社会開発調査部報告書

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THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RECIFE METROPOLITAN AREA IN THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT

SUMMARY

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

BRAZILIAN COOPERATION AGENCY (ABC),
STATE SECRETARIAT OF PLANNING AND SOCIAL DEVELOPMENT,
STATE OF PERNAMBUCO (SEPLANDES)
FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RECIFE METROPOLITAN AREA IN THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT SUMMARY

JANUARY 2001

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO

The cost estimate was made based on prevailing market price in July 2000 and expressed in US$ according to the following exchange rate.

US$1.00 = R$ 1.80 = Yen 110.00
(As of June 2000)

PREFACE

In response to a request from the Government of Federative Republic of Brazil, the Government of Japan decided to conduct a development Study on Stormwater Drainage and Sewerage Management Plan for Recife Metropolitan Area in the Federative Republic of Brazil and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Hajime Tanaka of Pacific Consultants International Co., Ltd. to Brazil, three times between October 1999 to January 2001. In addition, JICA set up an advisory committee headed by Shin'ichiro Uchida, Executive Adviser of Japan Sewerage Works Agency between October 1999 to January 2001, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Brazil, and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Brazil for their close cooperation extended to the Team.

January 2001

Kunihiko Saito
President
Japan International Cooperation Agency

THE STUDY

ON

STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RECIFE METROPOLITAN AREA

IN

THE FRDERATIVE REPUBLIC OF BRAZIL

January, 2001

Mr. Kunihiko Saito
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

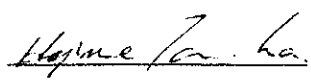
Dear Sir,

We are pleased to submit the final report entitled the" The Study on Stormwater Drainage and Sewerage Management Plan for Recife Metropolitan Area in the Federative Republic of Brazil". This report has been prepared by the Study Team in accordance with the contracts signed on October 1999 and May 2000 between the Japan International Cooperation Agency and Pacific Consultants International.

In the Study, the Study Team presents the Master Plan Study based on the analysis of the existing wastewater problems and Feasibility Study on the priority projects. The report consists of the Summary, Main Report, Supporting Report and Data Book.

All members of the Study Team wish to express sincere appreciation to the personnel of your Agency, Advisory Committee, and the Embassy of Japan in Brazil, and also to the officials concerned of the Government of the Federative Republic of Brazil and the State Government of Pernambuco for their cooperation extended to the Study Team. The Study Team sincerely hopes that the results of the Study will contribute to the stormwater drainage and sewerage management for the Recife Metropolitan Region and also to the promotion of socio-economic development for the area.

Yours Faithfully



Hajime Tanaka
Team Leader of the Study Team

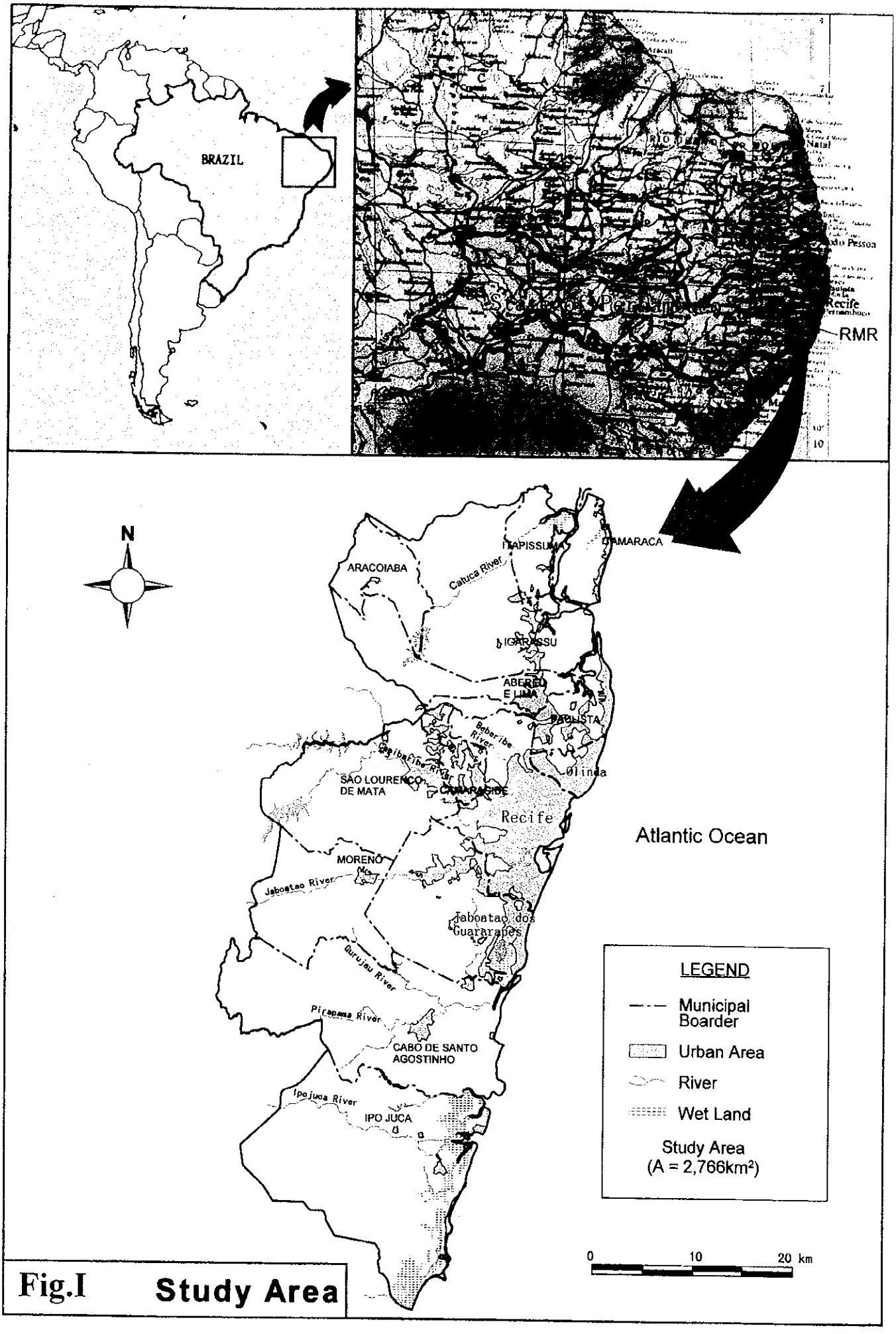
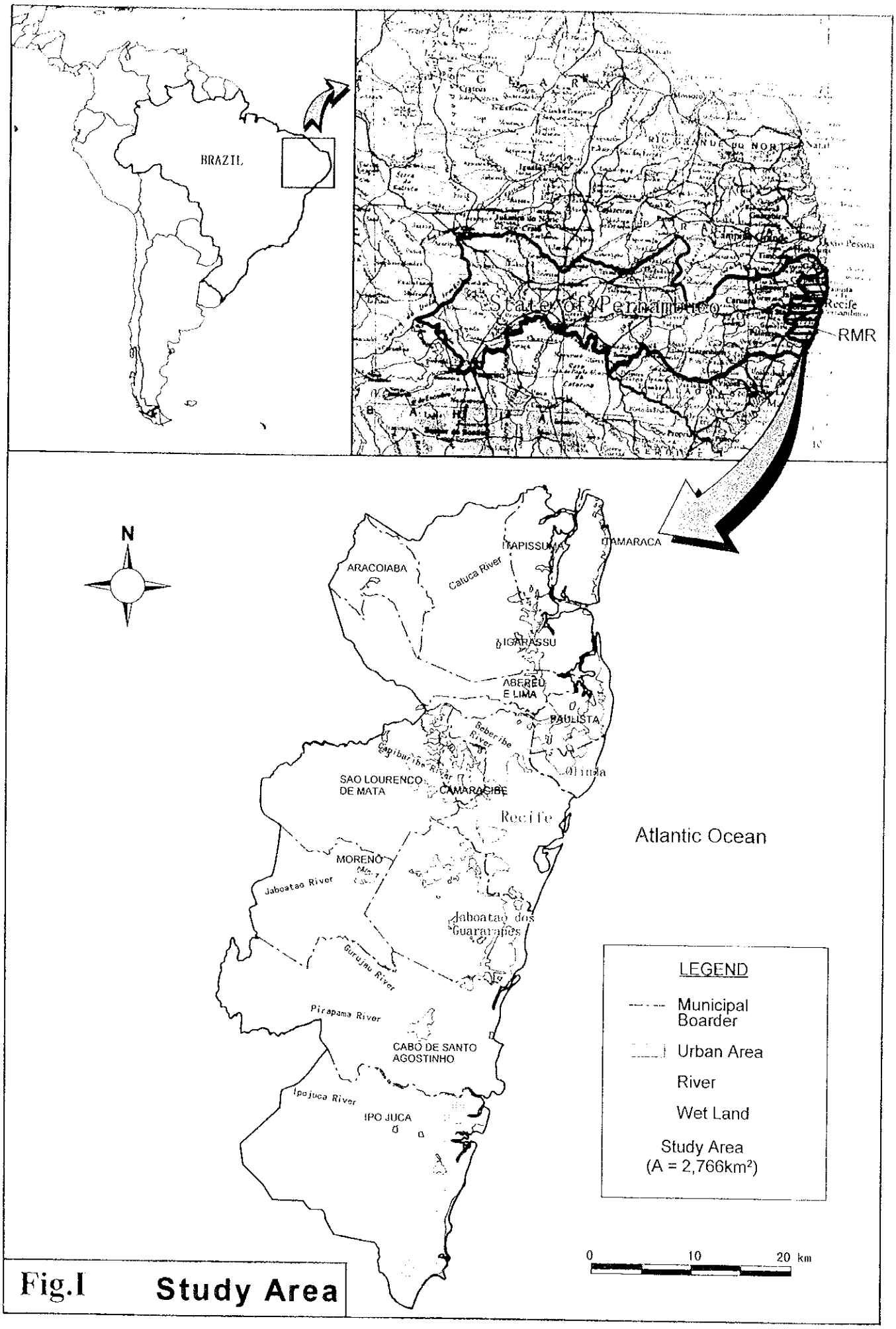


Fig.I Study Area



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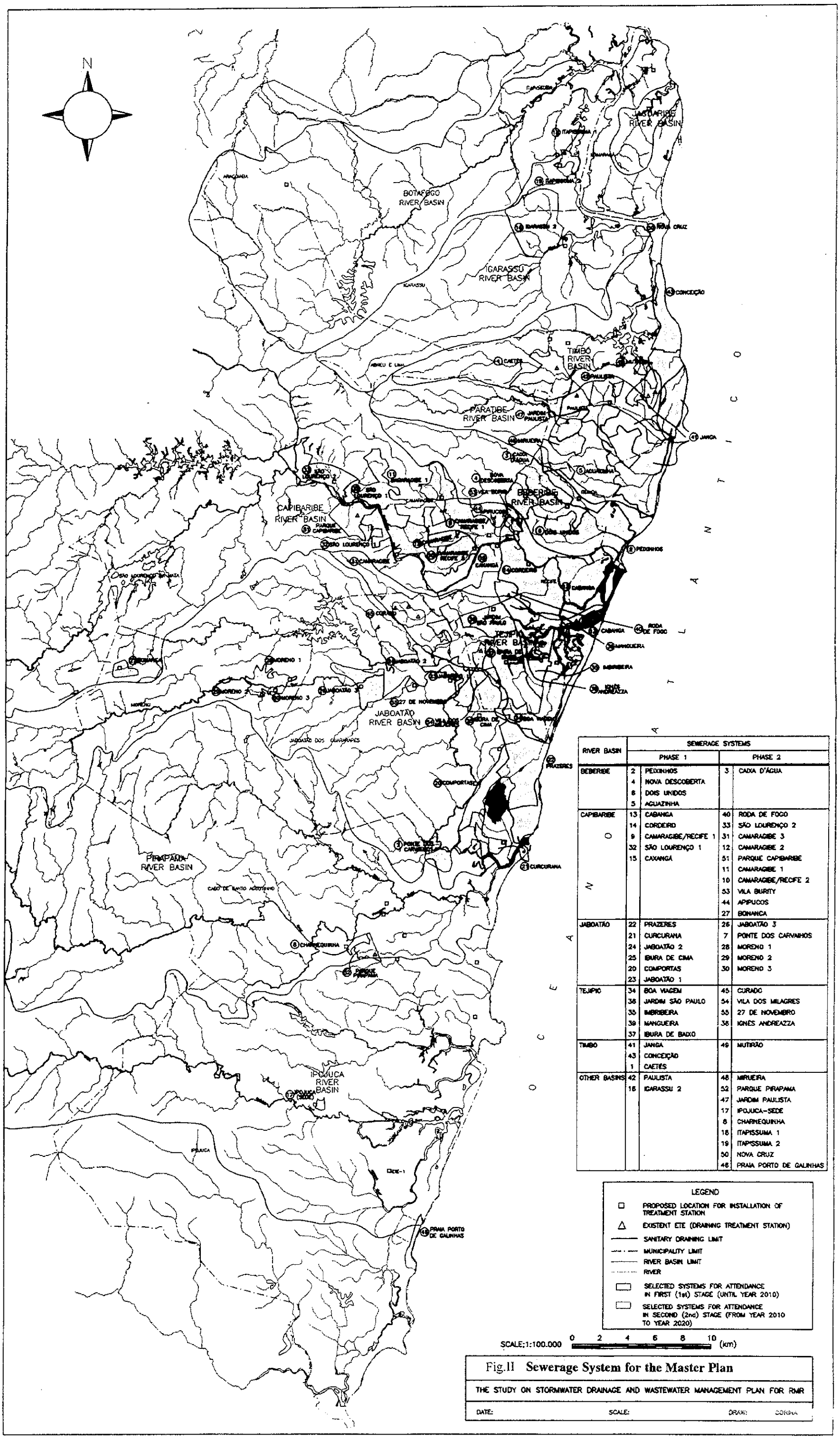


RIVER BASIN	SEWERAGE SYSTEMS			
	PHASE 1		PHASE 2	
BEBERIBE	2	PEDRINHOS	3	CAIXA D'ÁGUA
	4	NOVA DESCOBERTA		
	6	DOIS UNIDOS		
	5	AGUAZINHA		
CAPIBARIBE	13	CABANGA	40	RODA DE FOGO
	14	CORDEIRO	33	SÃO LOURENÇO 2
	9	CAMARAGIBE/RECIFE 1	31	CAMARAGIBE 3
	32	SÃO LOURENÇO 1	12	CAMARAGIBE 2
	15	CAXANGÁ	51	PARQUE CAPIBARIBE
			11	CAMARAGIBE 1
			10	CAMARAGIBE/RECIFE 2
			53	VILA BURITY
			44	APIPUCOS
			27	BONANÇA
JABOATÃO	22	PRAZERES	26	JABOATÃO 3
	21	CURCURANA	7	PONTE DOS CARVALHOS
	24	JABOATÃO 2	28	MORENO 1
	25	IBURA DE CIMA	29	MORENO 2
	20	COMPORTAS	30	MORENO 3
	23	JABOATÃO 1		
TEJIPIÓ	34	BOA VIAGEM	45	CURADO
	36	JARDIM SÃO PAULO	54	VILA DOS MILAGRES
	35	IMBIRIBEIRA	55	27 DE NOVEMBRO
	39	MANGUEIRA	38	IGNÊS ANDREAZZA
	37	IBURA DE BAIXO		
TIMBÓ	41	JANGA	49	MUTIRÃO
	43	CONCEIÇÃO		
	1	CAETÉS		
OTHER BASINS	42	PAULISTA	48	MIRUEIRA
	18	IGARASSU 2	52	PARQUE PIRAPAMA
			47	JARDIM PAULISTA
			17	IPOJUCA-SEDE
			8	CHARNEQUINHA
			16	ITAPISSUMA 1
			19	ITAPISSUMA 2
			50	NOVA CRUZ
			46	PRAIA PORTO DE GALINHAS

