the initial cost.

In short SONEES will be given a full managerial and financial power as well as responsibility in the sewerage sector.

As regard the rain water drainage sector the power of SONEES will remain limited as at present because the sector will continue to need the financial and other protection of the state.

4) Elevation of Sanitation-Related Organizational Set-up in SONEES

At present the organizational set-up directly related to sanitation in SONEES is the Sanitation Service (Service Assainissement). It is one of the 33 services and manned by about 100 workers accounting for 6.8% of the total manpower. It performs unblocking, dredging, pumping and treatment of wastewater, and little extension, connection and prefabrication works in accordance with the contract between the state and SONEES.

It is recommended that as a gradual process the organizational set-up related to sanitation be enlarged and elevated to such a one as will eventually in 2010 be consisted of one department and four services under the Directorate of Sewerage, namely the Planning Service, the Construction Service, the Water Pollution Control Service, the Operation & Maintenance Department, and the Administration and Finance Service. (Refer to Fig B.3.23.)

The Planning Service will work out the long and medium term plans on sewerage demands, construction of sewerage, revenues/expenses, financial resources, personnel requirements, etc. It will be composed of three divisions, i.e. the Facility Planning, Financial Planning and Personnel Planning Divisions. It will have 20 personnel.

The Construction Service will perform the planning, designing and execution of the sewerage projects. It will consist of three divisions, that is, the Technical Research, Planning & Design and Contracts Divisions. It will be manned by 50 people.

The Water Pollution Control Service will implement the related provisions in the related laws including the Bill of Sanitation Law (Project de Loi portant Code de l'Assainissement), the Bill of Environment Law (Projet de Loi portant Code de l'Environnement), the Water Law (Loi portant Code de l'Eau), the Hygiene Law (Loi portant Code de l'Hygiene) and the Town Development Law (Loi portant Code de l'Urbanisme). This service will control the Water Pollution Division and the Water Pollution Monitoring Division. It will have 20 staff.

The Operation & Maintenance Department will perform the operation & maintenance, inspection, liaison with organizations concerned and keeping of technical records. It will consist of five divisions, namely the Technical Records, Liaison, Inspection, Operation & Maintenance and Workshop Divisions. This department will be manned by 120 workers.

The Administration and Finance Service perform the functions of general administration, finance, accounting, public relations and internal audit. It will be made up of five divisions, i.e. Internal Audit, Public Relations, Personnel and General Administration, Accounting and Finance Divisions. It will have 40 personnel.

The total staffing of this directorate will be 250.

5) Establishment of Coordination Committee

The general lack of coordination between government organizations (such as the ministries) concerned was strongly voiced in the interviews with the key persons concerned. The construction and operation & maintenance of the sewerage facilities involve many other domains of activities as already explained in Section 3.8.1. The failure of adequate coordination has sometimes actually resulted in major or minor economic losses.

To avoid such circumstances it is recommended that the Coordination Committee be set up, composed of SONEES, the local autonomous bodies, the Ministry of Hydraulics (Ministere de l'Hyrdaulique), the Ministry of Economy, Finance and Planning (Ministere de l'Economie, des Finances et du Plan), the Ministry of Environment and the Protection of Nature (Ministere de l'Environnement et de la Protection de la Nature), the Ministry of Town Planning and Housing (Ministere de l'Urbanisme et de l'Habitat), the Ministry of Energy, Mining and Industry (Ministere de l'Energie, des Mines et de l'Industrie), the Ministry of Public Health and Social Action (Ministere de la Sante Publique et de l'Action Sociale), the Ministry of Equipment and Transportation (Ministere de l'Equipement et des Transports), and the Ministry of the City (Ministere de la Ville). It will be the standing committee and the regular session will be held every two months. The extraordinary session will be convened as the need arises.

The major items for communication and discussion will be long and medium term investment plans, designing and execution of construction works, financial resources, water pollution monitoring, impact on environment, daily operation & maintenance, tariff, manpower, etc.

6) Establishment of Quality Standards for Industrial Wastewater Discharges

It is high time for the state to institutionalize the quality standards of industrial wastewater to be discharged. Standard values will be established for physical, chemical, organic and other parameters.

Physical parameters will include turbidity, temperature and color.

Chemical parameters will include Hg, NH3-N, As, Fe, B, F, Cd, PO4-P, Cl2, Cl, Cr, Cr(VI), Ni, NO3-N, NO2-N, pH, Zn, SO4, H2S-S, Cu and Pb.

Organic parameters will include phenol, oil and grease, methylene blue active substance, CN and KMnO4 value.

Special parameters will include BOD (biochemical oxygen demand) and COD (chemical oxygen demand), SS (suspended solid), dissolved solid, settleable solid, pesticide and radioactivity.

Also it is advised that the quality standards for sea water be established as soon as possible. Standard values will be established for physical, chemical and biological parameters. Those parameters are shown hereunder for reference.

Physical parameters will include color, odor, transparency, turbidity, SS (suspended solid), floating solid, oil film and temperature.

Chemical parameters will include pH, salinity, DO (dissolved oxygen), BOD5 (biochemical oxygen demand), COD (chemical oxygen demand), NH4-N, NO2-N, CN, H2S, crude oil, phenol compound and metal/semi-metal (Hg, Cr(VI), As, Se, Cd, Cu, Pb, Zn, Ni, Ag).

Biological parameters will include fecal coliform, pathogens and plankton.

Also, radioactive parameters will be added, which will include alpha, beta, Sr-90 and Ra-226.

Industry has to set aside a substantial financial resources if it is to abide by the quality standards of its effluents. It is advised in order to facilitate the introduction and implementation of such a regulation that the custom duties be suspended for the importation of anti-pollution equipment and supplies and also that direct taxes be alleviated by permitting an accelerated depreciation of such equipment.

7) Institutional Support for Reuse of Wastewater

Supposing the unit cost of the recycling of domestic wastewater is less than that of the production of piped water, then the gardening crop growers will be able to buy the recycled domestic wastewater at a cheaper price than piped water. It is not only a good thing for them, but also for the consumers since they can buy cheaper gardening products.

Similarly, supposing the unit cost of the recycling of industrial wastewater is less than that of the production of piped water, then the industry will prefer to use the recycled industrial wastewater in order to reduce production cost. It constitutes a benefit for the industry. Also, it may lead to a cheaper price of industrial products, thus benefiting consumers.

In short the cheap recycled wastewater can benefit the economy as a whole. The state can help the things to move in this direction by institutionally facilitating recycling processes. That is to say, it can exempt duties and direct taxes for the equipment and chemicals concerned.

3.9 PROJECT EVALUATION

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

The proposed Master Plan has following distinct objectives:

- To enable the maximum utilization of the existing capacity of the Camberene WWTP, which was constructed by a loan from the African Development Bank and only 40 % of its capacity is presently utilized.

- To expand the sewerage service area towards the Pikine area, which is being established as a new urban center.

- To balance the development of sewage collection area and sewage treatment area in Pikine area by expanding the Camberene WWTP.

Purposes of the development of a sewerage system are to collect and eliminate wastewater from areas where the wastewater is generated, to improve sanitation conditions of the areas as it was so in the initial stage of the sewerage history, and to reduce pollutants loads to the nature by treatment in order to improve the water quality, environment inside and/or surrounding areas, which is now a major concern in most of the urban areas. Thus sewerage system usually consists of a set of collection system and treatment system, resulting in high projects costs. However, if such project costs are not affordable, it is reasonable to put priority on either of two purposes namely sewage collection or sewage treatment by considering urgent requirements of the project area. In this regard, the sewage collection has been put a higher priority in the study area, which is situated in an arid zone and has few natural water surface except the surrounding sea. The initial environmental investigation conducted in this study has identified possible adverse effects to the western shoreline in limited periods of a year (June and August) by continuing untreated wastewater discharge from Fann. However it is not judged to be so severe to require urgent improvement. Therefore, it can be justified to put a higher priority on the expansion of the sewage collection than the treatment of wastewater presently discharged to the sea.

Another big concern in this area is the pollution of the groundwater which is at present one of the major water supply sources. The proposed sewerage plan may result in the reduction of wastewater infiltration that is supposed to be a major cause of the groundwater contamination up to some extent, but the infiltration from on-site system that will remain in the un-sewered areas is estimated to be big enough to increase the contamination. The on-site treatment that eliminate the infiltration was investigated but judged to be not feasible. Therefore, the plan recommends the substitution of the present wells by a surface water source.

In terms of the financial feasibility, the proposed projects, the total costs of which is 102,279 million FCFA, is judged to be affordable by considering the people's willingness to pay for sewerage service and the subsidy by the government.

3.10 RECOMMENDATION

- The Sewerage Master Plan was proposed by shifting out several project components from the Sewerage Development Plan that covered the whole study area, because of budget constraint. The proposed Sewerage Master Plan is considered to be the essential components to satisfy the minimum requirements to improve the present sewerage conditions of the area and to ensure the further development following the sifted out project components. Therefore, it is recommended to implement projects according to the proposed Master Plan as earliest as possible. In this regard, the political decision to provide special financial supports to the projects are strongly required.

- It is desired to review this master plan when the projects in the plan proceed to the some extent to cope with areas not included in this master plan.

- Either by re-organization of SONEES or by creation of a new organization, one organization should take responsibilities for planning and execution of projects, operation and maintenance of facilities and management of organization and finance of sewerage system, as SONEES is presently doing in the water supply system. The Ministry Hydraulics, which is presently responsible for the projects execution, should be involved in the system as an governmental authority to give approvals to each activities.

- Efforts to improve present conditions existing in the Study Area, especially to increase wastewater flow to the Camberene WWTP by promoting house connections in the existing sewered areas, should be continued. Provision of installment would help these efforts.

- Though industrial wastewater was recognized as one of major pollutant sources, sewerage system for industrial zones were shifted out from the Master Plan. This is because that industrial wastewater was judged to be treated either by individual treatment or by treatment plant to be constructed and operated by such industries. Therefore, it is recommended that the government apply regulations for the wastewater discharges to encourage this direction.

- Improvement of toilet facilities of the on-site system should be encouraged to mitigate the sanitary problems of the area, in particular bacteriological contamination of shallow well water.

- Substitution of Thiaroye water supply source by other water sources would be essential to avoid supplying water with the high concentrations of the nitrate nitrogen. In this regard, earlier implementation of the Cayor Canal project is strongly recommended.

- Reuse of raw sewage from the Niaye WWTP for agricultural purpose should be ceased as soon as possible.

- The coordination and cooperation among the Ministries and the other organizations concerned are prerequisites if the sewerage construction project and the operation & maintenance of the sewerage facilities are to be successfully conducted. In this connection the establishment of the Coordination Committee is recommended.

TABLE B.3.1 COMPONENT UNITS IN SEWERAGE ZONES

Sewerage Zone	Units
1 Dakar	24, 25, 26, 27, 28, 29, 30, 50, 50b, 51, 51b, 52, 52b, 52t, 53, 53b, 53t, 54, 55, 55b, 56, 57, 58, 59, 59b, 60, 61, 62, 63, 63b, 65, 66, 67, 68, 69, 70, 71, 71b, 72, 73, 74, 75, 75b, 76, 77, 78
2 Parcelles Assainies and its Surroundings	33, 34, 35, 36, 37, 38, 39b, 40, 41, (42), 98, 99, 100, 101, (102), 103, 104, 105
3 Grand Yoff	31, 32, 43, 43b, 44, 45, 46, 46b, 47, 48, 49
4 Hann	(81), 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92
5 Pikine Regular	94, 94b, 111, 112, 112b, 113, 114, 115b
6 Guediawaye	107, 108, 108b, 109, 109b, 129, 130, 130b, 131, 132, 133, 134
7 Malika Housing Dev.	142b
8 Mbao Housing Dev.	159
9 Almadies	1, 2, 3, (4), 5, 6, 7, 8
10 Ouakam	9, 10, 11, 12, 13, 14, 15, 16, (17), 18, 19, (20), 21, 22, 23
11 Dakar Port	79, 80 (part)
12 Pikine Industrial	80 (part), 115, 116, 117, 118
13 Tiaroye Industrial	80 (part), 120, 123, 153
14 Pikine Irregular	119, 121, 124, 125, 126, 127, 128, (135), (136), 137, 138, (139), 143, 144, 145, (146), 147, 148, 149

Note : Unit number in parentheses is small bore sewer system.

Source : Study Team

TABLE B.3.2 WASTEWATER FLOW IN 2010 (COMPLETE)

(unit : m3/day)

Sewerage Zone	Daily Average Flow	Peak Flow
1 Dakar	124,524	249,046
2 Parcelles Assainies and Its Surroundings	39,383	78,762
3 Grand Yoff	24,110	48,219
4 Hann	10,783	20,537
5 Pikine Regular	23,379	45,030
6 Guediawaye	39,098	75,590
7 Malika Housing Development	22,472	43,272
8 Mbao Housing Development	44,604	86,620
9 Almadies	12,008	24,175
10 Ouakam	9,001	17,998
11 Dakar Port	8,362	16,723
12 Pikine Indusrial	648	1,201
13 Tiaoye Industrial	4,466	8,486
14 Pikine Irregular	63,611	120,560
Total	426,449	836,219

Source : Study Team

TABLE B.3.3 WASTEWATER FLOW IN 2010 (ACTUAL)

(unit : m3/day)

Sewerage Zone	Daily Average Flow	Peak Flow
1 Dakar	115,327	230,653
2 Parcelles Assainies and Its Surroundings	23,946	47,886
3 Grand Yoff	17,037	34,074
4 Hann	8,807	16,585
5 Pikine Regular	10,848	19,969
6 Guediawaye	8,890	15,173
7 Malika Housing Development	22,472	43,272
8 Mbao Housing Development	44,604	86,620
9 Almadies	4,111	8,222
10 Ouakam	5,231	10,459
11 Dakar Port	15,351	30,701
12 Pikine Indusrial	2,212	4,329
13 Tiaoye Industrial	8,791	7,108
14 Pikine Irregular	48,290	89,918
Total	335,917	644,969

Source : Study Team

TABLE B.3.4 BOD CONCENTRATION OF DOMESTIC SEWAGE

Sewerage Zone	BOD Load (kg/day)	Daily Average Flow (m3/day)	BOD Concentration (mg/l)
1 Dakar	36,992	115,327	321
2 Parcelles Assainies and Its Surroundings	10,403	23,946	434
3 Grand Yoff	6,601	17,037	387
4 Hann	2,961	8,807	336
5 Pikine Regular	5,256	10,848	485
6 Guediawaye	2,643	8,890	297
7 Malika Housing Development	7,800	22,472	347
8 Mbao Houing Develoment	15,756	44,604	353
9 Almadies	1,437	4,111	350
10 Ouakam	2,182	5,231	417
14 Pikine Irregular	26,285	48,290	544
Total	118,316	309,563	382

Source : Study Team

TABLE B.3.5 BOD CONCENTRATION OF INDUSTRIAL SEWAGE

Sewerage Zone	BOD Load (kg/day)	Daily Average Flow (m3/day)	BOD Concentration (mg/l)
11 Dakar Port	14,634	15,351	953
12 Pikine Industrial	2,318	2,212	1,048
13 Tiaroye Industrial	8,569	8,791	974
Total	25,521	26,354	968

Source : Study Team

TABLE B.3.6 CONSTRUCTION COST FOR TWO ALTERNATIVES, DAKAR

(unit: million FCFA)

Facility	Alternative A	Alternative B
Pipes and Culverts	5,068	874
Pumping Station	-	1,880
Total	5,068	2,754

TABLE B.3.7 CONSTRUCTION COST FOR TWO ALTERNATIVES FOR MALIKA AND MBAO

(unit: million FCFA)

Component Facility	Alternative A Individual Treatment	Alternative B Combined Treatment
Treatment Plant, No.5	9,592	21,312
Treatment Plant, No.7	15,822	-
Pumping Station, Mbao (to send to No.5)	-	3,446
Pumping Station, Malika	2,506	4,699
Force Main and Ocean Outfall, Malika (for effluent discharge)	459	1,918
Total	28,379	31,375

TABLE B.3.8 CONSTRUCTION COSTS FOR TWO ALTERNATIVES FOR ALMADIES

(unit: million FCFA)

Component Facility	Alternative A Individual Treatment	Alternative B Combined Treatment
Treatment Plant, No. 9	6,100	-
Treatment plant, No. 8	25,418	26,305
Pumping Stations (2)	-	3,759
Force Main, from No. 9 to No. 8	-	1,077
Additional Collectors	192	-
Total	31,710	31,141

TABLE B.3.9 WASTE WATER TREATMENT PLANTS AND CORRESPONDING SEWERAGE ZONES

WWTP	Sewerage Zone
1. Ouakam	Dakar(part), Ouakam
2. Camberene	Dakar(part), Parcelles Assainies, Grand Yoff, Hann, Pikine Regular, Guediawaye
3. Malika	Malika Housing Development
4. Mbao	Mbao Housing Development
5. Almadies	Almadies
6. Mbao Industrial	Dakar Port, Pikine Industrial, Tiaroye Industrial
7.Lac Warouwaye	Pikine Irregular

TABLE B.3.10 PROPOSED TRUNK SEWERS AND FORCE MAINS

items		DAKAR	CAMBERENE	MALIKA	MBAO	ALMADIES	OUAKAM	INDUSTRY	P.IRREGULAR	TOTAL
Trunk Sewer	350 mm diameter		210	1,030						1,240
	400 mm diameter		940							940
	450 mm diameter		630	1,150						1,780
	500 mm diameter		60			370				430
	600 mm diameter		2,440		3,000	1,600				7,040
	700 mm diameter	1,700	4,370	1,750	2,100	1,910		1,700	570	14,100
	800 mm diameter	2,100	540			1,090		2,700	980	7,410
(Concrete Pipe)	900 mm diameter	150	3,900			50		6,100	1,040	11,240
	1000 mm diameter		0		3,200				420	3,620
	1100 mm diameter		1,000						1,630	2,630
	1200 mm diameter		490						210	700
	1350 mm diameter		2,190						400	2,590
	1500 mm diameter		2,010						1,560	3,570
	1650 mm diameter		4,520							4,520
	Total	3,950	23,300	3,930	8,300	5,020	0	10,500	6,810	61,810
Force Main	150 mm diameter		430							
	200 mm diameter		3,530							
	250 mm diameter		2,500							2,500
	300 mm diameter					680				680
	350 mm diameter		2,380							
(Ductile Iron Pipe)	500 mm diameter								40	40
	600 mm diameter								170	170
	700 mm diameter			1,300					640	1,940
	800 mm diameter	1,300								1,300
	900 mm diameter		1,100							
	1000 mm diameter	4,000								4,000
	1350 mm diameter		1,100							1,100
	Total	5,300	11,040	1,300	0	680	0	0	850	19,170

TABLE B.3.11 PROPOSED PUMPING STATIONS

Sewerage System	Zone	No.	Capacity (l/s)
Ouakam	Dakar	1	2,000
		2	650
		3	133
		4	67
Camberene	Guediawaye	1	133
		2	250
	Pikine Regular	3	750
	Hann	4	417
	Pacelles Assainies	5	144
Malika	Malika	1	500
Almadies	Almadies	1	83

