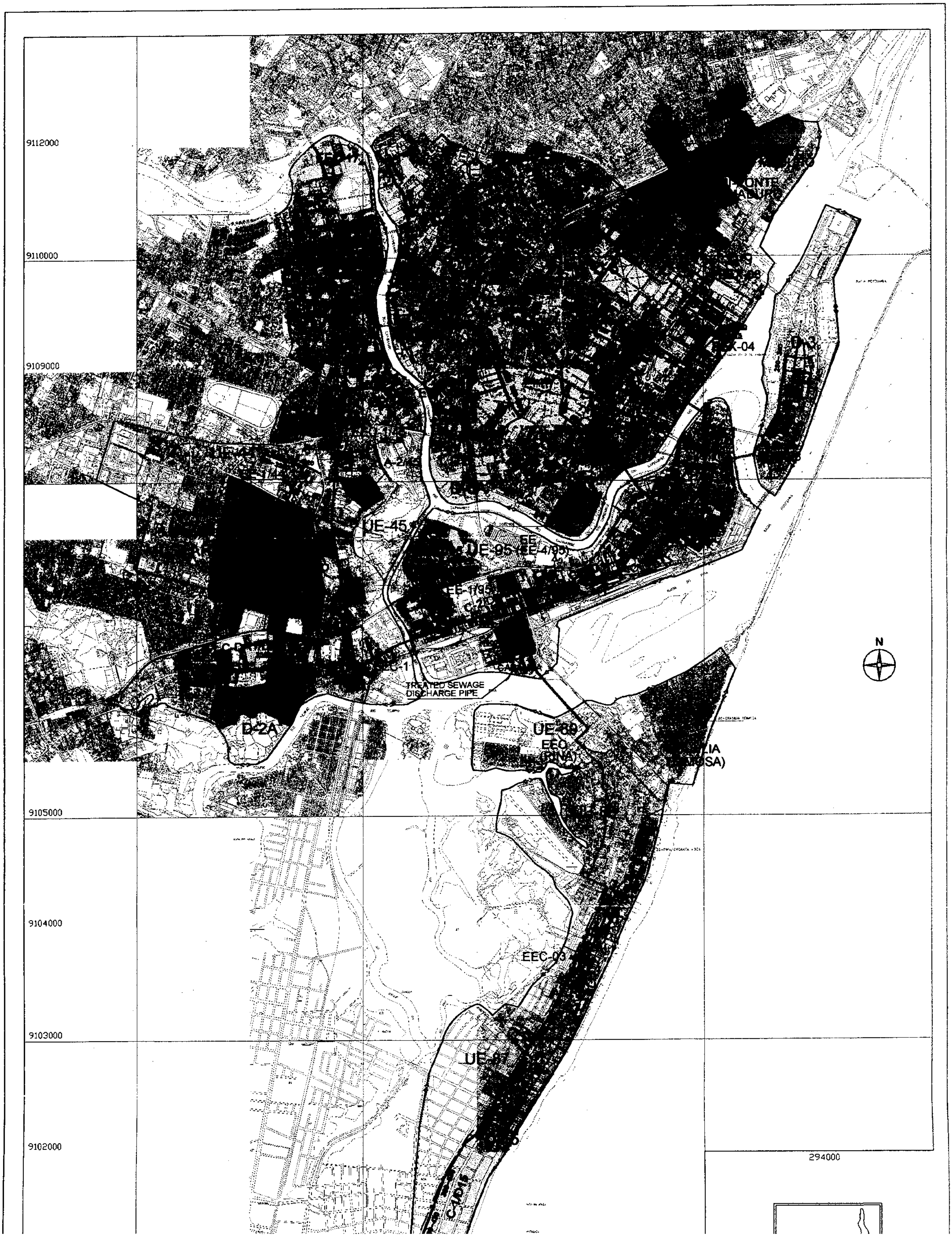
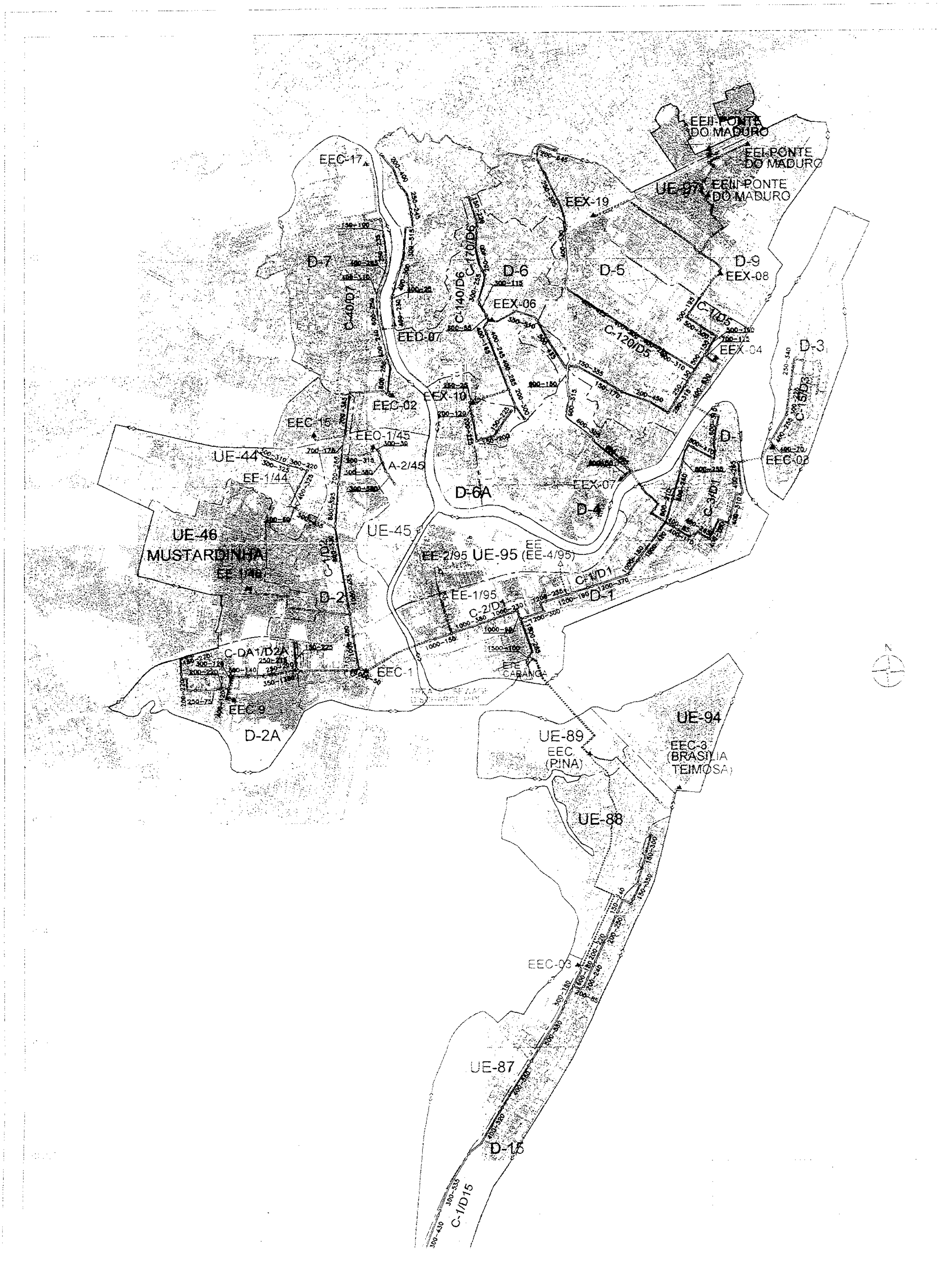


9112000
9110000
9109000
9105000
9104000
9103000
9102000
294000
UE-45
UE-95
(EE-4/95)
EE-1/95
TREATED SEWAGE
DISCHARGE PIPE
D-2A
UE-89
EEC-03
N


EEII PONTE DO MADURO
EEI PONTE DO MADURO
UE-97
EEC-17
EEX-19
D-7
D-6
D-5
D-9
EEX-08
C-40/D7
C-140/D6
C-170/D6
EEX-06
C-1/D5
C-120/D5
EEX-04
D-3
C-15/D3
EED-07
EEC-02
EEX-10
EEC-15
EEC-1/45
A-2/45
UE-44
EE-1/44
D-1
EEC-03
D-6A
EEX-07
D-4
C-3/D1
UE-46
MUSTARDINHA
EE 1/46
UE-45
EE-2/95
UE-95
EE
(EE-4/95)
C-1/D1
D-1
D-2
EE-1/95
C-2/D1
C-DA1/D2A
EEC-1
ETE CABANGA
EEC-9
D-2A
UE-89
EEC
(PINA)
UE-94
EEC-3
(BRASILIA
TEIMOSA)
UE-88
EEC-03
UE-87
D-15
C-1/D15
N

