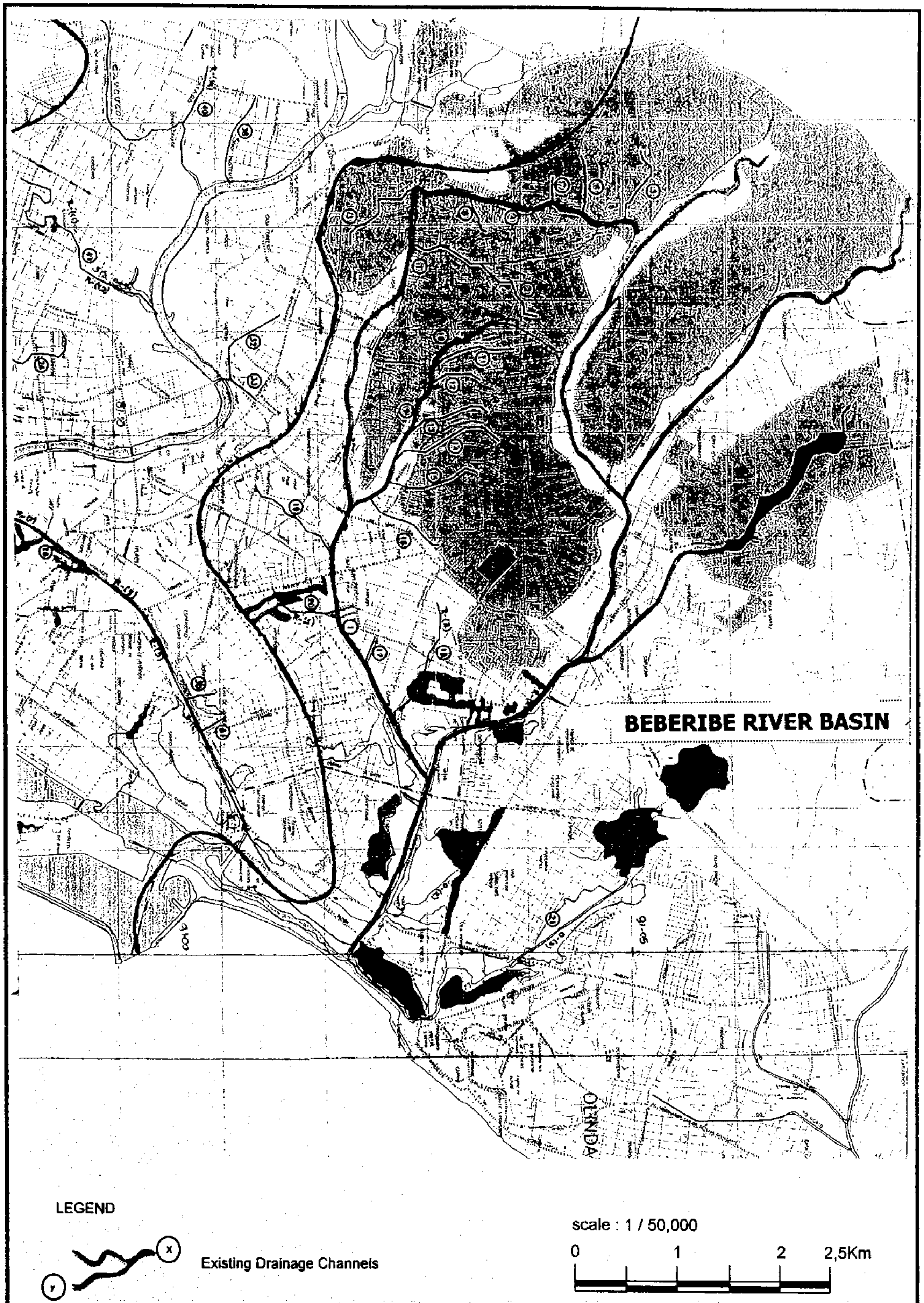
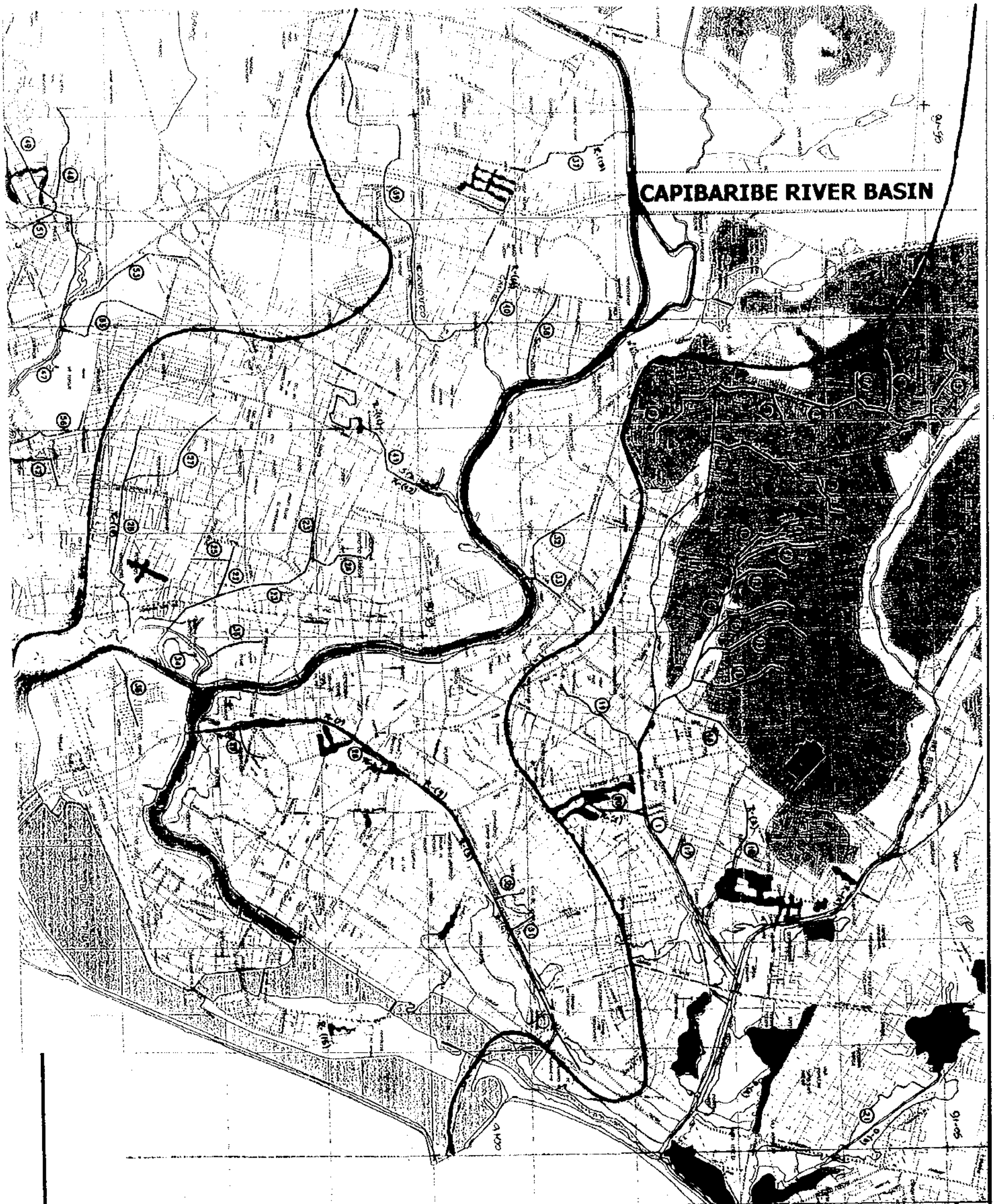


Fig. 2.9-1 (1/4)	Drainage Channels in Urban Areas - Beberibe River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR



LEGEND

Existing Drainage Channels

scale : 1 / 50,000

0 1 2 2,5Km

Fig. 2.9-1 (2/4)	Drainage Channels in Urban Areas - Capibaribe River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR

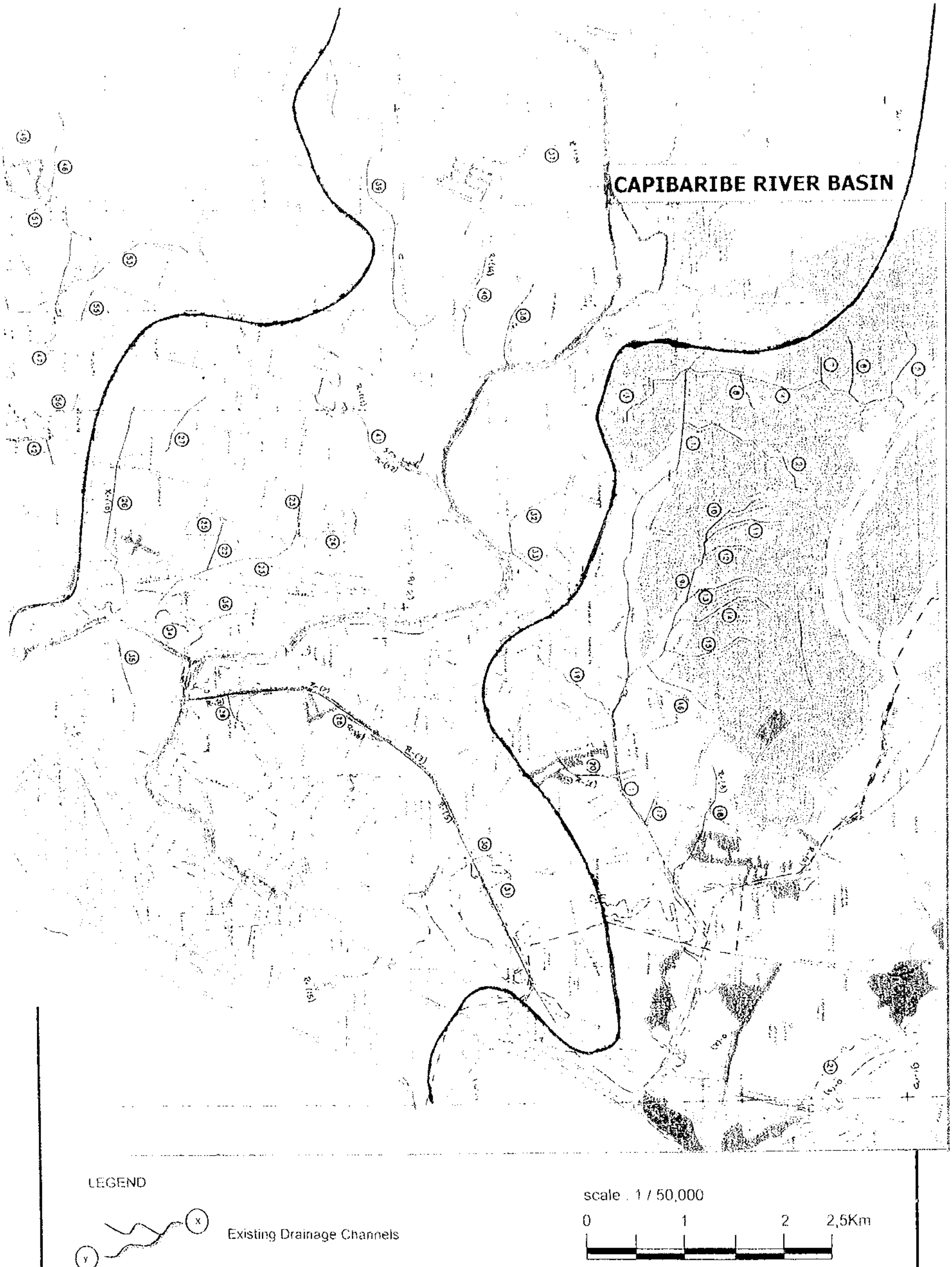
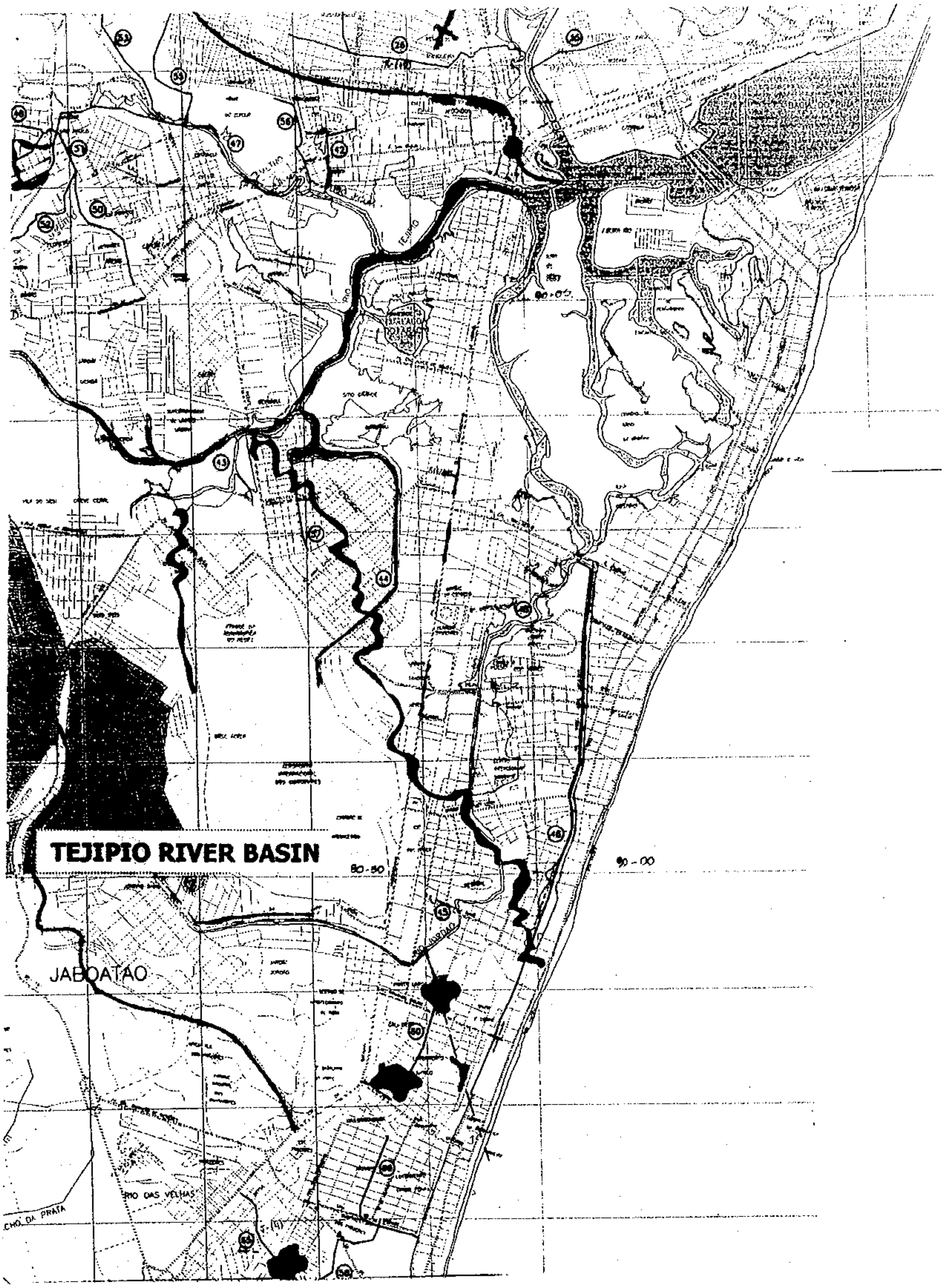