TABLE B.3.12 PROPOSED WASTE WATER TREATMENT PLANT

Sewerage System (m3/day)	Location	Process*	Capacity
Ouakam	Ouakam	AS	85,400
Camberene	Camberene	AS	100,000
Malika	Malika	AS	22,500
Mbao	Mbao	AS	44,600
Almadies	Ngor	OD	4,200
Pikine Irregular	Lac Warouwaye	AS	63,600
Industrial	Mbao	AS	26,400

Note *AS = Activated Sludge
OD = Oxidation Ditch

TABLE B.3.13 CHARACTERISTICS OF INDUSTRIAL WASTEWATER AND WASTEWATER QUANTITY

Industry Type	Characteristic of Wastewater	Objective Parameters	Industrial Wastewater Quantity (cu.m/d)	
			1993	2010
Fishing & Canning	contains blood, gut, meet and oil from fish.	BOD, SS, n-Hexane ex.	1585	3486
Beer, Beverage, Condensed Milk, others	Wastewater from machine washing	BOD, SS	1463	3217
Cooking Oil	contains oil	n-Hexane ex., BOD	1463	3217
Textile	Wastewater from washing	COD, BOD	4389	9652
Fuel	contains oil	n-Hexane ex.	1341	2949
Fertilizer	Process wastewater	pH, SS	1219	2681
Shipbuilding	contains oil	n-Hexane ex.	244	536
Slaughterhouse	contains blood, gut, meet	BOD, SS	488	1072
Total	-	-	12192	26810

TABLE B.3.14 EFFECTIVE TREATMENT PROCESSES BY WATER QUALITY PARAMETERS

Parameters	Treatment Processes
pH	Neutralization
BOD (COD)	Sedimentation, Biological treatment (Activated Sludge process, Tricking filter, Oxidation ditch, Aerated Lagoon)
SS	Sedimentation, Filtration
n-hexane extracts	Oil-water separation(pressurized flotation), Biological treatment
Cd	Precipitation, Coagulation, Ion-exchange
CN	Alkaline oxidation
Pb	Precipitation, Coagulation, Ion-exchange
Cr(hexavalent)	
As	
Hg(total)	Coagulation, Adsorption
Hg(alkyl)	
Se	Precipitation, Coagulation, Ion-exchange
Agricultural chemicals	Adsorption
PCB	-
Number of coliform groups	Sterilization (Chlorination)
Phenols	Adsorption
Cu	Precipitation, Coagulation, Ion-exchange
Zn	
sol-Fe	
sol-Mn	
Cr	
F	Coagulation, Adsorption

TABLE B.3.15 CONSTRUCTION COSTS OF INDUSTRIAL WASTEWATER TREATMENT PLANT (ON SITE)

Treatment Processes	Industry Type	Industrial Wastewater Quantity in 2010 (cu.m/d)	Unit Construction Cost (million CFA/cu.m/d)	Construction Cost in 2010 (million CFA)
Biological Tr. & Sedimentation	Fishing & Canning	3,486	0.44	1,534
	Beer, Beverage, Condensed Milk, others	3,217		1,416
	sub-total	6,703		2,950
Flotation & Biological Tr.	Cooking Oil, Slaughterhouse	4,289	1.22	5,232
Coagulation & Sedimentation	Textile	9,652	0.70	6,756
	Fertilizer	2,681		1,876
	sub-total	12,333		8,632
Flotation	Fuel	2,949	0.96	2,832
	Shipbuilding	536		514
	sub-total	3,485		3,346
Total		26,810	-	20,160

TABLE B.3.16 POPULATION FOR ON-SITE TREATMENT BY HOUSING TYPES AND OIL SOIL TYPES

Housing Types		Soil Types							TOTAL
		I	II	III	III'	IV	V	VI	
1	Village	26,270	16,548	303,055	61,375	0	0	85,044	492,292
2	Spontaneous, irregular	5,557	5,556	293,767	0	0	0	49,502	354,382
3	Spontaneous, regular	8,900	0	423,109	11,736	55,471	0	0	499,216
4	Planned	7,146	0	38,974	442	0	0	3,775	50,337
5	Detached	9,800	3,234	2,946	3,234	0	490	3,071	22,775
6	Flats	23,328	3,234	0	3,234	0	0	0	29,796
TOTAL		81,001	28,572	1,061,851	80,021	55,471	490	141,392	1,448,798

Notes for Soil types:
For distribution, refer to Figure B.3 - 15
II, III and VI are considered not to be suitable for infiltration because of risks of groundwater contamination.
I and V are considered to be suitable for discharging treated wastewater.

TABLE B.3.17 ESTIMATION OF WATER DEMAND FOR IRRIGATION IN THE STUDY AREA

Name of Crop	Total Cultivated area in the Study Area (ha)	Irrigation Rates (m^3/ha/year)	*** Number of months cultivated in a year	Daily rates (m^3/ha)	Irrigation demands by crop (m^3)
Potato	539	2000	6	11.1	5,989
Onion	290	5000	8	20.8	6,042
Cabbage*	561	3000	12	8.3	4,675
Tomato*	390	7200	12	20.0	7,800
Kidney beans	220	**3700	5	24.7	5,427
Pepper*	62	**3700	10	12.3	765
Turnip	117	2400	12	6.7	780
Lettuce*	264	3000	12	8.3	2,200
Jaxatu*	162	**3700	12	10.3	1,665
Aubergine	53	7200	12	20.0	1,060
Carrot	72	**3700	12	10.3	740
Others*	260	**3700	12	10.3	2,672

Note: * : Freshly eatable crop.
** : Average of those for others crops, no data available.
*** : For cultivation schedule, refer to *Figure 5.* .

TABLE B.3.18 SEVERAL POTENTIAL USES OF THE TREATED WATER AND THEIR REQUIRED QUALITY AND NECESSARY TREATMENT PROCESS

Uses	Irrigation			Recreational		Industrial
	Crops not directly to be eaten	Crops eaten after cooking	Crops freshly eaten	Not contact to water	Contact to water	
Required water quality	Free from crude solids and parasites	Less bacteria. free from hazardous chemical materials	Free from bacteria and hazardous materials	Less bacteria	Free from bacteria and irritable chemical materials	Free from bacteria/ virus
Primary treatment	X	X	X	X	X	X
Secondary treatment, including disinfection		X	X	X	X	X
Sand filtration			X		X	X
Nitrification						X
Denitrofication						X
Activated carbon absorption						X
Ion Exchange						X
Sterilization			X	X	X	X

X: Necessary treatment process.

TABLE B.3.19 UNIT CONSTRUCTION COST FOR TRUNK SEWERS

(unit: FCFA/m)

Diameter (mm)	Earth 1.0	Covering 3.0	(m) 6.0
300	117,500	305,500	(888,300)
500	235,000	376,000	(987,000)
800	352,500	423,000	(1,217,300)
1,500	376,000	N.A.	N.A.
2,000	582,800	N.A.	N.A.
2,500	658,000	N.A.	N.A.

Note : Figures in parentheses are driving method

TABLE B.3.20 UNIT CONSTRUCTION COST FOR FORCE MAINS

Diameter (mm)	300	600	800
Unit Cost (FCFA/m)	141,000	323,000	526,000

TABLE B.3.21 COSTS FOR HOUSE CONNECTIONS

WWTP	Sewerage Zone	Cost (million FCFA)
1. Oukam	Dakar	2,616
	Ouakam	976
	Sub-total	3,592
2. Camberene	Dakar	-
	Parcelles Assainies	2,431
	Grand Yoff	3,740
	Hann	5,601
	Pikine Regular	2,689
	Guediawaye	1,122
	Sub-total	15,583
3. Malika	Malika Housing Development	6,155
4. Mbao	Mbao Housing Development	9,527
5. Almadies	Almadies	2,888
6. Lac Warouwaye	Pikine Irregular	13,049

TABLE B.3.22 PROJECT COST FOR SIX SEWERAGE SYSTEMS (1)

(unit:1,000 FCFA)

Item	DAKAR	CAMBERENE	MALIKA	MBAO	ALMADIES	OUAKAM	INDUSTRY	P.IRREGULAR	TOTAL
I. Direct Construction Cost									
1. Sewer Network	2,616,633	21,946,680	6,155,050	9,527,075	2,887,573	976,268	3,052,493	13,049,295	60,211,067
2. Trunk Sewer									
350 (Concrete Pipe)	0	31,921	338,870	0	0	0	0	0	370,791
400 (Concrete Pipe)	0	212,199	0	0	0	0	0	0	212,199
450 (Concrete Pipe)	0	151,011	405,375	0	0	0	0	0	556,386
500 (Concrete Pipe)	0	14,280	0	0	86,950	0	0	0	101,230
600 (Concrete Pipe)	0	767,781	0	1,195,680	601,600	0	0	0	2,565,061
700 (Concrete Pipe)	1,156,200	1,983,834	740,250	888,300	807,930	0	359,550	398,338	6,334,402
800 (Concrete Pipe)	937,650	759,285	0	0	1,255,135	0	1,205,550	517,953	4,675,573
900 (Concrete Pipe)	222,075	1,805,439	0	0	65,800	0	2,867,000	587,872	5,548,186
1000 (Concrete Pipe)	0	0	0	1,579,200	0	0	0	204,674	1,783,874
1100 (Concrete Pipe)	0	423,000	0	0	0	0	0	815,424	1,238,424
1200 (Concrete Pipe)	0	1,217,394	0	0	0	0	0	109,388	1,326,782
1350 (Concrete Pipe)	0	1,128,444	0	0	0	0	0	207,612	1,336,056
1500 (Concrete Pipe)	0	1,180,875	0	0	0	0	0	1,349,020	2,529,895
1650 (Concrete Pipe)	0	5,981,690	0	0	0	0	0	0	5,981,690
sub-total	2,315,925	15,657,153	1,484,495	3,663,180	2,817,415	0	4,432,100	4,190,281	34,560,549
3. Force Main									
150 (Ductile Iron Pipe)	0	18,490	0	0	0	0	0	0	18,490
200 (Ductile Iron Pipe)	0	197,680	0	0	0	0	0	0	197,680
250 (Ductile Iron Pipe)	0	167,500	0	0	0	0	0	0	167,500
300 (Ductile Iron Pipe)	0	0	0	0	95,880	0	0	0	95,880
350 (Ductile Iron Pipe)	0	418,881	0	0	0	0	0	0	418,881
500 (Ductile Iron Pipe)	0	0	0	0	0	0	0	10,415	10,415
600 (Ductile Iron Pipe)	0	0	0	0	0	0	0	54,702	54,702
700 (Ductile Iron Pipe)	0	0	458,250	0	0	0	0	241,279	699,529
800 (Ductile Iron Pipe)	534,747	0	0	0	0	0	0	0	534,747
900 (Ductile Iron Pipe)	0	618,499	0	0	0	0	0	0	618,499
1000 (Ductile Iron Pipe)	2,083,040	0	0	0	0	0	0	0	2,083,040
1350 (Ductile Iron Pipe)	0	803,100	0	0	0	0	0	0	803,100
sub-total	2,617,787	2,224,150	458,250	0	95,880	0	0	306,396	5,702,463
4.Pumping Station									
No.1	4,698,750	1,566,250	2,506,000	0	1,096,375	0	0	563,850	10,431,225
N0.2	2,819,250	2,192,750	0	0	0	0	0	2,819,250	7,831,250
No.3	1,566,250	3,132,500	0	0	0	0	0	3,759,000	8,457,750
No.4	783,125	1,879,500	0	0	0	0	0	2,192,750	4,855,375
No.5	0	256,700	0	0	0	0	0	0	256,700
No.6	0	53,900	0	0	0	0	0	0	53,900
No.7	0	53,900	0	0	0	0	0	0	53,900
Replacement	0	130,999	0	0	0	0	0	0	130,999
sub-total	9,867,375	9,266,499	2,506,000	0	1,096,375	0	0	9,334,850	32,071,099

TABLE B.3.22 PROJECT COST FOR SIX SEWERAGE SYSTEMS (2)

(unit:1,000 FCFA)

Item	DAKAR	CAMBERENE	MALIKA	MBAO	ALMADIES	OUAKAM	INDUSTRY	P.IRREGULAR	TOTAL
5.Treatment Plant	0	26,414,080	9,592,000	15,822,400	6,100,160	38,127,443	10,776,232	15,030,400	121,862,715
6. Ocean Outfall		709,060							709,060
total	17,417,720	76,217,622	20,195,795	29,012,655	12,997,403	39,103,711	18,260,825	41,911,222	255,116,953
II. Land Acquisition and Compensation									
Pumping Station	4,500	5,450	0	0	0	0	0	0	9,950
Treatment Plant	0	820,000	54,000	51,000	16,000	100,000	51,500	60,000	1,152,500
sub-total	4,500	825,450	54,000	51,000	16,000	100,000	51,500	60,000	1,162,450
III. Engineering Service	1,741,772	7,621,762	2,019,580	2,901,266	1,299,740	3,910,371	1,826,083	4,191,122	25,511,695
IV. Government Administration	261,266	1,143,264	302,937	435,190	194,961	586,556	273,912	628,668	3,826,754
V. Physical Contingency	1,741,772	7,621,762	2,019,580	2,901,266	1,299,740	3,910,371	1,826,083	4,191,122	25,511,695
VI. Project Cost	21,167,030	93,429,861	24,591,891	35,301,376	15,807,845	47,611,009	22,238,402	50,982,135	311,129,548

TABLE 5.15 PROJECT COST UP TO 2010

(Unit: 1,000 FCFA)

Cost Item		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL
I. Direct Construction Cost	L/C	77,295	77,295	392,043	326,769	912,263	1,108,498	1,572,211	1,992,675	1,858,659	3,038,942	2,241,568	1,388,053	393,268	160,136	676,999	676,999	16,893,673
	F/C	180,354	180,354	2,060,861	2,231,776	3,841,680	4,809,944	6,076,924	8,459,560	7,700,133	7,694,018	6,616,602	4,570,960	3,110,516	2,742,143	3,165,029	3,165,029	66,605,883
	Total	257,649	257,649	2,452,904	2,558,545	4,753,943	5,918,442	7,649,135	10,452,235	9,558,792	10,732,960	8,858,170	5,959,013	3,503,784	2,902,279	3,842,028	3,842,028	83,499,556
II. Land Acquisition and Compensation		0	0	250	50	0	550	820,700	0	1,600	1,000	800	0	0	1,700	0	0	826,650
III. Engineering Service	L/C	69,464	69,464	116,674	116,674	155,355	186,633	242,249	242,249	242,248	211,040	195,039	156,358	147,078	147,078	103,692	103,692	2,504,987
	F/C	162,084	162,084	272,239	272,239	362,496	435,478	565,247	565,247	565,246	492,426	455,090	364,834	343,181	343,181	241,948	241,948	5,844,968
	Total	231,548	231,548	388,913	388,913	517,851	622,111	807,496	807,496	807,494	703,466	650,129	521,192	490,259	490,259	345,640	345,640	8,349,955
IV. Government Administation		3,865	3,865	36,794	38,378	71,310	88,777	114,737	156,784	143,383	160,995	132,873	89,385	52,557	43,534	57,630	57,630	1,252,497
V. Physical Contingency		25,765	25,765	245,290	255,855	475,394	591,844	764,914	1,045,224	955,880	1,073,297	885,817	595,901	350,378	290,227	384,202	384,202	8,349,955
VI.Project Cost	L/C	176,389	176,389	791,051	737,726	1,614,322	1,976,302	3,514,811	3,436,932	3,201,770	4,485,274	3,456,097	2,229,697	943,281	642,675	1,222,523	1,222,523	29,827,762
	F/C	342,438	342,438	2,333,100	2,504,015	4,204,176	5,245,422	6,642,171	9,024,807	8,265,379	8,186,444	7,071,692	4,935,794	3,453,697	3,085,324	3,406,977	3,406,977	72,450,851
	Total	518,827	518,827	3,124,151	3,241,741	5,818,498	7,221,724	10,156,982	12,461,739	11,467,149	12,671,718	10,527,789	7,165,491	4,396,978	3,727,999	4,629,500	4,629,500	102,278,613

TABLE B.3.24 ANNUAL OPERATION AND MAINTENANCE COST

Item	Quantity	Unit Cost (FCFA)	Cost (million FCFA/Year)
1. Sewer Pipes	13 persons	2,160,000/person	28
2. Pumping Stations			
Electricity	33,400,000 m3	4.66/m3	156
Repairing	Construction Cost x 0.5 %		46
Personnel	12 persons	2,160,000 /person	26
Sub-total			228
3. Treatment Plant			
Electricity	36,500,000 m3	22/m3	803
Chemicals	36,500,000 m3	1.5/m3	55
Repairing	Construction Cost x 0.5%		132
Personnel	50 persons	2,160,000/person	108
Sub-total			1,098
4. Overheads	75 persons	2,160,000/person	162
Total			1,516

TABLE B.3.25 WILLINGNESS TO PAY FOR SEWERAGE SERVICE

1. Households

Type of Housing	Willingness to Pay (%)	Monthly Water Charge (FCFA)	Willingness to Pay (FCFA)
Village	32.2	1,083	349
Spontaneous, irregular	21.5	1,454	313
Spontaneous, regular	44.7	2,781	1,243
Planned	18.4	6,518	1,199
Detached (large) houses	8.1	19,221	1,557
Flats	9.9	11,142	1,103
Average	24.7	3,632	896

Note: 1. Willingness to pay (%): The amount households are willing to pay for sewerage service as percentage of water supply charge

2. Monthly water charge (FCFA): Monthly water supply charge per household

3. Willingness to pay (FCFA): The amount a household is willing to pay for sewerage service per month

2. Commerce/Institutions/Industry

Type of Beneficiaries	Willingness to Pay (%)
Big Commerce	9.1
Small Commerce	24.5
Institutions	27.9
Industries	15.4
Average	18.7

Note: Willingness to pay (%): The amount beneficiaries are willing to pay for sewerage service as percentage of water supply charge

Source: Results of the questionnaire survey conducted by JICA

TABLE B.3.26 WILLINGNESS TO PAY FOR SEWERAGE SERVICE AS PERCENTAGE OF HOUSEHOLD INCOME

Type of Housing	Willingness to Pay (FCFA)	Monthly Income (FCFA)	Willingness to Pay (%)
Village	349	43,344	0.8
Spontaneous, irregular	313	45,466	0.7
Spontaneous, regular	1,243	69,350	1.8
Planned	1,199	92,388	1.3
Detached (large) houses	1,557	236,667	0.7
Flats	1,103	133,340	0.8
Average	896	70,865	1.3

Note: 1. Willingness to pay (FCFA): The amount a household is willing to pay for sewerage service per month

2. Monthly income (FCFA): Monthly income per household

3. Willingness to pay (%): The amount households are willing to pay for sewerage service as percentage of income

Source: Results of the questionnaire survey conducted by JICA

TABLE B.3.27 REVENUE FROM SEWERAGE CHARGE IN CASE OF PROJECT IMPLEMENTATION

(Unit: thousand m3, FCFA million)

Year	Wastewater Generation	Sewerage Revenue
1995	31,650	460
1996	31,650	460
1997	31,650	460
1998	40,087	583
1999	51,899	755
2000	67,086	976
2001	71,561	2,560
2002	76,037	2,720
2003	80,512	2,880
2004	84,987	3,040
2005	89,462	3,201
2006	93,938	3,361
2007	98,413	3,521
2008	102,888	3,681
2009	107,364	3,841
2010	111,839	4,001
2011	111,839	8,002
2012	111,839	8,002
2013	111,839	8,002
2014	111,839	8,002
2015	111,839	8,002

Note: 1. <Wastewater generation> concerns the clients other than farmers and big industrialists.