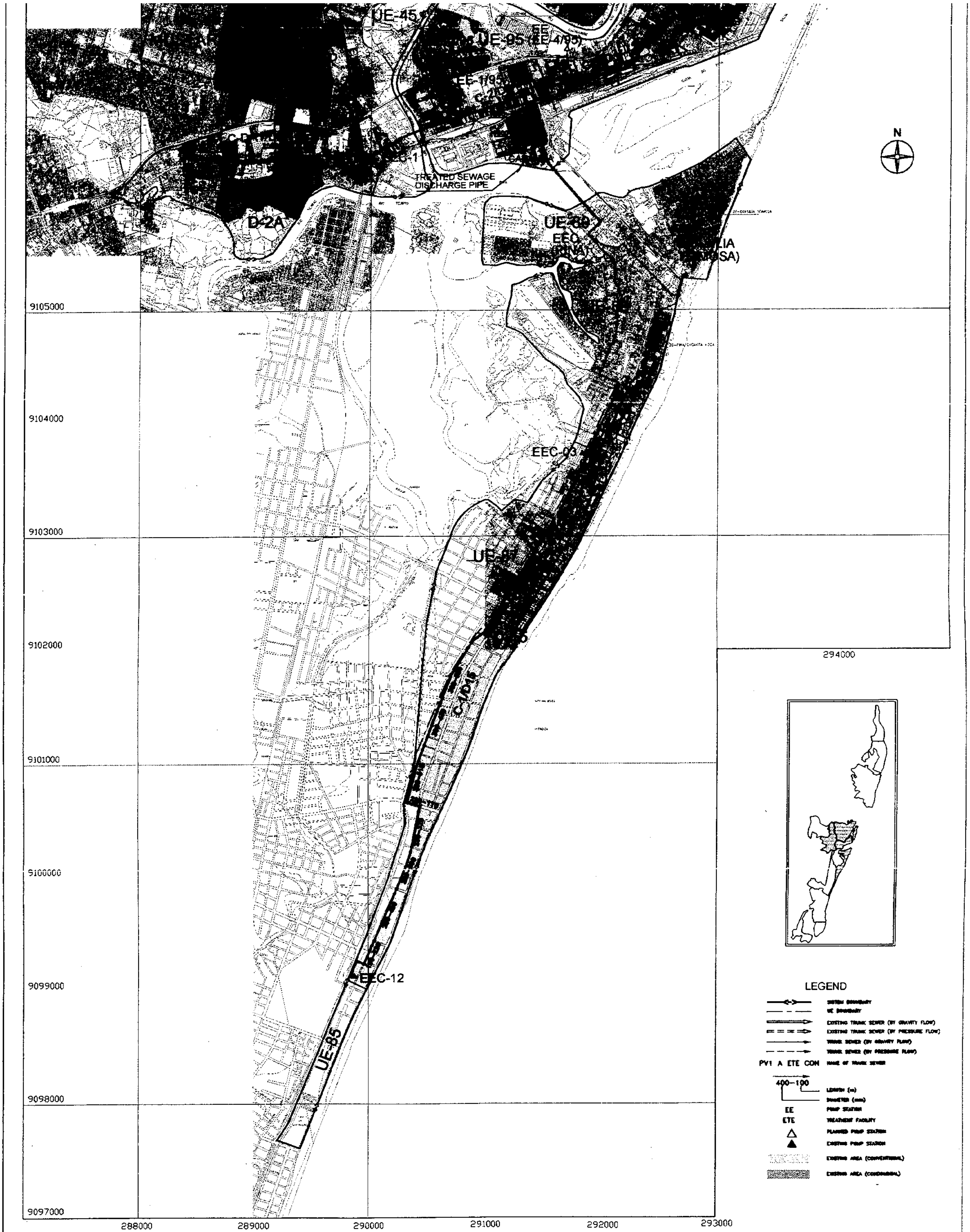


Fig.4.2-4	Layout Plan of Cabanga System

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

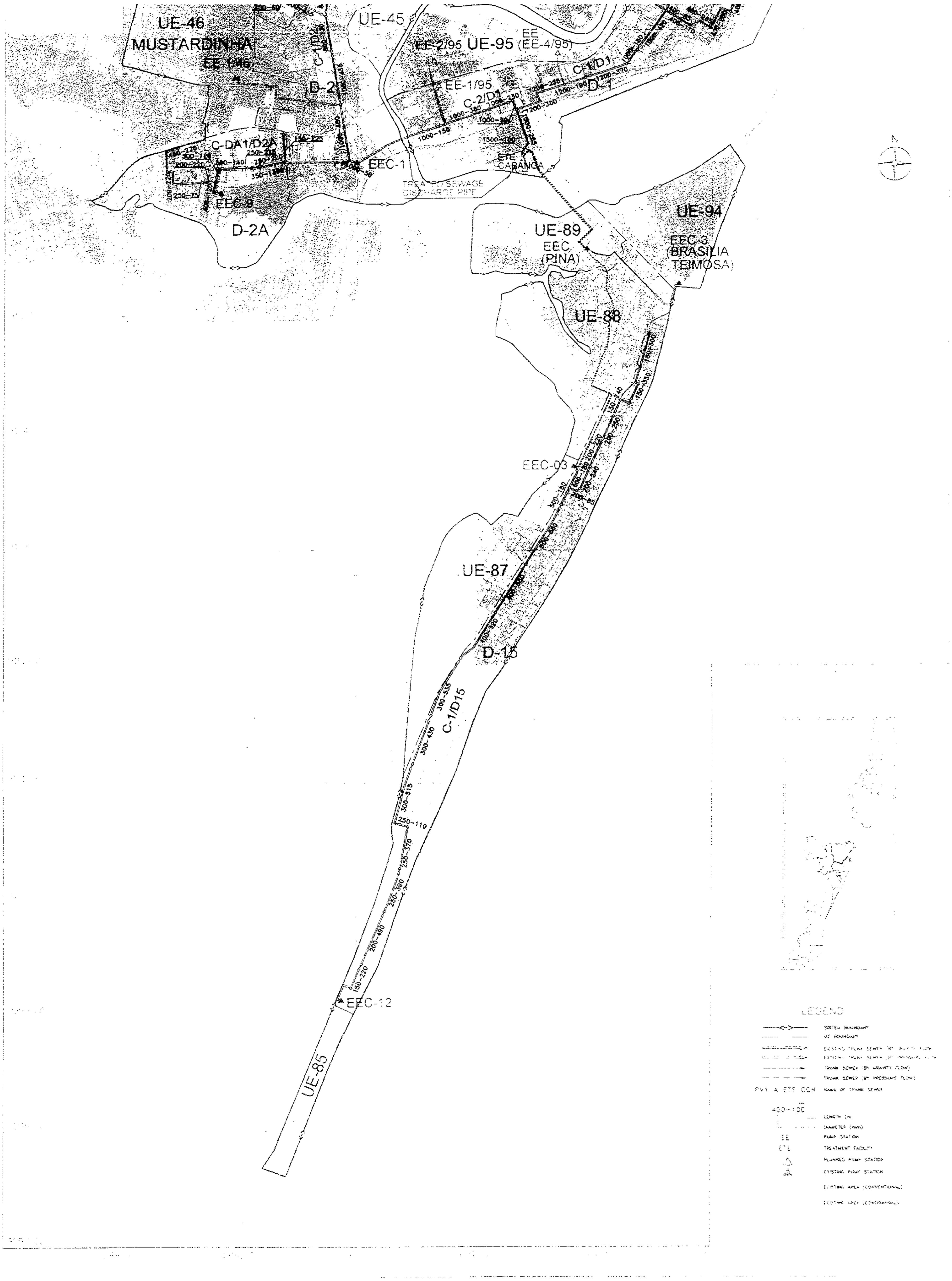
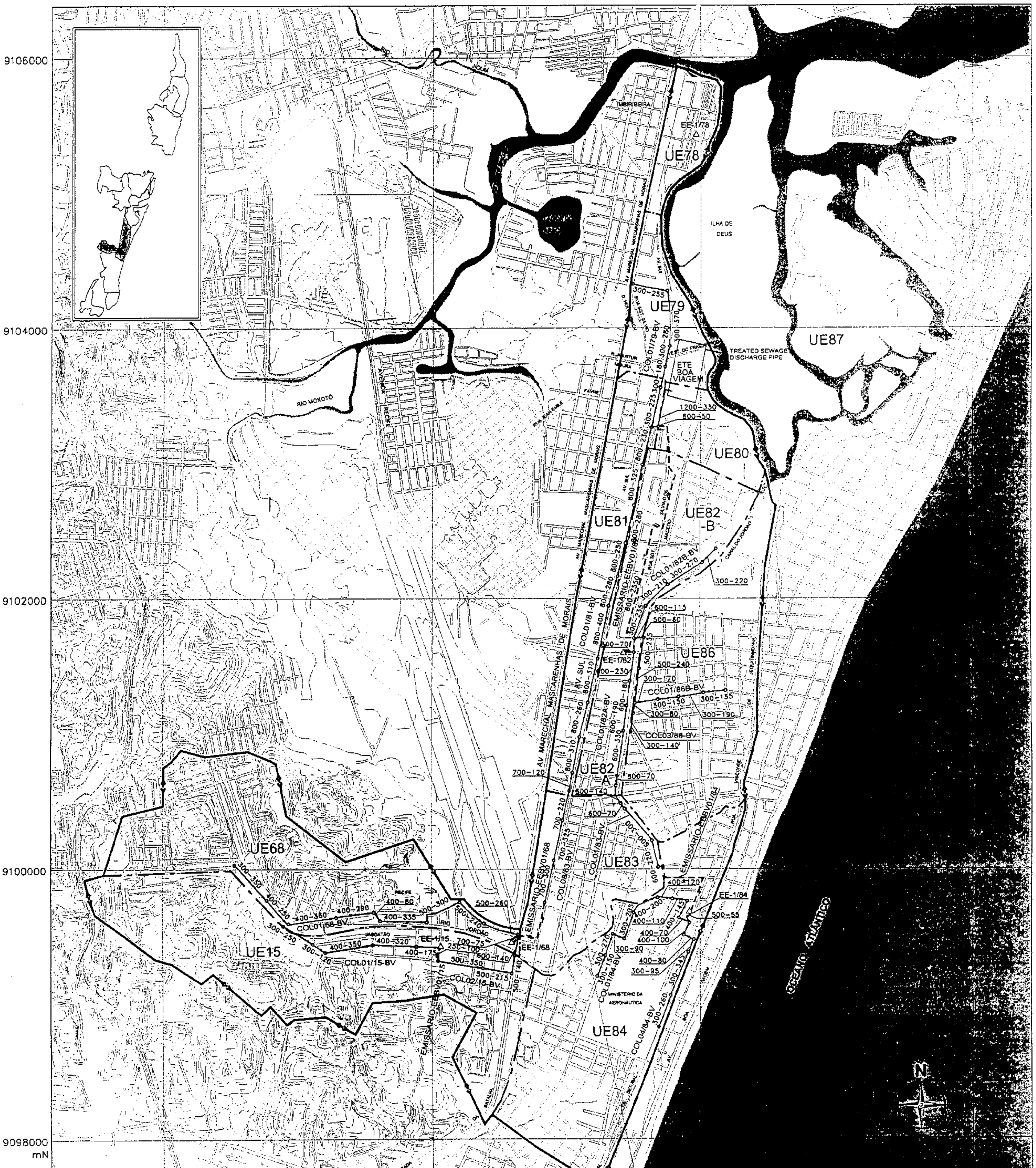


Fig.4.2-4

Layout Plan of Cabanga System



LEGEND

<->	SISTEM BOUNDARY
— - —	UE BOUNDARY
——►	TRUNK SEWER (BY GRAVITY FLOW)
— — —►	TRUNK SEWER (BY PRESSURE FLOW)
COL01/81-BV	NAME OF TRANK SEWER
400-100	LENGTH (m) / DIAMETER (mm)
EE	PUMP STATION
ETE	TREATMENT FACILITY
△	PLANNED PUMP STATION
▲	EXISTING PUMP STATION

SCALE 1:30,000

0 1000 2000 m

Fig.4.2-5 Layout Plan of Boa Viagem System

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

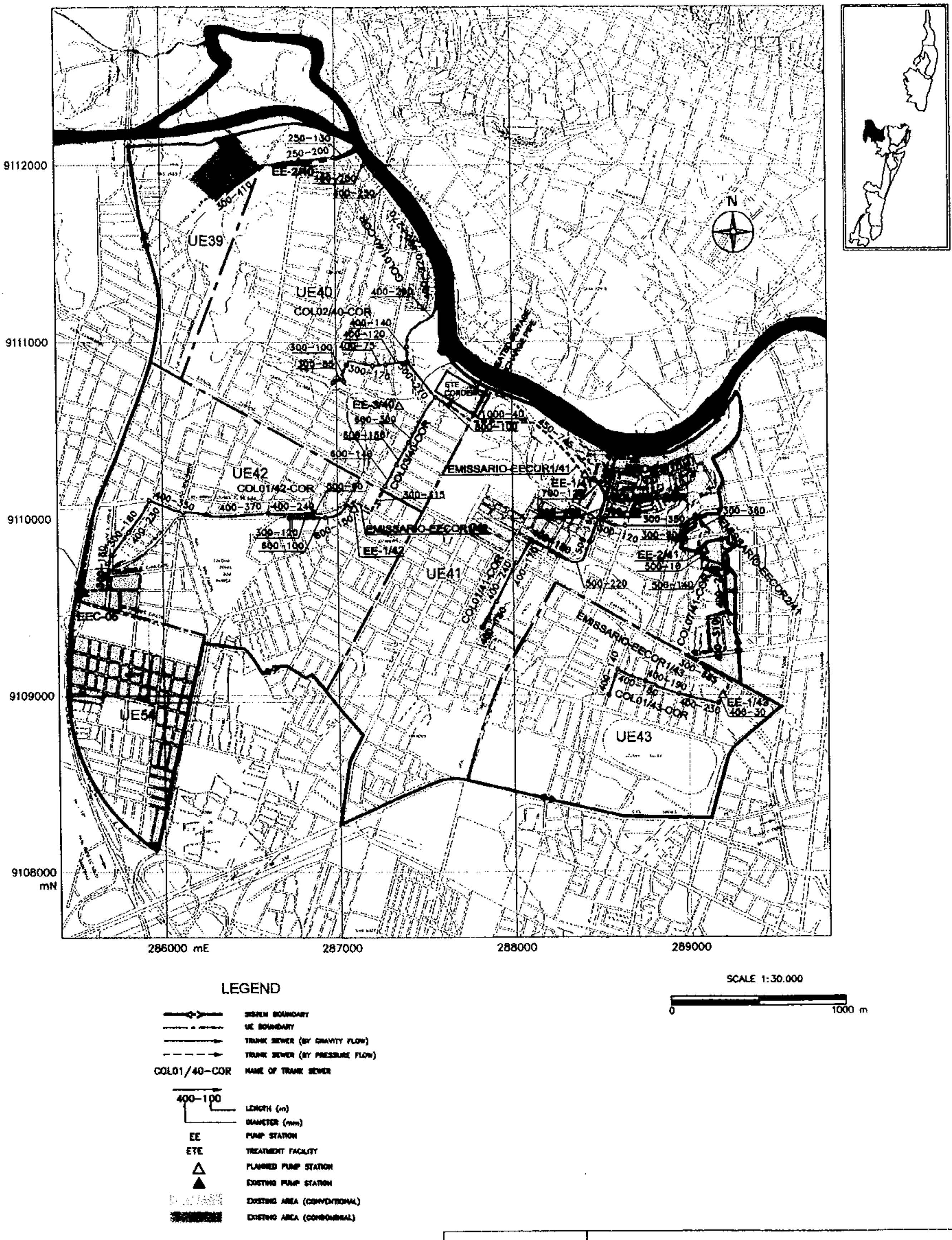
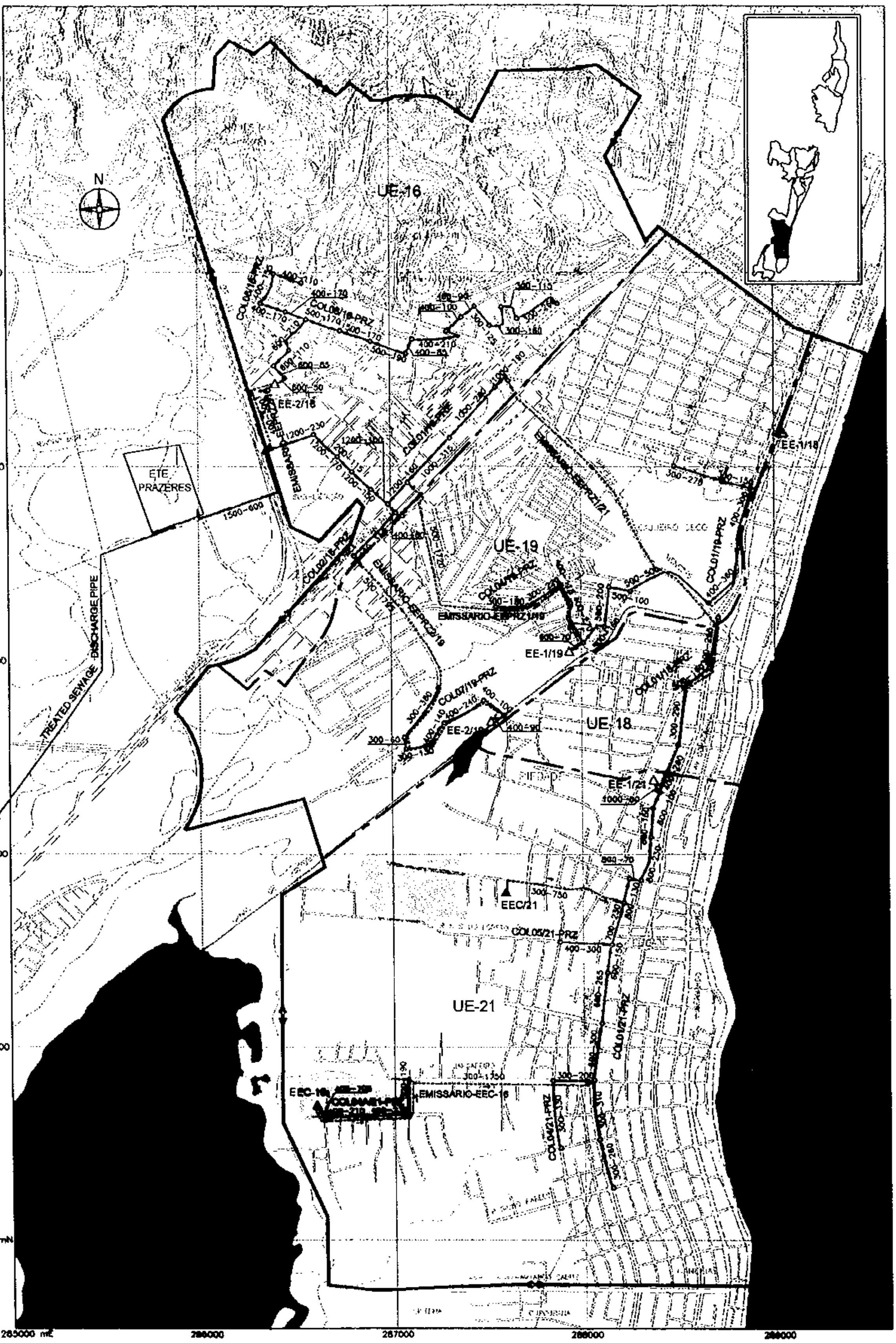


Fig.4.2-6	Layout Plan of Cordeiro System
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	