LEGEND

- PROPOSED LOCATION FOR INSTALLATION OF TREATMENT STATION
- EXISTENT ETE (DRAINING TREATMENT STATION)
- SANITARY DRAINING LIMIT
- MUNICIPALITY LIMIT
- RIVER BASIN LIMIT
- RIVER
- SELECTED SYSTEMS FOR ATTENDANCE IN FIRST (1st) STAGE (UNTIL YEAR 2010)
- SELECTED SYSTEMS FOR ATTENDANCE IN SECOND (2nd) STAGE (FROM YEAR 2010 TO YEAR 2020)

SCALE;1:100.000 0 2 4 6 8 10 (km)

Fig.II **Sewerage System for the Master Plan**

THE STUDY ON STORMWATER DRAINAGE AND WASTEWATER MANAGEMENT PLAN FOR RMR

DATE: SCALE: DRAW: CORPLA

RIVER BASIN	NO	PRIORITY PROJECTS SYSTEM	SERVED AREA(HA)	POPULATION IN 2020
CAPIBARIBE	13	■	2,260	304,394
	14	■	675	100,048
		SUB-TOTAL	2,935	404,442
JABOATÃO	22	■	1,548	233,403
	21	■	910	123,636
		SUB-TOTAL	2,458	357,039
TEJIPIO	34	■	1,281	159,314
		SUB-TOTAL	1,281	159,314
TIMBO	41	■	2,879	316,075
	43	■	710	62,445
		SUB-TOTAL	3,589	378,520
OTHER BASINS				
		SUB-TOTAL	0	0
PRIORITY PROJECTS TOTAL			12,811	1,698,154

LEGEND

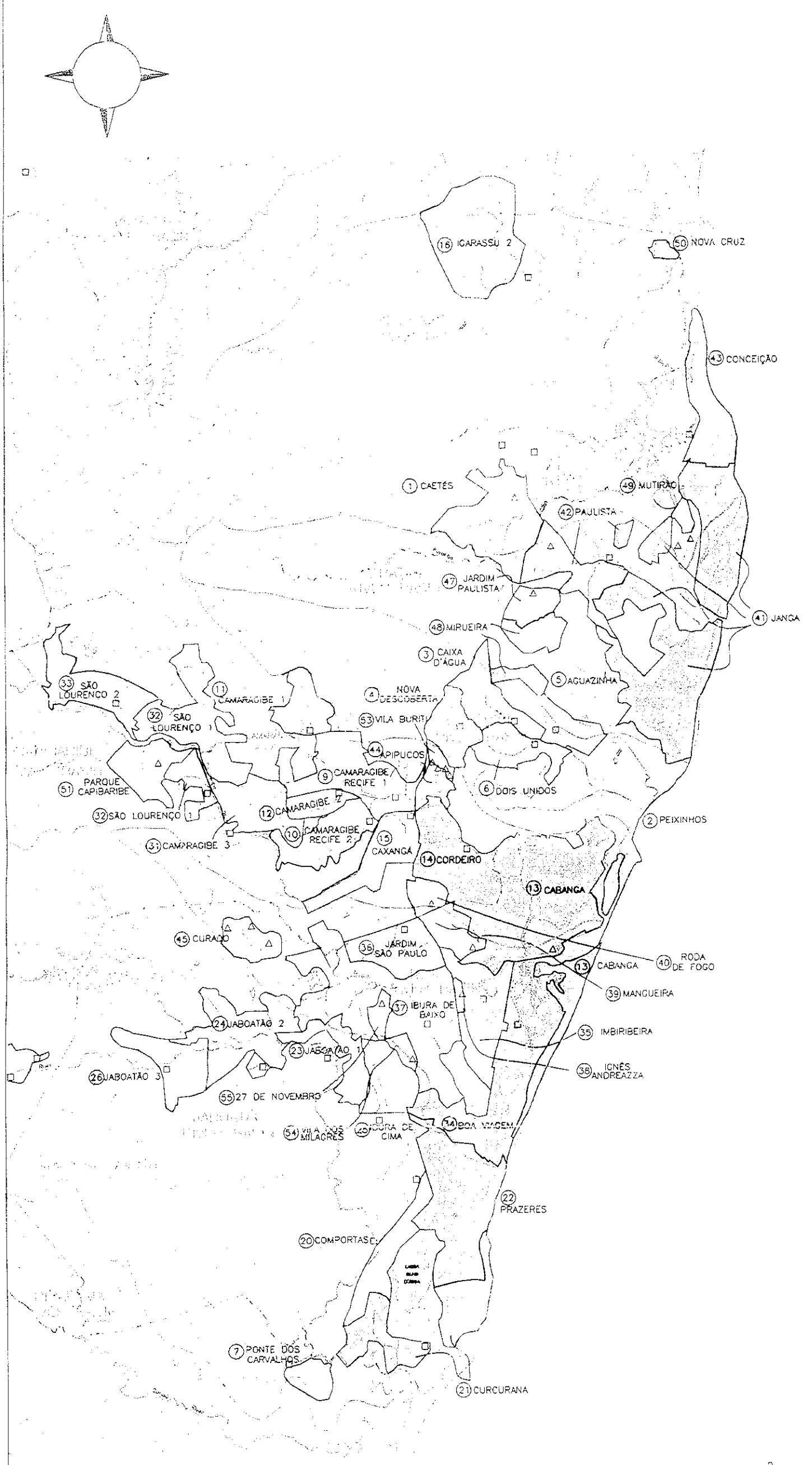
- □ PROPOSED LOCATION FOR INSTALLATION OF TREATMENT STATION
- △ EXISTENT ETE (DRAINING TREATMENT STATION)
- SANITARY DRAINING LIMIT
- MUNICIPALITY LIMIT
- RIVER BASIN LIMIT
- RIVER
- ■ Priority Projects

SCALE;1:100.000 0 2 4 6 8 10 (km)

Fig.III **Sewerage systems for Phase-1 and Priprity Projects**

THE STUDY ON STORMWATER DRAINAGE AND WASTEWATER MANAGEMENT PLAN FOR RMR

DATE: SCALE: DRAW: CORINA



RIVER BASIN	NO	PRIORITY PROJECTS SYSTEM	SERVED AREA(HA)	POPULATION IN 2020
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- MUNICIPALITY LIMIT
- RIVER BASIN LIMIT
- RIVER
- Priority Projects

SCALE,1:100,000 0 2 4 6 8 10 (km)

Fig.III **Sewerage systems for Phase-1 and Priprity Projects**

THE STUDY ON STORMWATER DRAINAGE AND WASTEWATER MANAGEMENT

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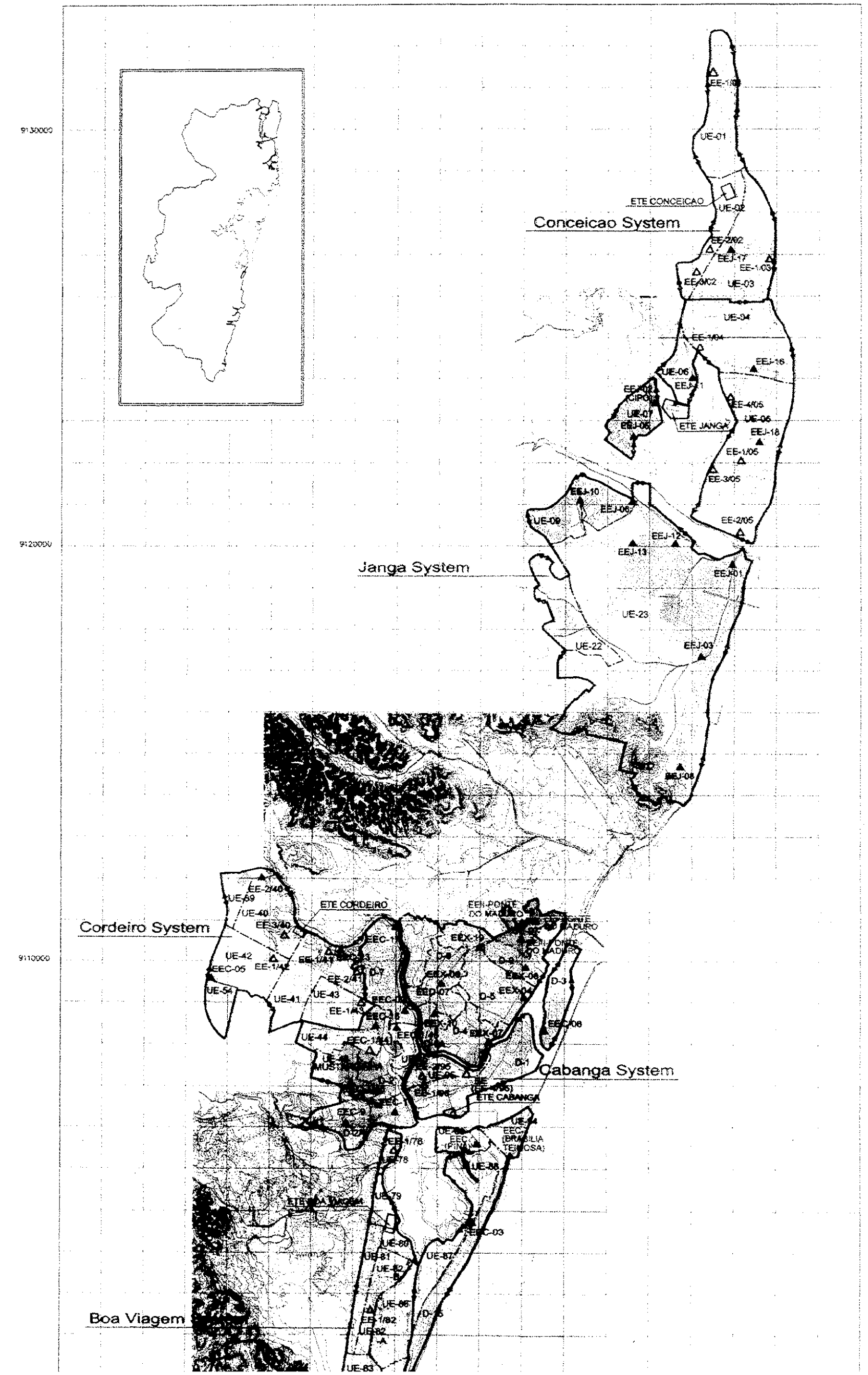
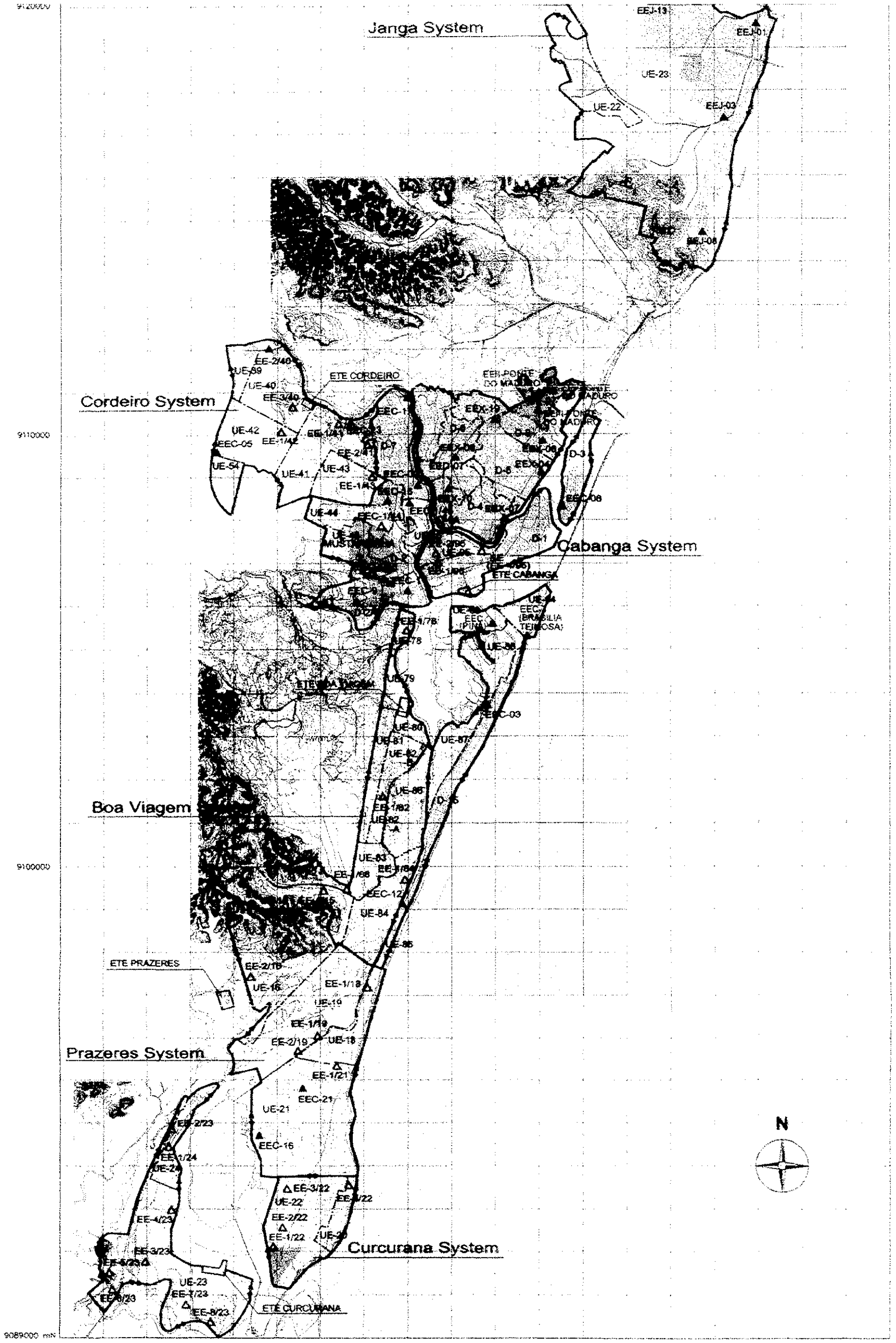




LEGEND

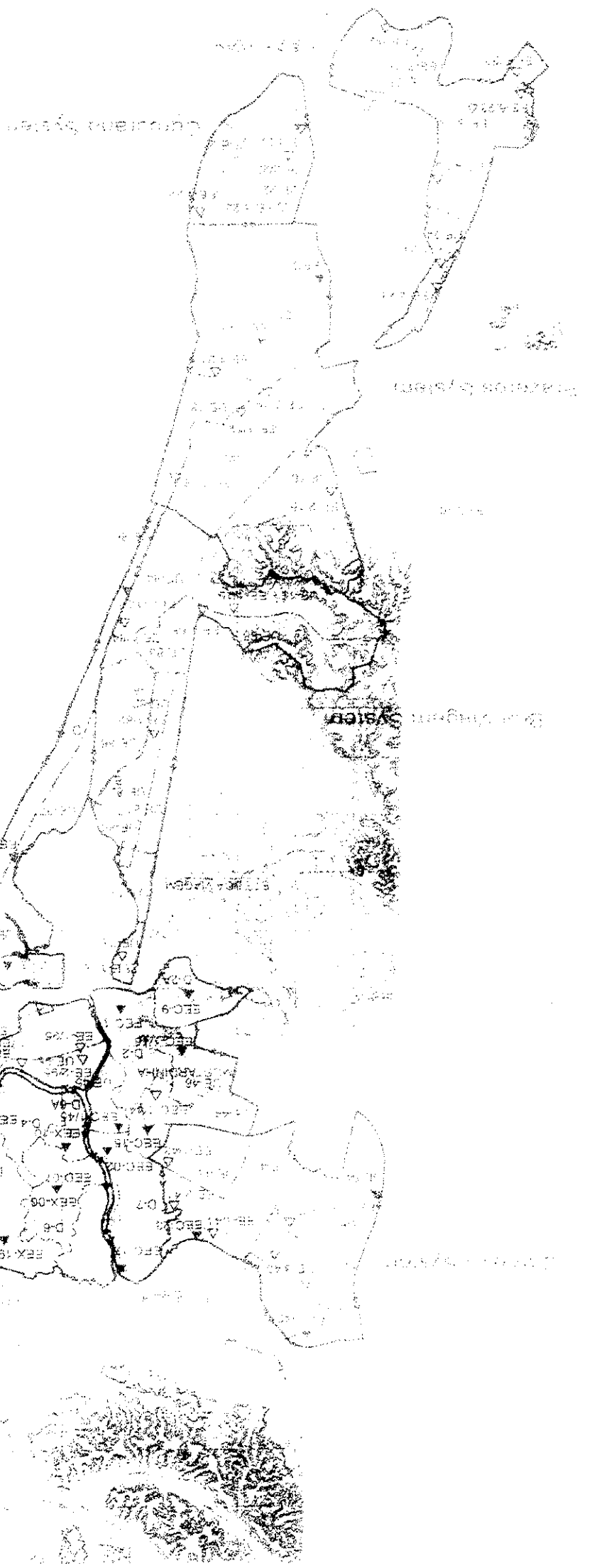
- SISTEM BOUNDARY
- UE BOUNDARY
- UE — SEWERAGE UNIT
- EE — PUMP STATION
- ETE — TREATMENT FACILITY
- △ — PLANNED PUMP STATION
- ▲ — EXISTING PUMP STATION
- EXISTING AREA (CONVENTIONAL)
- EXISTING AREA (CONDOMINIAL)

SCALE 1:80,000

0 1000 2000 m

Fig.IV Layout Plan of 7 Systems

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR



OUTLINE OT THE STUDY

1 Introduction

This Study has been conducted on the Master Plan of Stormwater drainage and sewerage management plan for Recife Metropolitan Area and the Feasibility Study on the priority projects identified in the Master Plan.