2. Average sewerage charge is assumed as 39.75 FCFA/m3 from 2001 to 2010 and 79.50 FCFA/m3 from 2011 onward.

3. Charge collection rate is assumed as 90%.

4. The sewerage revenue is at 1993 prices.

Source: JICA

TABLE B.3.28 FINANCIAL STATEMENT (1)

(Unit: FCFA million)

No.	1	2	3	4	5	6	7	8	9	10
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Statement										
Revenue	611	623	635	900	1,279	1,777	3,836	4,190	4,556	4,935
Operation and Maintenance	425	532	644	759	879	1,003	1,372	1,510	1,653	1,802
Depreciation	0	0	51	103	192	302	462	671	869	1,119
Payment of Interest	0	0	0	0	0	24	47	194	344	620
Expenditure	425	532	695	862	1,071	1,329	1,880	2,374	2,867	3,541
Profit before Tax	185	90	-59	39	208	448	1,956	1,815	1,689	1,393
Tax	56	27	0	12	62	134	587	545	507	418
Profit after Tax	130	63	-59	27	145	314	1,369	1,271	1,182	975
Funds Statement										
Profit after Tax	130	63	-59	27	145	314	1,369	1,271	1,182	975
Loans	370	378	2,321	2,456	4,497	5,693	8,167	10,221	9,593	10,813
Subsidies	159	162	995	1,053	1,927	2,440	3,500	4,380	4,111	4,634
Depreciation	0	0	51	103	192	302	462	671	869	1,119
Sources	659	603	3,307	3,639	6,761	8,748	13,498	16,542	15,755	17,541
Capital Works	529	540	3,315	3,509	6,424	8,133	11,667	14,601	13,704	15,447
Payment of Principal	0	0	0	0	0	14	30	121	221	406
Working Capital	130	63	-8	130	337	601	1,801	1,821	1,830	1,688
Applications	659	603	3,307	3,639	6,761	8,748	13,498	16,542	15,755	17,541
Loan Liabilities	389	805	3,282	6,025	11,048	17,540	26,916	38,679	50,120	62,953
Cash Balance	390	453	444	574	911	1,513	3,314	5,134	6,964	8,652

Source: JICA

TABLE B.3.28 FINANCIAL STATEMENT (2)

(Unit: FCFA million)

No.	11	12	13	14	15	16	17	18	19	20
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Income Statement										
Revenue	5,327	5,733	6,153	6,588	7,038	7,503	14,030	14,310	14,597	14,889
Operation and Maintenance	1,956	2,115	2,280	2,451	2,627	2,810	3,291	3,356	3,424	3,492
Depreciation	1,330	1,486	1,581	1,667	1,785	1,905	1,905	1,905	1,905	1,962
Payment of Interest	963	1,452	2,055	2,595	3,191	3,656	3,919	4,010	4,051	4,136
Expenditure	4,249	5,054	5,916	6,713	7,603	8,370	9,114	9,271	9,380	9,589
Profit before Tax	1,078	679	237	-125	-565	-868	4,916	5,039	5,217	5,299
Tax	323	204	71	0	0	0	1,475	1,512	1,565	1,590
Profit after Tax	754	476	166	-125	-565	-868	3,441	3,527	3,652	3,710
Funds Statement										
Profit after Tax	754	476	166	-125	-565	-868	3,441	3,527	3,652	3,710
Loans	9,163	6,361	3,982	3,443	4,361	4,449	0	0	0	0
Subsidies	3,927	2,726	1,706	1,476	1,869	1,907	0	0	0	0
Depreciation	1,330	1,486	1,581	1,667	1,785	1,905	1,905	1,905	1,905	1,962
Sources	15,175	11,050	7,435	6,461	7,450	7,392	5,346	5,432	5,557	5,671
Capital Works	13,090	9,088	5,688	4,919	6,231	6,355	0	602	526	650
Payment of Principal	646	994	1,438	1,880	2,391	2,865	3,253	3,570	3,881	4,244
Working Capital	1,438	968	310	-338	-1,172	-1,828	2,092	1,260	1,150	778
Applications	15,175	11,050	7,435	6,461	7,450	7,392	5,346	5,432	5,557	5,671
Loan Liabilities	74,112	82,052	86,842	90,325	93,838	96,681	94,343	91,480	88,121	84,148
Cash Balance	10,091	11,059	11,369	11,031	9,859	8,031	10,124	11,384	12,533	13,311

Source: JICA

TABLE B.3.28 FINANCIAL STATEMENT (3)

(Unit: FCFA million)

No.	21	22	23	24	25	26	27	28	29	30
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Income Statement										
Revenue	15,186	15,490	15,800	16,116	16,438	16,767	17,102	17,444	17,793	18,149
Operation and Maintenance	3,562	3,633	3,706	3,780	3,855	3,933	4,011	4,091	4,173	4,257
Depreciation	1,984	2,032	2,082	2,132	2,220	2,296	2,362	2,403	2,446	2,505
Payment of Interest	4,207	3,976	3,733	3,478	3,210	2,929	2,636	2,329	2,020	1,707
Expenditure	9,753	9,641	9,520	9,390	9,286	9,157	9,009	8,824	8,639	8,469
Profit before Tax	5,434	5,849	6,280	6,726	7,152	7,610	8,094	8,620	9,154	9,680
Tax	1,630	1,755	1,884	2,018	2,146	2,283	2,428	2,586	2,746	2,904
Profit after Tax	3,803	4,094	4,396	4,708	5,006	5,327	5,666	6,034	6,408	6,776
Funds Statement										
Profit after Tax	3,803	4,094	4,396	4,708	5,006	5,327	5,666	6,034	6,408	6,776
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	1,984	2,032	2,082	2,132	2,220	2,296	2,362	2,403	2,446	2,505
Sources	5,787	6,126	6,477	6,840	7,227	7,622	8,027	8,437	8,854	9,281
Capital Works	687	1,516	1,546	1,577	2,765	2,349	2,075	1,298	1,324	1,861
Payment of Principal	4,627	4,859	5,102	5,357	5,625	5,868	6,123	6,191	6,249	6,101
Working Capital	472	-248	-171	-94	-1,163	-594	-170	948	1,281	1,319
Applications	5,787	6,126	6,477	6,840	7,227	7,622	8,027	8,437	8,854	9,281
Loan Liabilities	79,520	74,662	69,560	64,203	58,578	52,710	46,587	40,396	34,147	28,046
Cash Balance	13,783	13,534	13,364	13,270	12,107	11,513	11,343	12,291	13,572	14,890

Source: JICA

TABLE B.3.29 COST BENEFIT STREAMS

Unit : FCFA Million

No.	Year	Capital Costs (a)	O/M Costs (b)	Costs (c= a + b)	Benefits (d)	Cash flow (d-c)
1	1995	363	417	780	599	-181
2	1996	363	512	875	599	-276
3	1997	2,187	607	2,794	599	-2,195
4	1998	2,269	701	2,970	832	-2,138
5	1999	4,073	796	4,869	1,158	-3,711
6	2000	5,055	891	5,946	1,578	-4,368
7	2001	7,110	1,194	8,304	3,340	-4,964
8	2002	8,723	1,289	10,012	3,576	-6,436
9	2003	8,027	1,384	9,411	3,812	-5,599
10	2004	8,870	1,478	10,348	4,048	-6,300
11	2005	7,369	1,573	8,942	4,284	-4,658
12	2006	5,016	1,668	6,684	4,520	-2,164
13	2007	3,078	1,763	4,841	4,757	-84
14	2008	2,610	1,857	4,467	4,993	526
15	2009	3,241	1,952	5,193	5,229	36
16	2010	3,241	2,047	5,288	5,465	177
17	2011	0	2,350	2,350	10,020	7,670
18	2012	422	2,350	2,772	10,020	7,248
19	2013	361	2,350	2,711	10,020	7,309
20	2014	437	2,350	2,787	10,020	7,233
21	2015	454	2,350	2,804	10,020	7,216
22	2016	981	2,350	3,331	10,020	6,689
23	2017	981	2,350	3,331	10,020	6,689
24	2018	981	2,350	3,331	10,020	6,689
25	2019	1,685	2,350	4,035	10,020	5,985
26	2020	1,403	2,350	3,753	10,020	6,267
27	2021	1,215	2,350	3,565	10,020	6,455
28	2022	746	2,350	3,096	10,020	6,924
29	2023	746	2,350	3,096	10,020	6,924
30	2024	1,028	2,350	3,378	10,020	6,642
31	2025	1,028	2,350	3,378	10,020	6,642
32	2026	1,028	2,350	3,378	10,020	6,642
33	2027	422	2,350	2,772	10,020	7,248
34	2028	361	2,350	2,711	10,020	7,309
35	2029	437	2,350	2,787	10,020	7,233
36	2030	454	2,350	2,804	10,020	7,216
37	2031	981	2,350	3,331	10,020	6,689
38	2032	981	2,350	3,331	10,020	6,689
39	2033	981	2,350	3,331	10,020	6,689
40	2034	1,685	2,350	4,035	10,020	5,985

TABLE B.3.30 FINANCIAL STATEMENT, ALTERNATIVE I (1)

(Unit: FCFA million)

No.	1	2	3	4	5	6	7	8	9	10
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Statement										
Revenue	611	623	635	900	1,279	1,777	4,476	4,888	5,315	5,757
Operation and Maintenance	425	532	644	759	879	1,003	1,372	1,510	1,653	1,802
Depreciation	0	0	73	147	274	431	660	958	1,241	1,599
Payment of Interest	0	0	0	0	0	34	67	277	492	886
Expenditure	425	532	717	906	1,153	1,468	2,098	2,745	3,387	4,287
Profit before Tax	185	90	-81	-5	126	308	2,377	2,143	1,928	1,470
Tax	56	27	0	0	38	93	713	643	579	441
Profit after Tax	130	63	-81	-5	88	216	1,664	1,500	1,350	1,029
Funds Statement										
Profit after Tax	130	63	-81	-5	88	216	1,664	1,500	1,350	1,029
Loans	529	540	3,315	3,509	6,424	8,133	11,667	14,601	13,704	15,447
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	0	0	73	147	274	431	660	958	1,241	1,599
Sources	659	603	3,307	3,650	6,786	8,780	13,991	17,059	16,295	18,075
Capital Works	529	540	3,315	3,509	6,424	8,133	11,667	14,601	13,704	15,447
Payment of Principal	0	0	0	0	0	20	42	172	316	580
Working Capital	130	63	-8	141	362	627	2,281	2,286	2,275	2,048
Applications	659	603	3,307	3,650	6,786	8,780	13,991	17,059	16,295	18,075
Loan Liabilities	556	1,150	4,689	8,608	15,783	25,058	38,452	55,256	71,600	89,933
Cash Balance	390	453	444	586	948	1,574	3,856	6,142	8,416	10,464

Source: JICA

TABLE B.3.30 FINANCIAL STATEMENT, ALTERNATIVE I (2)

(Unit: FCFA million)

No.	11	12	13	14	15	16	17	18	19	20
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Income Statement										
Revenue	6,215	6,689	7,179	7,686	8,211	8,753	17,856	18,213	18,577	18,949
Operation and Maintenance	1,956	2,115	2,280	2,451	2,627	2,810	3,291	3,356	3,424	3,492
Depreciation	1,900	2,124	2,259	2,382	2,550	2,721	2,721	2,721	2,721	2,751
Payment of Interest	1,376	2,074	2,935	3,707	4,558	5,223	5,598	5,729	5,788	5,908
Expenditure	5,232	6,313	7,474	8,539	9,735	10,754	11,610	11,806	11,932	12,152
Profit before Tax	983	376	-296	-853	-1,525	-2,001	6,246	6,407	6,645	6,797
Tax	295	113	0	0	0	0	1,874	1,922	1,994	2,039
Profit after Tax	688	263	-296	-853	-1,525	-2,001	4,372	4,485	4,652	4,758
Funds Statement										
Profit after Tax	688	263	-296	-853	-1,525	-2,001	4,372	4,485	4,652	4,758
Loans	13,090	9,088	5,688	4,919	6,231	6,355	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	1,900	2,124	2,259	2,382	2,550	2,721	2,721	2,721	2,721	2,751
Sources	15,678	11,474	7,652	6,447	7,256	7,076	7,093	7,206	7,373	7,510
Capital Works	13,090	9,088	5,688	4,919	6,231	6,355	0	602	526	650
Payment of Principal	923	1,420	2,054	2,686	3,416	4,092	4,648	5,100	5,545	6,062
Working Capital	1,665	967	-91	-1,157	-2,391	-3,372	2,446	1,504	1,302	797
Applications	15,678	11,474	7,652	6,447	7,256	7,076	7,093	7,206	7,373	7,510
Loan Liabilities	105,875	117,217	124,060	129,036	134,055	138,115	134,775	130,685	125,887	120,211
Cash Balance	12,129	13,096	13,005	11,848	9,457	6,084	8,530	10,034	11,336	12,134

Source: JICA

TABLE B.3.30 FINANCIAL STATEMENT, ALTERNATIVE I (3)

(Unit: FCFA million)

No.	21	22	23	24	25	26	27	28	29	30
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Income Statement										
Revenue	19,328	19,715	20,109	20,511	20,921	21,340	21,766	22,202	22,646	23,099
Operation and Maintenance	3,562	3,633	3,706	3,780	3,855	3,933	4,011	4,091	4,173	4,257
Depreciation	2,763	2,789	2,816	2,843	2,890	2,930	2,966	2,988	3,011	3,043
Payment of Interest	6,011	5,680	5,333	4,969	4,586	4,184	3,765	3,328	2,885	2,439
Expenditure	12,336	12,102	11,854	11,591	11,331	11,047	10,742	10,407	10,069	9,738
Profit before Tax	6,992	7,612	8,254	8,920	9,590	10,293	11,024	11,795	12,576	13,360
Tax	2,098	2,284	2,476	2,676	2,877	3,088	3,307	3,538	3,773	4,008
Profit after Tax	4,895	5,329	5,778	6,244	6,713	7,205	7,717	8,256	8,803	9,352
Funds Statement										
Profit after Tax	4,895	5,329	5,778	6,244	6,713	7,205	7,717	8,256	8,803	9,352
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	2,763	2,789	2,816	2,843	2,890	2,930	2,966	2,988	3,011	3,043
Sources	7,658	8,118	8,594	9,087	9,603	10,135	10,683	11,244	11,814	12,395
Capital Works	687	1,516	1,546	1,577	2,765	2,349	2,075	1,298	1,324	1,861
Payment of Principal	6,611	6,941	7,288	7,653	8,035	8,383	8,747	8,845	8,927	8,716
Working Capital	360	-339	-241	-143	-1,197	-596	-139	1,102	1,563	1,818
Applications	7,658	8,118	8,594	9,087	9,603	10,135	10,683	11,244	11,814	12,395
Loan Liabilities	113,601	106,659	99,371	91,718	83,683	75,300	66,553	57,709	48,781	40,065
Cash Balance	12,494	12,154	11,913	11,770	10,573	9,977	9,838	10,940	12,503	14,320

Source: JICA

TABLE B.3.31 COST BENEFIT STREAMS, ALTERNATIVE I

Unit : FCFA Million

No.	Year	Capital Costs (a)	O/M Costs (b)	Costs (c= a + b)	Benefits (d)	Cash flow (d-c)
1	1995	519	417	936	599	-337
2	1996	519	512	1,031	599	-432
3	1997	3,124	607	3,731	599	-3,132
4	1998	3,242	701	3,943	832	-3,111
5	1999	5,819	796	6,615	1,158	-5,457
6	2000	7,222	891	8,113	1,578	-6,535
7	2001	10,157	1,194	11,351	3,896	-7,455
8	2002	12,462	1,289	13,751	4,172	-9,579
9	2003	11,467	1,384	12,851	4,447	-8,404
10	2004	12,672	1,478	14,150	4,723	-9,427
11	2005	10,528	1,573	12,101	4,998	-7,103
12	2006	7,166	1,668	8,834	5,274	-3,560
13	2007	4,397	1,763	6,160	5,549	-611
14	2008	3,728	1,857	5,585	5,825	240
15	2009	4,630	1,952	6,582	6,101	-481
16	2010	4,630	2,047	6,677	6,376	-301
17	2011	0	2,350	2,350	12,752	10,402
18	2012	422	2,350	2,772	12,752	9,980
19	2013	361	2,350	2,711	12,752	10,041
20	2014	437	2,350	2,787	12,752	9,965
21	2015	454	2,350	2,804	12,752	9,948
22	2016	981	2,350	3,331	12,752	9,421
23	2017	981	2,350	3,331	12,752	9,421
24	2018	981	2,350	3,331	12,752	9,421
25	2019	1,685	2,350	4,035	12,752	8,717
26	2020	1,403	2,350	3,753	12,752	8,999
27	2021	1,215	2,350	3,565	12,752	9,187
28	2022	746	2,350	3,096	12,752	9,656
29	2023	746	2,350	3,096	12,752	9,656
30	2024	1,028	2,350	3,378	12,752	9,374
31	2025	1,028	2,350	3,378	12,752	9,374
32	2026	1,028	2,350	3,378	12,752	9,374
33	2027	422	2,350	2,772	12,752	9,980
34	2028	361	2,350	2,711	12,752	10,041
35	2029	437	2,350	2,787	12,752	9,965
36	2030	454	2,350	2,804	12,752	9,948
37	2031	981	2,350	3,331	12,752	9,421
38	2032	981	2,350	3,331	12,752	9,421
39	2033	981	2,350	3,331	12,752	9,421
40	2034	1,685	2,350	4,035	12,752	8,717

TABLE B.3.32 FINANCIAL STATEMENT, ALTERNATIVE II (1)

(Unit: FCFA million)