LEGEND

COL01/16-PRZ

400-100

EE

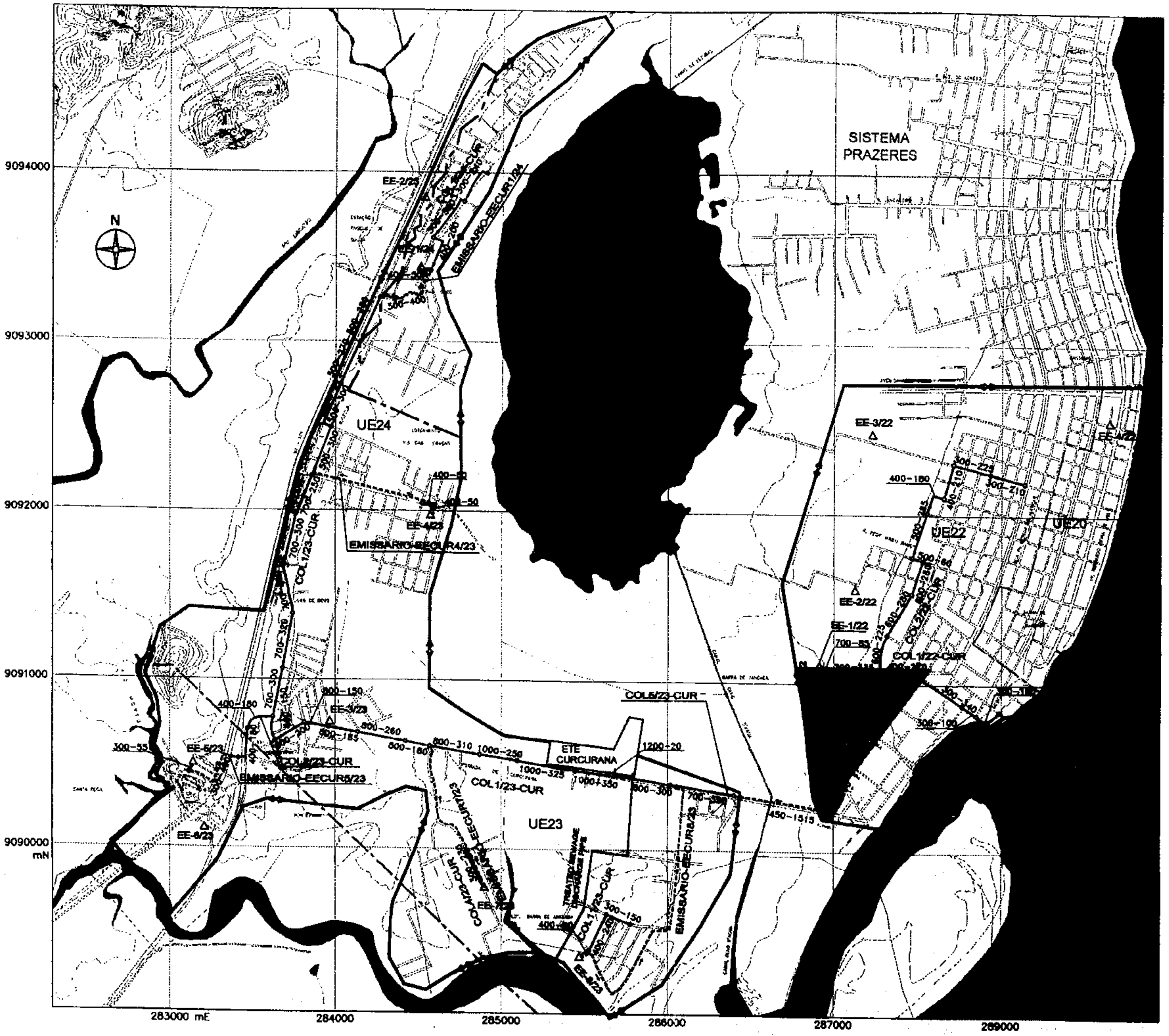
ETE

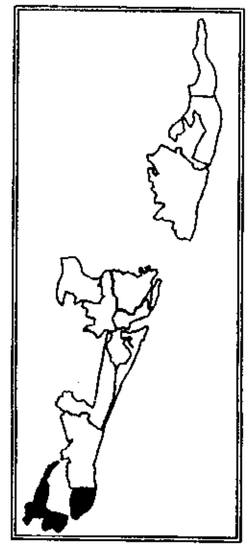
SCALE 1:30,000

0 500 1000 m

Fig.4.2-7	Layout Plan of Prazeres System

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR





LEGEND

	SISTEM BOUNDARY
	UE BOUNDARY
	TRUNK SEWER (BY GRAVITY FLOW)
	TRUNK SEWER (BY PRESSURE FLOW)
COL1/24-CUR	NAME OF TRANK SEWER
400-100	LENGTH (m) / DIAMETER (mm)
EE	PUMP STATION
ETE	TREATMENT FACILITY
△	PLANNED PUMP STATION
▲	EXISTING PUMP STATION
	EXISTING AREA (CONVENTIONAL)
	EXISTING AREA (CONDOMINIAL)

SCALE 1:30.000

0 500 1000 m

Fig.4.2-8 Layout Plan of Curcurana System

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

Fig.4.2-8	Layout Plan of Curcurana System

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

4.3 Sewage Collection Facility Plan

4.3.1 General

In the Study area there are existing sewer systems, which were mostly developed before the 1980s and partly covers the seven sewerage systems. The coverage of the existing sewer system is estimated and shown in the following table:

Priority Sewerage System	Design Sewerage Service Area	Existing Sewer System (%)
Conceicao	853 ha	0 ha (0.0 %)
Janga	3,954 ha	1,289 ha (32.6 %)
Cabanga	2,671 ha	1,495 ha (56.0 %)
Boa Viagem	1,203 ha	0 ha (0.0 %)
Cordeiro	1,054 ha	108 ha (10.3 %)
Prazeres	1,570 ha	28 ha (1.8 %)
Curcurana	1,160 ha	38 ha (3.3 %)

The existing sewer system is damaged in places and does not function well. A lot of the existing pumping stations has been damaged or is broken and not active. For developing the collecting facilities of the seven sewerage systems, the preliminary design of sewer networks and pump facilities has been conducted and rehabilitation requirements of the existing sewer and pump facilities have been studied based on the collected data through the field study.

4.3.2 Design Conditions and Criteria

(1) Sewer Pipe

The trunk sewers have been planned mainly along the existing roads. In the case of crossing the canals or rivers, trunk sewers are to be installed along the existing bridges. The design criteria applied for the sewer networks are as follows:

1) Minimum Size of Pipe

The minimum pipe sizes are 100 mm and 150 mm for pressure flow and gravity flow respectively.

2) Pipe material

The following sewer network materials are planned depending on its size and flow system:

Gravity Flow System: PVC for ϕ150 - ϕ400,
HDPE, or Reinforced Concrete Pipe for ϕ450 - ϕ1,500,

Pressurized Flow System: PVC for ϕ150 - ϕ300, HDPE for ϕ350- ϕ630, Ductile Cast Iron Pipe for ϕ350- ϕ800.

3) Minimum Soil Cover and Maximum Depth of Pipe

Cover and depth of piping are as follows:

- Minimum Cover: Pavements 0.65 m
  Roads 0.90 m
- Maximum Depth: 5.0 m to 6.0 m (depending on the soil condition)

4) Maximum Distance between Manholes

The planned maximum distance between manholes is shown in the following table:

Diameter of pipe (mm)	Maximum distance between manholes (m)
ϕ150	70
ϕ200	80
ϕ250 to ϕ300	90
ϕ350 to ϕ500	100
ϕ500 to ϕ700	110
Over ϕ700	120

5) Hydraulic calculation

Manning's Formula is applied for the gravity flow system and Hazen Williams' Formula is applied for the pressure flow system.

6) Width of ditch

There are different formulae to determine the width of ditches. The following formula is adopted:

$$BD = 1.34Di + 0.20$$

Where BD: Width of ditch at the level of the top of the piping, in meter
Di :Internal diameter of pipe, in meter

(2) Pumping Station

The sewage pumping stations are planned based on the peak flow rates (hourly maximum flow rates). All pipe fittings and conduits are to be designed to convey the design peak flow rates. For planning the pumping stations the following points were considered:

1) Pumping Station Construction

Pumping station substructures are planned to be reinforced concrete. The exterior walls below grade and wet-well walls below the maximum high wet-well level are to be coated with tar to prevent leakage.

The ground floor of the station is set above the flood plain of the surrounding area to eliminate the possibility of flooding the station.

2) Type of Pumping Station

Three types of pumping stations, i.e. standard, simplified and manhole types, are planned to be used depending on their importance, the type of pumping system and the maintenance required.

The standard pumping station is with a dry-well and a wet-well, and the simplified and manhole type pumping stations are with wet-well pits. The standard pumping station is planned when it requires a high pump head and it is necessary to convey a large sewage inflow. It is also used the capacity of a submersible pump would be insufficient to counteract water hammer.

The simplified type pumping station and the manhole type pumping station are applied in the case of small sewage inflows and are provided with submersible pumps. The difference between the two types is that the simplified type is with a grit pit and the manhole type is without a grit pit.

3) Design Flow

The design of pumping station is based on the peak flow of the sewerage. All piping and conduits are also designed based on the peak flow of the sewerage.

4) Screening

The pumping station is planned to be provided with a bar screen and a basket to collect garbage inflows and protect pump facilities.

5) Grit Removal Facility

It is necessary to remove grit from sewage inflows before the well pit to avoid damage to the pump equipment.

6) Number of Pumps

At least two pumps are provided for each pumping station. One standby pump is required at every pumping station. 3- 4 pumps are needed for the standard type and the simplified type pumping stations and 2 pumps for the manhole type pumping station. When one pump is out of order, the remaining pumps must have the capacity to handle the design sewage flows.

7) Control

Pump controls are of float tube type. Location of control float tubes should not be unduly affected by flows entering the well or by the suction of pumps. Float tubes in dry wells are extended high enough to prevent overflows.

8) Force Main

A cleaning velocity of 0.6 m/s should be maintained for the design average flow. An automatic air relief valve will be placed at high points in the force main to prevent air locking. Induced aeration equipment may be provided in pumping stations where it is necessary to prevent sulfide buildup in the force mains.

4.3.3 Preliminary Design of Collection Facilities

(1) Trunk Sewers

General sewer alignments of the seven sewerage systems are shown in Fig.4.2-2 to 4.2-8. All trunk sewers are planned based on the design criteria, as stated in the former section.

Two types of flow system, gravity and pressure flow system, will be applied for these 7 sewerage systems.

Regarding the installation depth of the trunk sewers, it should be decided taking into account the minimum earth covering, underground facilities, soil conditions and traffic load.

Force mains must be anchored to resist the thrusts that develop at angles, bends, branches, and plugs in the pipe. The typical cross sections planned for trunk sewers are shown in Fig.4.3-1.

Total length of trunk sewers and force mains are summarized as follows,

Conceicao

Total Length of Trunk Sewers	: 6,460 m (Gravity flow)
Diameter of Trunk Sewers	: Ø 300 – Ø 700 mm
Total Length of Force Mains	: 1,655 m (Pressure flow)
Diameter of Force Mains	: Ø 100 – Ø 300 mm

Janga

Total Length of Trunk Sewers	: 11,935 m (Gravity flow)

Diameter of Trunk Sewers	: Ø 300 – Ø 700 mm
Total Length of Force Mains	: 16,800 m (Pressure flow)
Diameter of Force Mains	: Ø 150 – Ø 700 mm

Cabanga

Total Length of Trunk Sewers	: 2,480 m (Gravity flow)
Diameter of Trunk Sewers	: Ø 300 – Ø 400 mm
Total Length of Force Mains	: 6,755 m (Pressure flow)
Diameter of Force main	: Ø 100 – Ø 500 mm

Boa Viagem

Total Length of Trunk Sewers	: 15,850 m (Gravity flow)
Diameter of Trunk Sewers	: Ø 300 – Ø 1200 mm
Total Length of Force Mains	: 4,520 m (Pressure flow)
Diameter of Force Mains	: Ø 150 – Ø 600 mm

Cordeiro

Total Length of Trunk Sewers	: 8,680 m (Gravity flow)
Diameter of Trunk Sewers	: Ø 300 – Ø 1000 mm
Total Length of Force Mains	: 2,105 m (Pressure flow)
Diameter of Force Mains	: Ø 300 – Ø 450 mm

Prazeres

Total Length of Trunk Sewers	: 13,875 m (Gravity flow)
Diameter of Trunk Sewers	: Ø 300 – Ø 1500 mm
Total Length of Force Mains	: 7,445 m (Pressure flow)
Diameter of Force Mains	: Ø 300 – Ø 700 mm

Curcurana

Total Length of Trunk Sewers	: 10,480 m (Gravity flow)
Diameter of Trunk Sewers	: Ø 300 – Ø 1200 mm
Total Length of Force Mains	: 7,445 m (Pressure flow)
Diameter of Force Mains	: Ø 150 – Ø 450 mm

Total length of trunk sewers and force mains in the project area are 69,760 m and 46,725 m, respectively. Summary of bill of quantities of trunk sewers is shown in Table 4.3-1.

(2) Branch and Collector Sewers

Branch and collector sewers are to be designed using the same criteria proposed for trunk sewers. Sufficient earth covering is to be left between the top of the sewer and the bottom of the roadway surface to protect the sewers from traffic loads and to avoid undue interference with other underground facilities.

All branch and collector sewers are to be designed with a minimum diameter of 150 mm. Sewer material is generally of PVC.

Total length of branch and collector sewers in the project area is summarized as follows,

Collector Sewers	: 419,700 m (Ø 150, Ø 200, Ø 250 mm)
Branch Sewers	: 979,400 m (Ø 150 mm)

Total length of branch and collector sewers is approximately 1,400,000 m. Summary of bill of quantities of branch and collector sewers is shown in Table 4.3-2.

(3) Pumping Station

The pumping stations are planned based on design criteria, which are summarized in Table 4.3-2, and explained as follows:

1) Type of pumping station

(a) Standard Type Pumping Station

The Standard type pumping station is to have a relatively large sewage flow volume and a high pumping capacity. It is composed of the following facilities:

a) Screen
b) Grit Chamber
c) Wet-well
d) Dry-well

A drawing of the standard type pumping station is shown in Figs.4.3-2 and 4.3-3.

(b) Simplified Type Pumping Station

The simplified type pumping station included of a basket and a grit pit. Drawings of the simplified type are shown in Figs.4.3-4 and 4.3-5.

(c) Manhole Type Pumping Station

The manhole type pumping station is similar to the simplified type pumping station, but has no grit pit. The size of the manhole type pumping station is planned for two sets of pumps. A basket for the garbage inflow is to be provided to protect pumps. A drawing of the manhole type of pumping station is shown in Fig.4.3-6.

(d) Selection of pump type

A centrifugal vertical type of pump is applied for the standard type pumping station and a submersible type of pump is applied for both the simplified type and the manhole type.

(e) Control System

Unmanned operation system except the standard pumping station should be recommended. Therefore establishment of control system, which will be notified the trouble of pump and another equipment, should be considered. Control system has the functions the followings,

Observation with trouble alarms of pumps
Remote control at the central control room located in the STF
No inter-telephone communication between central control room and pumping station

(f) Required space for each type of pumping station

The space required for each type of pumping station is approximately as follows:

Type of Pumping Station	Required Space (m^2)
Manhole type pumping station	80
Simplified type pumping station (1)	170
Simplified type pumping station (2)	190
Standard type pumping station (1)	560
Standard type pumping station (2)	650

4.3.4 Rehabilitation of Existing Sewer Networks

(1) Sewer Network

The existing sewers were mostly constructed before the 1980s. According to the inspection report on the existing gravity flow sewer systems in the municipality of RECIFE, about 10-15 % of the existing sewers has been replaced. The absence of preventive measures and also lack of proper maintenance of the sewer networks has provoked silting and sedimentation in the sewers. The sewage and deposits left for a long time have caused deterioration of the sewer facilities. Rehabilitation of the existing sewer networks is required to some extent, but the real situations of the existing sewer networks are not clear. All the existing sewers should be systematically checked before implementation of the new sewer networks.

According to the design computation of the gravity-flow and pressure-flow sewer, it turned out that some of existing sewers are insufficient to flow the designed sewage flow. In this case, existing sewer pipes should be replaced to the new sewer pipes to flow the designed sewage flow. Total length of replacement of existing sewer pipes are summarized as follows,

Janga
Total length of replacement of existing sewer pipes : 3,615 m
Diameter of replacement of existing sewer pipes : Ø 200 –300 mm

Cabanga
Total length of replacement of existing sewer pipes : 3,210 m
Diameter of replacement of existing sewer pipes : Ø 500 –1500 mm

Prazeres
Total length of replacement of existing sewer pipes :1,760 m
Diameter of replacement of existing sewer pipes : ϕ350 mm

Total length of replacement of existing sewer pipes in this project is 8585 m. Summary of bill of quantities of replacement of existing sewers pipes is shown in Table4.3-1.