Fig. 2.9-1 (2/4)	Drainage Channels in Urban Areas - Capibaribe River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR



LEGEND

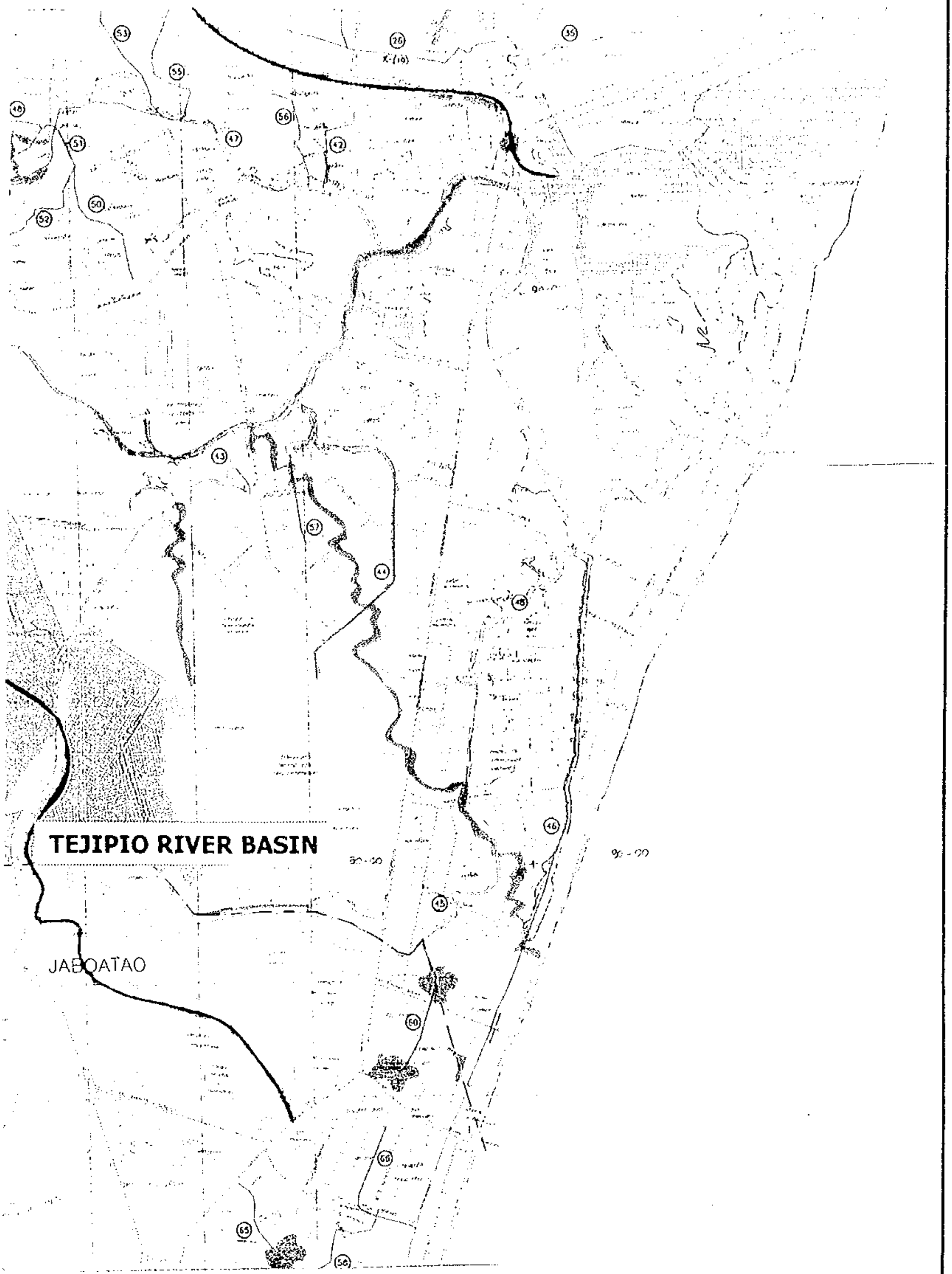
Existing Drainage Channels

scale : 1 / 50,000

0 1 2 2,5Km

Fig. 2.9-1 (3/4)	Drainage Channels in Urban Areas - Tejipio River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR



LEGEND

Existing Drainage Channels

scale : 1 / 50,000

0 1 2 2,5Km

Fig. 2.9-1 (3/4)	Drainage Channels in Urban Areas - Tejipio River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR

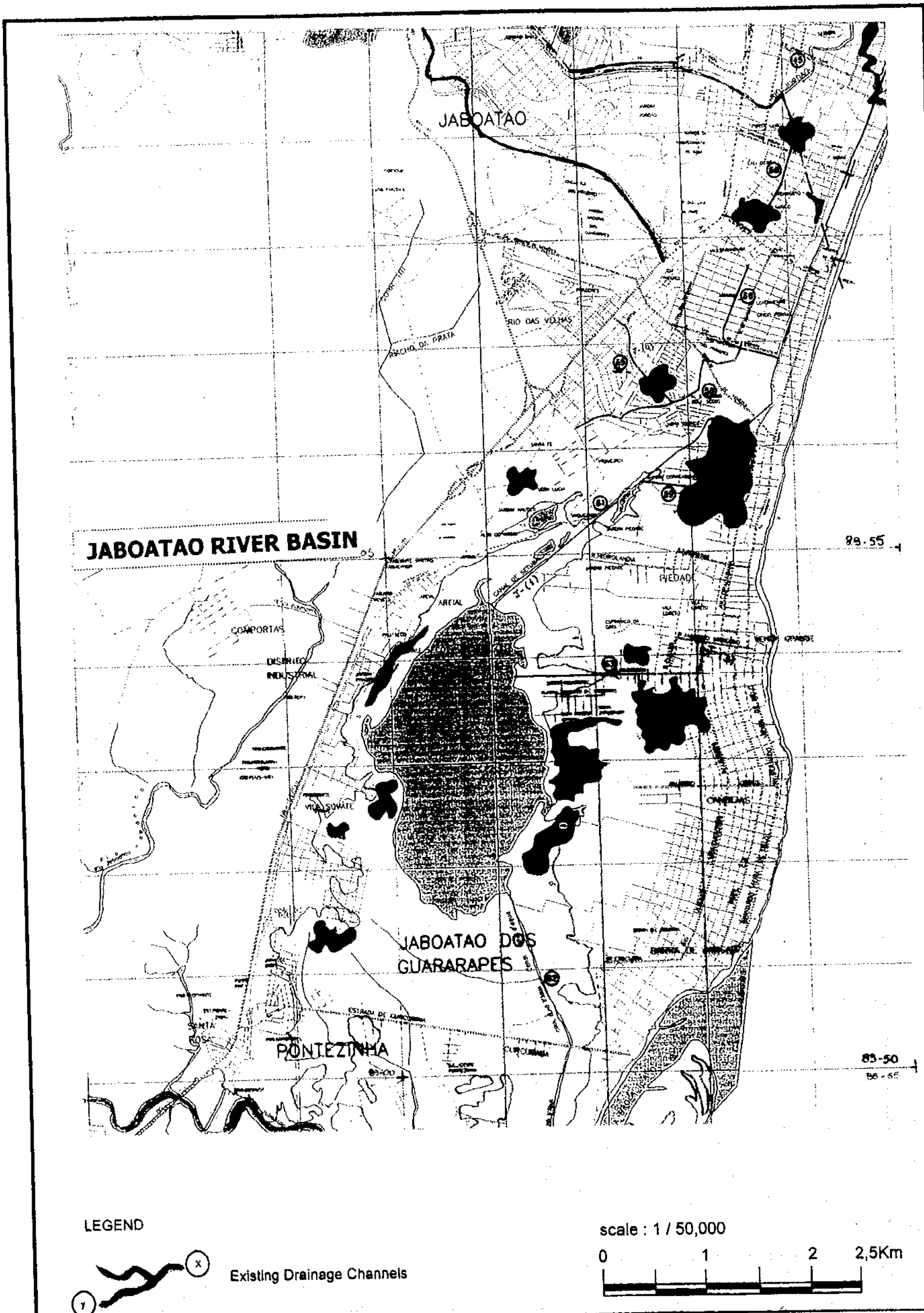


Fig. 2.9-1 (4/4)	Drainage Channels in Urban Areas - Jaboatao River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR

2.10 Organization

2.10.1 Existing Organization

(1) Overall Administrative Structure of Pernambuco State

The state government is composed of seventeen (17) secretariats under the governor, (December 1999). Besides these secretariats, there are thirty-seven (37) external organs under the respective secretariats. The organizational diagram of the state is shown in Fig. 2.10-1. In the figure, agencies and external organizations related to the current study are indicated with broken lines.

The state secretariats are as follows:

1. SEPLANDES; State Secretariat of Planning and Social Development
2. SEIN: State Secretariat of Infrastructure
3. SRH: Secretariat of Water Resources
4. SECTMA: Secretariat of Science, Technology and the Environment

The external agencies are:

1. COMPESA; Sanitation Company of Pernambuco,
2. CONDEPE: Civil Defense Board of Pernambuco
3. FIDEM: RMR Development Foundation
4. ITEP: Technological Institute of Pernambuco
5. CPRH: Environment Company of Pernambuco

(2) Agencies concerned with Sewerage System

In the State of Pernambuco, most of the sewerage systems are operated by COMPESA, which was established as a public corporation under the jurisdiction of SEIN in July 1971. The State Government owns the whole stock of COMPESA and SEIN is the main shareholder. In the RMR, COMPESA manages water supply, sanitation services and most of the existing sewerage systems and is also entrusted with the maintenance of other treatment systems by users on request.

It has 174 municipal branch offices in the total 185 municipalities in the state and provides water supply services for 4.9 million people, and sewerage and sanitary services for 1.1 million people.

COMPESA, as shown in Fig. 2.10-2, comprises four departments under the president. The four directors, i.e., Management, Technical, Operation and Commercial Directors manage the departments. The operations director controls the operation and maintenance of the water supply and sewerage systems. The 14 regional managers and their staff are to conduct the actual O&M of the systems. The sewerage system in the RMR is managed under the Division of Metropolitan Sewerage and Sanitation. The division manager is in charge of the following four sewerage systems: Cabanga, Peixinhos, Janga and South. These systems cover around 1 million people or 36% of the total population in the RMR.

(3) Agencies Concerned with Stormwater Drainage System

There are no well-defined management models for the urban drainage in the Brazilian institutional framework, that clearly identifies the responsibilities at each level of government (federal, state and municipal). In reality the municipal governments are responsible for the implementation and maintenance of the micro and macro drainage systems in their territories. In the case of basins covering more than one municipality, each municipality carries out the maintenance at present. There is no clear definition about the responsibility of the State Government.

In the RMR the Municipal Government in principle manages the stormwater drainage system in each municipality. In the municipal governments, the executive agency is usually the Municipal Secretariat of Civil Works and Infrastructure, or any similar Secretariat. The agency is responsible for their construction and maintenance of drainage structures such as canals, box culverts in addition to rivers and brooks. As for decision-making, it is usually the responsibility of the Municipal Secretariat of Planning.