The Recife Metropolitan Region (RMR) had a population of 3.1 Million (in 1996), covering 2,766 $km^{2,}$ which are composed of 11 major river basins. The RMR is rich in tourism resources such as beautiful beaches and historical towns and buildings. Once the RMR were developed on the basis of port activities, the sugar cane industry and an important agricultural production area of sugar, cotton, fruits, etc, but now the tourism is the leading industry of the State due to the sluggish of the agricultural sector. The RMR is characterized by a heavy concentration of population in the urban area, a wide distribution of the poverty areas or informal settlements and a scarcity of basic infrastructures such as sewerage systems and drainage systems.

The population of the RMR doubled between 1950 and 1970 and has been increasing ever since. According to the 1996 Census about 40% of the population (7.4 Million) of the State Pernambuco, were living in the RMR and 83% of the urban population of the RMR were living in the five municipalities in the central part of the RMR. The population in the poverty areas is estimated to be more than 40% of the urban population of the RMR and slums or informal settlements have been developed at the hilly areas and the low-lying areas along rivers and water bodies in the urban area. They are usually lack of basic infrastructure like drainage and sewerage facilities and accordingly accelerating the devastation of the urban environment.

The households connected to the sewer systems and to the sewage treatment plants are to be 36 % and 21 % respectively. Due to being superannuated and also poorly maintained, many of the existing sewerage facilities (sewer pipes, pumping facilities and sewage treatment facilities) are inactive. Accordingly the collected domestic wastewater of the RMR is mostly discharged directly or indirectly into the rivers or water bodies without proper treatment. As the results drainage channels are polluted, water bodies are eutrophicate, and river/coastal waters are polluted. Due to the Study 91 % of the total BOD pollution load was discharged into the five major rivers, i.e., the Capibaribe, Beberibe, Jaboatao, Tejipio and Timbo Rivers.

The incidence of water borne diseases and a high death rate, affected by living conditions in the neighborhoods, and also stagnation of the tourism industry, and the drainage and sewerage management is an urgent measure for the State Government to solve.

2. Master Plan for Stormwater Drainage and Sewerage Management

2.1 Framework for the Target Year 2020

The frameworks of urban population, urban area, Gross Regional Domestic Product (GRDP) for the target year 2020 were formulated as follows:

- Urban population: 3,635 thousand inhabitants
- Urbanized area: 364.25 square km
- GRDP of the State: R$ 65 billion (at 1997 constant prices). This is 2.8 times of that of 1997 (R$ 23.26 billion). The growth rate is expected to be 3.2 % in 2020, which is larger than the rate (2.7 %) in 1997.
- GRDP per capita: R$ 7,600 at 1997 constant prices. This is 2.4 times of that of 1997 (R$ 3,100). It is projected to be 79 % of the national average, which will have increased by 58 % since 1997.

2.2 Sewerage Facility Development Plan

The 86 sewerage systems proposed for the RMR in the PQA were reviewed and 55 sewerage systems were selected for the Master Plan (Fig.2). For the 55 sewerage systems rehabilitation of existing sewerage facilities, development of new sewerage facilities and also strengthening of the implementation organization and the O&M organization are planned. By completion of the 55 sewerage systems the percentage of sewer population will be 91 %.

The Master Plan was planned to be executed in the following two phases:

- Phase 1(2001-2010) : Improvement of sewerage facilities for the 25 sewerage systems,
- Phase 2 (2011-2020): Improvement of sewerage facilities for 30 sewerage systems.

2.3 Stormwater Drainage Management Plan

Currently flood and drainage problems in the RMR are identified locally at the low-lying areas along the rivers and water bodies in the municipalities of Olinda, Recife and Jaboatao.

In the past the major part of the urban area of the RMR were frequently affected by floods from the Capibaribe River, however, two dams (Carpina and Goita) were constructed in the river basin and the river channel were improved at the upper reach of the national road No.101. Since 1978 no big floods have been occurred in the central part of the RMR. The drainage facilities planned in the PQA for Olinda, Recife and Jaboatao are planned to be implemented for the time being. The preparation of basic hydrological and river data and the formulation of drainage and flood mitigation measures are proposed.

2.4 Project Cost

The project costs of the Master Plan are composed of direct cost (construction cost and rehabilitation cost, land acquisition and compensation cost) and indirect cost (administration cost, engineering cost, physical contingency) shown as follows:

1) Sewerage project

The project cost for the sewerage projects is estimated to be R$ 852.7 Million (US$ 448.8 Million) as detailed below:

Project Cost for the Sewerage Project (Unit: R$ Million)

Item	Phase 1	Phase 2	Total
1 Direct cost	528.3	133.9	662.2
2 Indirect cost	151.5	39.0	190.5
Total	679.8	172.9	852.7

Note:

1) Price level is presented under the economic conditions that prevailed in November 1999. The exchange rates: R$1.90 = US$1.00 = ¥105.00.
2) The project cost includes the following items:

- Direct cost : Construction cost, including rehabilitation cost, and land acquisition and compensation cost,
- Indirect cost: 30 % of the direct construction cost,

2) Stormwater drainage project

Project Cost for the Stormwater Drainage project (Unit: R$ Million)

Item	Phase 1
1 Direct cost	
1) Construction for Recife	0.81
2) Construction for Olinda	1.03
3) construction fir Jaboatao	2.34
Sub total	4.18
2 Indirect cost	0.84
Total	5.02

Note: The exchange rates and the composition of indirect cost are the same as the sewerage project.

3) The annual operation and maintenance costs (O&M costs) are estimated as follows:

1) Annual O&M cost for the sewerage project is estimated at R$ 44 million, 7.0 % of the direct construction cost,

2) Annual O&M cost for the stormwater drainage is estimated at R$ 0.083 million, 2.0 % of the direct construction cost.

2.5 Project Evaluation

The project was evaluated in their financial, economic, social and environmental terms as well as technical term.

The technical evaluation is to inspect the reduction effects of pollution loads by sewerage facilities and the financial and economic evaluation are to be conducted in accordance with the conventional methodology that is commonly applied in the evaluation of development programs in Brazil with finance from the World Bank and the other international agencies.

The financial evaluation is to inspect the proposed projects from the financial point of view, involving tests of earning capacity and financial efficiency. The economic evaluation is to examine the proposed project from the economic point of view, that is, viability of social investment in the national economy.

The opportunity cost of capital is assumed to be between 10 % and 12 %, but 12 % is used as the discount rate referring the projects by international financial agencies in Brazil.

The benefits are quantifiable or tangible benefits of direct effects are quantified as project benefits. In this study, the following three benefits were chosen as tangible benefits

Tangible Benefits with Sewerage Projects

No.	Tangible Benefits	Quantified Benefits
1)	Sewage treatment saving benefits for inhabitants	Elimination of installation and O&M costs of other treatment systems and septic tanks outside the existing sewerage collection service areas
2)	Decrease of medical expenses and losses due to absence from work	Cost reduction of medical expenses for water borne diseases, and Reduction of losses from absence from work due to water borne diseases
3)	Elimination of tourism recession owing to maintenance of tourism resources	Maintaining tourist attractions and promotion of regional industries related to tourism in the RMR

The financial and economic evaluation indices of the entire project were calculated at 6.1% of FIRR and 14.4 % of EIRR as follows:

FIRR and EIRR Evaluation Indices

	Description	FIRR	EIRR (%)
	Entire Projects	6.1	14.4
1.	Capibaribe River Basin	6.9	14.4
2.	Beberibe River Basin	7.4	18.9
3.	Jaboatão River Basin	4.7	13.0
4.	Tejipio River Basin	5.8	11.2
5.	Timbo River Basin	8.3	13.7
6.	Other River Basins	7.2	3.7

The proposed projects are evaluated as feasible in technical, financial, economic, social and environment as shown in Table 7. By the implementation of 55 sewage subsystems the master plan is expected to produce the following positive effects:

- It will expand the sewerage service area from 8,516 ha to 29,985 ha by 2020 and increase the sewage treatment level from no more than 21 % of the urban population in 1997 to about 90 % in 2020. By the expansion of sewerage service areas, living and sanitary conditions in the RMR will be improved.
- The FIRR is estimated at 6.1 %, which is lower than the 12% decisive factor. However, the projects could be manageable, if the state government procures financial sources with an interest rate of less than 6.1 %. The financial condition of the operational body will be further improved by increasing tariffs and by utilizing government the capital investment.
- The EIRR is estimated at 14.4 %, so the projects could be viable from the economic point of view.
- It will improve the sanitary conditions of the poverty areas by providing with sewerage facilities for some 885,000 inhabitants in these areas.
- The five major river basins (Capibaribe, Beberibe, Jaboatão, Tejipio and Timbo) are to have a high priority for early implementation.

2.6 Initial Environmental Examination (IEE)

According to the Manual of Guidelines for Evaluation of Environmental Impacts by the CPRH, 1998 and the Environmental Guidelines by JICA, 1994, the IEE of the project covered "Physical Resources", "Ecological Impacts" and "Socio-economic Impacts".

No significant adverse impacts by the construction of the priority projects are to be expected on air quality, hydrological situation, ecological resources and water quality, however, further study on the impacts by the priority projects are proposed as follows:

- The sewage treatment facilities may give an offensive odor to the surrounding

settlement areas,

- The effluent discharge may cause adverse impacts on the river environment,
- The construction of the projects may have adverse impacts on ecology,

2.7 Priority Project

The Priority Projects for F/S were selected from the sewerage systems in the major river basins for restoration of the urban environment. The following sewerage systems have been selected as the priority projects for F/S.

Priority Projects for F/S

System	River basin	Municipality	Service Population
1. Conceicao	Timbo	Paulista	62,440
2. Janga	Timbo	Paulista	322,450
3. Cabanga	Capibaribe	Recife	306,690
4. Boa Viagem	Tejipio	Recife	157,010
5. Cordeiro	Capibaribe	Recife	109,230
6. Prazeres	Jaboatao	Jaboatao dos Guararapes	233,400
7. Curcurana	Jaboatao	Jaboatao dos Guararapes	150,160
Total			1,341,380

Note: The priority projects do not include sewerage systems in the Beberibe River Basin because the Beberibe River Basin has already been selected for the Pro-Metropole Project (Project of Infrastructure in Low-income Areas of the RMR) financed by the World Bank, which includes the construction or improvement of drainage and sewerage systems.

2.8 Action Plan

The Master Plan planned to establish a Project Management Unit (PMU) and to implement the projects in two Phases by 2020. The tasks required in each phase are planned as follows:

(1) Tasks Phase 1 (2001-2010)

(Sewerage)

- Implementation of the phase 1 projects (25 sewerage systems),
- Execution of routine O&M activities after completion of the Phase 1 projects,
- Promotion of environmental education as a non-structural measure,

(Drainage)

- Installation and observation of automatic rain gauges, and execution of basic river surveys,
- Implementation of the drainage projects in the PQA,

- Preparation of river improvement plan for the major reaches.

(2) Tasks in the Phase 2 (2011-2020)

(Sewerage)

- Implementation of the Phase 2 projects,
- Execution of routine O&M activities,

(Drainage)

- Establishment of design conditions,
- Formulation of stormwater drainage and river improvement plan for major rivers.

3 Feasibility Study on the Priority Projects

3.1 Sewerage Facility Plan

The sewer networks and major facilities for the seven sewerage systems are planned based on the topographic maps (1:10,000) provided by FIDEM. The proposed facilities are summarized as follows:

● Trunk sewer:	125.4 km
● Pump stations:	81 stations (Construction: 43 stations, Rehabilitation: 38 stations),
● Sewage treatment stations:	7 stations (Construction: 5 stations, Rehabilitation: 2 stations)

Rehabilitation of the existing sewage treatment facilities is planned at Janga and Cabanga sewerage systems. Sewage treatment process is composed of biological treatment process, disinfection and sludge treatment processes as follows:

1) Biological treatment system

- "RAFA + Bio-filtration" process is applied for Cabanga and Cordeiro have a certain limitation for land space.
- "RAFA + Aerated lagoon + Polishing pond" process is applied for Conceicao, Janga, Boa Viagem Prazeres and Curcurana where have no limitation for land space.

2) Disinfection System

The chlorine process is the most advantageous in terms of economic efficiency. However, the residual chlorine and generated chlorine compounds might produce adverse impacts on the aquatic ecosystem.

Though a specific policy of disinfection method has not been established in the RMR yet, the ultra violet process is planned to be applied for the seven sewage treatment facilities to avoid any adverse effects on the aquatic ecosystem including mangroves growing along the rivers and also to consider future regulation by the CPRH.

3) Sludge Treatment Process

- A certain mechanical dehydration is applied for Cabanga, Boa Viagem and Cordeiro sewage treatment facilities which have a limited lad space or be located in densely populated area.
- A natural drying bed is applied for Conceicao, Janga, Prazeres and Curcurana sewage treatment facilities, which have an enough land apace or be not located in a densely populated area.
- Final disposal is to be disposal by sanitary landfill.

3.2 Project Cost

(1) The project cost, consists of 1) Construction cost, 2) Land acquisition and compensation cost, 3) Engineering service cost, 3) Administration cost, and 4) Physical contingencies. The project cost is estimated to be R$ 344.5 million (as shown in the following table:

Project Cost

Item	Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana	Total
I Direct cost								
1 Construction cost 1) Sewage treatment Plants	5,618	13,506	15,133	7,094	6,928	10,571	9,839	68,689
2) Trunk sewers and Pumping stations	3,452	18,009	12,605	10,060	5,714	12,131	6,483	68,454
3) Branch sewers, etc.	7,065	27,168	12,027	10,765	8,414	13,798	10,040	89,277
Sub total	16,135	58,683	39,765	27,919	21,056	36,500	26,362	226,420
2 Land acquisition cost	3,296	48	480	24,251	1,427	14,999	1,024	45,525
3 O&M equipment cost	649	711	711	649	649	649	649	4,667
II Indirect cost								
1 Engineering services cost	1,614	5,868	3,977	2,792	2,106	3,650	2,636	22,643
2Government administration cost	807	2,934	1,988	1,396	1,053	1,825	1,318	11,321
3. Physical contingency	2,420	8,802	5,965	4,188	3,158	5,475	3,954	33,962
Total	24,921	77,046	52,886	61,195	29,449	63,098	35,943	344,538

Note: 1. Exchange rates: R$1.80 = US$1.0 = ¥110.00 (in July 2000),

2. Direct cost: Construction cost, including rehabilitation cost, land acquisition/compensation cost, procurement of O&M equipment

3. Indirect cost: Administration cost (5 % of the direct construction cost), Engineering cost (10 % of the direct construction cost) and physical contingency (15% of the direct construction cost)

(2) O&M cost

The annual cost for O&M was estimated to be R$ 13.6 million, 6 % of the direct construction cost.

