SUPPORTING 9

OPERATION AND MAINTENANCE

TABLE OF CONTENTS

LIST OF TABLES

SUPPORTING 9 OPERATION AND MAINTENANCE

1. OPERATION AND MAINTENANCE (O&M)

1.1 O&M TASKS

Major tasks required for the collection and WWTP components O&M, which are the basis for estimating the additional staffing and equipment requirements. There are two classes of maintenance; preventive and corrective. The preventive maintenance involves initial inspection of the collection and WWTP system, and analysis of existing data to identify trouble areas. This provides guidance in developing the type, degree, and frequency of planned preventive maintenance required.

Corrective maintenance means emergency or unplanned maintenance. This can deal with the failure of equipment; collapse of an existing sewer; stoppage due to solid waste, roots or grease; or excessive inflow or infiltration. These conditions require immediate action to correct the problem.

The objectives are to improve service, reduce emergency occurrences, and to minimize the cost of the preventive maintenance program.

1.2 COLLECTION SYSTEM

(1) General

The operation and maintenance of the new sewerage system will require sewer cleaning and maintenance equipment for the local operations and maintenance staff. For the planned wastewater system, several sets of vehicles and equipment should be available including a van or truck, an on-board generator and compressor, a trailer-mounted high pressure jetting unit, and dewatering pumping and hoses.

Under the Project a total of 1,890 km long sewers—including branch/lateral, main/trunk sewers—and six pumping stations are to be built which start their operations by mid- 2010. These facilities need to use vehicles and mobile equipment for sewer and auxiliary facilities inspection, cleaning and repair works.

The works will consist of the following three distinct operations:

- Inspection for deterioration of manholes, steps and the interior of lines, and to reduce potential sewer stoppages by removal of deposited materials in manholes;
- Emergency and routine repairs of pipelines and appurtenant structures; and
- Cleaning pipelines by means of mechanical equipment.

(2) Yards and Shops

In general, the sewer maintenance equipment and personnel should be housed in one general yard in each “Sewer System” or at least in “Division.” It is desirable, however, that a portion of any such yard be designated for sewer maintenance activities and storage of specialized material and equipment to reduce operating confusion and localize responsibility.

Administrative personnel should study the problem of yard location in the light of present and future traffic conditions. Further, prompt investigation of sewer complaints within the shortest possible time reflects to the credit of the CEDAE and enhances public relations.

The yard should be so arranged as to house properly all equipment and to store all necessary materials. Depending on the land area available, the office may or may not be attached to the other buildings. The facilities required for operating personnel include a rocker room, an assembly room, and lavatories.

The shop size and machinery requirements will vary widely depending on what works will be done. The O&M equipment generally required for the wastewater system are listed in the following tables.

(3) Collection System

1) Sewers

A year-round pipeline maintenance program should be developed with the emphasis on preventive maintenance. Under the program, sewers, including manholes, pumping stations, and special structures, should be regularly inspected and, if necessary, repaired.

Three-or four-person (according to the type of work and size of sewer) pipeline maintenance crews, operating throughout the service area, should clean and maintain large sewer lines, and where necessary chemically treat sewers for root control, and perform insect and rodent abatement work.

Cleaning and flushing to remove blockages or build up of deposition of grit and wastewater debris may be required from time to time. The risk of structural deterioration should also be assessed in relation to ground conditions, the quality of the constructed sewers, and the nature and characteristics of the wastewater. This assessment will provide a base to judge inspection frequencies throughout the overall length of the sewers and the items to be observed and recorded when inspections take place.

Inspection of the main sewers should be carried out with the aim of detecting trends of deterioration as well as obvious defects that might be observed during an inspection. Assuming a long asset life, minimum inspection frequencies may be as follows:

- General walk through the man-entry main sewers once every two-year;
- Of the non man-entry sewers a visual inspection of the sewer from the manholes should also be carried out once every- or two-year; and
- Detailed inspection of selected sections once every five years.
- Groups will be responsible for (1) planned cleaning and the review of retained projects, (2) emergency cleaning, and (3) sewer repairs.

2) Pumping Stations

As there are many items of equipment to be inspected, a detailed planned maintenance program should be prepared and mounted on display within the control panels of any small local district stations and within the superstructure of the larger pumping stations.

In pumping stations, screens, wet-wells and grit chambers will be the major sources of odors. Wastewater screenings should be kept in closed containers until they are transported to a landfill for burial or dewatered and incinerated. These precautions can prevent the release of odors from sulfur- and nitrogen-bearing organic compounds.

Wet-wells frequently contain or receive septic wastewater. In addition to hydrogen sulfide being released, odors evolve from grease deposits on walls and the liquid surface. The walls should be cleaned daily and the scum removed and placed in covered containers to be disposed of along the screenings.

(4) Equipment for Inspection and Cleaning

In addition to the inspection and personal equipment, the operation and maintenance of the new sewerage system will require the purchase of sewer cleaning and maintenance equipment for the operation and maintenance staff. For the wastewater project, at least one (1) complete set of the following equipment is considered appropriate.

Table 1 List of Standard Equipment

	Equipment	Nr. of Unit
I.	**General Equipment**	
1	Trucks of 5-ton or larger, that may be equipped with following items;	1 unit
2	Power- or manually-operated winch.	1 unit
3	Air compressors for operating pneumatic tools, 2.5m^3/min.	1 unit
4	Trailer-mounted turbo blower, 250m^3/min x 30kW x 3450 Pa.	1 unit
5	Power generator, portable 75kVA.	1 unit
6	Truck-mounted high pressure water jetting unit	1 unit
4	Breathing apparatus including spare parts and ancillary items.	sum
5	Ventilators.	2 units
6	Minor equipment; shovels, picks, mattocks, hydrant and manhole tools, flashlights, rubber boots, coats and gloves, buckets and rope.	sum
7	Safety equipment; hydrogen sulfide detector, carbon monoxide detector, combustible gas detector, hose mask with safety harness, safety belts (2 or 3) with rope, complete first-aid kit, manhole guard rails, traffic signs and flags, lamps and flares.	sum
8	Trailer-mounted high pressure jetting unit.	1 unit
9	Dewatering pump and hoses, 100mmϕ x 7.5kW x m^3/min. x 25m.	1 unit
10	Basic hand tools; lifting equipment and pipe rodding equipment, with flexible steel rods of 150m, flexible steel cable of 300m, and sewer flushing bags.	sum
II	**Equipment for Workshop**	sum
1	Floor drill press.	
2	Hacksaw	
3	Grinding wheels.	
4	Welding room.	
5	Small lathe.	
6	Blacksmith furnace.	
7	Anvil	

Note: The sizes, numbers and capacities of the above equipment are of standard, and actual No. or specification may deviate from the above, depending upon the conditions

1.3 WASTEWATER TREATMENT PLANTS (WWTPS)

(1) Operation and Maintenance Requirements

Outline of major parameters to be monitored for the operation of conventional activated sludge treatment process may be summarized as follows:

Table 2 Operation Parameters Monitored by Central Control System

Operation Process	Monitoring Parameter
Grit chambers	Influent gates opening/closing
	Influent wastewater level and volume
	Elevation of pre- and post-screening wastewater
	Grit collector operation
Pumping station	Water level at wet well
	Supplied water flow
	Effluent water level
	Valve opening/closing
	Bearing temperature of pump and motor
Primary clarifiers	Receiving water level
	Underflow sludge volume
Reactor tanks	Gate opening/closing
	Receiving water level
	Air volume
Blower equipment	Intake air flows of blowers
	Supplied air flows and pressure of blowers
	Bearing temperatures of blowers and motors
Final clarifiers	Receiving water level
	Underflow sludge volume
	Excess sludge volume
	Water level of sludge sedimentation pond
Outfall pipelines	Effluent discharge volume
	Water level of receiving water

Table 3 Sludge Treatment Operation Parameters

Operation Process	Monitoring Parameter
Sludge gravity thickeners	Inflow sludge volume
	Tank water level
	Sludge-liquid interface level
	Underflow sludge volume
Anaerobic sludge digesters	Inflow sludge volume
	Tank water surface level
	Digested sludge withdrawal volume
	Supernatant volume
	Sludge gas production
	Tank temperature
	pH level
Centrifuges for thickening and dewatering	Inflow sludge volume
	Chemical dosage
	Sludge cake volume
Gas holders	Storage volume
	Gas holder level
	Excess gas volume
Sludge Dryers	Sludge input (Volume and dry solids weight)
	Moisture contents of dried solids
	Temperature of sludge or wet bulb temperature of exit gas

Routine and disassembly inspections are essential to keep proper function of devices, including:

Table 4 Necessary Maintenance Work

Frequency	Check Item
Daily	Check appearance, unusual vibration and sound
	Check condition of lubricants
Monthly	Check gland packing wear and leakage around seals
	Check and, if necessary, replenish lubricants
	Check tension and wear of chains
Yearly	Replace lubricants and gland packing
	Tighten bolts
	Check operation of electric and mechanical devices
	Check operation of protective devices
	Dry up tanks/reservoirs and check submerged devices
Once every 1 to 4 years	Overhaul, paint or greasing devices

Results of inspections and any maintenance activities should be recorded in daily or monthly logs. Maintenance staff should request necessary spare parts and consumables so that administrative staff can properly manage them.

(2) Sludge Transportation/Disposal

The sludge conveyance equipment should be tight to prevent loss of material and minimize the prospect of a methane gas explosion along the way. Transported sludge solids will be in a continual state of decomposition, and as such gas production, and odor problems may cause difficulties and should be considered.

When properly stored, the material should not be lost by leaching or by air movement, nor should it be diluted by water runoff from surrounding areas. Storage of solid sludge normally requires that consideration be given to collecting any surface drainage that has come into contact with the sludge. Surface water should be diverted from the storage area. As the potential exists for pathogen recycles from stored material, storage of sludge for several weeks following stabilization is a desirable practice.

Under the Project, no particular equipment or device for sludge disposal are considered other than sludge dewatering, drying and loading facilities, and sludge transportation vehicles.

(3) O&M Equipment for WWTPs

Tools should include the ordinary hand tools, wood tools, grinding tools, wrecking tools, pipe fitting tools, and such machine tools as may be used economically by the plant personnel. In addition to tools for the maintenance of equipment there should be provided the ordinary janitor supplies; also picks, shovels, rakes, shears, etc.

Typical O&M equipment and tools are shown in the following table:

Table 5 Typical WWTP O&M Equipment and Tools

	Equipment/Tool	Nr. of Unit	Remarks
I	**Tools** Ordinary hand tools; wood tools, grinding tools, wrecking tools, and pipefitting tools, and machine tools. Ordinary janitor supplies; Ground maintenance tools; picks, shovels, rakes, shears, and wheelbarrows. Garden hose and fire hose for sprinkling lawns and flushing tanks, walks, and other equipment.	1 lot	
II	**Equipment**(*) Electrical equipment; fuses, light bulbs, thermal elements, and other minor electrical equipment. Spare parts; for machines required for emergency and cannot otherwise be obtained without delay.	1 lot	

Note: (*) Judgment and advice of the manufacturer should be followed in the selection of these items to avoid an accumulation of unnecessary, obsolete and forgotten items.

2. STAFFING REQUIREMENTS

2.1 BASIC FUNCTIONS

Under this study, the estimation of staffing requirements is limited only to those additionally required for the Project facilities operation and maintenance work.

The basic functions of the collection system management organizations are inspections, cleanings and other O&M works of sewers and pumping stations; whereas the WWTPs management organizations are—in addition to the routine facilities O&M work—the treatment of wastewater and the final disposal of treated sludge.

2.2 CRITERIA FOR DEFINING NEW O&M ORGANIZATION

The Project O&M organizations, in their general structure, should meet the existing organization of the CEDAE. In this sense, the Project O&M work may be assigned to the "Metropolitan Center/North Division for Pavuna and Sarapui, and West & Green Coast Division fro Bangu and Acari, Operation Directorate of CEDAE," and the organization should respond to its specific needs, taking into account the organization scheme used by CEDAE.

This plan is to be developed following the descending hierarchy; General Manager, Service Manager or Administrative Manager (which are at the same level), Sections and Work groups.

The Administrative Manager provides general services relative to the sewerage system operation such as cleaning, gardening, guarding, inventory, time controlling, etc.

2.3 OTHER CONSIDERATIONS

The following aspects may also be taken into account:

- All security personnel, building janitors and time controllers for the WWTPs will be assigned to the WWTPs general services section;

- The WWTPs should be self-sufficient from the view points of water quality analysis, for the control of treatment processes, research and development purposes;
- The operation personnel will work in principle in two-shift. Its location in the WWTPs and the required number of people will be performed according to i) the places where the controls are concentrated, ii) the importance of the different areas constituting the WWTPs, and iii) convenience for a constant direct visual control of equipment performance and areas;
- The maintenance personnel will basically work during the day. According to the experience in the similar WWTPs, failures in the electrical and mechanical areas may be the most common, making it necessary for the continuous presence of a technician in this specialty; and
- It is assumed that no personnel from CEDAE may be required at the final sludge disposal site.

2.4 STAFFING REQUIREMENTS

Projected staffing requirements at the end of 2010 are estimated and summarized for each of the system components. As the existing Pavuna, Sarapuí and Acari WWTPs, and sewer maintenance sections already have operation staff, only the additionally required staffs for the First Stage facilities are estimated. The staff projections are made in consideration of the scale of facilities and wastewater flow rates.

The staff proposals are derived through discussions between CEDAE and the Study Team, the main objective being to improve the quality of maintenance delivered and to handle the increase in O&M workload arising from the increase in sewer length, and additional WWTPs facilities.

(1) Collection System

The collection system O&M office may be under the control of one Superintendent or Engineer, under which are separate five sections. General Services section may consist of an Office Manager and one employee who keeps a record of the financial operations of the office. In addition, there will be another person who would accept and dispatch trouble calls and be familiar with the sewer maps so that the person could give information to the public or to plumbers and contractors seeking information regarding new house connections.

The General Foreman may keep track of the work of each crew by making a round of the jobs each morning and afternoon. He should stay with crew that needs help until the problem is solved and the work is laid out. The General Foreman should have charge of all crews with the exception of the emergency crew, which should be dispatched from the office to expedite a customer’s trouble call.

Each of the cleaning parties should comprise at least three crew, one of whom will be the nominal foreman. Three crews may be able to handle most of the cleaning procedures, build manholes, the customary dig-up jobs, and make minor repairs and excavations. At least one party should have the primary job of preventive cleaning. Its members should be experienced in the various cleaning procedures, and make periodic inspections of all lines.

The emergency or routine crew should be trained to handle the sewer rods, bucket machines, and/or hydraulic water jets to give immediate service to customer trouble calls. They should not be expected to make major repairs or excavations. The personnel requirements for the sewer O&M section are as shown in the following table:

(2) Pumping Stations

Pumping stations in the sewer system will be required to operate 24 hours a day and seven days a week. The present staff level should be increased to ensure adequate cleaning and supervision, even though pump operation is automatic. One pump operator should be assigned to at least two pumping stations during their shift (depends on the scale and structure of pumping station).

As for the pumping station operation (except for those automatically controlled), it is preferred that the 24-hour coverage is provided in two 12-hour shifts rather than one 24-hour shift, but understand the potential problems in increased transportation and the change in working practice. The study team prefers shifts of not more than 12 hours but the increased transportation needs as this would also apply to WWTPs, and the risks of disrupting workers' present arrangements for additional earnings (if any).

(3) Staff Requirement for Sewers and Pumping Station Maintenance

The staff required for operation and maintenance of sewers is supposed to include that of pumping stations and is calculated based on the following assumptions.

- Every part of sewer is inspected once every two years,
- The length of sewer to be inspected in a day is 300 meters,
- One crew consists of five members,
- Equipment needed for maintenance is included in personnel cost, and
- Working days are 220 days in a year.

The number of personnel required in each sewer district is calculated as follows.

Table 6 O&M Personnel for Sewers

Sewer District	Total Length of Sewer(m)	Required Period(day)	Required Crews	Required Personnel
Pavuna	717,812	1985	6	30
Acari	581,838	1609	5	25
Sarapui	102,750	285	1	5
Bangu	429,580	1188	4	20
total	1,831,980		16	80

(4) Wastewater Treatment Plants (WWTPs)

Within a WWTP, the head of the management organization for O&M should be a superintendent, responsible for all the activities relating to O&M of the overall facilities under his control.

The second line of management should include Section Chiefs responsible to Sections of i) Operation, ii) Maintenance, and iii) Laboratory. These three Chiefs would be responsible for the control and direction of the personnel making up the allocated manning levels for the various stages of the project development.

Manning levels for the WWTP management need to be high, because the operation of facilities at the WWTPs, particularly those installed for secondary biological treatment and possibly nutrient removal in the future may require relatively high technology.

The implementation of automatic instrumentation and control systems is a common feature of the sewerage systems: however, such systems will be progressively adopted in the wastewater management system, but there may be an initial preference to utilize available resources and to instead rely on manual detection and activation with a consequent higher manning requirement for wastewater collection and treatment facilities.

For each of Acari and Bangu WWTPs, additional staff of 49 would be required by 2010; whereas for Pavuna and Sarapuí WWTPs, administration and managers offices are considered to be not changed, but additional staff of 29 and 21 respectively would be required to provide more system operation support to cope with up to the increased field workload.

The current practice may be applicable to other two new WWTPs under the First Stage Project. However, due to physical, financial, human resources constraints, more practical/realistic procedures or manuals will be required to improve the daily treatment performance for the WWTPs.

To meet the effluent quality standards, the wastewater flow should be measured daily, treated wastewater samples are taken daily, and the parameters required by the standards are analyzed in the laboratory at WWTP except those for nutrients, heavy metals, toxic substances, etc. As Pavuna and Sarapuí WWTPs have laboratory facilities, no additional laboratory system provision is considered under the First Stage Project.

All the four WWTPs will be operated 24 hours a day and seven days a week: however, when the WWTPs are being operated, potential solutions for this issue should be re-examined with a view to proper implementation. Generally, the changes in staff numbers result from some rationalization of staffing policy. Once the final design is accomplished, complementary timing and methods studies will be performed in order to determine the exact number of personnel required in each position.

The standard personnel lists for the WWTPs include all the necessary personnel to the conditions of 2020: however, for the purpose of O&M cost estimates for the First Stage requirements are separately estimated. The additionally required First Stage staff numbers for Pavuna and Sarapuí WWTPs are then estimated assuming that the additional staff numbers are in proportion to the facilities treatment capacities - i.e. 1,500 to 1,500 (50%) for Pavuna and 1,500 to 1,000 (40%) for Sarapuí WWTPs. Tables 7 to 9 are shown at the end of this chapter.

Table 7 Estimated WWTPs Staff Numbers of Acari and Bangu WWTPs (1,100 and 1,000L/s Treatment Capacities)

Jobs	Nr. Of staff	Assigned location	Day shift	Day/night shifts
1. Administration/General Service				-
A. Superintendent	1	Administrative building	1	-
B. Administration assistant	1	- “ -	1	-
C. Secretary	1	- “ -	1	-
D. Time Controller	1	- “ -	1	
E. Auditing Staff	1	- “ -	1	
F. Guards	*)3	- “ -	-	*)3
G. Cleaning Staff	2	- “ -	2	-
H. Driver	1	- “ -	1	-
I. Gardeners	1	- “ -	1	-
Subtotal of Item 1	12		9	3
2. Operation Section				
A. Chief	1	Supervise overall Operation work	1	-
B. Operators	*)3	Process operation	-	*)3
C. Equipment Operators	*)3	Central control	-	*)3
“	*)3	Liquid treatment facilities	-	*)3
“	*)3	Sludge treatment facilities	-	*)3
D. Auxiliary staff	1	Liquid treatment facilities	1	-
"	1	Sludge treatment facilities	1	-
Subtotal of Item 2	15		3	12
3. Maintenance Section				
A. Chief	1	Supervise overall Maintenance work	1	-
B. Supervisor	1	- “ -	1	-
C. Mechanic	1	Prelim./prim./sec. systems	1	-
D. Mechanic	1	Digesters/dewatering	1	-
E. Mechanic	1	Blowers, diffusers, pumps , conveyors, valves, etc.	1	-
F. Turner	1	All equipment	1	-
G. Maintenance staff	1	Lubrication/painting	1	-
H. Auxiliary staff	1	Blowers, compressors	1	-
“	1	Clarifiers, screens	1	-
“	1	Digesters, dewatering	1	-
I. Instrumentation Chief	1	Responsible for instrumentation Operation work	1	-
J. Instrumentation Technician	1	Assist Chief	1	-
K. Electrician I	1	Responsible for electric work	1	-
“	1	Motor maintenance	1	-
“	1	Electric substation	1	-
L. Auxiliary staff	1		1	-
M. General concrete works	1	Repairing of structures	1	-
N. Stock clerk	1	Control of store inventory	1	-
Subtotal of Item 3	18		18	
4. Laboratory Section			1	-
A. Chief		Responsible for all labs. work		
B. Chemist	1		1	-
C. Microbiologist	1		1	-
D. Sampling auxiliary staff	1		1	-
Subtotal of Item 4	4		4	-
Total	49		34	15

(1,100 and 1,000L/s treatment capacities)

Note: (*) For these tasks, three persons working in day and night shifts are required. Two persons will work during a typical 24-hour day---- one person each working 12-hour a day either in day or night shift. The additional one will serve as replacement so that the three may rest two days a week

Table 8 Estimated Pavuna WWTP Staff Numbers (3,000 L/s Treatment Capacity)

Jobs	Nr. Of staff	Assigned location	Day shift	Day/night shifts
1. Administration/General Service				-
A. Superintendent	1	Administrative building	1	-
B. Administration assistant	2	- " -	2	-
C. Secretary	2	- " -	2	-
D. Time Controller	1	- " -	1	
E. Auditing Staff	1	- " -	1	
F. Guards	*)3	- " -	-	*)3
G. Cleaning Staff	2	- " -	2	-
H. Driver	2	- " -	2	-
I. Gardeners	2	- " -	2	-
Subtotal of Item 1	16		13	3
2. Operation Section				
A. Chief(Engineer)	1	Supervise overall Operation work	1	-
B. Operators(Engineer)	*)3	Process operation	-	*)3
C. Equipment Operators	*)3	Central control	-	*)3
"	*)3	Liquid treatment facilities	-	*)3
"	*)3	Sludge treatment facilities	-	*)3
D. Auxiliary staff	2	Liquid treatment facilities	2	-
"	2	Sludge treatment facilities	2	-
Subtotal of Item 2	17		5	12
3. Maintenance Section				
A. Chief	1	Supervise overall Maintenance work	1	-
B. Supervisor	1	- " -	1	-
C. Mechanic I	1	Prelim./prim./sec. systems	1	-
D. Mechanic II	2	Digesters/dewatering	2	-
E. Mechanic II	2	Blowers, diffusers, pumps , conveyors, valves, etc.	2	-
F. Turner	1	All equipment	1	-
G. Maintenance staff	1	Lubrication/painting	1	-
H. Auxiliary staff	1	Blowers, compressors	1	-
"	1	Clarifiers, screens	1	-
"	1	Digesters, dewatering	1	-
I. Instrumentation Chief	1	Responsible for instrumentation Operation work	1	-
J. Instrumentation Technician	1	Assist Chief	1	-
K. Electrician I	1	Responsible for electric work	1	-
"	1	Motor maintenance	1	-
"	1	Electric substation	1	-
L. Auxiliary staff	1		1	-
M. General concrete works	1	Repairing of structures	1	-
N. Stock clerk	1	Control of store inventory	1	-
Subtotal of Item 3	20		20	
4. Laboratory Section				-
A. Chief	1	Responsible for all labs. work	1	
B. Chemist	1		1	-
C. Microbiologist	1		1	-
D. Sampling auxiliary staff	1		1	-
Subtotal of Item 4	4		4	-
Total	57		42	15

Note: (*) For these tasks, three persons working in day and night shifts are required. Two persons will work during a typical 24-hour day— one person each working 12-hour a day either in day or night shift. The additional one will serve as replacement so that the three may rest two days a week

Table 9 Estimated Sarapuí WWTP Staff Numbers (2,500 L/s Treatment Capacity)

Jobs	Nr. Of staff	Assigned location	Day shift	Day/night shifts
1. Administration/General Service				-
A. Superintendent	1	Administrative building	1	-
B. Administration assistant	2	- " -	1	-
C. Secretary	1	- " -	2	-
D. Time Controller	1	- " -	1	
E. Auditing Staff	1	- " -	1	
F. Guards	*)3	- " -	-	*)3
G. Cleaning Staff	2	- " -	2	-
H. Driver	1	- " -	1	-
I. Gardeners	2	- " -	2	-
Subtotal of Item 1	14		11	3
2. Operation Section				
A. Chief(Engineer)	1	Supervise overall Operation work	1	-
B. Operators(Engineer)	*)3	Process operation	-	*)3
C. Equipment Operators	*)3	Central control	-	*)3
"	*)3	Liquid treatment facilities	-	*)3
"	*)3	Sludge treatment facilities	-	*)3
D. Auxiliary staff	2	Liquid treatment facilities	2	-
"	2	Sludge treatment facilities	2	-
Subtotal of Item 2	17		5	12
3. Maintenance Section				
A. Chief	1	Supervise overall Maintenance work	1	-
B. Supervisor	1	- " -	1	-
C. Mechanic I	1	Prelim./prim./sec. systems	1	-
D. Mechanic II	1	Digesters/dewatering	1	-
E. Mechanic II	1	Blowers, diffusers, pumps , conveyors, valves, etc.	1	-
F. Turner	1	All equipment	1	-
G. Maintenance staff	1	Lubrication/painting	1	-
H. Auxiliary staff	1	Blowers, compressors	1	-
"	1	Clarifiers, screens	1	-
"	1	Digesters, dewatering	1	-
I. Instrumentation Chief	1	Responsible for instrumentation Operation work	1	-
J. Instrumentation Technician	1	Assist Chief	1	-
K. Electrician I	1	Responsible for electric work	1	-
"	1	Motor maintenance	1	-
"	1	Electric substation	1	-
L. Auxiliary staff	1		1	-
M. General concrete works	1	Repairing of structures	1	-
N. Stock clerk	1	Control of store inventory	1	-
Subtotal of Item 3	18		18	
4. Laboratory Section				-
A. Chief	1	Responsible for all labs. work	1	
B. Chemist	1		1	-
C. Microbiologist	1		1	-
D. Sampling auxiliary staff	1		1	-
Subtotal of Item 4	4		4	-
Total	53		38	15

Note: (*) For these tasks, three persons working in day and night shifts are required. Two persons will work during a typical 24-hour day— one person each working 12-hour a day either in day or night shift. The additional one will serve as replacement so that the three may rest two days a week

(5) WWTPs Laboratories

A comprehensive, accurate and reliable wastewater influent/effluent monitoring is an essential component of the sewerage system project. Each in Acari and Bangu WWTP under the First Stage Project will have a laboratory to monitor wastewater qualities. The monitor could be adapted in the future, or supplemented with additional equipment, for the measurement of other chemistries, including metals, cyanide and phenols when it is justified necessary.

No changes are anticipated to staff numbers and jobs in the Pavuna and Sarapuí WWTPs laboratories. A new laboratory will be set up each at Bangu and Acari WWTP to conduct routine wastewater/sludge sampling and testing.

In the new WWTPs one each of Chief, Chemist, Microbiologist and sampling staff will be required. It is understood that the laboratory has a sufficient space to accommodate two technicians who will be performing analyses, and that an office space can be found for the section supervisor.

Minimum analytical items in the laboratory in the wastewater treatment plant under the First Stage Project will be as shown in Table 10:

Table 10 Analytical Items for WWTPs Laboratories

Sampling point	Daily or at time of inspection	Periodical (weekly)	Periodical (monthly)
influent	appearance, odor, water temperature, turbidity, pH	SS, COD	BOD, ammonia-N orthophophate-P
aeration tank	appearance, odor, water temperature, turbidity, pH	MLSS	microorganisms
effluent	appearance, odor, water temperature, turbidity, pH	SS, COD	BOD, ammonia-N, nitrate-N orthophophate-P

Analysis of some of the above items may be entrusted to other institutions or laboratories, as necessary. A range of sampling and testing equipment to be purchased and installed may include:

- pH/temperature/conductivity meters (at least 2);
- DO meters (at least 2);
- Low power and high power microscopes;
- Digital balances;
- Drying ovens;
- incubators;
- Laboratory flocculation apparatus;
- TOC analyzer;
- Hot plate stirrers;
- Digestion apparatus;
- Laboratory centrifuge;
- Vacuum pumps (large and small), with blower facility;
- Evaporation equipment (water baths, etc.);
- Distillation equipment (quick fit) and rotary film evaporator;
- Fume cupboards with ventilation equipment;

- COD apparatus;
- Turbidity meter;
- Extensive range of laboratory ware (glass, silica, metal retorts, bunsens, etc.);
- Continuous still (for distilled water) and deionizer units; and
- Miscellaneous instruments and spares (electrodes, etc.).

(6) Total Staff Requirements

The following Table 11 summarizes the number of staff members required for the wastewater collection and treatment systems in the Project corresponding to the capacities.

Table 11 Summary of Staffing Requirements under the First Stage Project

Facility	Day-shift Staff	Day- and night-shift staff	Total in First Stage	Remarks
1. WWTPs				
Pavuna	21 (42)	8 (15)	29 (57)	For portion of 1,500L/s
Acari	34 (34)	15 (15)	49 (49)	For total capacity
Sarapuí	15 (38)	6 (15)	21 (53)	For portion of 1,000L/s
Bangu	34 (34)	15 (15)	49 (49)	For total capacity
Subtotal of 1	104 (148)	44 (60)	148 (208)	
2. Collection System				Including those for pump stations
Pavuna	30	-	30	
Acari	25	-	25	
Sarapuí	5	-	5	
Bangu	20	-	20	
Subtotal of 2	80	-	80	
Total Staff for the Project	184	44	228	

Note: The figures in ( ) are those required for the total planned capacities. Others are those required only for the First Stage Portion.