(2) Pumping Station

1) Flow Diagram of Existing Sewerage System

All the pumping stations and sewer pipes connected to the Janga and Cabanga sewage treatment facilities have been investigated based on the data provided by COMPESA and the GME. Also other independent small systems maintained by the GME have been investigated. The sewage flow diagrams of the Janga system and the Cabanga system were prepared after the field investigation and are shown in Figs.4.3-7 and 4.3-8 respectively.

2) Field Survey of Existing Pumping Stations

The Study Team together with COMPESA staff carried out the investigation and data collection to clarify the present condition of the existing pumping stations for a rehabilitation plan. The existing pumping stations are grouped into seven systems in accordance with the priority projects. The results of the investigation are summarized as follows:

a) Basic Information

The following data have been identified and are shown in Table 4.3-4.

- Completion dates of the pumping stations,
- Relation between a pumping station and its existing sewage treatment plant,
- Relation between a pumping station and its maintenance offices,
- Types of the pumping stations.

b) Operational Situation

The following items have been identified and are shown in Table4.3-5.

- Type of pumps
- Quantity of pumps in operation, being repaired, broken and missing parts.

The current operational situation of pumps and motors is summarized as follows:

Operational Situation of Pumps

Item	Situation	Quantity	%
In Use	Operating	35	36
Out of Use	Being Repaired	9	9
	Broken	18	19
	Missing Parts	35	36
	Sub-Total	62	64
Total		97	100

"Operating" signifies pumps in use, including old pumps. "Being repaired" signifies all the pumps in the workshops under repairing. "Broken" signifies all the pumps being on site, but out of use due to breakage or lack of maintenance. "Missing Parts" signifies all the pumps, which have not been replaced by COMPESA as yet.

c) Specifications of pumps and motors

The following items have been investigated and are shown in Table 4.3-6.

- Pump: Flow rate (m^3/hr) and Total Head (m)
- Motor: Output (HP), Pole, Phase, Voltage and Frequency (Hz)

Almost all the specifications have been investigated on site because they are not available in COMPESA, because the data has not been updated since equipment was repaired, modified and replaced. The flow rate of the pumps and output of the motors are shown in m^3/hr and HP respectively, being the units used in Brazil.

d) Equipment manufacturers of pumps, motors and distribution boards

Equipment manufacturers of pumps, motors and distribution boards are shown in Table 4.3-7.

e) Valves and Gates

The current situation is summarized as follows:

Current Situation of Valves and Gates

Remarks		Quantity and (%)		
		Valves	Check Valves	Gates
Good in use		53 (28)	27 (28)	3 (14)
Rehabilitation	To be repaired	0 (0)	0 (0)	0 (0)
	To be replaced	137 (72)	69 (72)	18 (86)
	Sub-Total	137 (72)	69 (72)	18 (86)
Total		190 (100)	96 (100)	21 (100)

f) Ancillary equipment

Ancillary equipments for the pumping station are as follows,

- Bar screen
- Grit chamber
- Pumping house

The current situations of the existing bar screens, grit chambers and pumping houses are summarized as follows:

Current Situation of Ancillary Equipment (Bar Screen and Grit Chamber)

Remarks		Quantity and (%)	
		Bar Screen	Grit Chamber
Good in use		7 (35)	0 (0)
Rehabili -tation	To be repaired	0 (0)	0 (0)
	To be replaced	13 (65)	1 (100)
	Sub-Total	13 (65)	1 (100)
Total		20 (100)	1 (100)

Current Situation of Pumping House

Remarks		Quantity and (%)	
		With Pump Well	Without Pump Well
Good in use		2 (12)	0 (0)
Rehabili -tation	To be repaired	15 (88)	7 (100)
	To be replaced	0 (0)	0 (0)
	Sub-Total	15 (88)	7 (100)
Total		17 (100)	7 (100)

(3) Rehabilitation Required for Existing Pumping Stations

Based on the field survey results, the existing pump facilities to be required rehabilitation are listed as follows:

- Pumps and motors: 81 of 97
- Distribution boards: 32 of 38
- Valves: 137 of 190
- Check valves: 69 of 96
- Gates 18 of 21
- Bar screens: 27 of 34
- Grit chambers 1 of 1
- Pumping house 22 of 24

The rehabilitation works are including repair, replacement and new installation.

(4) Problems of the Existing Pumping Stations

The present situation of the existing pumping stations is very serious. The major problems are summarized as follows:

1) The pumping stations are old and have had little or no maintenance. The existing facilities need to be restored.

2) There are 97 pumps and 35 of them are operating, but one is in very bad condition. The others (62 pumps) are inactive due to breakage, maintenance problems and missing parts. There seems to be little possibility of restoring them due to lack of funds.

3) The 62 inactive pumps consist of 9 being repaired, 18 broken equipment and 35 missed. There is little possibility that the pumps, which are broken and missing, will be restored because COMPESA has no funds allocated for this.

4) In some cases at the pumping stations, although the pumps work, they are not operated due to problems in pressure pipelines, blockage of sewage flows, or bar screen and/or grit chamber problems. In other cases, when the pump is removed from the pump well, the sewage flows directly into the canals or rivers.

5) All the pumping stations, where pumps are inactive, have a direct connection via the bypass lines into the canals or rivers.

6) In order to check the updated specifications of equipment, it is suggested that a nameplate of the equipment should be placed on the wall of the pumping house. This is especially necessary in the case of the submersible pumps.

7) Maintenance and Ancillary Systems
After investigating the pumping stations and visiting the maintenance factory of COMPESA (DME = Mechanical Maintenance Division), as well as some maintenance contractors in Recife, it is clear that not only does equipment need replace but it is also necessary to establish an organization for a better maintenance and support system as soon as the project is carried out. The setting up of this organization requires the training of staff as well as the provision of measuring and testing devices to ensure quality control.

(5) Rehabilitation Plan for Existing Pumping Stations

As stated in the former section, most of the existing pumps and motors are damaged and do not function well. And also the following aspects were clarified as results of pump capacity computation.

Pump capacity is insufficient to lift up designed sewerage flow

Pump capacity is sufficient to lift up designed sewerage flow, however, it will not function well because of surfeit allowance.

Problem for the maintenance because of the different specification between the existing pumps and the new ones

Therefore, all existing pumps and motors will be replaced as rehabilitation plan.

4.3.5 Required O & M

(1) General

The O&M of sewage collection facilities would be mainly the pumping station through a periodic inspection. In terms of O/M and periodic inspection, the systemization should be established based on the size and control method of pumping station.

It is also important to establish the structures that are able to feedback the historical experiences such as accidents in order to prevent future problems.

The main maintenance of trunk sewers is removal of the deposit, trunk sewers inspection and repair of trunk sewers. Removal of the deposits is assumed once a year. The method of removing the deposits is to flushed-out using the high pressurized cleaning machine in case of small pipe. Hence, in case of large pipe, it will be removed by manual taking care of sulfide gas.

(2) Required Work Items for O & M

There are four major O & M procedures namely, daily inspection, site investigation, sewer pipe cleaning and rehabilitation of damaged sewer pipes.

The following table shows work items related to the O & M type.

O & M Type	Work Items
Daily Inspection	-Operation of Pump Facilities -Operation of Electrical Facilities
Site Investigation	-Identification of Damage and Blockage locations -Identification of Inflow/Infiltration points -Investigation of overflow from manholes -Inspection of New House Connection -Measurement of the volume of sediment in the sewer
Pipe Cleaning	-Removal of Sediment and Other Foreign Matter

Rehabilitation	Replacement/Repair of Damaged Sewer

(3) Required number of staffs for O & M

Required number of staffs for O & M should be decided taking into account the procedures of O & M. Four main procedures will be recommended for sufficient O & M. as stated before.

Mechanic and electrician will be needed at least one for each sewerage system for operation of pumping facilities as daily inspection and maintenance. Drivers for high pressurized cleaning machine, vacuum car operator for sewer pipe cleaning and operator for TV camera set as sewer pipe inspection will be needed. Laborer as assistants and security guards for standard type pumping station will also be required.

Required number of staffs for adequate O & M is summarized in the following table

Unit; person

Position	Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana	Total
Chief	1	1	1	1	1	1	1	7
Mechanic	1	1	1	1	1	1	1	7
Electrician	1	1	1	1	1	1	1	7
Driver	3	4	4	3	3	3	3	23
Labor Works	5	6	6	5	5	5	5	37
Security Guard	0	4	2	2	0	1	0	9
Total	11	17	15	13	11	12	11	90

(4) Equipment for operation and maintenance

A high pressurized cleaning machine, a vacuum car, a truck to transport the equipments, a damp truck to transport the surplus of deposits and equipments for repair should be prepared at each sewage system. TV camera set should also be prepared to inspect the existing pipe condition.

The number of equipment to be procured in each sewerage system for efficient O/M is shown in the following table,

	Concecao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana	Total
Truck	1	2	2	1	1	1	1	9
Light Truck	1	2	2	1	1	1	1	9
High Pressurized Cleaning Machine	1	1	1	1	1	1	1	7
Vacuum Car	1	1	1	1	1	1	1	7
TV Camera Set	1	1	1	1	1	1	1	7
Total	5	7	7	5	5	5	5	39

Table 4.3-1 Summary of Trank Sewers (1/2)

(A) Gravity Flow

Unit; m

Diameter of Pipe(mm	Material	Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana	Total (m)
ö300	PVC	580	2,002	1,645	4985	1,625	3,885	2,030	16,752
ö400	PVC	2,040	7,065	835	2865	4,845	3,990	1,510	23,150
ö500	RC	3060	1250		1880	920	1490	1495	10,095
ö600	RC		370		1915	850	1240	785	5,160
ö700	RC	780	1248		1040	300	230	2280	5,878
ö800	RC				2835	100	680	1435	5,050
ö1000	RC					40	835	925	1,800
ö1200	RC				330		925	20	1,275
ö1500	RC						600		600
Total		6,460	11,935	2,480	15850	8,680	13,875	10,480	69,760

(B) Pressure Flow

Diameter of Pipe(mm	Material	Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana	Total (m)
ö100	PVC	245		250					495
ö150	PVC		300	1055	780			455	2,590
ö200	PVC	720		465	100			1515	2800
ö250	PVC		1020	435				1770	3225
ö300	PVC	690				1360	750	2190	4990
ö350	CIP			1200	1090				2290
ö400	CIP						500		500
ö450	CIP					745		1515	2260
ö500	CIP		5480	3350			3515		12345
ö600	CIP		2800		2550				5350
ö700	CIP		7200				2680		9880
Total		1655	16800	6755	4520	2105	7445	7445	46725

Table 4.3-1 Summary of Trank Sewers (2/2)

(C) Rehabilitation (Replacement)

Diameter of Pipe(mm	Material	Conceicao	Janga	Cabanga	Boa Viagem	Cordeiro	Prazeres	Curcurana	Total (m)
ö200	PVC		425						425
ö300	PVC		3190						3190
ö350	CIP						1760		1760
ö500	CIP			630					630
ö800	CIP			210					210
ö1000	CIP			890					890
ö1200	CIP			1095					1095
ö1500	CIP			385					385
Total			3615	3210	0	0	1760	0	8585

Table 4.3-2 Summary of Branch and Collector Sewers

Excavation Depth (m)		Total
Collector	150 PVC	251,842
	200 PVC	83,948
	250 PVC	83,949
Sub total		419,739
Branch	150 PVC	979,391
Total		1,399,130

Table 4.3-3 Number of Pumping Station for each Sewerage System

Sewerage System	Quantities					
	Manhole Type P/S	Simplified Type(I) P/S	Simplified Type(II) P/S	Standard Type(I) P/S	Standard Type(II) P/S	Total
Conceicao	3	1	0	0	0	4
Janga	2	0	2	0	1	5
Cabanga	6	0	0	0	0	6
Boa Viagem	1	2	0	1	1	5
Cordeiro	3	2	1	0	0	6
Prazeres	2	0	2	0	1	5
Curcurana	11	0	1	0	0	12
Total	28	5	6	1	3	43

P/S : Pumping Station

Table 4.3-4 Basic Informations of Existing Pumping Stations

No.	Project Sewerage Sub-system	Pumping Station Name	Pumping Station Established Year	Sewage Treatment Facilities	Maintenance Station	Type of Pumping Station
1	Conceicao	EEJ-16	1981	Janga	Janga	Dry-1
2	Janga	ETE Janga	-	-	-	-
3		EEJ-01	1981	Janga	Janga	Dry-2
4		EEJ-02	1980	Janga	Janga	Wet-2
5		EEJ-03	1982	Janga	Janga	Wet-1
6		EEJ-05	1980	Janga	Janga	Wet-2
7		EEJ-06	1982	Janga	Janga	Wet-1
8		EEJ-08	1984	Janga	Janga	Wet-1
9		EEJ-10	1985	Janga	Janga	Wet-1
10		EEJ-11	1980	Janga	Janga	Wet-1
11		EEJ-12	1981	Janga	Janga	Wet-1
12		EEJ-13	1985	Janga	Janga	Wet-1
13		EEJ-17	1985	Janga	Janga	Wet-1
14		EEJ-18	1982	Janga	Janga	Dry-1
15		EEJ-21	1980	Janga	Janga	Wet-1
16	Cabanga	ETE C-01	1972	Cabanga	Cabanga	Dry-2
17		EEC-01	1970	Cabanga	Cabanga	Dry-2
18		EEC-02	1916	Cabanga	Cabanga	Dry-1
19		EEC-03	1957	Cabanga	Cabanga	Dry-1
20		EEC-08	1910	Cabanga	Cabanga	Dry-1
21		EEC-09	1970	Cabanga	Cabanga	Dry-1
22		EEC-12	1974	Cabanga	Cabanga	Wet-1
23		EEC-15	1973	Cabanga	Cabanga	Wet-1
24		EEC-17	1977	Cabanga	Cabanga	Wet-1
25		EEC-19	1978	Cabanga	Cabanga	Wet-1
26		EEC-33	1996	Cabanga	Cabanga	Wet-1
27		EEC-Pina	2000	Cabanga	Cabanga	Wet
28		EEX-04	1916	Cabanga	Peixinho	Dry-2
29		EEX-06	1981	Cabanga	Peixinho	Wet-1
30		EEX-07	1911	Cabanga	Peixinho	Dry-1
31		EEX-08	1965	Cabanga	Peixinho	Dry-1
32		EEX-10	1968	Cabanga	Peixinho	Dry-2
33		EEX-19	1995	Cabanga	Peixinho	Wet-1
34	Cordeiro	EEC-23	1980	Peixinho	Cabanga	Wet-1
35		EEC-28	1998	T. Proper	Cabanga	Dry-1
36	Boa Viagem	EEC-20	1978	Cabanga	Cabanga	Wet-2
37	Prazeres	EEC-16	1900	T. Proper	Cabanga	Wet-1
38		EEC-29	1995	T. Proper	Cabanga	Wet-1
39	Curcurana	EEC-10	1980	T. Proper	Cabanga	Wet-1
40		EEC-11	1980	T. Proper	Cabanga	Wet-1