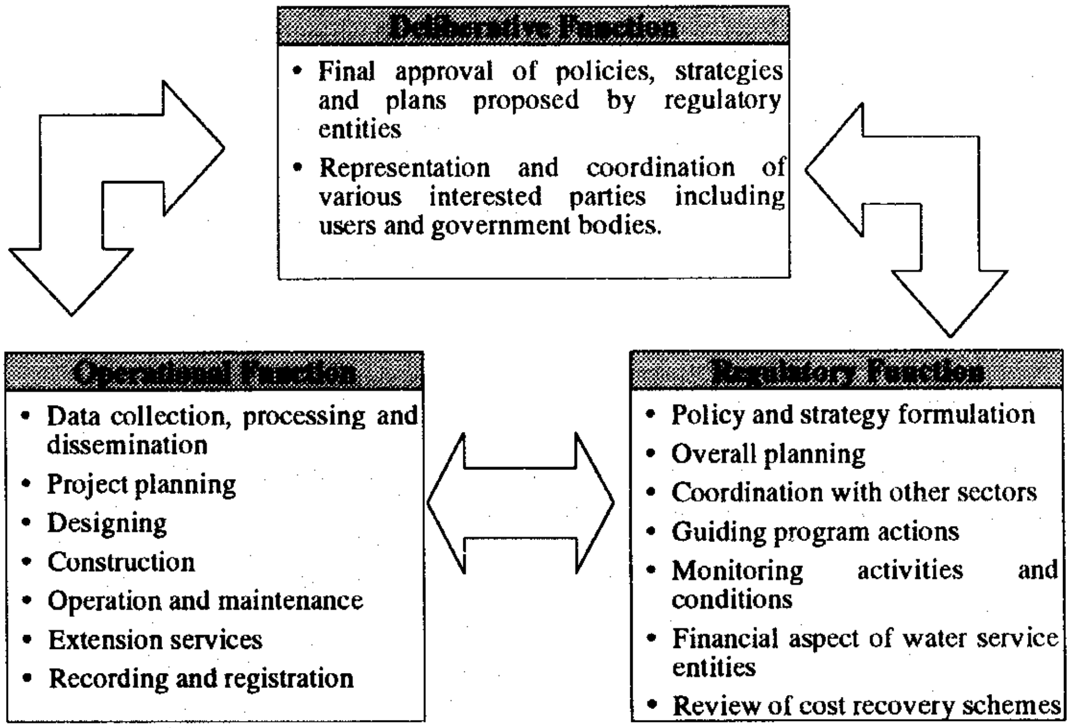
In the case of a drainage basin spreading over more than 2 municipalities, the state government has to manage the drainage system. In this case, SEIN is the executive agency and SEPLANDES is responsible for decision-making. In 1999, the SRH was newly created through State Law No. 11416, 17th of January 1997. The SRH is also responsible for flood control and stormwater drainage from the viewpoint of water resources management.

As stipulated in the 1988 federal constitution, the federal government manages drainage basin spreading over more than one state. However, the study area of the RMR has no rivers within this situation.

2.10.2 Institutional Functions

(1) Functional Structure of Water Sector Organization

In general, the governmental actions have three basic functions. They are deliberative, regulatory and operational functions. In the water sector, they work to improve overall water system management. The details of the respective functions and their relations are illustrated as follows.



1) Function of Deliberative Organization

The deliberative organization gives final approval to policies, strategies and plans proposed by regulatory entities. Its activities are based on legal fairness and response to changing conditions of the country. It includes policies of water system management, water resources management, formulation of basic regulations and authorization processes, and funding of basic programs and projects. Their final decisions should represent and coordinate the various stakeholders, community organizations and government bodies in their territory. Thus, the deliberative function is generally exercised through a board, council or committee.

2) Function of Regulatory Organization

The regulatory organization creates the framework for guiding program actions and monitoring results in conformity with certain objectives, particularly in the environmental area. It includes monitoring activities and conditions in the territories, and enforcing laws, regulations, and agreements on specific-purposes concerning water affairs. It covers

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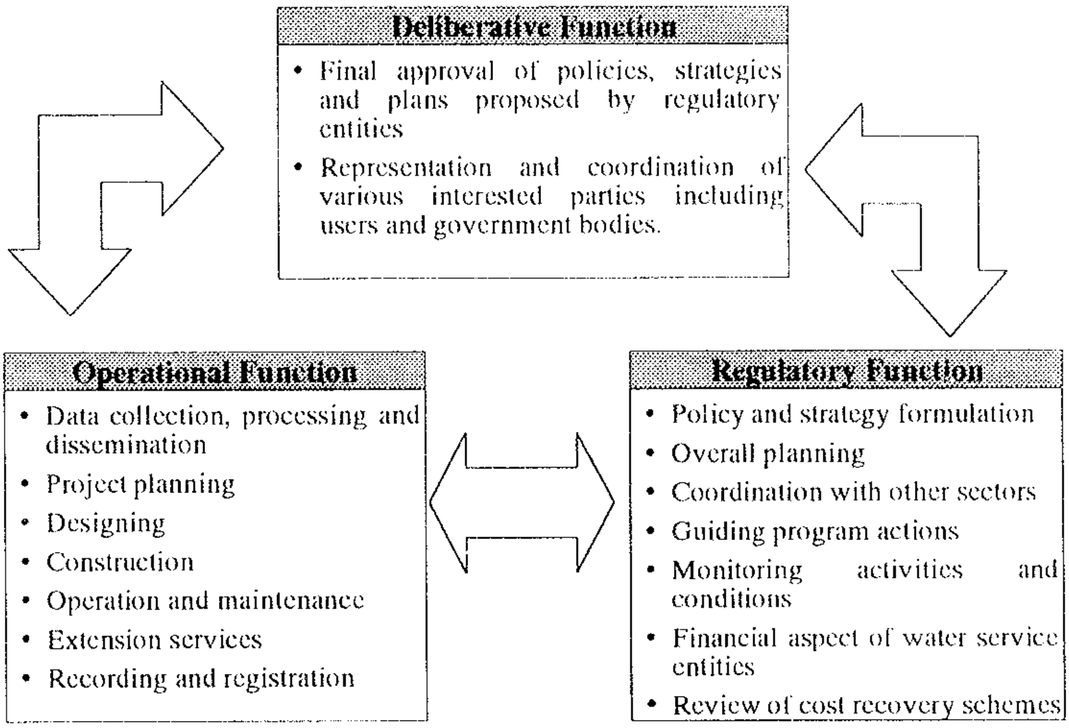

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2) Function of Regulatory Organization

The regulatory organization creates the framework for guiding program actions and monitoring results in conformity with certain objectives, particularly in the environmental area. It includes monitoring activities and conditions in the territories, and enforcing laws, regulations, and agreements on specific-purposes concerning water affairs. It covers leadership of water and sewerage service management, and controlling the agencies concerned with water affairs. It aims to collect and provide useful information regarding water and sanitation and on appropriate water and sewerage service charges. Monitoring water quality, and observing environment impacts brought about by water users and effluent discharges are also its responsibility.

3) Function of Operation Organization

The operation organization deals with planning, design, construction, and O&M activities. In addition, it carries out data collection, processing and public relations related to water affairs, registration of water users and effluent dischargers, and sewerage and water supply connection services. The primary activities of the operation organization are prescribed by the deliberative body. Operation organizations deal with the activities undertaken to utilize and manage water resources. Governmental agencies carry out these operational activities in most countries.

(2) Arrangement of Existing Organizations

In the State of Pernambuco the responsibilities for the three functions in terms of water and sanitation management are allocated to the following organs.

	Deliberative	Regulatory	Operational
Water Supply	(SEPLANDES)	SEIN (ARPE)	COMPESA
Sewerage Treatment	(SEPLANDES)	SEIN (ARPE)	COMPESA
Stormwater Drainage	(SEPLANDES)	SEIN (ARPE)	Municipal Government
Refuse Collection	(SEPLANDES)	SEIN (ARPE)	Municipal Government

Note: ARPE is being established following the publication of a State Law.

Currently, the sewerage services in the RMR and other urban areas are managed by COMPESA, which functions as an operational organ in the State. COMPESA is subordinated to SEIN, which, in turn, functions as a regulatory organ for sewage treatment as well as water supply.

At the beginning of 2000, ARPE (Agência Estadual de Regulação dos Serviços Públicos Delegados do Estado de Pernambuco - *State Agency for the Regulation of Delegated Public Services in the State of Pernambuco*) was established by state law (N° 11742, January 15, 2000). It is an autonomous body financially, functionally and administratively. It is directly connected with the Cabinet of the Governor, and is independent of the state secretariats. It was created to carry out the following functions in the State:

- To promote the economic and technical efficiency of delegated public services so as to provide a regular, continuous, safe, modern service at reasonable cost over a wide area. (Art. 2/I)
- To protect users against abuse of economic power. (Art. 2/II)
- To propose tariffs to the entity which grants concessions. (Art. 4/I)
- To enforce state legislation with respect to delegated public services. (Art. 4/II)
- To advise on tenders and contracts with delegated companies (Art. 4/III and IV)
- To arbitrate in cases of conflicts and provide information to interested parties (Art. 4/VI and VII)
- To inspect all aspects of the entity holding a concession (Art. 4/X)
- To prepare a budget for services, to be included in State Budget. (Art. 4/XIV)

ARPE is embodied by the state decree (N° 22184, April 12, 2000) under state law. It is composed of a board of directors, a council and a judiciary. Under the board of directors, the following posts are organized: cabinet, judicial advisory, administrative/financial department, public relations department, and four management departments covering energy, communication, transport, sanitation and refuse collection. The council consists of nine councilors. The judiciary has an arbitrator who deals with complaints from the public.

ARPE is expected to function, in the place of SEIN, as a regulatory body for public infrastructure services including the sewerage system in the state in the near future. However, the establishment of ARPE is still under discussion in the governor's office. At present, the alternative models of delegation of sanitation services are being studied with the support of BNDES. In a short time, ARPE will propose appropriate models for sanitation services in the State. The form of privatization is one of the alternatives for the present managing entities in public infrastructure services. Thus, there is no clear formulation of institutional functions at the moment.

Part of the deliberative functions in the State is carried out by SEPLANDES at present. It functions in the fields of policy formulation, strategies and global planning, including the preparation of master plans. In the RMR, CONDERM (Conselho de Desenvolvimento da Região Metropolitana do Recife - *Recife Metropolitan Region Development Council*) is legally established to carry out the same functions. They foster the interest of citizens in public sector activities through public hearings and meetings, thus promoting public participation in the formulation of policy and planning.

2.10.3 Financial Conditions

(1) Federal Government

In 1997, the government spent around R$ 9.9 billion on capital investment. It accounted for 2.2% of total expenditure and 2.5% of the total fiscal revenue. Of the total investment, R$ 4.2 billion was transferred to local governments and public corporations throughout the country. Meanwhile, the debt service, i.e., interest and principal payments amounted to R$ 249.1 billion, accounting for 58 % of the total expenditure.

(2) State Government

In 1999, the State Government spent around R$ 517 million on capital investment. This accounted for 11.7 % of total expenditure. Meanwhile, the debt service amounted to R$ 597 million, accounting for 13.5 % of the total expenditure.

However, the financial statements of the state government show a performance very different from the budgets. The total expenditure recorded considerably smaller amounts than the budgetary expenditures. Their ratios were: 66 % in 1995, 69 % in 1996, 55 % in 1997 and 86 % in 1998. In terms of expenditure for capital investment, the actual amounts were R$ 37 million or 1.7 % of the total expenditure in 1995, R$ 44 million or 1.6 % in 1996, R$ 27 million or 1.3 % in 1997, and R$ 21 million or 0.5 % in 1998. These investments were also only 4 %, 7 %, 5 % and 4 % of the budget amounts, respectively.

SEIN is the secretariat responsible for infrastructure in the state. The total expenditure amounted to R$ 142 million. Of the total expenditure of R$ 192 million in 1999, SEIN allotted the following amounts;

- For sewerage systems: R$ 64.8 million or 46 % of the total expenditure
- For stormwater drainage: R$ 2.1 million or 1.5 % of the total expenditure

(3) Municipal Governments

In 1997 the municipalities of the RMR altogether had a surplus of around 2 % of their total income. However, if analyzed separately, it can be seen that only Recife, Cabo and Olinda had a surplus and the other 11 municipalities had deficits. The total expenditure of the 14 municipalities accounted for 20 % of the actual state expenditure in 1997.

Over the years, Recife has made an effort to modernize its administration; up-dating property records in terms of building types and uses, as well as adopting measures to reduce defaulting of municipal taxes. The percentage of municipal taxes to the total revenue including transfer payment from both the federal and state governments was raised to 4.5 % in 1996, from 1.7 % only in 1991. Significant improvement in income was attained as a result.

(4) COMPESA

COMPESA is the public enterprise in charge of sewerage services in the state, as mentioned before. Table 2.10-1 shows its operating performance during the three years from 1995 to 1997. It treated 65million m^3 of sewage in 1997, which was collected from 275 thousand units.

The financial statements of COMPESA for the three years from 1995 to 1999 are shown in Table 4.8-1. The statements show that COMPESA recorded a small profit, in 1995 and 1997. In recent two years, the statements recorded serious losses, due to a long period of dry weather. Therefore, the income from water supply dropped down from R$ 199 million in 1998 to R$ 144 million in 1999. The income from sewerage services was almost a quarter of that from water supply.