SUPPORTING 10

COST ESTIMATES

TABLE OF CONTENTS

Page

SUPPORTING 10 COST ESTIMATES

LIST OF TABLES

LIST OF FIGURES

SUPPORTING 10 COST ESTIMATES

1. PROJECT

1.1 IMPLEMENTATION SCHEDULE

The Project formulated under the Strategy Plan is to be implemented over a seven-year period from 2004 through 2010. In each of the sewer districts the construction of collection systems and WWTPs is scheduled to continue over 36 months. Upon completion of all the WWTPs facilities, a six-month period for the startup and acclimation of treatment processes is arranged for proper system operation.

1.2 PROJECT COMPONENTS

(1) Sewer Districts

The area of the sewer districts under the Project are shown in the following:

Table 1 Area of Sewer Districts

Sewer System	Sewer District	Existing Area	F/S Area	Other Area	Total Area
Pavuna -Meriti	Pavuna	4,900	3,660		8,560
	Acari	730	3,100	600	4,430
	Sub-Total	5,630	6,760	600	12,990
Sarapui	Sarapui	7,300	640		7,940
Bangu	Bangu	0	1,870		1,870
Total Area		12,930	9,270	600	22,800

(Unit: ha)

(2) Population and Wastewater Flows

Design sewered populations and wastewater quantities estimated for the year 2020 are summarized below:

Table 2 First Stage Population and Wastewater Flow (in 2020)

Sewer System	Sewer District	Population (person)	Wastewater Flow(L/s)	Total WWTP Capacity (L/s)	Existing WWTP Capacity (L/s)	F/S WWTP Capacity (L/s)
Pavuna -Meriti	Pavuna	1,029,600	2,860	3,000	1,500	1,500
	Acari	390,200	1,084	1,100		1,100
	Sub-Total	1,419,800	3,944	4,100	1,500	2,600
Sarapui	Sarapui	825,900	2,294	2,500	1,500	1,000
Bangu	Bangu	363,200	1,009	1,000		1,000
Total Area		2,608,900	7,247	7,600	3,000	4,600

Note: All figures are those estimated for the year 2020 conditions.

1.3 SEWERAGE SYSTEM COMPONENTS

The sewerage component facilities subject to O&M are those to be constructed under the Project that encompasses the following collection and WWTP facilities.

(1) Collection System

1) Sewers and Pumping Stations

Totally 70 km long main/trunk sewers, ranging from 400 to 1,500 mm in diameter, are to be constructed under the Project. Branch and lateral sewers consisting of 150 to 350 mm in diameter of about 1,760,000 km long will be laid to cover approximately 9,270 ha. area.

The numbers, lengths, sizes and capacities of sewers by the sewer district are shown in the following table (For more details see *Supporting-8 "Facility Planning*"):

Table 3 Sewer System Components

Facility/Equipment		Quantity	Unit	Size, Type, Specification	Service Area
1. Pavuna Sewer District					
1	Branch/lateral sewers	695,000	m	D150 mm～300mm ,RC/PVC, by open cut	3,660 ha.
2	Main/trunk sewers	7,170	m	D400 mm～900mm, RC, by open cut	
3	Main/trunk sewers	15,642	m	D500 mm～1500mm, RC, pipe jacking	
	Sub-total	717,812	m		
4	Pumping station	1	lot	Total capacity: 7.70m^3/min.	
2. Acari Sewer District					
1	Branch/lateral sewers	558,000	m	D150 mm～300mm,RC/PVC, by open cut	3,100 ha.
2	Pressure pipes	1,010	m	D100 mm～500mm, DIP, by open cut	
3	Main/trunk sewers	7,690	m	D400 mm～900mm, RC, by open cut	
4	Main/trunk sewers	16,148	m	D500 mm～1500mm, RC, pipe jacking	
	Sub-total	582,848	m		
5	Pumping stations	4	lots	Total capacity: 27.34m^3/min	
3. Sarapuí Sewer District					
1	Branch/lateral sewers	96,000	m	D150 mm～300mm ,RC/PVC, by open cut	640 ha.
2	Main/trunk sewers	2,090	m	D400 mm～900mm, RC, by open cut	
3	Main/trunk sewers	4,660	m	D500 mm～900mm, RC, pipe jacking	
4	Sub-total	102,750	m		
4. Bangu Sewer District					
1	Branch/lateral sewers	410,900	m	D150 mm～300mm ,RC/PVC, by open cut	1,870 ha.
2	Main/trunk sewers	5,770	m	D400 mm～900mm, RC, by open cut	
3	Main/trunk sewers	12,910	m	D500 mm～1200mm, RC, pipe jacking	
	Sub-total	429,580	m		
4	Pumping station	1	lots	Total capacity: 2.3 m^3/min.	

Note: Estimates by JICA Study Team and CEDAE's information.

2) Wastewater Treatment Plants (WWTPs)

Additional trains of activated sludge treatment facilities are to be built in Pavuna and Sarapuí WWTPs to add treatment capacities of 1,500 and 1,000 L/s, respectively. For Acari and Bangu sewer districts, new activated sludge WWTPs of total capacities of 1,100 and 1,000 L/s are to be constructed.

Table 4 First Stage WWTPs Capacities

WWTPs	Treatment Process	Design Treatment Capacity (L/s)	Remarks
Pavuna	Conventional Activated Sludge	1,500	Expansion of existing plant
Sarapuí	Conventional Activated Sludge	1,000	Expansion of existing plant
Acari	Conventional Activated Sludge	1,100	Construction of new plant
Bangu	Conventional Activated Sludge	1,000	Construction of new plant

2. PROJECT COSTS

The First Stage Project costs are estimated based on the project component facilities and the implementation plan up to the year 2010. Labor and material costs as of July 2003 are first estimated then unit costs are developed therefrom for the component facilities. The direct costs of major facilities are estimated multiplying unit costs by quantities, which include profit and other expenses of contractors.

2.1 COMPOSITION OF PROJECT COSTS

- The project cost comprises the following compositions and each cost item is estimated.
- Direct Construction Cost
- Land Acquisition and Compensation
- Administrative Expenses
- Engineering Services
- Physical Contingency

2.2 CONDITIONS AND ASSUMPTION FOR COST ESTIMATE

The project cost is estimated based on the following conditions.

(1) Price Level

The price level of the project cost is August 2003. The exchange rate applied for the cost estimate is as follows:

One US Dollar = 2.9 Brazilian Real (R$) = 120 Japanese Yen (￥)

(2) Foreign and Local Currency Portions

The project costs composed of two portions, foreign currency (F.C.) and local currency (L.C.). The allocation of F.C. and L.C. is determined by the assumed percentages for each work. Both currencies are expressed in terms of US Dollar.

(3) Direct Construction Costs

The feasibility study area comprises four sewer districts; namely Pavuna, Acari, Sarapuí and Bangu. The construction works in each district include i) sewers, ii) pumping stations, iii) expansion of two existing WWTPs, and iv) two new WWTPs.

The direct construction costs are estimated for each sewer district and in major component facilities. First, unit costs of collection system are developed as presented in Tables 5 through 8, then, direct costs of component facilities are estimated as shown in *Tables 19* through *32*.

The direct construction cost for the WWTPs, pumping stations and main/trunk sewers are estimated in view of the recently contracted similar project costs, but for some electrical and mechanical portions quotations are obtained from manufacturers.

For the First Stage cost estimate of branch and lateral sewers, pipe length by diameter from 150mm to 350mm are estimated based on such data as road lengths and their distributions obtained from representative existing sewer districts.

(4) Land Acquisition and Compensation

Land acquisition is required for the construction of a new WWTP in Bangu sewer district, but those for new pump stations are all to be constructed on the right-of-ways. The required land area for the WWTP is estimated at approximately 6.5 hectares by the actual layout plan. The unit land cost is advised by CEDAE as US$10 per m^2.

(5) Administrative Expenses

Administrative expenses for CEDAE and other related agencies for the implementation of the project are assumed to be 5 percent of the direct construction costs.

(6) Engineering Services

Engineering service costs are estimated at 10 percent of the direct construction costs, including works of basic and detailed designs, tender documents preparation, and construction supervision services. No foreign currency portion is estimated.

(7) Physical Contingency

Physical contingencies are estimated at 10 % of the direct construction costs.

2.3 CONSTRUCTION RESOURCES

(1) Construction Material

Major construction materials of civil work, such as cement, aggregate, ready-mixed concrete, concrete and PVC pipe for sewers, asphalt concrete, shield tunneling machines, etc. are locally available in Rio de Janeiro Area. Information regarding material resources and unit costs are presented by CEDAE. Some particular types of mechanical equipment for the WWTPs may be imported.

(2) Construction Equipment

Such heavy construction equipment are available in Rio de Janeiro Region, as excavator, dozer, wheel loader, mobile generator, submersible pump, shield tunneling, pipe jacking, etc. are available as rental basis.

(3) Human Resource

Average costs of human resource for construction, operation and maintenance are obtained from CEDAE and other sources as summarized by each specialty in related tables.

3. CONSTRUCTION COSTS

Construction unit costs of major civil work are given by CEDAE's experience and shown in table below:

3.1 COST OF SEWER

Table 5 Sewer Unit Construction Cost by Method

Diameter (mm)	Open Cut		Pipe Jacking
	Gravity Flow	Pressure Flow	
100		124	
150	90	151	
200	96	176	
250	120	223	
300	123	241	
400	183	312	
500	192	412	1,032
700	228		
900	285		1,097
1200			1,563
1500			2,031
2000			2,751

(Unit: US$/m)

Table 6 Costs of Open Cut Method (Gravity Flow) (per 100 m of length)

Pipe Diameter (mm)	150	200	250	300	400	500	700	900	1200
Pipe Depth	2m	2m	2.5m	2.5m	3m	3m	3m	3m	3m
Pipe material	1,316	2,063	2,091	2,834	8,900	8,900	13,746	22,230	38,419
House Connection	410	410	410	410					
Earth work (Excavation)	1,369	1,449	2,013	2,013	3,140	3,623	4,106	4,589	5,796
Earth work (Backfilling)	1,780	1,834	2,547	2,490	3,826	4,245	4,426	4,517	4,890
Compact earth	1,192	1,228	1,706	1,668	2,562	2,843	2,964	3,024	3,275
Transportation	2,203	2,333	3,240	3,240	5,054	5,832	6,610	7,387	9,331
Temporary structure	5,596	5,596	6,995	6,995	8,394	8,394	8,394	8,394	8,394
Pipe laying	232	356	566	658	1,223	1,223	1,748	2,495	5,764
Manhole installation	5,150	5,150	6,207	6,207	6,274	6,274	7,097	8,872	11,217
Re-pavement	893	946	1,051	1,051	1,366	1,577	1,787	1,997	2,522
Sub-Total	20,141	21,364	26,825	27,565	40,739	42,910	50,877	63,505	89,608
Miscellaneous (30%)	6,042	6,409	8,047	8,270	12,222	12,873	15,263	19,051	26,883
Grand Total (R$/100m)	26,183	27,774	34,872	35,835	52,961	55,782	66,140	82,556	116,491
Gand total (R$/m)	262	278	349	358	530	558	661	826	1,165
Grand total (US$/m)	90	96	120	123	183	192	228	285	402

Table 7 Costs of Open Cut Method (Pressure Flow) (per 100 m of length)

Pipe Diameter (mm)	100	150	200	250	300	400	500
Pipe material	11,220	15,894	20,715	25,865	30,173	37,802	56,804
Earth work (Excavation)	1,369	1,369	1,449	2,013	2,013	3,140	3,623
Earth work (Landfill)	1,780	1,780	1,834	2,547	2,490	3,826	4,245
Compact earth	1,192	1,192	1,228	1,706	1,668	2,562	2,843
Transportation	2,203	2,203	2,333	3,240	3,240	5,054	5,832
Temporary structure	5,596	5,596	5,596	6,995	6,995	8,394	8,394
Pipe laying	3,366	4,768	5,179	6,466	6,035	7,560	8,521
Re-pavement	893	893	946	1,051	1,051	1,366	1,577
Sub-Total	27,619	33,695	39,279	49,882	53,664	69,705	91,837
Miscellaneous (30%)	8,286	10,108	11,784	14,965	16,099	20,911	27,551
Grand Total (R$/100m)	35,904	43,803	51,063	64,846	69,763	90,616	119,388
Gand total (R$/m)	359	438	511	648	698	906	1,194
Grand total (US$/m)	124	151	176	223	241	312	412

Table 8 Cost of Pipe Jacking Method (per 100 m of length)

Pipe Diameter (mm)	500	900	1200	1500	2000
Pipe material	39,057	48,822	73,024	97,225	109,221
Pipe jacking	110,299	116,821	165,446	214,071	314,916
Starting shaft	51,101	51,101	71,181	91,262	117,316
Arriving shaft	51,101	51,101	71,181	91,262	117,316
Manhole installation	8,684	8,684	13,454	18,225	34,892
Sub-Total	260,242	276,529	394,286	512,045	693,661
Miscellaneous (15%)	39,036	41,479	59,143	76,807	104,049
Ground Total (R$/100m)	299,278	318,008	453,429	588,852	797,710
Ground Total (R$/m)	2,993	3,180	4,534	5,889	7,977
Grand total (US$)	1,032	1,097	1,563	2,031	2,751

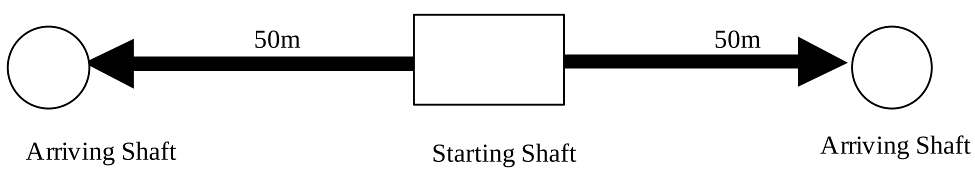


Figure 1 Concept of Pipe Jacking

3.2 COST OF PUMPING STATION

The costs of existing pumping Station (PDBG) are shown in table below:

Table 9 Construction Cost of Pumping Station (PDBG)

Locasions	Q (m^3/min.)	Costs (US$1,000)
Bairro Vila Columbia	0.2508	17
Bairro das Gracas	0.5508	31
Bairro Boa Esperanca	0.676	30
Bairro Vila Rosario	0.861	24
Santo Elias	8.6328	177
Jardim Metropole	30.663	197
Praca da Bandeira	32.534	142

And model calculations of pumping station are shown in table below:

Table 10 Construction Cost of Pumping Station

Q (m^3/min.)	Estimated Costs (US$1,000)
2.0	55
4.0	63
6.0	70
10.0	180

The breakdown of each cost in Table 10 is shown below.

Table 11 Construction Cost of Pumping Station (Q=2.0 m^3/min)

Item	Unit	Unit Cost	Cost (US$)	Remarks
Mechanical	3	14,000	42,000	1.0m^3/min x 100mm
Electrical	1	21,000	21,000	Pump x 0.5
Civil	1	50,400	50,400	(M+E) x 0.8
Sub-Total			113,400	
Miscellaneous			45,360	Sub-Total x 0.4
Total (R$)			158,760	

Table 12 Construction Cost of Pumping Station (Q=4.0 m^3/min)

Item	Unit	Unit Cost	Cost (US$)	Remarks
Mechanical	3	16,000	48,000	2.0m^3/min x 150mm
Electrical	1	24,000	24,000	Pump x 0.5
Civil	1	57,600	57,600	(M+E) x 0.8
Sub-Total			129,600	
Miscellaneous			51,840	Sub-Total x 0.4
Total (R$)			181,440	
Total (US$)			62,566	

Table 13 Construction Cost of Pumping Station (Q=6.0 m^3/min)

Item	Unit	Unit Cost	Cost (US$)	Remarks
Mechanical	3	18,000	54,000	3.0m^3/min x 200mm
Electrical	1	27,000	27,000	Pump x 0.5
Civil	1	64,800	64,800	(M+E) x 0.8
Sub-Total			145,800	
Miscellaneous			58,320	Sub-Total x 0.4
Total (R$)			204,120	
Total (US$)			70,386	

Table 14 Construction Cost of Pumping Station (Q=10.0 m^3/min)

Item	Unit	Unit Cost	Cost (US$)	Remarks
Mechanical	3	46,000	138,000	5.0m^3/min x 250mm
Electrical	1	69,000	69,000	Pump x 0.5
Civil	1	165,600	165,600	(M+E) x 0.8
Sub-Total			372,600	
Miscellaneous			149,040	Sub-Total x 0.4
Total (R$)			521,640	
Total (US$)			179,876	

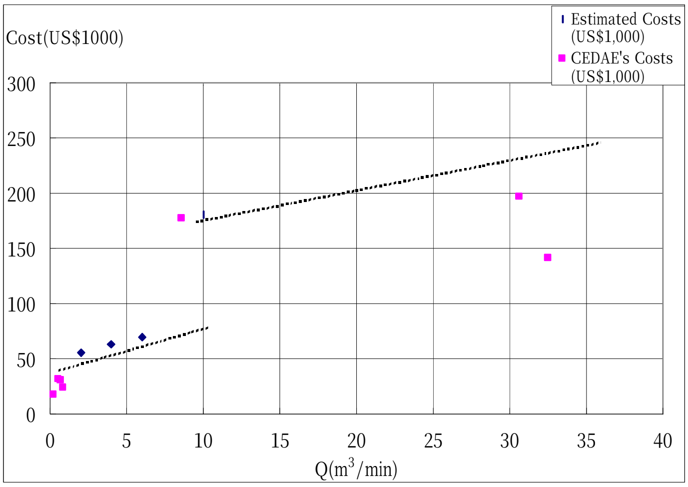


Figure 2 Comparison of Pumping Station Costs

3.3 COST OF WWTPS

For Pavuna and Sarapui WWTPs, detail design is already made and its results are just copied here. For Acari and Bangu WWTPs, bill of quantity of primary clarifier, aeration tank and secondary clarifier is calculated for their civil works and multiplied by EMOP unit costs. For mechanical and electrical equipment of these new WWTPs, actual costs of Pavuna and Sarapui WWTPs are referred to.

4. DIRECT COSTS

Direct Costs of Sewer Districts summarized below and the details follow.

Table 15 Construction Costs of Sewer Districts

Items	Pavuna	Acari	Sarapui	Bangu	Total
WWTPs	14,872	28,293	11,741	26,935	81,841
Sewers	90,374	72,548	14,416	54,745	232,083
Pumping Stations	75	370		50	495
Total	105,321	101,211	26,157	81,730	314,419

(Unit: US$1000)

4.1 COLLECTION SYSTEM

Total direct costs for collection system is estimated at US$ 232,083 million for the Project as shown in table below:

Table 16 Construction Costs of Sewers

Items	Dia.(mm)	Unit Cost (US$/m)	Pavuna	Acari	Sarapui	Bangu	Total
Branch Sewer	150	90	56,250	45,180	7,776	33,300	142,506
	200	96	2,688	2,112	365	1,574	6,739
	250	120	2,520	2,040	348	1,476	6,384
	300	123	2,583	2,091	357	1,513	6,544
	Sub-Total		64,041	51,423	8,846	37,863	162,173
Trunk Sewer Open Cut	400	183	533	604	92	673	1,902
	500	192	317	301	81	150	849
	700	228	465	435	112	135	1,147
	900	285	162	259	194	205	820
	Sub-Total		1,477	1,599	479	1,163	4,718
Trunk Sewer Pipe Jacking	500	1032	1,816	8,300	341	3,148	13,605
	900	1097	2,106	4,350	4,750	6,686	17,892
	1200	1563	11,222	5,689		5,885	22,796
	1500	2031	9,712	1,016			10,728
	2000	2751					
	Sub-Total		24,856	19,355	5,091	15,719	65,021
Trunk Sewer Pressure Pipe	100	124		60			60
	150	151		62			62
	500	412		49			49
				171			171
Total			90,374	72,548	14,416	54,745	232,083

(Unit: US$1000)

Table 17 Construction Costs of Pumping Stations

	Pavuna	Acari	Sarapui	Bangu	Total
EE-1	75	60	-	50	
EE-2	-	90	-	-	
EE-3	-	40	-	-	
EE-4	-	180	-	-	
Total	75	370	-	50	495

(Unit: US$1,000)

4.2 WWTPs

The following table summarizes the construction costs of four WWTPs and the details follow.

Table 18 Summary of WWTPs Direct Costs

Comporrents	Pavuna	Acari	Sarapui	Bangu	Total
Civil & Architectual work	5,184	13,680	3,880	12,433	35,177
Mechanical Work	8,520	13,236	6,693	13,125	41,574
Electrical Work	1,168	1,377	1,168	1,377	5,090
Total	14,872	28,293	11,741	26,935	81,841
Foreign Currency	3,320	4,483	2,586	4,463	14,852

Note: Foreign currency is included in mechanical cost. (Unit:US$1,000)

(1) Pavuna WWTP

Table 19 Pavuna WWTP Civil and Architectural Works Costs

Name of Facility	Number of Tanks (Units)	Cost (R$)	Remarks
Pumping Station	1	370,657	*
Grit Chamber	1	75,625	*
Primary Clarifier	2	2,514,456	
Primary Sludge Pumping Station	1	102,710	*
Intermediate Pumping Station	1	31,143	*
Aeration Tank	2	2,485,596	
Blower Building	1	130,697	*
Secondary Clarifier	3	2,896,752	
Return Sludge Pumping Station	1	923,126	
Sludge Treatment Building	1	154,542	*
Thermal Drying Building	1	1,053,414	
Sub-total		10,738,718	
Overhead Cost		4,295,487	40% of sub-total
Total		15,034,000	round number
		5,184,000	in $US

Note: *)additional costs except for structure

Table 20 Pavuna WWTP Mechanical Works Costs

Facility	Equipment	Quantity	Unit Cost (US$)	Cost (US$)	Remarks
Pumping Station	Inlet pump	2	275,519	551,038	
	Bar screen	2	97,832	195,664	
Chemical Feeding	Chemical tank	1	108,401	108,401	
Primary Clarifier	Clarifier	2	171,635	343,270	imported
Intermediate Pumping Station	Intermediate pump	1	222,246	222,246	
Aeration Tank	Blower	3	93,250	279,750	imported
	Diffuser	3	246,940	740,820	imported
Secondary Clarifier	Clarifier	3	222,246	666,738	imported
Return Sludge Facility	Return sludge pump	3	49,358	148,074	
Sludge Treatment	Centrifuge for Thickening	1	208,451	208,451	imported
	Lime mixing system	1	203,587	203,587	
	Thermal dryer	1	1,081,367	1,081,367	imported
Sub-total (1)				4,749,406	
Others	Smaller equipment, valves, ducts and pipes			949,881	20% of sub-total (1)
Sub-total (2)				5,699,287	
Installation				854,893	15% of sub-total (2)
Sub-total (3)				6,554,180	
Overhead Cost				1,966,254	30% of sub-total (3)
Pavuna Total	in US$			8,520,000	Rounded number
	in R$			24,708,000	2.9*(toal in US$) Rounded number
Imported equipment of Pavuna WWTP Mechanical Works (included in mechanical equipment) (in US$)				3,320,000	

Table 21 Pavuna WWTP Electrical Works Costs

Equipment	Quantity	Unit Cost (US$)	Cost (US$)	Remarks
Transformer	2	12,350	24,700	
Distribution Panels	4	99,000	396,000	
Control Center of Motors	1	74,500	74,500	
Panels	3	29,600	88,800	
Sub-Total (1)			584,000	
Instrunmentation Control and Automation			146,000	25% of Sub-total (1)
Cables			116,800	20% of Sub-total (1)
Assembly			87,600	15% of Sub-total (1)
Sub-Total (2)			934,400	
Overhead Cost			233,600	25% of Sub-total (2)
Total			1,168,000	US$
			3,387,000	R$

(2) Acari WWTP

1) Civil Structures Quantification

a. Primary Clarifier

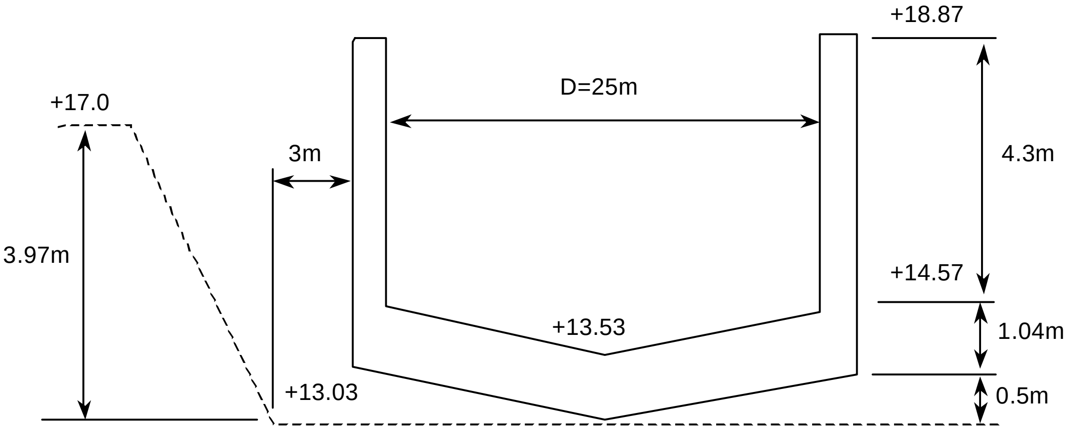


Figure 3 Concept of Primary Clarifier Earth Work

Primary Clarifier Quantities - Acari WWTP -4 tanks

D = Diameter (m) =	25
t = smaller thickness (m) =	0.35
T = larger thickness (m) =	0.5
h = base height (m) =	1.04
H = tank height (m) =	4.3
he = excavation height (m) =	3.97

Per Tank

Excavation:
1/4x((25+0.7+6)^2+(25+0.7+6+7.94)^2x3.14x1/2x3.97 = 4,010 m^3

Excess soil dispose:
1/4x(25+7)^2x3.14x3.97 = 2,060 m^3 3,710 ton
σ_{earth}=1.8 ton/m^3

Backfill:
4,010 - 2,060 = 1,950 m^3

Concrete (fck = 20 Mpa):
(25+0.35)x3.14x0.35x4.3+((12.5^2+1^2)^1/2)^2x3.14x0.5))= 367 m^3

Steel bar:
120kg/m^3x367= 44,040 kg

Form:
3.14x(25+25+0.7)x4.3= 680 m^2

Weight (concrete and wastewater)
2.5x367+1x12.5^2x3.14x3.5= 2,630 ton

Pile:
2,630/90= 30 unit

Pile:
30x12m= 360 m

b. Aeration Tank

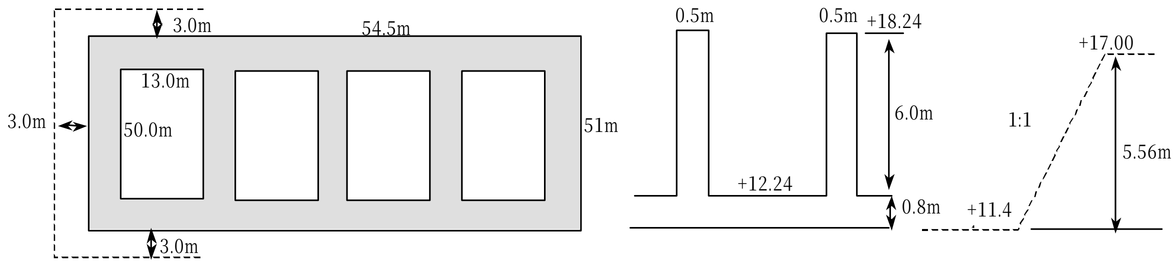


Figure 4 Concept of Aeration Tank Earth Work

Aeration Tank Aquantities - Acari WWTP - 2 sets

W = Width (m) =		13.00
L = Length (m) =		50.00
t = thickness (m) =		0.50
T = base thickness (m) =		0.80
M = number of tanks per set =		4.00
H = tank height (m) =		6.00
he = excavation height (m) =		5.56
L total =		51.0
W total =		54.5
a = area per tank =		650

<u>per Tank</u>

Excavation:
(54.5+6)x(51.6+6)+(54.5+6+2x5.56)x(51+6+2x5.56)x5.56/2/4 = 5,790 m^3

Excess soil dispose:
(54.5x51x5.56)/4 = 3,870 m^3 6,970 ton
σ_{earth}=1.8 ton/m^3

Backfill:
5,790- 3,870 = 1,920 m^3

Concrete (fck = 20 Mpa):
[(54.5x51x6.8)-(4x13x50x6)]/4= 825 m^3

Steel bar:
120kg/m^3x825= 99,000 kg

Form
[(2x(54.5+51)x6.8+4x2x(13+50)x6)/4= 1,120 m^2

Weight (concrete and wastewater)
2.5x825+13x50x5= 5,320 ton

Pile:
5,320/90= 60 unit

Pile:
60x12m= 720 m

c. Secondary Clarifier

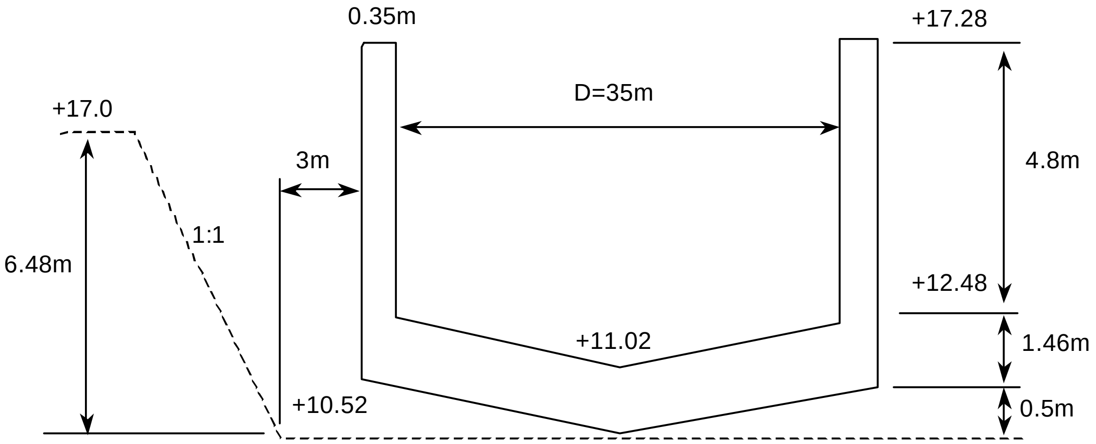


Figure 5 Concept of Secondary Clarifier Earth Work

Secondary Clarifier Quantities - Acari WWTP -4 tanks

D = Diameter (m) =	35.00
t = smaller thickness (m) =	0.35
T = larger thickness (m) =	0.50
h = base height (m) =	1.46
H = tank height (m) =	4.80
he = excavation height (m) =	6.48