No.	1	2	3	4	5	6	7	8	9	10
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Statement										
Revenue	611	623	635	900	1,279	1,777	2,238	2,444	2,657	2,879
Operation and Maintenance	425	532	644	759	879	1,003	1,372	1,510	1,653	1,802
Depreciation	0	0	0	0	0	0	0	0	0	0
Payment of Interest	0	0	0	0	0	0	0	0	0	0
Expenditure	425	532	644	759	879	1,003	1,372	1,510	1,653	1,802
Profit before Tax	185	90	-8	141	400	773	866	934	1,004	1,077
Tax	56	27	0	42	120	232	260	280	301	323
Profit after Tax	130	63	-8	99	280	541	606	654	703	754
Funds Statement										
Profit after Tax	130	63	-8	99	280	541	606	654	703	754
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	529	540	3,315	3,509	6,424	8,133	11,667	14,601	13,704	15,447
Depreciation	0	0	0	0	0	0	0	0	0	0
Sources	659	603	3,307	3,608	6,704	8,674	12,274	15,255	14,407	16,200
Capital Works	529	540	3,315	3,509	6,424	8,133	11,667	14,601	13,704	15,447
Payment of Principal	0	0	0	0	0	0	0	0	0	0
Working Capital	130	63	-8	99	280	541	606	654	703	754
Applications	659	603	3,307	3,608	6,704	8,674	12,274	15,255	14,407	16,200
Loan Liabilities	0	0	0	0	0	0	0	0	0	0
Cash Balance	390	453	444	543	823	1,364	1,971	2,625	3,327	4,081

Source: JICA

TABLE B.3.32 FINANCIAL STATEMENT, ALTERNATIVE II (2)

(Unit: FCFA million)

No.	11	12	13	14	15	16	17	18	19	20
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Income Statement										
Revenue	3,107	3,344	3,589	3,843	4,105	4,376	5,102	5,204	5,308	5,414
Operation and Maintenance	1,956	2,115	2,280	2,451	2,627	2,810	3,291	3,356	3,424	3,492
Depreciation	0	0	0	0	0	0	0	0	0	119
Payment of Interest	0	0	0	0	0	0	0	0	0	0
Expenditure	1,956	2,115	2,280	2,451	2,627	2,810	3,291	3,356	3,424	3,611
Profit before Tax	1,152	1,229	1,309	1,392	1,478	1,567	1,811	1,847	1,884	1,803
Tax	345	369	393	418	443	470	543	554	565	541
Profit after Tax	806	860	917	975	1,035	1,097	1,268	1,293	1,319	1,262
Funds Statement										
Profit after Tax	806	860	917	975	1,035	1,097	1,268	1,293	1,319	1,262
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	13,090	9,088	5,688	4,919	6,231	6,355	0	0	0	0
Depreciation	0	0	0	0	0	0	0	0	0	119
Sources	13,896	9,948	6,605	5,894	7,265	7,452	1,268	1,293	1,319	1,381
Capital Works	13,090	9,088	5,688	4,919	6,231	6,355	0	602	526	650
Payment of Principal	0	0	0	0	0	0	0	0	0	0
Working Capital	806	860	917	975	1,035	1,097	1,268	691	793	731
Applications	13,896	9,948	6,605	5,894	7,265	7,452	1,268	1,293	1,319	1,381
Loan Liabilities	0	0	0	0	0	0	0	0	0	0
Cash Balance	4,887	5,748	6,664	7,639	8,674	9,770	11,038	11,729	12,522	13,253

Source: JICA

TABLE B.3.32 FINANCIAL STATEMENT, ALTERNATIVE II (3)

(Unit: FCFA million)

No.	21	22	23	24	25	26	27	28	29	30
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Income Statement										
Revenue	5,522	5,633	5,745	5,860	5,977	6,097	6,219	6,343	6,470	6,600
Operation and Maintenance	3,562	3,633	3,706	3,780	3,855	3,933	4,011	4,091	4,173	4,257
Depreciation	164	265	369	474	658	815	953	1,039	1,128	1,252
Payment of Interest	0	0	0	0	0	0	0	0	0	0
Expenditure	3,726	3,898	4,074	4,253	4,513	4,747	4,964	5,131	5,301	5,508
Profit before Tax	1,796	1,734	1,671	1,607	1,464	1,350	1,255	1,213	1,169	1,091
Tax	539	520	501	482	439	405	376	364	351	327
Profit after Tax	1,257	1,214	1,170	1,125	1,025	945	878	849	819	764
Funds Statement										
Profit after Tax	1,257	1,214	1,170	1,125	1,025	945	878	849	819	764
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	164	265	369	474	658	815	953	1,039	1,128	1,252
Sources	1,422	1,479	1,538	1,598	1,683	1,760	1,831	1,888	1,946	2,016
Capital Works	687	1,516	1,546	1,577	2,765	2,349	2,075	1,298	1,324	1,861
Payment of Principal	0	0	0	0	0	0	0	0	0	0
Working Capital	734	-36	-8	21	-1,082	-589	-243	590	622	154
Applications	1,422	1,479	1,538	1,598	1,683	1,760	1,831	1,888	1,946	2,016
Loan Liabilities	0	0	0	0	0	0	0	0	0	0
Cash Balance	13,988	13,951	13,943	13,964	12,882	12,293	12,050	12,640	13,262	13,417

Source: JICA

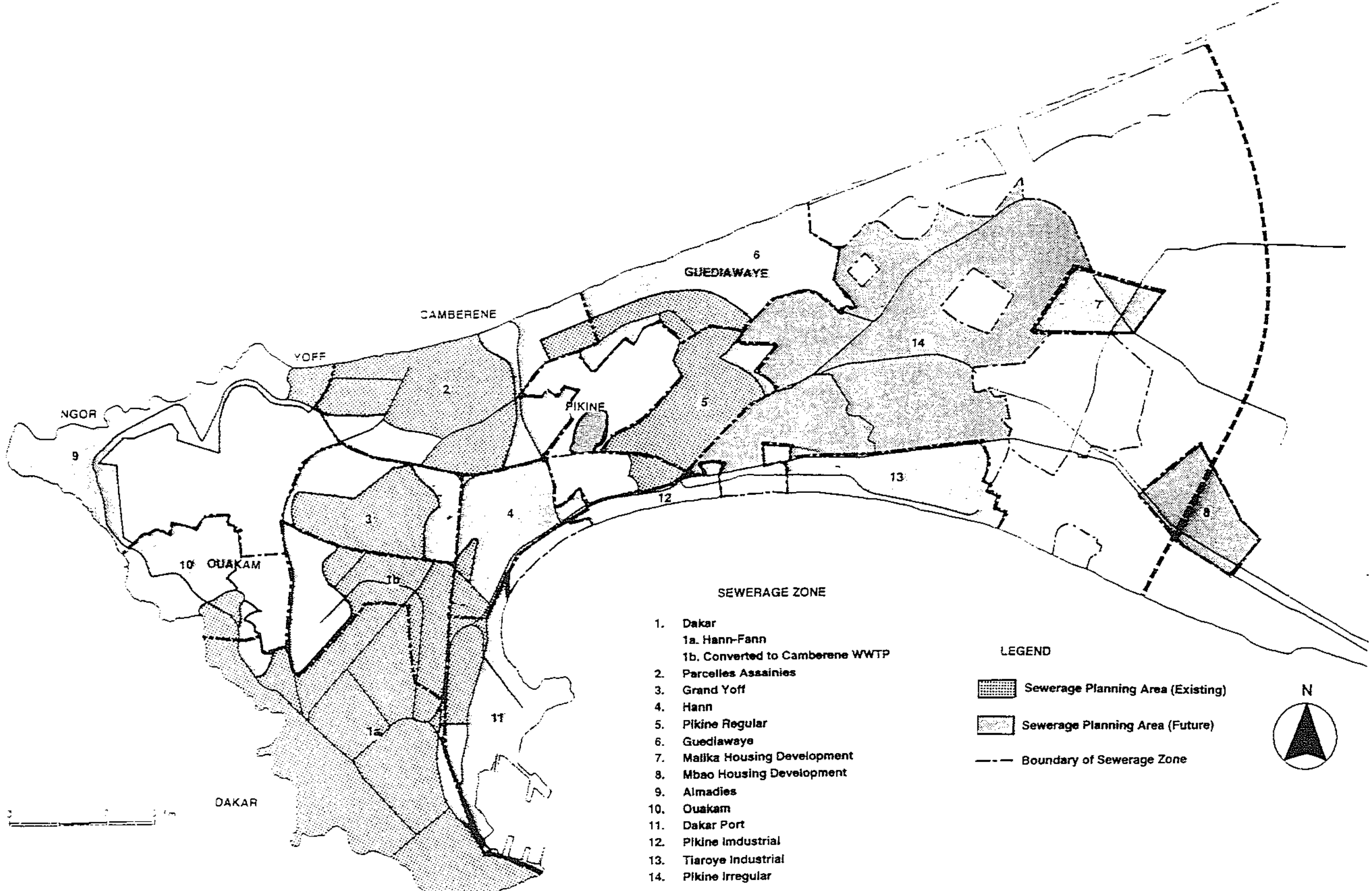


FIGURE B.3.1 SEWERAGE ZONES

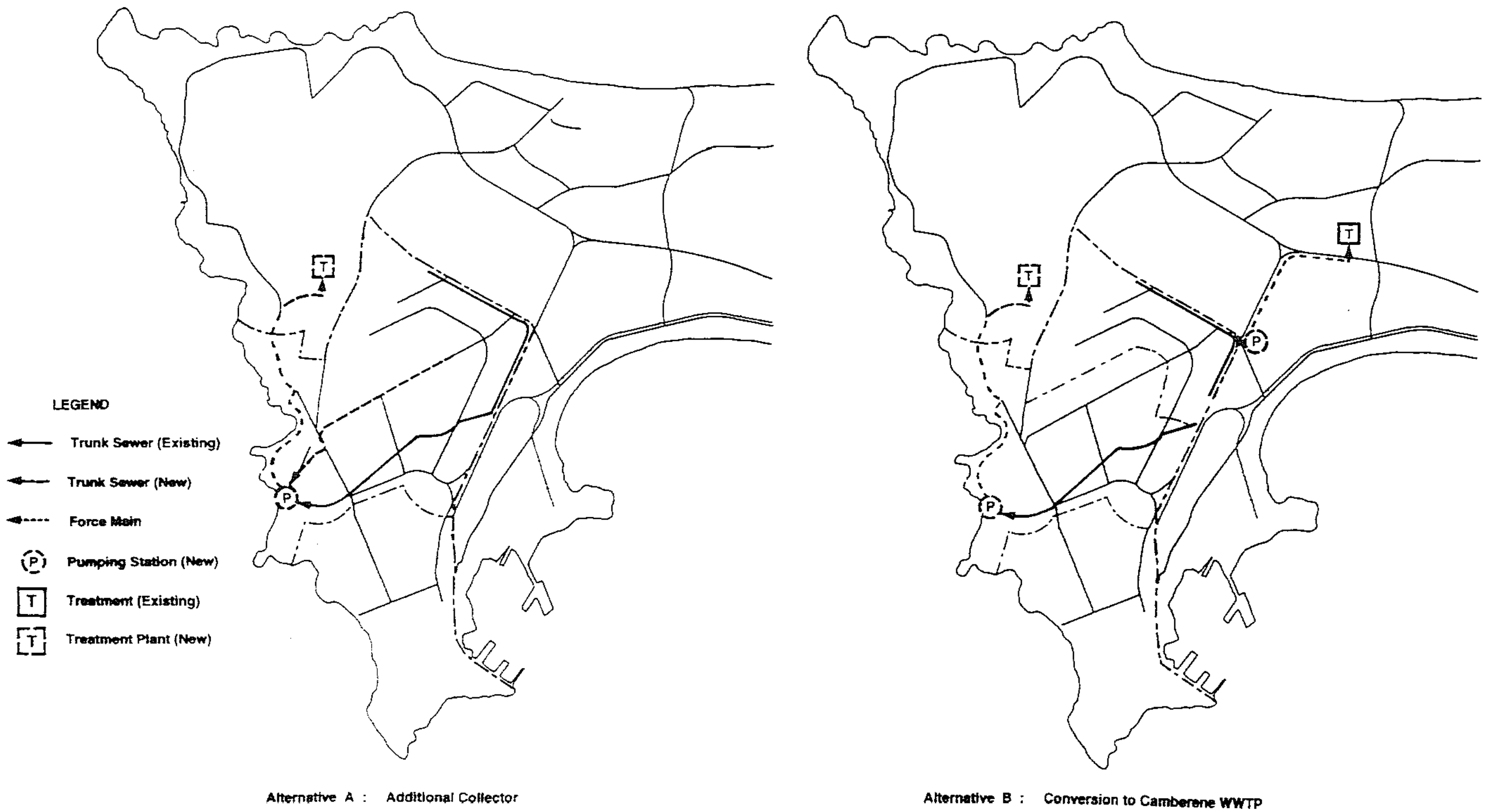


FIGURE B.3.2 ALTERNATIVES FOR DAKAR ZONE

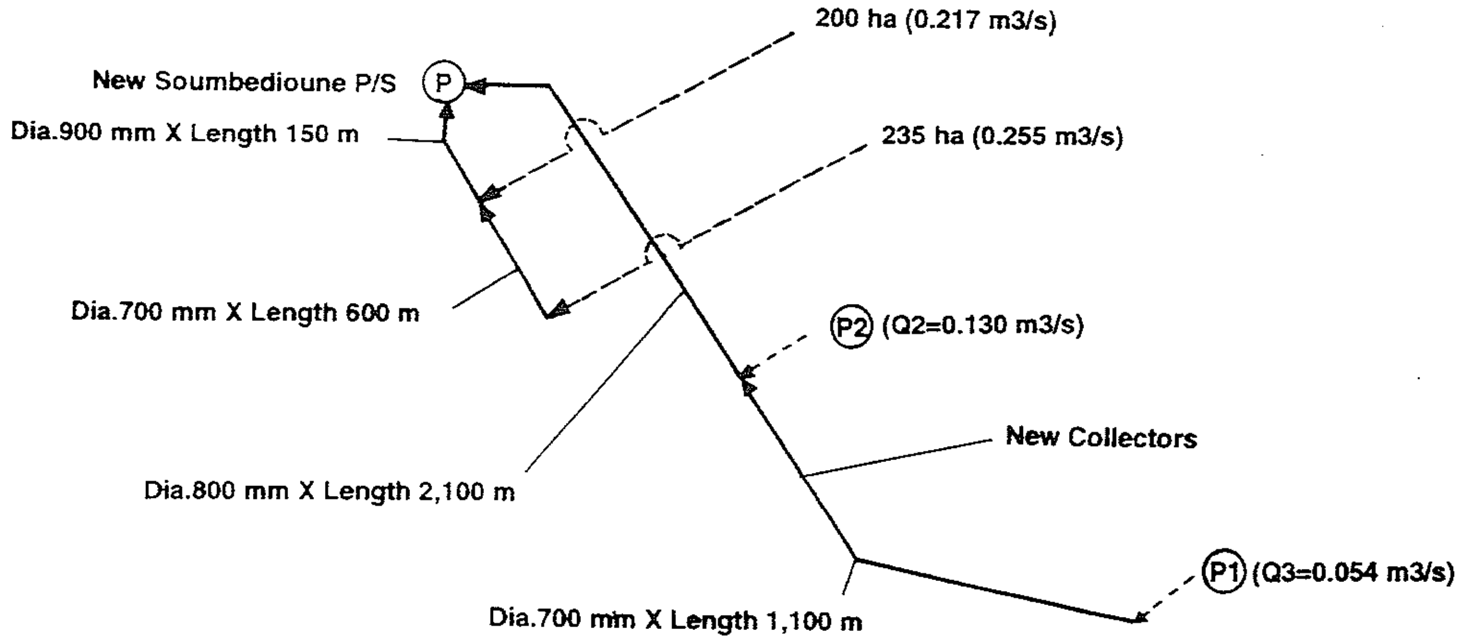
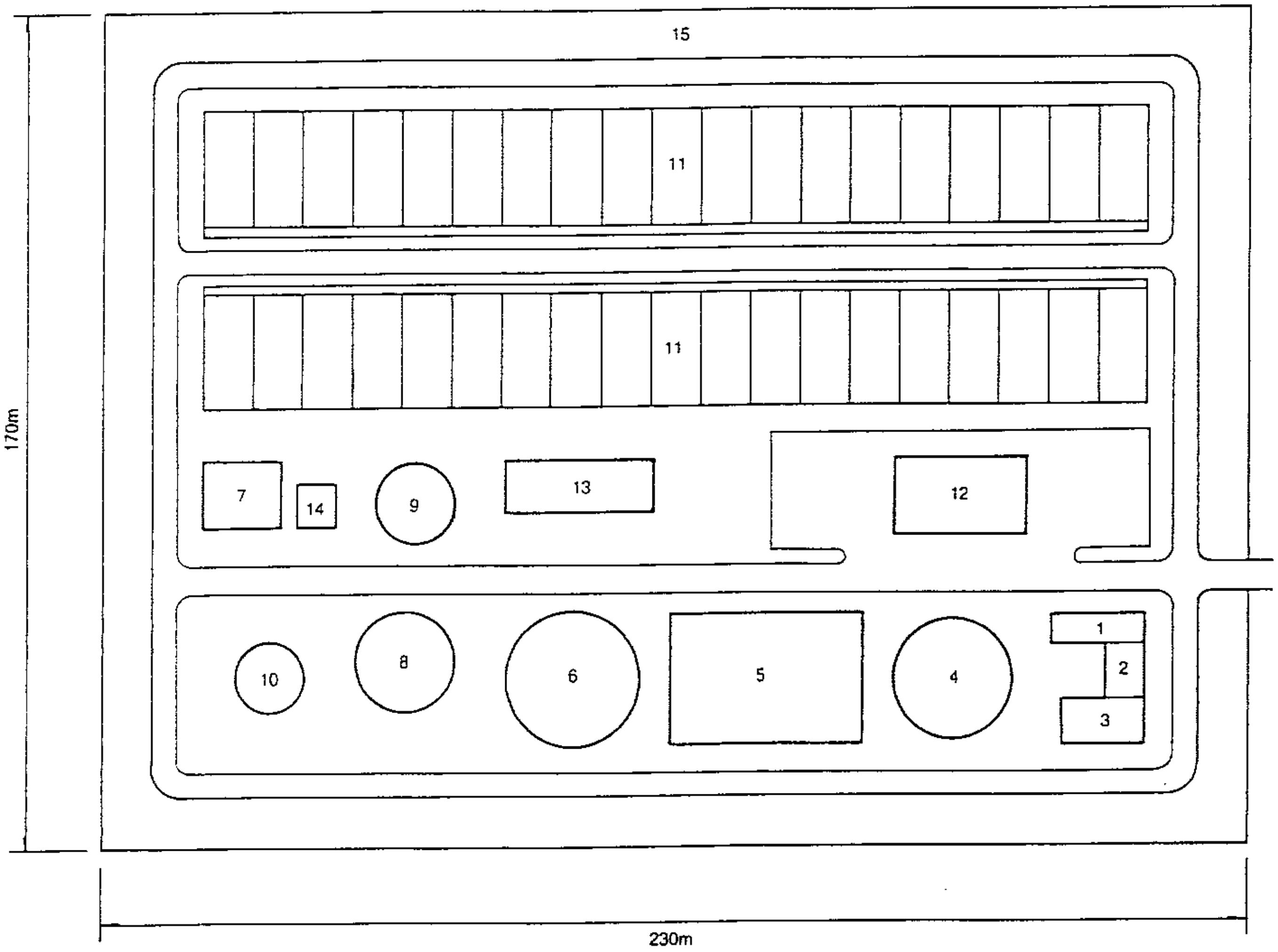