(3) Construction schedule

The priority project is to be completed within 7 years from 2001.

3.3 Environmental Impact Assessment (EIA)

(1) The impacts on the rivers caused by effluent discharge of the proposed sewage treatment facilities are evaluated to be insignificant as follows:

- The effluent discharge would not cause any significant adverse impacts on the river environment
- The wastewater treatment facilities would not give any significant offensive odor to the surrounding settlement areas except the Cabanga sewage treatment facility and the Cabanga STF could reduce the odor by installation of a green belt and other countermeasures.
- The construction of the projects would not have any significant adverse impacts on ecology, because there are no species of flora and fauna at risk of extinction in the project sites.

(2) Any new project shall be accorded environmental licenses by the state government in accordance with the procedures specified. The project is categorized under "Item 4: Wastewater Projects" under Environmental Licensing Manual, 1998 (CPRH). The project requires getting environmental licenses from the CPRH before implementation. There are three environmental licenses, namely "Preliminary license", "Installation license" and "Operation license" that are to be issued separately.

3.4 Project Evaluation

The financial and economic evaluation indices of the entire project were calculated at 7.9 % of EIRR and 13.1%of EIRR as follows:

Financial and Economic Evaluation Indices

	Description	FIRR (%)	EIRR (%)
1.	Conceição	3.1	12.6
2.	Janga	9.9	12.8
3.	Cabanga	15.0	15.5
4.	Boa Viagem	4.1	11.7
5.	Cordeiro	6.6	10.8
6.	Prazeres	4.9	14.1
7.	Curcurana	7.2	14.6
	Entire Systems	7.9	13.1

The overall project evaluation based on urgency (total pollution loads in the basin), technical evaluation (reduction in amount of BOD (kg/day). financial/economic evaluation (values of FIRR/EIRR for the projects), social /environmental impact (total served population, and the

served population in poverty areas). By the implementation of sewage systems the priority projects are expected to produce the following positive effects:

- It will expand the sewerage service area from 8,516 ha to 12,464 ha in 2010 and increase the sewage treatment level from no more than 21% of the urban population (in 1996) to about 37 % of that in 2010. By the expansion of sewerage service areas, living and sanitary conditions in the RMR will be improved.
- The FIRR is estimated at 7.9 %, which is lower than the 12% decisive factor. However, the projects could be manageable, if the State government procures financial sources with an interest rate of less than 7.9 %. The financial condition of the operational body will be further improved by increasing tariffs and by a subsidy by the State government.
- The EIRR is estimated at 13.1 %, so the projects could be viable from the economic point of view.
- It will improve the sanitary conditions of the poverty areas by developing the sewerage system to provide for some 324,000 inhabitants in these areas.

Overall Evaluation of Priority Projects

System	River Basin	Generated BOD Load in the River Basin (kg/day)	Basic Conditions				Urgency		Technical Evaluation		Economic Evaluation		Financial Evaluation		Social Environmental impact		Impacts by Construction		Evaluation as a whole	
		(Ratio (%) of the total pollution load in the RMR)	Area (ha)	Population in 2020.	BOD load (kg/day)	Construction cost (1000R$)	Based on the river basin and location.		Based on the reduction amount of BOD load (kg/day), and reduction rate (%) of the total BOD load from the basin,		Based on the value of EIRR for the Sewerage System.		Based on the value of FIRR for the Sewerage System.		Based on the number of serviced population, and the served population in the poverty areas.					
Conceição	Timbo	25,874 (13.1%)	853	62,440	3,372	16,135	Urgent	B	Reduction amount of BOD: 3,035 kg/day, Reduction rate:11.7%	C	12.6%	A	3.1%	B	Served population: 62,445 Served population in poverty area: No data.	C	Impacts unknown, but no significant impacts expected	B	Effective	B —
Janga	Timbo	25,874 (13.1%)	3,954	322,450	17,423	58,683	Very urgent	A	Reduction amount of BOD: 15,681 kg/day, Reduction rate: 60.6%	A	12.8%	A	9.9%	A	Served population: 322,450 Served population in poverty area: No data.	A	No significant impacts expected.	A	Very effective	A
Cabanga	Capibaribe	43,839 (22.2%)	2,671	306,690	17,443	39,765	Very urgent	A	Reduction amount of BOD: 15,699 kg/day, Reduction rate: 35.8%	A	15.5%	A	15.0%	A	Served population: 306,690, Served population in poverty areas: 72,869 (24%)	A	No significant impacts expected.	A	Very effective	A
Boa Viagem	Tejipio	30,366 (15.4%)	1,203	157,010	8,525	27,919	Very urgent	A	Reduction amount of BOD: 7,673 kg/day, Reduction rate:25.2%	B	11.7%	B	4.1%	B	Served population: 157,010, Served population in poverty area:34,008 (22%)	A	Some impacts to the housing area nearby.	C	Effective	B+
Cordeiro	Capibaribe	43,839 (22.2%)	1,054	109,230	5,898	21,056	Urgent	B	Reduction amount of BOD: 5,508 kg/day, Reduction rate: 12.1%	C	10.8%	B	6.6%	A	Served population: 109,230 Served population in poverty areas: 29,215 (29%)	B +	Some impacts to the surrounding poverty area nearby.	C	Effective	B+
Prazeres	Jaboatao	35,139 (17.8%)	1,570	233,400	12,604	36,500	Very Urgent	A	Reduction amount of BOD: 11,344 kg/day. Reduction rate: 32.3%	A	14.1%	A	4.9%	B	Served population: 233,403, Served population in poverty areas:138,204 (60%)	A	Impacts Unknown, but no significant impacts expected	B	Very effective	A —
Curcurana	Jaboatao	35,139 (17.8%)	1,160	150,160	8,108	26,362	Urgent	B	Reduction amount of BOD: 7,297 kg/day, Reduction rate:20.8%	B	14.5%	A	7.2%	A	Served population: 150,160, Served population in poverty area:48,011 (32%)	B -	No significant impacts expected.	A	Very effective	A

Evaluation Criteria

Evaluation Item	A	B	C
Technical evaluation (Reduction amount of BOD)	Above 10,000 kg/day	10,000~5,000 kg/day	Below 5,000 kg/
Economic evaluation	Above 12.0 %	12.0 %~10.0%	Below 10.0 %
Financial evaluation	Above 5.0 %	5.0 %~2.0 %	Below 2.0 %
Social environmental evaluation	Very high	High	Low

3.5 Institutional Organization

SEPLANDES as an umbrella agency for implementation of the project shall establish a PMU with a committee organized by the representatives from SEPLANDES, SEIN, SRH, COMPESA, CONDEPE, FIDEM, ITEP and CPRH. The PMU is to be established before the detailed design stage.

A preparation committee for the PMU should be organized immediately after the Study.

3.6 O&M Plan

In the State of Pernambuco, the sewerage systems are to have been under COMPESA since 1971. COMPESA should continue the routine O&M activities for the existing sewerage facilities. Detailed O&M plan should be prepared in the detailed design stage.

For the time being COMPESA is considered to be responsible for O&M of the sewerage systems in the State and the staff of COMPESA should be trained for the routine O&M activities required after the completion of the project.

3.7 Implementation Plan

(1) SEPLANDES as an umbrella agency or as a general coordination organization should establish a Project Management Unit (PMU) before the implementation of the projects.

(2) The preparation of the detailed design (including tender documents) of the projects and the supervision of the construction works should be done by a team of consultants procured through a guideline of the financing agency.

(3) The construction of the projects should be done by contractors procured through a guideline of the financing agency.

(4) Human resources development should be done through On-the-Job-Training in principle through the detailed design and supervision.

- Preparation of sewerage facility data base as a O&M tool is to be done in the detailed design stage,
- Preparation of a O&M plan is to be done in the detailed design stage,
- Preparation for O&M of the projects is to be done in the supervision stage

(5) Immediately after the Study it is necessary for SEPLANDES to set up a preparation committee for implementation of the project. The committee consists of some of the

counterpart personnel and representatives of the agencies concerned in addition to the executive secretariat.

Implementation Plan for Priority Projects

Sewerage System	Work Item	Phase 1									
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Conceicao	Preparation/Arrangement										
	Designing and Tender										
	Construction and Supervision										
	Operation and Maintenance										
Janga	Preparation/Arrangement										
	Designing and Tender										
	Construction and Supervision										
	Operation and Maintenance										
Cabanga	Preparation/Arrangement										
	Designing and Tender										
	Construction and Supervision										
	Operation and Maintenance										
Boa Viagem	Preparation/Arrangement										
	Designing and Tender										
	Construction and Supervision										
	Operation and Maintenance										
Cordeiro	Preparation/Arrangement										
	Designing and Tender										
	Construction and Supervision										
	Operation and Maintenance										
Prazeres	Preparation/Arrangement										
	Designing and Tender										
	Construction and Supervision										
	Operation and Maintenance										
Curcurana	Preparation/Arrangement										
	Designing and Tender										
	Construction and Supervision										
	Operation and Maintenance										

Disbursement Schedule of Priority Projects (Unit: 1,000)

Sewerage System	Project Cost	Period					
		2002	2003	2004	2005	2006	2007
Conceisao	24,921	3,344	2,294	4,500	8,167	6,616	—
Janga	77,046	5,796	1,980	11,639	20,807	20,807	16,017
Cabanga	52,886	4,152	1,566	9,037	9,037	16,401	12,693
Boa Viagem	61,195	14,872	13,055	5,537	9,900	9,900	7,931
Cordeiro	29,449	2,924	1,555	5,874	10,659	8,437	—
Prazeres	63,098	11,092	8,716	7,240	12,941	12,941	10,168
Curcurana	35,943	3,277	1,566	7,354	13,346	10,400	—
Total	344,538	45,457	30,732	51,181	84,857	85,502	46809

4. Conclusion and Recommendation

In the RMR the water quality of the rivers and drainage channels has been polluted and the water environment is deteriorated. The restoration of the river environmental conditions, especially water quality, is an urgent measure for the RMR to meet.

The proposed Master Plan for Stormwater Drainage and Sewerage Management for the RMR is feasible in technical, economic, financial, social and environmental terms. By implementation of the proposed projects, the water quality in the RMR will be improved and the water environment will be restored.

It is recommended for the State Government of Pernambuco to take immediate actions for implementation of the following:

(1) For early restoration of the urban environment of the RMR, it is very important for the State Government to take immediate actions to implement the seven sewerage systems identified as priority projects and the water environment will be restored.
(2) Also it is important to take necessary actions to implement the stormwater drainage facilities proposed in the PQA from technical aspects.
(3) For smooth implementation of the Master Plan and the Priority Projects, it is necessary for the State Government and SEPLANDES to organize a preparation committee for PMU immediately after the Study and to establish a PMU before the detailed design stage. Also SEPLANDES is to take necessary actions to develop the human resources in order to strengthen the related organizations.
(4) For strengthening the O&M activities COMPESA shall prepare basic data of the existing sewerage facilities and their conditions, including the examination of the existing sewer networks.
(5) For implementation of successful condominial sewerage systems the State Government should support COMPESA to take systematic and continuos actions to guide the communities through all the stages (planning, implementation and O&M stages).
(6) For preparation of optimum measures for stormwater drainage and flood control of the RMR in future, it is necessary for the RMR to install automatic rain gauges in the urban area, at least at Olinda, Recife and Jaboatao dos Guararapes, in order to collect rainfall data of short duration, and it is also necessary to conduct river surveys for the major rivers in order to prepare optimum flood control measures.

SUMMARY

SUMMARY

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SUMMARY

1 INTRODUCTION

This is a summary of Final Report on "the Study on Stormwater Drainage and Sewerage Management Plan for Recife Metropolitan Area in the Federative Republic of Brazil" (hereinafter referred to as "the Study"). This report has been prepared in accordance with the Scope of Work and the Minutes of Meeting agreed upon between the State Secretariat of Planning and Social Development, State of Pernambuco (hereinafter to as "SEPLANDES") and the Brazilian Cooperation Agency (ABC), and the Japan International Cooperation Agency (hereinafter referred to as "JICA") on March 3, 1999.

The Study Area is the Recife Metropolitan Region (RMR) of the State of Pernambuco, which is the socio-economic center in the Northeast Region. The RMR covers 2,766 km^2 with a population of 3.1 million (in 1996), composing of 14 municipalities and 11 major river basins as shown in Fig. I and the figure in page 3. The urban area covers 302 km^2.

The RMR is under a heavy concentration of population in the urban area, a wide distribution of the poverty areas (or informal settlements) and a scarcity of basic infrastructures such as sewerage systems and drainage systems. Due to the 1996 census about 40 % (3,0 million) of the population of the State of Pernambuco, which was 7.4 million of population, were located in the RMR and 83% of the urban population were living in the five municipalities, i.e., Recife, Olinda, Jaboatão dos Guararapes, Paulista and Camaragibe. The population in the poverty area and the informal settlements in the urban area are increasing.

The population in the poverty areas is estimated to be more than 40 % of the urban population and the increment of poverty areas in the urban area, which are usually lack of infrastructure like drainage and sewerage facilities, are accelerating the deterioration of the urban environment.

In the Recife City Proper there are the sewerage facilities, which were mostly constructed before the 1980s. The households connected to the sewer systems are 36 % of the whole households, but those connected to the sewage treatment systems are 21 % of the whole households. Many of the existing sewerage facilities are inactive due to superannuated and poor O&M activities. Accordingly a large part of the urban wastewater is discharged directly or indirectly into the rivers without proper treatment. The rivers and water bodies, in the central part of the RMR, have been polluted by the wastewater from the urban areas.

that causes bad effects on the health of inhabitants and also stagnation of the tourism industry, which is the leading industry in the State, and the sewage treatment is an urgent measure for the State Government to solve.

For the improvement of the poverty area ZEIS (Special Zones of Social Interest), PRO-METROPPOLE (Integrated Action Program in the RMR Low Income Areas) etc. have being conducted, however, basic measures for drainage and sewerage are serious concern to the State Government to meet.

In order to cope with the unfavorable environmental situation, "Program for Water Quality Improvement and "Water Pollution Control (PQA)" was implemented for three years by SEPLANDES since 1996, with the financial assistance from the International Bank for Reconstruction and Development (IBRD). In the PQA stormwater drainage and sewerage management systems were studied, but the PQA seems to have economic and technical problems for early implementation of the management systems.

In response to the request of the government of Brazil, the government of Japan has decided to conduct the Study through JICA, the official agency responsible for the implementation of the technical cooperation program of the government of Japan.