<u>Per Tank</u>

Excavation:
1/4x((35+0.7+6)^2+(35+0.7+6+12.96)^2x3.14x1/2x6.48= 12,020 m^3

Excess soil dispose:
1/4x(35+0.7)^2x3.14x6.48= 6,480 m^3 11,660 ton
σ_{earth}=1.8 ton/m^3

Backfill:
12,020 - 6,480 = 5,540 m^3

Concrete (fck = 20 Mpa):
(35+0.35)x3.14x0.35x4.8+((17.5^2+1.46^2)^1/2)^2x3.14x0.5))= 671 m^3

Steel bar:
120kg/m^3x671= 88,520 kg

Form:
3.14x(35+35+0.7)x4.8= 1,070 m^2

Weight (concrete and wastewater)
2.5x671+1x17.5^2x3.14x4.0= 5,524 ton

Pile:
5,524/90= 62 unit

Pile:
62x12m= 744 m

2) Cost Calculation

Table 22 Acari WWTP Civil Works

Name of Facility	Kind of Work	Specified Work	Quantity	Unit	Unit Cost (R$)	Cost (R$)
Primary Clarifier 4 tanks	Earth Work	Excavation	16,040	m^3	3.05	48,922
		Backfill	7,800	m^3	5.18	40,404
	Excess Soil Disposal	Freight and end-dumping	14,840	ton	3.32	49,269
		Transportation	14,840	ton	4.80	71,232
	Foundation	Bearing pile	1,440	m	107.73	155,131
	Concrete	fck=20 MPa	1,468	ton	206.78	303,553
	Form	Form	2,720	m^2	18.25	49,640
	Reinforcing Steel Bar	Steel Bar CA50B	176,160	kg	1.78	313,565
		Processing and Placing	176,160	kg	0.90	158,544
	Sub-Total					1,190,260
	others (10% of Sub-Total)					119,026
	total					1,309,286
Aeration Tank 2 sets of 4 tanks	Earth Work	Excavation	46,300	m^3	3.05	141,215
		Backfill	15,400	m^3	5.18	79,772
	Excess Soil Disposal	Freight and End-dumping	55,600	ton	3.32	184,592
		Transportation	55,600	ton	4.80	266,880
	Foundation	Bearing Pile	5,688	m	107.73	612,768
	Concrete	fck=20 MPa	6,600	ton	206.78	1,364,748
	Form	Form	8,920	m^2	18.25	162,790
	Reinforcing Steel Bar	Steel Bar CA50B	792,000	kg	1.78	1,409,760
		Processing and Placing	792,000	kg	0.90	712,800
	Sub-Total					4,935,325
	Others (10% of Sub-Total)					493,533
	Total					5,428,858
Secondary Clarifier 4 tanks	Earth Work	Excavation	48,080	m^3	3.05	146,644
		Backfill	22,160	m^3	5.18	114,789
	Excess Soil Disposal	Freight and End-dumping	46,640	ton	3.32	154,845
		Transportation	46,640	ton	4.80	223,872
	Foundation	Bearing Pile	2,976	m	107.73	320,604
	Concrete	fck=20 MPa	2,684	ton	206.78	554,998
	Form	Form	4,280	m^2	18.25	78,110
	Reinforcing Steel Bar	Steel Bar CA50B	322,080	kg	1.78	573,302
		Processing and Placing	322,080	kg	0.90	289,872
	Sub-Total					2,457,036
	Others (10% of Sub-Total)					245,704
	Total					2,702,740

Table 23 Acari WWTP Civil and Architectural Works Costs

Name of Facility	Number of Tanks (Units)	Cost (R$)	Remarks
Pumping Station	1	3,257,314	1.2*(5,428,858/2)
Primary Clarifier	4	1,309,286	
Aeration Tank	8	5,428,858	
Secondary Clarifier	4	2,702,740	
Gravity Thickener	4	183,300	0.14*1,309,286
Digester	4	6,834,472	5.22*1,309,286
Sludge Treatment Building	1	1,974,545	
Administration Building	1	1,923,828	
Sub-Total (1)		23,614,343	
Other Facilities		4,722,869	20% of sub-total (1)
Sub-Total (2)		28,337,212	
Overhead Cost		11,334,885	40% of sub-total (2)
Total		39,672,000	round number
		13,680,000	in $US

Table 24 Acari WWTP Mechanical Works Costs

Facility	Equipment	Quantity	Unit Cost (US$)	Cost (US$)	Remarks
Pumping Station	Inlet Pump	4	88,000	352,000	
	Bar Screen	5	115,000	575,000	
Grit Chamber	Grit Removal	2	150,000	300,000	
Primary Clarifier	Clarifier	4	155,000	620,000	imported
Aeration Tank	Blower	5	120,000	600,000	imported
	Diffuser	8	38,500	308,000	imported
Secondary Clarifier	Clarifier	4	235,000	940,000	imported
Return Sludge Facility	Return Sludge Pump	5	40,000	200,000	
Gravity Thickener	Sludge Scraper	4	97,000	388,000	
Digester	Hydraulic Mixer	3	360,000	1,080,000	
Sludge Treatment	Centrifuge for Thickening	3	218,000	654,000	imported
	Centrifuge for Dewatering	2	218,000	436,000	imported
	Thermal Dryer	1	925,000	925,000	imported
Sub-total (1)				7,378,000	
Others	Smaller Equipments, Valves, Ducts and Pipes			1,475,600	20% of sub-total (1)
Sub-Total (2)				8,853,600	
Installation				1,328,040	15% of sub-total (2)
Sub-Total (3)				10,181,640	
Overhead Cost				3,054,492	30% of sub-total (3)
Total	in US$			13,236,000	Rounded number
	in R$			38,380,000	2.9*(toal in US$) Rounded number
Imported equipment of Acari WWTP Mechanical Works (included in mechanical equipment) (in US$)				4,483,000	

Table 25 Acari WWTP Electrical Works Costs

Facility	Equipment	Quantity	Unit Cost (US$)	Cost (US$)
Transformer	4	13,000	52,000	
Frequency Invertor	3	60,000	180,000	
Distribution Panels	6	43,000	258,000	
Panels	4	8,600	34,400	
Control Center of Motors	5	35,000	175,000	
Sub-Total (1)			699,400	
Instrumentation Control and Automation			174,850	25% of Sub-total (1)
Cables			139,880	20% of Sub-total (1)
Assembly			87,590	15% of Sub-total (1)
Sub-Total (2)			1,101,720	
Overhead Cost			275,280	25% of Sub-total (2)
Total			1,377,000	in $US
			3,993,000	in $R

(3) Sarapuí WWTP

Table 26 Sarapui WWTP Civil and Architectural Works Costs

Name of Facility	Number of Tanks (Units)	Cost (R$)	Remarks
Pumping Station	1	381,998	*
Grit Chamber	1	42,957	*
Primary Clarifier	1	1,257,228	
Primary Sludge Pumping Station	1	51,355	*
Intermediate Pumping Station	1	93,427	*
Aeration Tank	2	2,406,848	
Blower Building	1	85,167	*
Secondary Clarifier	2	1,935,100	
Return Sludge Pumping Station	1	684,968	
Sludge Treatment Building	1	111,417	*
Thermal Drying Building	1	986,812	
Sub-Total		8,037,277	
Overhead Cost		3,214,911	40% of sub-total
Total		11,252,000	Rounded number
		3,880,000	in US$

*)additional costs except for structure

Table 27 Sarapui WWTP Mechanical Works Costs

Facility	Equipment	Quantity	Unit Cost (US$)	Cost (US$)	Remarks
Pumping Station	Inlet Pump	1	316,169	316,169	
	Bar Screen	2	97,832	195,664	
Chemical Feeding	chemical tank	1	108,401	108,401	
Primary Clarifier	Clarifier	1	171,635	171,635	imported
Intermediate Pumping Station	Intermediate Pump	1	222,246	222,246	
Aeration Tank	Blower	2	93,250	186,500	imported
	Diffuser	2	246,940	493,880	imported
Secondary Clarifier	Clarifier	2	222,246	444,492	imported
Return Sludge Facility	Return Sludge Pump	2	49,358	98,716	
Sludge Treatment	Centrifuge for Thickening	1	208,451	208,451	imported
	Lime Mixing System	1	203,587	203,587	
	Thermal Dryer	1	1,081,367	1,081,367	imported
Sub-total (1)				3,731,108	
Others	Smaller Equipments, Valves, Ducts and Pipes			746,222	20% of sub-total (1)
Sub-total (2)				4,477,330	
Installation				671,599	15% of sub-total (2)
Sub-total (3)				5,148,929	
Overhead Cost				1,544,679	30% ofsub-total (3)
Total	in US$			6,693,000	round number
	in R$			19,409,000	2.9*(toal in US$) rounded number
Imported equipment of Sarapui WWTP Mechanical Works (included in mechanical equipment) (in US$)				2,586,000	

Table 28 Sarapuí WWTP Electrical Works Costs

Facility	Equipment	Quantity	Unit Cost (US$)	Cost (US$)
Transformer	2	12,350	24,700	
Distribution Panels	4	99,000	396,000	
Control Center of Motors	1	74,500	74,500	
Panels	3	29,600	88,800	
Sub-Total (1)			584,000	
Instrumentation Control and Automation			146,000	25% of Sub-total (1)
Cables			116,800	20% of Sub-total (1)
Assembly			87,600	15% of Sub-total (1)
Sub-Total (2)			934,400	
Overhead Cost			233,600	25% of Sub-total (2)
Total			1,168,000	in US$
			3,387,000	in R$

(4) Bangu WWTP

1) Bangu WWTP Major Civil Structures Quantification

a Primary Clarifier

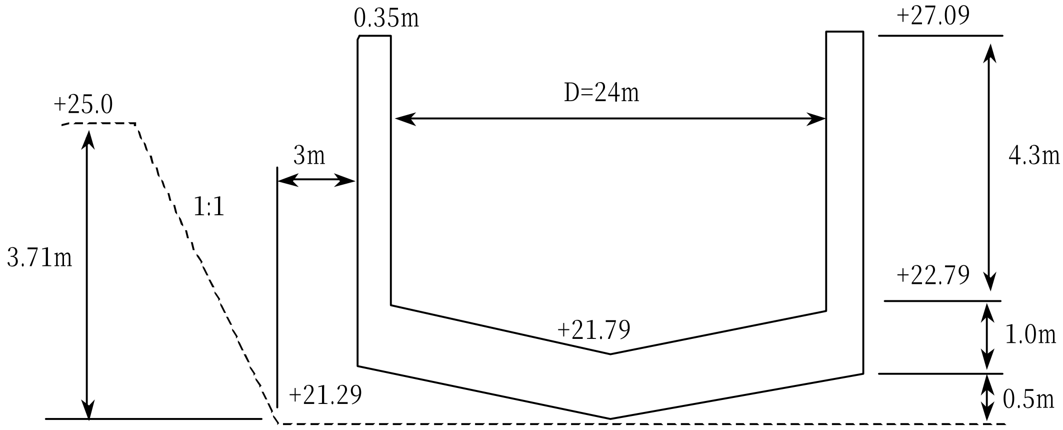


Figure 6 Concept of Primary Clarifier Earth Work

Primary Clarifier Quantities - Bangu WWTP -4 tanks

D = Diameter (m) =	24
t = smaller thickness (m) =	0.35
T = larger thickness (m) =	0.5
h = base height (m) =	1.0
H = tank height (m) =	4.3
he = excavation height (m) =	3.71

<u>Per Tank</u>

Excavation:
1/4x((24+0.7+6)^2+(24+0.7+6+7.42)^2x3.14x1/2x3.71 = 3,490 m^3

Excess soil dispose:
1/4x(24+7)^2x3.14x3.71 = 1,780 m^3 3,200 ton
σ_{earth}=1.8 ton/m^3

Backfill:
4,490 - 1,780 = 1,710 m^3

Concrete (fck = 20 Mpa):
(24+0.35)x3.14x0.35x4.3+((12.0^2+1^2)^1/2)^2x3.14x0.5))= 343 m^3

Steel bar:
120kg/m^3x343= 41,160 kg

Form:
3.14x(24+24+0.7)x4.3= 660 m^2

Weight (concrete and wastewater)
2.5x343+1x12.0^2x3.14x3.5= 2,440 ton

Pile:
2,440/90= 28 unit

Pile:
28x12m= 336 m

b. Aeration Tank

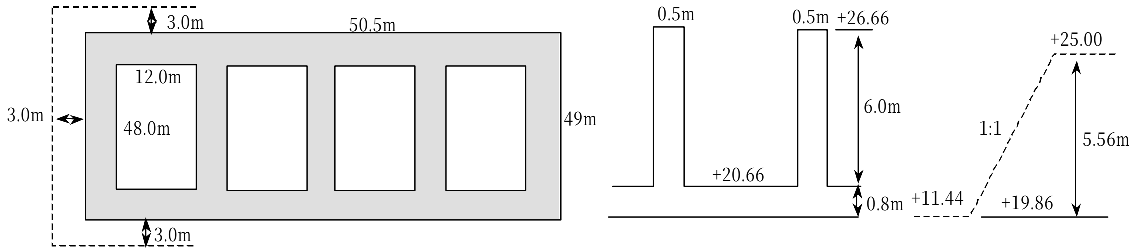


Figure 7 Concept of Aeration Tank Earth Work

Aeration Tank Aquantities - Bangu WWTP - 2 sets

W = Width (m) =	12.00
L = Length (m) =	48.00
t = thickness (m) =	0.50
T = base thickness (m) =	0.80
M = number of tanks per set =	4
H = tank height (m) =	6
he = excavation height (m) =	5.14
L total =	49.0
W total =	50.5
a = area per tank =	576

<u>per Tank</u>

Excavation:
(50.5+6)x(49+6)+(50.5+6+2x5.14)x(49+6+2x5.14)x5.14/2/4 = 4,800 m^3

Excess soil dispose:
(50.5x49x5.14)/4 = 3,180 m^3 5,720 ton
σ_{earth}=1.8 ton/m^3

Backfill:
4,800- 3,870 = 1,920 m^3

Concrete (fck = 20 Mpa):
[(50.5x49x6.8)-(4x12x48x6)]/4= 750 m^3

Steel bar:
120kg/m^3x750= 90,000 kg

Form
[(2x(50.5+49)x6.8+4x2x(12+48)x6)/4= 1,060 m^2

Weight (concrete and wastewater)
2.5x750+12x48x5= 4,760 ton

Pile:
4,760/90= 53 unit

Pile:
53x12m= 636 m

c. Secondary Clarifier

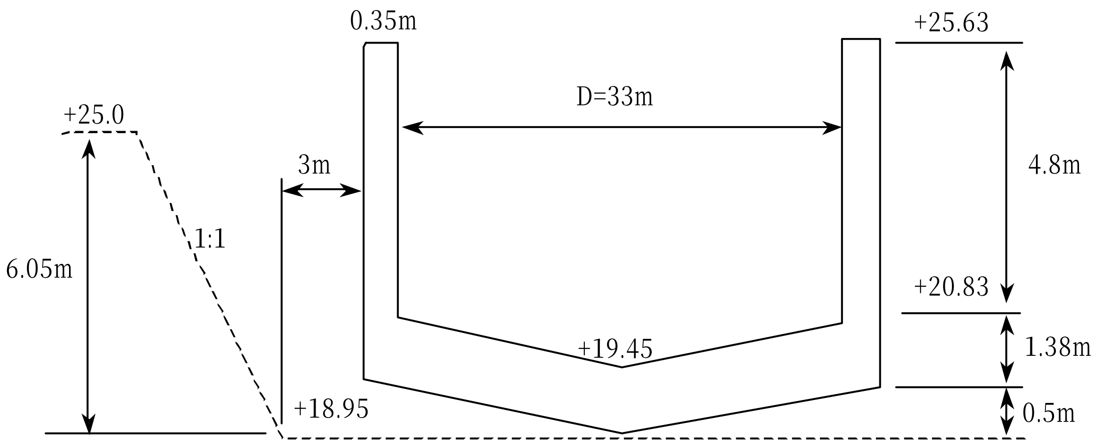


Figure 8 Concept of Secondary Clarifier Earth Work

Secondary Clarifier Quantities - Acari WWTP -4 tanks

D = Diameter (m) =	33.00
t = smaller thickness (m) =	0.35
T = larger thickness (m) =	0.50
h = base height (m) =	1.48
H = tank height (m) =	4.80
he = excavation height (m) =	6.05

Per Tank

Excavation:
1/4x((33+0.7+6)^2+(33+0.7+6+12.1)^2x3.14x1/2x6.05= 10,110 m^3

Excess soil dispose:
1/4x(33+0.7)^2x3.14x6.05= 5,390 m^3 9,700 ton
σ_{earth}=1.8 ton/m^3

Backfill:
10,110 - 5,390 = 4,720 m^3

Concrete (fck = 20 Mpa):
(33+0.35)x3.14x0.35x4.8+((16.5^2+1.38^2)^1/2)^2x3.14x0.5))= 606 m^3

Steel bar:
120kg/m^3x606= 72,720 kg

Form:
3.14x(33+33+0.7)x4.8= 1,010 m^2

Weight (concrete and wastewater)
2.5x606+1x16.5^2x3.14x4.0= 4,934 ton

Pile:
4,934/90= 55 unit

Pile:
55x12m= 660 m

(2) Cost Calculation

Table 29 Bangu WWTP Civil Works

Name of Facility	Kind of Work	Specified Work	Quantity	Unit	Unit Cost (R$)	Cost (R$)
Primary Clarifier 4 tanks	Earth Work	Excavation	13,960	m^3	3.05	42,578
		Backfill	6,840	m^3	5.18	35,431
	Excess Soil Disposal	Freight and End-Dumping	12,800	ton	3.32	42,496
		Transportation	12,800	ton	4.8	61,440
	Foundation	Bearing Pile	1,344	m	107.73	144,789
	Concrete	Fck=20 MPa	1,372	ton	206.78	283,702
	Form	Form	2,640	m^2	18.25	48,180
	Reinforcing Steel Bar	Steel Bar CA50B	164,640	kg	1.78	293,059
		Processing and Placing	164,640	kg	0.90	148,176
	Sub-Total					1,099,852
	additional works (10% of subtotal)					109,985
	Total					1,209,837
Aeration Tank 2 sets of 4 tanks	Earth Work	Excavation	38,380	m^3	3.05	117,059
		Backfill	12,940	m^3	5.18	67,029
	Excess Soil Disposal	Freight and End-Dumping	45,800	ton	3.32	152,056
		Transportation	45,800	ton	4.8	219,840
	Foundation	Bearing Pile	5,088	m	107.73	548,130
	Concrete	Fck=20 MPa	6,000	ton	206.78	1,240,680
	Form	Form	8,460	m^2	18.25	154,395
	Reinforcing Steel Bar	Steel Bar CA50B	720,000	kg	1.78	1,281,600
		Processing and Placing	720,000	kg	0.90	648,000
	Sub-Total					4,428,789
	Others (10% of subtotal)					442,879
	Total					4,871,668
Secondary Clarifier 4 tanks	Earth Work	Excavation	40,440	m^3	3.05	123,342
		Backfill	18,880	m^3	5.18	97,798
	Excess Soil Disposal	Freight and End-Dumping	38,800	ton	3.32	128,816
		Transportation	38,800	ton	4.8	186,240
	Foundation	Bearing Pile	2,640	m	107.73	284,407
	Concrete	Fck=20 MPa	2,424	ton	206.78	501,235
	Form	Form	4,040	m^2	18.25	73,730
	Reinforcing Steel Bar	Steel Bar CA50B	290,880	kg	1.78	517,766
		Processing and Placing	290,880	kg	0.90	261,792
	Sub-Total					2,175,127
	Others (10% of subtotal)					217,513
	Total					2,392,639

Construction costs for administration and sludge buildings are the same as those in Pavuna and Sarapui WWTPs. 20% of all those facilities will be added to these WWTPs as the construction costs of grit chamber, return sludge pumping facility, Blower building, substation, workshop, connecting ducts and distribution tanks.

Table 30 Bangu WWTP Civil and Architectural Works Costs

Name of Facility	Number of Tanks (Units)	Cost (R$)	Remarks
Pumping Station	1	2,923,000	1.2*(4,871,668/2)
Primary Clarifier	4	1,209,837	
Aeration Tank	8	4,871,668	
Secondary Clarifier	4	2,392,639	
Gravity Thickener	4	169,377	0.14*1,209,837
Digester	4	5,997,837	5.22*1,149,011
Sludge Treatment Building	1	1,974,545	
Administration Building	1	1,923,828	
Sub-total (1)		21,462,731	
Other Facilities		4,292,546	20% of sub-total (1)
Sub-Total (2)		25,755,277	
Overhead Cost		10,302,111	40% of sub-total (2)
Total		36,057,000	Round number
		12,433,000	in US$

Table 31 Bangu WWTP Mechanical Works Costs

Facility	Equipment	Quantity	Unit Cost (US$)	Cost (US$)	Remarks
Pumping Station	Inlet Pump	4	80,000	320,000	
	Bar Screen	5	115,000	575,000	
Grit Chamber	Grit Removal	2	145,000	290,000	
Primary Clarifier	Clarifier	4	150,000	600,000	imported
Aeration Tank	Blower	5	120,000	600,000	imported
	Diffuser	8	38,500	308,000	imported
Secondary Clarifier	Clarifier	4	235,000	940,000	imported
Return Sludge Facility	Return Sludge Pump	5	40,000	200,000	
Gravity Thickener	Sludge Scraper	4	97,000	388,000	
Digester	Hydraulic Mixer	3	360,000	1,080,000	
Sludge Treatment	Centrifuge for Thickening	3	218,000	654,000	imported
	Centrifuge for Dewatering	2	218,000	436,000	imported
	Thermal Dryer	1	925,000	925,000	imported
Sub-total (1)				7,316,000	
Others	Smaller Equipments, Valves, Ducts and Pipes			1,463,200	20% of sub-total (1)
Sub-total (2)				8,779,200	
Installation				1,316,880	15% of sub-total (2)
Sub-total (3)				10,096,080	
Overhead Cost				3,028,824	30% of sub-total (3)
Total	in US$			13,125,000	round number
	in R$			38,100,000	2.9*(toal in US$) Rounded number
Imported equipment of Bangu WWTP Mechanical Works (included in mechanical equipment) (in US$)				4,463,000	

Table 32 Bangu WWTP Electrical Works Costs

Equipment	Quantity	Unit Cost (US$)	Cost (US$)	Remarks
Transformer	4	13,000	52,000	
Frequency Invertor	3	60,000	180,000	
Distribution Panels	6	43,000	258,000	
Panels	4	8,600	34,400	
Control Center of Motors	5	35,000	175,000	
Sub-Total (1)			699,400	
Instrumentation Control and Automation			174,850	25% of Sub-total (1)
Cables			139,880	20% of Sub-total (1)
Assembly			87,590	15% of Sub-total (1)
Sub-Total (2)			1,101,720	
Overhead Cost			275,280	25% of Sub-total (2)
Total			1,377,000	in US$
			3,993,000	in R$

5. OPERATION AND MAINTENANCE (O&M)COSTS

5.1 TOTAL O&M COSTS IN EACH SEWER DISTRICT

The operation and maintenance (O&M) costs for the Project's collection and WWTP systems are estimated for the socioeconomic and hydraulic conditions expected in 2020. The required crews for collection system O&M are estimated based on the estimated frequencies of sewer cleaning and routine repairs. WWTPs O&M costs are calculated assuming the staff required for routine operation and maintenance of the plant facilities, necessary electric power to operate mechanical equipment, chemicals for sludge conditionings, sludge and grit hauling, and materials for routine repairs.

The following table shows the overall operation and maintenance costs for each of four sewer districts and their accumulated values. The details are described from *Table 34 to 40.*

Table 33 Operation and Maintenance Costs by Sewer District

1) PAVUNA

	Item	Unit cost	Unit	Quantity	Cost (US$/yr)	Remarks
Sewers	Personnel for Sewers	20,700	US$/yr/person	30	621,000	
WWTP	Personnel for WWTP	20,700	US$/yr/person	29	600,300	
	Electricity	0.069	US$/kwH	17,778,420	1,226,711	
	Chemicals	7	US$/kg	141,378	989,646	
	Sludge Disposal	4.76	US$/ton	16,790	79,920	46*365=16,790
	Routine Repairs	0.01	US$/US$/yr	6,546,087	65,461	1.0%/year of mech./elec. Construction cost 5,699,287+584,000*1.45 =6,546,087
	WWTP Total				2,962,038	
Total					3,583,038	

2) ACARI

	Item	Unit cost	Unit	Quantity	Cost (US$/yr)	Remarks
Sewers	Personnel for sewers	20,700	US$/yr/person	25	517,500	
WWTP	Personnel for WWTP	20,700	US$/yr/person	49	1,014,300	
	Electricity	0.069	US$/kWh	12,067,630	832,666	
	Chemicals	7	US$/kg	63,895	447,265	
	Sludge Disposal	4.76	US$/ton	6,315	30,059	17.3*365=6,315
	Routine Repairs	0.01	US$/US$/yr	9,867,730	98,677	1.0%/year of mech./elec. Construction cost 8,853,600+699,400*1.45 =9,867,730
	WWTP Total				2,422,967	
Total					2,940,467	

3) SARAPUI

ITEM	Item	Unit cost	Unit	Quantity	Cost (US$/yr)	Remarks
Sewers	Personnel for Sewers	20,700	US$/yr/person	5	103,500	
WWTP	Personnel for WWTP	20,700	US$/yr/person	21	434,700	
	Electricity	0.069	US$/kwH	11,286,165	778,745	
	Chemicals	7	US$/kg	94,253	659,771	
	Sludge Disposal	4.76	US$/ton	11,206	53,341	30.7*365=11,206
	Routine Repairs	0.01	US$/US$/yr	5,324,955	53,250	1.0%/year of mech./elec. Construction cost 4,477,330+583,948*1.45 =5,324,055
	WWTP Total				1,979,807	
Total					2,083,307	

4) BANGU

ITEM	Item	Unit cost	Unit	Quantity	Cost (US$/yr)	Remarks
Sewers	Personnel for Sewers	20,700	US$/yr/person	20	414,000	
WWTP	Personnel for WWTP	20,700	US$/yr/person	49	1,014,300	
	Electricity	0.069	US$/kwH	11,352,960	783,354	
	Chemicals	7	US$/kg	58,083	406581	
	Sludge Disposal	4.76	US$/ton	5,731	27,280	15.7*365=5731
	Routine Repairs	0.01	US$/US$/yr	9,793,330	97,933	1.0%/year of mech./elec. Construction cost 8,779,200+699,400*1.45 =9,793,330
	WWTP Total				2,329,448	
Total					2,743,448	

5) Total

	Item	Unit cost	Unit	Quantity	Cost (US$/yr)	Remarks
Sewers	Personnel for Sewers	20,700	US$/yr/person	80	1,656,000	
WWTP	Personnel for WWTP	20,700	US$/yr/person	148	3,063,600	
	Electricity	0.069	US$/kwH	52,485,175	3,621,476	
	Chemicals	7	US$/kg	357,609	2503263	
	Sludge Disposal	4.76	US$/ton	40,042	190,600	
	Routine Repairs	0.01	US$/US$/yr	31,532,102	315,321	1.0%/year of mech./elec. Construction cost 8,779,200+699,400*1.45 =9,793,330
	WWTP Total				9,694,260	
Total					11,350,260	

5.2 REQUIRED PERSONNEL FOR SEWERS

The required personnel is estimated assuming that,
Every part of sewer is inspected once every two years,
The length of sewer to be inspected in a day is 300m

- One party consists of five members,
- Equipment cost needed for maintenance is included in personnel cost,
- Working days are 220 days in a year.

The number of personnel to be required in each sewer district is calculated as follows.

Table 34 Required Personnel for Sewers

Sewer District	Total Length of Sewer(m)	Required Period(day)	Required Parties	Required Personnel
Pavuna	717,812	1,197	6	30
Acari	582,848	972	5	25
Sarapui	102,750	172	1	5
Bangu	429,680	717	4	20
Total	1,833,090	3,058	16	80

5.3 REQUIRED PERSONNEL FOR WWTPS

The required personnel for WWTP is shown in the following table. The detail is described in *Supporting-9.(Operation and Maintenance)*

Table 35 Required personnel for WWTPs

Sewer District	F/S			ALL			Remarks
	Day-Shift Staff	Day-and Night-Shift Staff	Total	Day-Shift Staff	Day-and Night-Shift Staff	Total	
Pavuna	21	8	29	42	15	57	1500/3000
Acari	34	15	49	34	15	49	
Sarapui	15	6	21	38	15	53	1000/2500
Bangu	34	15	49	34	15	49	
Total	104	44	148	148	60	208	

5.4 ELECTRICITY CONSUMPTION

Mechanical equipment whose output per unit is more than 30 kW is listed and its electricity consumption to the plant capacity is calculated.