FIGURE B.3.3 COLLECTOR SYSTEM FOR MADELEINES, DAKAR ZONE



1. Main Pump
2. Screen
3. Grit Chamber
4. Primary Sedimentation Tank
5. Aeration Tank
6. Final Sedimentation Tank
7. Chlorination Tank
8. Sludge Digester (First)
9. Sludge Digester (Second)
10. Gas Holder
11. Sludge Drying Beds
12. Administration Building
13. Workshop
14. Chlorinator House
15. Green Belt

Conventional Activated Sludge Process
Q=10,000 m3/day
Area 3.91 ha

FIGURE B.3.4 GENERAL PLAN OF TREATMENT PLANT (CONVENTIONAL ACTIVATED SLUDGE PROCESS)

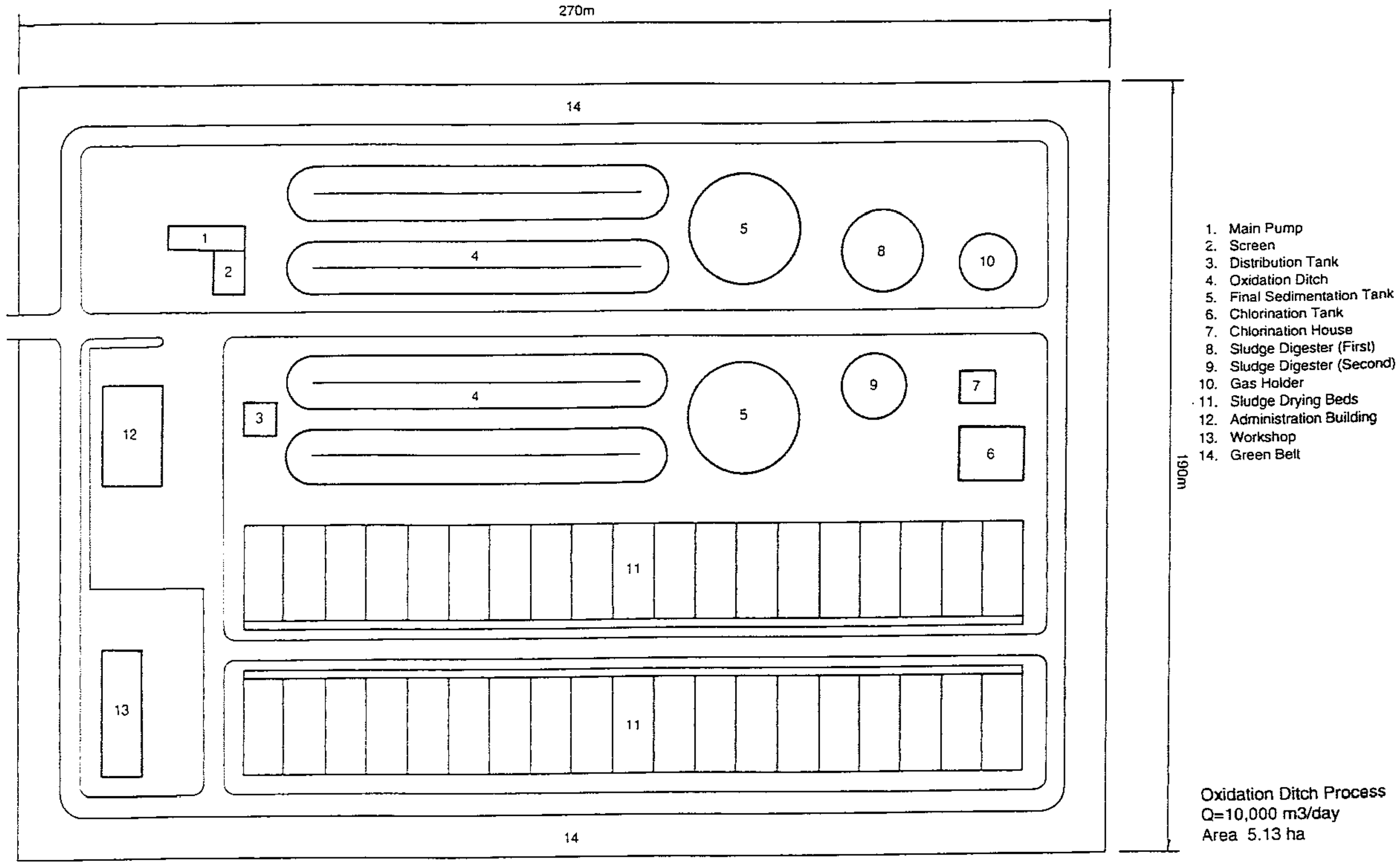
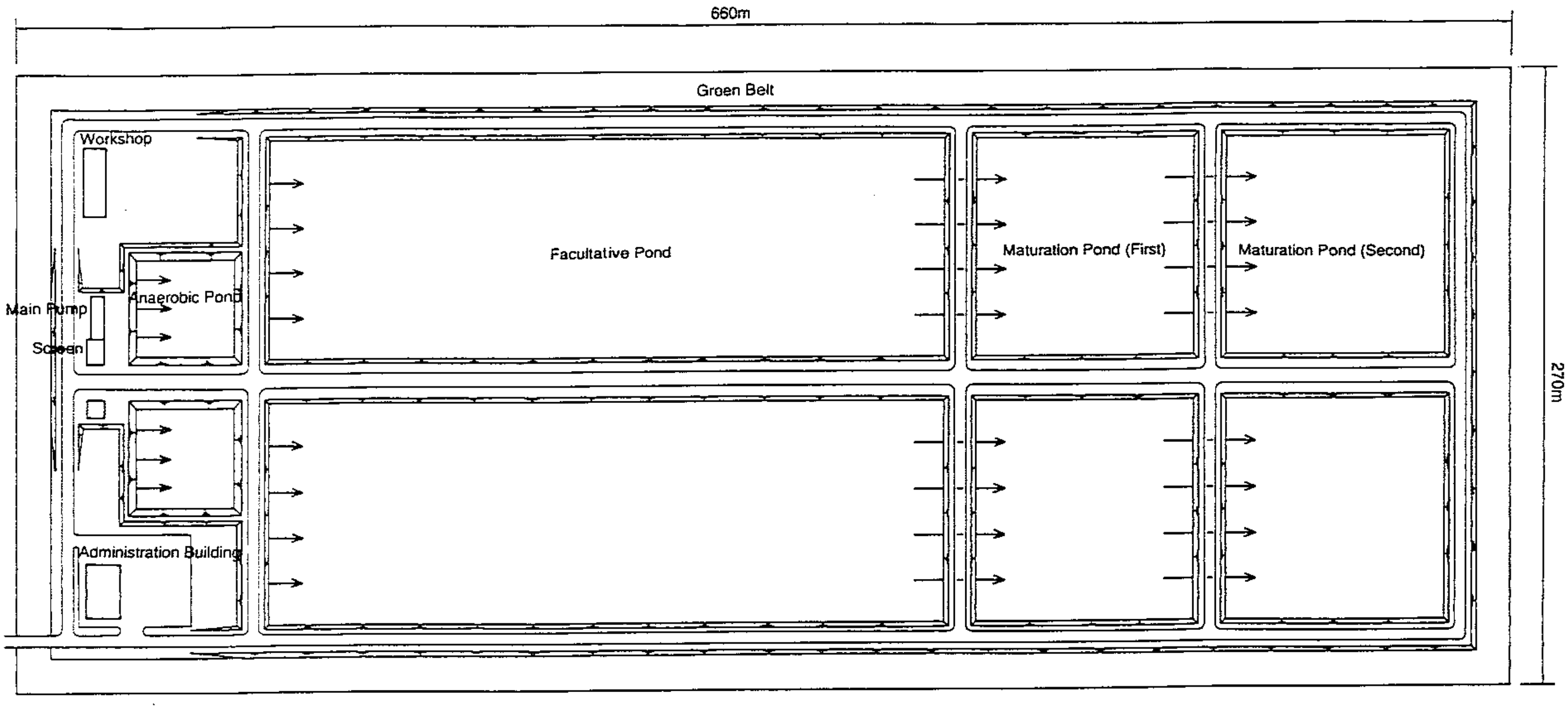


FIGURE B.3.5 GENERAL PLAN OF TREATMENT PLANT (OXIDATION DITCH)



Oxidation Pond Process
Q=10,000 m3/day
Area 17.82 ha

FIGURE B.3.6 GENERAL PLAN OF TREATMENT PLANT (OXIDATION POND)

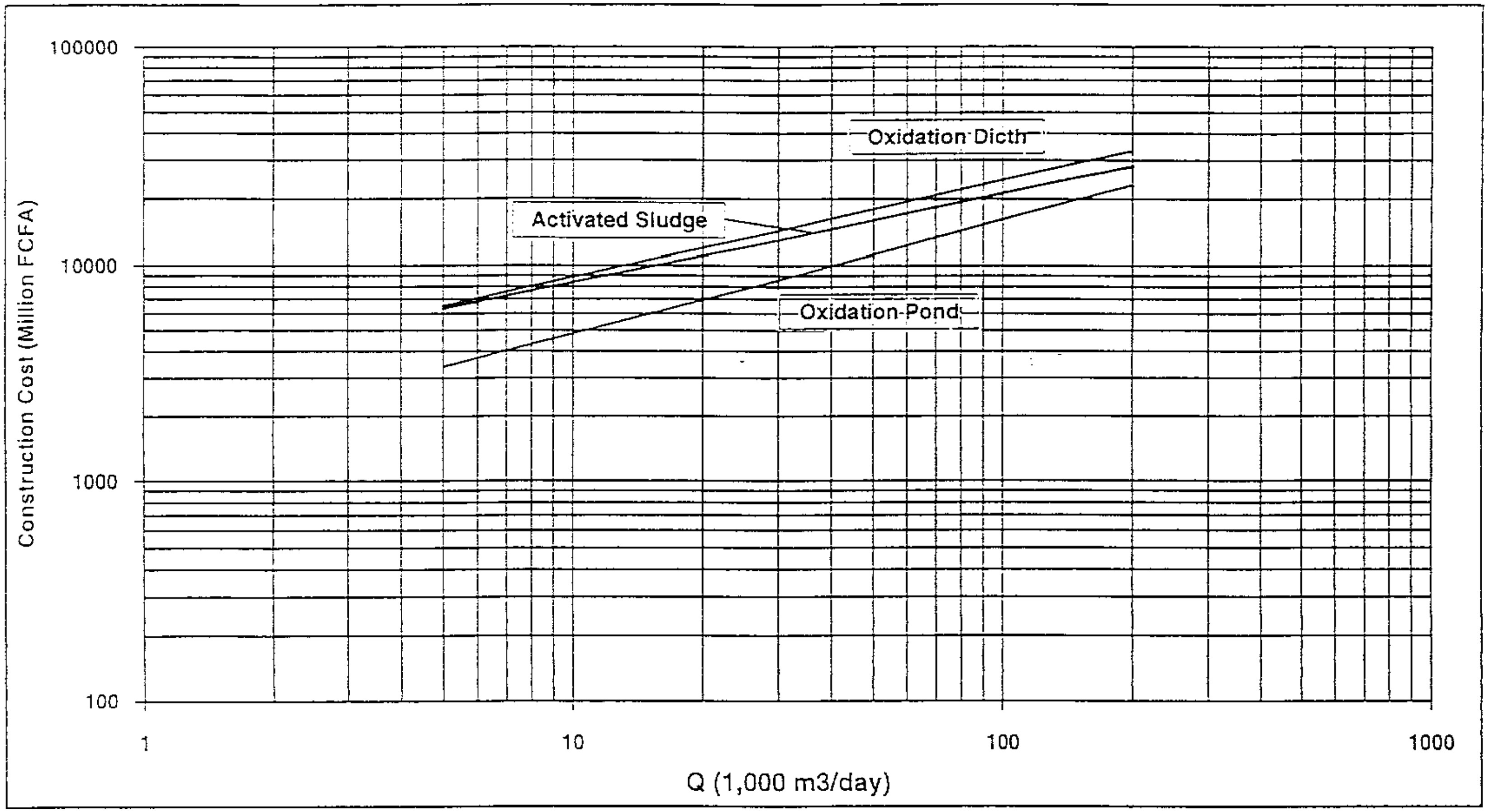
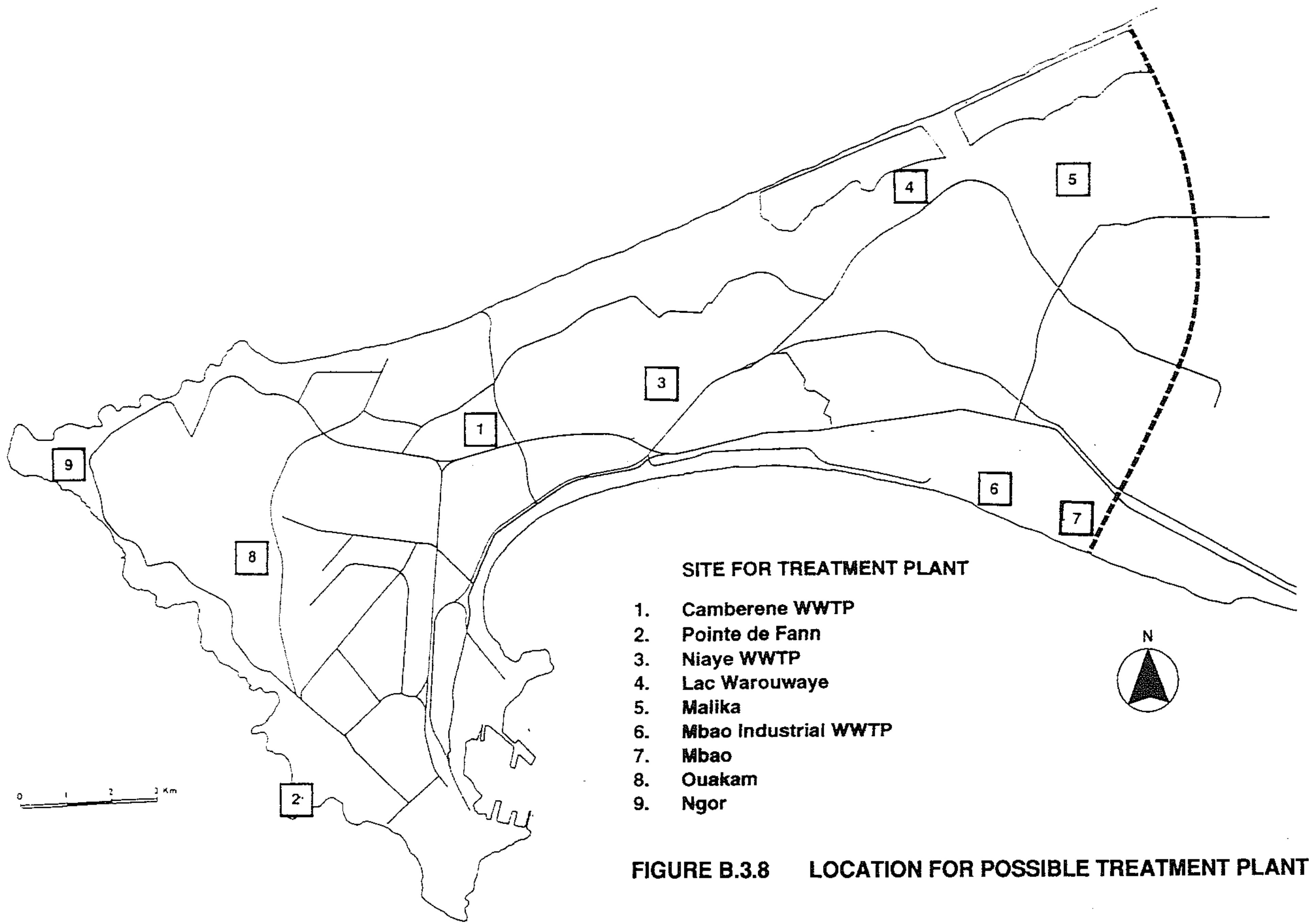


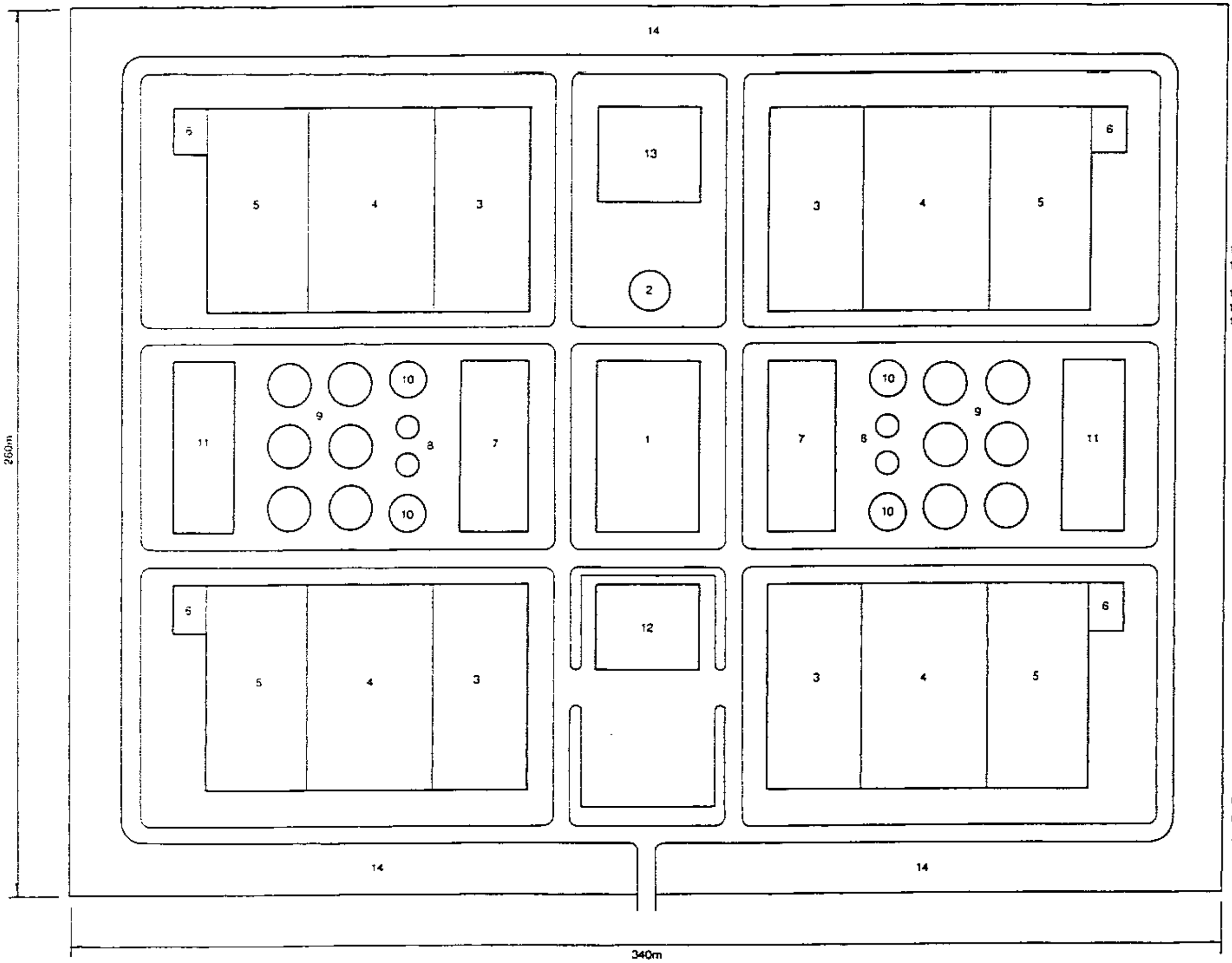
FIGURE B.3.7 CONSTRUCTION COSTS FOR THREE PROCESSES



SITE FOR TREATMENT PLANT

1. Camberene WWTP
2. Pointe de Fann
3. Niaye WWTP
4. Lac Warouwaye
5. Malika
6. Mbao Industrial WWTP
7. Mbao
8. Ouakam
9. Ngor