Note: Type of pumping station: Wet-1= Submersible pump and no pumping house Wet-2= Submersible pump in pumping house, Dry-1= Centrifugal horizontal pump installed in a pumping house, Dry2= Centrifugal vertical pump installed in a pumping house

Table 4.3-5 Operational Situation of Existing Pumping Stations

No.	Project Sewerage System	Name of Existing Pumping Station	Type of Pump	Quantity of Pumps				
				Current Situation				
				Operating	Repairing	Broken	Missing	Total
1	Conceicao	EEJ-16	C.H.	2	0	0	0	2
2	Janga	ETE Janga	-	-	-	-	-	-
3	Do	EEJ-01	C.V.P	2	2	0	0	4
4	Do	EEJ-02	Subm.P.	0	1	0	2	3
5	Do	EEJ-03	Subm.P.	0	0	0	3	3
6	Do	EEJ-05	Subm.P.	0	0	0	3	3
7	Do	EEJ-06	Subm.P.	1	0	0	2	3
8	Do	EEJ-08	Subm.P.	1	0	0	1	2
9	Do	EEJ-10	Subm.P.	2	0	0	1	3
10	Do	EEJ-11	Subm.P.	0	0	0	2	2
11	Do	EEJ-12	Subm.P.	0	0	1	1	2
12	Do	EEJ-13	Subm.P.	1	0	0	1	2
13	Do	EEJ-17	Subm.P.	1	0	0	1	2
14	Do	EEJ-18	C.H.P	1	0	1	0	2
15	Do	EEJ-21	Subm.P.	1	0	0	1	2
16	Cabanga	ETE Cabanga	C.V.P	5	0	0	0	5
17	Do	EEC-01	C.V.P	1	2	0	0	3
18	Do	EEC-02	C.H.P	0	0	3	0	3
19	Do	EEC-03	C.H.P	0	0	3	0	3
20	Do	EEC-08	C.H.P	2	0	1	0	3
21	Do	EEC-09	C.H.P	0	0	3	0	3
22	Do	EEC-12	Subm.P.	1	1	0	0	2
23	Do	EEC-15	Subm.P.	0	0	0	2	2
24	Do	EEC-17	Subm.P.	0	0	0	2	2
25	Do	EEC-19	Subm.P.	0	1	1	0	2
26	Do	EEC-33	Subm.P.	1	1	0	0	2
27	Do	EEC-Pina	Subm.P.	Under Construction			---	---
28	Do	EEX-04	C.V.P.	1	0	2	0	3
29	Do	EEX-06	Subm.P.	1	0	0	2	3
30	Do	EEX-07	C.H.P	0	0	3	0	3
31	Do	EEX-08	C.H.P.	2	0	0	1	3
32	Do	EEX-10	C.V.P	2	0	0	0	2
33	Do	EEX-19	Subm.P.	1	1	0	0	2
34	Cordeiro	EEC-23	Subm.P.	0	0	0	2	2
35	Do	EEC-28	C.H.P	3	0	0	0	3
36	Boa Viagem	EEC-20	Subm.P.	1	0	0	1	2
37	Prazeres	EEC-16	Subm.P.	0	0	0	2	2
38	Do	EEC-29	Subm.P.	0	0	0	2	2
39	Curcurana	EEC-10	Subm.P.	1	0	0	2	3
40	Do	EEC-11	Subm.P.	1	0	0	1	2
	Total			35	9	18	35	97

Note: Subm.P.= Submersible Pump, C.H.P.= Centrifugal Horizontal Pump
C.V.P.= Centrifugal Vertical Pump

Table 4.3-6 Specifications of Pumps and Motors of Existing Pumping Stations

No.	Project Sewerage Sub-system	Name of Pumping Station	Type of Pump	Quantity	Specification			
					Pump		Motor (60Hz)	
					Q	H	3 Phase x 380V	
					m3/hr	m	HP	Pole
1	Conceicao	EEJ-16	C.H.	2	250	53.5	100	4
2	Janga	ETE Janga	-	-	-	-	-	-
3		EEJ-01	C.V.P	4	820	18	150	6
4		EEJ-02	Subm.P.	3	79	15	77	6
5		EEJ-03	Subm.P.	3	434	15	32	6
6		EEJ-05	Subm.P.	3	525	4	77	6
7		EEJ-06	Subm.P.	3	90	7	35	6
8		EEJ-08	Subm.P.	2	79	20	9.4	6
9		EEJ-10	Subm.P.	3	162	12	9.4	6
10		EEJ-11	Subm.P.	2	126	22	18	6
11		EEJ-12	Subm.P.	2	83	8.35	5	6
12		EEJ-13	Subm.P.	2	83	14	5	6
13		EEJ-17	Subm.P.	2	51	20	9.5	4
14		EEJ-18	C.H.P	2	145	10	75	4
15		EEJ-21	Subm.P.	2	150	15	6	4
16	Cabanga	ETE Cabanga	C.V.P	5	1260	9	75	6
17		EEC-01	C.V.P	3	266.7	8	75	4
18		EEC-02	C.H.P	3	154	10	50	6
19		EEC-03	C.H.P	3	216.3	10	50	6
20		EEC-08	C.H.P	3	215	10	15	6
21		EEC-09	C.H.P	3	78	8	15	4
22		EEC-12	Subm.P.	2	44.8	5	5	4
23		EEC-15	Subm.P.	2	28.8	8	6	2
24		EEC-17	Subm.P.	2	68.15	8	20	4
25		EEC-19	Subm.P.	2	11.7	6	5	4
26		EEC-33	Subm.P.	2	208.8	10.4	12	6
27		EEC-Pina	Subm.P.	Under Construction		-	-	-
28		EEX-04	C.V.P.	3	72	10	75	6
29		EEX-06	Subm.P.	3	75	7	20	4
30		EEX-07	C.H.P	3	80	10	40	6
31		EEX-08	C.H.P.	3	200	15	25	6
32		EEX-10	C.V.P	2	40	15	10	6
33		EEX-19	Subm.P.	2	27	11.5	2.2	4
34	Cordeiro	EEC-23	Subm.P.	2	162	10	9.4	4
35		EEC-28	C.H.P	3	38	13	3	2
36	Boa Viagem	EEC-20	Subm.P.	2	82	8	5	6
37	Prazeres	EEC-16	Subm.P.	2	162	11	9.4	4
38		EEC-29	Subm.P.	2	176.4	6	15	4
39	Curcurana	EEC-10	Subm.P.	3	80	10	9.4	4
40		EEC-11	Subm.P.	2	16	8	5	4

Note: Subm.P.= Submersible Pump, C.H.P.= Centrifugal Horizontal Pump
C.V.P.= Centrifugal Vertical Pump

Table 4.3-7 Equipment Manufacutures of Existing Pumping Stations

No.	Project Sewerage Sub-system	Name of Pumping Station	Type of Pump	Name of Manufacturer		
				Pump	Motor	Electrical Panel
1	Conceicao	EEJ-16	C.H.	KSB	Bufalo	Siemens
2	Janga	ETE Janga	-	-	-	-
3		EEJ-01	C.V.P	Worthington	GE	Siemens
4		EEJ-02	Subm.P.	Flygt	Flygt	Siemens
5		EEJ-03	Subm.P.	Flygt	Flygt	Siemens
6		EEJ-05	Subm.P.	Flygt	Flygt	Siemens
7		EEJ-06	Subm.P.	Flygt	Flygt	Siemens
8		EEJ-08	Subm.P.	Flygt	Flygt	Siemens
9		EEJ-10	Subm.P.	Flygt	Flygt	Siemens
10		EEJ-11	Subm.P.	Flygt	Flygt	Siemens
11		EEJ-12	Subm.P.	Flygt	Flygt	Siemens
12		EEJ-13	Subm.P.	Flygt	Flygt	Siemens
13		EEJ-17	Subm.P.	Flygt	Flygt	Siemens
14		EEJ-18	C.H.P	KSB	Bufalo	Siemens
15		EEJ-21	Subm.P.	Flygt	Flygt	Siemens
16	Cabanga	ETE Cabanga	C.V.P	Worthington	GE	Siemens
17		EEC-01	C.V.P	Worthington	Arno	Siemens
18		EEC-02	C.H.P	Worthington	Bufalo	Siemens
19		EEC-03	C.H.P	Worthington	Arno	Siemens
20		EEC-08	C.H.P	Sulzer	WEG	Siemens
21		EEC-09	C.H.P	Worthington	GE	Siemens
22		EEC-12	Subm.P.	Flygt	Flygt	Siemens
23		EEC-15	Subm.P.	Flygt	Flygt	Siemens
24		EEC-17	Subm.P.	Flygt	Flygt	Siemens
25		EEC-19	Subm.P.	Flygt	Flygt	Siemens
26		EEC-33	Subm.P.	KSB	KSB	Siemens
27		EEC-Pina	Subm.P.	Under Construction	---	---
28		EEX-04	C.V.P.	Worthington	Arno	Siemens
				Ingersoll Dresser	WEG	Siemens
29		EEX-06	Subm.P.	Flygt	Flygt	Siemens
30		EEX-07	C.H.P	Worthington	Arno	Siemens
31		EEX-08	C.H.P.	KSB	WEG	Siemens
32		EEX-10	C.V.P	Worthington	Arno	Siemens
33		EEX-19	Subm.P.	ABS	ABS	Siemens
34	Cordeiro	EEC-23	Subm.P.	Flygt	Flygt	Siemens
35		EEC-28	C.H.P	Jacuzzi	WEG	Siemens
36	Boa Viagem	EEC-20	Subm.P.	Flygt	Flygt	Siemens
37	Prazeres	EEC-16	Subm.P.	Flygt	Flygt	Siemens
38		EEC-29	Subm.P.	ABS	ABS	Siemens
39	Curcurana	EEC-10	Subm.P.	Flygt	Flygt	Siemens
40		EEC-11	Subm.P.	Flygt	Flygt	Siemens

Note: Subm.P.= Submersible Pump, C.H.P.= Centrifugal Horizontal Pump
C.V.P.= Centrifugal Vertical Pump

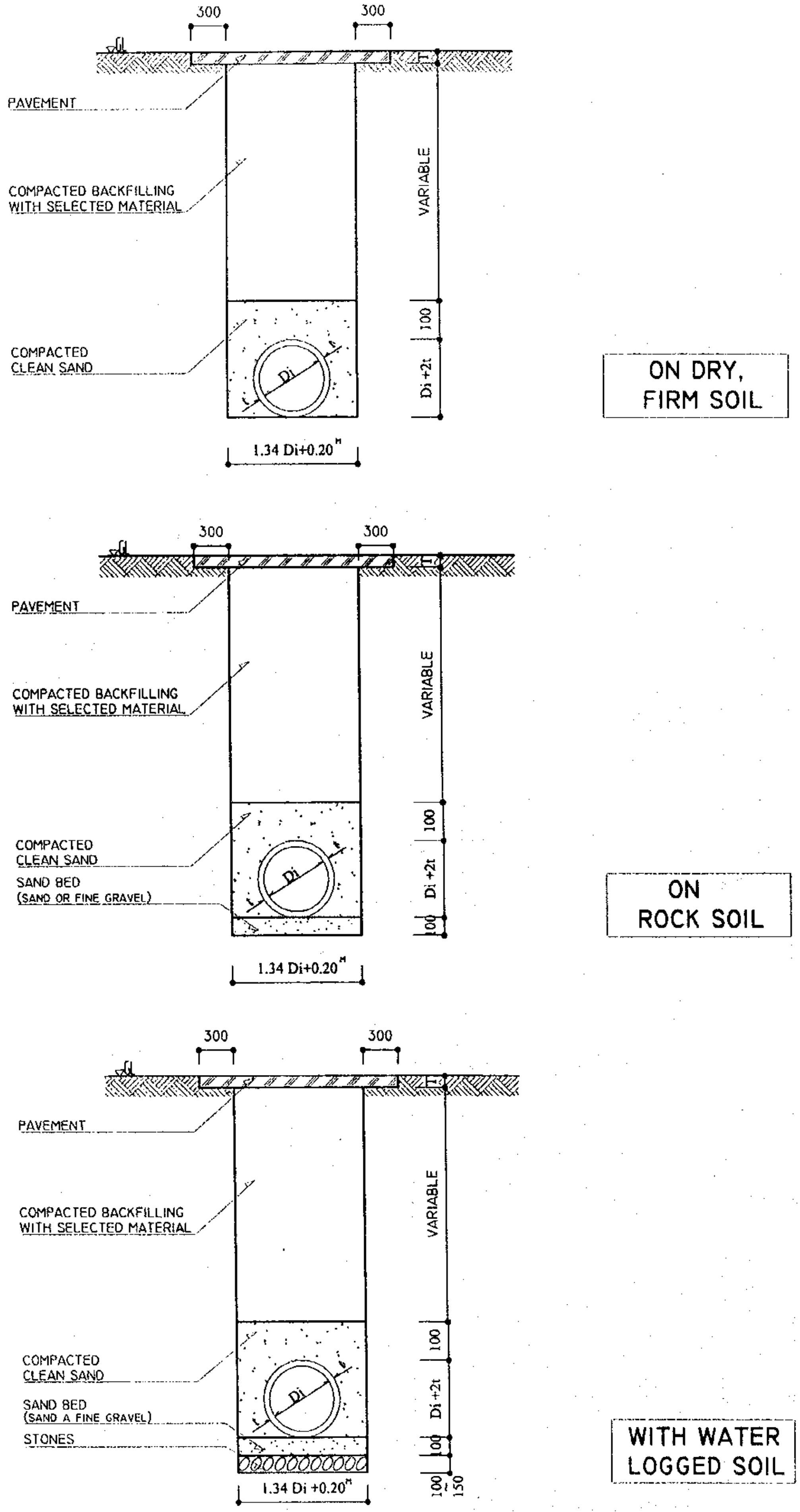
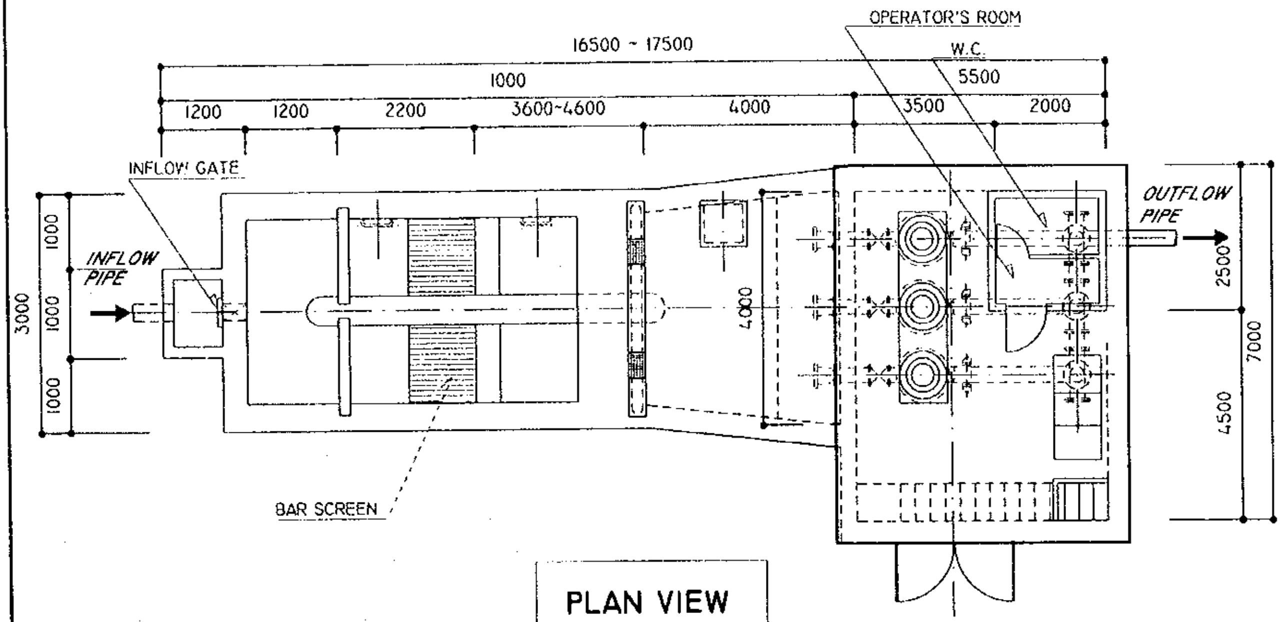
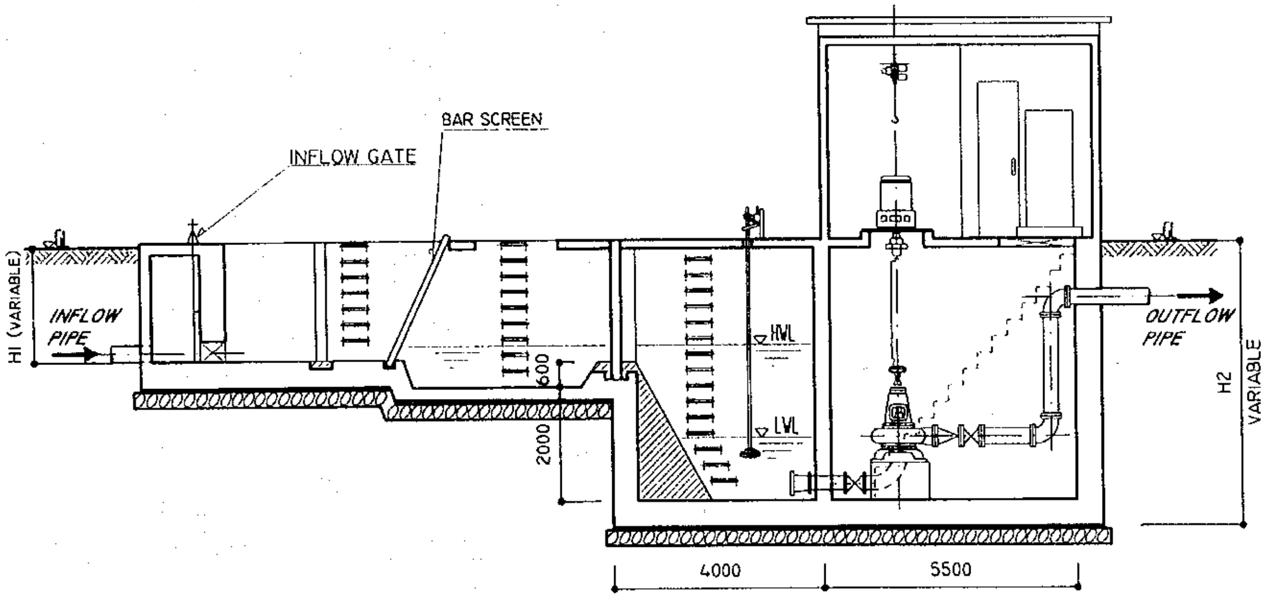