(1) Pavuna WWTP

Operation time in hours of each equipment for the flow from F/S area is calculated as follows.

inlet pump - the ratio in a day at which pumps are operated to raise wastewater of 1.5 m^3/s

$$24*\{1.5/(175/60)\} = 12$$

intermediate pump - same as in inlet pump

$$24*\{1.5/(144/60)\} = 17$$

blower - the ratio at which blowers are operated in a day supplying 30000 Nm^3/h for 1.5 m^3/s

$$24*(30000/36000) = 20$$

return sludge pump - return sludge ratio is 60% the influent

24*{(1.5*0.6)/(90/60) = 14

thickening centrifuge - to be operated for 24 hours a day

dewatering centrifuge - to be operated for 24 hours a day

sludge dryer - to be operated for 24 hours a day

Table 36 Electricity Consumption of Pavuna WWTP

Items	Capacity per Unit		Output per Unit (kW)	Number of Unit for 1.5 m^3/s	Total Capacity	Operation Time (hrs/day)	Power Consumption per day (kW/day)
Inlet Pump	70	m^3/min	320	2.5	175	12	9,600
Intermediate Pump	96	m^3/min	112	1.5	144	17	2,856
Blower	12,000	Nm^3/hour	373	3	36,000	20	22,380
Return Sludge Pump	30	m^3/min	37	3	90	14	1,554
Thickening Centrifuge	47	m^3/hour	45	1	141	24	1,080
Dewatering Centrifuge	26	m^3/hour	45	0.5	52	24	540
Sludge Dryer	-		215	0.5	-	24	2,580
Sub-Total							40,590
Others (20%)							8,118
Total							48,708
						kwh/year	17,778,420

(2) Acari WWTP

Operation time in hours of each equipment for the design flow is calculated as follows.

inlet pump - the ratio in a day at which pumps are operated to raise wastewater of 1.1 m^3/s

24*{1.1/(119/60)} = 13

blower - the ratio at which blowers are operated in a day supplying 39840 Nm^3/h for 1.1 m^3/s

24*(39840/39840) = 24

dewatering centrifuge - to be operated for 20 hours a day

sludge dryer - to be operated for 24 hours a day

Table 37 Electricity Consumption of Acari WWTP

Items	Capacity per Unit		Output per Unit (kW)	Number of Unit for 1.1 m^3/s	Total Capacity	Operation Time (hrs/day)	Power Consumption per day (kW/day)
Inlet Pump	40	m^3/min	100	3	119	13	3,900
Blower	9,960	Nm^3/hour	192	4	39,840	24	18,432
Thickening Centrifuge	46	m^3/hour	45	2	92	20	1,800
Dewatering Centrifuge	21	m^3/hour	45	1	21	20	900
Sludge Dryer	-		105	1	-	24	2,520
Sub-Total							27,552
Others (20%)							5,510
Total							33,062
						kwh/year	12,067,630

(3) Sarapui WWTP

Operation time in hours of each equipment for the flow from FS area is calculated as follows.

inlet pump - the ratio in a day at which pumps are operated to raise wastewater of 1.0 m^3/s

24*{1.0/(101/60)} = 14

intermediate pump - same as in inlet pump

24*{1.0/(115/60)} = 13

blower - the ratio at which blowers are operated in a day supplying 20000 Nm^3/h for 1.0 m^3/s

24*(20000/24000) = 20

return sludge pump - return sludge ratio is 60% the influent

24*{(1.0*0.6)/(60/60) = 14

thickening centrifuge - to be operated for 24 hours a day

dewatering centrifuge - to be operated for 24 hours a day

sludge dryer - to be operated for 24 hours a day

Table 38 Electricity Consumption of Sarapui WWTP

Items	Capacity per Unit		Output per Unit (kw)	Number of Unit for 1.0 m^3/s	Total Capacity	Operation Time (hrs/day)	Power Consumption per day (kwh/day)
Inlet Pump	84	m^3/min	280	1	101	14	4,704
Intermediate Pump	96	m^3/min	112	1	115	13	1,747
Blower	12,000	Nm^3/hour	373	2	24,000	20	14,920
Return Sludge Pump	30	m^3/min	37	2	60	14	1,036
Thickening Centrifuge	47	m^3/hour	45	1	38	24	864
Dewatering Centrifuge	26	m^3/hour	45	0	10	24	432
Sludge Dryer	-		215	0	-	24	2,064
Sub-Total							25,767
Others (20%)							5,153
Total							30,921
						kwh/year	11,286,165

(4) Bangu WWTP

Operation time in hours of each equipment for the design flow is calculated as follows.

inlet pump - the ratio in a day at which pumps are operated to raise wastewater of 1.0 m^3/s

24*{1.0/(108/60)} = 13

blower - the ratio at which blowers are operated in a day supplying 36480 Nm^3/h for 1.0 m^3/s

24*(36480/36480) = 24

thickening centrifuge - to be operated for 20 hours a day

dewatering centrifuge - to be operated for 20 hours a day

sludge dryer - to be operated for 24 hours a day

Table 39 Electricity Consumption of Bangu WWTP

Items	Capacity per Unit		Output per Unit (kW)	Number of Unit for 1.0 m^3/s	Total Capacity	Operation Time (hrs/day)	Power Consumption per day (kWhday)
Inlet Pump	36	m^3/min	100	3	108	13	3,900
Blower	9,120	Nm^3/hour	175	4	36,480	24	16,800
Thickening Centrifuge	41	m^3/hour	45	2	82	20	1,800
Dewatering Centrifuge	19	m^3/hour	45	1	19	20	900
Sludge Dryer	-		105	1	-	24	2,520
Sub-Total							25,920
Others (20%)							5,184
Total							31,104
						kW/year	11,352,960

5.5 CHEMICALS CONSUMPTION

Polymer of 1.0% per dry basis sludge is mixed prior to dewatering. Another 0.2% is added for centrifugal thickening. The cost for lime amendment in Pavuna and Sarapui WWTPs is supposed to be included in polymer cost.

Table 40 Chemicals Consumption

Sewer District	Flow Rates (L/s)	Dry Basis Weight of Sludge to Dewater (kg/day)	Polymer Addition Rate (%)	Polymer Consumption (kg/year)
Pavuna	1,500	32,278	1.2	141,378
Acari	1,100	14,588	1.2	63,895
Sarapui	1,000	21,519	1.2	94,253
Bangu	1,000	13,261	1.2	58,083
Total	4,600	81,646		357,609

5.6 O&M COSTS IN EACH YEAR

O&M costs for sewers in each sewer district are the same as in *Table 33*, since sewers inspection has to be done regardless of the flow quantity once they are constructed. On the other hand, O&M costs for WWTPs in each year are calculated for actual flow. The following table shows the ratio of influent to the capacity in each WWTP. The ratio is multiplied by O&M cost in *Table 41* and O&M costs in each year for each sewer district are obtained as shown in *Table 42*

Table 41 Ratio of Flow Rate in Each Year to Capacity

Sewer District	Items	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Capacity (m^3/day)
Pavuna	**m^3/day**	235,656	236,688	237,720	238,704	239,688	240,672	241,656	242,640	243,533	244,426	245,318	246,211	247,104	259,200
Pavuna (FS)	**m^3/day**	117,828	118,344	118,860	119,352	119,844	120,336	120,828	121,320	121,766	122,213	122,659	123,100	123,552	129,600
	Ratio to the Capacity	0.9092	0.9131	0.9171	0.9209	0.9247	0.9285	0.9323	0.9361	0.9396	0.9430	0.9464	0.9498	0.9533	
Acari	**m^3/day**	-	89,648	90,072	90,446	90,821	91,195	91,569	91,944	92,285	92,626	92,966	93,307	93,648	95,040
	Ratio to the Capacity	-	0.9433	0.9477	0.9517	0.9556	0.9595	0.9635	0.9674	0.9710	0.9746	0.9782	0.9818	0.9854	
Sarapui	**m^3/day**	182,342	183,883	185,424	186,749	188,074	189,398	190,723	192,048	193,282	194,515	195,749	196,982	198,216	216,000
Sarapui (FS)	**m^3/day**	72,936	73,553	74,170	74,700	75,230	75,759	76,289	76,819	77,313	77,806	78,300	78,793	79,286	86,400
	Ratio to the Capacity	0.8442	0.8513	0.8584	0.8646	0.8707	0.8768	0.8830	0.8891	0.8948	0.9005	0.9063	0.9120	0.9177	
Bangu	**m^3/day**	-	84,230	84,528	84,811	85,094	85,378	85,661	85,944	86,189	86,434	86,678	86,923	87,168	86,400
	Ratio to the Capacity	-	0.9749	0.9783	0.9816	0.9849	0.9882	0.9914	0.9947	0.9976	1.0004	1.0032	1.0061	1.0089	

Note: Pavuna and Sarapui sewerage facilities will begin their operation in 2008, and Acari and Bangu facilities in 2009.

Table 42 Maintenance Cost in Each Year

Sewer District	Items	for Capacity	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pavuna	**Ratio to Capacity**	1 (1.5 m^3/s)	0.9092	0.9131	0.9171	0.9209	0.9247	0.9285	0.9323	0.9361	0.9396	0.943	0.9464	0.9498	0.9533
	O/M Cost of WWTP	2,962	2,694	2,705	2,717	2,728	2,739	2,751	2,762	2,773	2,784	2,794	2,804	2,814	2,824
	O/M Cost of Sewer	621	0	621	621	621	621	621	621	621	621	621	621	621	621
	Total	3,583	2,694	3,326	3,338	3,349	3,360	3,372	3,383	3,394	3,405	3,415	3,425	3,435	3,445
Acari	**Ratio to Capacity**	1 (1.1 m^3/s)	0	0.9433	0.9477	0.9517	0.9556	0.9595	0.9635	0.9674	0.9710	0.9746	0.9782	0.9818	0.9854
	O/M Cost of WWTP	2,423	0	2,286	2,297	2,306	2,316	2,325	2,335	2,345	2,353	2,362	2,371	2,379	2,388
	O/M Cost of Sewer	518	0	0	518	518	518	518	518	518	518	518	518	518	518
	Total	2,941	0	2,286	2,815	2,824	2,834	2,843	2,853	2,863	2,871	2,880	2,889	2,897	2,906
Sarapui	**Ratio to Capacity**	1 (1.0 m^3/s)	0.8442	0.8513	0.8584	0.8646	0.8707	0.8768	0.883	0.8891	0.8948	0.9005	0.9063	0.912	0.9177
	O/M Cost of WWTP	1,980	1,672	1,686	1,700	1,712	1,724	1,737	1,749	1,761	1,772	1,783	1,795	1,806	1,818
	O/M Cost of Sewer	104	0	104	104	104	104	104	104	104	104	104	104	104	104
	Total	2,084	1,672	1,790	1,804	1,816	1,828	1,841	1,853	1,865	1,876	1,887	1,899	1,910	1,922
Bangu	**Ratio to Capacity**	1 (1.0 m^3/s)	0	0.9749	0.9783	0.9816	0.9849	0.9882	0.9914	0.9947	0.9976	1.0004	1.0032	1.0061	1.0089
	O/M Cost of WWTP	2,329	0	2,271	2,279	2,287	2,294	2,302	2,309	2,317	2,324	2,330	2,337	2,344	2,350
	O/M Cost of Sewer	414	0	0	414	414	414	414	414	414	414	414	414	414	414
	Total	2,743	0	2,271	2,693	2,701	2,708	2,716	2,723	2,731	2,738	2,744	2,751	2,758	2,764
GRAND TOTAL			4,366	9,673	10,650	10,690	10,730	10,772	10,812	10,853	10,890	10,926	10,964	11,000	11,037

Note: Pavuna and Sarapui sewerage facilities will begin their operation in 2008, and Acari and Bangu facilities in 2009. (Cost: US$1,000)

SUPPORTING 11

CONSTRUCTION PLAN

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

SUPPORTING 11 CONSTRUCTION PLAN

1. FIRST STAGE SYSTEM COMPONENTS

As discussed in *Supporting 8 "Facility Planning*" and *Supporting 10 "Cost Estimates*," the First Stage sewerage project (the Project) comprises the construction of collection and WWTPs facilities, covering the four priority sewer districts, namely; i) Pavuna, ii) Acari, iii) Sarapuí, and iv) Bangu.

1.1 SEWERS

The sewers to be constructed under the Project range from 150 to 1500 mm in diameter with the total length of 1,833km, including construction methods of open-cut and pipe jacking, as classified by the sewer type in the following:

Table 1 Pipe Length by Size

Type of Sewer	Diameter (mm)	Pavuna	Acari	Sarapui	Bangu	Total
Branch/lateral Sewers	150	625,000	502,000	86,400	370,000	1,583,400
	200	28,000	22,000	3,800	16,400	70,200
	250	21,000	17,000	2,900	12,300	53,200
	300	21,000	17,000	2,900	12,300	53,200
	Sub-total	695,000	558,000	96,000	411,000	1,760,000
Trunk Sewer Open Cut	400	2,910	3,300	500	3,680	10,390
	500	1,650	1,570	420	780	4,420
	700	2,040	1,910	490	590	5,030
	900	570	910	680	720	2,880
	Sub-total	7,170	7,690	2,090	5,770	22,720
Trunk Sewer Pipe Jacking	500	1,760	8,043	330	3,050	13,183
	900	1,920	3,965	4,330	6,095	16,310
	1200	7,180	3,640		3,765	14,585
	1500	4,782	500			5,282
	Sub-total	15,642	16,148	4,660	12,910	49,360
Trunk Sewer Pressure Pipe	100	-	480	-	-	480
	150	-	410	-	-	410
	500	-	120	-	-	120
	Sub-total		1,010			1,010
Total		717,812	582,848	102,750	429,680	1,833,090

(Unit: m)

1.2 PUMPING STATIONS

Under the Project, totally six units of submersible-type pumping stations are to be constructed for three sewer districts. The pumping station capacities in each district are as summarized below:

Table 2 Pumping Stations

*)Pumping Station Nominal Nr.	Pavuna	Acari	Sarapui	Bangu
EE-1	7.70	4.16	-	2.30
EE-2	-	8.79	-	-
EE-3	-	0.99	-	-
EE-4	-	13.40	-	-
Total	7.70	27.34	-	2.30

(Unit:m^3/min)

Note: *) These are assigned numbers for pumping stations in each sewer district as shown on the sewer layout plans (Refer to *Appendix-12 Facility Planning*).

1.3 WWTPs

The expansion of existing Pavuna and Sarapuí WWTPs, and construction of new WWTPs in Acari and Bangu sewer districts are planned under the First Stage Project. The treatment capacities of existing and new activated sludge WWTPs are as follows:

Table 3 Capacity of WWTPs

Item	Pavuna	Acari	Sarapui	Bangu
First Stage plant capacity (L/s)	1,500	1,100	1,000	1,000
Existing plant capacity (L/s)	(1,500)	-	(1,500)	-

2. CONSTRUCTION SCHEDULE

2.1 OVERALL CONSTRUCTION SCHEDULE

The Project on the whole is schedule to start early in 2004 when the feasibility of high priority project is confirmed. Under the pre-construction stage, planned to start in early 2004, financial arrangement should first be secured. Upon authorization of the financial arrangement, engineering consultants are to be selected to undertake the detailed design and tender documentation for the project construction packages.

The design work should be conducted according to the implementation priority when the financial arrangement is made. The design of collection and WWTP systems of this magnitude will require extensive site investigations, surveys and documentations; hence needs a considerable time to complete.

The design work for the collection and WWTP systems is scheduled to complete within 6 to 12 months for each sewer district, as shown in *Figure 1*, including bid document preparation for each contract package, then, the selection and award of contractor(s) for the works will be made. The construction supervision services may start in 2005 when the sewer construction works in Pavuna and Sarapuí districts start, and for Acari and Bangu districts in mid-2005 for the sewer system. The sewer construction works will last until mid-2010 when sewers in Acari and Bangu are completed following the priority of construction requirements.

Expansion works of WWTPs are scheduled to start simultaneously in the beginning of 2006 for Pavuna and Sarapuí districts, both lasting about 2 years until the end of 2007. Whereas the construction of new WWTPs in Acari and Bangu districts are planned to start by 2007 and complete by the end of 2008. Upon completion of these new WWTPs construction, startup and acclimation of the process will be carried out, may be over a six-month period.

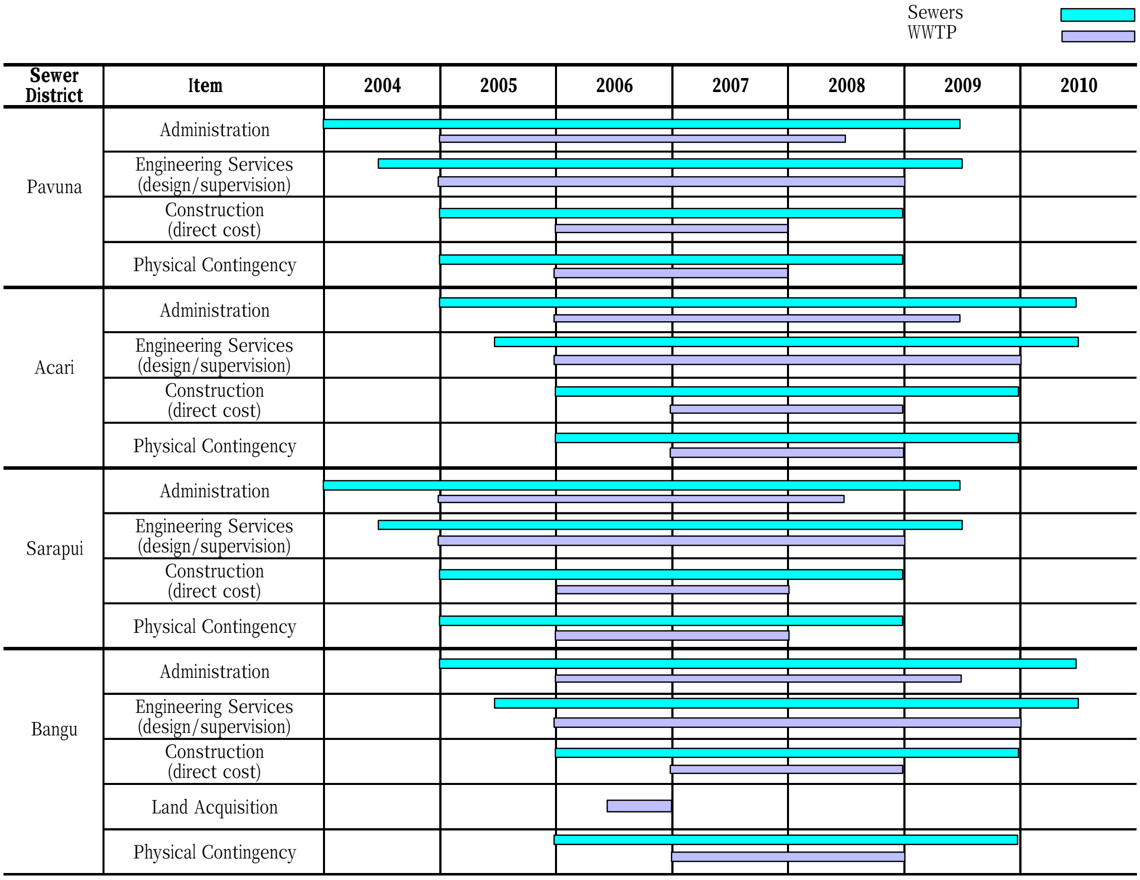


Figure 1 Construction Schedule for the Project

The Project implementation calls for international financing and will require assignment of contractor (s) to be selected through international competitive biddings.

2.2 COLLECTION SYSTEM

A total of 1,760 km branch and lateral sewers, ranging from 150 to 300 mm in diameter, are to be installed to collect the wastewaters from residences, commercial, institutional and some part of industrial origins, together with those from unsewered poor residential areas. The collected wastewaters flow down to 73.09 km long main/trunk sewers of 400 to 1,500 mm in diameter, and are finally led to the WWTPs.

Although the sewer pipelines are to be laid with proper gradients to convey the wastewaters by gravity to the maximum extent practicable, pumps are required at certain locations due to topographies or obstruction structures preventing sewers from gravity flowing of the sewage. Thus, totally six pumping stations are required.

2.3 WWTPs

Sufficiently wide land spaces for the WWTPs have already been secured by CEDAE except for Bangu WWTP. The candidate site for Bangu WWTP is at present a vacant flatland with shrubs and bushes, but neither residence nor structure exists in the vicinity of the site boundary. Therefore, no significant land improvement and preparatory works will be required except for vegetation and topsoil removal, and grading before the construction work starts.

Major civil works and machineries will be installed on reinforced concrete structures or bases, which could be built by conventional construction methods. It is known by available geo-technical investigation data that such large-scale foundations of particular types as sheet pilings, subsoil replacement/improvement, etc., are considered not required.

As general facilities, security fences and gates, roads, parking, and administration buildings are to be built. Some types of mechanical and electric equipment may be imported (For more detail see Appendix-8 "Facility Planning," Supporting Report).

3. CONSTRUCTION/DISBURSEMENT SCHEDULE

3.1 TOTAL PROJECT

The estimated total project capital cost and disbursement schedule are summarized in the following table. The disbursement plan is worked out in view of the construction schedule by sewer district (Refer to Tables 5 through 8).

Table 4 Capital Costs and Disbursement Plan

Sewer Districts	Item	2004	2005	2006	2007	2008	2009	2010	Total
Pavuna	Administration (5%)	814	1,022	1,022	1,022	934	452		5,266
	Engineering Services (10%)	905	2,181	2,181	2,181	2,180	904		10,532
	Construction Cost		22,612	30,048	30,048	22,613			105,321
	Land Acquisition								
	Physical Contingency (10%)		2,261	3,005	3,004	2,262			10,532
	Total	1,719	28,076	36,256	36,255	27,989	1,356		131,651
Acari	Administration (5%)		656	1,052	1,052	1,052	883	366	5,061
	Engineering Services (10%)		729	2,165	2,165	2,165	2,166	731	10,121
	Construction Cost			18,230	32,377	32,376	18,228		101,211
	Physical Contingency (10%)			1,823	3,238	3,237	1,823		10,121
	Total		1,385	23,270	38,832	38,830	23,100	1,097	126,514
Sarapui	Administration (5%)	130	294	294	294	225	71		1,308
	Engineering Services (10%)	144	582	582	582	580	146		2,616
	Construction Cost		3,604	9,475	9,474	3,604			26,157
	Physical Contingency (10%)		361	948	948	359			2,616
	Total	274	4,841	11,299	11,298	4,768	217		32,697
Bangu	Administration (5%)		493	870	870	870	709	275	4,087
	Engineering Services (10%)		548	1,770	1,770	1,770	1,768	548	8,174
	Construction Cost			13,699	27,167	27,166	13,698		81,730
	Land Acquisition			650					650
	Physical Contingency (10%)			1,370	2,717	2,717	1,370		8,174
	Total		1,041	18,359	32,524	32,523	17,545	823	102,815
Total	Administration (5%)	944	2,465	3,238	3,238	3,081	2,115	641	15,722
	Engineering Services (10%)	1,049	4,040	6,698	6,698	6,695	4,984	1,279	31,443
	Construction Cost		26,216	71,452	99,066	85,759	31,926		314,419
	Land Acquisition			650					650
	Physical Contingency (10%)		2,622	7,146	9,907	8,575	3,193		31,443
	Total	1,993	35,343	89,184	118,909	104,110	42,218	1,920	393,677

(Unit:US$1,000)

3.2 PAVUNA SEWER DISTRICT

3.2.1 CONSTRUCTION SCHEDULE

The design work for collection system is scheduled to start by mid-2004 firstly for the collection system, then, the design for WWTP by early 2005. The construction supervision services by consultants will continue throughout the construction stage by mid-2009. These are shown in the following construction schedule:

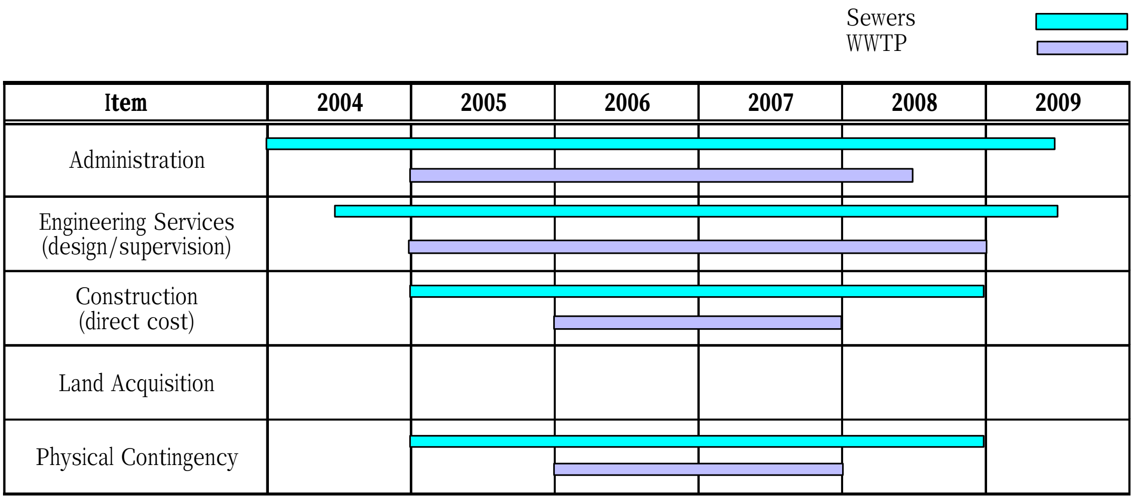


Figure 2 Construction Schedule of Pavuna Sewer District

3.2.2 DISBURSEMENT PLAN

The disbursement plan for the sewerage system construction in the Pavuna Sewer District is summarized in the following table:

Table 5 Disbursement Plan of Pavuna Sewer District

Items		2004	2005	2006	2007	2008	2009	Total
Sewers	Administration (5%)	814	814	814	814	814	452	4,522
	Engr.Services (10%)	905	1,809	1,809	1,809	1,809	904	9,045
	Construction Cost		22,612	22,612	22,612	22,613		90,449
	Phys. Conting.(10%)		2,261	2,261	2,261	2,262		9,045
	Total	1,719	27,496	27,496	27,496	27,498	1,356	113,061
WWTP	Administration (5%)		208	208	208	120		744
	Engr.Services (10%)		372	372	372	371		1,487
	Construction Cost			7,436	7,436			14,872
	Phys. Conting.(10%)			744	743			1,487
	Total		580	8,760	8,759	491		18,590
Total	Administration (5%)	814	1,022	1,022	1,022	934	452	5,266
	Engr. Services (10%)	905	2,181	2,181	2,181	2,180	904	10,532
	Construction Cost		22,612	30,048	30,048	22,613		105,321
	Phys. Conting. (10%)		2,261	3,005	3,004	2,262		10,532
	Administration (5%)	1,719	28,076	36,256	36,255	27,989	1,356	131,651
Foreign Currency Portion				1,660	1,660			3,320

(Unit: US$1,000)

3.3 ACARI SEWER DISTRICT

3.3.1 CONSTRUCTION SCHEDULE

The preparatory work for the construction will start in the beginning of 2005 and the design work at mid-2005, so that the collection system construction can start in early 2006 in the priority districts. The design work for the WWTP may start in 2006 then construction works in early 2007, lasting until the end of 2008. For the new WWTP, about a six month period is considered for commissioning/startup of the process.

The construction schedule of Acari district is illustrated in the following:

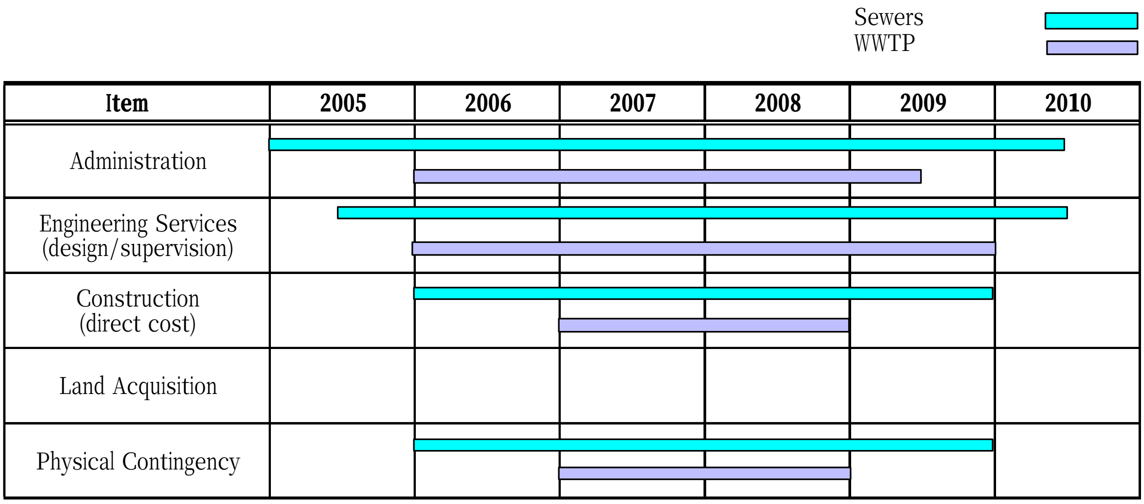


Figure 3 Construction Schedule of Acari Sewer District

3.3.2 DISBURSEMENT PLAN

The disbursement plan for the sewerage system construction in the Acari district is summarized in the following table:

Table 6 Disbursement Plan of Acari Sewer District

	Items	2005	2006	2007	2008	2009	2010	Total
Sewers	Administration (5%)	656	656	656	656	656	366	3,646
	Engr.Services (10%)	729	1,458	1,458	1,458	1,458	731	7,292
	Construction Cost		18,230	18,230	18,230	18,228		72,918
	Physical Cont. (10%)		1,823	1,823	1,823	1,823		7,292
	Total	1,385	22,167	22,167	22,167	22,165	1,097	91,148
WWTP	Administration (5%)		396	396	396	227		1,415
	Engr.Services (10%)		707	707	707	708		2,829
	Construction Cost			14,147	14,146			28,293
	Physical Cont. (10%)			1,415	1,414			2,829
	Total		1,103	16,665	16,663	935		35,366
Total	Administration (5%)	656	1,052	1,052	1,052	883	366	5,061
	Engr.Services (10%)	729	2,165	2,165	2,165	2,166	731	10,121
	Construction Cost		18,230	32,377	32,376	18,228		101,211
	Physical Cont. (10%)		1,823	3,238	3,237	1,823		10,121
	Total	1,385	23,270	38,832	38,830	23,100	1,097	126,514
Foreign Currency				2,242	2,242			4,483

(Unit: US$1,000)

3.4 SARAPUÍ SEWER DISTRICT

3.4.1 CONSTRUCTION SCHEDULE

The preparatory work for Sarapuí district will start at the beginning in 2004, and the part of design work will start by mid-2004. After six months of the design work, the sewer construction can start in 2005 continuing until the end of 2008. Whereas the design work for the WWTP expansion works is scheduled to start at the beginning of 2005 and lasting until the end of 2008.