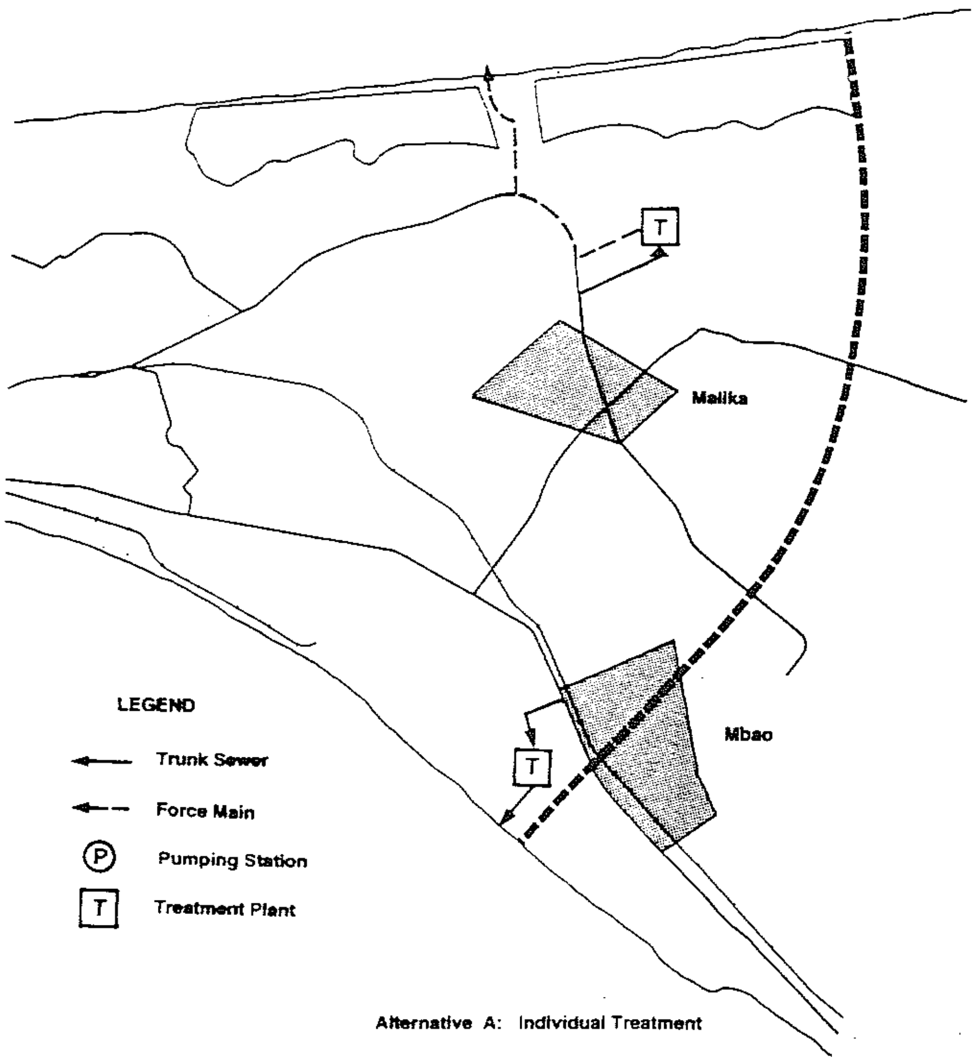
FIGURE B.3.8 LOCATION FOR POSSIBLE TREATMENT PLANT



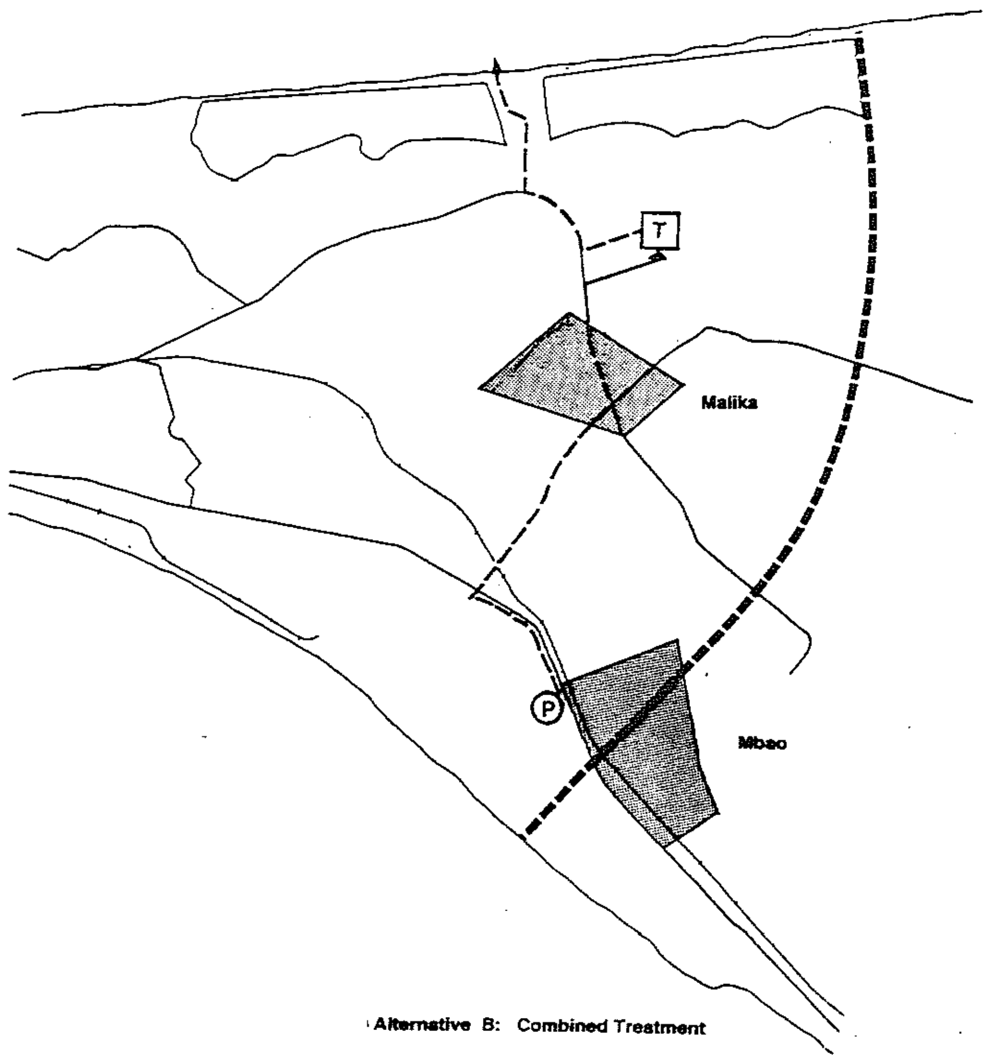
1. Pump Building
   (Main Pump)
   (Screen)
   (Grit Chamber)
2. Distribution Tank
3. Primary Sedimentation Tank
4. Aeration Tank
5. Final Sedimentation Tank
6. Chlorination Tank
7. Blower Building
8. Sludge Thickener
9. Sludge Digester
10. Gas Holder
11. Sludge Treatment Building
    (Mechanical Dewatering)
12. Administration Building
13. Workshop
14. Green Belt

Conventional Activated Sludge Process
Q=100,000 m3/day
Area 8.84 ha

FIGURE B.3.9 GENERAL PLAN OF ACTIVATED SLUDGE TREATMENT PLANT (Q=100,000 M^3/DAY)



Alternative A: Individual Treatment



Alternative B: Combined Treatment

FIGURE B.3.10 ALTERNATIVES FOR MALIKA AND MABAO SEWERAGE ZONES

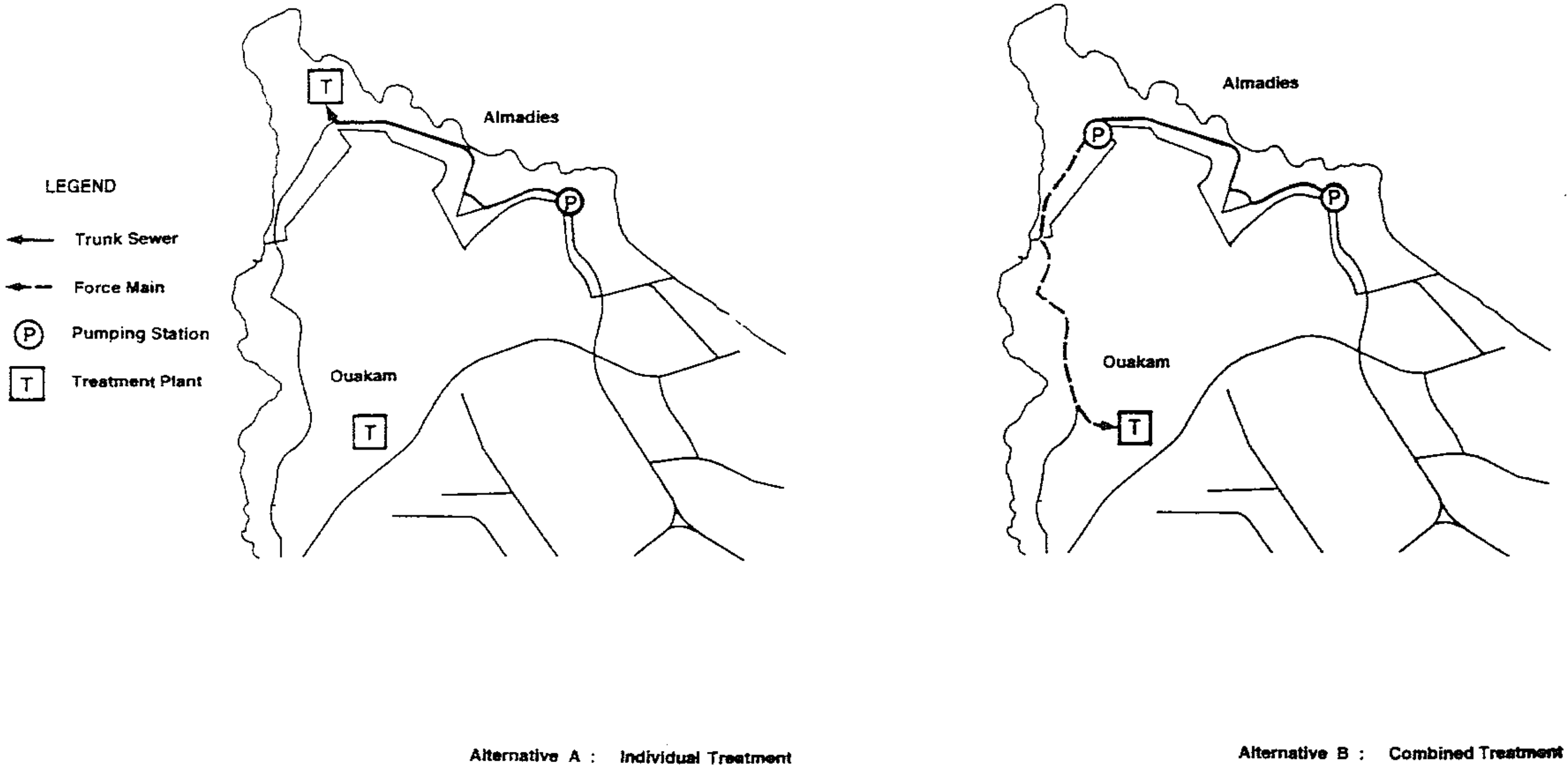


FIGURE B.3.11 ALTERNATIVES FOR ALMADIES ZONE

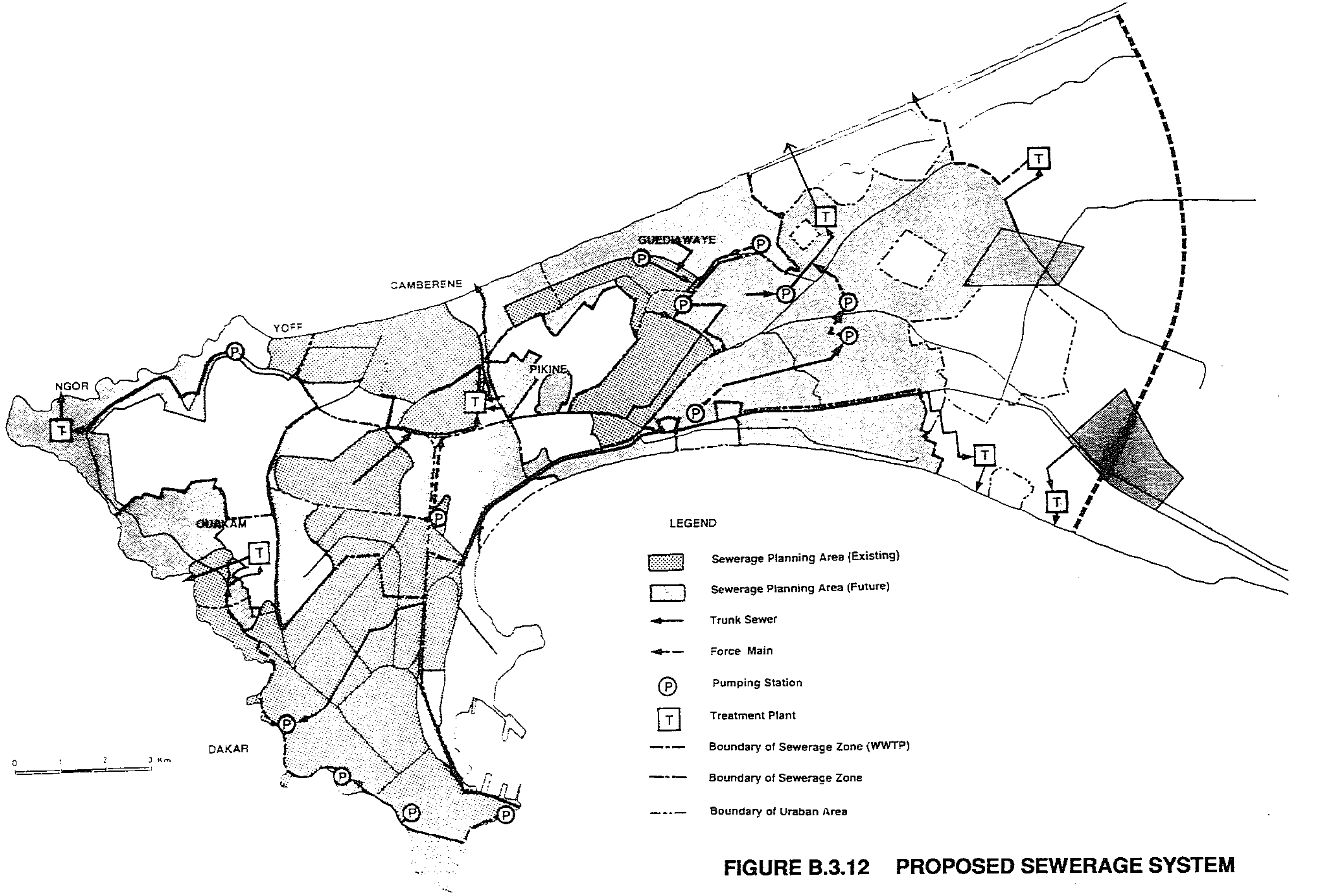
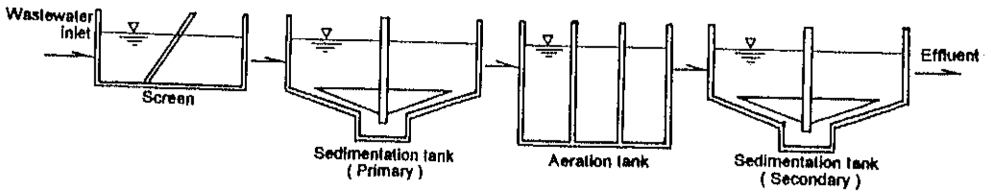
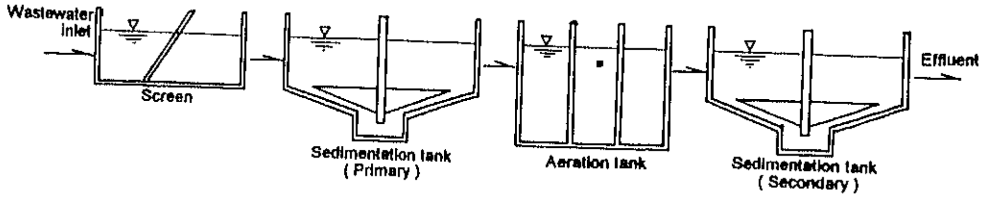


FIGURE B.3.12 PROPOSED SEWERAGE SYSTEM

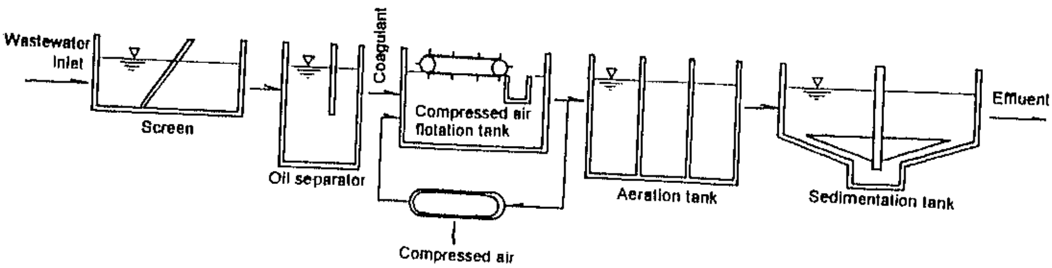
Fishing & Canning (Biological Treatment & Sedimentation)



Beer, Beverage, Condensed Milk (Biological Treatment & Sedimentation)



Cooking Oil (Flotation - Biological Treatment & Sedimentation)



Textile (Coagulation & Sedimentation)