Fig. 4.3-1	Typical Cross Section for Trunk Sewer

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR



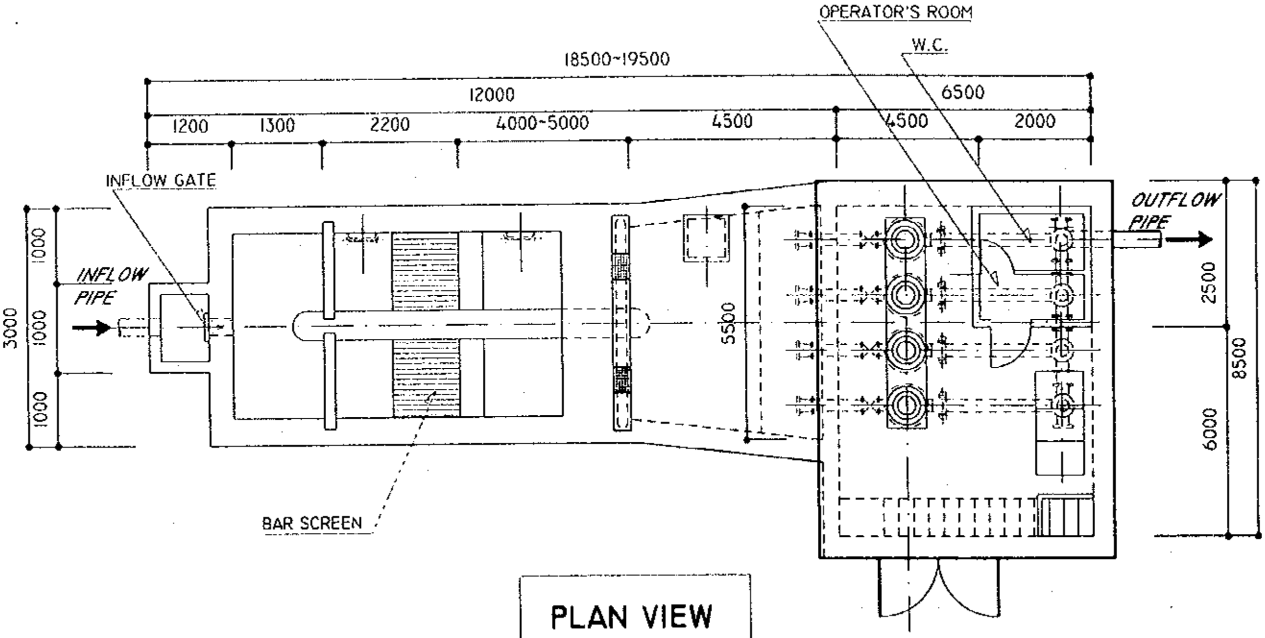
PLAN VIEW



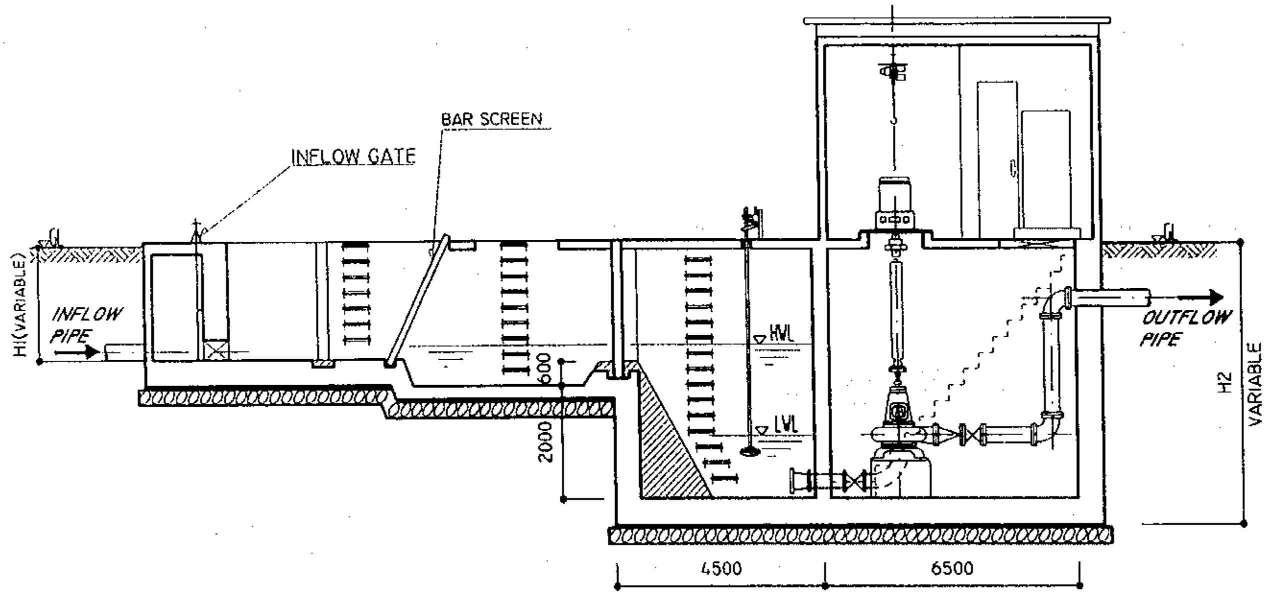
LONGITUDINAL SECTION

Fig. 4.3-2	Standard Type Pumping Station (I)

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR



PLAN VIEW



LONGITUDINAL SECTION

Fig. 4.3-3 Standard Type Pumping Station (II)

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

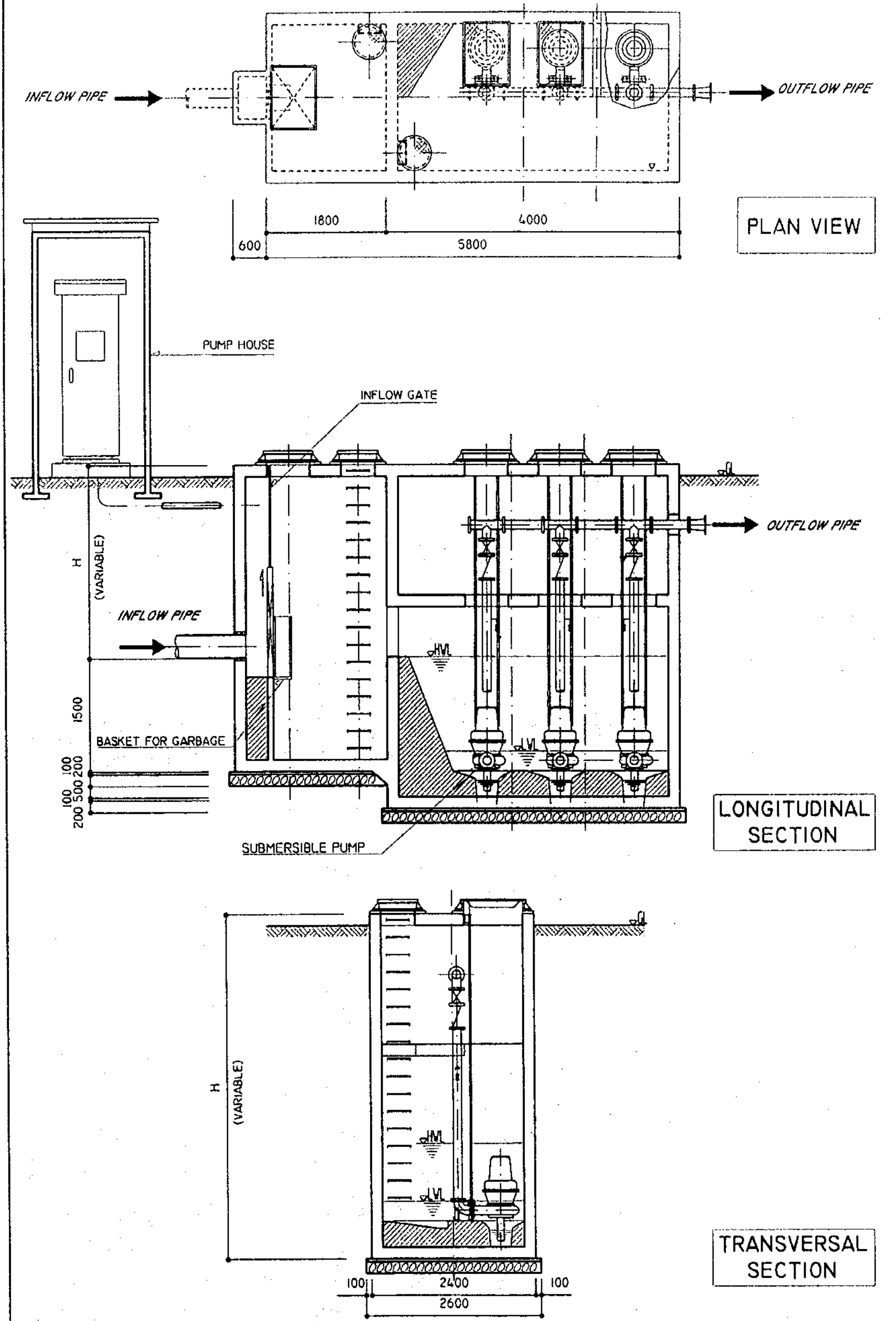


Fig. 4.3-4	Symplified Type Pumping Station (I)

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

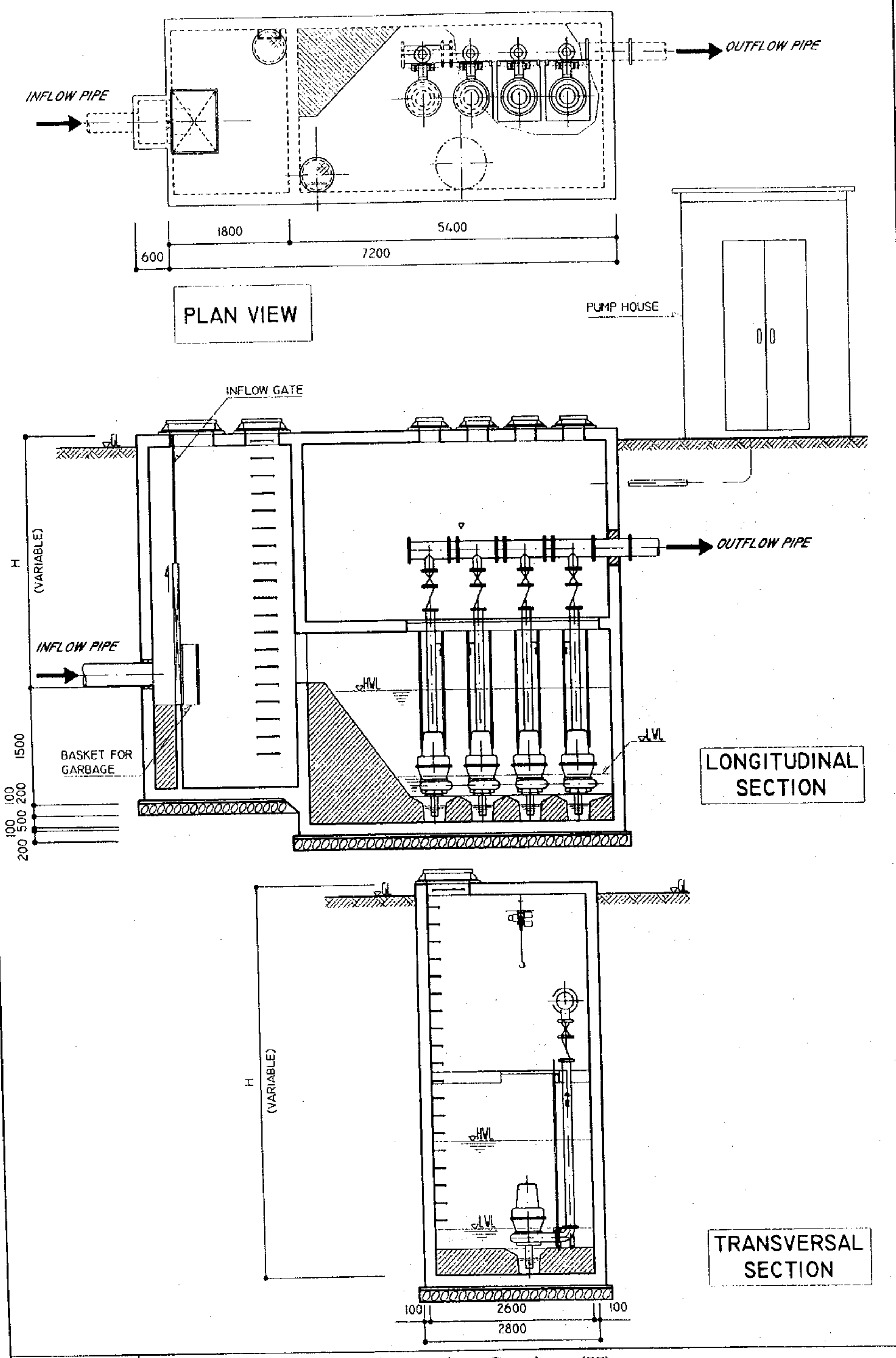


Fig. 4.3-5	Symplified Type Pumping Station (II)