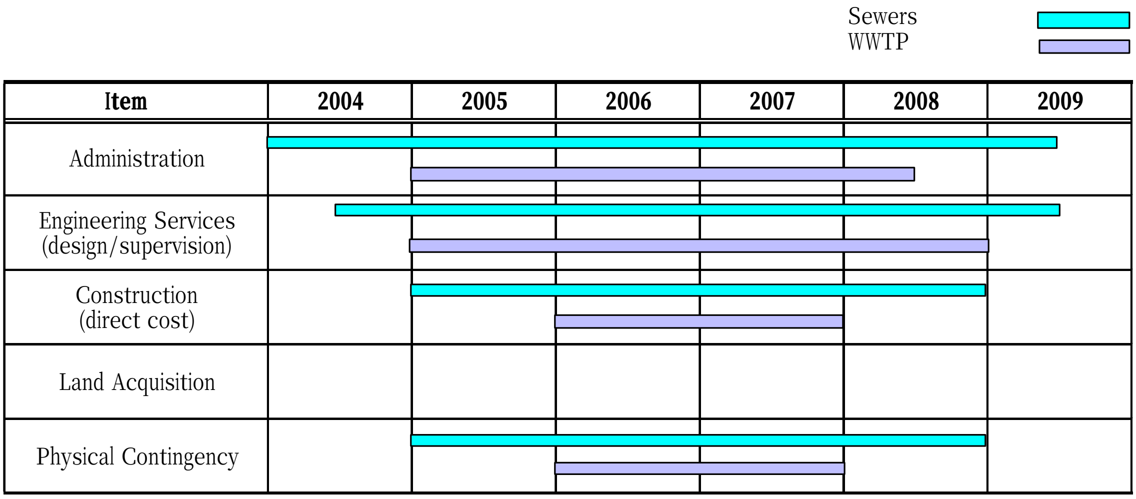


Figure 4 Construction Schedule of Sarapuí Sewer District

3.4.2 DISBURSEMENT PLAN

The disbursement plan for the above-mentioned construction works in Sarapuí district is:

Table 7 Disbursement Plan of Sarapui Sewer District

Items		2004	2005	2006	2007	2008	2009	Total
Sewers	Administration (5%)	130	130	130	130	130	71	721
	Engr.Services (10%)	144	288	288	288	288	146	1,442
	Construction Cost		3,604	3,604	3,604	3,604		14,416
	Physical Cont.(10%)		361	361	361	359		1,442
	Total	274	4,383	4,383	4,383	4,381	217	18,021
WWTP	Administration (5%)		164	164	164	95		587
	Engr.Services (10%)		294	294	294	292		1,174
	Construction Cost			5,871	5,870			11,741
	Physical Cont. (10%)			587	587			1,174
	Total		458	6,916	6,915	387		14,676
Total	Administration (5%)	130	294	294	294	225	71	1,308
	Engr.Services (10%)	144	582	582	582	580	146	2,616
	Construction Cost		3,604	9,475	9,474	3,604		26,157
	Physical Cont. (10%)		361	948	948	359		2,616
	Total	274	4,841	11,299	11,298	4,768	217	32,697
Foreign Currency Portion				1,293	1,293			2,586

(Unit: US$1,000)

3.5 BANGU SEWER DISTRICT

3.5.1 CONSTRUCTION SCHEDULE

For Bangu district the design work will start at mid-2005 and be ready for the construction of part of sewers, while the construction of WWTP works will start at the beginning of 2007 upon completion of the design work. The collection networks construction will take four years to complete.

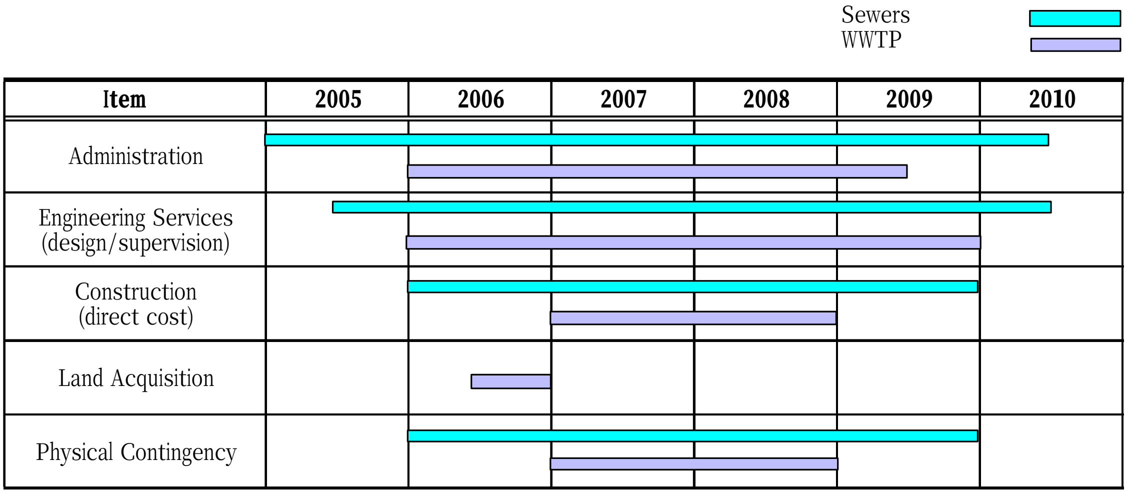


Figure 5 Construction Schedule of Bangu Sewer District

3.5.2 DISBURSEMENT PLAN

The disbursement plan for the sewerage system construction Bangu district is as summarized in the following table:

Table 8 Disbursement Plan of Bangu Sewer District

Items		2005	2006	2007	2008	2009	2010	Total
Sewers	Administration (5%)	493	493	493	493	493	275	2,740
	Engr. Services (10%)	548	1,096	1,096	1,096	1,096	548	5,480
	Construction Cost		13,699	13,699	13,699	13,698		54,795
	Physical Cont. (10%)		1,370	1,370	1,370	1,370		5,480
	Total	1,041	16,658	16,658	16,658	16,657	823	68,495
WWTP	Administration (5%)		377	377	377	216		1,347
	Engr. Services (10%)		674	674	674	672		2,694
	Construction			13,468	13,467			26,935
	Land Acquisition		650					650
	Physical Cont. (10%)			1,347	1,347			2,694
	Total		1,701	15,866	15,865	888		34,320
Total	Administration (5%)	493	870	870	870	709	275	4,087
	Engr. Services (10%)	548	1,770	1,770	1,770	1,768	548	8,174
	Construction Cost		13,699	27,167	27,166	13,698		81,730
	Land Acquisition		650					650
	Physical Cont. (10%)		1,370	2,717	2,717	1,370		8,174
	Total	1,041	18,359	32,524	32,523	17,545	823	102,815
Foreign Currency Portion				2,232	2,232			4,463

(Unit: US$1,000)

SUPPORTING 12

FINANCIAL AND ECONOMIC ANALYSES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUPPORTING 12 FINANCIAL AND ECONOMIC ANALYSES

1. INTRODUCTION

This chapter reports financial and economic analysis both of the strategic plan and the priority projects.

2. FINANCIAL ANALYSIS OF THE STRATEGIC PLAN

Although CEDAE and the State Government of Rio de Janeiro are separate financial bodies, they are treated as a single financial body in this chapter. Because the State Government have to support CEDAE in case of management crisis, and such assumption makes analysis easier. Project period is set as 17 years, from 2004 to 2020 in this financial analysis.

(1) Calculation of Cash Outflow

Cash outflow consists of construction cost, operation and maintenance cost, and residual value which is listed only in the end of the project period, 2020.

1) Construction Costs

Construction costs are divided into direct cost (wastewater treatment plant (WWTP) and sewer), contingency (10% of direct cost), administration cost (5% of direct cost), engineering service cost (10% of direct cost)[1]. Sum of annual disbursement of construction costs is shown in the *Table 1*. Detailed construction costs by facility are shown in *Table 44*.

2) O&M Costs

The Study Team set the following assumptions as for operation and maintenance costs (O&M costs).

- O&M costs consist of direct O&M cost and additional O&M cost.
- Direct O&M cost is used for operation and maintenance of facilities, and it consists of personnel expense, energy cost, and expense for chemicals. It is 5% of direct construction cost.
- Additional O&M cost is user for administration, and issuance and collection of water bill. It costs 50% of direct O&M cost[2].

Series of direct O&M cost, additional O&M cost and total O&M cost are shown in *Table 2*. Detailed O&M costs by facility is shown in *Table 44.*

3) Residual Value

Introduction of lifetime of sewerage facilities is calculated under the assumption in *Table 3*. Construction of WWTP is divided into civil works and building works, mechanical equipment and electrical equipment, and each cost occupies 40%, 50% and 10% respectively, according to experience in PDBG and other sewerage development. On the other hand, lifetime of each facility is 50 years, 15 years, and 15 years. Then weighted lifetime of 29 years is adopted as the lifetime of WWTPs.

---

[1] Land acquisition cost is also included in construction cost. It is needed only Bangu WWTP in the first group, which will be constructed until 2010. For some of other WWTPs, location has not been decided to date. And land acquisition cost for Bang WWTP is only US$650 thousand and very limited share in total construction cost. Therefore land acquisition cost is not handled in this analysis.

[2] According to the financial statement in 2001, proportion of administration cost to facility O&M cost was 25%. Proportion of commercial cost to facility O&M cost was 65%, but additional commercial cost will be lower than the level, because CEDAE has already have the system for invoicing and collection of water bill.

The result comes from:

$$40\% \times 50 + 50\% \times 15 + 10\% \times 15 = 29$$

Construction of sewer network consists of only civil works, and lifetime of sewer is estimated 50 years. Thus 50 years lifetime is adopted for the sewerage network.

Residual value is calculated from difference between lifetime and the period of operation until 2020. Diminishing method is adopted here; thus construction cost of facilities is divided by lifetime and divided value, construct cost per a year, is accumulated by the rest of lifetime after 2020. Residual value is calculated in every Sewer District.

According to the implementation plan in the *Supporting 11*, Pavuna Sewer District and Bangu Sewer District will start operation in 2008, and other Sewer Districts will start operation one after another since 2009. Total residual value calculated under the lifetime assumption is US$-713.5 million, and it is listed at the end of the project period. Residual value by facility is shown in *Table 44.*

Table 1 Annual Disbursement of Construction Cost

Year	Direct cost	Contingency	Administration cost	Engineering service cost	Total Construction cost
2004	0	0	1,096	2,191	3,287
2005	26,216	2,622	2,961	5,618	37,416
2006	71,451	6,402	2,961	5,618	86,431
2007	99,065	9,163	2,961	5,618	116,806
2008	85,759	8,576	2,961	5,618	102,913
2009	31,928	3,193	2,961	5,618	43,699
2010	0	0	1,865	3,426	5,291
2011	0	0	377	754	1,131
2012	5,799	580	377	754	7,510
2013	16,811	1,681	377	754	19,623
2014	16,811	1,681	377	754	19,623
2015	5,799	580	3,810	7,619	17,808
2016	64,987	6,499	4,348	8,491	84,324
2017	149,534	14,953	3,971	8,657	177,116
2018	164,723	16,472	3,971	8,148	193,314
2019	88,737	8,874	3,971	7,942	109,524
2020	8,561	856	3,971	7,942	21,331

Source: JICA Study Team (Unit: US$1,000)

Table 2 Series of O&M Costs

Year	Direct O&M cost	Additional O&M Cost	Total O&M Cost
2008	6,574	3,287	9,861
2009	14,809	7,405	22,214
2010	14,809	7,405	22,214
2011	14,809	7,405	22,214
2012	14,809	7,405	22,214
2013	14,809	7,405	22,214
2014	14,809	7,405	22,214
2015	17,071	8,535	25,606
2016	17,071	8,535	25,606
2017	17,071	8,535	25,606
2018	17,071	8,535	25,606
2019	35,033	17,517	52,550
2020	40,898	20,449	61,346

Source: JICA Study Team (Unit: US$1,000)

Table 3 Cost Structure and Lifetime of Sewerage Facilities

Facilities		Cost Share (%)	Lifetime of Facilities (Year)	Adopted lifetime (Year)
WWTP	Civil works and Building works	40	50	29
	Mechanical equipment	50	15	
	Electrical equipment	10	15	
Sewers	Civil works	100	50	50

Source: JICA Study Team

4) Cash Outflow

Table 4 presents series of cash outflow, which is sum of construction cost, residual value and total O&M cost.

Table 4 Series of Cash Outflow

Year	Construction Cost	Total O&M Cost	Residual value	Cash outflow
2004	3,287	0	0	3,287
2005	37,416	0	0	37,416
2006	86,431	0	0	86,431
2007	116,806	0	0	116,806
2008	102,913	9,861	0	112,773
2009	43,699	22,214	0	65,914
2010	5,291	22,214	0	27,506
2011	1,131	22,214	0	23,345
2012	7,510	22,214	0	29,724
2013	19,623	22,214	0	41,837
2014	19,623	22,214	0	41,837
2015	17,808	25,606	0	43,413
2016	84,324	25,606	0	109,930
2017	177,116	25,606	0	202,721
2018	193,314	25,606	0	218,920
2019	109,524	52,550	0	162,074
2020	21,331	61,346	-713,532	-630,854

Source: JICA Study Team (Unit: US$1,000)

(2) Cash Inflow

Cash inflow comes from operational revenue. It will generate from 2008 when WWTP and sewer network starts operation[3]. The Study Team set the following assumption for the operational revenue.

- CEDAE can collect user charge which is R$1.14 (US$0.39) per $1m^3$. It is the same level as average wastewater bill rate in 2001,
- Unearned water bill rate will decrease by 11%, from 21%to 10% until 2008, and
- Volume of wastewater follows the result of the analysis in the SUPPORING 7.

Table 5 shows total volume of increased wastewater and increased sewerage revenue. These figures of each Sewer District are shown in *Table 45*.

Table 5 Total Volume of Increased Wastewater and Increased Sewerage Revenue

Year	Total volume of increased wastewater (m^3)	Increased wastewater bill charge (US$)
2008	37,273	13,187
2009	105,390	37,286
2010	129,045	45,655
2011	130,156	46,048
2012	131,273	46,443
2013	132,395	46,841
2014	133,524	47,240
2015	142,007	50,241
2016	147,147	52,060
2017	174,552	61,755
2018	174,552	61,755
2019	292,686	103,550
2020	292,686	103,550

Note: Wastewater bill per $1m^3$ is R$1.14 (=US$0.39)
Source: JICA Study Team

(3) Impacts on Investment Expenditure

In the financial analysis of the strategic plan, the following two cases are examined, and preferable cases are selected, with consideration of the result of FIRR (Financial Internal Rate of Return) and assurance of conditions. The following cases are assumed:

- The State Government of Rio de Janeiro doesn't disburse investment expenditure for the strategic plan from state coffer and/or funds (Case1),
- The State Government of Rio de Janeiro disburses investment expenditure for the strategic plan from state coffer and/or funds (Case2).

1) Case 1: No investment Expenditure from the State Government

In Case 1, change of cash inflow cash outflow and net cash flow is presented in *Table 6*. Cash inflow consists of construction cost (*Table 1*), residual value (US$-713.5 million) and total O&M cost (*Table 3*). Cash outflow is increased sewerage revenue (*Table 5*). Net cash flow is cash inflow minus cash outflow.

Financial Internal Rate of Return (FIRR) of this case, which is calculated from the net cash flow, is 0.5%. It is quite low level.

[3] In 2008 Pavuna WWTP and Sarapui WWTP will start operation. It is assumed that WWTPs can work more than 90% of capacity, by use of existing sewer network, although sewer network in these districts has developed 75% of completion at that time.

Table 6 Cash Flow: Case 1

Year	Cash outflow	Cash inflow	Net cash flow
2004	3,287	0	-3,287
2005	37,416	0	-37,416
2006	86,431	0	-86,431
2007	116,806	0	-116,806
2008	112,773	13,187	-99,587
2009	65,914	37,286	-28,627
2010	27,506	45,655	18,150
2011	23,345	46,048	22,704
2012	29,724	46,443	16,719
2013	41,837	46,841	5,003
2014	41,837	47,240	5,403
2015	43,413	50,241	6,827
2016	109,930	58,998	-50,932
2017	202,721	59,667	-143,054
2018	218,920	60,350	-158,570
2019	162,074	102,840	-59,234
2020	-630,854	103,550	734,404

Source: JICA Study Team (Unit: US$1,000)

2) Case 2: Financial Support from the State Government

In Case 2, it is assumed that the State Government will disburse US$4 million (R$12 million) for the strategic plan. The State Government disbursed the same amount for PDBG in 2001 and in 2002. In Case 2, disbursement will start after 2005 when the State Government will disburse all local portion of PDBG. Cash flow changes in *Table 7*. FIRR improves to 1.6%, but still remains low level.

Table 7 Cash Flow: Case 2

Year	Cash outflow	Cash inflow	Investment expenditure	Net cash flow
2004	3,287	0		-3,287
2005	37,416	0		-37,416
2006	86,431	0	4,000	-82,431
2007	116,806	0	4,000	-112,806
2008	112,773	13,187	4,000	-95,587
2009	65,914	37,286	4,000	-24,627
2010	27,506	45,655	4,000	22,150
2011	23,345	46,048	4,000	26,704
2012	29,724	46,443	4,000	20,719
2013	41,837	46,841	4,000	9,003
2014	41,837	47,240	4,000	9,403
2015	43,413	50,241	4,000	10,827
2016	109,930	58,998	4,000	-46,932
2017	202,721	59,667	4,000	-139,054
2018	218,920	60,350	4,000	-154,570
2019	162,074	102,840	4,000	-55,234
2020	-630,854	103,550	4,000	738,404

Source: JICA Study Team (Unit: US$ 000)

(4) Impacts on Management Reform of CEDAE

Even if the State Government disburses investment expenditure for the strategic plan, level of FIRR is very low level, and the strategic plan doesn't have financial feasibility. Therefore it is necessary to add another financial resource to cash inflow.

The Study Team tried to add two financial resources which are strongly related to management reform of CEDAE. The first one is decrease of unearned water bill rate[4]. And the second one is decrease of non-revenue water rate[5]. As written in the section 2.4.2 of Main Report, CEDAE's Management, unearned water bill rate of CEDAE in 2001 is 21%, and more than 10% higher than SABESP and EMBASA. As same as unearned water bill rate, non-revenue water rate in 2001 is also very high level, 57%, and more than 20% higher than SABESP and EMBASA.

If unearned water bill rate decreases to 10%, and 50% of generated cash is allocated to the strategic plan, then US$9.7 million (R$28.1 million) of new cash inflow is listed in the cash flow table every year. In such an assumption, FIRR of Case 1 and Case 2 improve to 2.8% and to 4.0% respectively. If non-revenue water rate will decrease to 35%, and 15% of generated cash new cash flow is allocated to the strategic plan, US$25.7 million (R$74.6 million) of new cash inflow is listed in the cash flow table every year. In this case FIRR of Case1 and Case 2 improves to 5.3%, and to 8.3%, respectively. If combination of these two new cash flows occur, FIRR of Case1 and Case 2 improves to 7.7% and to 10.8% respectively, shown in *Table 8*. And change of unearned water bill rate and non-revenue water rate is illustrated in *Figure 1*

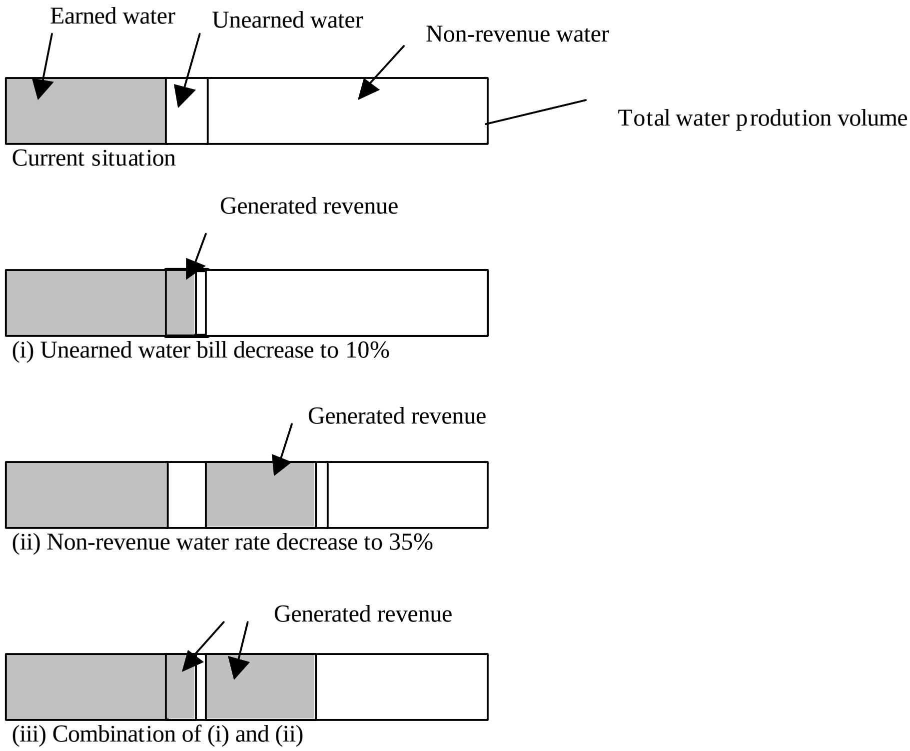
Table 8 Additional Financial Resource and Improvement of FIRR

	(i) Unearned water bill rate will decrease to 10%	(ii) Non-revenue water rate will decrease to 35%	(iii) Combination of (i) and (ii)
Additional cash inflow in a year (US$1,000)	9,723	25,726	34,999
FIRR: Case 1	2.8	5.3	7.7
FIRR: Case 2	4.0	8.3	10.8

Source: JICA Study Team (Unit: %)

[4] Unearned water bill rate is percentage of unearned water bill amount to total invoiced amount. The reason of unearned water comes from refusing payment by users, and uncollected water bill, etc.

[5] Non-revenue water rate is percentage of non-revenue water volume to total production volume. The reason of non-revenue water comes from illegal connection, water leakage and unbilled water charge, etc.



Source: JICA Study Team

Figure 1 Change of unearned water bill rate and non-revenue water rate

Table 8 shows that additional financial resources, which are generated from management reform of CEDAE, have big impact on improvement of FIRR. Therefore it is important for CEDAE to carry out management reform along with the implementation of the strategic plan.

(5) Users' Affordability

In financial analyses above, rise in water bill rate is not considered. Therefore sewerage users could accept the strategic plan easily, and users' burden is affordable level.

Indeed new sewerage users have to pay user charge, but it is the same rate with existing users. Some persons have financial burden by the decrease of unearned water bill rate and non-revenue water rate. But such users should pay water bill equable to services they have, and all users should burden cost of sewerage service. Of course CEDAE has to consider introducing and improving special water bill system for poor families, just as the commercial department is planning to introduce in *Favela* area.

(6) Evaluation and Conclusion

As of June 2003, difference between SELIC rate (basic interest rate in Brazil) and IPCA (representing indicator of Consumer Price Index, CPI) is 8.53%. And loan conditions of state banks for CEDAE are summarized in *Table 9*. Therefore the Study Team estimated that long-term real interest rate for CEDAE and the State Government is set as 8%.

Table 9 Loan Conditions of Sewerage Network Construction

Name	Real interest rate	Loan period	Grace period
Caixa Econômica Federal	6.5	120 months	24 months
Banco do Brasil	10.12	240 months	-

Source: CEDAE

Table 10 shows FIRRs of the strategic plan in eight cases. In the following two cases, FIRR exceeds 8%:

- "The State Government disburses investment expenditure", and "Non-revenue water rate will decrease to 35%" (FIRR is 8.3%),
- "The State Government disburses investment expenditure," "Unearned water bill rate will decrease to 10%", and "Non-revenue water rate will decrease to 35%" (FIRR is 10.8%).

Table 10 Comparison of FIRR

	FIRR: Case 1	FIRR: Case 2
(i) Original cash flow	0.5	1.6
(ii) Unearned water bill rate will decrease to 10%	2.8	4.0
(iii) Non-revenue water rate will decrease to 35%	5.3	8.3
(iv) Combination of (ii) and (iii)	7.7	10.8

Source: JICA Study Team (Unit: %)

The result of FIRR reports that the priority projects are feasible in case the State Government continues disbursing US$4 million (R$12 million) for the strategic plan. But it may be difficult for the State Government to continue it, due to limited financial resource.

In case the State Government cannot continue disbursement, CEDAE has to borrow loans from banks. Financial feasibility with bank loans is analyzed in the section 3 of this chapter, "Financial and Economic Analysis of the Priority Projects."

3. ECONOMIC ANALYSIS OF THE STRATEGIC PLAN

Economic benefit is evaluated from the result of Economic Internal Rate of Return, and it is calculated in the following procedures; conversion of project costs into economics cost, measurement of economic benefits, analysis of cash inflow and cash outflow, and evaluation of EIRR. In this analysis, project period is assumed to be 17 years, from 2004 to 2020, as same as financial analysis of the strategic plan.

(1) Cash Outflow

Cash outflow consists of construction costs, operation and maintenance cost, and residual value, as same as financial analysis. In economic analysis, these costs are converted to economic cost.

1) Construction Costs

Primary, taxes imposed on construction costs are removed. As shown *Table 11*, construction of WWTP is divided into the three components; civil and building work, mechanical equipment and electrical equipment. And construction of sewer network consists of only civil and building work. The following taxes are imposed in each component:

- Custom for imported goods (20%),
- IDT[6] for civil and building work (5%),
- ICMS[7] and IPI[8] for mechanical equipment and electrical equipment, which are produced in Brazil (12%+7%).

Cost structure of the components is presented in *Table 2.* And only mechanical equipment includes imported goods, percentage of which is 40%.

Table 11 Cost Structure and Tax Rates

Items		Cost share	Share of imported goods
WWTP	Civil and building work	40	0
	Mechanical equipment	50	40
	Elwctrical equipment	10	0
Sewer	Civil and building work	100	0

Source: JICA Study Team (Unit: %)

Based on the assumption above, taxation on the construction costs is removed. If construction cost of WWTP and sewer network are 100 units, construction cost without tax payment for WWTP is 87 units, and it for sewer network is 95 units, respectively. Economic cost of WWTPs is calculated in the following formula:

$$40\times50\%+50\times50\%\times(12+5)\%+50\times40\%\times20\%+10\times(12+5)\%=87.5....$$

Secondary, unskilled labor cost is evaluated by opportunity cost. According to data of PDBG, unskilled labors receiver R$336, 60% higher than minimum wage at that time, per a month, but opportunity cost of them were less than minimum wage, R$200 per a month. If personnel expenditure occupies 30% of total construction cost, and 50% of is used for payment to unskilled labor, then economic construction cost of sewer network will decrease more than 10%. Therefore it is assumed that economic construction cost of WWTP is 87% of original cost, and that of sewer network is 85% of original cost, respectively.

In this analysis, opportunity cost of land isn't considered because location of WWTPs, which are constructed after 2010 is not decided, and percentage of land acquisition cost of Bangu WWTP is very small. It is only 0.05% of total construction cost.

Table 12 presents disbursement of construction costs, which is converted from original construction cost in financial analysis. It includes direct cost, contingency, administration cost and engineering service cost, as well as financial analysis. Percentage of these costs to direct cost is also the same as financial analysis. Detailed construction costs by facility are shown in *Table 46.*

2) O&M Costs

Table 13 shows series of O&M costs. As same as financial analysis, the Study Team set the following assumptions. Detailed O&M costs by facility is shown in *Table 46.*

---

[6] IDT is tax for municipal governments and imposed on civil works.
[7] ICMS is tax for State Governments. It is like a value added tax, and also imposed on trading of goods, communication and transportation services.
[8] IPI is tax for the Federal Government. It is imposed on industrial goods.

- O&M cost consist of direct O&M cost and additional O&M cost.
- Direct O&M cost is used for operation and maintenance of facilities, and it consists of personnel expense, energy cost, and expense for chemicals. Direct O&M Cost is 5% of direct construction costs.
- Additional O&M cost is user for administration, and issuance and collection of water bill. It costs 50% of direct O&M cost[9].

3) Residual Value

Residual value is calculated from lifetime of WWTP and sewer. The methodology is as same as financial analysis. Thus;

- The same lifetime of facilities (29 years for WWTPs and 50 years for sewer network) is used,
- Construction cost of facilities is divided by lifetime and rest of lifetime after 2020 and divided value, construct cost per a year, is accumulated by the rest of lifetime.

The residual value amounts to US$-609 million. Residual value by facility is shown in *Table 44.*

4) Cash Outflow

Table 14 shows cash outflow of the strategic plan in economic analysis.

Table 12 Annual Disbursement of Construction Cost

Year	Direct cost	Contingency (10% of direct cost)	Administration cost (5% of direct cost)	Engineering service cost (10% of direct cost)	Total construction cost
2004	0	0	936	1,871	2,807
2005	22,284	2,228	2,241	4,482	31,235
2006	60,999	6,100	2,241	4,482	73,822
2007	85,024	8,502	2,241	4,482	100,248
2008	73,447	7,345	2,241	4,482	87,514
2009	27,139	2,714	2,241	4,482	36,575
2010	0	0	1,305	2,610	3,915
2011	0	0	321	642	963
2012	4,929	493	321	642	6,386
2013	14,335	1,434	321	642	16,732
2014	14,335	1,434	321	642	16,732
2015	4,929	493	3,251	6,502	15,176
2016	55,239	5,524	3,713	7,425	71,900
2017	127,843	12,784	3,391	6,783	150,802
2018	140,973	14,097	3,391	6,783	165,245
2019	75,646	7,565	3,391	6,783	93,385
2020	7,277	728	3,391	6,783	18,179

Source: JICA Study Team (Unit: US$1,000)

[9] According to the financial statement in 2001, proportion of administration cost to facility O&M cost was 25%. Proportion of commercial cost to facility O&M cost was 65%, but additional commercial cost will be lower than the level, because CEDAE has already have the system for invoicing and collection of water bill.