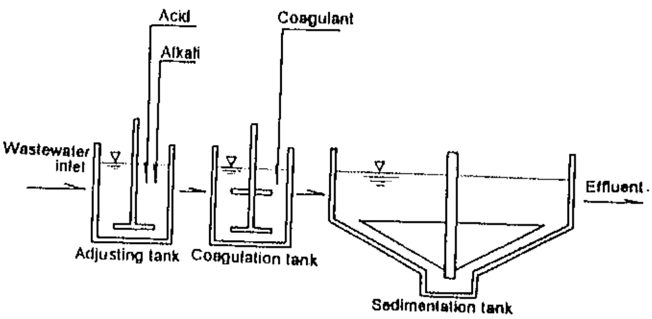
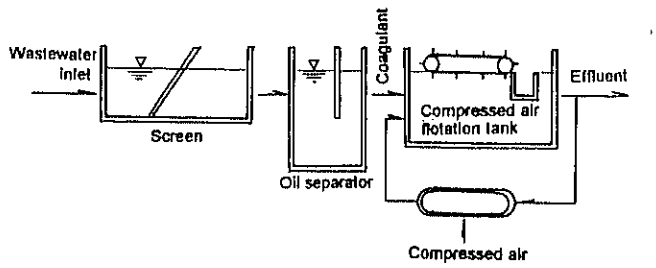
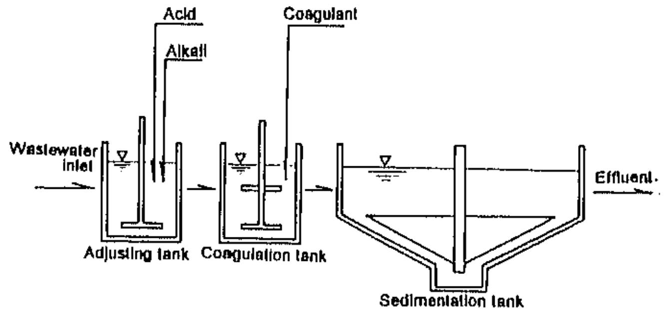


FIGURE B.3.13 TYPICAL TREATMENT PROCESS FOR INDUSTRIAL WASTEWATER (1)

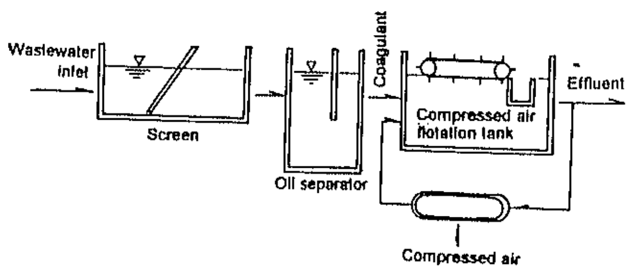
Fuel (Flotation)



Fertilizer (Coagulation & Sedimentation)



Shipbuilding (Flotation)



Slaughterhouse (Flotation - Biological Treatment & Sedimentation)

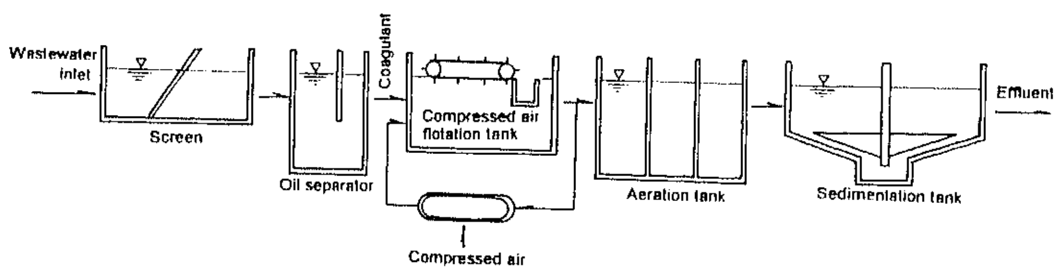


FIGURE B.3.13 TYPICAL TREATMENT PROCESS FOR INDUSTRIAL WASTEWATER (2)

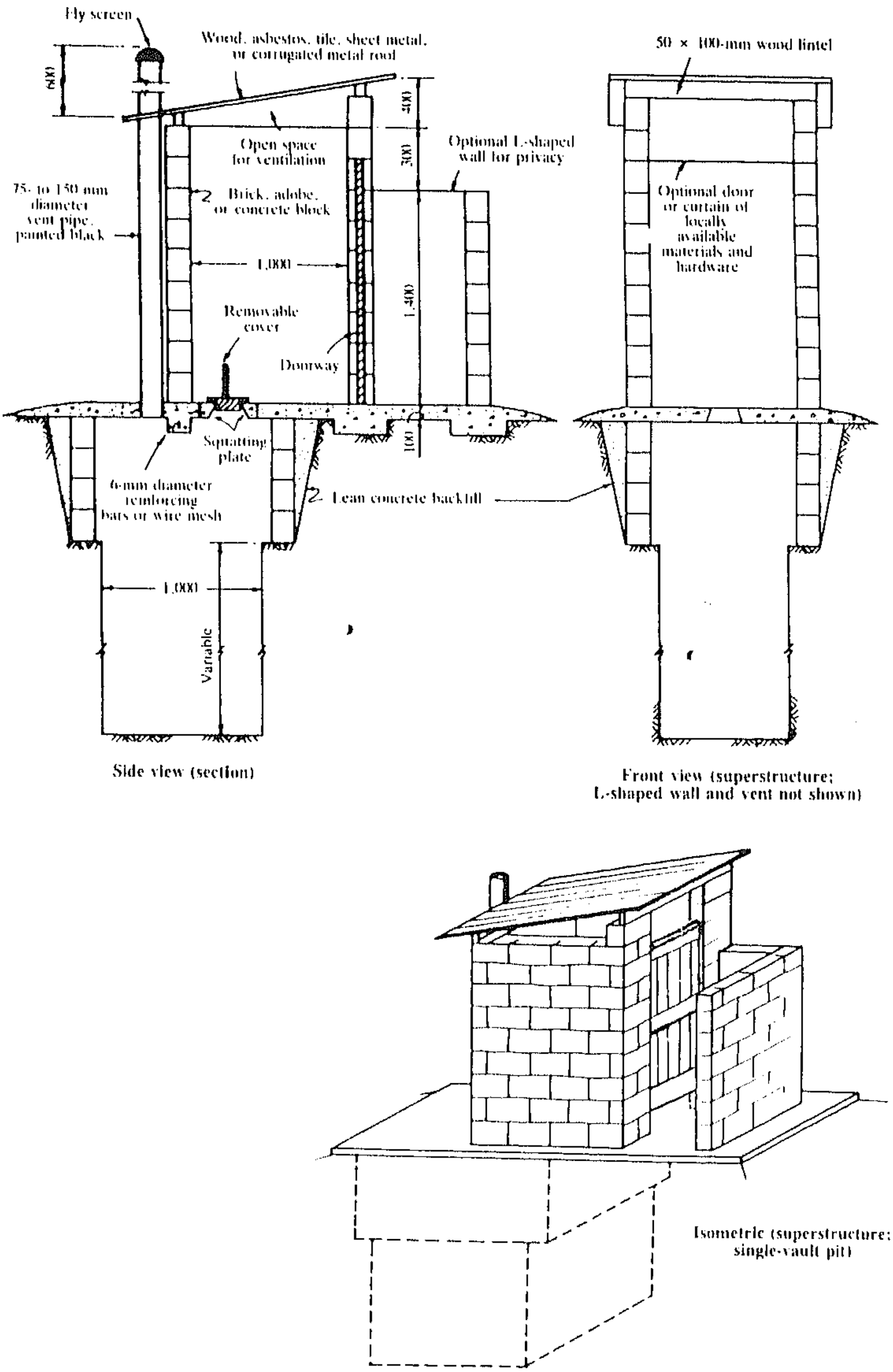


FIGURE B.3.14 AN EXAMPLE OF FLY FREE, SMELL FREE TOILET

SOURCE: A PLANNING AND DESIGN MANUAL, WORLD BANK STUDIES IN WATER SUPPLY AND SANITATION 2

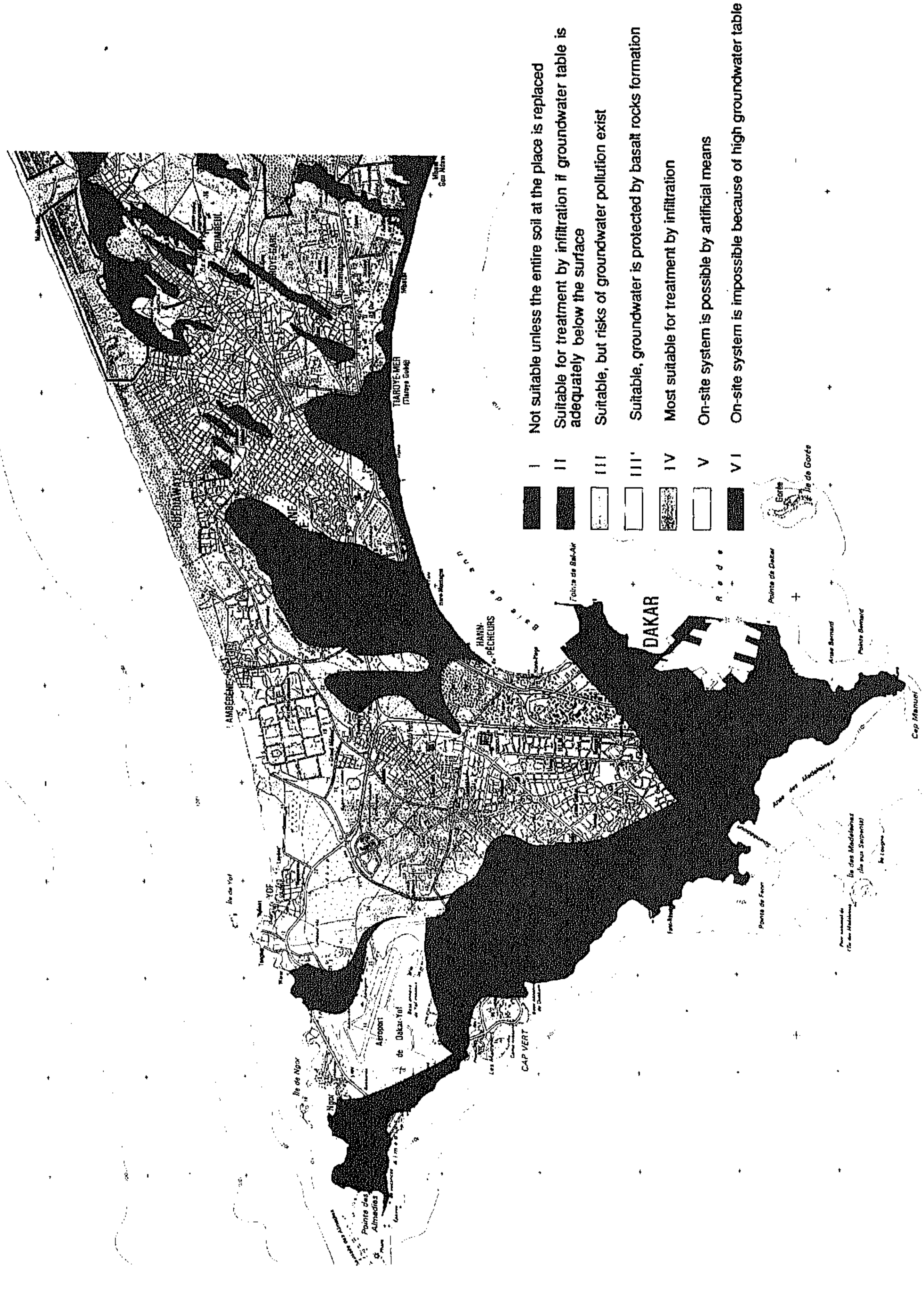


FIGURE B.3.15 CLASSIFICATION OF SOILS BY SUITABILITY FOR WASTEWATER DISPOSAL

Type of Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cabbage	■	■	■	■	■	■	■	■	■	■	■	■
Kideny beans	■	■	■								■	■
Aubergine	■	■	■	■	■	■	■	■	■	■	■	■
Onion	■	■	■	■	■					■	■	■
Pepper			■	■	■	■	■	■	■	■	■	■
Potato	■	■	■	■							■	■
Tomato	■	■	■	■	■	■	■	■	■	■	■	■

■ : Month in cultivation

FIGURE B.3.16 TYPICAL CULTIVATION SCHEDULE OF MAJOR CROPS IN THE STUDY AREA

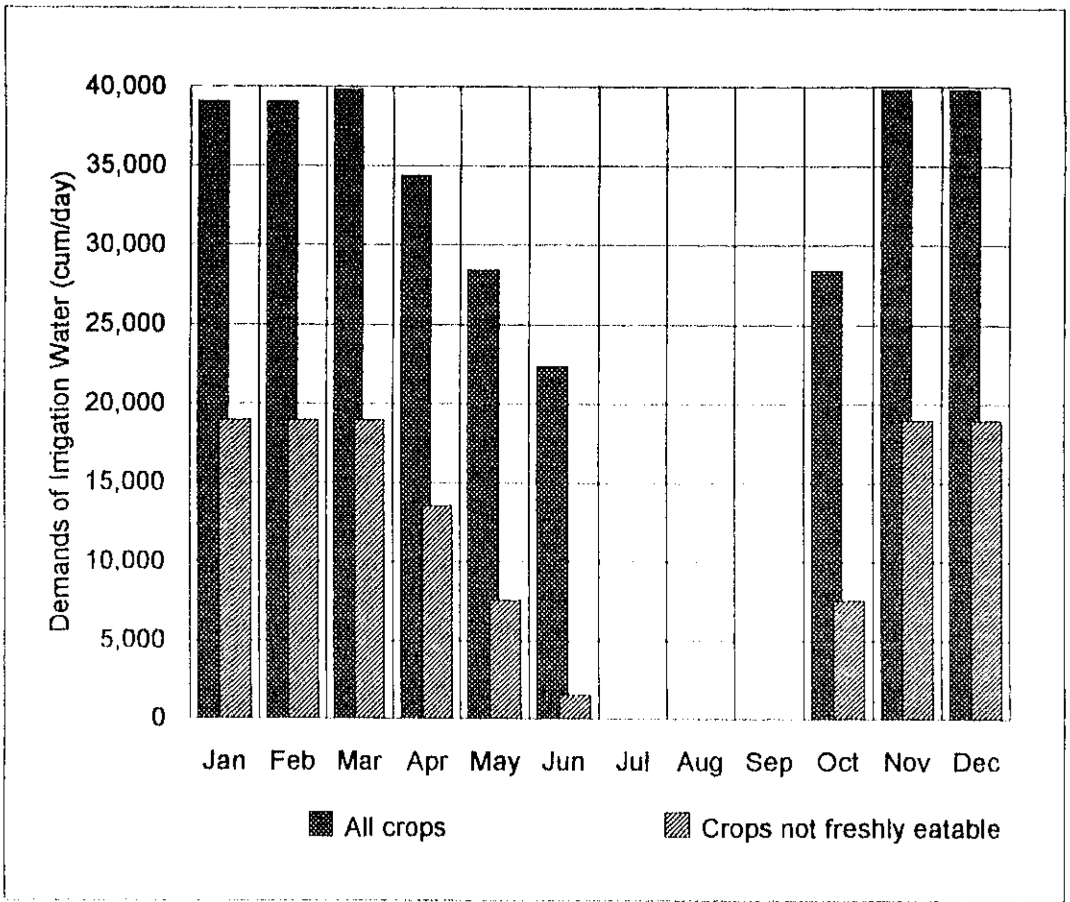
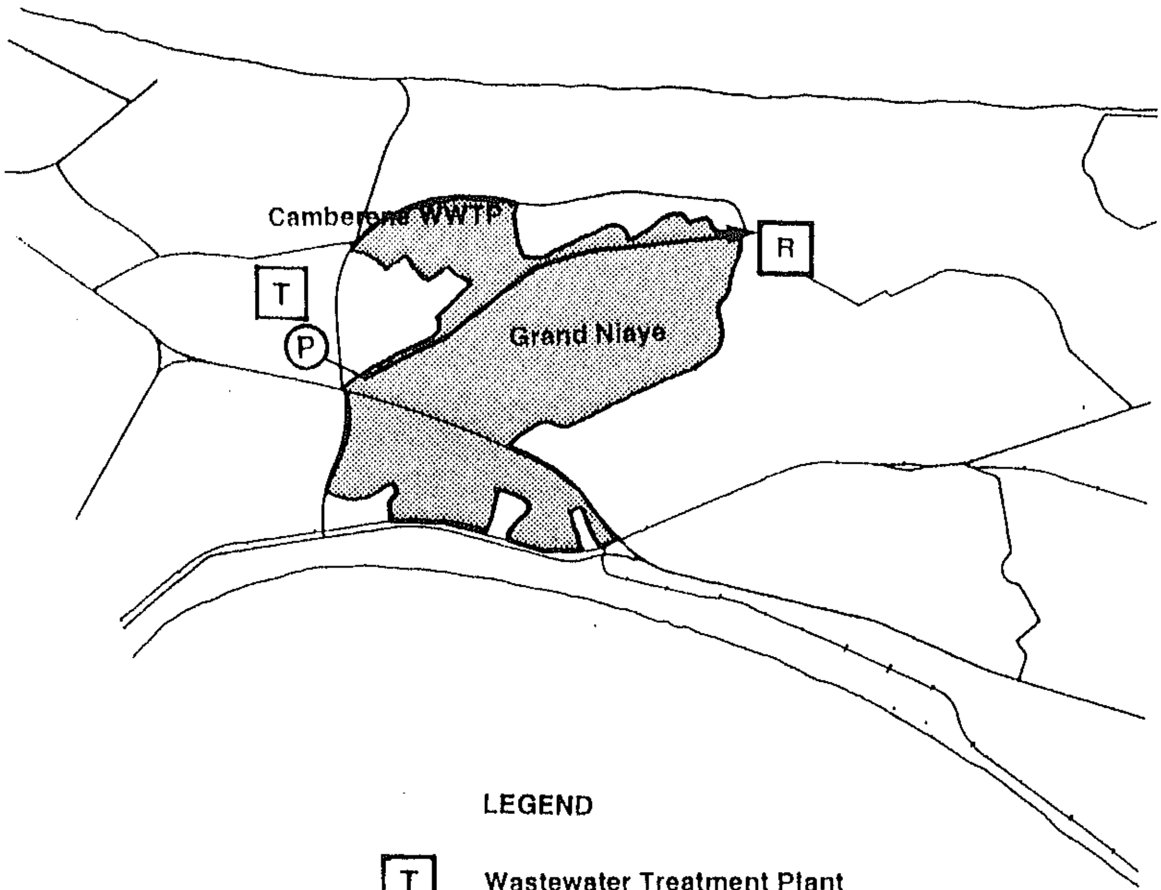


FIGURE B.3.17 ESTIMATED WATER DEMAND FOR IRRIGATION IN THE STUDY AREA

(REUSE.XLS1993/11/19)



LEGEND

T	Wastewater Treatment Plant
P	Pumping Station for Reuse
←	Force Main
R	Reservoir

FIGURE B.3.18 FACILITY PLAN OF REUSE (IRRIGATION)