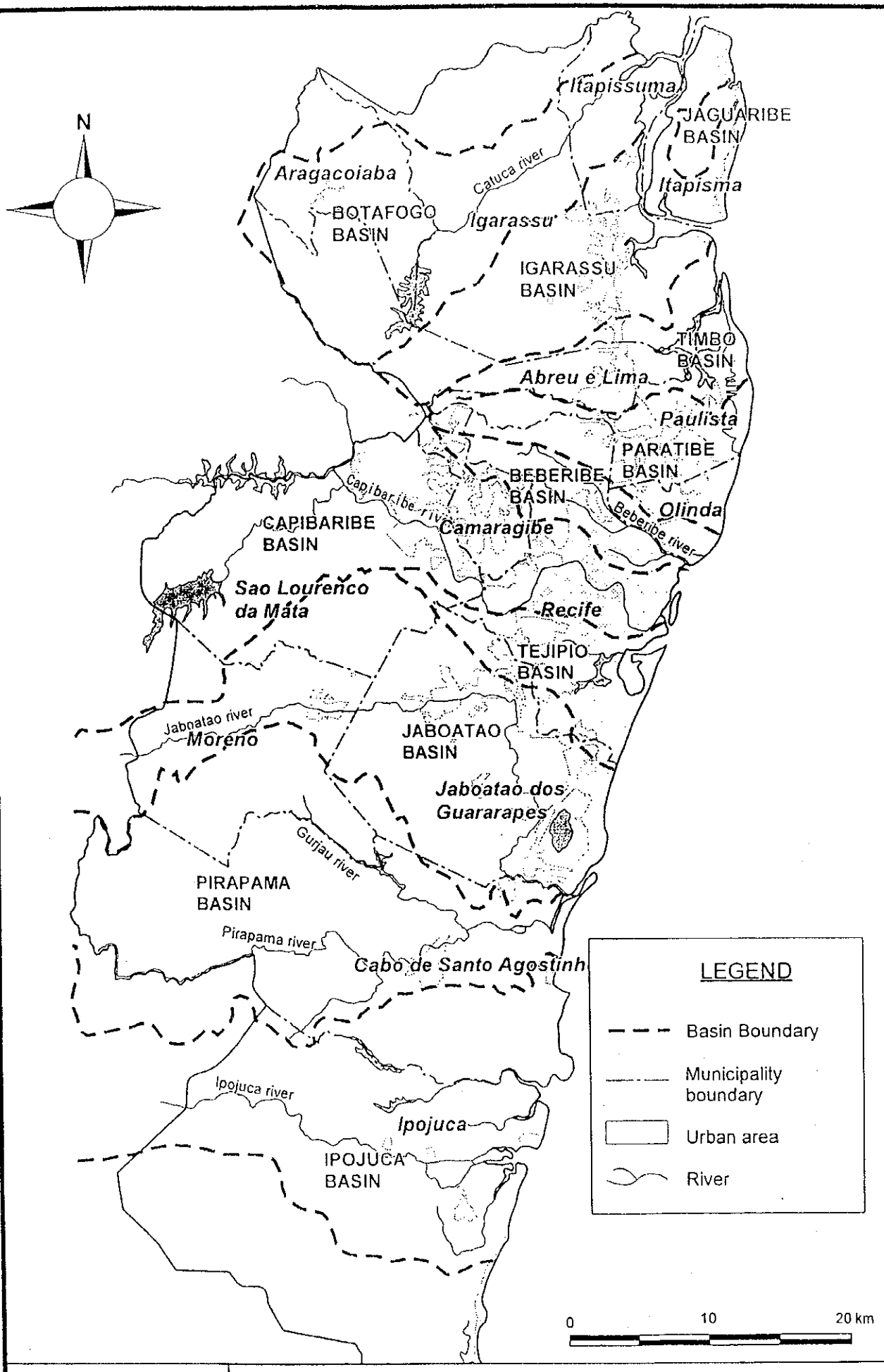
In February 1999, JICA dispatched the Preparatory Study Team headed by Mr. Shinichiro Uchida to Brazil for the preliminary survey for the Study and discussed the Scope of Work with SEPLANDES and ABC.

Under these circumstances, the objectives of the Study are:

1) to formulate a Master Plan for Stormwater Drainage and Sewerage Management in Recife Metropolitan Area (RMR) for the target year of 2020 in order to improve the urban environment,
2) to conduct a Feasibility Study (F/S) on the urgent and /or priority project(s), which will be selected from the master plan and,
3) to carry out technology transfer to the counterpart personnel in the course of the Study.

The Study was scheduled to be conducted in two phases, i.e. Phase 1 (Master Plan Study) from October 1999 to March 2000 and Phase 2 (Feasibility Study) from May 2000 to January 2001). During Phase 1 a Master Plan for stormwater drainage and sewerage management for the RMR was

formulated and the priority projects for F/S were selected in March 2000. The Master Plan and the Priority Projects were presented in the Interim Report (March 2000) and the F/S on the priority projects were conducted from May to November 2000 after discussion with SEPLANDES in May 2000.



Municipal Boundary and Major River Basins in the RMR

THE STUDY ON STORMWATER DRAINAGE AND WASTEWATER MANAGEMENT PLAN FOR RMR

2. BACKGROUND

2.1 Existing Sewerage System

(1) The sewerage system in the RMR was designed as a separate system to collect sewage only. The sewerage facilities are under the management of COMPESA and some of the sewerage facilities were transferred from the municipal control to COMPESA in the 1970s, along with the inauguration of the national sewerage and sanitation policy in Brazil. The existing sewerage systems in the RMR are divided into two categories, which are four comparative large systems i.e., Janga (7 sub-systems), Peixinhos (9 sub-systems), Cababga (11 sub-systems) and Southern (17 sub-systems), located in the central part of the RMR and many small independent sewerage systems scattered through out the urban area (refer Figs.1 and 2). The design sewage treatment capacity is 223,000 m^3/day. The major treatment stations in the sewerage systems are Janga treatment station (Design capacity: 34,000 m^3/day, Treatment process: Oxidation Ditch), Peixinhos treatment station (Design capacity: 36,000 m^3/day, Treatment process: Biological Filtration) and Cabanga treatment station (Design capacity: 80,000 m^3/day, Treatment process: Primary Sedimentation) (refer Fig. 3). The existing sewerage facilities are summarized in the following table.

Existing Sewerage Facilities in the RM

System	Length of Pipe (km)	Number of Pumps		Treatment Capacity (m^3/day)	Served Population
		Total	Broken		
Major System					
Janga	441	50	23	54,919	265,717
Peixinhos	185	43	20	34,148	330,285
Cabanga	135	51	16	107,436	233,036
Southern	141	23	7	26,815	104,338
Sub-total	902	167	66	223,318	933,376
Other Systems					105,943
Total					1,038,409

Source – Diagnosis at the Sewerage System Operated by COMPESA in the RMR

(2) The sewerage facilities under the management of COMPESA were mostly constructed before the 1980s and superannuated. Many of the facilities (treatment stations and pumping stations) are damaged and inactive. Due to the inactive pumping stations a large part of the sewage is, instead of being sent to the treatment stations, discharged into nearby rivers and water bodies directly or indirectly. As for the actual sewage treatment capacity the major treatment stations

are also mostly inactive. Janga treatment station is mostly inactive, Cabanga is totally inactive and Peixinhos station is active but treating less than a half of the design capacity.

(3) There are thirty-one (31) small-scale independent sewerage systems with the service population of about 106,000, which were mainly constructed in specific areas like housing estates, and also there are fifty-four (54) condominial-type systems, serving some 117,000 residents in the poverty areas. The condominial sewerage system has been implemented in the RMR, also in several places in Brazil, since the beginning of the 1980s, aiming an economical solution to improve the sanitary conditions in the poverty area with participation of the users. However, there are many inactive systems. Only 22 condominial systems have been transferred to the management of COMPESA.

(4) During the Study a questionnaire survey were conducted on 10 condominial systems (7 systems: constructed by Recife City, 3 systems: constructed by COMPESA) about actual conditions during their planning, execution and O&M stages. According to the results of the survey, in order to construct a successful condominal system it is necessary for the state government and COMPESA to give a systematic guidance to the community from its planning stage through the construction stage to the O&M stage.

(5) The municipal pollution loads (BOD) discharged in 1997 was estimated to be 105,763 kg/day out of the generated load of 160,156 kg/day. The runoff coefficient is 0.66. The major five rivers (Beberibe, Capibaribe, Tejipio, Jaboatao and Timbo rivers), located in the central part of the RMR, received 91% of the total pollution load generated in the RMR as shown in Table 3 and Fig. 4.

(6) For the individual sewerage systems with septic tanks, periodical desludging is essential. However the system for sludge removal and disposal has not been established in the RMR yet. There are several private companies that work with the sludge removal, but the numbers are very limited.

(7) The industrial wastewater generated from manufacturing factories in the RMR is inspected and controlled by the CPRH along with specified criteria for effluent water qualities, and handled separately from domestic sewage based on the policy of COMPESA. Regarding the industrial pollution sources authorized by CPRH in the RMR, 38 factories present a higher degradation potential, causing a total BOD load of 310 ton/day. 9 of these sources are responsible for 96 % of the total BOD loads.

2.2 Flooding and Existing Drainage Problems

(1) The urban area in the delta of the Capibaribe River was frequently suffered from floods caused by the river until 1977. However, in the Capibaribe River basin the two flood control dams (Carpina and Goita dams) have been in operation since 1978 and also the main channel upstream the crossing of the National Road No.101 has been improved. Due to these flood control works, there have been no significant problems caused by floods from the river since 1978. Current flood problems are likely caused by storm rains in the downstream basin of the dams.

(2) The flooding problems in the RMR are mostly identified in the low-lying areas in the municipalities of Olinda, Recife and Jaboatao dos Guararapes, where many informal or low-income settlements are located (refer Fig. 5). The problems are summarized as follows:

1) Many low-income settlements (or informal settlements) are located in the flood hazard areas caused by high tide and river flooding at the swampy areas near the river mouths, coast and lake.

2) Also many low-income settlements (or informal settlements) along the river courses are located in the flood hazard area, caused by floods because of the decreasing flood conveyance capacities due to the accumulation of solid waste, aquatic plants and sedimentation in the river.

3) Development of the hills and slope areas has been increasing flood discharges and sediment runoffs.

4) Flooding of roads due to inadequate drainage facilities.

2.3 Environmental Aspects

(1) In the State of Pernambuco, the CPRH deals with all environmental affairs and plays major roles in environmental prevention, control and repression as well as environmental protection.

(1) For surface water quality control, there are Water Quality Standards (fresh water: Class 1 – Class 4, Seawater: Class 5 –Class 6 and Brackish Water: Class 7 – Class 8) established by CONAMA, and in the State of Pernambuco, according to prevailing use Effluent Discharging

Limits for watercourses are classified from Class 1 – Class 4 based on State Law No. 7269 of 5th of June 1981.

(3) The water quality of the main rivers of the RMR was classified based on their prevailing uses. The rivers are classified to class 2 to class 3 and seriously polluted by Coliforms due to the water quality data provided by the CPRH.

- Beberibe River Class 2 and Class 3,
- Capibaribe River: Class 2,
- Jaboatan River: Class 2 and Class 3
- Ipojuka River: Class 2.

2.4 Related Organizations

(1) The state government is composed of 17 secretariats under the Governor and 37 external organs under the respective secretariats. The state secretariats and external agencies related to the Study are shown in Fig. 6 and listed as follows:

(Related Secretariat)

- SEPLANDES
- SEIN
- SRH and
- SECTMA

(Related External Agency)

- COMPESA (under SEIN)
- CONDEPE (under SEPLANDES)
- FIDEM (under SEPLANDES)
- ITEP (under SECTMA)
- CPRH.(under SECTMA)

SEPLANDES is the counterpart agency for the Study and responsible for carrying out the basic planning, coordination, monitoring and evaluation of the executive actions promoted by the State Government. SEIN is responsible for coordinating formulation and execution of the

governmental policies related to transport, energy, communication, n dwelling and sanitation SRH was newly created in the new administration started in 1999, which through State Law No.11416, 17th January 1997 and is responsible of managing water resources in the state.

(2) COMPESA that was established as a public corporation under the jurisdiction of SEIN in July 1971, manages water supply services and sanitary services, providing 4.9 million people with water supply services and 1.1 million people with sewerage / sanitary services.

(3) The municipal government manages the stormwater drainage systems inside its administrative boundary in principle. Once a drainage basin spreads over two or more municipalities, the state government should manage the drainage system. In this case, SEPLANDES is the responsible agency for decision-making and SEIN is the executing agency. Also SRH is one of the responsible agencies for flood control and stormwater drainage from the viewpoint of managing water resources in the state.

As stipulated in the federal constitution 1988, the federal government should manage the river basin spreading over more than one state. However, there are no river basins to cover the other state in the Study area.

2.5 Operation and Maintenance Activities by COMPESA

GME of COMPESA is in charge of conducting the operation and maintenance (O&M) for most of the sewerage systems in the RMR. However, periodical inspections of the sewerage facilities have not been conducted since the economic crisis in 1980s and a lot of the sewerage facilities are left inactive because of damage. GME is allocated 219 employees composed of 3 professional, 6 engineers, 14 technicians and 196 others and the present O&M activities are removal of grit and sand in sewer and repaire of damaged pipes informed by residents. Though COMPESA has no O&M record, However, currently COMPESA has started digitizing basic information on the pipeline networks both for water supply and sewerage. Due to the survey conducted by remote controlled TV camera from 1998 to 1999, about 10 % of the surveyed sewer (11.6 km) were observed damaged and requiring repair.

2.6 Sewer User Charge

The households connected to the sewer system pay the sewer user charges to COMPESA together with the water charges. The water charges are based on the user types, i.e., residential, commercial, industrial and public users, and the progressive charging system for households, under which the sewer user charges are calculated as a proportion of the water charge. The

proportion of the sewer user charge ranges from 40 % to 100 % depending on the type of a sewage treatment plant and the type of sewage collection system. The user of condominial-type sewerage systems and those connected to simplified treatment systems are given favor in the sewer user charge as follows:

-1 Conventional treatment station

- Conventional collection system: 100 % of the water charge,
- Condominal type collection system: 50 % of the water charge.

-2 Simplifies treatment station

- Conventional collection system: 80 % of the water charge,
- Condominial collection system: 40 % of the water charge.

The unit water charges (1.0 m^3) are:

- Residential use: R$ 0.73 - 3.25 (Minimum charge: R$ 4.6 up to 10 m^3),
- Commercial use: R$ 2.2 (Minimum charge: R$ 11.1 up to 10 m^3),
- Industrial use: R$ 2.96 (Minimum charge: R$ 13.9 up to 10 m^3),
- Public use: R$ 1.63 (Minimum charge: R$ 10.7 up to 10 m^3).

The average sewerage treatment charges are estimated to be R$ 0.84 per m^3 based on the revenue from sewage treatment services and the sewage volume collected in July 1999.

2.7 Financial Conditions of COMPESA

The gross revenues of COMPESA range from R$ 155.5 million to 254.1 million from 1995 to 1999. According to the Profit and Loss table of COMPESA from 1995 to 1999, from 1995 to 1997 it showed a small profit, but recorded the net loss of R$ 27 million in 1998 and the larger net loss of R$ 76.0 million in 1999 because the state suffered a serious drought and the services of COMPESA were significantly impaired.

According to the balance sheet for the five-year from 1995 to 1999, the accumulated loss was R$ 230.31 million in 1995, but increased to be R$ 333.64 million in 1999. It is necessary for COMPESA to improve the managerial and operational rationalization of business.

3. MASTER PLAN

3.1 Basic Concept

(1) The framework of the Master Plan was formulated for the population, urban area of the RMR the Gross Regional Domestic Product (GRDP) and the Gross Domestic Product (GDP) in the target year 2020 were projected as follows:

- Urban population: 3,635,000 inhabitants (Table-1)
- Urbanized area: 364.25 square km (Table-1)
- GRDP of the State: R$ 65 billion (at 1997 constant prices). This is 2.8 times of that of 1997 (R$ 23.26 billion). The growth rate will be 3.2 % in 2020, which is larger than the rate (2.7 %) in 1997.
- GRDP per capita: R$ 7,600 (at 1997 constant prices). This is 2.4 times of that of 1997 (R$ 3,100). It is projected to be 79 % of the national average, which will have increased by 58 % since 1997. Thus, regional disparity will be reduced and the standard of living will approach the national level.

The future GDP and GRDP were estimated on the basis of the following assumptions.

1) Until the year 2003, GDP would increase at the growth rates predicted in the national plan. The economic growth rates of the State of Pernambuco were assumed to continue 20 % higher than the national growth rates, referring to the ratio of average growth between 1994 and 1997.

2) Beyond the year 2003, growth was assumed to slow down to the following rate:

   - Until the year 2010: Growth was set at 4.4 % referring to the World Bank report on "Global Economic Prospects 1998/99
   - Between 2011 and 2020: Growth was estimated at 3.3 % (three -quarter of the previous growth rate).