Table 13 Series of O&M Costs

Year	O&M cost (5%of direct cost)	Addiitonal O&M cost (50% of O&M cost)	Total O&M cost
2008	5,614	2,807	8,422
2009	13,445	6,722	20,167
2010	13,445	6,722	20,167
2011	13,445	6,722	20,167
2012	13,445	6,722	20,167
2013	13,445	6,722	20,167
2014	13,445	6,722	20,167
2015	15,371	7,686	23,057
2016	15,371	7,686	23,057
2017	15,371	7,686	23,057
2018	15,371	7,686	23,057
2019	32,952	16,476	49,427
2020	35,720	17,860	53,580

Source: JICA Study Team (Unit: US$1,000)

Table 14 Cash Outflow of the Strategic Plan

Year	Construction cost	Total O&M cost	Residual value	Total cash outflow
2004	2,807	0	0	2,807
2005	31,235	0	0	31,235
2006	73,822	0	0	73,822
2007	100,248	0	0	100,248
2008	87,514	8,422	0	95,936
2009	36,575	20,167	0	56,742
2010	3,915	20,167	0	24,082
2011	963	20,167	0	21,130
2012	6,386	20,167	0	26,553
2013	16,732	20,167	0	36,899
2014	16,732	20,167	0	36,899
2015	15,176	23,057	0	38,232
2016	71,900	23,057	0	94,957
2017	150,802	23,057	0	173,858
2018	165,245	23,057	0	188,301
2019	93,385	49,427	0	142,812
2020	18,179	53,580	-609,315	-537,556

Source: JICA Study Team (Unit: US$1,000)

(2) Cash Inflow

In this economic analysis, economic benefit was defined as "the value Guanabara Bay with improved water quality". The Study Team introduced Contingent Valuable Method (CVM) to assess the value, and conducted "Economic Benefit Survey" from June to August in 2003.

1) Economic Benefit of the Strategic Plan

In the Economic Benefit Survey, the Study Team classified beneficiaries into three categories: resident (people living in Rio de Janeiro State), Brazilian tourist, and international tourist. Willingness to pay of a person is calculated through the following question to interviewees, which consist of 238 residents, 103 Brazilian tourists and 58 international tourists.

"A Foundation constructs wastewater treatment plant near the bay and operate it to clean seawater. The plant is constructed and operated by contributions from households in Rio de Janeiro State and tourists. This project would improve water quality of Guanabara Bay, and people could have the following benefits:

- *People will enjoy swimming in beaches (Botafogo, Flamengo, Niterói, Copacabana, Ipanema, and Leblon). People won't doubt water quality.*
- *Eco-system in Guanabara Bay will recover and people can see fishes and marine creature more in the bay.*
- *People won't smell bad and won't see dirty seawater."*

Result of the survey indicates that willingness of pay per a person is R$8 (resident), R$13 (Brazilian tourist), and R$25 (international tourist), respectively.

2) Assumed Economic Benefit

The status of water quality of Guanabara Bay in the questionnaire means the target of the strategic plan in 2020. Therefore willingness of pay times number of person in each category is economic benefit in each category (third, fifth, seventh of *Table 15*), and sum of them, shown in the eighth of *Table 15* is "assumed economic benefit," if water quality of Guanabara Bay were improved as same level as 2020. However, the sewerage development is proposed year by year in the Strategic Plan, and the target will be achieved only in 2020. Therefore economic benefit generated every year comes from proportion of treated wastewater volume to the volume in 2020. *Table 16* shows percentage of treated wastewater volume and actual economic benefit.

In *Table 15*, the following methods are used for forecast of resident, Brazilian tourist and International tourist.

- Annual population of Rio de Janeiro State is calculated based on the analysis in the Chapter 4.
- Data on Brazilian tourist was compiled in annual statistical yearbooks (Anuário Estatístico do Estado do Rio de Janairo) until 1995/96. According to the statistical yearbook in 1995/96, Brazilian tourist arrivals in 1995 were 9.3 million and increased 1.4 % annually. These figures are utilized in the forecast until 2020.
- International tourist arrivals to Rio de Janeiro State were estimated from tourist statistics and international tourist survey in 2000 (Estudo da Demanda Turística Internacional 2000). Growth rate of international tourist arrivals to Rio de Janeiro is set as 4%, as well as growth rate from 1999 to 2000.

Table 15 Calculation of Economic Benefit*

Year	Residents		Brazilian tourists		International tourists		Assumed economic benefit
	Population (persons)	Economic benefit	Population (persons)	Economic benefit	Population (persons)	Economic benefit	
2008	15,450,257	42,621	11,112,599	49,815	5,069,516	43,703	136,139
2009	15,582,987	42,988	11,263,099	50,490	5,272,297	45,451	138,928
2010	15,716,858	43,357	11,415,638	51,174	5,483,189	47,269	141,799
2011	15,830,027	43,669	11,570,243	51,867	5,702,517	49,160	144,695
2012	15,944,010	43,983	11,726,941	52,569	5,930,617	51,126	147,679
2013	16,058,813	44,300	11,885,762	53,281	6,167,842	53,171	150,752
2014	16,174,444	44,619	12,046,733	54,003	6,414,556	55,298	153,920
2015	16,290,907	44,940	12,209,885	54,734	6,671,138	57,510	157,184
2016	16,388,559	45,210	12,375,246	55,475	6,937,983	59,810	160,495
2017	16,486,797	45,481	12,542,847	56,227	7,215,503	62,203	163,910
2018	16,585,624	45,753	12,712,718	56,988	7,504,123	64,691	167,432
2019	16,685,043	46,028	12,884,889	57,760	7,804,288	67,278	171,066
2020	16,785,058	46,304	13,059,392	58,542	8,116,459	69,969	174,815

Note: * Assumed economic benefit if water quality of Guanabara Bay had achieved the target in 2020 (Unit: US$1000)

Source: JICA Study Team

Table 16 Series of Economic Benefit

Year	Assumed economic benefit	% of treated wastewater volume to 2020	Economic benefit
2008	136,139	19	26,064
2009	138,928	42	58,977
2010	141,799	44	62,519
2011	144,695	45	64,558
2012	147,679	45	66,398
2013	150,752	45	68,303
2014	153,920	46	70,275
2015	157,184	49	76,263
2016	160,495	50	80,689
2017	163,910	60	97,753
2018	167,432	60	99,853
2019	171,066	100	171,066
2020	174,815	100	174,815

Source: JICA Study Team (Unit: US$1,000)

(3) Net Cash Flow and Economic Internal Rate of Return

Cash inflow, cash outflow and net cash flow of the strategic plan were summarized as *Table 17*, and Economic Internal Rate of Return (EIRR) is 10.0 %.

Table 17 Cash Flows of the Strategic Plan

Year	Cash inflow	Cash outflow	Net cash flow
2004	0	2,807	-2,807
2005	0	31,235	-31,235
2006	0	73,822	-73,822
2007	0	100,248	-100,248
2008	26,064	95,936	-69,872
2009	58,977	56,742	2,235
2010	62,519	24,082	38,437
2011	64,558	21,130	43,427
2012	66,398	26,553	39,846
2013	68,303	36,899	31,404
2014	70,275	36,899	33,376
2015	76,263	38,232	38,031
2016	80,689	94,957	-14,268
2017	97,753	173,858	-76,106
2018	99,853	188,301	-88,448
2019	171,066	142,812	28,254
2020	174,815	-537,556	712,371

Source: JICA Study Team (Unit: US$ 000)

(4) Sensitivity Test

The Study Team tested sensitivity of economic analysis in the following four cases:

- Case 1: Willing ness to pay of resident increases 50% to R$12 per a year,
- Case 2: Construction cost increases 10 %,
- Case 3: O&M cost increases 10%,
- Case 4: Combination of Case1 and Case 2.

Table 18 shows results of sensitivity analysis. If willingness to pay of resident increases to R$12, EIRR will increase 2.8 points. On the other hand, construction cost and O&M cost increases 10 %, EIRR will down to 8.7% and to 9.4%, respectively. In combination of Case 1 and Case 2, EIRR will rise 1.3 points.

Table 18 Results of Sensitivity Analysis

Cases	EIRR
Case 1: Willingness to pay of resident increase R$12	12.8
Case 2: Construction cost increases 10%	8.7
Case 3: O&M cost increases 10%	9.4
Case 4: Combination of Case 1 and Case 2	11.3

Source: JICA Study Team (Unit: %)

(5) Marginal Opportunity Cost of Capital in Brazil and Conclusion of Economic Analysis

Marginal opportunity cost of capital in Brazil is set as 10%, reflecting low economic growth ratio in recent years.

The value of EIRR is on the real opportunity cost of capital, and fulfills economic feasibility in minimum level. However it is under the real opportunity cost if cash outflow increases. On the other hand, increase of willingness to pay will improve EIRR a lot. Case 1, willingness to pay of resident increase to R$12, improves EIRR by 2.8 point, and Case 4, combination of willingness to pay increase and construction cost increase, improves EIRR by 1.3 point.

Comparing with Brazilian tourist and international tourist, willingness to pay of a resident seems to be low. That comes from residents' low awareness of environment of Guanabara Bay. Environmental education program will enable residents to be aware of the importance of environment of Guanabara Bay, and to increase willingness to pay to improve water quality of Guanabara Bay.

4. FINANCIAL ANALYSIS OF THE PRIORITY PROJECTS

Although CEDAE and the State Government of Rio de Janeiro are separate financial bodies, they are treated as single financial body, in this analysis. Because the State Government have to support CEDAE in case of management crisis, and such assumption help to analyze financial feasibility simply. The roles of CEDAE and the State Government will clarify after this financial analysis, in Financial Plan. Project period is set as 25 years, from 2004 to 2028, considering the assumption of 25-years loan.

(1) Calculation of Cash Outflow

Cash outflow consists of construction cost, operation and maintenance cost, and residual value which is listed only at the end of the project period, 2028.

1) Construction Costs

Construction costs are divided into direct cost (wastewater treatment plant (WWTP) and sewer), contingency (10% of direct cost), administration cost (5% of direct cost), engineering service cost (10% of direct cost) and land acquisition. Sum of annual disbursement of construction cost is shown in the *Table 19.* Detailed disbursement plan is shown in *Table 47.*

Table 19 Annual Disbursement of Construction Cost

Year	Administration	Engineering Service	Direct cost	Land acquisition	Contingency	Construction cost
2004	944	1,049	0	0	0	1,993
2005	2,465	4,040	26,216	0	2,622	35,343
2006	3,238	6,698	71,452	650	7,146	89,184
2007	3,238	6,698	99,066	0	9,907	118,909
2008	3,081	6,695	85,759	0	8,575	104,110
2009	2,115	4,984	31,926	0	3,193	42,218
2010	641	1,279	0	0	0	1,920

Source: JICA Study Team (Unit: US$1,000)

2) O&M Costs

The Study Team set the following assumptions as for Operation and maintenance cost (O&M cost).

- O&M cost consist of direct O&M cost and additional O&M cost.
- Direct O&M cost is used for operation and maintenance of facilities, and it consists of personnel expense, energy cost, and expense for chemicals. It is set in the *Supporting 10*.
- Additional O&M cost is user for administration, and issuance and collection of water bill. It costs 50% of direct O&M cost[10].
- These O&M costs from 2021 to 2028 are assumed to follows the costs in 2020.

Series of direct O&M cost, additional O&M cost and total O&M costs are shown in *Table 20*. Detailed O&M costs by facility is shown in *Table 47*

Table 20 Series of O&M Costs

Year	WWTP	Sewer	WWTP + Sewer	Additional O&M	Total O&M
2008	4,366	0	4,366	2,183	6,549
2009	9,024	725	9,749	4,875	14,624
2010	9,069	1,657	10,726	5,363	16,089
2011	9,110	1,657	10,767	5,384	16,151
2012	9,149	1,657	10,806	5,403	16,209
2013	9,192	1,657	10,849	5,425	16,274
2014	9,232	1,657	10,889	5,445	16,334
2015	9,273	1,657	10,930	5,465	16,395
2016	9,311	1,657	10,968	5,484	16,452
2017	9,347	1,657	11,004	5,502	16,506
2018	9,385	1,657	11,042	5,521	16,563
2019	9,422	1,657	11,079	5,540	16,619
2020	9,459	1,657	11,116	5,558	16,674
2021	9,459	1,657	11,116	5,558	16,674
2022	9,459	1,657	11,116	5,558	16,674
2023	9,459	1,657	11,116	5,558	16,674
2024	9,459	1,657	11,116	5,558	16,674
2025	9,459	1,657	11,116	5,558	16,674
2026	9,459	1,657	11,116	5,558	16,674
2027	9,459	1,657	11,116	5,558	16,674
2028	9,459	1,657	11,116	5,558	16,674

Source: JICA Study Team (Unit: US$1,000)

3) Residual Value

Introduction of lifetime of sewerage facilities is calculated under the assumption in *Table21*. It is the same method used in the financial analysis of the strategic plan. Construction of WWTP is divided into civil works and building works, mechanical equipment and electrical equipment, and each cost occupies 40%, 50% and 10% respectively, according to experience in PDBG and other countries. On the other hand, lifetime of each facility is 50 years, 15 years, and 15 years.

[10] According to the financial statement in 2001, proportion of administration cost to facility O&M cost was 25%. Proportion of commercial cost to facility O&M cost was 65%, but additional commercial cost will be lower than the level, because CEDAE has already have the system for invoicing and collection of water bill.

Then weighted lifetime of 29 years is adopted as the lifetime of WWTPs. The result comes from the following formula:

$$40\% \times 50 + 50\% \times 15 + 10\% \times 15 = 29$$

Otherwise, construction of sewer network consists of only civil works, and lifetime of sewer is estimated 50 years. Thus lifetime of sewer network is 50 years.

Residual value is calculated from difference between lifetime and the period of operation until 2028. Diminishing method is adopted here; thus construction cost of facilities is divided by lifetime and divided value, construct cost per a year, is accumulated by the rest of lifetime after 2028. Residual value is calculated in every Sewer District.

According to the implementation plan in the *Supporting 11*, Pavuna Sewer District and Bangu Sewer District will start operation in 2008, and other Sewer Districts will start operation one after another since 2009. Total residual value calculated under these lifetimes is US$-181.2 million.

Table 21 Cost Structure and Lifetime of Sewerage Facilities

Facilities		Cost Share (%)	Lifetime of Facilities (Year)	Adopted lifetime (year)
WWTP	Civil works and Building works	40	50	29
	Mechanical equipment	50	15	
	Electrical equipment	10	15	
Sewers	Civil works	100	50	50

Source: JICA Study Team

4) Cash Outflow

Table 22 presents series of cash outflow, which is sum of construction cost, residual value and total O&M cost.

(2) Cash Inflow

Cash inflow comes from operation revenue. It will generate from 2008 when WWTP and sewer network starts operation[11]. The Study Team set the following assumption for the operational revenue.

- CEDAE can collect user charge which is R$1.14 (US$0.39) per 1m^3. It is the same level as average wastewater bill rate in 2001,
- Unearned water bill rate will decrease by 10%, from 21%to 10% until 2008, and
- Volume of wastewater follows the analysis in the *Supporting 7*.

Table 23 shows total volume of increased wastewater and increased sewerage revenue. These figures in each Sewer District are shown in *Table 48*.

[11] In 2008 Pavuna WWTP and Sarapui WWTP will start operation. It is assumed that WWTPs can work more than 90% of capacity, by use of existing sewer network, although sewer network in these districts has developed 75% of completion at that time.

Table 22 Series of Cash Outflow

Year	Construction cost	O&M cost	Residual value	Cash Outflow
2004	1,993	0	0	1,993
2005	35,343	0	0	35,343
2006	69,184	0	0	69,184
2007	114,909	0	0	114,909
2008	100,110	6,549	0	106,659
2009	38,218	14,624	0	52,842
2010	1,920	16,089	0	18,009
2011	0	16,151	0	16,151
2012	0	16,209	0	16,209
2013	0	16,274	0	16,274
2014	0	16,334	0	16,334
2015	0	16,395	0	16,395
2016	0	16,452	0	16,452
2017	0	16,506	0	16,506
2018	0	16,563	0	16,563
2019	0	16,619	0	16,619
2020	0	16,674	0	16,674
2021	0	16,674	0	16,674
2022	0	16,674	0	16,674
2023	0	16,674	0	16,674
2024	0	16,674	0	16,674
2025	0	16,674	0	16,674
2026	0	16,674	0	16,674
2027	0	16,674	0	16,674
2028	0	16,674	-181,229	-164,555

Source: JICA Study Team (Unit: US$1,000)

Table 23 Total Volume of Increased Wastewater and Increased Sewerage Revenue

Year	Total volume of increased wastewater (m^3)	Increased wastewater bill charge (US$)
2008	37,273	13,187
2009	105,390	37,286
2010	129,045	45,655
2011	130,156	46,048
2012	131,273	46,443
2013	132,395	46,841
2014	133,524	47,240
2015	134,659	47,641
2016	135,677	48,002
2017	136,700	48,363
2018	137,728	48,727
2019	138,761	49,093
2020	139,799	49,460
2021	139,799	49,460
2022	139,799	49,460
2023	139,799	49,460
2024	139,799	49,460
2025	139,799	49,460
2026	139,799	49,460
2027	139,799	49,460
2028	139,799	49,460

Note: Wastewater bill per $1m^3$ is R$1.14 (=US$0.39)
Source: JICA Study Team

(3) Impacts on Investment Expenditure

Financial analysis of the feasibility study examines the following three cases, and selects the best case with consideration of the result (Financial Internal Rate of Return) and assurance of conditions of each case:

- The State Government doesn't disburse any investment costs for the priority projects from state coffer and/or funds (Case 1),
- The State Government disburses US$20 million in 2006, and US$4 million from 2007 to 2009 for the priority projects (Case 2), and
- The State Government disburses US$20 million from 2006 to 2009 for the priority projects (Case 3).

1) Case 1: No Investment Expenditure from the State Government

In Case 1, change of cash inflow, cash outflow and net cash flow is presented in *Table 24*. Cash outflow consists of construction cost (*Table 19*), total O&M costs (*Table 20*) and residual value (US$-181.2 million). Cash inflow is increased sewerage revenue (*Table 23*). Net cash flow is difference between cash inflow and cash outflow.

Financial Internal Rate of Return (FIRR) of this case, which is calculated from the net cash flow, is 6.3%.

Table 24 Cash Flow: Case 1

Year	Cash outflow	Cash inflow	Net cash flow
2004	1,993	0	-1,993
2005	35,343	0	-35,343
2006	89,184	0	-89,184
2007	118,909	0	-118,909
2008	110,659	13,187	-97,472
2009	56,842	37,286	-19,555
2010	18,009	45,655	27,646
2011	16,151	46,048	29,898
2012	16,209	46,443	30,234
2013	16,274	46,841	30,567
2014	16,334	47,240	30,906
2015	16,395	47,641	31,246
2016	16,452	48,002	31,550
2017	16,506	48,363	31,857
2018	16,563	48,727	32,164
2019	16,619	49,093	32,474
2020	16,674	49,460	32,786
2021	16,674	49,460	32,786
2022	16,674	49,460	32,786
2023	16,674	49,460	32,786
2024	16,674	49,460	32,786
2025	16,674	49,460	32,786
2026	16,674	49,460	32,786
2027	16,674	49,460	32,786
2028	-164,555	49,460	214,015

Source: JICA Study Team

The Study Team supposed that the implementation body of the feasibility study borrows bank loans. And the following loan patterns are prepared,

- Case 1a: 60% of construction cost is financed by low interest rate (2.5%) with 7-year grace period and 25-year of loan period,
- Case 1b: 60% of construction cost is financed by international market interest rate (5.5%) with 7-year grace period and 25-year of loan period, and
- Case 1c: 30% of construction cost is financed by low interest rate (2.5%) with 7-year grace period and 25-year of loan period, and 30% of construction cost is financed by international market interest rate (5.5%) with 7-year grace period and 25-year of loan period.

Table 25 presents improvement of FIRR in each case. FIRR improves 2.6 point, 0.2 point and 1.9 point respectively.

Table 25 FIRR of Each Case

Cases	FIRR
Case 1: Non public investment from the State Government	6.3
Case 1a: Case1 with bank loan (low interest rate)	8.9
Case 1b: Case1 with bank loan (market interest rate)	6.5
Case 1c: Case1 with co-finance of Case1b and Case 1c	8.2

Source: JICA Study team (Unit: %)

2) Case 2: Investment Expenditure from the State Government

In Case 2, it is assumed that the State Government will disburse US$20 million (R$59 million) in 2006, and US$4 million from 2007 to 2009. According to the official newspaper of Rio de Janeiro State, the State Government is going to disburse US$20 million for PDBG in 2003. And the State Government have to continue disburse the same amount in 2004 and 2005, in order to fulfill the all amount of local portion. Therefore disbursement for the feasibility study stars in 2006.

Financial resource of the disbursement comes from FECP (State Fund for Combat to Poverty and Social Inequality). According to the State Law No. 4056/2002, the State Government collects 5% of ICMS or its substitute until 2006, and 1% of them from 2007 to2009, respectively. It means that annual financial resource of the fund will decrease 80% after 2006. Therefore it is supposed that disbursement of the State Government will decrease to 20%, US$4 million from 2007. Under this assumption, change of cash flow is presented in *Table 26*.

In this case, FIRR improves to 6.8%, compared with the original of Case 1.

Assumption of bank loans, which is the same as the Case 1, is also introduced in the cash flow above. Thus, the following loan patterns are prepared,

- Case 2a: 60% of construction cost is financed by low interest rate (2.5%) with 7-year grace period and 25-year of loan period,
- Case 2b: 60% of construction cost is financed by international market interest rate (5.5%) with 7-year grace period and 25-year of loan period, and
- Case 2c: 30% of construction cost is financed by low interest rate (2.5%) with 7-year grace period and 25-year of loan period, and 30% of construction cost is financed by international market interest rate (5.5%) with 7-year grace period and 25-year of loan period.

Table 27 presents improvement of FIRR in each case. FIRR improves 3.4 point, 0.8 point and 2.9 point respectively.

Table 26 Cash Flow: Case 2

Year	Disbursement from the State Government	Cash inflow	Cash outflow	Net cash flow
2004	0	1,993	0	-1,993
2005	0	35,343	0	-35,343
2006	20,000	69,184	0	-69,184
2007	4,000	114,909	0	-114,909
2008	4,000	106,659	13,187	-93,472
2009	4,000	52,842	37,286	-15,555
2010	0	18,009	45,655	27,646
2011	0	16,151	46,048	29,898
2012	0	16,209	46,443	30,234
2013	0	16,274	46,841	30,567
2014	0	16,334	47,240	30,906
2015	0	16,395	47,641	31,246
2016	0	16,452	48,002	31,550
2017	0	16,506	48,363	31,857
2018	0	16,563	48,727	32,164
2019	0	16,619	49,093	32,474
2020	0	16,674	49,460	32,786
2021	0	16,674	49,460	32,786
2022	0	16,674	49,460	32,786
2023	0	16,674	49,460	32,786
2024	0	16,674	49,460	32,786
2025	0	16,674	49,460	32,786
2026	0	16,674	49,460	32,786
2027	0	16,674	49,460	32,786
2028	0	-164,555	49,460	214,015

Source: JICA Study Team

Table 27 FIRR of Each Case

Cases	FIRR
Case 1: Non public investment from the State Government	6.8
Case 1a: Case1 with bank loan (low interest rate)	10.6
Case 1b: Case1 with bank loan (market interest rate)	7.6
Case 1c: Case1 with co-finance of Case1b and Case 1c	9.7

Source: JICA Study team (Unit: %)

3) Case 3: More Investment Expenditure from the State Government

In Case 3, it is assumed that the State Government will disburse US$20 million (R$59 million) until 2009. It is necessary for the State Government to approve amendment of the Law No. 4056/2002, and to collect increase of ICMS or its substitute (5%) for the FECP until 2010, in order to realize this assumption. Under this assumption, change of cash flow is presented in *Table 28.*

Table 28 Cash Flow: Case 3

Year	Disbursement from the State Government	Cash inflow	Cash outflow	Net cash flow
2004	0	1,993	0	-1,993
2005	0	35,343	0	-35,343
2006	20,000	69,184	0	-69,184
2007	20,000	98,909	0	-98,909
2008	20,000	90,659	13,187	-77,472
2009	20,000	36,842	37,286	445
2010	0	18,009	45,655	27,646
2011	0	16,151	46,048	29,898
2012	0	16,209	46,443	30,234
2013	0	16,274	46,841	30,567
2014	0	16,334	47,240	30,906
2015	0	16,395	47,641	31,246
2016	0	16,452	48,002	31,550
2017	0	16,506	48,363	31,857
2018	0	16,563	48,727	32,164
2019	0	16,619	49,093	32,474
2020	0	16,674	49,460	32,786
2021	0	16,674	49,460	32,786
2022	0	16,674	49,460	32,786
2023	0	16,674	49,460	32,786
2024	0	16,674	49,460	32,786
2025	0	16,674	49,460	32,786
2026	0	16,674	49,460	32,786
2027	0	16,674	49,460	32,786
2028	0	-164,555	49,460	214,015

Source: JICA Study Team (Unit: %)

In this case, FIRR rises by 1.8 point to 8.1%, compared with the original of Case 1.

Assumption of bank loans, which is the same as the Case 1 and Case 2, is also introduced in the cash flow above. Thus, the following loan patterns are prepared,

- Case 3a: 60% of construction cost is financed by low interest rate (2.5%) with 7-year grace period and 25-year of loan period,
- Case 3b: 60% of construction cost is financed by international market interest rate (5.5%) with 7-year grace period and 25-year of loan period, and
- Case 3c: 30% of construction cost is financed by low interest rate (2.5%) with 7-year grace period and 25-year of loan period, and 30% of construction cost is financed by international market interest rate (5.5%) with 7-year grace period and 25-year of loan period.

Table 29 presents improvement of FIRR in each case. FIRR improves by 4.7 point, 1.5 point and 3.1 point respectively.

Table 29 FIRR of Each Case

Cases	FIRR
Case 3: More public investment from the State Government	8.1
Case 3a: Case1 with bank loan (low interest rate)	12.8
Case 3b: Case1 with bank loan (market interest rate)	9.6
Case 3c: Case1 with co-finance of Case1b and Case 1c	11.2

Source: JICA Study team (Unit: %)

(4) Users' Affordability

In financial analyses above, rise of water bill rate is not considered, as well as the financial analysis of the strategic plan. Therefore sewerage users could accept the priority projects, and users' burden is affordable level.

(5) Evaluation and Conclusion

Long-term real interest rate for CEDAE and the State Government is set as 8%, with consideration of difference between SELIC rate (treasury bill rate) and IPCA (representing indicator of Consumer Price Index, CPI), which is 8.5%, and current loan conditions of CEDAE. It is the same level of financial analysis of the strategic plan.

Table 30 shows FIRR of the feasibility study in 12 cases. In the following 8 cases, FIRR exceeds 8%:

- All cases in Case 3 (Case3, Case3a, Case3b, and Case3c),
- Case 2a and Case 2c, and
- Case 1a and Case 1c.

Table 30 Comparison of FIRR

	Case 1	Case 2	Case 3
Original cash flow	6.3	6.8	8.1
a: Loan woth low interest rate	8.9	10.4	12.8
b: Loan with international market interest rate	6.5	7.6	9.6
c: Combination of (a) and (b)	8.2	9.7	11.2

Source: JICA Study Team (Unit: %)

Considering assurance of conditions, CEDAE and the State Government have two uncertainties. The first one is public expenditure from the State Government. It may be difficult for the State Government to disburse US$ 20 million for four years. Because the state house approves amendment of the State Law No. 4056/2002 in order to carry out such disbursement. Thus, Case 3 needs action both of administration body and legislative body. Otherwise the State Government could disburse investment expenditure in Case 3 if it keeps proportion of sewerage development in total amount of FECP in this year. Thus Case 2 need fewer actions than Case 3.

The other one is loan amount. If a single bank will borrow a loan, loan amount will exceed US$217 million. In case of low interest rate, it is difficult for almost banks to lend such a big amount; therefore it is realistic that a bank with lower interest rate will co-finance with a bank with market interest rate.

Based on the consideration above, the Study Team decided that Case 2c (Combination of loans under the State Government disburses US$20 million in 2006, and US$4 million from 2007 to 2009) is the best result of the financial analysis, and selects it as FIRR of this projects. Cash flow in this case is presented in *Table 31*.

The priority projects are financially feasible from the result of the financial analysis (9.7%). Even if the State Government cannot disburse all amounts, FIRR of the projects would be still over 8%. Even in the worst case that the State Government can't disburse investment expenditure at all, FIRR would be 8.2%.

Table 31 Cash Flow of the Priority Projects

Year	Net cash flow (Original)	Loan (low rate)			Loan (market rate)			Net cash flow (Case2c)
		Loan amount	Interest payment	Capital refund	Loan amount	Interest payment	Capital refund	
2004	-1,993	598	15	0	598	33	0	-845
2005	-35,343	10,603	280	0	10,603	616	0	-15,033
2006	-69,184	20,755	799	0	20,755	1,725	0	-30,197
2007	-114,909	34,473	1,661	0	34,473	3,038	0	-50,662
2008	-93,472	30,033	2,412	0	30,033	5,305	0	-41,123
2009	-15,555	11,465	2,698	0	11,465	5,936	0	-1,259
2010	27,646	576	2,713	0	576	5,968	0	20,118
2011	29,898	0	2,713	6,028	0	5,968	6,028	9,162
2012	30,234	0	2,562	6,028	0	5,636	6,028	9,980
2013	30,567	0	2,411	6,028	0	5,305	6,028	10,795
2014	30,906	0	2,260	6,028	0	4,973	6,028	11,617
2015	31,246	0	2,110	6,028	0	4,642	6,028	12,439
2016	31,550	0	1,959	6,028	0	4,310	6,028	13,225
2017	31,857	0	1,808	6,028	0	3,978	6,028	14,015
2018	32,164	0	1,658	6,028	0	3,647	6,028	14,804
2019	32,474	0	1,507	6,028	0	3,315	6,028	15,596
2020	32,786	0	1,356	6,028	0	2,984	6,028	16,390
2021	32,786	0	1,206	6,028	0	2,652	6,028	16,872
2022	32,786	0	1,055	6,028	0	2,321	6,028	17,354
2023	32,786	0	904	6,028	0	1,989	6,028	17,837
2024	32,786	0	753	6,028	0	1,658	6,028	18,319
2025	32,786	0	603	6,028	0	1,326	6,028	18,801
2026	32,786	0	452	6,028	0	995	6,028	19,283
2027	32,786	0	301	6,028	0	663	6,028	19,766
2028	214,015	0	151	6,028	0	332	6,028	201,477

Source: JICA Study Team (Unit: US$ 000)

5. ECONOMIC ANALYSIS OF THE PRIORITY PROJECTS

Economic benefit is evaluated from the result of Economic Internal Rate of Return, and it is calculated in the following procedures; conversion of project cost into economic costs, measurement of economic benefit, analysis of cash inflow and cash outflow, and evaluation of EIRR. In this analysis, project period is assumed to be 17 years, from 2004 to 2020.