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

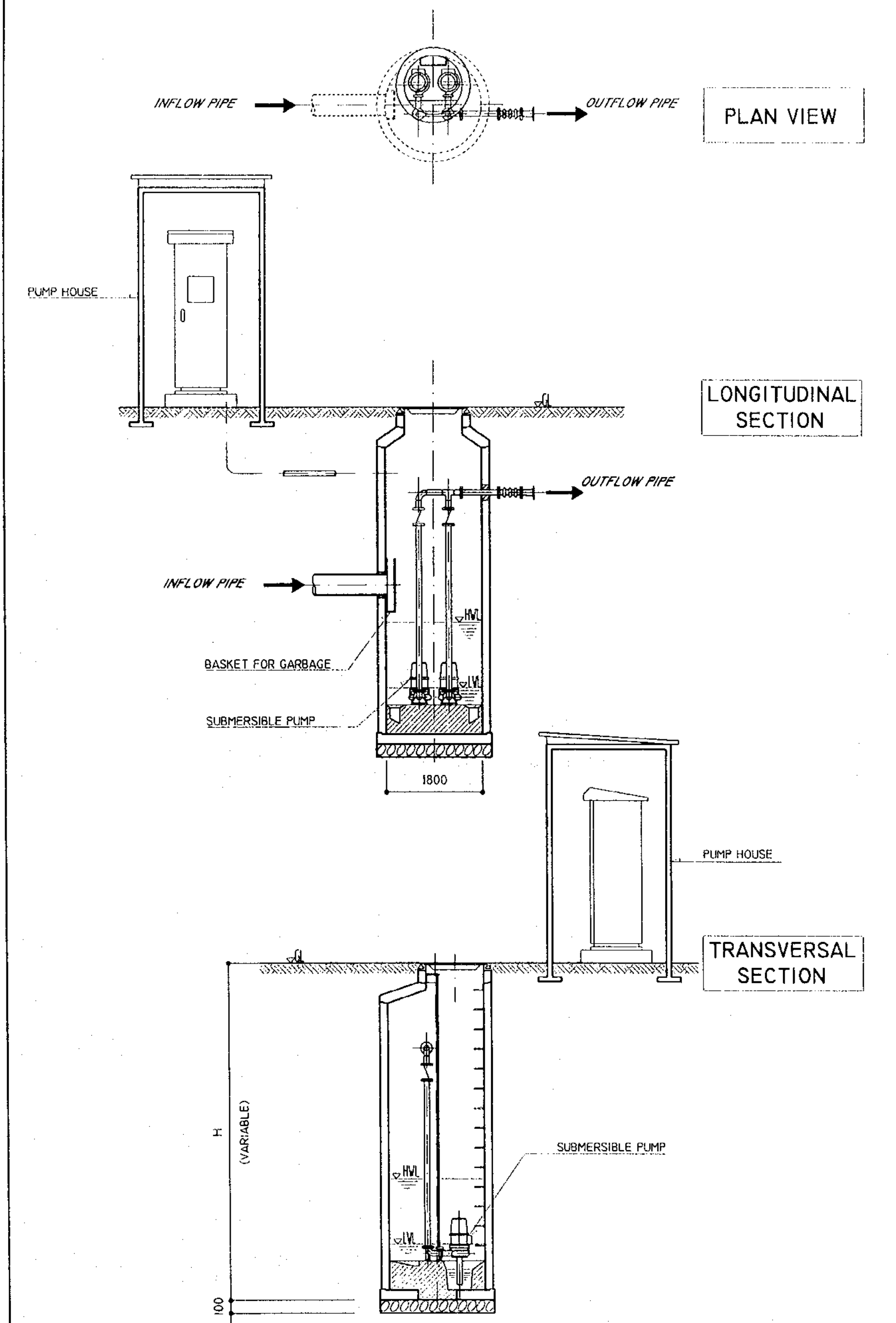


Fig. 4.3-6	Manhole Type Pumping Station
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

Fig.4.3-7 Flow Diagram of Existing Janga Sewerage System

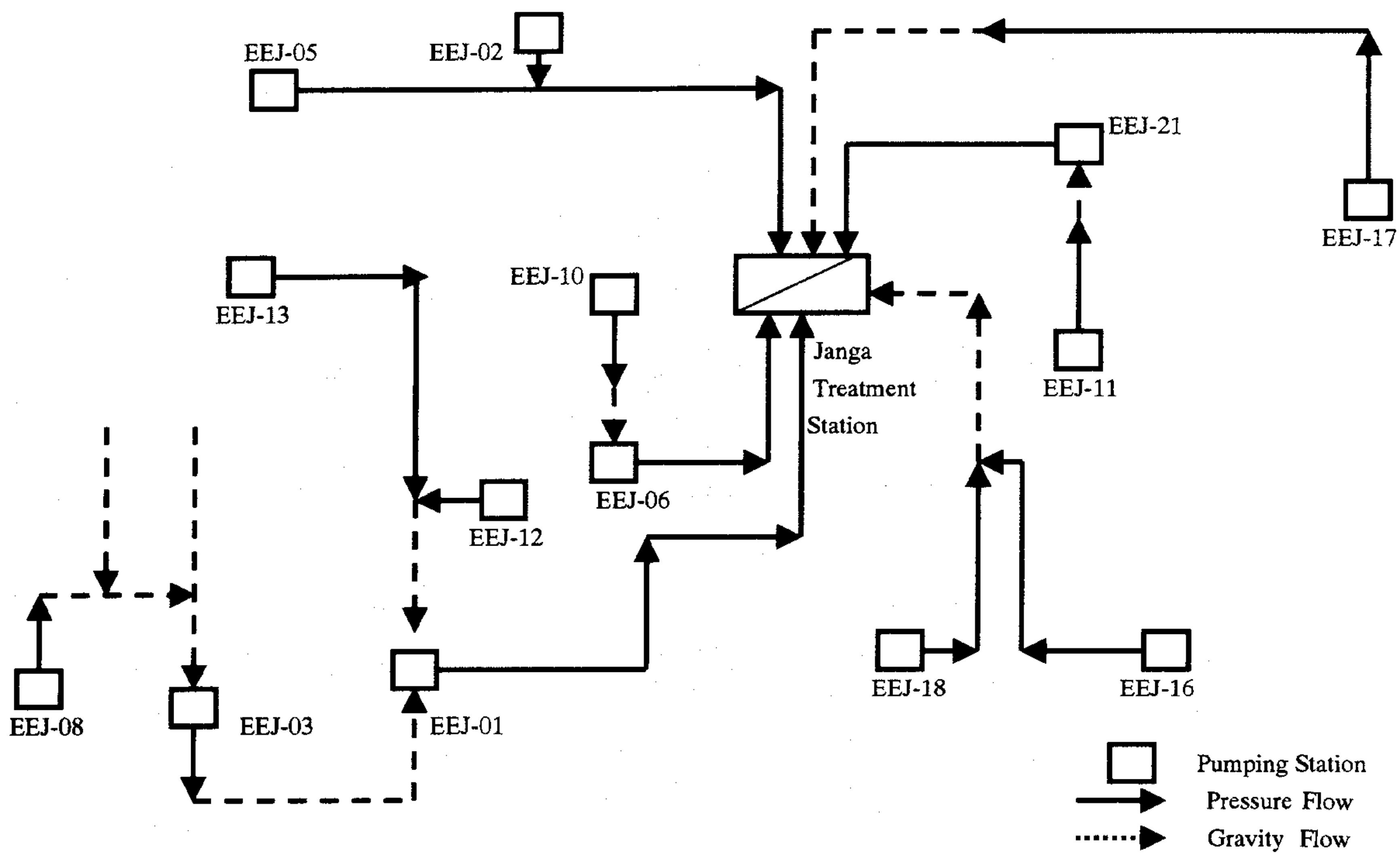
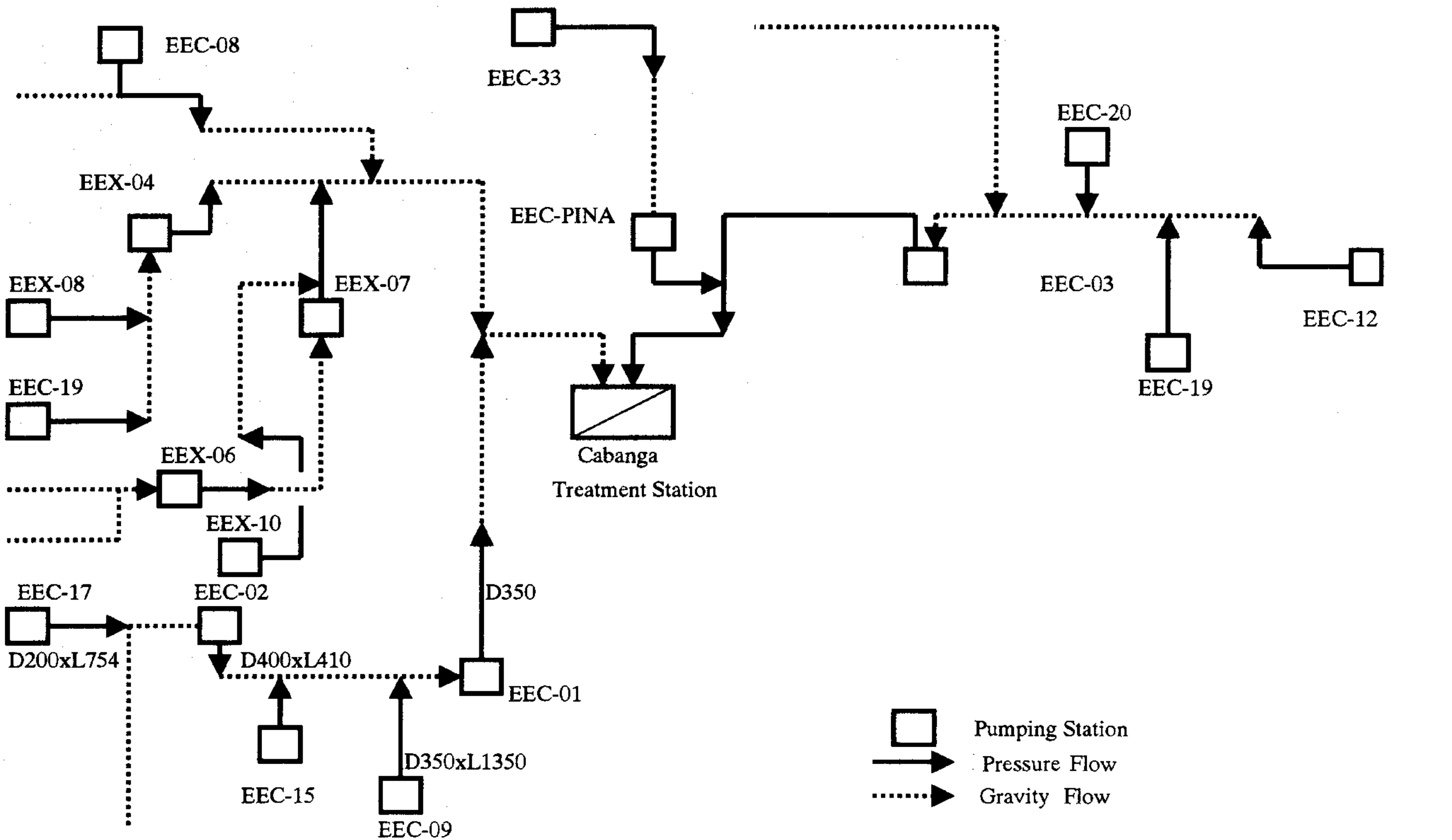


Fig. 4.3-8 Flow Diagram of Existing Cabanga Sewerage System



4.4 Sewage Treatment Facility Plan

4.4.1 Design Conditions

The preliminary designs of the STFs were carried out in accordance with the following conditions.

(1) Sewage flow

Basically, the sewage flows (daily maximum, daily average and hourly maximum) in 2020 of the systems, as shown in the following table, are adopted in the preliminary design. In the Janga STF, however, the design flow is calculated by deducting that of the existing facilities, since almost all of them are used separately from the newly installed facilities.

Meanwhile, in the Cabanga STF, the sewage flows in 2020 are used for the preliminary design. This is because parts of existing facilities are used in combination with newly installed facilities.

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

(2) Water quality

The BOD and SS of inflow sewage for the STFs are based on the results of the sewerage planning study shown in the following table.

The treated water quality in terms of BOD and SS is defined as the removal rate of 90 % for all STFs, in compliance with the instruction of No. 2002 issued by the CPRH.

Besides, the temperature of 28 °C of inflow sewage is applied in the preliminary design.

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

4.4.2 Preliminary Design of Sewage Treatment Facilities

(1) Construction sites

While the sites of seven (7) STFs were basically predetermined in the PQA, some locations of them were changed, because of future land use plans. The respective municipalities have already earmarked the sites for the construction of the sewage treatment station, which are shown in Fig. 4.4-1.

These construction sites are deemed to be appropriate for the construction of STFs for the following reasons:

- There is enough land space to accommodate planned treatment facilities,
- No obstacle to the conveyance of collected sewage to the treatment station,
- Compatible with the land use plan established by municipalities for the internal and surrounding areas,
- Located at places where watercourses can be used for the discharge of treated sewage,
- No existence of potential environmental hazards caused by the construction and operation of treatment facilities, and
- Presence of appropriate physical conditions for construction works and operation, such as access roads, electricity, water supply, etc.