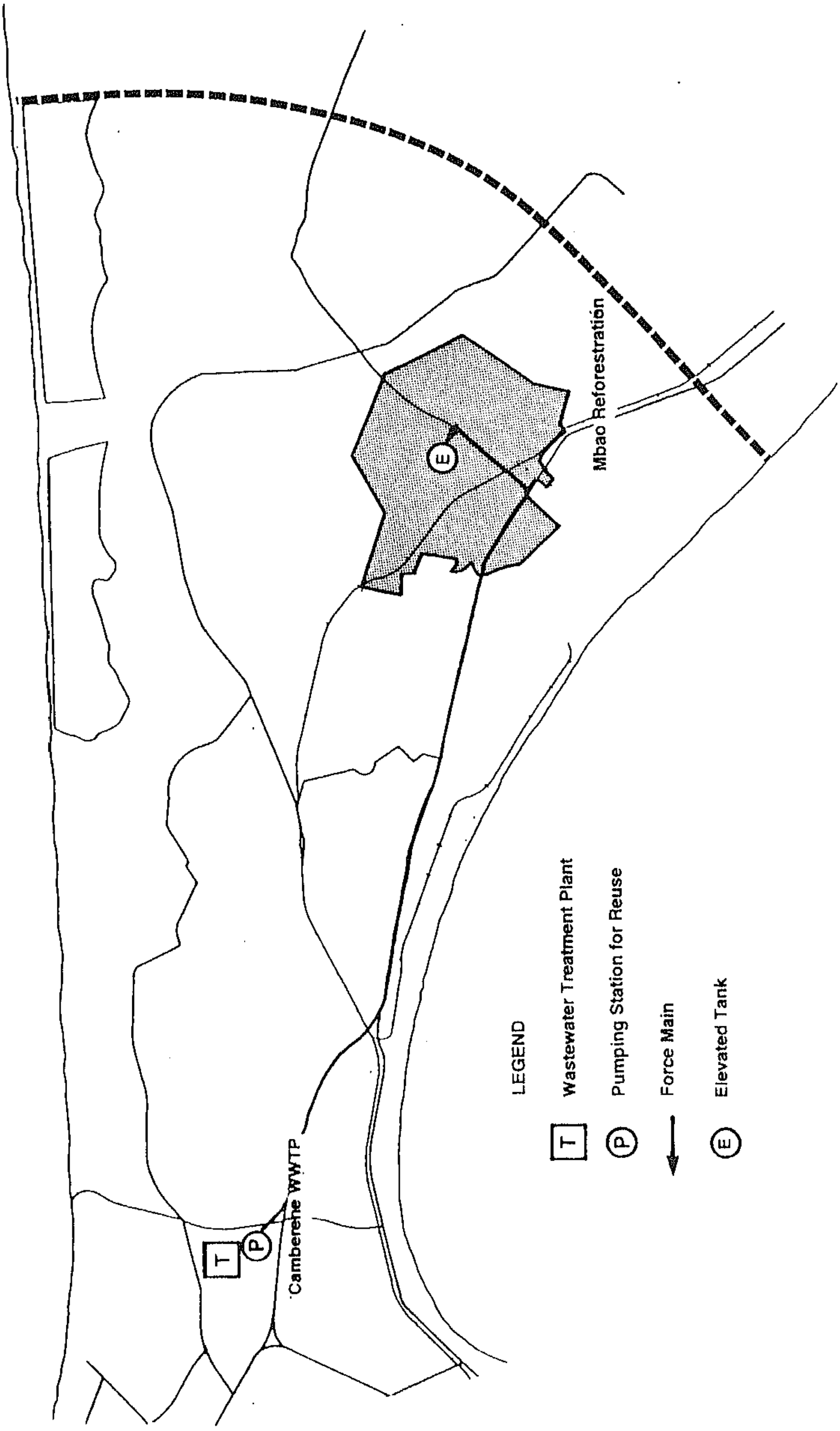


FIGURE B.3.19 FACILITY PLAN OF RE-USE (REFORESTATION)

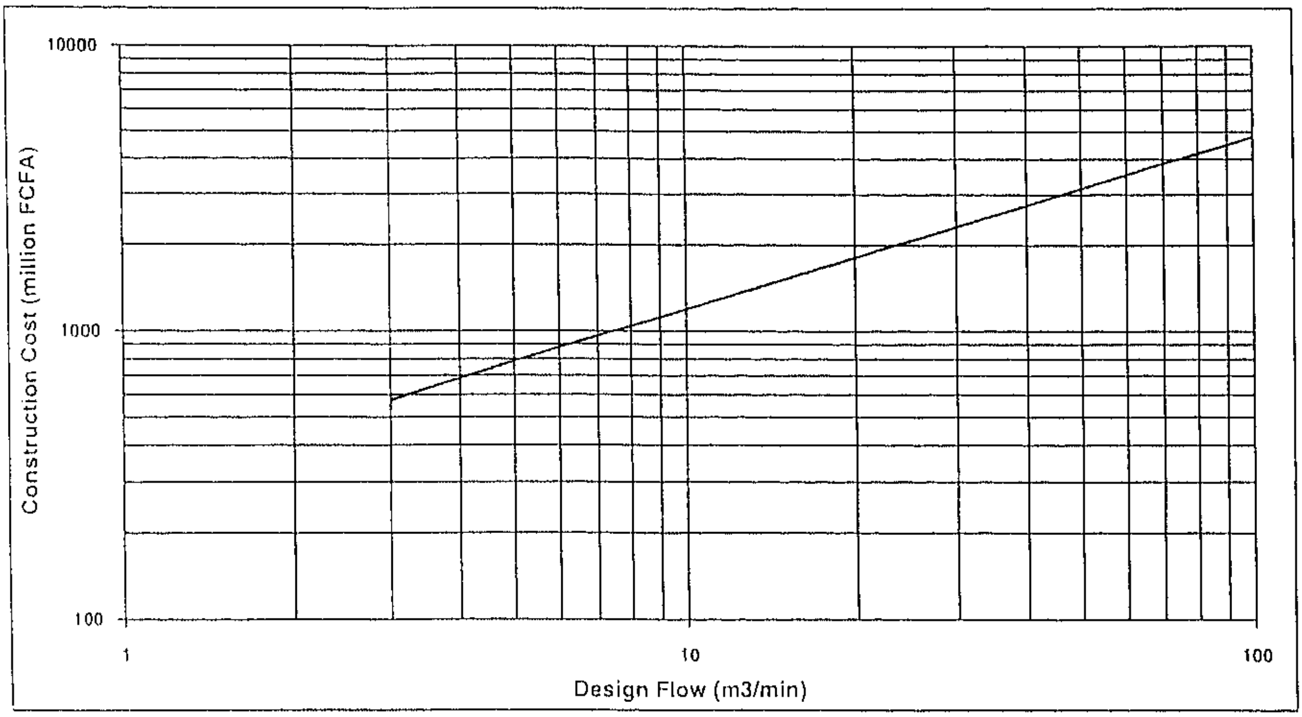


FIGURE B.3.20 CONSTRUCTION COST FOR PUMPING STATION

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I.Camberene																
1.Parcelles-Assainies																
1) Survey, Design, Contract Process	- - -	- - -														
2) LandAcquisition/Compensation		- - -	- - -	- - -	- - -											
3) Trunk Sewer			———	———	———	———										
4) Sewer Network	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———
5) Treatment Plant			———	———	———	———	———	———	———	———	———	———	———	———	———	———
2. Grand Yoff																
1) Survey, Design, Contract Process			- - -	- - -												
2) Trunk Sewer					———	———	———	———								
3) Sewer Network							———	———	———	———						
3.Hann																
1) Survey, Design, Contract Process					- - -	- - -										
2) Trunk Sewer							———	———	———							
3) Sewer Network							———	———	———	———	———					
4.Dakar (Camberene)																
1) Survey, Design, Contract Process												- - -	- - -			
2) LandAcquisition/Compensation													- - -			
3) Trunk Sewer														———	———	———
4) Pumping Station															———	———
5.Guediawaye																
1) Survey, Design, Contract Process							- - -	- - -								
2) LandAcquisition/Compensation									- - -	- - -	- - -					
3) Trunk Sewer									———	———	———	———				
4) Sewer Network										———	———	———	———			
5) Pumping Station										———	———	———				
6. Pikine Reguar																
1) Survey, Design, Contract Process						- - -	- - -									
2) Trunk Sewer								———	———	———	———					
3) Sewer Network										———	———	———	———			
II. Dakar																
1) Survey, Design, Contract Process			- - -	- - -												
2) LandAcquisition/Compensation				- - -	- - -											
3) Trunk Sewer					———	———	———	———	———							
4) Pumping Station							———	———	———							
5) Sewer Network					———	———	———	———	———							

FIGURE B.3.21 IMPLEMENTATION SCHEDULE

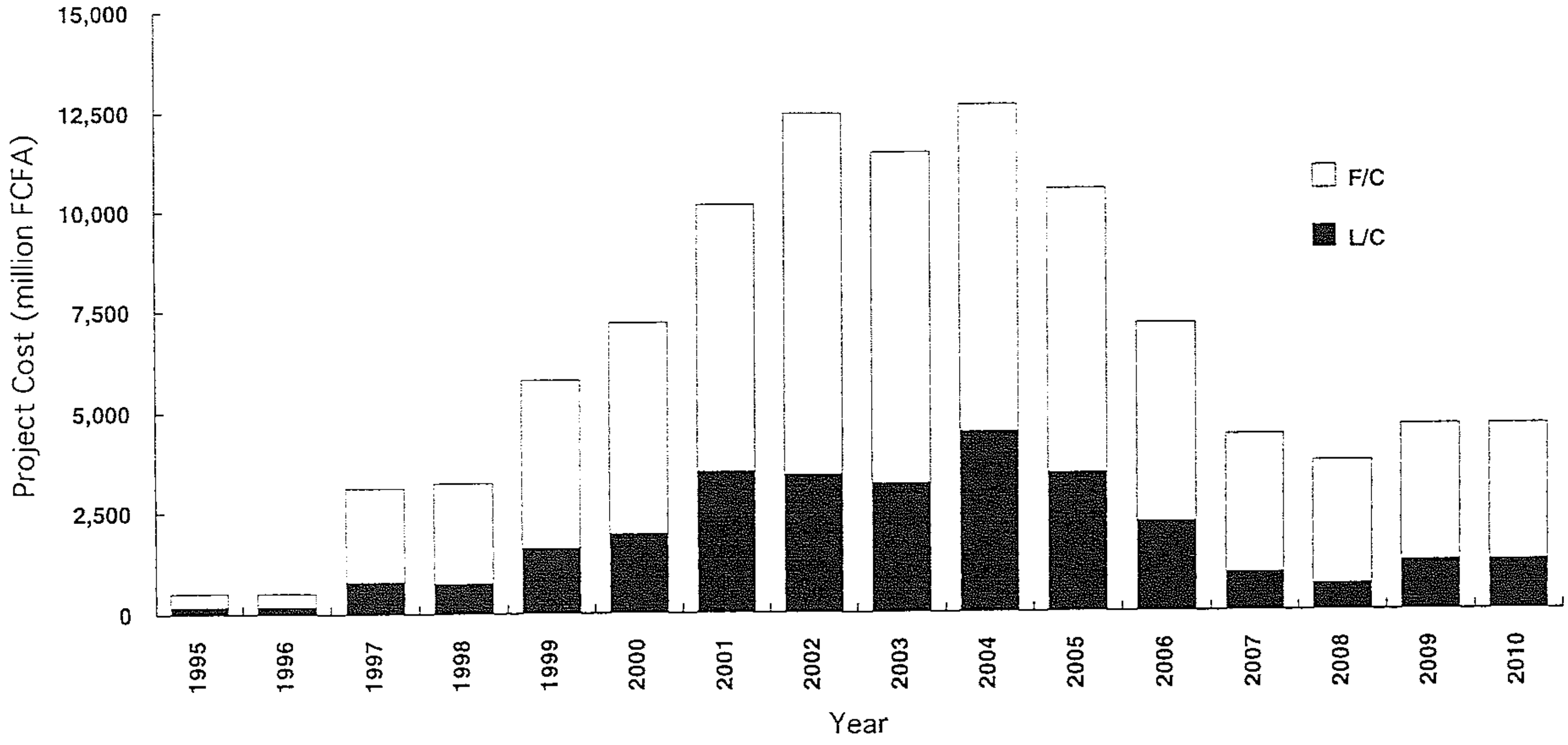


FIGURE B.3.22 PROJECT COST UP TO 2010

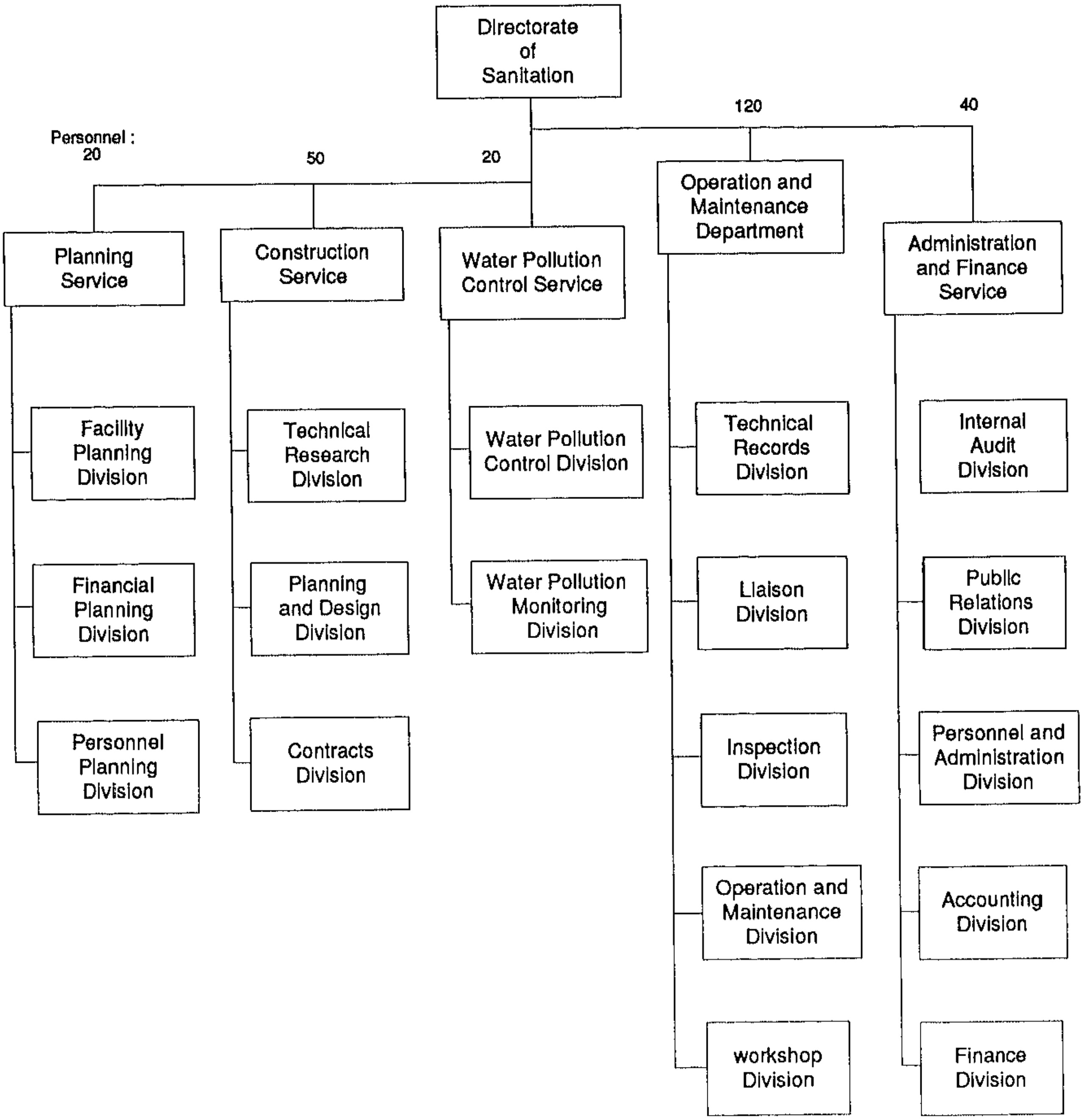


FIGURE B.3.23 PROPOSED ORGANIZATIONAL STRUCTURE FOR SANITATION SECTOR FOR SONEES MODIFICATION OR NEW ORGANIZATION

CHAPTER 4 FEASIBILITY STUDY ON THE WASTEWATER PRIORITY PROJECT

4.1 PROJECT AREA

4.1.1 Feasibility Study Area

The feasibility study area for the wastewater priority project was selected under the Master Plans, and it is Parcelles Assainies and Its Surroundings sewerage zone which is shown in Figure B.4.1. The study area is one of the sewerage zones of the Camberene sewerage system.

As shown in the figure, the zone is divided into 14 subzones taking into account the service areas of the existing pumping stations and development conditions. There are eight (8) pumping stations in the Parcelles Assainies housing development and one (1) in Djily Mbaye housing development. Each of the service areas of the existing nine (9) pumping stations forms a subzone.

Patte d'Oie subzones is provided with sewer networks and all the wastewater which had been treated at the old Patte d'Oie WWTP is now transferred to the Camberene WWTP for treatment.

Three subzones, viz. Nord Foire, Stadium and East to Patte d'Oie, are classified as new development areas. Housing development in the Nord Foire subzone started a few years ago and a large open space is still remain. A development plan for the subzone was established by the Ministry of City Planning and Housing (Ministere de l'Urbanisme et de l'Habitat). The latter two subzones are open spaces at present and no development plan is available.

Three areas are excluded from the sewerage service area. These are Cemetery (Unit 39), Grand Niaye and Grand Medina (Unit 42). The first two areas are open space and no wastewater generated. Grand Medina is a spontaneous irregular housing area where conventional sewer system can not be constructed. Nevertheless, a part of wastewater from Grand Medina is taken into account in the preliminary designing of sewerage facilities because small bore sewer system can be applied in the area in the future.

The project area for the sewerage project totals 820 ha, and areas of the subzones are as follows.

No.	Name of Subzones	Area (ha)
1	P.A. P/S Unite 2	69
2	P.A. P/S Unite 7	55
3	P.A. P/S Unite 9	19
4	P.A. P/S Unite 13	64
5	P.A. P/S Unite 17	6
6	P.A. P/S Unite 15	130
7	P.A. P/S Unite 22	19
8	P.A. P/S Unite 23	26
9	North to Stadium	57
10	Djily Mbaye P/S	46
11	Nord Foire	129
12	Stadium	92
13	Patte d'Oie	80
14	East to Patte d'Oie	28
	Total	820

4.1.2 Existing Sewer Networks

At present provision of sewer networks in subzones varies greatly. There are sewer networks in all subzones in Pacelles Assainies except North to Stadium subzone, although they are rather thinly provided and connection ratio is as low as 25 % on an average.

In Djily Mbaye subzone, all the houses are connected to the sewer networks although development is now progressing and many houses are yet to be constructed. All wastewater in this subzone is collected to the existing Djily Mbaye pumping station at the lowest point. Wastewater from undeveloped areas