(1) Cash Outflow

Cash outflow consists of construction cost, operation and maintenance cost, and residual value, and these costs are converted to economic costs, as same as economic analysis of the strategic plan.

1) Construction Costs

Primary, land acquisition cost listed in Bangu Sewer District is excluded, because the prepared land is not used foe production activity, and opportunity cost of the land is zero now.

Secondary, taxation imposed in the cost is excluded. As shown *Table 32,* construction of WWTP is divided into the three components; civil and building work, mechanical equipment and electrical equipment. And construction of sewer network consists of only civil and building work. The following taxes are imposed in each component:

- Custom for imported goods (20%),
- IDT[12] for civil and building work (5%),
- ICMS[13] and IPI[14] for mechanical equipment and electrical equipment, which are produced in Brazil (12%+7%).

And shown in *Table 32,* only mechanical equipment has imported goods, percentage of which is 40%.

Table 32 Cost Structure and Tax Ratio

		Cost share	Share of imported goods
WWTP	Civil and building work	40	0
	Mechanical equipment	50	40
	Elwctrical equipment	10	0
Sewer	Civil and building work	100	0

Source: JICA Study Team (Unit: %)

Based on the assumption above, taxation on the construction cost is removed. If construction cost of WWTP and sewer network are 100 units, construction cost without tax payment for WWTP is 87 units, and it for sewer network is 95 units, respectively. Economic cost of WWTPs is calculated in the following formula:

$$40 \times 5\% + 50 \times 60\% \times (12+5)\% + 50 \times 40\% \times 20\% + 10 \times (12+5)\% = 87.5....$$

Thirdly, unskilled labor cost is calculated by opportunity cost. According to existing data, unskilled labors working in PDBG receiver R$336, 60% higher than minimum wage at that

[12] IDT is tax for municipal governments and imposed on civil works.
[13] ICMS is tax for State Governments. It is like a value added tax, and also imposed on trading of goods, communication and transportation services.
[14] IPI is tax for the Federal Government. It is imposed on industrial goods.

time, per a month, but opportunity cost of them were less than minimum wage, R$200 per a month. If personnel expenditure occupies 30% of total construction cost, and 50% of is used for payment to unskilled labor, then economic construction cost of sewer network will decrease more than 10%. Therefore it is assumed that economic construction cost of WWTP is 87% of original cost, and that of sewer network is 85% of original cost, respectively.

Table 33 presents disbursement of construction costs, which is converted from original construction costs in financial analysis. It includes direct cost, contingency, administration cost and engineering service cost, as well as construction cost in financial analysis. Percentage of these costs to direct cost is also the same as financial analysis. Detailed construction costs by facility are shown in *Table 49.*

2) O&M Costs

Table 34 shows series of O&M costs. As same as financial analysis, the Study Team set the following assumptions. Detailed O&M costs by facility are shown in *Table 49.*

- O&M costs consist of direct O&M cost and additional O&M cost.
- Direct O&M cost is used for operation and maintenance of facilities, and it consists of personnel expense, energy cost, and expense for chemicals.
- Additional O&M cost is user for administration, and issuance and collection of water bill. It costs 50% of direct O&M cost[15].

3) Residual Value

Residual value is calculated from lifetime of WWTP and sewer. The methodology is as same as financial analysis. Thus;

- The same lifetime of facilities (29 years for WWTPs and 50 years for sewer network) is used,
- Construction cost of facilities is divided by lifetime and rest of lifetime after 2020 and divided value, construct cost per a year, is accumulated by the rest of lifetime.

The residual value amounts to US$-208 million.

4) Cash Outflow

Table35 shows cash outflow of the strategic plan in economic analysis.

Table 33 Annual Disbursement of Construction Cost

Year	Administration (5% of Direct Cost)	Engineering Service Cost (10% of Direct Cost)	Direct cost	Contingency (10% of Direct Cost) (10% of Direct Cost)	Total construction cost
2004	802	891			1,694
2005	2,101	3,443	22,284	2,228	30,056
2006	2,783	5,821	60,923	6,092	75,620
2007	2,783	5,821	85,275	8,689	102,568
2008	2,645	5,821	73,775	7,539	89,781
2009	1,812	4,355	27,140	2,714	36,021
2010	543	1,086			1,628

Source: JICA Study Team (Unit: US$1,000)

[15] According to the financial statement in 2001, proportion of administration cost to facility O&M cost was 25%. Proportion of commercial cost to facility O&M cost was 65%, but additional commercial cost will be lower than the level, because CEDAE has already have the system for invoicing and collection of water bill.

Table 34 Series of O&M Costs

Year	O&M cost (5% of direct cost)	Additional O&M cost (50% of O&M cost)	Total O&M cost
2008	3,797	1,899	5,696
2009	9,144	4,572	13,717
2010	8,772	4,386	13,158
2011	8,811	4,406	13,217
2012	8,851	4,425	13,276
2013	8,890	4,445	13,335
2014	8,929	4,464	13,393
2015	9,360	4,680	14,040
2016	9,004	4,502	13,506
2017	9,039	4,520	13,559
2018	9,075	4,537	13,612
2019	9,110	4,555	13,666
2020	9,146	4,573	13,719

Source: JICA Study Team (Unit: US$1,000)

Table 35 Cash Outflow of the Priority Projects

Year	Construction cost	Total O&M cost	Residual value	Cash outflow
2004	1,694	0	0	1,694
2005	30,056	0	0	30,056
2006	75,620	0	0	75,620
2007	102,568	0	0	102,568
2008	89,781	5,696	0	95,477
2009	36,021	13,717	0	49,738
2010	1,628	13,158	0	14,786
2011	0	13,217	0	13,217
2012	0	13,276	0	13,276
2013	0	13,335	0	13,335
2014	0	13,393	0	13,393
2015	0	14,040	0	14,040
2016	0	13,506	0	13,506
2017	0	13,559	0	13,559
2018	0	13,612	0	13,612
2019	0	13,666	0	13,666
2020	0	13,719	-208,110	-194,391

Source: JICA Study Team (Unit: US$1,000)

(2) Cash Inflow

In this economic analysis, economic benefit was defined as "the value Guanabara Bay with improved water quality", as same as the economic analysis of the strategic plan. The Study Team introduced Contingent Valuable Method (CVM) to assess the value, and conducted "Economic Benefit Survey" from June to August in 2003.

1) Economic Benefit of the Strategic Plan

In the survey, the Study Team classified beneficiaries into three categories: resident (people living in Rio de Janeiro State), Brazilian tourist, and international tourist. Willingness to pay of a person is calculated though the following question to interviewees, which consist of 238 residents, 103 Brazilian tourists and 58 international tourists.

"A Foundation is established, and constructs wastewater treatment plant. The plant is constructed and operated by contributions from households in Rio de Janeiro State and tourists. This project would improve water quality of Guanabara Bay, and people could have the following benefits:

- *People will enjoy swimming in beaches (Botafogo, Flamengo Niterói, Copacabana, Ipanema, and Leblon). People won't doubt water quality.*
- *Eco-system in Guanabara Bay will recover and people can see fishes and marine creature more in the bay.*
- *People won't smell bad and won't see dirty seawater."*

Result of the survey indicates that willingness of pay per a person is R$8 (resident), R$13 (Brazilian tourist), and R$25 (International tourist), respectively.

2) Assumed Economic Benefit

The statement of water quality condition of Guanagara Bay in the questionnaire shows the target of the strategy plan in 2020. Therefore willingness of pay times number of each category, shown in the third, fifth and seventh column of *Table 36* is economic benefit in each category, and sum of them, shown in the eighth column of *Table 36* presents assumed economic benefit if water quality of Guanabara Bay were improved as same level as 2020 in each year. However it is impossible to achieve the target in 2020 before that, because volume of treated wastewater is different. Therefore economic benefit generated every year comes from proportion of treated wastewater volume to the volume in 2020. *Table 37* shows percentage of treated wastewater volume and actual economic benefit.

Table 36 Calculation of Economic Benefit*

Year	Residents		Brazilian tourists		International tourists		Assumed economic benefit
	Population (persons)	Economic benefit	Population (persons)	Economic benefit	Population (persons)	Economic benefit	
2008	15,450,257	42,621	11,112,599	49,815	5,069,516	43,703	136,139
2009	15,582,987	42,988	11,263,099	50,490	5,272,297	45,451	138,928
2010	15,716,858	43,357	11,415,638	51,174	5,483,189	47,269	141,799
2011	15,830,027	43,669	11,570,243	51,867	5,702,517	49,160	144,695
2012	15,944,010	43,983	11,726,941	52,569	5,930,617	51,126	147,679
2013	16,058,813	44,300	11,885,762	53,281	6,167,842	53,171	150,752
2014	16,174,444	44,619	12,046,733	54,003	6,414,556	55,298	153,920
2015	16,290,907	44,940	12,209,885	54,734	6,671,138	57,510	157,184
2016	16,388,559	45,210	12,375,246	55,475	6,937,983	59,810	160,495
2017	16,486,797	45,481	12,542,847	56,227	7,215,503	62,203	163,910
2018	16,585,624	45,753	12,712,718	56,988	7,504,123	64,691	167,432
2019	16,685,043	46,028	12,884,889	57,760	7,804,288	67,278	171,066
2020	16,785,058	46,304	13,059,392	58,542	8,116,459	69,969	174,815

(Unit: US$1,000)

Note: * Assumed economic benefit if water quality of Guanabara Bay had achieved the target in 2020
Source: JICA Study Team

In *Table 36*, the following methods are used in forecast of resident, Brazilian tourist and International tourist.

- Annual population of Rio de Janeiro State is calculated based on the analysis in the Chapter 4.
- Data on Brazilian tourist was compiled in annual statistical yearbooks (Anuário Estatístico do Estado do Rio de Janairo) until 1995/96. According to the statistical yearbook in 1995/96, Brazilian tourist arrivals in 1995 were 9.3 million and increased 1.4 % annually. These figures are utilized in the forecast until 2020.
- International tourist arrivals to Rio de Janeiro State were estimated from tourist statistics and international tourist survey in 2000 (Estudo da Demanda Turística Internacional 2000). Growth rate of international tourist arrivals to Rio de Janeiro is set as 4%, as well as growth rate from 1999 to 2000.

Table 37 Series of Economic Benefit

Year	Assumed economic benefit	% of treated waste water volume to 2020	Economic benefit
2008	136,139	19	27,657
2009	138,928	42	62,158
2010	141,799	44	65,431
2011	144,695	45	67,109
2012	147,679	45	68,544
2013	150,752	45	68,303
2014	153,920	46	70,275
2015	157,184	46	72,317
2016	160,495	48	76,659
2017	163,910	48	78,290
2018	167,432	48	79,973
2019	171,066	48	81,708
2020	174,815	48	83,499

Source: JICA Study Team (Unit: US$1,000)

(3) Net Cash Flow and Economic Internal Rate of Return

Cash inflow, cash outflow and net cash flow of the priority projects were summarized as *Table 38*, and Economic Internal Rate of Return (EIRR) is 12.9 %.

Table 38 Cash Flow of the Priority Plan

Year	Cash outflow	Cash inflow	Net cash flow
2004	1,694	0	-1,694
2005	30,056	0	-30,056
2006	75,620	0	-75,620
2007	102,568	0	-102,568
2008	95,477	27,657	-67,819
2009	49,738	62,158	12,420
2010	14,786	65,431	50,645
2011	13,217	67,109	53,892
2012	13,276	68,544	55,268
2013	13,335	68,303	54,969
2014	13,393	70,275	56,882
2015	14,040	72,317	58,277
2016	13,506	76,659	63,153
2017	13,559	78,290	64,731
2018	13,612	79,973	66,361
2019	13,666	81,708	68,043
2020	-194,391	83,499	277,890

Source: JICA Study Team (Unit: US$1,000)

(4) Sensitivity Test

Sensitivity of economic analysis is tested for the following four cases:

- Case 1: Willing ness to pay of resident increases 50% to R$12 per a year,
- Case 2: Construction cost increases 10 %,
- Case 3: O&M cost increases 10%,
- Case 4: Combination of Case1 and Case 2.

Table 39 shows results of sensitivity analysis. If willingness to pay of resident increases to R$12, EIRR will increase 1.2 points. On the other hand, construction cost and O&M cost increases 10 %, EIRR will down to 11.5% and 12.6%, respectively. Impact of O&M cost increase is very limited. In combination of Case 1 and Case 2, EIRR downs a little to 12.7%.

Table 39 Results of Sensitivity Analysis

Cases	EIRR
Case 1: Willingness to pay of resident increase R$12	14.1
Case 2: Construction cost increases 10%	11.5
Case 3: O&M cost increases 10%	12.6
Case 4: Combination of Case 1 and Case 2	12.7

Source: JICA Study Team (Unit: %)

(5) Marginal Opportunity Cost of Capital in Brazil and Conclusion of Economic Analysis

Marginal opportunity cost of capital in Brazil is set as 10%, reflecting low economic growth ratio in recent years. It is the same assumption in the economic analysis of the strategic plan.

Sensitivity analysis indicates that even if construction costs or O&M costs increase, the level of EIRR is over the real opportunity cost of capital. Therefore the Study Team concludes that the priority projects have enough economic feasibility.

6. FINANCIAL PLAN

In the financial analysis of the priority project, CEDAE and the State Government are treated as a single project implementation body due to simplification. This section clarifies the demarcation of these organizations. And this section also reports loan conditions and financing methodology when net cash flow is minus in each year.

6.1 ROLES OF CEDAE AND THE STATE GOVERNMENT FOR THE PRIORITY PROJECT

Each cash flow of CEDAE and the State Government is presented in *Table 40* and *Table 41*. Each organization has the following roles for the implementation of the priority plan, respectively.

CEDAE will:

- Prepare finance resource which is not covered by loans in construction stage,
- Operate and maintain sewer facilities,
- Collect user charge, and
- Transfer the amount, which is equal to operational revenue minus O&M cost, to the state government, for interest payment and principal refund.

The State Government will:

- Make loan contract with banks, and Borrow loans,
- Disburse investment expenditure for the priority project,
- Transfer bank loans to CEDAE, and
- Disburse interest payment and principal refund.

Table 40 Cash flow of CEDAE

Year	**Cash inflow**	Transfer from the State Government	Revenue	**Cash outflow**	Construction cost	O&M cost	Transfer to the State Government
2004	**1,196**	1,196		**1,993**	1,993		
2005	**21,206**	21,206		**35,343**	35,343		
2006	**41,510**	41,510		**49,184**	49,184		
2007	**68,945**	68,945		**110,909**	110,909		
2008	**73,253**	60,066	13,187	**109,297**	96,110	6,549	6,638
2009	**60,217**	22,931	37,286	**71,504**	34,218	14,624	22,663
2010	**46,807**	1,152	45,655	**45,655**		16,089	29,566
2011	**46,048**		46,048	**46,048**		16,151	29,898
2012	**46,443**		46,443	**46,443**		16,209	30,234
2013	**46,841**		46,841	**46,841**		16,274	30,567
2014	**47,240**		47,240	**47,240**		16,334	30,906
2015	**47,641**		47,641	**47,641**		16,395	31,246
2016	**48,002**		48,002	**48,002**		16,452	31,550
2017	**48,363**		48,363	**48,363**		16,506	31,857
2018	**48,727**		48,727	**48,727**		16,563	32,164
2019	**49,093**		49,093	**49,093**		16,619	32,474
2020	**49,460**		49,460	**49,460**		16,674	32,786
2021	**49,460**		49,460	**49,460**		16,674	32,786
2022	**49,460**		49,460	**49,460**		16,674	32,786
2023	**49,460**		49,460	**49,460**		16,674	32,786
2024	**49,460**		49,460	**49,460**		16,674	32,786
2025	**49,460**		49,460	**49,460**		16,674	32,786
2026	**49,460**		49,460	**49,460**		16,674	32,786
2027	**49,460**		49,460	**49,460**		16,674	32,786
2028	**49,460**		49,460	**49,460**		16,674	32,786

Source: JICA Study Team

Table 41 Cash flow of the State Government

Year	Cash inflow	Loan from banks	Transfer from CEDAE	Cash outflow	Investment expenditure	Transfer to CEDAE	Interest payment	Principal repayment
2004	**1,196**	1,196		**1,244**		1,196	48	
2005	**21,206**	21,206		**22,102**		21,206	896	
2006	**41,510**	41,510		**64,034**	20,000	41,510	2,524	
2007	**68,945**	68,945		**77,644**	4,000	68,945	4,698	
2008	**66,704**	60,066	6,638	**71,783**	4,000	60,066	7,717	
2009	**45,594**	22,931	22,663	**35,565**	4,000	22,931	8,634	
2010	**30,718**	1,152	29,566	**9,832**		1,152	8,680	
2011	**29,898**		29,898	**20,736**			8,680	12,056
2012	**30,234**		30,234	**20,254**			8,198	12,056
2013	**30,567**		30,567	**19,772**			7,716	12,056
2014	**30,906**		30,906	**19,289**			7,234	12,056
2015	**31,246**		31,246	**18,807**			6,751	12,056
2016	**31,550**		31,550	**18,325**			6,269	12,056
2017	**31,857**		31,857	**17,843**			5,787	12,056
2018	**32,164**		32,164	**17,360**			5,305	12,056
2019	**32,474**		32,474	**16,878**			4,822	12,056
2020	**32,786**		32,786	**16,396**			4,340	12,056
2021	**32,786**		32,786	**15,914**			3,858	12,056
2022	**32,786**		32,786	**15,432**			3,376	12,056
2023	**32,786**		32,786	**14,949**			2,893	12,056
2024	**32,786**		32,786	**14,467**			2,411	12,056
2025	**32,786**		32,786	**13,985**			1,929	12,056
2026	**32,786**		32,786	**13,503**			1,447	12,056
2027	**32,786**		32,786	**13,020**			964	12,056
2028	**32,786**		32,786	**12,538**			482	12,056

Source: JICA Study Team

6.2 LOAN CONDITIONS

The State Government will have two loan agreements with two banks. Loan conditions are set as described below.

In the one side, loan condition is:

- Interest rate is 2.5% per a year,
- Loan period is 25 years, from 2004 to 2028, and
- Grace period is 7 years from 2004 to 2010.

In the other side, loan condition is:

- Interest rate is 5.5% per a year,
- Loan period is 25 years, from 2004 to 2028, and
- Grace period is 7 years from 2004 to 2010.

6.3 FINANCING METHOD

From 2004 to 2009, net cash flow will record red, shown in *Table 42*. Therefore CEDAE and the State Government have to find another finance source. The Study Team recommends using generated cash inflow from decrease of unearned water bill rate and non-revenue water rate.

Table 43 presents the relation between decrease of these rates and generated. If CEDAE is successful in decreasing unearned water bill rate to 10%, it would have US$18 million of cash inflow every year, and If CEDAE is successful in decreasing non-revenue water rate to30%, it would have US$157 million cash inflow every year. A part of these cash inflow should be used for the priority project. Commercial department of CEDAE reports that non-revenue water rate has improved 9% from March to April 2003, due to re-registration of users and replacement of new meter. Therefore CEDAE would have about US$50 million if it could keep the level.

In case CEDAE cannot generate enough cash inflow, CEDAE and the State Government should consider borrow loan from state banks such as Caixa Econômica Federal,and Banco do Brasil.

Table 42 Net Cash Flow of the Priority Project from 2004 to 2010

Year	2004	2005	2006	2007	2008	2009	2010
Net cash flow	-845	-15,033	-30,197	-50,662	-41,123	-1,259	20,118

Source: JICA Study Team (Unit: US$1,000)

Table 43 Relation between Decrease of Two Rates and Generated Cash Inflow

Unearned water bill rate (%)	21*	20	15	10	-	-
generated cash inflow for CEDAE	-	1,987	10,266	18,545	-	-
Non revenue water rate (%)	57**	50	45	40	35	30
generated cash inflow for CEDAE	-	41,325	70,427	99,528	128,630	157,732

Note: * performance in 2001 (Unit: US$1,000)
** performance in 2001

Source: JICA Study Team

Table 44 Cash Outflow by Each Facility (Financial Analysis of the Strategic Plan, 1)

			2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pavuna-Meriti	a WWTP				7436	7436													
	b Sewer			22,612	22,612	22,612	22,612												
	c Direct	a+b		22,612	30,048	30,048	22,612												
	d Indirect	10% of c		2,261	2,261	2,261	2,261												
	e Administration	5% of c	878	878	878	878	878	878											
	f E Service	10% of c	1,755	1,755	1,755	1,755	1,755	1,755											
	g Total Const	c+d+e+f	2,633	27,507	34,943	34,943	27,507	2,633											
	h O&M	5% of c					5,266	5,266	5,266	5,266	5,266	5,266	5,266	5,266	5,266	5,266	5,266	5,266	5,266
	i Other	50% of g					2,633	2,633	2,633	2,633	2,633	2,633	2,633	2,633	2,633	2,633	2,633	2,633	2,633
	j Total O&M	h+i					7,899	7,899	7,899	7,899	7,899	7,899	7,899	7,899	7,899	7,899	7,899	7,899	7,899
	k Res value																		-75,138
Acari	a WWTP					14,147	14,147												
	b Sewer				18,230	18,230	18,230	18,230											
	c Direct	a+b			18,230	32,376	32,376	18,230											
	d Indirect	10% of c			1,823	3,238	3,238	1,823											
	e Administration	5% of c		843	843	843	843	843	843										
	f E Service	10% of c		1,383	1,383	1,383	1,383	1,383	1,383										
	g Total Const	c+d+e+f		2,226	22,279	37,840	37,840	22,279	2,226										
	h O&M	5% of c						4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149
	i Other	50% of g						2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075
	j Total O&M	h+i						6,224	6,224	6,224	6,224	6,224	6,224	6,224	6,224	6,224	6,224	6,224	6,224
	k Res value																		-72,003
Sarapui	a WWTP				5,871	5,871													
	b Sewer			3,604	3,604	3,604	3,604												
	c Direct	a+b		3,604	9,475	9,475	3,604												
	d Indirect	10% of c		360	947	947	360												
	e Administration	5% of c	218	218	218	218	218	218											
	f E Service	10% of c	436	436	436	436	436	436											
	g Total Const	c+d+e+f	654	4,618	11,076	11,076	4,618	654											
	h O&M	5% of c					1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308
	i Other	50% of g					654	654	654	654	654	654	654	654	654	654	654	654	654
	j Total O&M	h+i					1,962	1,962	1,962	1,962	1,962	1,962	1,962	1,962	1,962	1,962	1,962	1,962	1,962
	k Res value																		-17,146
Bangu	a WWTP					13,468	13,468												
	b Sewer				13,699	13,699	13,699	13,699											
	c Direct	a+b			13,699	27,166	27,166	13,699											
	d Indirect	10% of c			1,370	2,717	2,717	1,370											
	e Administration	5% of c		1,022	1,022	1,022	1,022	1,022	1,022										
	f E Service	10% of c		2,043	2,043	2,043	2,043	2,043	2,043										
	g Total Const	c+d+e+f		3,065	18,134	32,948	32,948	18,134	3,065										
	h O&M	5% of c						4,087	4,087	4,087	4,087	4,087	4,087	4,087	4,087	4,087	4,087	4,087	4,087
	i Other	50% of g						2,043	2,043	2,043	2,043	2,043	2,043	2,043	2,043	2,043	2,043	2,043	2,043
	j Total O&M	h+i						6,130	6,130	6,130	6,130	6,130	6,130	6,130	6,130	6,130	6,130	6,130	6,130
	k Res value																		-57,434
Bota	a WWTP															57,753	57,753		
	b Sewer														52,664	52,664	52,664	52,664	
	c Direct	a+b													52,664	110,417	110,417	52,664	
	d Indirect	10% of c													5,266	11,042	11,042	5,266	
	e Administration	5% of c												2,718	2,718	2,718	2,718	2,718	2,718
	f E Service	10% of c												5,436	5,436	5,436	5,436	5,436	5,436
	g Total Const	c+d+e+f												8,154	66,084	129,612	129,612	66,084	8,154
	h O&M	5% of c																13,675	16,308
	i Other	50% of g																6,837	8,154
	j Total O&M	h+i																20,512	24,462
	k Res value																		-309,769

Table 44 Cash Outflow by Each Facility (Financial Analysis of the Strategic Plan, 2)

				2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Iguaçu	a	WWTP																15,189	15,189	
	b	Sewer															8,561	8,561	8,561	8,561
	c	Direct	a+b														8,561	23,750	23,750	8,561
	d	Indirect	10% of c														856	2,375	2,375	856
	e	Administration	5% of c													539	539	539	539	539
	f	E Service	10% of c													1,077	1,077	1,077	1,077	1,077
	g	Total Const	c+d+e+f													1,616	11,033	27,741	27,741	11,033
	h	O&M	5% of c																	3,231
	i	Other	50% of g																	1,616
	j	Total O&M	h+i																	4,847
	k	Res value																		-62,891
Alcantara	a	WWTP											7,034	7,034						
Alcantara	b	Sewer										4,225	4,225	4,225	4,225					
	c	Direct	a+b									4,225	11,258	11,258	4,225					
	d	Indirect	10% of c									422	1,126	1,126	422					
	e	Administration	5% of c								258	258	258	258	258	258				
	f	E Service	10% of c								516	516	516	516	516	516				
	g	Total Const	c+d+e+f								774	5,421	13,158	13,158	5,421	774				
	h	O&M	5% of c												1,548	1,548	1,548	1,548	1,548	1,548
	i	Other	50% of g												774	774	774	774	774	774
	j	Total O&M	h+i												2,322	2,322	2,322	2,322	2,322	2,322
	k	Res value																		-26,028
Alcantara	a	WWTP															18,234	18,234		
Others	b	Sewer														12,323	12,323	12,323	12,323	
	c	Direct	a+b													12,323	30,556	30,556	12,323	
	d	Indirect	10% of c													1,232	3,056	3,056	1,232	
	e	Administration	5% of c												715	715	715	715	715	715
	f	E Service	10% of c												1,429	1,224	2,144	1,635	1,429	1,429
	g	Total Const	c+d+e+f												2,144	15,494	36,470	35,961	15,699	2,144
	h	O&M	5% of c																4,288	4,288
	i	Other	50% of g																2,144	2,144
	j	Total O&M	h+i																6,432	6,432
	k	Res value																		-81,271
Iboassu	a	WWTP											3,979	3,979						
	b	Sewer										1,575	1,575	1,575	1,575					
	c	Direct	a+b									1,575	5,553	5,553	1,575					
	d	Indirect	10% of c									157	555	555	157					
	e	Administration	5% of c								119	119	119	119	119	119				
	f	E Service	10% of c								238	238	238	238	238	238				
	g	Total Const	c+d+e+f								356	2,088	6,465	6,465	2,088	356				
	h	O&M	5% of c												713	713	713	713	713	713
	i	Other	50% of g												356	356	356	356	356	356
	j	Total O&M	h+i												1,069	1,069	1,069	1,069	1,069	1,069
	k	Res value																		-11,853
Total	a	WWTP		0	0	13,307	40,921	27,614	0	0	0	0	11,012	11,012	0	0	75,986	91,175	15,189	0
	b	Sewer		0	26,216	58,145	58,145	58,145	31,928	0	0	5,799	5,799	5,799	5,799	64,987	73,548	73,548	73,548	8,561
	c	Direct	a+b	0	26,216	71,451	99,065	85,759	31,928	0	0	5,799	16,811	16,811	5,799	64,987	149,534	164,723	88,737	8,561
	d	Indirect	10% of c	0	2,622	6,402	9,163	8,576	3,193	0	0	580	1,681	1,681	580	6,499	14,953	16,472	8,874	856
	e	Administration	5% of c	1,096	2,961	2,961	2,961	2,961	2,961	1,865	377	377	377	377	3,810	4,348	3,971	3,971	3,971	3,971
	f	E Service	10% of c	2,191	5,618	5,618	5,618	5,618	5,618	3,426	754	754	754	754	7,619	8,491	8,657	8,148	7,942	7,942
	g	Total Const	c+d+e+f	3,287	37,416	86,431	116,806	102,913	43,699	5,291	1,131	7,510	19,623	19,623	17,808	84,324	177,116	193,314	109,524	21,331
	h	O&M	5% of c	0	0	0	0	6,574	14,809	14,809	14,809	14,809	14,809	14,809	17,071	17,071	17,071	17,071	35,033	40,898
	i	Other	50% of g	0	0	0	0	3,287	7,405	7,405	7,405	7,405	7,405	7,405	8,535	8,535	8,535	8,535	17,517	20,449
	j	Total O&M	h+i	0	0	0	0	9,861	22,214	22,214	22,214	22,214	22,214	22,214	25,606	25,606	25,606	25,606	52,550	61,346
	k	Res value		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-713,532

Table 45 Cash Inflow by Each Facility (Financial Analysis of the Strategic Plan)