The JICA Study Team undertook a series of topographic and soil condition surveys for the respective STF sites in the Feasibility Study.

Information on the current situation of the STF sites is given in the other section.

(2) Selection of treatment processes

The STFs comprise:

- Biological treatment system,
- Disinfection system, and
- Sludge treatment system.

The processes of the STFs to be applied have to meet regional requirements and characteristics of the RMR. They were selected and justified as follows:

1) Biological treatment system

In the phase of the Master Plan Study, six (6) kinds of biological processes were compared from the viewpoint of the applicability to regional requirements in the RMR. These were activated sludge, oxidation ditch, aerated lagoon and bio-filtration for aerobic treatment, and the "RAFA + lagoon" and the "RAFA + bio-filtration" for combined anaerobic treatment. Of these, the Master Plan Study selected combined anaerobic treatment such as the "RAFA + lagoon" and the "RAFA + bio-filtration" processes as promising for the RMR.

Moreover, in the light of the attributes of these processes, the following criteria were established in the Master Plan Study:

- When there is no limitation in the land space of the treatment station, the "RAFA + lagoon" process is the most suitable, and
- When there is a certain limitation in the land space of the treatment station, the "RAFA + bio-filtration" process is the most suitable.

Based on these results, the lagoon treatment was studied in more detail as the post-treatment of RAFA.

In general, lagoon treatment includes various types, such as aerated lagoons, the "aerated lagoon + polishing pond", facultative lagoons, anaerobic lagoons, etc. Of these, the "aerated lagoon + polishing pond" and the facultative lagoon were evaluated from the technical and economical viewpoints, since they potentially meet the requirements of this Study.

"Aerated lagoon + polishing pond" process:

An aerated lagoon is equipped with aerators to supply oxygen necessary for bio-degradation. In the combined anaerobic process, sewage pre-treated by the RAFA, undergoes secondary treatment in aerated lagoons and is finally clarified in polishing ponds. Following the RAFA, with its BOD removal rate of 75 %, an overall rate of 90 % can be achieved by the combination of an aerated lagoon and a polishing pond.

Facultative lagoon process:

A facultative lagoon is the treatment process in which the necessary oxygen for bio-degradation is supplied by algae growing on the water surface and by natural wind. Therefore, this is considered to be a nearly natural purification process.

In the RMR, this treatment has been adopted for the Mangueira Treatment Station where there is a facultative lagoon with a 3-day hydraulic retention time. However, significant BOD removal has not been found in its facultative lagoon after some 36 months of operation, resulting in far less than 90 % removal of overall BOD. This is explained by:

- A facultative lagoon with a 3-day hydraulic retention time, in terms of biological treatment, cannot be a process that achieves significant BOD removal. In other words, an enormous volume may be required to get higher removal,
- With the sewage characteristics and climatic conditions in the RMR, algae proliferate excessively in lagoons and retard BOD decomposition. They may even cause an increase of BOD in some cases.

Consequently, it has been learnt that, in practice, an overall BOD removal rate of 90 % is impossible in the combined anaerobic treatment using facultative lagoons.

From the above, the "aerated lagoon + polishing pond" treatment was selected as the most feasible system as the post-treatment of the RAFA in a combined anaerobic system.

Thus, the following criteria are applicable to the selection of a biological treatment system, incorporating the results of the Master Plan Study on this matter:

- When there is no limitation in the land space of the treatment station, the "RAFA + aerated lagoon + polishing pond" process is the most suitable, and
- When there is a certain limitation in the land space of the treatment station, the "RAFA + bio-filtration" process is the most suitable.

2) Disinfection system

To reduce coliform bacteria in biologically treated sewage, various disinfection processes such as chlorine, ultra-violet light, the ozone process and others are generally used.

Of these, the chlorine process is the most advantageous in terms of economic efficiency in both initial cost, and operation and maintenance costs. However, the influence of residual chlorine and generated chlorine compounds on aquatic lives has been proved in recent studies. This is why many developed countries are substituting ultra violet process for chlorine process.

While a specific policy of disinfection method has not been established in the RMR yet, the CPRH suggested that ultra violet disinfection be desirable to protect mangroves growing along riversides. Considering that almost all of seven (7) STFs discharge treated water into rivers, whose shores have mangroves, the ultra violet process will be applied in this Study to protect the environment.

3) Sludge treatment system

At present, all the existing sewage treatment stations in the RMR rely on sludge drying beds to treat sludge. Given the climatic conditions in the region, the natural sludge drying process is considered to be the most economical method. However, i) it requires a large area of land due to the low-rate of drying, and ii) it might generate an offensive odor.

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

- Mechanical dehydration shall be introduced at the STFs that are limited in area, or that are sited in densely populated areas, and
- Natural drying bed shall continue to be used at the STFs that have large areas where odor will not cause concern in the surrounding environment.

Due to the increase of the sewerage coverage, it will become essential that mechanical dehydration be introduced in the RMR.

The unit processes of mechanical dehydration being used widely are belt press filtration, pressure filtration, centrifuge separation, vacuum filtration, etc. Of these, belt-press filtration is currently the most prevalent throughout the world, since it gives satisfactory performance in the reduction of sludge volume without special accessory machinery.

Comparing dehydration performance, ease of operation and maintenance, cost, and space requirement, belt-press filtration is recommended as the most suitable process for the RMR.

4) Overall treatment processes selected for priority systems

Based on the examination and criteria above, the selected processes for the STFs are shown in Table 4.4-1.

In terms of biological system, the Cabanga STF and the Cordeiro STF shall apply the "RAFA + bio-filtration" process due to the limitation of available land space. Meanwhile, the "RAFA + aerated lagoon + polishing pond" shall be used at the other STFs, which have enough space.

For sludge treatment, mechanical dehydration shall be used in the Cabanga STF, the Boa Viagem STF and the Cordeiro STF, since they are located in densely populated urban areas with smaller sites. The other STFs shall use a natural drying process for sludge treatment.

(3) Applied design criteria

1) General

The preliminary design was carried out in accordance with the "Guidance on Sewerage Facilities Planning and Design" (issued by the Japan Sewage Works Association). ABNT standards and norms relevant to sewerage facility design were also incorporated, when they were considered appropriate and suitable for this Study.

2) Basic design criteria

In the preliminary design of the STFs, the following were adopted:

(a) Layout plan of STFs

The layout plans of the STFs were formulated in accordance with the following basic criteria:

- The facilities were located to allow enough space for routine and periodical operation /maintenance and overhauls, and
- The plans and sections were designed so that water in main lines flows by gravity, as a rule.

(b) Utility and auxiliary facilities

Sewage treatment facilities, in general, should be equipped with a source of electricity allowing for continuous operation. However, emergency alternative power facilities shall not be provided in the STF, as the STF can cope with potential power stoppages in the RMR.

Supervision boards shall be installed in the control room of the administration buildings. The supervision and monitoring of the operating status of not only the STFs but also the pump stations in the respective sewerage areas shall take place at these boards, collectively.

Adequate sanitation facilities (water supply and toilets) shall be provided in treatment stations.

The STFs shall be equipped with laboratory facilities necessary for daily and periodical measurements/analyses of water and sludge quality.

(c) Site preparation and access roads

The ground surfaces of STF sites shall be leveled off by grading or reclamation at the elevation required to protect against submersion of sites and to allow for the discharge of treated sewage into an outfall by gravity.

Access roads of at least six (6) meters in width, from major roads to STF sites shall be provided, if they are not available at present.

(d) Measures to deal with environmental problems

The following preventive and preservation measures shall be incorporated to avoid environmental problems arising from the construction works and operation of the STFs:

- Green zones (10 m in width at least, as a rule) shall be laid around the periphery of STF sites to mitigate offensive odor and noise, and to avoid damage to the surrounding landscape,
- To prevent offensive odor from the emission, influent systems consisting of grit chambers, bar screens, influent pumps and dehydrators shall be accommodated inside the building and a simple deodorizer shall treat exhausted air,
- Emitted gas from RAFA reactors, which contains offensive odor constituents, shall be diffused from a centralized stack into the air,
- The STF installation shall be avoided in mangrove areas in the land suggested by the Counterpart.

3) Design criteria for facilities

Facilities shall be designed in accordance with the following criteria:

(a) Grit chamber

Type:	Rectangular type
Design base flow:	Hourly max. flow
Water surface loading rate:	Max. 1,300 m^3/m^2/day
Hydraulic Retention Time:	40 sec.
Main functions:	To remove grit particles with larger than 0.15 mm in diameter.

(b) Influent pump

Type:	Vertically mixed flow or centrifugal type
Design base flow:	Hourly maximum flow
Suction side velocity:	Less than 2 m/sec
Main functions:	To lift up incoming sewage to the subsequent system.

(c) RAFA reactor

Type:	Rectangular type
Design base flow:	Daily max. flow
BOD removal rate:	75 %
Hydraulic detention time:	7 hours
Depth of reactor:	5.0 - 6.0 m
Main functions:	To decompose organic pollutants in sewage by anaerobic biological degradation.

As for the treatment performance of RAFA, the operation records at the Mangueira Treatment Station and the "Sewage Treatment by Anaerobic Process" issued by the "Program of Investigation on Basic Sanitation in Brazil, 1999" were referred to.

(d) Aerated lagoon

Type:	Rectangular type with aeration
Design base flow:	Daily max. flow
BOD removal rate:	60 % (after polishing ponds)
Hydraulic detention time:	1.0 day
Water depth of lagoon:	3.8 m
Main functions:	To remove organic pollutants remaining in the outflow

from RAFA reactors by aerobic biological purification.

(e) **Polishing pond**

Type: Rectangular type without aeration
Design base flow: Daily max. flow
Functions: Settling and separation of solids
Hydraulic detention time: 1.5 day
Water depth of lagoon: 3.6 m
Main functions: To settle suspended solids in the outflow from aerated lagoons by gravity separation and also to digest anaerobically a part of accumulating sludge.

(f) **Bio-filter**

Type: Circular and high-rate type
Design base flow: Daily max. flow
BOD removal rate: 60 %
BOD loading rate: Max. 0.75 kg-BOD/m^3/day
Depth of filter media: 2.0 m
Main functions: To remove organic pollutants remaining in the outflow from RAFA reactors by aerobic biological purification.
Circulation rate of treated water: 2.0 to the influent sewage flow.

(g) **Sedimentation tank**

Type: Circular or rectangular type
Design base flow: Daily max. flow
Water surface loading rate: Max. 24 m^3/m^2/day
Main function: To settle suspended solids in the outflow from bio-filters by gravity.

(h) **Disinfection tank**

Type: Rectangular type with UV light unit
Design base flow: Daily max. flow
Main function: To reduce pathogens and parasites in biologically treated sewage so as to meet the discharge standard for total coliforms.

(i) **Sludge thickener**

Type:	Rectangular and gravity type
Design base flow:	Daily average flow
Sludge content:	Inlet 1.0 % and outlet 3.5 %
Solid surface loading rate:	Max. 60 kg-DS/m^2/day
Main function:	To thicken the sludge generated from the biological treatment system and homogenize it.

(j) **Sludge dehydrator**

Type:	Belt-press type
Design base flow:	Daily average flow
Operation hour:	8 hours per day
Water content of sludge:	Inlet 96.5 % and outlet 80 %
Filtration rate:	Max. 130 kg-DS/m/hour
Main function:	To dewater the sludge generated from the biological treatment system.

(k) **Sludge drying Bed**

Type:	Natural drying bed type with roof
Design base flow:	Daily average flow
Water content of sludge:	Inlet 99 % and outlet about 50 to 60 %
Drying rate:	1.3 kg-DS/m^2/day
Main function:	To naturally dry the sludge generated from the biological treatment system.

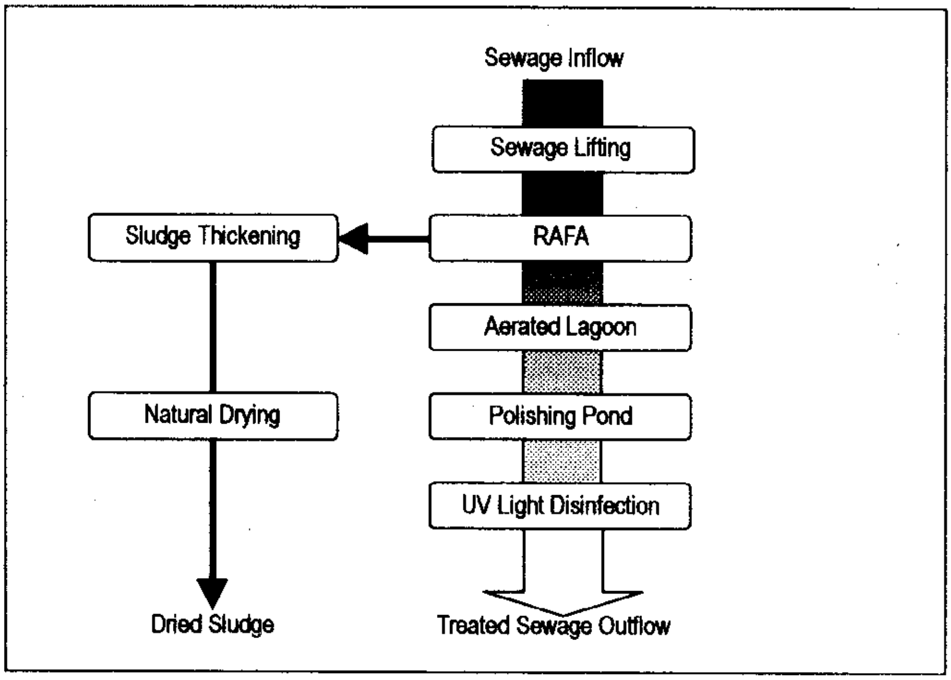
(4) **Results of preliminary design**

1) **Conceicao STF**

(a) **General**

The Conceicao STF consists of the following steps: the "RAFA + aerated lagoon + polishing pond" for the biological treatment system and the "natural drying" for the sludge treatment system, as shown below.

Treatment Flow of Conceicao STF



Treated sewage shall be discharged by gravity into the Timbo River through embedded discharge pipes. The sludge generated from the treatment facilities shall be disposed of at landfill sites, transported after being dried naturally at the STF site.

The layout plan of the STF is shown in Fig. 4.4-2.

(b) **Construction site**

The site is situated at the locally determined coordinates, 2.97E / 91.29N, in the Municipality of Paulista and lies near lagoons in the estuary of the Timbo River. The land of 8.2 ha shall used as the treatment station. At present, the land belongs to a private enterprise, which has a cement factory nearby.

At the moment, the land is vacant with bushes and trees. A beverage factory is in operation next to the site to the south and residential houses are sited to the east.

The present ground surface at the site is inclined from the north to the south with the level between 20 m and 2 m (+ MSL). The STF shall be constructed on a plot at a level of 4.5 m (+ MSL), prepared by grading and reclamation to prevent the site from submersion and to discharge treated sewage by gravity.

(c) Major facilities and structural works

Main specifications of major facilities and structural works for the STF are shown in Table 4.4-2.