Table 2.10 - 1 Business Performance of COMPESA: 1995 to 1997

Item	Water Supply			Sewerage Services		
	1995	1996	1997	1995	1996	1997
Number of Connections						
Residential	926,321	941,175	956,299	132,975	137,918	157,943
Comercial	40,556	40,148	40,953	11,256	11,085	13,940
Industrial	3,410	3,356	3,414	672	624	754
Public	8,130	8,187	8,449	901	909	1,023
Total	978,417	992,866	1,009,115	145,804	150,536	173,660
Number of Consumption Units						
Residential	1,103,699	1,114,524	1,126,390	224,368	224,183	243,131
Comercial	62,285	62,276	64,140	24,725	25,342	30,153
Industrial	3,866	3,803	3,861	770	717	864
Public	8,568	8,621	8,898	941	952	1,093
Total	1,178,418	1,189,224	1,203,289	250,804	251,194	275,241
Average Number of Consumption Units per Connection						
Residential	1.2	1.2	1.2	1.7	1.6	1.5
Comercial	1.5	1.6	1.6	2.2	2.3	2.2
Industrial	1.1	1.1	1.1	1.1	1.1	1.1
Public	1.1	1.1	1.1	1.0	1.0	1.1
Total	1.2	1.2	1.2	1.7	1.7	1.6
Volume Processed (1000 m^3 per year)						
Residential	184,039	188,268	199,036	47,965	48,617	52,224
Comercial	16,959	17,329	16,338	8,033	8,352	8,525
Industrial	3,868	4,427	4,645	790	714	649
Public	9,823	10,034	10,384	3,545	3,329	3,496
Total	214,689	220,058	230,403	60,333	61,012	64,894
Average Volume per Consumption Unit (m^3 per unit per month)						
Residential	13.9	14.1	14.7	17.8	18.1	17.9
Comercial	22.7	23.2	21.2	27.1	27.5	23.6
Industrial	83.4	97.0	100.3	85.5	83.0	62.6
Public	95.5	97.0	97.2	314.0	291.4	266.5
Total	15.2	15.4	16.0	20.0	20.2	19.6

Source: PQA, Documento Estrategico de Investimentos, 1999, SEPLANDES

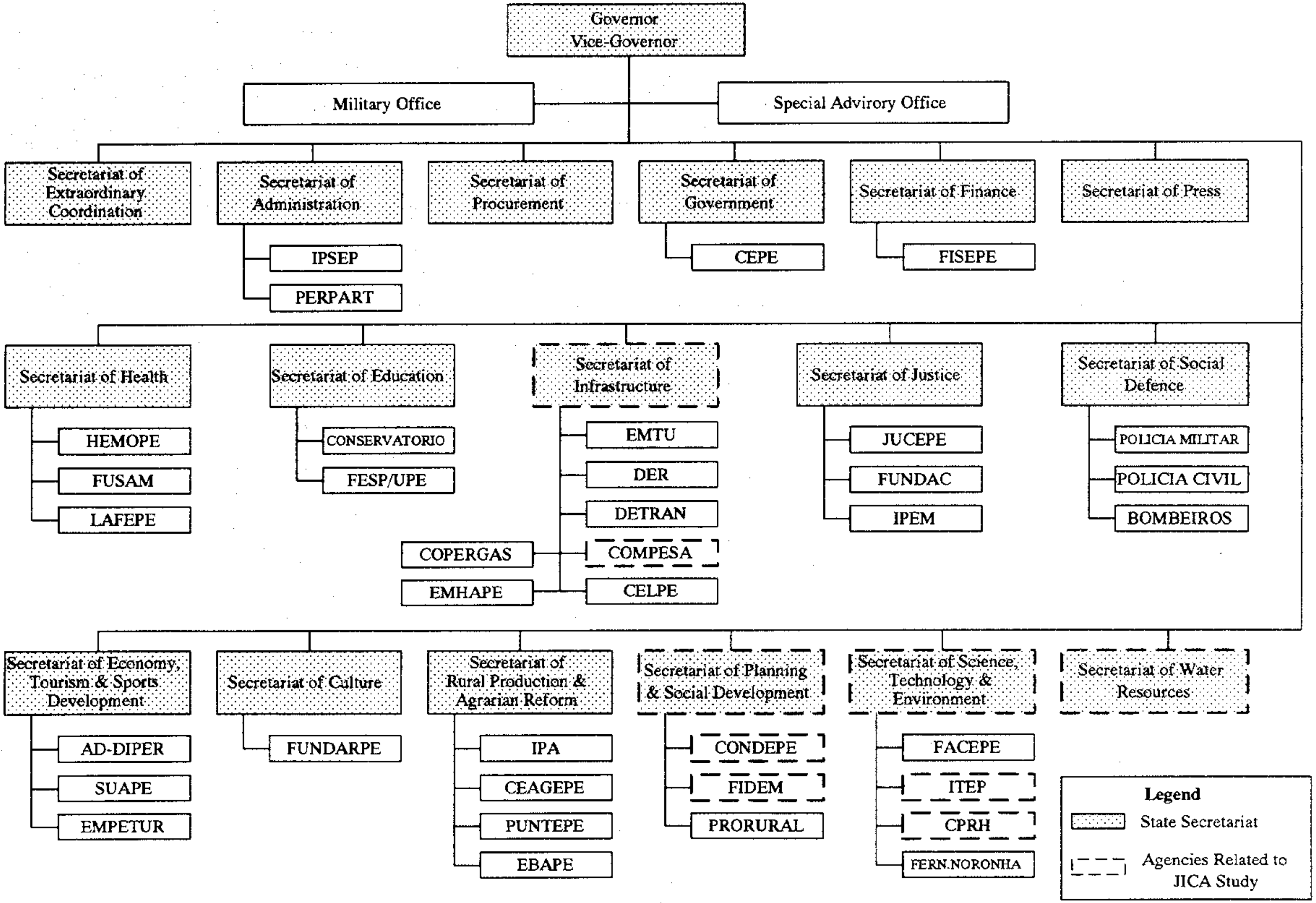


Fig. 2.10-1 Organizational Diagram of Pernambuco State Government

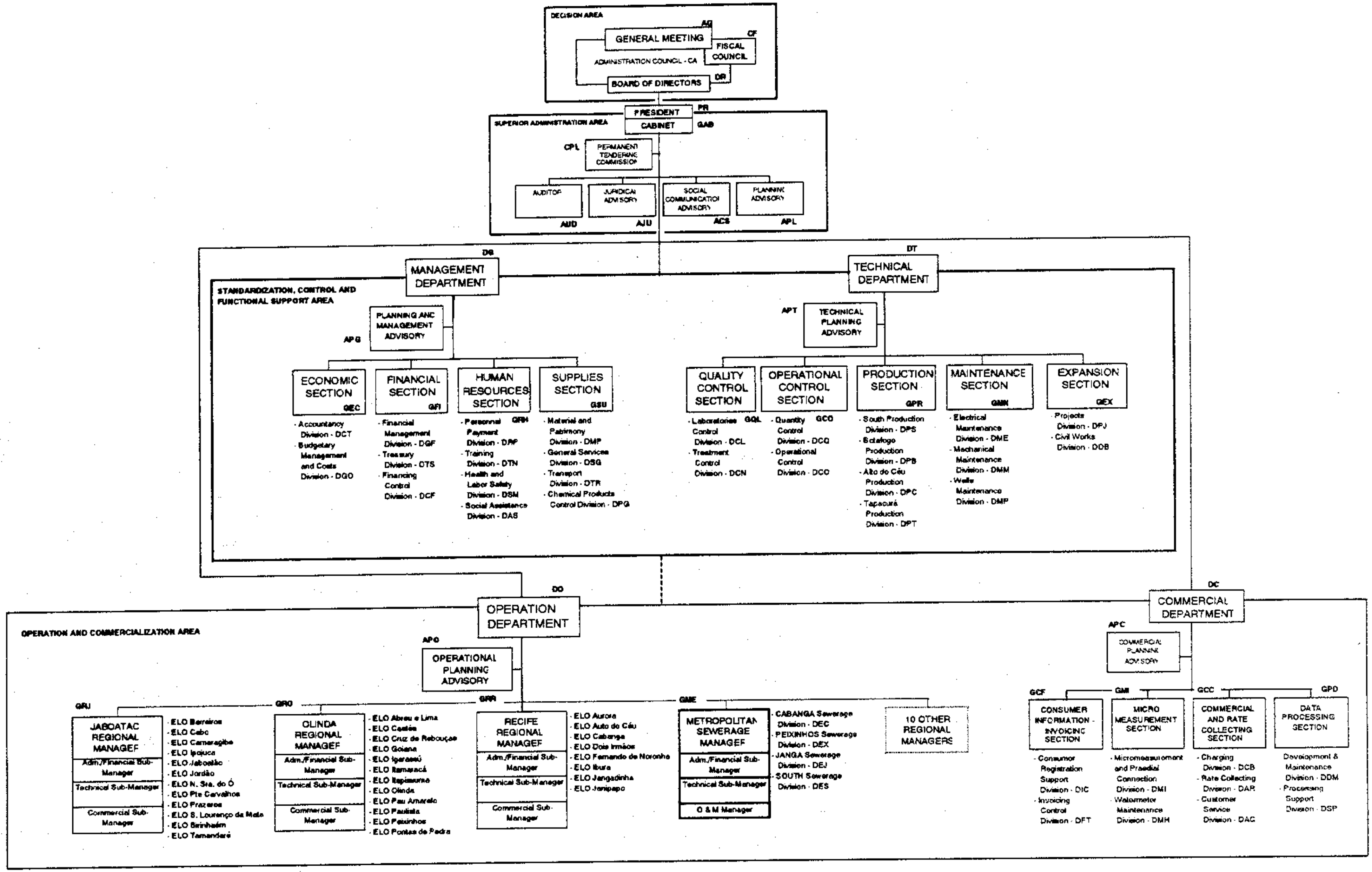


Fig. 2.10-2 Organizational Diagram of COMPESA

2.11 Major Issues

The water quality of the rivers and channels located in the central part of the RMR has deteriorated due to the wastewater from the urban areas, causing not only social problems but also economic problems. The present conditions of the aquatic environment have been assessed on the bases of the PQA and the supplementary data and information collected during the Study. The measures required for the improvement of stormwater drainage and wastewater management in the RMR are summarized as follows:

1) Early implementation of urgent measures:

In order to improve the aquatic environment of the RMR, measures and actions necessary for improvement of the environmental conditions should be studied. It is important for the RMR to make an effort to implement urgent measures in at early stage in order to improve the existing environmental situation. Since the 1980s little investment has been made in sewerage management, comprising only the rehabilitation and extension of the existing systems and the current investment in the sewerage sector. As a result, little has been done to maintain a favorable environment to keep pace with the rapid increase in population in the RMR.

2) Improvement of routine O/M activities:

It is necessary to improve routine operation and maintenance (O/M) activities that enable the appropriate actions to be invested in for the rehabilitation of the existing sewerage facilities and for the development of new sewerage systems. It is necessary for the COMPESA to establish routine O/M activities for the management of the sewerage systems. This will require basic tools such as detailed record of facilities and O&M manuals.

There are many existing facilities, which are not working or not fulfilling their original functions. This is most likely due to insufficient budget allocations and lack of proper O&M activities. A large volume of collected sewage is being discharged into rivers and channels without adequate treatment due to damage to sewers and the breakdown of pumping facilities and treatment plants. This is accelerating the deterioration of the urban environment.

3) Establishment of a sludge removal, treatment and disposal system:

It is necessary to establish a system for sludge removal, treatment and disposal. Currently about three quarters of the urban population rely on septic tanks to dispose of their wastewater. Most of the septic tanks seem to be malfunctioning and discharging their effluents into rivers, channels or the soil. This is accelerating the deterioration of surface water and also contaminating groundwater. The RMR should establish a system to remove, treat and dispose of sludge from on-site treatment facilities as soon as possible so that further deterioration of water can be kept to a minimum until the Master Plan is completed, and a public system is provided.

4) Full consideration of the measures proposed by the PQA

The proposed condominial sewerage system and RAFA sewage treatment process are to be studied in terms of their applicability.

The condominial sewerage system seems to be an economical and effective sanitary system for the expansion of the sewerage service area of the RMR, and many sewerage systems have been constructed in poverty areas. However, it is necessary for the RMR to establish a method of public participation to avoid any problems during the planning, construction and O&M of the systems.

The PQA proposed RAFA as the main process of sewage treatment, because it is easy to manage and less expensive. The RAFA process of anaerobic treatment is already efficiently utilized in seven treatment stations in the RMR, supported by technical aid from the State University of Pernambuco. It is necessary to carry out a technical study on its applicability as a sewage treatment process for the priority sewerage systems.

5) Installation of automatic rain gauges in the RMR

There are thirty (30) rainfall monitoring stations in the RMR that record daily rainfall at a fixed time of 7:00 A.M. The stormwater drainage facilities proposed in the PQA are based on the analyses on the daily rainfall data. However, it would be better to plan drainage facilities based on the analyses of the rainfall data of short duration (10 min, 30 min, 60 min and 120 min etc) for many years, considering the comparatively small size of the drainage basins. It is necessary to install at least three automatic rain gauges and to start observation of the rainfall of short duration as soon as possible.

6) Preparation of basic data for planning river and drainage channels

In the Study Area there are some flood hazard areas and river improvement will be required. It is especially serious in the Beberibe and the Jaboatao River basins, because of small hydraulic gradients and hydraulic conveyance capacities. For an effective river and stormwater drainage improvement plan, the RMR would be required to prepare more detailed data and information, including river cross sections and hydrological data for major floods.

7) Required development study

For the improvement of urban environmental conditions in the RMR, various development studies are required, including the following.

- River basin management for selected rivers in the RMR,
- Water resources management for the RMR,
- Solid waste management plan for the RMR based on PQA proposals.

CHAPTER 3

MASTER PLAN

CHAPTER 3 MASTER PLAN

3.1 Basic Concept

In the RMR the water related diseases are of considerable significance as causes of both sickness and death, causing large social costs in terms of human health. In order to improve the water environment, it will be required to get restoration of the water quality in rivers and water bodies in the RMR.

The Study is to propose a Master Plan for improvement of the stormwater drainage and sewerage management in the RMR and to select optimum urgent measures as priority projects for F/S. For formulation of the Master Plan the following points are considered:

1) For improvement of the water quality, preventive measures will be required to reduce the pollution loads discharged to the rivers and other water bodies. The preventive measures studied are as follows:

   - Improvement and extension of the existing drainage and sewerage systems,
   - Execution of proper O/M activities for the drainage and sewerage facilities,
   - Execution of proper sludge management (removal, treatment and disposal),
   - Control of the effluent discharge from industries into the water bodies, and
   - Promotion of people's participation in environmental improvement.

2) The stormwater drainage and sewerage improvement plans studied in the PQA are considered in principle.

3) For reduction of the flood damage and for restoration of the river water quality, the following structural and non-structural measures are considered.

   Structural measures:

   - Rehabilitation and extension of the existing sewerage facilities to improve the service level of the existing sewerage system in the RMR
   - Improvement of the stormwater drainage facilities for the critical flood areas identified in the municipalities of Recife, Jaboatao and Olinda to reduce the flood damage in the RMR.