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.

(2) The Master Plan has proposed fundamental measures for improvement of the stormwater drainage and sewerage management systems in the RMR and identified priority projects for F/S in order to restore the sanitary and environmental conditions of the RMR.

3.2 Sewerage Management Plan

(1) Basic conditions

1) The basic measures consist of the rehabilitation and extension of the existing sewerage facilities (sewer systems, pumping stations and sewage treatment plants) and the construction of new sewerage facilities, together with improvement of the executing organization for development and management of sewerage systems.

2) The design units of population, and water consumption and wastewater volumes per capita per day proposed in the PQA, were applied in the master plan. The population, urban area and population density for 1997, 2010 and 2020 in the RMR are summarized as follows

	1997	2010	2020
● Population (1000 persons):	2,959	3,344	3,635
● Population density (person/km²) :	89.6	-	101.0
● Urban area (km²):	316.61	-	364.25

The details are shown in Table 1.

The design units of water consumption and wastewater volumes are shown in Table 2. The daily average water consumption and daily discharge are varied due to the social conditions and the urban areas are divided into four management districts by COMPESA. Due to the management districts the design units are varied as follows:

- Daily water consumption (liter/capita): 100 - 200
- Daily wastewater discharge
  - Daily average (liter/capita): 80 - 160
  - Daily maximum (liter/capita): 100 - 190
  - Hourly maximum (liter/capita): 150 - 285

3) The rehabilitation plan proposed in the PQA for the existing sewerage facilities was reviewed and proposed in order to recover their original functions.

4) The industrial wastewater generated from large factories (Discharging wastewater volumes over 500 m^3/month) in the RMR is not included in the sewerage system.

(2) Sewerage facility development plan

1) The 86 sewerage systems proposed for the RMR in the PQA were reviewed and 55 sewerage systems were selected for the Master Plan based on the following conditions:

- Discharging sewage without treatment,
- High necessities to improve the existing sewerage facilities,
- Having a high population density of low income class,
- Having a high pollution loads,
- Located in the major river basin,

The details and locations of the 55 systems are shown in Table 4 and in Fig. II and also the rehabilitation plan was prepared based on the plan proposed in the PQA for the existing sewerage facilities and shown in Table 4.

2) The 55 sewerage systems were planned to be implemented in the two phases as follows:

- Phase 1 (2001-2010): 25 systems,
- Phase 2 (2011-2020): 30 systems.

After completion of the 55 sewerage systems the sewerage service population is planned to cover 91 % of the urban population of the RMR in 2020.

The implementation schedule of each project is composed of three stages, i.e., preparation, construction and O&M. The implementation schedules for 55 systems are shown in the table next page.

Implementation Plan for 55 sewerage Systems

River Basin	Sewerage System	2020 Population	Construction cost(1000R$)	Phase 1 2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Phase 2 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Ruberibe	Peixinhos	398,839	48,558																				
	Nova Descoberta	65,506	11,529																				
	Dois Unidos	63,495	11,790																				
	Aguazinha	59,005	10,882																				
	Casa D'Água	35,305	11,340																				
Capibaribe	Cabanga	304,394	30,376																				
	Cordeiro	100,048	17,128																				
	Camaragibe/Recife 1	61,043	20,424																				
	São Lourenço 1	45,783	18,301																				
	Caxangá	37,326	12,733																				
	Roda de Fogo	27,810	2,149																				
	São Lourenço 2	33,288	16,064																				
	Camaragibe 3	30,238	13,395																				
	Camaragibe 2	26,107	6,556																				
	Parque Capibaribe	23,475	2,061																				
	Camaragibe 1	24,870	7,830																				
	Camaragibe/Recife 2	16,477	5,939																				
	Vila Bumty	11,397	1,654																				
	Apipucos	10,339	3,970																				
	Bonanca	5,025	3,420																				
Jaboatão	Prazeres	233,403	44,768																				
	Curcurana	123,636	26,570																				
	Jaboatão 2	56,231	22,163																				
	Ibura de Cima	51,984	7,119																				
	Comportas	49,970	12,794																				
	Jaboatão 1	45,472	9,543																				
	Jaboatão 3	36,974	13,027																				
	Poste dos Carvalhos	24,365	3,955																				
	Moreno 1	18,792	6,532																				
	Moreno 2	6,435	1,342																				
	Moreno 3	3,465	1,929																				
Tejipio	Boa Viagem	159,314	37,145																				
	Jardim Sao Poulo	56,101	16,932																				
	Imbiribeira	56,497	11,160																				
	Mangueira	42,642	4,050																				
	Ibura de Baixo	179,179	32,217																				
	Curado	18,626	1,049																				
	Vila dos Milagres	14,289	122																				
	27 de Novembro	9,369	1,158																				
	Ignês Andreazza	6,579	1,038																				
Timbo	Janga	316,075	47,192																				
	Conceição	62,445	17,688																				
	Caetés	60,779	4,647																				
	Molirão	6,380	683																				
Other Basins	Paulista	68,930	11,191																				
	Igarassu 2	50,251	17,772																				
	Mirueira	34,009	3,296																				
	Parque Pirapama	32,794	3,288																				
	Jardim Paulista	24,851	1,298																				
	Ipojuca - Sede	17,856	3,239																				
	Charequinha	15,096	3,101																				
	Itapissuma 1	10,679	3,339																				
	Itapissuma 2	10,416	2,818																				
	Nova Cruz	5,244	2,231																				
	Praia Porto de Galinhas	3,705	2,027																				

Note: Preparation

Execution

O&M

3.3 Stormwater Drainage Management Plan

(1) In the RMR current drainage and flood problem areas are mostly located in the municipalities of Olinda, Recife and Jaboatao dos Guararapes. They are mostly drainage problems of small scale (Fig. 5).

(2) The design rainfall (20-year return period) proposed in the PQA, were applied for the Study. In the RMR the small rivers and drainage channels may be wide enough and it is possible to apply them the design rainfall of a 10 to 20-year return period, if the existing informal settlements in the channels are relocated.

(3) Design tide level and river flood level were assumed and proposed as follows:
The maximum high spring tide during the rainy season (March to August) was proposed as the lower boundary condition. The maximum spring tide is 2.50 - 1.14 = 1.36 m (say 1.35m) above mean sea level. (The tide-gauge datum at Recife Port is 1.14m below mean sea level.). Observed maximum tide level is 2.82 – 1.14 = 1.68m above mean sea level.

As for river flood levels 0.5m below bank level was assumed to be the river flood level for the drainage planning in this stage. The river flood level is an outlet condition of a drainage channel. However, river improvement plans, which include longitudinal profiles, typical cross sections and alignments of the rivers, shall be required for the Beberibe, Capibaribe and Jaboatao River systems in future.

(4) For preparing permanent drainage plan for the RMR an early preparation of basic hydrological and river data are indispensable. There are 30 rainfall stations in the RMR measuring only daily rainfall, but rainfall observation of short duration (10min, 30min, 60min, 2hours, etc) for many years is required for preparing of an optimum drainage plan.

Automatic rainfall gauges shall be installed soon after the Study and the design rainfall for the drainage plan shall be reviewed based on the observed data. For preparing an optimum drainage plan for the RMR, also basic river surveys are required for the Beberibe River, Capibaribe River and Jaboatao River.

(5) Design discharges of the PQA are applied for drainage plan. For drainage plan of other rivers or channels, the relation curves showing the relationship between drainage area and discharge (20-year return period) or some specific discharges could be used as required. For micro

drainage (drainage of road surface and small areas), some standard discharge or standard design described in the PQA could be applied. For designing drainage channels the Manning's Formula proposed in the PQA was adopted.

(6) Project components of stormwater drainage improvement plan is as follows

The drainage improvement plan in the PQA was basically adopted and reviewed. The PQA plan for drainage improvements in the municipalities of Recife, Jaboatao dos Guararpes and Olinda are summarized below:

Recife City: Drainage improvements in the 15 critical flood areas including,

- Revetment of two open channels (950m),
- Cleaning of channel (200m)
- Culverts and pipes (450 m):
- Road surface drains, pavements and manholes

Jaboatao City: Drainage improvements in the 4 critical flood areas including,

- Revetment of three open channels (3,500m)
- Cleaning of channel (2,800m)
- Culverts and pipes (:550m), Cleaning 700m, Rehabilitation 80m
- Road surface drains, pavements and manholes

Olinda City: Drainage improvements in the 3 critical flood areas including,

- Revetment of two open channels (1,800m)
- Cleaning of channel (400m)
- Culverts and pipes: Cleaning 1,500m, Rehabilitation 150m
- Road surface drains, pavements and manholes.

3.4 Project Cost

(1) The project costs of the Master Plan are composed of direct cost and indirect cost (administration cost, engineering cost, physical contingency) shown as follows:

1) Sewerage project

The project cost for the sewerage projects is estimated to be R$ 852.7 Million as detailed below:

Project Cost for the Sewerage Project (Unit: R$ 1,000,000)

Item	Phase 1	Phase 2	Total
1 Direct cost			
1) Expansion work	487.4	127.1	614.5
2) Rehabilitation work	17.3	2.7	28.0
Sub total	504.7	129.8	634.5
3) Land acquisition cost	23.6	4.1	27.7
2 Indirect cost			
1) Administration cost	50.5	13.0	63.5
2) Engineering service cost	50.5	13.0	63.5
3) Physical contingency	50.5	13.0	63.5
Sub total	151.5	39.0	190.5
Total	679.8	172.9	852.7

Note:

1) Price level is presented under the economic conditions that prevailed in November 1999. The exchange rates: R$1.90 = US$1.00 = ¥105.00.

2) The project cost includes the following items:

- Direct cost : Construction cost, including rehabilitation cost, and land acquisition and compensation cost,
- Administration cost: 10 % of the direct construction cost,
- Engineering cost: 10 % of the direct construction cost,
- Physical contingency: 10 % of the direct construction cost.

2) **Stormwater drainage project**

Project Cost for the Stormwater Drainage project (Unit: R$ 1,000,000)

Item	Phase 1
1 Direct cost	
1) Construction for Recife	0.81
2) Construction for Olinda	1.03
3) construction fir Jaboatao	2.34
Sub total	4.18
2 Indirect cost	
1) Administration cost	0.42
2) Physical contingency	0.42
Sub total	0.84
Total	5.02

Note: The exchange rates and the composition of indirect cost are the same as the sewerage project.

(2) **The annual operation and maintenance costs (O&M costs) are estimated as follows:**

1) Annual O&M cost for the sewerage project is estimated at R$ 44 million, 7.0 % of the direct construction cost,
2) Annual O&M cost for the stormwater drainage is estimated at R$ 0.083 million, 2.0 % of the direct construction cost.

3.5 Project Evaluation

(1) The project was evaluated in their financial, economic, social and environmental aspects as well as technical aspects. The technical evaluation is based on the reduction of pollution loads by the sewerage facilities. The financial and economic evaluation is conducted in accordance with the conventional methodology that is commonly applied in the evaluation of development programs in Brazil with finance from the World Bank, Inter-American Development Bank and other international agencies concerned with technical and economic cooperation. The evaluation factors are Internal Rate of Return (IRR) as a main indicator, and Net Present Value (NPV) and Benefit-Cost Ratio (B/C) as supplementary indices. The social and environmental aspects are evaluated by the improvement of living conditions in the poverty area and the environmental impacts caused by implementation of the sewage treatment plants. The opportunity cost of capital is assumed to be between 10 % and 12 %, but 12 % is used as the discount rate referring the projects by international financial agencies in Brazil.

(2) The financial evaluation is to inspect the proposed projects from the financial point of view, involving tests of earning capacity and financial efficiency. The economic evaluation is to examine the proposed projects from the economic point of view, testing the viability of social investment in the national economy. In addition, the socio-economic impacts of the proposed projects are discussed.

Financial analysis was carried out on the basis of market values of project costs and incomes from the proposed projects. The revenue of sewerage treatment services was calculated as a product of a volume of sewerage treated and sewerage treatment service rates lay down by COMPESA. The financial viability of the proposed project was examined by means of evaluation indices of "financial internal rate of return (FIRR)".

(3) The financial evaluation indices of the entire project were calculated at 6.1 % of FIRR, 0.58 of B/C and minus R$225 million as follows:

Evaluation Indices

	Description	FIRR	B/C*1	NPV*1 (R$ Million)
	Entire Projects	6.1%	0.58	-225
1.	Capibaribe River Basin	6.9%	0.68	-42
2.	Beberibe River Basin	7.4%	0.70	-27
3.	Jaboatão River Basin	4.7%	0.51	-66
4.	Tejipio River Basin	5.8%	0.58	-41
5.	Timbo River Basin	8.3%	0.74	-18
6.	Other River Basins	7.2%	0.71	-9

Note: *1 Discounted at 12 %.

- The FIRR indicates that the projects are manageable, if they procure financial sources with an interest rate of less than 6.1 %.
- If it is desired to have the FIRR of more than 12 % only through revenue increase, the charging rates for all consumers would have to be increased by 73 % over present rates. The results of this countermeasure case (named Case 1) are tabulated in Table 3.7-8. It might not be acceptable for the beneficiaries to be charged the higher rates of sewerage treatment services in the present economic situation. In the future, however, the beneficiaries might accept the higher charge after their living conditions are improved owing to economic development.
- On the other hand, it would be possible to make the projects viable if some subsidies for the investment costs are available. The analysis indicates that the projects would be made viable by the covering almost 53 % of the capital investment cost with a subsidy. The results of this countermeasure case (named Case 2) are tabulated in Table 3.7-9.

(4) The economic evaluation is to examine the proposed project from the economic point of view, that is, viability of social investment in the national economy. In estimating the economic benefit, the following criteria and assumptions are applied to transfer the financial values of project benefits to the economic ones.

- The economic costs are assumed to be approximately 94 % of the financial costs for local portions. This rate is called the standard conversion factor (SCF).

- The shadow wage rate of skilled workers is fixed at 1.0. On the other hand, unskilled workers are assumed to be 0.5 of the legislated wage rate, referring to the project concerned reports.
- In the RMR, most lands expropriated for the projects are not utilized for productive activity at present. In this economic evaluation, accordingly, the value of these lands is evaluated as zero.

(5) The benefits are quantifiable or tangible, and non-quantifiable or intangible. To identify indicators for economic evaluation, only tangible benefits of direct effects are quantified as project benefits. In this study, the following three benefits were chosen as tangible benefits.

Tangible Benefits with Sewerage Projects

No.	Tangible Benefits	Quantified Benefits
1)	Sewage treatment saving benefits for inhabitants	Elimination of installation and O&M costs of other treatment systems and septic tanks outside the existing sewerage collection service areas
2)	Decrease of medical expenses and losses due to absence from work	Cost reduction of medical expenses for water borne diseases, and Reduction of losses from absence from work due to water borne diseases
3)	Elimination of tourism recession owing to maintenance of tourism resources	Maintaining tourist attractions and promotion of regional industries related to tourism in the RMR

Note: Detailed benefit structure is shown in Fig. 3.7-2 in the Main Report

(6) The economic evaluation indices of the entire project were calculated at 14.4 % of FIRR, 1.18 of B/C and R$ 90 million as follows:

Evaluation Indices

	Description	EIRR	B/C*1	NPV*1 (R$ Million)
	Entire Projects	14.4%	1.18	90
1.	Capibaribe River Basin	14.4%	1.16	18
2.	Beberibe River Basin	18.9%	1.56	47
3.	Jaboatão River Basin	13.0%	1.08	10
4.	Tejipio River Basin	11.2%	0.94	-5
5.	Timbo River Basin	18.7%	1.54	34
6.	Other River Basins	3.7%	0.56	-13

Note: Discounted at 12 %.