   Non-structural measures:

   - Water quality control through regular monitoring of the river water quality,
   - River basin management for the major rivers in the RMR,

- Promotion of environmental education, sanitary guidance with emphasis on preventive measures.

4) Priority Projects for F/S were selected from the sewerage projects from technical and environmental aspects. However, sewerage projects in the Beberibe River Basin are not considered because the Beberibe river basin have already been selected as a project, Pro-Metropole (Project of Infrastructure in Low-income Areas of the RMR), financed by the World Bank. It included improvement of the infrastructures such as drainage, sewerage, water supply, etc.

5) The projects proposed in the Master Plan are scheduled to be completed by 2020 through two phases.

   - Phase 1 (From 2001 to 2010)
   - Phase 2 (From 2011 to 2020)

6) For implementation of the Master Plan, a Project Management Unit (PMU) is studied as an implementation organizations to conduct the following:

   - to give general support for the related organization to arrange budget, manpower, training and others in need,
   - to prepare D/D and tender documents, and tendering for implementation of the project,
   - to supervise the construction works, and
   - to develop human resources for implementation of the Master Plan.

7) SEPLANDES is considered as a general coordination organization to take responsibilities in general for implementation of the Master Plan, including establishment of the PMU.

8) Some development studies are to be considered for further improvement of the environmental conditions of the RMR.

3.2 Framework for Target Year 2020

3.2.1 Population Projection

The Brazilian Institute of Geography and Statistics Foundation (IBGE) provides population projections for the country up to the year 2020 in the yearbook, "Anuário Estatístico do Brasil 1997". It does not indicate any projections of subdivisions such as state, municipality or district. According to this projection, the population in Brazil is projected to increase as follows: 166 million in 2000, 188 million in 2010 and 208 million in 2020. Since Brazil had a population of 157 million in 1996 according to the diagonal census of population, it will have 51 million or one-third more by 2020.

The population in the study area was projected in the PQA reports. The report estimated the future population using a mathematical model for the respective municipalities in the RMR. In the model, the growth rates of the respective municipalities were calculated applying an inferior asymptote. To set the plausible growth rates, the report uses a program called "People". The results of the population projection in the RMR are tabulated up to the year 2020 at 10-year intervals in the following table.

Municipality	Population (1000)				Average Growth Rate (%)		
	1996	2000	2010	2020	'96/'00	'00/'10	'10/'20
Abreu e Lima	72.7	74.4	77.8	80.8	0.6	0.5	0.4
Araçoiaba	10.2	11.0	13.0	15.0	1.9	1.7	1.4
Cabo de Santo Agostinho	125.1	135.0	159.9	186.9	1.9	1.7	1.6
Camaragibe	111.1	120.3	142.1	163.8	2.0	1.7	1.4
Igarassu	65.2	73.8	98.8	130.0	3.2	3.0	2.8
Ipojuca	30.4	34.4	44.5	55.5	3.1	2.6	2.2
Itamaracá	11.2	12.8	17.8	24.6	3.4	3.3	3.3
Itapissuma	16.1	17.7	21.7	26.0	2.4	2.1	1.8
Jaboatão dos Guararapes	457.7	487.3	553.9	616.7	1.6	1.3	1.1
Moreno	32.1	32.3	33.0	33.6	0.2	0.2	0.2
Olinda	349.3	355.1	367.0	377.8	0.4	0.3	0.3
Paulista	229.5	248.4	292.9	337.2	2.0	1.7	1.4
Recife	1,346.0	1,376.5	1,444.0	1,505.8	0.6	0.5	0.4
São Lourenço da Mata	78.8	83.2	94.6	107.0	1.4	1.3	1.2
RMR Total	2,935.4	3,062.2	3,361.1	3,660.1	1.1	0.9	0.9

Source: PQA, Documento Estratégico de Investmentos, Sept. 1999, SEPLANDES

Population projections have been presented in several official development plans. These plans are listed also in the PQA Final Report as references. "Documento Estrategico de Investmentos (Final Investment Scheme), September 1999, SEPLANDES" described their outlines. In this current study, the population projection for the target year 2020 is formulated referring to the PQA. The future population in the study area is shown in the table above.

The population of the RMR was estimated at 3.66 million for the target year 2020. It has grown at a rate of 1.1% on average between 1996 and 2000, and at 0.9% between 2000 and 2020. The core towns of the RMR, Recife and Olinda, are set to grow at the comparatively low rates of 0.6% to 0.3% as shown in the table.

3.2.2 Land Use

Future urban growth is expected and imposes restrictions on the protection of water resources, the protection of estuaries and ecological reserves, and on risk areas such as landslide and flood prone areas. The expansion of urban areas was delineated based on the following hypotheses in the PQA report.

1) By 2020 the limits of urban growth will not pass beyond the permitted areas or the urban limits.
2) In municipalities where their limits of population density have already been reached, urban areas will not expand – only increase in density. (Recife and Olinda)
3) In municipalities where limits have not been reached, population increases will be absorbed at the outskirts of existing urban areas at the same density.

The urban areas in the PQA were established by reviewing the previous Metropolitan Development Plan (PDM) of 1983 and the land use plan of the City of Recife. During the preparation of the PQA in 1997, land use plan was being drawn up for the cities of Olinda and Cabo. Other cities do not have land use plans. The urban area of the RMR is 316.61 km^2 and 364.25 km^2 in 1997 and 2020 respectively.

1)	Total urban population	3.6 million inhabitants
2)	Urban area	364 km^2

3.2.3 GRDP Projection

The long-term projection of the GRDP is indispensable for formulating the future framework of socio-economic structure in the study area. However, the official GRDP projection is not available. At present, the national development plan named "Plano Plurianual 2000-2003, Orçamentos da Uniao 2000" is available as of December 1999. It proposes a target growth of around 4.6 % per annum on average for the planning period. The plan, however, presents the projections only until the year 2003. After that, no projection scenarios have been suggested in any of the existing development plans. Therefore, the GDP and GRDP in the future are estimated on the following assumptions.

(1) Until the year 2003, the GDP will increase at the growth rates predicted in the national plan.

(2) Beyond the year 2003, the growth rates were assumed to slow down to the following pace. Until the year 2010, 4.4% growth was set referring to the World Bank report on "Global Economic Prospects 1998/99". For the final decade between 2011 and 2020, three-quarters (3.3%) of the previous growth rate was assumed to apply.

(3) The GRDP of the state will increase at a 1.2 times higher rate than the GDP growth after 1999, referring to the performance of GRDP growth in the State of Pernambuco from 1994 to 1997.

The GRDP projected with the above assumptions are shown in Table 3.2-1. By 2020, the GRDP of the state will reach R$ 65 billion at 1997 constant prices. It will be 2.8 times of that of 1997 (R$ 23.26 billion). Thus, the growth rate will be 3.2 % in 2020, which is larger than the rate (2.7 %) in 1997.

The GRDP per capita in 2020 was calculated as R$ 7,600 at 1997 constant prices, as shown in the table. It was 2.4 times that of 1997 (R$ 3,100). It will be 79 % of the national average, which is larger than that of 1997 (58 %). Thus, the regional disparity may diminish and living standard may get closer to the national level in this period.

Table 3.2-1 GDP and GRDP Projection at 1997 Constant Prices: 1998 to 2020

Item	1997*1	1998	1999	2000	2003	2010	2020
1. GDP and GRDP Projection (R$ Billion at 1997 Constant Prices)							
1) Brazil	864.11	863.25	896.05	931.89	1,073.65	1,451.32	2,008.02
2) Pernambuco	23.26	23.52	24.59	25.77	30.52	43.81	64.85
Growth Rate (%/annum)			Four -Year Plan 2000-2003				
			1999	2000	2001	2002	2003
1) Brazil	3.60	-0.10	3.80	4.00	4.50	5.00	5.00
	3.52 (Average Growth Rate Between '94 & '97)						
						After the Year 2003*2	
						--2010	--2020
						4.40	3.30
2) Pernambuco*2	3.40	1.10					
	4.23 (Average Growth Rate Between '94 & '97)						
			Projection of GRDP Growth *3				
			1999	2000	2001	2002	2003
			4.56	4.80	5.40	6.00	6.00
						After the Year 2003	
						--2010	--2020
						5.30	4.00
	1997*1	1998	1999	2000	2003	2010	2020
2. Population Projection (1,000)							
1) Brazil	159,636	161,790	163,948	166,113	172,359	187,862	207,697
2) Pernambuco	7,455	7,567	7,738	7,623	7,760	8,087	8,537
3. Per Capita GDP and GRDP (R$)							
1) Brazil	5,413	5,336	5,465	5,610	6,229	7,725	9,668
2) Pernambuco	3,120	3,108	3,178	3,380	3,933	5,417	7,596
4. Ratios of Per Capita GRDP to GDP (%) *3	58	58	58	60	63	70	79
5. GRDP by Major Economic Sector at 1997 Constant Prices							
1) Agriculture	2.14	2.21	2.25	2.29	2.48	2.88	3.07
2) Industry	7.67	7.24	7.44	7.66	8.57	10.70	12.70
- Manufacturing	3.88	4.06	4.17	4.29	4.80	5.99	7.11
3) Services	13.46	14.06	14.90	15.82	19.46	30.23	49.08
- Hotel & Restaurant	0.90	0.92	0.96	1.01	1.20	1.73	2.50
6. GRDP Growth Rate (% per annum)							
1) Agriculture	-	-	1.6	1.8	2.7	2.1	0.6
2) Industry	-	-	2.7	2.9	3.8	3.2	1.7
- Manufacturing	-	-	2.7	2.9	3.8	3.2	1.7
3) Services	-	-	6.0	6.2	7.1	6.5	5.0
- Hotel & Restaurant	-	-	4.8	5.0	5.9	5.3	3.8

Source: Plano Plurianual 2000-2003, Orcamentos da Uniao 2000, 1999, GOB, MPO
Anuario Estatistico do Brasil 1996, 1997, IBGE
Global Economic Prospects, 1998/99, The World Bank

Note: *1 Actual Performance
*2 The economic growth rates in the country are assumed as follows:
Beyond 2003, 4.4% per annum referring to "Global Economic Prospects"
Between 2011 and 2020, three-quarters of the previous growth during 2004-2010.
*3 The economic growth rates of Pernambuco State are assumed to continue 20% higher than the national one, referring to the ratio of average growth between 1994 and 1997.
Accordingly, the disparity between the national average and the state average will shrink, as the ratio of per capita GRDP to GDP will increase from 58% in 1997 to 79% in 2020

3.3 Sewerage

3.3.1 General

During the Study, the PQA, which were studied for about three years and completed at the end of 1999, were reviewed through fieldwork and analyses of supplementary information.

The major pollution sources in the RMR are municipal sewage in the central part of the RMR. This sewerage study, therefore, is focused on the necessary measures to improve the municipal sewerage systems by the target year of 2020 and the identification of priority projects or urgent measures for a Feasibility Study.

3.3.2 Basic Conditions and Criteria

(1) Basic Conditions for Planning

The basic policies of the PQA, in which "Decentralization" and "Condominial Systems", are important policies in the sewerage plan, decided after a long-term study on local conditions are followed by the Study.

The "Decentralization" is to make each sewerage system to be small and:

- to save the construction cost of pipes, because they are shallower and shorter than a centralized system in general,
- to minimize the risk of accident or failure of the sewerage systems by making each system small, and
- to facilitate investment in sewerage.

The "Condominial Sewerage System" is closely related to "Decentralization" and is outlined as follows:

- It is a system to treat a block of houses as a horizontal apartment building.
- Collection of wastewater is through sewers within the house lots, where sewers are shorter and shallower than conventional ones, resulting in the lowering of costs by 20 to 30 %,
- The population is actively involved in construction and in O&M.

The PQA proposed to apply this system mainly in poverty areas, which have about a half of the population of the RMR.

(2) Planning Conditions

The planning conditions for the Master Plan have been decided based on the discussions with SEPLANDES, COMPESA and other related agencies as follows:

1) Target Area

The target area for the Master Plan is the urban area of the RMR. This Master Plan aims to propose measures to improve the water quality of rivers and water bodies in the urban area in order to restore the urban environment of the RMR. Rehabilitation of the existing sewerage facilities and construction of new sewerage facilities in order to reduce the pollution loads from the urban area realize this.

2) Future Land Use

The previous Metropolitan Development Plan (PDM) of 1983 and the land use plan of the city of Recife have been reviewed. The urban area was 316.61 km^2 in 1997 and projected to be 364.25 km^2 for 2020. During the study of the PQA in 1997, the land use plans for Olinda and Cabo Cities were still under preparation, but other cities have no land use plan.

The land use plan for the year 2020 projected in the PQA-RE is adopted in the Master Plan, however, the latest land use plan of the cities of Olinda and Cabo de Santo Agostinho are to be confirmed and revised, if necessary.

3) Future Population

The future population of 2010 and 2020 projected after reviewing the PDM is applied in the Master Plan. Present and future urban areas and population by municipality are shown in the following table.

Population and Urban Area in 1997 and 2020

Municipality	1997		2020	
	Area (km^2)	Population	Area (km^2)	Population
Abreu e Lima	10.94	73,113	11.84	80,835
Aracoiaba	0.83	10,289	1.18	15,007
Cabo	11.87	128,360	15.75	186,896
Camaragibe	23.02	113,622	29.12	163,760
Igarassu	12.36	54,874	17.61	104,140
Ipojuca	8.86	31,605	11.01	55,472
Itamaraca	6.30	11,826	12.56	24,639
Itapissuma	1.75	16,504	2.48	26,031
Jaboatao	44.82	465,708	54.71	616,734
Moreno	4.16	32,162	4.33	33,638
Olinda	26.42	350,999	26.48	377,825
Paulista	30.89	234,144	38.32	337,248
Recife	117.61	1,355,817	117.61	1,505,771
Sao Lourenco da Mata	16.87	80,358	21.25	107,044
RMR	316.61	2,959,381	364.25	3,635,040

A further breakdown of population and urban area is shown in Table 3.3-1.

4) Industrial Wastewater

Large-scale industrial wastewater (discharge of more than 500 m^3/month) is controlled by the CPRH and separated from the municipal sewerage system in the Master Plan as proposed in the PQA.

5) Unit Volume of Wastewater

The PQA proposed the unit water consumption for four (4) categories (ELO districts) depending on their socio-economic activities, which will affect wastewater volume. Unit volume of wastewater for each category is obtained by multiplying water consumption by an empirical coefficient of 0.8. Proposed water consumption and wastewater volumes are shown below.

Proposed Water Consumption and Wastewater Discharge

ELO District (LINK) (Management District of COMPESA)	Wastewater Discharge (liter/capita)			Daily Water Consumption (liter/capita)
	Daily average	Daily maximum	Hourly maximum	
Cabanga, Alto do Céu, Aurora, Dois Irmãos, Prazeres, Pau Amarelo e Olinda	160	190	285	200
Jangadinha, Ipojuca, Nossa Senhora do Ó, Camela, Ponte dos Carvalhos, Pontezinha, Cabo, Abreu e Lima, Igarassú, Cruz de Rebouças, Nova Cruz, Itamaracá, Paulista, Peixinhos e São Lourenço da Mata	125	150	225	155
Ibura, Jenipapo, Jordão, Jaboatão, Moreno, Bonança, Vera Cruz, Caetés, Itapissuma e Camaragibe, Navarro, Paratibe, Jardim Paulista, Maranguape II, Araçoiaba, Cidade Tabajara, Nossa Senhora da Luz	110	130	195	140
ZEIS and Informal Areas	80	100	150	100

The PQA defined major consumers as ones (as a unit of water consumption) who used more than 500m^3/month of water. These consumers, such as large apartment buildings, small domestic plants, hotels and restaurants, are located in Recife, Olinda and Abreu e Lima and their wastewater is incorporated into domestic wastewater. These consumers and their daily water consumption are shown below.

Major Consumers and Daily Water Consumption

Municipality	Number of Consumers	Daily Consumption (m^3/day)
Recife	62	5,189
Olinda	4	142
Abreu e Lima	1	35
Total	67	5,366

Wastewater volumes for the major consumers are obtained by multiplying water consumption by an empirical coefficient of 0.8. The proposed total wastewater volume is 4,293 m^3/day (daily average).

Large-scale wastewater (discharge of more than 500 m^3/month) discharged from those major consumers has similar nature to domestic wastewater in terms of hourly discharge variation in volume.

Therefore, the design wastewater discharge is proposed to be calculated as follows:

- Daily maximum: Daily average discharge x 1.2
- Hourly maximum : Daily maximum discharge x 1.5

The total design wastewater volume was estimated by summing up the result from individual consumers and major consumers and also taking into account the ground water infiltration as well.

6) Design Infiltration of Groundwater

The volume of infiltration of groundwater from manholes and joints into sewers, were estimated to be 0.5 l/sec/km based on the Brazilian Sewerage Standard (NBR 9469/1986).

7) Pollution Load

As proposed in the PQA, unit BOD load for domestic wastewater of 54 g/capita/day, based on the Brazilian Sewerage Standard, was used for the Master Plan. The SS load of 60 g/capita/day was considered in the planning of sewage treatment, though it was not considered in the PQA.

3.3.3 Proposed Sewerage System

(1) Proposed Sewerage System for the whole Urban Area of the RMR

In the PQA the future urban area of the RMR was divided into 266 sewerage areas (UE) based on the following:

- Drainage basin for sewerage collection
- Topography
- Existing sewerage facilities and buildings

After combining the 266 sewage collection units, the PQA proposed 86 sewerage systems for the future urban area based on the following criteria:

- To avoid transporting sewage between drainage basins
- To use existing facilities as much as possible
- To minimize the total cost of construction and O&M of the sewerage facilities

The main features of the 86 sewerage systems are shown in Table 3.3-2 (1/3) to (3/3).

(2) Proposed Sewerage Systems for the Master Plan

During the Study the 86 sewerage systems proposed in the PQA were reviewed based on the following:

- Area with collection systems with no treatment facility.
- Area with large pollution load.
- Area with low-income population of more than 10,000.
- Area with population density of more than 30 persons per ha in 2020.
- Area without large public facilities such as airport or public zones.

The fifty-five (55) systems out of the 86 were selected for the Master Plan. Their basic conditions and main features are shown in Table 3.3-3.

Served population in 2020 will be 91 % of the total population. Main features of the Master Plan are as follows:

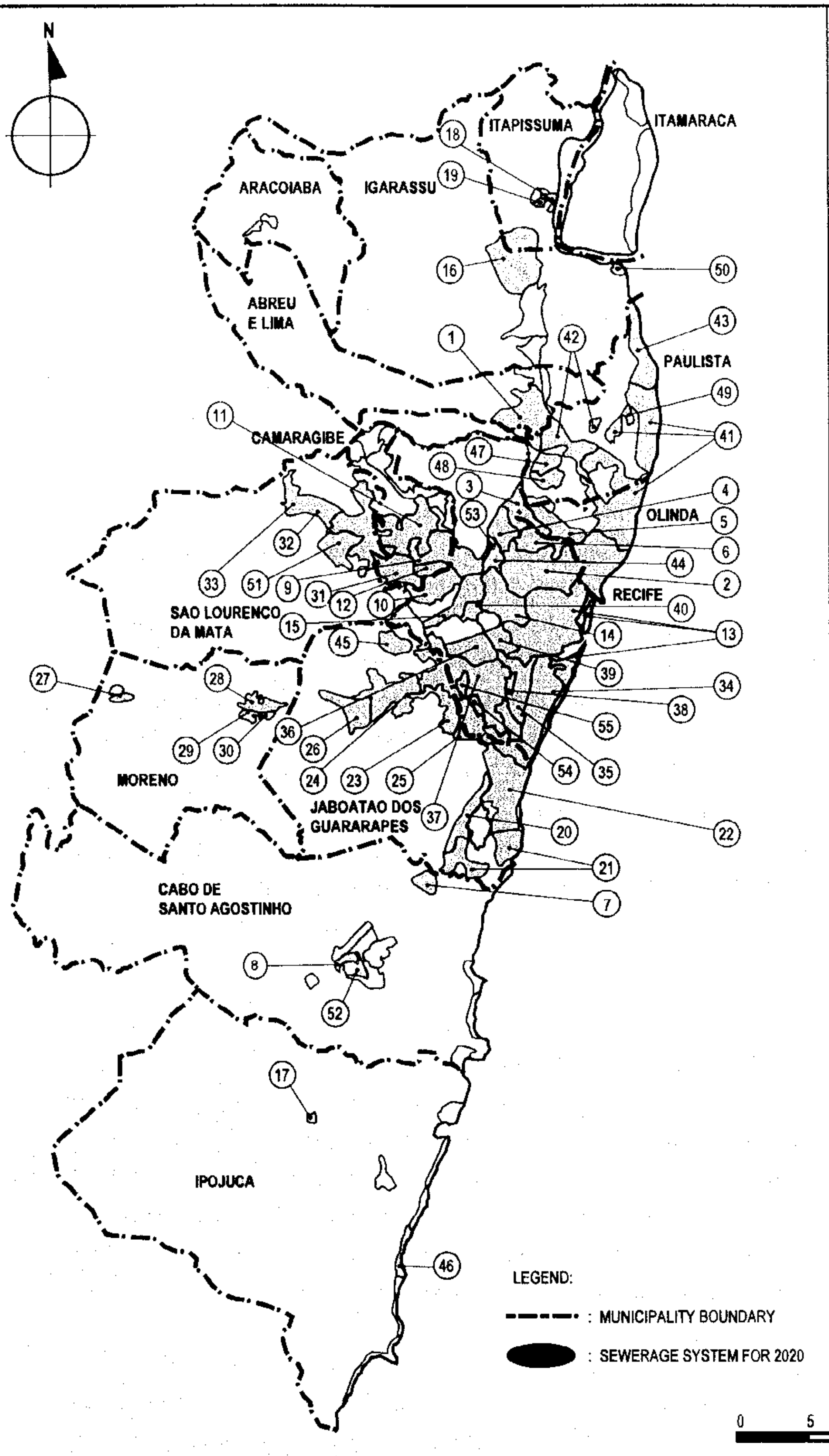
- Number of systems: 55systems
- Served population in 2020: 3.293 million

- Sewerage area in 2020: 29,985 ha (100%)
  1. New construction area 4,878 ha (16.1%)
  2. Expansion area 16,564 ha (55.3%)
  3. Area covered by existing system 8,516 ha (28.4%)

- Capacity of existing treatment facilities 210,102 m^3/day

- Sewage volume in 2020:
  1. Daily average 530,710 m^3/day
  2. Daily Max 611,682 m^3/day
  3. Hourly Max 852,970 m^3/day

The Location of Proposed 55 sewerage systems for the Master Plan is shown in Fig.3.3-1.



No	Sewerage Systems
1	Caetes
2	Peixinhos
3	Caixa D'Agua
4	Nova Descoberta
5	Aguazinha
6	Dois Unidos
7	Ponte dos Carvalhos
8	Charnequinha
9	Camaragibe / Recife 1
10	Camaragibe / Recife 2
11	Camaragibe 1
12	Camaragibe 2
13	Cabanga
14	Cordeiro
15	Caxanga
16	Igarassu 2
17	Ipojuca Sede
18	Itapissuma 1
19	Itapissuma 2
20	Comporttas
21	Curcurana
22	Prazeres
23	Jaboatao 1
24	Jaboatao 2
25	Ibura de Cima
26	Jaboatao 3
27	Bonanca
28	Moreno 1
29	Moreno 2
30	Moreno 3
31	Camaragibe 3
32	S. Lourenco 2
33	S. Lourenco 3
34	Boa Viagem
35	Imbiribeira
36	Jardim Sao Paulo
37	Ibora de Baixo
38	Ignes Andreazza
39	Mangueira
40	Roda de Fogo
41	Janga
42	Paulista
43	Conceicao
44	Apipucos
45	Curado
46	Praia Porto de Galinhas
47	Jardim Paulista
48	Mirueira
49	Mutirao
50	Nova Cruz
51	Parque Capibaribe
52	Parque Pirapama
53	Vila Burity
54	Vila dos Milagres
55	27 de Novembro

Proposed Sewerage Subsystem for Master Plan

(3) Level of Sewage Treatment

1) Secondary treatment

The regulation of the CPRH on discharged wastewater requires that the facilities generating more than 50kg/day of pollution load (BOD) remove more than 90% of their pollution load. The 55systems selected for the Master Plan all have the pollution load of over 50kg/day and need the removal rate of over 90%. This means that the systems have to have secondary treatment facilities.

2) Disinfection

Since sewage usually contains a large numbers of pathogenic microorganisms, measuring the number of coliforms in sewage usually monitors this type of contamination. The number of microorganisms in sewage is usually decreased through the treatment process; absorbed, consumed and inactivated by the sludge. Its level is further diminished in a secondary treatment process in which almost 99% of coliform is removed compared with the inflow sewage at the sewage treatment plant. However, in the RMR sewage doesn't satisfy the water quality standard for public water bodies by the CPRH even after secondary treatment. In order to reduce the coliform level and to keep it below the environmental standard, the installation of disinfection system is indispensable.
Although at present there is no regulations about water quality of the effluent from sewage treatment plants, the CPRH is now discussing the matter including the level of coliform.

(4) Sludge Disposal

1) Sewerage Sludge

There are mainly three final destinations for the sludge generated in sewage treatment; sanitary landfill, agricultural use, and use for construction materials after being burned and smelted. In the RMR, however, the third option is ruled out because waste material is never burned because of environmental consideration. As for the agricultural use, SANEPAR of the state of Parana carried out a study (07/1999-12/1999) and EBAPE of the State of Pernambuco both suggest that the sludge from sewage treatment can be effectively utilized for promoting agriculture in the arid hinterland of Pernambuco.

The problem with this disposal method is, however, that sludge sometimes contains harmful substances such as arsenic, cadmium and mercury. As a matter of fact, the sludg from Janga and Peixinho sewage treatment plants contain some of these harmful substances even though no wastewater from large scale industries is coming into the plants. The authorities have just started discussion on this matter and there is not state or federal standard about the quality of sludge for agricultural use at the moment.

In consideration of this situation, the basic stance in the Master Plan is that sludge is used for agriculture if the sludge contains no harmful substances. Otherwise, it is simply disposed in landfill along with other solid waste.

The planning of sludge disposal requires meeting the state policy on this matter, which will be prepared in future.

2) Septic tank Sludge

The sludge from septic tanks in the RMR is collected by private companies and taken to Janga treatment station where the sludge is dumped. The Janga treatment plant, even after the expansion proposed in the Master Plan, will not be able to accommodate all the sludge from septic tanks in the other parts of the RMR. Therefore more treatment plants should be designed and constructed to treat the sludge or the sludge should be at least disposed of in the treatment plants in each sewerage system.

3.3.4 Sewerage Facility Plan

(1) General

The sewerage facility plan proposed here is a structural measure to attain the goals of the sewerage improvement toward 2020. The 55 sewerage systems were selected for the sewerage improvement and specific planning conditions for them were proposed, also.

As sewage collection type, a completely separate system is adopted, following the existing sewerage system in the RMR.

A number of sewerage facilities comprising sewage collection facilities and sewage treatment facilities (STF) are existing in the RMR. To implement the sewerage improvement, it is essential that existing facilities should be used as much as possible, after proper rehabilitation. Accordingly, the proposed plan of sewerage facilities are comprised of the following schemes:

- Development of new facilities: To increase the hydraulic capacity of sewers and the treatment facilities and the performance capacity of water quality, by means of new installation or additional installation of necessary facilities,
- Rehabilitation of existing facilities: To restore the original functions and capacities of existing facilities, by means of the replacement of equipment, the supplement provisions of necessary components, etc.