The EIRR of the entire projects is 14.4 %, more than the opportunity cost of capital of 12 %. So the EIRR of the Tejipio River Basin is slightly less than 12%, but the other major basins have favorable rates of more than 12 %, so these projects are feasible and should be promoted from the economic point of view. Even the Tejipio River Basin has a value approximating the opportunity cost of capital. The EIRRs of the major five river basin projects almost all exceed 12 %, so the proposed projects could be viable economically. However, the projects of other river basins were rather lower than 12 %, so they would not be viable from the economic point of view.

(7) It is obvious that commencement of construction works such as sewerage treatment projects stimulate regional economy in the sectors related to construction works as well as construction sector itself. In general, one unit of construction work could induce 1.50 to 2.00 units of economic effects in the national and regional economy. In other words, construction work would bring about a 50 % to 100 % ripple effect on related works in various economic sectors in monetary terms. This effect could increase employment opportunities and stimulate the regional economy in the State of Pernambuco.

(8) The project evaluation in each river basin was made based on the following items:

– Urgency :	Total pollution loads in the basin.
– Technical Evaluation :	Reduction in amount of BOD (kg/day).
– Financial/Economic Evaluation :	Value of FIRR/EIRR for the river basin.
– Social Environmental Impact :	Total served population, and the served population in poverty area.

The proposed projects are evaluated as feasible in technical, financial, economic, social and environment as shown in Table 6. By the implementation of 55 sewage subsystems the master plan is expected to produce the following positive effects:

- It will expand the sewerage service area from 8,516 ha to 29,985 ha in 2020 and increase the sewage treatment level from no more than 20 % of the urban population to about 90 % in 2020. By the expansion of sewerage service areas, living and sanitary conditions in the RMR will be improved.
- The FIRR is estimated at 6.1 %, which is lower than the 12 % decisive factor. However, the projects could be manageable, if the state government procures financial sources with

an interest rate of less than 6.1 %. The financial condition of the operational body will be further improved by increasing tariffs and by utilizing government the capital investment.

- The EIRR is estimated at 14.4 %, so the projects could be viable from the economic point of view.
- It will improve the sanitary conditions of the poverty areas by developing the sewerage system to provide for some 885,000 inhabitants in these areas.
- The five major river basins (Capibaribe, Beberibe, Jaboatão, Tejipio and Timbo) are to have a high priority for early implementation.

3.6 Initial Environmental Examination (IEE)

(1) According to the Manual of Guidelines for Evaluation of Environmental Impacts by the CPRH, 1998 and the Environmental Guidelines by JICA, 1994, the IEE of the project covered "Physical Resources", "Ecological Impacts" and "Socio-economic Impacts". The IEE was carried out for the priority projects based on the secondary data.

(2) No significant adverse impacts on air quality, hydrological situation, ecological resources and water quality caused are to be expected by the construction of the priority projects, the following impacts by the priority projects, however, are to be studied in the F/S stage:

- The wastewater treatment facilities may give an offensive odor to the settlements nearby,
- The effluent discharge may cause adverse impacts on the river environment,
- The construction of the priority projects may have adverse impacts on ecology.

3.7 Implementation Organization

(1) The proposed project comprises many planning components. For implementation of the project, it is necessary to have a leading agency to coordinate the organizations and agencies concerned with the proposed projects. Also the leading agency is necessary to make arrangement with the federal government and international financing organizations in order to procure financial sources for the project.

(2) SEPLANDES is recommended to be a leading agency and shall take the responsibility for implementation of the projects proposed in the master plan and establish a Project Management Unit (PMU). The PMU has to have a coordination committee including representatives of

agencies concerned in addition to the executive secretariat. The committee is composed of representatives from SEIN, SRH, COMPESA, CONDEPE, FIDEM, ITEP and CPRH as well as SEPLANDES

3.8 Priority Project

(1) The Priority Projects for F/S were selected from the sewerage systems in the major river basins for restoration of the urban environment of the RMR, because about 91 % of the BOD pollution load from the urban area of the RMR was estimated to be discharged into the five major rivers, i.e., the Capibaribe, Beberibe, Jaboatao, Tejipio and Timbo rivers, which are located in the central part of the RMR. Effects of both the existing sewerage systems with rehabilitation and the proposed sewerage facilities are assessed for the RMR to reduce the pollution loads from these major river basins except the Beberibe River. The following sewerage systems were selected as the priority projects for F/S to restore the urban environment.

Priority Projects for F/S

Sewerage system	River basin	Municipality	Service population
1 Conceicao	Timbo	Paulista	62,440
2 Janga	Timbo	Paulista	322,450
3 Cabanga	Capibaribe	Recife	306,690
4 Boa Viagem	Tejipio	Recife	157,010
5 Cordeiro	Capibaribe	Recife	109,230
6 Prazeres	Jaboatao	Jaboatao dos Guararapes	233,400
7 Curcurana	Jaboatao	Jaboatao dos Guararapes	150,160
Total			1,341,380

Note: The sewerage systems in the Beberibe River Basin are not included in the priority projects because the Beberibe River Basin has already been selected for the Pro-Metropole Project (Project of Infrastructure in Low-income Areas of the RMR) financed by the World Bank, which includes the construction or improvement of drainage and sewerage systems.

The basic conditions and the evaluation of each system are shown in Table 7.

3.9 Action Plan

The projects proposed in the Master Plan are planned to be implemented in two phases and completed by 2020. The tasks required in each phase are as follows:

(1) Tasks in the phase 1 (2001-2010)

- Establishment of a Project Management Unit (PMU) for implementation of the Master Plan,

(Sewerage)

- Implementation of the phase 1 projects (25 sewerage systems),
- Routine O&M activities after completion of the projects in Phase 1,
- Promotion of environmental education,
- Preparation for the Phase 2 projects (30 sewerage systems).

(Drainage)

- Installation of automatic rain gauges and observation of rainfall of short duration, and execution of basic river surveys,
- Implementation of the drainage projects in the PQA,
- Promotion of environmental education,
- Preparation of river improvement plan for the major reaches,

(2) Tasks in the phase 2 (2011-2020)

(Sewerage)

- Implementation of the Phase 2 projects,
- Routine O&M activities,
- Promote of environmental education,

(Drainage)

- Review of hydrological data and establishment of design conditions
- Planning of optimum flood control and drainage improvement for major rivers.

4. FEASIBILITY STUDY ON THE PRIORITY PROJECTS

4.1 General Plan for the Project

(1) The seven sewerage systems proposed as priority projects in the Master Plan have been reviewed, and the sewage treatment areas and the served population have been set up for the Study. The F/S area was increased from 10,263 ha to 12,464 ha, mainly by expansion of service areas due to the new land use plans of municipalities and accordingly the served population was increased.

(2) The sewer networks and major sewerage facilities for the seven sewerage systems are planned based on the topographic maps (1:10,000) prepared by FIDEM and the design criteria and planning policies, which are the same as the Master Plan in principle. The proposed facilities are summarized as follows:

- Trunk sewer: 125.4 km (Sewer: 69.9 km, Pressure pipe: 46.9 km, Rehabilitation: 8.6 km)
- Pump stations: 81 stations (Rehabilitation: 38 stations , Construction:43 stations)
- Sewage treatment plants: 7 station (Rehabilitation: 2 plants, Construction: 5 plants)

-1 The trunk sewers were mainly planned along public roads and the sewage new pump sites were selected and confirmed with representatives of the respective municipalities.

-2 The sewage treatment facilities (STF) were basically planned at the sites predetermined in the PQA except the STF site for Curcurana, of which a new site was selected due to the future land use plan of the municipal government.

-3 The STF sites were earmarked by the respective municipalities and field surveys (ground survey, soil investigation and environmental survey) were conducted.

-4 Sewage treatment stations were planned to comprise secondary treatment, disinfection and sludge treatment systems.

The basic data for the seven sewerage systems are summarized and shown in the following table:

Basic Data and General Facility Plan

Planning Item		Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana	Total
Service Area	(ha)	853	3,954	2,671	1,203	1,054	1,570	1,160	12,465
Population	(person)	62,440	322,450	306,690	157,010	109,230	233,400	150,160	1,341,380
Daily Ave. Flow	(m^3/day)	13,135	64,464	57,381	27,087	19,308	32,677	24,795	238,847
Daily Max. Flow	(m^3/day)	14,900	73,585	66,374	31,337	22,245	38,218	28,762	275,421
Hourly Max. Flow	(m^3/day)	20,508	102,382	93,791	44,408	31,091	53,936	40,638	386,754
Inlet BOD	(mg/l)	257	270	304	315	305	386	327	
Inlet SS	(mg/l)	285	300	338	350	339	429	363	

The general facility plans for the seven sewerage systems are summarized and shown in the following table:

Sewerage Facilities Plan for the Priority Projects

Description				Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana	Total
Sewerage Facility	Pipe (km)	Trunk Sewers	Gravity Flow	6.5	11.9	2.5	15.9	8.7	13.9	10.5	69.9
			Pressure Flow	1.7	16.8	6.8	4.5	2.1	7.5	7.5	46.9
			Rehabilitation	0	3.6	3.2	0	0	1.8	0	8.6
			Total	8.2	32.3	12.5	20.4	10.8	23.2	18	125.4
		Side walk and Branch Pipes		110.9	426.4	188.2	168.4	132.3	215.9	157	1399.1
	Pump Stations (Spot)	New Construction		4	5	6	5	6	5	12	43
		Rehabilitation (Existing)		1	13	20	0	2	2	0	38
		Total		5	18	26	5	8	7	12	81
	S.T.F(Spot)			1	1	1	1	1	1	1	7

4.2 Sewage Collection Facility Plan

(1) The preliminary design of sewer facilities was conducted based on the sewerage facility plans as folows: shown in Figs. 7 to 13.

1 Conceicao sewerage system (Fig. 7),
2 Janga sewerage system (Fig. 8),
3 Cabanga sewerage system (Fig. 9),
4 Boa Viagem sewerage system (Fig. 10)
5 Cordeiro sewerage system (Fig. 11),
6 Prazeres sewerage system (Fig. 12),
7 Curcurana sewerage system (Fig. 13).

The results of preliminary deign of the seven sewerage facilities are shown in Tables. 8 and 9.

(2) The existing sewer networks, which were mostly constructed before the 1980s, covers about 2,958 ha of the proposed seven sewerage service areas and have many pumping facilities, many of the existing sewerage facilities, however, are damaged and not fully functioned because of absence of proper maintenance and preventive measures. There are many sewerage facilities that require rehabilitation.

(3) The existing sewer system consists of gravity flow, pressure flow and mixed flow systems. Some parts of the sewer pipes need to be replaced because of lack of flow capacity. The total length of the existing pressure flow pipes to be replaced is estimated to be about 4.2 km ((ϕ200, ϕ300 and ϕ500).

(4) Rehabilitation of the existing pumping facilities

All the pumping stations connected to the existing Janga and Cabanga sewage treatment facilities and the other sewerage systems (independent small systems) have been investigated. Many of the existing pump facilities have been damaged or broken by garbage and grit, and are inactive because of lack of proper maintenance and preventive measures such as bar screens and grits chambers. The rehabilitation of the existing pumping stations was planned for 38 stations.

4.3 Sewage Treatment Facility Plan

(1) Rehabilitation of the existing sewage treatment facilities were planned at Janga and Cabanga and construction of the five sewage treatment facilities were planned at the other five sewerage systems as shown in Fig.16. The proposed sewage treatment facility comprises biological treatment, disinfection, and sludge treatment systems. Preliminary design and layout plan were prepared for the seven sewage treatment facilities.

(2) The design sewage flows and water quality levels of sewage influent and treated sewage for the sewage treatment facilities are summarized in the following tables:

Design Sewage Flow

Design sewage flows	Units	Sewage Treatment Facilities (STFs)						
		Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana
Sewage Flow in 2020								
Daily maximum flow	(m^3/d)	14,900	73,585	66,374	31,337	22,245	38,219	28,762
Daily average flow	(m^3/d)	13,135	64,464	57,381	27,087	19,308	32,677	24,795
Hourly maximum flow	(m^3/d)	20,508	102,382	93,791	44,408	31,091	53,937	40,638
Capacity of Existing Treatment Facilities								
Daily maximum flow	(m^3/d)	-	39,200	80,000	-	-	-	-
Daily average flow	(m^3/d)	-	34,341	69,161	-	-	-	-
Hourly maximum flow	(m^3/d)	-	54,541	113,045	-	-	-	-
Sewage Flows for Expansion or New Installation								
Daily maximum flow	(m^3/d)	14,900	34,385	66,374	31,337	22,245	38,219	28,762
Daily average flow	(m^3/d)	13,135	30,123	57,381	27,087	19,308	32,677	24,795
Hourly maximum flow	(m^3/d)	20,508	47,841	93,791	44,408	31,091	53,937	40,638

Water Quality of Inflow Sewage and Treated Sewage

Design parameters		Units	Sewage Treatment Facilities (STF)						
			Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana
Inflow Sewage Quality									
	BOD	(mg/l)	257	271	304	315	305	386	327
	SS (Suspended solids)	(mg/l)	285	301	338	350	339	429	363
Treated Sewage Quality									
	Removal rate	(%)	90	90	90	90	90	90	90
	BOD	(mg/l)	26	27	30	32	31	39	33
	SS (Suspended solids)	(mg/l)	29	30	34	35	34	43	36

1) Biological treatment system

In the Master Plan Study, several biological treatment processes were studied as to the applicability in the local conditions of the RMR. These were "activated sludge", "oxidation ditch", "aerated lagoon", "bio-filtration process for aerobic treatment", and "RAFA + lagoon" process, "RAFA + bio-filtration" process for combined anaerobic treatment. Among these, combined anaerobic treatment such as the "RAFA + lagoon" process and the "RAFA + bio-filtration" process were recommended as promising treatment methods in the RMR. However, following RAFA with its BOD removal rate of 75 %, in order to achieve overall BOD removal rate 90 %, a combination of aerated lagoon and polishing pond will be required. The biological treatment system was applied as follows:

- A certain limitation of land space of STF::

  "RAFA + bio-filtration" process is applied.

  This process is applied for the three SFT, i.e., Cabanga and Cordeiro.
- No limitation of land space of STF:

  "RAFA + aerated lagoon + polishing pond" process is applied.

  This process is applied for the four STF, i.e., Conceicao, Janga, Boa Viagem, Prazeres and Curcurana.

RAFA (Retor Anaerobico de Fllux Ascendente: / Upflow Anaerobic Sludge Blanket Process: UASB)

2) Disinfection system

To reduce coliform group bacteria in biologically treated sewage, various disinfection processes such as chlorine, ultra-violet, ozone and others are generally used. Among them, the chlorine process is the most advantageous in terms of economic efficiency. However, the residual chlorine and generated chlorine compounds might produce adverse impacts on the aquatic ecosystem. Though a specific policy of disinfection method has not been established in the RMR yet, the ultra violet process is planned to be applied for the seven sewage treatment facilities to avoid any adverse effects on the aquatic ecosystem and in the mangrove eco-system along the rivers and also to consider future regulation under preparation by the CPRH.

3) Sludge treatment system

At present, the sludge treatment system of the existing sewage treatment stations rely on a sludge drying bed method, which requires a large land space due to the low drying rate and also generates an offensive odor.

The mechanical dehydration processes widely used are belt press filtration, pressure filtration, centrifuge separation, vacuum filtration, etc. Comparing their dehydration performance, ease of operation and maintenance, cost performance, and space requirement. Belt-press filtration was recommended as the most suitable in the RMR.

In the Study the sludge treatment methods were planned as follows:

- A certain mechanical dehydration is applied at the STFs where land space is limited or which are located in densely populated area.
  This method is applied for Cabanga, Boa Viagem and Cordeiro sewage treatment facilities.
- A natural drying bed is applied at the STFs, which have enough land or which are not located in densely populated area.
  This method is applied for Conceicao, Janga, Prazeres and Curcurana sewage treatment facilities.