Based on the surveyed data on existing sewerage, the development schemes for respective 55 systems are shown in Table 3.3-4. In 55 sewerage system, the development by new installation works will take place in 19 sewage collection facilities and in 38 STFs. In the rest of sewerage systems, different kinds of additional installation will take place along with necessary rehabilitation.

(2) Development of sewage collection facilities

1) General

The sewers to collect and transport sewage are comprised of collectors, branch sewers, trunk sewers and pressure sewers. In this Study, these are defined as follows:

- Condominial collectors:

  This is the sewer to collect sewage in condominial type sewerage for poverty areas, embedded mainly in the backyard or front yard of individual house plots.

- Conventional collectors:

  This is the sewer to collect sewage in conventional type sewerage for ordinary areas, embedded mainly along sidewalks.

- Branch sewers:

  This is the sewer to transport sewage from collectors into trunk sewers.

- Trunk sewers:

  This is to collect sewage from branch sewers and transport sewage generated in the UEs (the abbreviation of Sewerage Unit in Portuguese) at the upstream. Sewage in trunk sewers flows by gravity.

- Pressure sewers:

  This is to transport sewage from trunk sewers to a downstream UE or a sewage treatment station. Sewage in pressure sewers flows by pumping up.

Fig. 3.3-1 shows the conceptual layout of sewers and other related facilities in sewerage systems. Sewerage areas are usually comprised of several UEs, which are the minimum units of sewage discharge. When sewage cannot be conveyed from one UE to another by gravity, pump stations are introduced.

2) Proposed plan of sewage collection facilities

Of the total sewerage area 29,960 ha planned in 2020, the area of 21,440 ha (72 %) are not equipped with sewers, at present. Development works of sewage collection facilities will take place in the whole or a part of the sewerage areas of selected 55 sewerage systems.

The lengths of collectors and branch sewers were calculated by using the following assumed pipe densities:

- Condominial collectors: 120 m/ha
- Conventional collectors: 180 m/ha
- Branch sewers: 100 m/ha

The lengths of trunk and pressure sewers were calculated by assuming the sewer route on the map, referring the results of the PQA. The location of pump stations was determined on the map, reviewing the results of the PQA, also.

As a result, the total length of sewers to be expanded is about 5,900 km and the total power of pump stations is some 9,700 CV, as summarized in the table below. These are detailed in Table 3.3-5:

Summary of Development Works of Sewage Collection Facilities

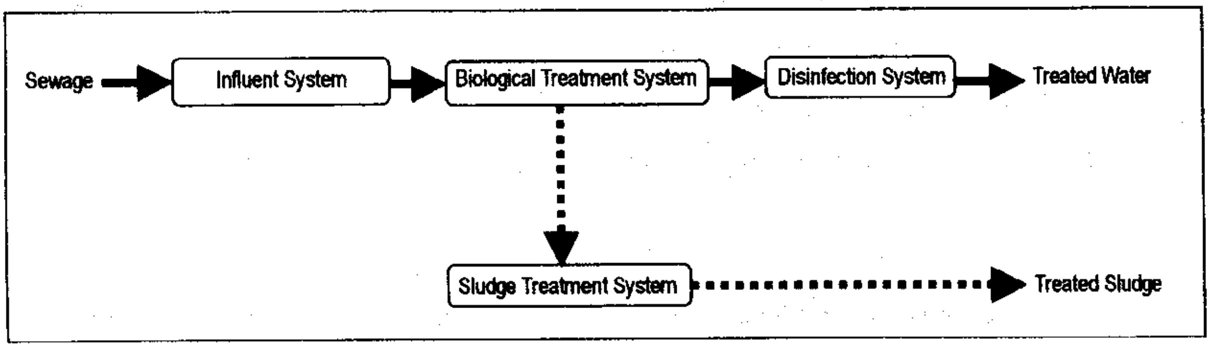
Items			Units	Quantities
Sewers	Condominial collectors	Pipe length	(km)	530
	Conventional collectors	Pipe length	(km)	3,077
	Branch sewers	Pipe length	(km)	2,063
	Trunk sewers	Pipe length	(km)	133
	Pressure sewers	Pipe length	(km)	65
	Total	Max. diameter	(mm)	1,000
		Pipe length	(km)	5,868
Pump stations		Total set number	(set)	441
		Total motor power	(CV)	9,748

(3) Development of sewage treatment facilities

1) General

In general, STFs comprise an influent system, a biological treatment system, a disinfection system and a sludge treatment system, as shown below:

General Flow Diagram of Sewage Treatment



Of these systems, a biological treatment system is a major part that may affect the performance, operability, adaptability, etc. of the entire treatment facilities. Different kinds of biological processes are examined and compared in the section 3.3.5.

2) Proposed plan of STF

The development of STFs was planned based on the capacity required for respective systems in terms of both the sewage flow and the water quality to be attained. Of selected 55 sewerage systems for 2020, 39 systems will have the new installation work of the whole treatment facilities. The rest will have the additional installation work for existing facilities, in line with respective conditions.

The capacities of both sewage influent systems and sludge treatment systems will be increased, if their capacities are not enough for the given conditions in 2020.
In the planning of biological treatment systems, the criteria in the section 3.3.5 were applied. Some facilities will continue to be used after additional installation and rehabilitation, in case the existing facilities are available at present.

The disinfection system will be added in all the systems, because all the current systems are not equipped with it.

Table 3.3-6 shows the results on overall development plans for selected 55 STFs, indicating expanded capacities and treatment processes to be applied.

The site locations of 55 STFs were predetermined in the PQA. These were endorsed in this Study, based on the following criteria:

- The existing sites continue to be used, unless there are particular reasons,
- The new sites have been selected, considering:
    - Accessibility to the watercourses for treated sewage,
    - Topographic conditions to collect and transfer sewage easily,
    - Allowable land space,
    - Land use situation of the surroundings, and
    - Accessibility to sites from main roads.

3) Specific plan of three major STFs

The STFs for three major systems: Janga, Peixinhos and Cabanga System, will be developed as follows:

- Janga STF:

    The existing STF of the Janga System is of oxidation ditch process. The sewerage flow in 2020 is increased to 59,900 m^3/day (daily average) from the present 34,200 m^3/day (daily average). The present BOD removal rate is almost 90 %, satisfying the given requirement in 2020.

    Fig. 3.3-2 shows the development scheme of the Janga STF. The existing series of treatment facilities will continue to be used as it is. For the incremental flow in

2020, the new series consisting of RAFA reactors and lagoons will be additionally installed adjacent to existing ones. This scheme is justified by the abundant land space in the existing site.

The disinfection system and sludge treatment system will be newly installed for the sludge generated from the existing and newly installed STF.

- Peixinhos STF:

  The existing STF for the Peixinhos System is comprised of primary sedimentation tanks, bio-filters and secondary sedimentation tanks. The sewage flow in 2020 is increased to 57,300 m^3/day (daily average) from the present 36,000 m^3/day (daily average). The present BOD removal remains 70 % to 80 % according to operation records.

  Fig. 3.3-3 shows the development scheme of the Peixinhos STF. To upgrade its BOD removal performance and hydraulic capacity, RAFA reactors, bio-filters and secondary sedimentation tanks will be installed additionally. The existing primary sedimentation tanks will be abolished.

  A disinfection tank will be added, also. As the sludge treatment system, a sludge thickener and sludge dehydrators will be newly installed. Existing sludge digesters, a gasholder and a bio-gas burner will continue to be used after being rehabilitated. Existing sludge drying beds will be abolished after the completion of the new sludge treatment system.

- Cabanga STF:

  The STF of the Cabanga System relies on only primary sedimentation at present. The sewage flow in 2020 is reduced into 55,300 m^3/day (daily average) from the existing 80,000 m^3/day (daily average). The present BOD removal rate remains only 40 % or so, according to the COMPESA's reports.

  Fig. 3.3-4 shows the development scheme of the Cabanga STF. To upgrade its performance, RAFA reactors and bio-filters will be added. The existing primary sedimentation tanks will be converted into the secondary sedimentation tanks after being rehabilitated.

  A disinfection tank will be installed newly. In the sludge treatment system, a sludge thickener and sludge dehydrators will be newly installed. Existing sludge digesters, a gas holder and a bio-gas burner will continue to be used after being rehabilitated. Existing sludge drying beds will be abolished to provide the installation space for RAFA reactors, bio-filters and other ancillary equipment.

(4) Rehabilitation plan of existing sewerage facilities

1) Sewage collection facilities

A total of 96 pump stations are existing at present in four (4) major sewerage systems, equipped with total 167 sets of different-type pumps. The site investigation has revealed that a large number of the pump facilities have been damaged.

The situation on damaged equipment may be described typically as follows:

- Several sets of total pumps are missing and only foundations are left,
- Drive motors for pumps are missing,
- Some pumps are left without working due to no replacement of consumable parts, and
- Most of electrical panel and water level instrument for pumps are imperfect.

As a result of the site survey and the review of the data prepared by COMPESA, major rehabilitation items entailed on 55 systems are summarized in Table 3.3-7. Ranging from the supplement of new pumps to the replacement of component parts, the rehabilitation works will include the necessary measures for respective pump stations in line with their present situation.

Of the total near 29,960 ha sewerage area in 2020, the area of 8,520 ha (28 %) is covered by sewer networks at present. These sewers are, however, suffering from broken and silting, and require urgent rehabilitation and dredging/cleaning.

Based on the data prepared by COMPESA and the site investigation, the quantities of repair and cleaning works for the existing sewage collection facilities were estimated. They contain the necessary rehabilitation works such as the supplement of pipelines, the repair of pipe connections, the inspection of silting, the dredging/cleanings, etc.

2) Sewage treatment facilities

A total of 44 Staffs are working in present sewerage systems. In these STFs, a certain facilities will be used after necessary rehabilitation, combined with newly installed facilities. The rehabilitation will take place to meet the functions and the capacities of their original design capacities.

Through the site investigation, the following typical damages in existing facilities have been identified:

- Of influent pumps, some are not working, because drive motors have been missing or broken,
- Most screens and grit chambers are not working due to no periodical cleaning,
- Most sewage inflow measurement equipment are missing,
- Almost one third of aerators are not working due to broken motors and mechanical parts,
- Some of sludge collectors for sedimentation tanks are not working due to mechanical failures, and
- Many parts of pipes, especially for sludge transport, are clogging or rusted and valves are broken.

Taking the above situation into account, necessary rehabilitation works for the STFs are listed up in Table 3.3-7.

3.3.5 Examination on Sewage Treatment Process

(1) General

Various processes are available for biological treatment systems and sludge treatment systems. To select optimum ones applicable for the RMR, the following examinations were made.

(2) Biological treatment system

At present, the lagoon process including aerated lagoon and stabilization pond process predominates in the RMR, except for septic tanks. The conventional activated sludge process, which is most prevalent in the world, does not exist in the RMR. A salient tendency in the RMR is the use of the RAFA process.

RAFA (Retor Anaerobico de Flux Ascendente in Portuguese), which is called UASB (Upflow Anaerobic Sludge Blanket) in English, is a process in which organic substances in sewage are removed by anaerobic granular-shaped organisms. This has been used in many places in Brazil, especially in the State of Parana. As a result, RAFA has been seen as the most promising process for sewage treatment, ever since a previous sewerage development study[1] recommended it several decades ago.

In this Study, the following processes were comparatively studied from the technical and economical point of view:

- Activated sludge process,
- Oxidation ditch process,
- Aerated lagoon,
- Bio-filtration process,
- "RAFA + lagoon" process:

  The BOD removal performance of the RAFA process by itself is limited to 70 to 80 %. Its combination with aerobic treatment can be expected to increase the removal rate to around 90 %. Usually, a lagoon accompanies RAFA reactors as a post treatment,

- "RAFA + bio-filtration" process:

  In this process, bio-filtration process follows RAFA reactors for the same reason as the "RAFA + lagoon" process. Over 90 % BOD removal may be expected in this process. This can greatly save the required land space.

Among these, it is regarded that the aerated lagoon process and the bio-filtration process alone cannot be adopted due to the inferior BOD removal rate (less than 90 %). Other processes were examined comparatively by using the weighted evaluation method, which allocates the following weighted points: i) 5 for construction cost, ii) 3 for energy consumption, iii) 3 for sludge generation rate, iv) 5 for ease of operation and maintenance, and v) 5 for required land space. The evaluation results are shown in the table below.

As evident from this comparison, the RAFA process combined with a lagoon or bio-filtration represents significant advantage. This result is attributed to the fact that:

- The RAFA process is of anaerobic treatment, which needs no energy for organic decomposition,

- The BOD space loading rate of the RAFA process is extremely high (some 1.5 kg-BOD/m^3/day) as compared to other processes, and,

- The sludge generation rate in the RAFA process is very low.

Evaluation of Biological Treatment Processes

Comparison Items		Weighting	Optional Processes			
			Activated Sludge	Oxidation Ditch	RAFA + Lagoon	RAFA + Bio-Filtration
Construction Cost	Basic score	5	1	1	5	3
	Weighted score		5	5	25	15
Energy Consumption	Basic score	3	1	1	5	3
	Weighted score		3	3	15	9
Sludge Generation Rate	Basic score	3	1	3	5	5
	Weighted score		3	9	15	15
Easiness of O and M	Basic score	5	1	3	5	3
	Weighted score		5	15	25	15
Required Land Space	Basic score	5	5	3	1	5
	Weighted score		25	15	5	25
Total Score			41	47	85	79

Note: The basic scores stand for: 5 - "excellent", 3 - "medium" and 1 - "inferior".

Based on these results, the following process selection criteria were induced, placing the RAFA process at the highest priority:

- Where there is no space limitation at the treatment station, the applicable one is:
    - "RAFA + lagoon" process,
- Where there is space limitation at the treatment station, the applicable one is:
    - "RAFA + bio-filtration " process (including sedimentation).

Fig. 3.3-5 shows a typical application of the combined process with RAFA reactors. A typical configuration of a RAFA reactor is shown in Fig. 3.3-6.

(3) Sludge treatment system

At present, all the existing STFs in the RMR rely on sludge drying beds to treat the sludge generated. Given the climatic conditions in the region, the natural sludge drying process is considered the most economical way. This practice, however, should be reassessed on the occasion of sewerage development.

The characteristics of the sludge drying process are evaluated as follows:

- It requires a large land space due to a low rate of drying, and
- It tends to generate an offensive odor.

Based on the above, the following criteria for the selection of a sludge treatment system are proposed:

- A mechanical dehydration should be introduced in the STFs that are limited in space, or that are sited in densely populated areas,
- A natural drying bed may continue to be applied in the STFs that are not constrained by lack of space, if there is no concern about the surrounding environment.

3.3.6 Operation and Maintenance

(1) Sewer System

The purposes of O&M of the sewer system are as follows.

- Maintaining the designed flow in sewer pipes.
- Preventing damage to sewers due to other construction work
- Preventing accidents caused by broken facilities.
- Preventing rainwater inflow into sewer pipes.
- Taking measures to restore facilities.

1) Inspection and check-up

COMPESA recently started inspecting sewer pipes using a remote controlled TV camera. This was introduced by PRODETUR (1998 - 1999) and 10% of the sewers were found to be damaged and requiring repair.

Thus, a complete visual inspection, or TV inspection, is proposed for existing networks, to be carried out in two years (2001 and 2002), to find out the real state of the sewers.

It is also proposed that routine inspections and cleaning be programmed in periods from once to four times a year. During these periods there is daily inspection and cleaning of sections until a whole system is covered. As the process evolves and rehabilitation is completed, the periods may be reprogrammed.

At the same time, this rehabilitation work does not make up part of the O&M, but is considered as being the responsibility of the department of works and projects.

2) Cleaning and Sediment Removal

An annual schedule with sites for the cleaning and removal of sediment from sewers should be planned, based on regular inspection data. Currently, COMPESA carries out cleaning only in response to complaints from users.

3) Repair work

This is usually done to rehabilitate older facilities for the purpose of extending their life and restoring their original performance. COMPESA conducts no regular repair work of broken facilities but it repairs subsidence of roads due to pipe breakage and replaces stolen manhole lids.

As a project of PRODETUR a total of 300m of sewers in the RMR have been replaced by the excavation method and 7m have been repaired by reinforcing the pipes from inside.

(2) Pump Stations

The following O&M items should be checked at pump stations.

- Regular inspection of grit chambers
- Operation of inflow gate
- Operation of screens
- Operation of sand removal device
- Operation of pumps
- Inspection and maintenance of mechanical and electrical devices

There are no regulations or manuals for the O&M of COMPESA pump stations. The sand that gets into the pump stations is somehow removed and dumped in a corner of the land. Likewise, broken machines are left unrepaired.

The O&M of EEs vary according to their size.

Small, PV type, EEs will be installed in various places and these should undergo routine inspections as well as being included in the routine cleaning and inspection of the sewerage network.

The medium-sized and large EEs should be permanently manned and this staff will also deal with emergencies in the PV type EEs.

In addition, all EEs should be inspected yearly.

(3) Treatment Facilities

The services of operation and maintenance for sewage treatment facilities may be subdivided into administration, operation, maintenance, water quality control and labor works. Their respective works are shown in the following table:

Classification of Operation and Maintenance Services

O and M Services

ADMINISTRATION:	Property management, Stock management, Document recordings, Personnel management,
OPERATION:	Monitoring of operation parameters, Manipulation of equipment, Recording of logs,
MAINTENANCE:	Routine inspection, Dismounting inspection, Repair, Recording logs,
WATER QUALITY CONTROL:	Measurement and analysis of water quality and other items, Establishment of operation parameters, Recording logs,
LABOR WORKS:	Replacement of equipment and chemicals, Site cleanings, Sludge removal, Miscellaneous labor works.

(4) Preparation of Inventory

Records are the basis for an overview of the system and serve not only as basic technical documents for O&M, but can also be useful in dealing with customer complaints and in discussions with associated bodies, besides providing data in the case of damage.

As COMPESA has electronically stored data on water and drainage systems, it can easily and quickly introduce a data base system.

The introduction of this system will facilitate the updating of plans, the revision of information, easy access to plans and the preparation of simplified plans. It will also make all activities related to wastewater drainage more efficient because of its complete O&M records and the aid it provides for planning and projects.

Numerous ETEs and EEs are proposed for the RMR, so to increase O&M efficiency, it is essential to establish a system that allows for the easy access to data from remote locations.

3.3.7 Phased Program

The projects proposed in the Master Plan will be completed by 2020, in two Phases (Phase 1 and Phase 2).

The projects are divided into six groups corresponding to six river basins.

Twenty-five (25) out of fifty-five (55) seweragesystems in the six river basins are selected to be implemented in Phase 1 and the remaining thirty (30) seweragesystems are in Phase 2 as shown below:

Phase	Period	No. of Groups	No. of systems
Phase 1	2001 - 2010	6	25
Phase 2	2011 - 2020	6	30

Phased schedule is shown in Fig.3.3-7.

The Systems for Phase 1 and Priority Projects is shown in Fig.3.3-8.

Table 3.3.-1 Population and Urban Area in 1997 and 2020

Municipality	Type	Population			Urban Area(km^2)		Population Density(persons/ha)	
		1997	2010	2020	1997	2020	1997	2020
Itamaraca		11,826	17,808	24,639	6.3	12.56	18.8	19.6
Itapissuma		16,504	21,692	26,031	1.75	2.48	94.3	105.0
Aracoiaba		10,289	13,008	15,007	0.83	1.18	124.0	127.2
Moreno		32,162	32,973	33,638	4.16	4.33	77.3	77.7
Cabo		128,360	159,936	186,896	11.87	15.75	108.1	118.7
Ipojuca		31,605	44,493	55,472	8.86	11.01	35.7	50.4
Igarassu		54,874	79,165	104,140	12.36	17.61	44.4	59.1
Abreu e Lima		73,113	77,827	80,835	10.94	11.84	66.8	68.3
Paulista		234,144	292,896	337,248	30.89	38.32	75.8	88.0
Sao Lourenco de Mata		80,358	94,632	107,044	16.78	21.25	47.9	50.4
Camaragibe	Formal 1	78,342	97,966	112,912	21.03	27.11	37.3	41.6
	ZEIS-2	35,280	44,118	50,848	1.99	2.01	177.3	253.0
	Sub-total	113,622	142,084	163,760	23.02	29.12	49.4	56.2
Jaboatao	Formal 1	257,088	305,783	340,460	33.92	43.69	75.8	77.9
	Formal 2	33,300	39,607	44,099	1.12	1.13	297.3	390.3
	ZEIS-3	175,320	208,527	232,175	9.79	9.89	179.1	234.8
	Sub-total	465,708	553,918	616,734	44.82	54.71	103.9	112.7
Olinda		350,999	367,041	377,825	26.42	26.48	132.9	142.7
Recife	ZEIS	593,830	629,970	661,204	32.56	32.56	182.4	200.7
	Formal	761,987	816,905	844,567	85.05	85.05	89.6	101.0
	Sub-total	1,355,817	1,446,875	1,505,771	117.61	117.61	115.3	129.2
Total RMR		2,959,381	3,344,348	3,635,040	316.61	364.25	89.6	101.0

Table 3.3.-2 Proposed Wastewater Discharge, Pollution Load and Wastewater Quality in 2020 for the Whole Sewerage Systems in the RMR (1/3)

No.	Sewerage System	Area (ha)	Population (persons)	Wastewater Discharge (m^3/ day)			Pollution Load (kg/ day)		Wastewater Quality (mg/l)	
				Daily average	Daily maximum	Hourly maximum	BOD	SS	BOD	SS
1	Caetés	885	60,779	11,014	12,395	16,665	3,294	3,660	299	332
2	Peixinhos	2,548	398,839	57,196	66,880	94,788	21,179	23,532	370	411
3	Caixa D'água	455	35,305	5,134	5,868	7,820	1,906	2,118	371	413
4	Nova Descoberta	387	65,506	7,138	8,456	11,849	3,537	3,930	496	551
5	Aguazinha	373	59,005	6,569	7,775	10,858	3,186	3,540	485	539
6	Dois Unidos	423	63,495	8,243	9,675	13,600	3,429	3,810	416	462
7	Ponte dos Carvalhos	132	35,164	4,964	5,844	8,481	1,899	2,110	382	425
8	Charnequinha	67	11,571	1,734	2,023	2,891	625	694	360	400
9	Camaragibe/Recife 1	954	61,043	11,254	12,722	17,022	3,296	3,663	293	325
10	Camaragibe/Recife 2	269	16,477	3,220	3,642	4,882	890	989	276	307
11	Camaragibe 1	446	24,870	4,450	4,952	6,464	1,343	1,492	302	335
12	Camaragibe 2	246	26,107	3,380	3,906	5,327	1,410	1,566	417	463
13	Cabanga	2,260	304,394	55,146	64,051	89,683	17,287	19,208	313	348
14	Cordeiro	675	100,048	16,479	19,187	27,226	5,457	6,063	331	368
15	Caxangá	509	37,326	7,150	8,176	10,889	2,171	2,412	304	337
16	Igarassu 2	817	50,251	9,690	10,906	14,595	2,714	3,015	280	311
17	Ipojuca - Sede	105	20,968	3,076	3,601	5,173	1,132	1,258	368	409
18	Itapissuma 1	102	10,679	1,614	1,828	2,522	577	641	357	397
19	Itapissuma 2	99	10,416	1,574	1,783	2,460	562	625	357	397
20	Comportas	487	49,970	8,275	9,545	13,265	2,698	2,998	326	362
21	Curcurana	910	123,636	21,280	24,678	35,051	6,676	7,418	314	349
22	Prazeres	1,548	233,403	32,581	38,122	53,840	12,604	14,004	387	430
23	Jaboatão 1	396	45,472	5,956	6,865	9,442	2,455	2,728	412	458
24	Jaboatão 2	803	56,231	9,656	10,780	14,435	3,036	3,374	314	349
25	Ibura de Cima	322	51,984	6,097	7,137	10,010	2,807	3,119	460	512
26	Jaboatão 3	528	36,974	6,349	7,088	9,492	1,997	2,218	314	349
27	Bonança	114	5,025	1,046	1,147	1,473	271	301	259	288
28	Moreno 1	209	18,792	2,969	3,345	4,566	1,015	1,128	342	380
29	Moreno 2	72	6,435	1,017	1,145	1,564	347	386	342	380

Table 3.3.-2 Proposed Wastewater Discharge, Pollution Load and Wastewater Quality in 2020 for the Whole Sewerage Systems in the RMR (2/3)

No.	Sewerage System	Area (ha)	Population (persons)	Wastewater Discharge (m^3/ day)			Pollution Load (kg/ day)		Wastewater Quality (mg/l)	
				Daily average	Daily maximum	Hourly maximum	BOD	SS	BOD	SS
30	Moreno 3	39	3,465	547	617	842	187	208	342	380
31	Camaragibe 3	622	30,238	5,967	6,599	8,555	1,633	1,814	274	304
32	São Lourenço 1	922	45,783	9,619	10,737	14,115	2,472	2,747	257	286
33	São Lourenço 2	653	33,288	6,981	7,813	10,309	1,798	1,997	258	286
34	Boa Viagem	1,281	159,314	27,877	32,213	45,420	8,677	9,641	311	346
35	Imbiribeira	550	56,497	10,153	11,687	16,311	3,068	3,409	302	336
36	Jardim São Paulo	497	56,101	8,335	9,665	13,299	3,119	3,465	374	416
37	Ibura de Baixo	1,400	179,179	23,735	27,605	38,289	9,631	10,701	406	451
38	Ignês Andreazza	47	6,579	988	1,148	1,620	355	395	360	400
39	Mangueira	286	42,642	5,815	6,789	9,587	2,116	2,351	364	404
40	Roda de Fogo	171	27,810	3,892	4,564	6,477	1,502	1,669	386	429
41	Janga	2,879	316,075	59,885	68,813	96,989	17,075	18,973	285	317
42	Paulista	783	68,930	11,052	12,460	16,997	3,722	4,136	337	374
43	Conceição	710	62,445	12,515	14,281	19,888	3,372	3,747	269	299
44	Apipucos	130	10,339	2,011	2,296	3,164	558	620	278	308
45	Curado	103	18,626	2,031	2,414	3,399	1,006	1,118	495	550
46	Praia Porto de Galinhas	49	3,409	588	657	878	184	205	313	348
47	Jardim Paulista	282	24,851	3,954	4,451	6,066	1,342	1,491	339	377
48	Mirueira	402	34,009	5,478	6,169	8,386	1,836	2,041	335	372
49	Mutirão	73	6,380	1,334	1,525	2,132	345	383	258	287
50	Nova Cruz	92	5,244	1,053	1,184	1,577	283	315	269	299
51	Parque Capibaribe	460	23,475	4,923	5,510	7,270	1,268	1,409	258	286
52	Parque Pirapama	173	47,638	6,700	7,891	11,464	2,572	2,858	384	427
53	Vila Burity	68	11,397	1,350	1,578	2,220	615	684	456	507
54	Vila dos Milagres	99	14,289	1,853	2,139	2,994	772	857	416	463
55	27 de Novembro	49	9,369	963	1,150	1,620	506	562	525	584
56	Abreu e Lima 1	141	9,377	1,779	2,012	2,713	506	563	285	316
57	Abreu e Lima/Igarassu 1	391	23,710	4,653	5,246	7,024	1,280	1,423	275	306
58	Aeroporto	143	12,183	1,946	2,191	2,977	658	731	338	376