The sewage treatment systems planned are shown in the following table:

Treatment Process Applied for Priority STFs

STFs	Biological Treatment System		Sludge Treatment System		
	RAFA + Bio-Filtration	RAFA + Aerated Lagoon + Polishing Pond	Sludge Digestion	Mechanical Dehydration	Natural Drying
Conceicao		+			+
Janga		+			+
Cabanga	+		+	+	
Boa Viagem		+		+	
Cordeiro	+			;+	
Prazeres		+			+
Curcurana		+			+

The general facility layout plans for the priority projects are shown in Figs. 17 - 23.

4.4 Cost Estimate

(1) The project cost, consists of 1) Construction cost, 2) Land acquisition and compensation cost, 3) Procurement cost of O&M equipment, 4) Engineering service cost, 5) Administration cost, and 6) Physical contingencies. The project cost is estimated to be R$ 344.5 million as shown in the following table:

Project Cost for Priority Projects

Item	Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana	Total
I Direct cost								
1 Construction cost								
1) STF	5,618	13,506	15,133	7,094	6,928	10,571	9,839	68,689
2) Trunk sewers, etc.	3,452	18,009	12,605	10,060	5,714	12,131	6,483	68,454
3) Branch sewers, etc.	7,065	27,168	12,027	10,765	8,414	13,798	10,040	89,277
Sub total	16,135	58,683	39,765	27,919	21,056	36,500	26,362	226,420
2 Land acquisition	3,296	48	480	24,251	1,427	14,999	1,024	45,525
3 O&M equipment	649	711	711	649	649	649	649	4,667
II Indirect cost								
1 Engineering services	1,614	5,868	3,977	2,792	2,106	3,650	2,636	22,643
2 Administration	807	2,934	1,988	1,396	1,053	1,825	1,318	11,321
3.Physical contingency	2,420	8,802	5,965	4,188	3,158	5,475	3,954	33,962
Total	24,921	77,046	52,886	61,195	29,449	63,098	35,943	344,538

Note:

1. Exchange rates: R$1.80 = US$1.0 = ¥110.00 (in July 2000),
2. Direct cost: Construction cost, including rehabilitation cost, land acquisition/compensation cost, procurement of O&M equipment
3. Indirect cost: Administration cost (5 % of the direct construction cost), Engineering cost (10 % of the direct construction cost) and physical contingency (15 % of the direct construction cost)

(2) O&M cost

The annual cost for O&M was estimated to be R$ 13.6 million, 6 % of the direct construction cost.

(3) Construction schedule

The priority project is to be completed within 7 years from 2001.

4.5 Environmental Impact Assessment (EIA)

(1) The environmental impacts by the implementation of the seven sewage treatment facilities of the priority project were studied based on the Manual of Guidelines for Evaluation of Environmental Impacts by the CPRH, 1998 and the Environmental Guidelines by JICA, 1994. Required environmental preventive measures during the implementation and the O&M stages of the projects were studied and considered in the Study.

The impacts on the rivers caused by effluent discharge of the proposed sewage treatment facilities are evaluated to be insignificant as follows:

- The effluent discharge would not cause any significant adverse impacts on the river environment
- The wastewater treatment facilities would not give any significant offensive odor to the surrounding settlement areas except the Cabanga sewage treatment facility and the Cabanga STF could reduce the odor by installation of a green belt and other countermeasures.
- The construction of the projects would not have any significant adverse impacts on ecology, because there are no species of flora and fauna at risk of extinction in the project sites.

(2) According to the CONAMA Resolution dated January 23, 1986, any new project shall be accorded environmental licenses by the state government in accordance with the procedures specified. The project is categorized under "Item 4: Wastewater Projects" under Environmental Licensing Manual, 1998 (CPRH). The project requires getting environmental licenses from the CPRH before implementation. There are three environmental licenses in the planning, elaboration, implementation and operation phases of the project, namely "Preliminary license", "Installation license" and "Operation license" that are to be issued separately.

4.6 Project Evaluation

(1) Financial evaluation

The financial evaluation indices of the entire project were calculated at 7.9 % of EIRR, 0.71 of B/C and minus R$81.5 million as follows:

Financial Evaluation Indices

	Description	FIRR (%)	B/C*1	NPV*1 (R$ Million)
1.	Conceição	3.1	0.47	-11.4
2.	Janga	9.9	0.85	-9.2
3.	Cabanga	15.0	1.22	9.6
4.	Boa Viagem	4.1	0.46	-27.3
5.	Cordeiro	6.6	0.66	-8.7
6.	Prazeres	4.9	0.52	-24.8
7.	Curcurana	7.2	0.68	-9.9
	Entire Systems	7.9	0.71	-81.5

Note: *1Discounted at 12 %.

The FIRR values of the seven sewerage systems are lower than the decisive factor of 12 %. However, the FIRR indicates that the projects could be manageable, if they procure financial sources with an interest rate of less than 7.9 %. In order to get a higher FIRR value than 12 %, it is necessary to increase the charging rate by 40 % or to get 36 % of the capital investment cost with a subsidy.

(2) Economic evaluation

The economic evaluation indices of the entire project were calculated at 13.1 % of EIRR, 1.10 of B/C and R$ 21.30 Million as follows:

Economic Evaluation Indices

Sewerage System		EIRR (%)	B/C*1	NPV*1 (R$ Million)
1.	Conceição	12.6	1.06	0.87
2.	Janga	12.8	1.07	3.67
3.	Cabanga	15.5	1.34	12.07
4.	Boa Viagem	11.7	0.97	-0.70
5.	Cordeiro	10.8	0.90	-1.98
6.	Prazeres	14.1	1.24	7.40
7.	Curcurana	14.6	1.25	4.90
	Entire Systems	13.1	1.10	21.30

Note: *1 Discounted at 12 %.

The EIRR of the seven sewerage systems is 13.1 %, higher than the opportunity cost of the capital of 12 %. The FIRR values of the five systems (Janga, Cabanga, Curucurana, Prazeres, Cabanga) are higher than 12 % and they seems to be feasible in economic terms, but the other two systems (Boa Viagem and Cordeiro) seems to be marginal.

However, the economic analysis was based on a lot of assumptions. Accordingly these indices should be considered to be a reference for project evaluation. This stand is essential in projects for environmental purposes.

((3) Sensitivity Test

The test is made for the variations of the cost and benefit with respect to evaluation factors of the proposed projects. The results are given in the following table.

Results of Sensitivity Test

	Cost	Benefit	IRR (%)	B/C	NPV (R$ Million)
1.	Original Case	-	13.1	1.1	21.3
2.	-	10% Decrease	11.9	1.0	1.2
3.	-	10% Increase	14.3	1.2	43.8
4.	10% Increase	-	12.2	1.0	4.4
5.		10% Decrease	11.0	0.9	-18.1
6.		10% Increase	13.3	1.1	26.9
7.	10% Decrease	-	14.2	1.2	38.2
8.		10% Decrease	12.9	1.1	15.7
9.		10% Increase	15.4	1.3	60.7

The cases, of which the values of EIRR are less than 12 %, are as follows:

- 10 % decrease of the benefit, and
- 10 % increase of the cost and 10 % decrease the benefit,.

(4) Overall project evaluation

The project evaluation in each river basin was made based on urgency (total pollution loads in the basin), technical evaluation (reduction in amount of BOD (kg/day). financial/economic evaluation (values of FIRR/EIRR for the projects), social /environmental impact (total served population, and the served population in poverty areas)

The results of the project evaluation in each river basin are shown in Table 10. By the implementation of sewage systems the priority projects are expected to produce the following positive effects:

- It will expand the sewerage service area from 8,516 ha to 12,464 ha in 2010 and increase the sewage treatment level from no more than 20 % of the urban population to about 37 %. By the expansion of sewerage service areas, living and sanitary conditions in the RMR will be improved.
- The FIRR is estimated at 7.9 %, which is lower than the 12% decisive factor. However, the projects could be manageable, if the state government procures financial sources with an interest rate of less than 7.9 %. The financial condition of the operational body will be further improved by increasing tariffs and by a subsidy by the governmental.
- The EIRR is estimated at 13.1 %, so the projects could be viable from the economic point of view. Although the economic analyses were based on a lot of assumptions, these indices should be considered as a reference for project promotion.
- It will improve the sanitary conditions of the poverty areas by developing the sewerage system to provide for some 324,000 inhabitants in these areas.

The result of the comprehensive evaluation by the seven systems are tabulated as follows:

Sewerage Systems	Evaluation	
Conceicao	Effective	B-
Janga:	Very effective	A
Cabanga	Very effective	A
Boa Viagem	Effective	B+
Cordeiro	Effective	B+
Prazeres	Very Effective	A-
Curcurana	Very Effective	A-

4.7 Institutional Organization

(1) SEPLANDES as an umbrella agency for implementation of the project shall establish a PMU and organized a committee by the representatives from SEPLANDES, SEIN, SRH, COMPESA, CONDEPE, FIDEM, ITEP and CPRH.

(2) SEPLANDES shall organize a preparation committee for the PMU immediately after the Study and prepare for implementation of the project.

(3) SEPLANDES shall establish the PMU before the detailed design stage and necessary staff shall be procured from the related organization due to the progress of the project.

4.8 O&M Plan

(1) In the State of Pernambuco, the sewerage systems have been under management of COMPESA since 1971. COMPESA should continue the routine O&M activities for the existing sewerage facilities. The O&M organization of COMPESA required after completion of the priority projects should be reinforced within Phase 1.

COMPESA shall strengthen the OM organization of GME. The GME has only 20 technical staff (Engineer: 6, Technician: 14), but shall require 86 technical staff (Engineer: 21, Technician: 65) by 2008, when Phase 1 projects are scheduled to be complete.

O&M Staff Training Schedule

Type of Engineer	Phase 1										Total
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
(Senior Staff)											
1 Sewer	-	-	-	-	1	4	2	-	-	-	7
2 STF	-	-	-	-	3	7	4	-	-	-	14
Sub total	-	-	-	-	4	11	6	-	-	-	21
(Engineer)											
1 Sewer	3	3	-	-	1	4	3	-	-	-	14
2 STF	-	-	-	-	3	14	15	11	-	-	51
Sub total	3	3	-	-	4	15	18	11	-	-	65
Total	3	3	-	-	8	26	24	11	-	-	86

(2) For the time being COMPESA is considered to be responsible for O&M of the sewerage systems in the State and the staff of COMPESA should be trained for the routine O&M activities required after the completion of the project.

(3) Necessary basic data for O&M shall be prepared immediately. COMPESA should conduct a survey on the existing sewerage facilities and complete a database for them.

(4) The following equipment shall be required for proper O&M activities such as inspection, investigation and maintenance works.

- Truck: 9
- Small truck 9
- High pressurized cleaning machine: 9
- Vacuum car: 7
- TV Camera set: 7

4.9 Implementation Plan

The basic policy of the implementation plan is as follows:

(1) SEPLANDES as an umbrella agency or as a general coordination organization should establish a Project Management Unit (PMU) before the implementation of the projects.

(2) The preparation of the detailed design (including tender documents) of the projects and the supervision of the construction works should be done by a team of consultants.

(3) The construction works of the projects should be done by contractors.

(5) Human resources development should be done through On-the-Job-Training in principle through the detailed design and supervision.

- Sewerage facility data base shall be prepared for proper O&M activities in the detailed design stage,
- Detailed O&M plan for each sewage treatment facility, pumping facility and sewer network shall be prepared during the detailed design stage,

(5) Immediately after the Study it is necessary for SEPLANDES to set up a preparation committee for implementation of the project. The committee consists of some of the counterpart personnel and representatives of the agencies concerned in addition to the executive secretariat.

The implementation schedule of the projects and the disbursement schedule are shown in the following tables:

Implementation Plan for Priority Projects

Sewerage System	Work Item	Phase 1									
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Conceicao	Preparation/Arrangement	▬	▬								
	Designing and Tender		▬	▬							
	Construction and Supervision				▬	▬	▬				
	Operation and Maintenance							▬	▬	▬	▬
Janga	Preparation/Arrangement	▬	▬								
	Designing and Tender		▬	▬							
	Construction and Supervision				▬	▬	▬	▬			
	Operation and Maintenance	////	////	////	////	////	////	////	▬	▬	▬
Cabanga	Preparation/Arrangement	▬	▬								
	Designing and Tender		▬	▬							
	Construction and Supervision				▬	▬	▬	▬			
	Operation and Maintenance	////	////	////	////	////	////	////	▬	▬	▬
Boa Viagem	Preparation/Arrangement	▬	▬								
	Designing and Tender		▬	▬							
	Construction and Supervision				▬	▬	▬	▬			
	Operation and Maintenance								▬	▬	▬
Cordeiro	Preparation/Arrangement	▬	▬								
	Designing and Tender		▬	▬							
	Construction and Supervision				▬	▬	▬				
	Operation and Maintenance							▬	▬	▬	▬
Prazeres	Preparation/Arrangement	▬	▬								
	Designing and Tender		▬	▬							
	Construction and Supervision				▬	▬	▬	▬			
	Operation and Maintenance								▬	▬	▬
Curcurana	Preparation/Arrangement	▬	▬								
	Designing and Tender		▬	▬							
	Construction and Supervision				▬	▬	▬				
	Operation and Maintenance							▬	▬	▬	▬

Disbursement Schedule for Priority Projects

Sewerage System	Project Cost	Period					
		2002	2003	2004	2005	2006	2007
Conceisao	24,921	3,344	2,294	4,500	8,167	6,616	—
Janga	77,046	5,796	1,980	11,639	20,807	20,807	16,017
Cabanga	52,886	4,152	1,566	9,037	9,037	16,401	12,693
Boa Viagem	61,195	14,872	13,055	5,537	9,900	9,900	7,931
Cordeiro	29,449	2,924	1,555	5,874	10,659	8,437	—
Prazeres	63,098	11,092	8,716	7,240	12,941	12,941	10,168
Curcurana	35,943	3,277	1,566	7,354	13,346	10,400	—
Total	344,538	45,457	30,732	51,181	84,857	85,502	46809

5. CONCLUSION AND RECOMMENDATION

In the RMR the water quality of the rivers and drainage channels has been polluted and the water environment is deteriorated. The restoration of the river environmental conditions, especially water quality, is an urgent measure for the RMR to meet.

The existing sewerage management system has a sewage treatment capacity of less than 20% of the households in the urban area. The Master Plan has proposed to increase the sewage treatment capacity to 90% of the households in the urban area of 2020 by phased expansion of the sewerage facilities of the RMR. The seven sewerage systems have been selected as priority projects for the RMR to improve the water quality of the major river basins by improving the existing sewerage systems and developing the new sewerage facilities.

The proposed Master Plan for Stormwater Drainage and Sewerage Management for the RMR is feasible in technical, economic, financial, social and environmental terms. By implementation of the proposed projects, the water quality in the RMR will be improved and the water environment will be restored.

It is recommended for the State Government of Pernambuco to take immediate actions for implementation of the following:

(1) For early restoration of the urban environment of the RMR, it is very important for the State Government to take immediate actions to implement the seven sewerage systems identified as priority projects as well as the sewerage systems in Phase 1 of the Master Plan.

(2) Also it is important to take necessary actions to implement the stormwater drainage facilities proposed in the PQA for mitigate drainage problems.

(3) For smooth implementation of the Master Plan and the Priority Projects, it is necessary for the State Government and SEPLANDES to organize a preparation committee for the project immediately after the Study and to establish a PMU before the detailed design stage. Also SEPLANDES is to take necessary actions to develop the human resources in order to strengthen the related organizations.

(4) For strengthening the O&M activities COMPESA shall prepare basic data of the existing sewerage facilities and their conditions, including the examination of the existing sewer networks.

(5) For implementation of successful condominial sewerage systems the State Government should support COMPESA to take systematic and continuos actions to guide the communities through all the stages (planning, implementation and O&M stages).

(6) For preparation of optimum measures for stormwater drainage and flood control of the RMR in future, it is necessary for the RMR to install automatic rain gauges in the urban area, at least at Olinda, Recife and Jaboatao dos Guararapes, in order to collect rainfall data of short duration, and it is also necessary to conduct river surveys for the major rivers in order to prepare river improvement plan against flood and drainage problems.