			2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Existing capacity	Capacity to be increased
Pavuna-Meriti	Pavuna	Wastewater flow (l/s)	1,173	1,496	1,690	1,909	2,156	2,435	2,751	2,762	2,774	2,785	2,797	2,808	2,818	2,829	2,839	2,850	2,860	1,500	1,500
		Increased wastewater volume (l/s)					656	935	1,251	1,262	1,274	1,285	1,297	1,308	1,318	1,329	1,339	1,350	1,360		
		Increased wastewater volume (m3/year)					20,690	29,500	39,452	39,808	40,166	40,526	40,887	41,249	41,575	41,901	42,229	42,559	42,889		
	Acari	Wastewater flow (l/s)	211	215	295	404	555	761	1,043	1,047	1,051	1,056	1,060	1,064	1,068	1,072	1,076	1,080	1,084	0	1,100
		Increased wastewater volume (l/s)						761	1,043	1,047	1,051	1,056	1,060	1,064	1,068	1,072	1,076	1,080	1,084		
		Increased wastewater volume (m3/year)						23,984	32,892	33,023	33,155	33,288	33,421	33,554	33,680	33,805	33,931	34,058	34,185		
Sarapui	Sarapui	Wastewater flow (l/s)	1,146	1,653	1,769	1,893	2,026	2,168	2,320	2,336	2,353	2,369	2,386	2,403	2,418	2,434	2,449	2,464	2,480	1,500	1,000
		Increased wastewater volume (l/s)					526	668	820	836	853	869	886	903	918	934	949	964	980		
		Increased wastewater volume (m3/year)					16,582	21,064	25,860	26,376	26,895	27,419	27,946	28,477	28,957	29,439	29,925	30,413	30,905		
Bangu	Bangu	Wastewater flow (l/s)	0	0					978	981	985	988	992	995	998	1,001	1,003	1,006	1,009	0	1,000
		Increased wastewater volume (l/s)						978	978	981	985	988	992	995	998	1,001	1,003	1,006	1,009		
		Increased wastewater volume (m3/year)						30,842	30,842	30,949	31,056	31,163	31,270	31,378	31,466	31,554	31,642	31,731	31,820		
Bota	Bota	Wastewater flow (l/s)	0	0					92					97					3,154	100	3,110
		Increased wastewater volume (l/s)																3,054	3,054		
		Increased wastewater volume (m3/year)																96,311	96,311		
Iguacu	Iguacu	Wastewater flow (l/s)	0	0					0					0					631	0	640
		Increased wastewater volume (l/s)																631	631		
		Increased wastewater volume (m3/year)																19,899	19,899		
Alcantara	Alcantara	Wastewater flow (l/s)	0	0					0										233	0	240
		Increased wastewater volume (l/s)												233	233	233	233	233	233		
		Increased wastewater volume (m3/year)												7,348	7,348	7,348	7,348	7,348	7,348		
	Others	Wastewater flow (l/s)	0	0					0					0					692	0	700
		Increased wastewater volume (l/s)																692	692		
		Increased wastewater volume (m3/year)																21,823	21,823		
Iboassu	Iboassu	Wastewater flow (l/s)	121	646					687					726	753	780	809	838	869	765	110
		Increased wastewater volume (l/s)												0	753	780	809	838	869		
		Increased wastewater volume (m3/year)												0	23,733	24,602	25,503	26,437	27,405		
Total		Increased wastewater volume (m3/year)					37,273	105,390	129,045	130,156	131,273	132,395	133,524	142,007	166,758	168,650	170,579	290,680	292,686	3,865	9,400
	1.14	Tariff per a cubic meter (R$/m3)					13,187	37,286	45,655	46,048	46,443	46,841	47,240	50,241	58,998	59,667	60,350	102,840	103,550		
	0.39	Tariff per a cubic meter (US$/m3)																			
	10%	Unearned water bill rate from 2008																			

Table 46 Cash Outflow by Each Facility (Economic Analysis of the Strategic Plann, 1)

			2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pavuna-Meriti	a WWTP				6,469	6,469													
	b Sewer			19,220	19,220	19,220	19,220												
	c Direct	a+b		19,220	25,690	25,690	19,220												
	d Indirect	10% of c		1,922	2,569	2,569	1,922												
	e Administration	5% of c	749	749	749	749	749	749											
	f E Service	10% of c	1,497	1,497	1,497	1,497	1,497	1,497											
	g Total Const	c+d+e+f	2,246	23,388	30,504	30,504	23,388	2,246											
	h O&M	5% of c					4,491	4,491	4,491	4,491	4,491	4,491	4,491	4,491	4,491	4,491	4,491	4,491	4,491
	i Other	50% of g					2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246
	j Total O&M	h+i					6,737	6,737	6,737	6,737	6,737	6,737	6,737	6,737	6,737	6,737	6,737	6,737	6,737
	k Res value																		-64,031
Acari	a WWTP					12,307	12,307												
	b Sewer				15,495	15,495	15,495	15,495											
	c Direct	a+b			15,495	27,803	27,803	15,495											
	d Indirect	10% of c			1,550	2,780	2,780	1,550											
	e Administration	5% of c		722	722	722	722	722	722										
	f E Service	10% of c		1,443	1,443	1,443	1,443	1,443	1,443										
	g Total Const	c+d+e+f		2,165	19,209	32,748	32,748	19,209	2,165										
	h O&M	5% of c						4,330	4,330	4,330	4,330	4,330	4,330	4,330	4,330	4,330	4,330	4,330	4,330
	i Other	50% of g						2,165	2,165	2,165	2,165	2,165	2,165	2,165	2,165	2,165	2,165	2,165	2,165
	j Total O&M	h+i						6,495	6,495	6,495	6,495	6,495	6,495	6,495	6,495	6,495	6,495	6,495	6,495
	k Res value																		-61,534
Sarapui	a WWTP				5,107	5,107													
	b Sewer			3,063	3,063	3,063	3,063												
	c Direct	a+b		3,063	8,171	8,171	3,063												
	d Indirect	10% of c		306	817	817	306												
	e Administration	5% of c	187	187	187	187	187	187											
	f E Service	10% of c	374	374	374	374	374	374											
	g Total Const	c+d+e+f	562	3,931	9,550	9,550	3,931	562											
	h O&M	5% of c					1,123	1,123	1,123	1,123	1,123	1,123	1,123	1,123	1,123	1,123	1,123	1,123	1,123
	i Other	50% of g					562	562	562	562	562	562	562	562	562	562	562	562	562
	j Total O&M	h+i					1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685	1,685
	k Res value																		-14,703
Bangu	a WWTP					11,717	11,717												
	b Sewer				11,644	11,644	11,644	11,644											
	c Direct	a+b			11,644	23,361	23,361	11,644											
	d Indirect	10% of c			1,164	2,336	2,336	1,164											
	e Administration	5% of c		583	583	583	583	583	583										
	f E Service	10% of c		1,167	1,167	1,167	1,167	1,167	1,167										
	g Total Const	c+d+e+f		1,750	14,559	27,447	27,447	14,559	1,750										
	h O&M	5% of c						3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
	i Other	50% of g						1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
	j Total O&M	h+i						5,251	5,251	5,251	5,251	5,251	5,251	5,251	5,251	5,251	5,251	5,251	5,251
	k Res value																		-49,134
Bota	a WWTP															49,761	49,761		
	b Sewer														44,764	44,764	44,764	44,764	
	c Direct	a+b													44,764	94,526	94,526	44,764	
	d Indirect	10% of c													4,476	9,453	9,453	4,476	
	e Administration	5% of c												2,322	2,322	2,322	2,322	2,322	2,322
	f E Service	10% of c												4,643	4,643	4,643	4,643	4,643	4,643
	g Total Const	c+d+e+f												6,965	56,205	110,943	110,943	56,205	6,965
	h O&M	5% of c																13,929	13,929
	i Other	50% of g																6,965	6,965
	j Total O&M	h+i																20,894	20,894
	k Res value																		-264,554

Table 46 Cash Outflow by Each Facility (Economic Analysis of the Strategic Plan, 2)

			2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Iguaçu	a WWTP																13,130	13,130	
	b Sewer															7,277	7,277	7,277	7,277
	c Direct	a+b														7,277	20,407	20,407	7,277
	d Indirect	10% of c														728	2,041	2,041	728
	e Administration	5% of c													461	461	461	461	461
	f E Service	10% of c													923	923	923	923	923
	g Total Const	c+d+e+f													1,384	9,389	23,832	23,832	9,389
	h O&M	5% of c																	2,768
	i Other	50% of g																	1,384
	j Total O&M	h+i																	4,153
	k Res value																		-53,881
Alcantara	a WWTP											5,945	5,945						
Alcantara	b Sewer										3,591	3,591	3,591	3,591					
	c Direct	a+b									3,591	9,536	9,536	3,591					
	d Indirect	10% of c									359	954	954	359					
	e Administration	5% of c								219	219	219	219	219	219				
	f E Service	10% of c								438	438	438	438	438	438				
	g Total Const	c+d+e+f								656	4,606	11,146	11,146	4,606	656				
	h O&M	5% of c												1,313	1,313	1,313	1,313	1,313	1,313
	i Other	50% of g												656	656	656	656	656	656
	j Total O&M	h+i												1,969	1,969	1,969	1,969	1,969	1,969
	k Res value																		-22,070
Alcantara	a WWTP															18,234	18,234		
Others	b Sewer														12,323	12,323	12,323	12,323	
	c Direct	a+b													12,323	30,556	30,556	12,323	
	d Indirect	10% of c													1,232	3,056	3,056	1,232	
	e Administration	5% of c												715	715	715	715	715	715
	f E Service	10% of c												1,429	1,224	2,144	1,635	1,429	1,429
	g Total Const	c+d+e+f												2,144	15,494	36,470	35,961	15,699	2,144
	h O&M	5% of c																4,288	4,288
	i Other	50% of g																2,144	2,144
	j Total O&M	h+i																6,432	6,432
	k Res value																		-81,271
Iboassu	a WWTP											3,461	3,461						
	b Sewer										1,338	1,338	1,338	1,338					
	c Direct	a+b									1,338	4,800	4,800	1,338					
	d Indirect	10% of c									134	480	480	134					
	e Administration	5% of c								102	102	102	102	102	102				
	f E Service	10% of c								205	205	205	205	205	205				
	g Total Const	c+d+e+f								307	1,779	5,586	5,586	1,779	307				
	h O&M	5% of c												614	614	614	614	614	614
	i Other	50% of g												307	307	307	307	307	307
	j Total O&M	h+i												921	921	921	921	921	921
	k Res value																		-10,201
Total	a WWTP				11,577	35,601	24,024					9,406	9,406			65,327	78,457	13,130	
	b Sewer			22,284	49,423	49,423	49,423	27,139			4,929	4,929	4,929	4,929	55,239	62,516	62,516	62,516	7,277
	c Direct	a+b		22,284	60,999	85,024	73,447	27,139			4,929	14,335	14,335	4,929	55,239	127,843	140,973	75,646	7,277
	d Indirect	10% of c		2,228	6,100	8,502	7,345	2,714			493	1,434	1,434	493	5,524	12,784	14,097	7,565	728
	e Administration	5% of c	936	2,241	2,241	2,241	2,241	2,241	1,305	321	321	321	321	3,251	3,713	3,391	3,391	3,391	3,391
	f E Service	10% of c	1,871	4,482	4,482	4,482	4,482	4,482	2,610	642	642	642	642	6,502	7,425	6,783	6,783	6,783	6,783
	g Total Const	c+d+e+f	2,807	31,235	73,822	100,248	87,514	36,575	3,915	963	6,386	16,732	16,732	15,176	71,900	150,802	165,245	93,385	18,179
	h O&M	5% of c					5,614	13,445	13,445	13,445	13,445	13,445	13,445	15,371	15,371	15,371	15,371	32,952	35,720
	i Other	50% of g					2,807	6,722	6,722	6,722	6,722	6,722	6,722	7,686	7,686	7,686	7,686	16,476	17,860
	j Total O&M	h+i					8,422	20,167	20,167	20,167	20,167	20,167	20,167	23,057	23,057	23,057	23,057	49,427	53,580
	k Res value																		-609,315

Table 47 Cash Outflow by Each Facility (Financial Analysis of the Priority Project, 1)

				2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021-2028
Pavuna	Sewer	Admin	5% of Const	814	814	814	814	814	452												
		ES	10% of Const	905	1,809	1,809	1,809	1,809	904												
		Construction			22,612	22,612	22,612	22,613													
		Contingency	10% of Const		2,261	2,261	2,261	2,262													
		Total		1,719	27,496	27,496	27,496	27,498	1,356												
	WWTP	Admin	5% of Const		208	208	208	120													
		ES	10% of Const		372	372	372	371													
		Construction				7,436	7,436														
		Land Acquisition	10% of Const																		
		Contingency				744	743														
		Total			580	8,760	8,759	491													
	Total	Admin	5% of Const	814	1,022	1,022	1,022	934	452												
		ES	10% of Const	905	2,181	2,181	2,181	2,180	904												
		Construction			22,612	30,048	30,048	22,613													
		Land Acquisition																			
		Contingency			2,261	3,005	3,004	2,262													
		Total		1,719	28,076	36,256	36,255	27,989	1,356												
	Cap ratio		1(1.5 m3/s)					0.91	0.91	0.92	0.92	0.92	0.93	0.93	0.94	0.94	0.94	0.95	0.95	0.95	
	For WWTP		2962					2,694	2,705	2,717	2,728	2,739	2,751	2,762	2,773	2,784	2,794	2,804	2,814	2,824	2,824
	For Sewer		621					0	621	621	621	621	621	621	621	621	621	621	621	621	621
	Total		3583					2,694	3,326	3,338	3,349	3,360	3,372	3,383	3,394	3,405	3,415	3,425	3,435	3,445	3,445
Acari	Sewer	Admin	5% of Const		656	656	656	656	656	366											
		ES	10% of Const		729	1,458	1,458	1,458	1,458	731											
		Construction				18,230	18,230	18,230	18,228												
		Contingency	10% of Const			1,823	1,823	1,823	1,823												
		Total			1,385	22,167	22,167	22,167	22,165	1,097											
	WWTP	Admin	5% of Const			396	396	396	227												
		ES	10% of Const			707	707	707	708												
		Construction					14,147	14,146													
		Land Acquisition																			
		Contingency					1,415	1,414													
		Total				1,103	16,665	16,663	935												
	Total	Admin	5% of Const		656	1,052	1,052	1,052	883	366											
		ES	10% of Const		729	2,165	2,165	2,165	2,166	731											
		Construction				18,230	32,377	32,376	18,228												
		Land Acquisition	10% of Const																		
		Contingency				1,823	3,238	3,237	1,823												
		Total			1,385	23,270	38,832	38,830	23,100	1,097											
	Cap ratio		1 (1.1 m3/s)						0.94	0.95	0.95	0.96	0.96	0.96	0.97	0.97	0.97	0.98	0.98	0.99	
	For WWTP		2503						2,362	2,373	2,383	2,392	2,402	2,412	2,422	2,431	2,440	2,449	2,458	2,467	2,467
	For Sewer		518						0	518	518	518	518	518	518	518	518	518	518	518	518
	Total		3021						2,362	2,891	2,901	2,910	2,920	2,930	2,940	2,949	2,958	2,967	2,976	2,985	2,985
Sarapui	Sewer	Admin	5% of Const	130	130	130	130	130	71												
		ES	10% of Const	144	288	288	288	288	146												
		Construction			3,604	3,604	3,604	3,604													
		Contingency	10% of Const		361	361	361	359													
		Total		274	4,383	4,383	4,383	4,381	217												
	WWTP	Admin	5% of Const		164	164	164	95													
		ES	10% of Const		294	294	294	292													
		Construction				5,871	5,870														
		Land Acquisition																			
		Contingency				587	587														
		Total			458	6,916	6,915	387													
	Total	Admin	5% of Const	130	294	294	294	225	71												
		ES	10% of Const	144	582	582	582	580	146												
		Construction			3,604	9,475	9,474	3,604													
		Land Acquisition																			
		Contingency			361	948	948	359													
		Total		274	4,841	11,299	11,298	4,768	217												
	Cap ratio		1 (1.0 m3/s)					0.84	0.85	0.86	0.86	0.87	0.88	0.88	0.89	0.89	0.90	0.91	0.91	0.92	0.92
	For WWTP		1980					1,672	1,686	1,700	1,712	1,724	1,737	1,749	1,761	1,772	1,783	1,795	1,806	1,818	1,818
	For Sewer		104						104	104	104	104	104	104	104	104	104	104	104	104	104
	Total		2084					1,672	1,790	1,804	1,816	1,828	1,841	1,853	1,865	1,876	1,887	1,899	1,910	1,922	1,922

Table 47 Cash Outflow by Each Facility (Financial Analysis of the Priority Project, 2)

				2004	2005	2006	2007	2008	2009	2010	2011	2012
Bangu	Sewer	Admin	5% of Const		493	493	493	493	493	275		
		ES	10% of Const		548	1,096	1,096	1,096	1,096	548		
		Construction				13,699	13,699	13,699	13,698			
		Contingency	10% of Const			1,370	1,370	1,370	1,370			
		Total			1,041	16,658	16,658	16,658	16,657	823		
	WWTP	Admin	5% of Const			377	377	377	216			
		ES	10% of Const			674	674	674	672			
		Construction					13,468	13,467				
		Land Acquisition				650						
		Contingency					1,347	1,347				
		Total				1,701	15,866	15,865	888			
	Total	Admin	5% of Const		493	870	870	870	709	275		
		ES	10% of Const		548	1,770	1,770	1,770	1,768	548		
		Construction				13,699	27,167	27,166	13,698			
		Land Acquisition				650						
		Contingency				1,370	2,717	2,717	1,370			
		Total			1,041	18,359	32,524	32,523	17,545	823		
	Cap ratio		1 (1.0 m3/s)						0.97	0.98	0.98	0.98
	For WWTP		2329						2,271	2,279	2,287	2,294
	For Sewer		414						0	414	414	414
	Total		2743						2,271	2,693	2,701	2,708
Total	Sewer	Admin	5% of Const	944	2,093	2,093	2,093	2,093	1,672	641		
		ES	10% of Const	1,049	3,374	4,651	4,651	4,651	3,604	1,279		
		Construction			26,216	58,145	58,145	58,146	31,926			
		Contingency	10% of Const		2,622	5,815	5,815	5,814	3,193			
		Total		1,993	34,305	70,704	70,704	70,704	40,395	1,920		
	WWTP	Admin	5% of Const		372	1,145	1,145	988	443			
		ES	10% of Const		666	2,047	2,047	2,044	1,380			
		Construction				13,307	40,921	27,613				
		Land Acquisition				650						
		Contingency				1,331	4,092	2,761				
		Total			1,038	18,480	48,205	33,406	1,823			
	Total	Admin	5% of Const	944	2,465	3,238	3,238	3,081	2,115	641		
		ES	10% of Const	1,049	4,040	6,698	6,698	6,695	4,984	1,279		
		Construction			26,216	71,452	99,066	85,759	31,926			
		Land Acquisition	10% of Const			650						
		Contingency			2,622	7,146	9,907	8,575	3,193			
		Total		1,993	35,343	89,184	118,909	104,110	42,218	1,920		
	For WWTP		2329					4,366	9,024	9,069	9,110	9,149
	For Sewer		414						725	1,657	1,657	1,657
	Direct O&M		2743					4,366	9,749	10,726	10,767	10,806
	Overhead		50%					2,183	4,875	5,363	5,384	5,403
	Total O&M							6,549	14,624	16,089	16,151	16,209
	Res Value											

				2013	2014	2015	2016	2017	2018	2019	2020	2021-2028
Bangu	Sewer	Admin	5% of Const									
		ES	10% of Const									
		Construction										
		Contingency	10% of Const									
		Total										
	WWTP	Admin	5% of Const									
		ES	10% of Const									
		Construction										
		Land Acquisition										
		Contingency										
		Total										
	Total	Admin	5% of Const									
		ES	10% of Const									
		Construction										
		Land Acquisition										
		Contingency										
		Total										
	Cap ratio		1 (1.0 m3/s)	0.99	0.99	0.99	1.00	1.00	1.00	1.01	1.01	1.01
	For WWTP		2329	2,302	2,309	2,317	2,324	2,330	2,337	2,344	2,350	2,350
	For Sewer		414	414	414	414	414	414	414	414	414	414
	Total		2743	2,716	2,723	2,731	2,738	2,744	2,751	2,758	2,764	2,764
Total	Sewer	Admin	5% of Const									
		ES	10% of Const									
		Construction										
		Contingency	10% of Const									
		Total										
	WWTP	Admin	5% of Const									
		ES	10% of Const									
		Construction										
		Land Acquisition										
		Contingency										
		Total										
	Total	Admin	5% of Const									
		ES	10% of Const									
		Construction										
		Land Acquisition	10% of Const									
		Contingency										
		Total										
	For WWTP		2329	9,192	9,232	9,273	9,311	9,347	9,385	9,422	9,459	9,459
	For Sewer		414	1,657	1,657	1,657	1,657	1,657	1,657	1,657	1,657	1,657
	Direct O&M		2743	10,849	10,889	10,930	10,968	11,004	11,042	11,079	11,116	11,116
	Overhead		50%	5,425	5,445	5,465	5,484	5,502	5,521	5,540	5,558	5,558
	Total O&M			16,274	16,334	16,395	16,452	16,506	16,563	16,619	16,674	16,674
	Res Value											-181,229

Table 48 Cash Inflow by Each Facility (Financial Analysis of the Priority Project)

		2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020-2028	Existing Capacity	Capacity to be increased
Pavuna	Wastewater flow (l/s)	1,173	1,496	1,690	1,909	2,156	2,435	2,751	2,762	2,774	2,785	2,797	2,808	2,818	2,829	2,839	2,850	2,860	1,500	1,500
	Increased wastewater volume (l/s)		0			656	935	1,251	1,262	1,274	1,285	1,297	1,308	1,318	1,329	1,339	1,350	1,360		
	Increased wastewater volume (m3/year)					20,690	29,500	39,452	39,808	40,166	40,526	40,887	41,249	41,575	41,901	42,229	42,559	42,889		
Acari	Wastewater flow (l/s)	211	215	295	404	555	761	1,043	1,047	1,051	1,056	1,060	1,064	1,068	1,072	1,076	1,080	1,084	0	1,100
	Increased wastewater volume (l/s)		0				761	1,043	1,047	1,051	1,056	1,060	1,064	1,068	1,072	1,076	1,080	1,084		
	Increased wastewater volume (m3/year)						23,984	32,892	33,023	33,155	33,288	33,421	33,554	33,680	33,805	33,931	34,058	34,185		
Sarapui	Wastewater flow (l/s)	1,146	1,653	1,769	1,893	2,026	2,168	2,320	2,336	2,353	2,369	2,386	2,403	2,418	2,434	2,449	2,464	2,480	1,500	1,000
	Increased wastewater volume (l/s)		0			526	668	820	836	853	869	886	903	918	934	949	964	980		
	Increased wastewater volume (m3/year)					16,582	21,064	25,860	26,376	26,895	27,419	27,946	28,477	28,957	29,439	29,925	30,413	30,905		
Bangu	Wastewater flow (l/s)	0	0					978	981	985	988	992	995	998	1,001	1,003	1,006	1,009	0	1,000
	Increased wastewater volume (l/s)		0				978	978	981	985	988	992	995	998	1,001	1,003	1,006	1,009		
	Increased wastewater volume (m3/year)						30,842	30,842	30,949	31,056	31,163	31,270	31,378	31,466	31,554	31,642	31,731	31,820		
Total						37,273	105,390	129,045	130,156	131,273	132,395	133,524	134,659	135,677	136,700	137,728	138,761	139,799		
1.14	Tariff per a cubic meter (R$/m3)																			
0.39	Tariff per a cubic meter (US$/m3)					13,187	37,286	45,655	46,048	46,443	46,841	47,240	47,641	48,002	48,363	48,727	49,093	49,460		
10%	Unearned water bill rate																			

Table 49 Cash Outflow by Each Facility (Economic Analysis of the Priority Project, 1)

				2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pavuna	Sewer	Admin	5% of Const	692	692	692	692	692	384											
		ES	10% of Const	769	1,538	1,538	1,538	1,538	769											
		Construction			19,220	19,220	19,220	19,220												
		Contingency	10% of Const		1,922	1,922	1,922	1,922												
		Total		1,461	23,372	23,372	23,372	23,372	1,153											
	WWTP	Admin	5% of Const		180	180	180	103												
		ES	10% of Const		322	322	322	322												
		Construction				6,433	6,433													
		Land Acquisition	10% of Const																	
		Contingency				643	643													
		Total			502	7,578	7,578	425												
	Total	Admin	5% of Const	692	872	872	872	795	384											
		ES	10% of Const	769	1,859	1,859	1,859	1,859	769											
		Construction			19,220	25,653	25,653	19,220												
		Land Acquisition																		
		Contingency			1,922	2,565	2,565	1,922												
		Total		1,461	23,874	30,950	30,950	23,796	1,153											
	Cap ratio		1(1.5 m3/s)					0.91	0.91	0.92	0.92	0.92	0.93	0.93	0.94	0.94	0.94	0.95	0.95	0.95
	For WWTP		2962					2,343	2,353	2,363	2,373	2,383	2,393	2,402	2,412	2,421	2,430	2,439	2,448	2,457
	For Sewer		621						482	484	486	488	490	492	494	496	498	500	501	503
	Total		3583					2,343	2,835	2,847	2,859	2,871	2,883	2,895	2,906	2,917	2,928	2,938	2,949	2,960
Acari	Sewer	Admin	5% of Const		558	558	558	558	558	310										
		ES	10% of Const		620	1,240	1,240	1,240	1,240	620										
		Construction				15,496	15,496	15,496	15,496											
		Contingency	10% of Const			1,550	1,550	1,550	1,550											
		Total			1,178	18,843	18,843	18,843	18,843	930										
	WWTP	Admin	5% of Const			350	350	350	200											
		ES	10% of Const			700	700	700	700											
		Construction					12,495	12,495												
		Land Acquisition																		
		Contingency					1,250	1,250												
		Total				1,050	14,794	14,794	900											
	Total	Admin	5% of Const		558	908	908	908	758	310										
		ES	10% of Const		620	1,939	1,939	1,939	1,939	620										
		Construction				15,496	27,991	27,991	15,496											
		Land Acquisition	10% of Const																	
		Contingency				1,550	2,799	2,799	1,550											
		Total			1,178	19,892	33,637	33,637	19,742	930										
	Cap ratio		1 (1.1 m3/s)						0.94	0.95	0.95	0.96	0.96	0.96	0.97	0.97	0.97	0.98	0.98	0.99
	For WWTP		2503						2,054	2,064	2,072	2,081	2,089	2,098	2,107	2,114	2,122	2,130	2,138	2,146
	For Sewer		518						415	0	0	0	0	0	392	0	0	0	0	0
	Total		3021						2,469	2,064	2,072	2,081	2,089	2,098	2,498	2,114	2,122	2,130	2,138	2,146
Sarapui	Sewer	Admin	5% of Const	110	110	110	110	110	61											
		ES	10% of Const	123	245	245	245	245	123											
		Construction			3,063	3,063	3,063	3,063												
		Contingency	10% of Const		306	306	306	306												
		Total		233	3,725	3,725	3,725	3,725	184											
	WWTP	Admin	5% of Const		142	142	142	81												
		ES	10% of Const		253	253	253	253												
		Construction				5,067	5,067													
		Land Acquisition																		
		Contingency				507	507													
		Total			395	5,968	5,968	334												
	Total	Admin	5% of Const	110	252	252	252	191	61											
		ES	10% of Const	123	498	498	498	498	123											
		Construction			3,063	8,130	8,130	3,063												
		Land Acquisition																		
		Contingency			306	813	813	306												
		Total		233	4,120	9,693	9,693	4,059	184											
	Cap ratio		1 (1.0 m3/s)					0.84	0.85	0.86	0.86	0.87	0.88	0.88	0.89	0.89	0.90	0.91	0.91	0.92
	For WWTP		1980					1,454	1,466	1,479	1,489	1,500	1,510	1,521	1,532	1,541	1,551	1,561	1,571	1,581
	For Sewer		104						75	76	76	77	78	78	79	79	80	80	81	81
	Total		2084					1,454	1,542	1,555	1,566	1,577	1,588	1,599	1,610	1,620	1,631	1,641	1,652	1,662

Table 49 Cash Outflow by Each Facility (Economic Analysis of the Priority Project, 2)

				2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Bangu	Sewer	Admin	5% of Const		419	419	419	419	419	233										
		ES	10% of Const		466	932	932	932	932	466										
		Construction				11,644	11,644	11,644	11,644											
		Contingency	10% of Const			1,164	1,164	1,164	1,164											
		Total			885	14,159	14,159	14,159	14,159	699										
	WWTP	Admin	5% of Const			332	332	332	190											
		ES	10% of Const			593	593	593	593											
		Construction					11,857	11,857												
		Land Acquisition				0														
		Contingency					1,347	1,347												
		Total				925	14,129	14,129	783											
	Total	Admin	5% of Const		419	751	751	751	609	233										
		ES	10% of Const		466	1,524	1,524	1,524	1,524	466										
		Construction				11,644	23,501	23,501	11,644											
		Land Acquisition																		
		Contingency				1,164	2,511	2,511	1,164											
		Total			885	15,084	28,288	28,288	14,942	699										
	Cap ratio		1 (1.0 m3/s)						0.97	0.98	0.98	0.98	0.99	0.99	0.99	1.00	1.00	1.00	1.01	1.01
	For WWTP		2329						1,975	1,982	1,989	1,996	2,002	2,009	2,015	2,021	2,027	2,033	2,039	2,044
	For Sewer		414						323	324	325	326	327	328	329	330	331	332	333	334
	Total		2743						2,298	2,306	2,314	2,322	2,330	2,337	2,345	2,352	2,358	2,365	2,372	2,378
Total	Sewer	Admin	5% of Const	802	1,779	1,779	1,779	1,779	1,423	543										
		ES	10% of Const	891	2,868	3,954	3,954	3,954	3,063	1,086										
		Construction			22,284	49,423	49,423	49,423	27,140											
		Contingency	10% of Const		2,228	4,942	4,942	4,942	2,714											
		Total		1,694	29,159	60,099	60,099	60,099	34,339	1,628										
	WWTP	Admin	5% of Const		322	1,004	1,004	866	390											
		ES	10% of Const		575	1,868	1,868	1,868	1,293											
		Construction				11,500	35,852	24,352												
		Land Acquisition																		
		Contingency				1,150	3,746	2,597												
		Total			897	15,521	42,470	29,682	1,682											
	Total	Admin	5% of Const	802	2,101	2,783	2,783	2,645	1,812	543										
		ES	10% of Const	891	3,443	5,821	5,821	5,821	4,355	1,086										
		Construction			22,284	60,923	85,275	73,775	27,140											
		Land Acquisition	10% of Const																	
		Contingency			2,228	6,092	8,689	7,539	2,714											
		Total		1,694	30,056	75,620	102,568	89,781	36,021	1,628										
	For WWTP		2329					3,797	7,849	7,888	7,924	7,959	7,995	8,030	8,066	8,099	8,131	8,163	8,195	8,228
	For Sewer		414					0	1,295	884	888	891	895	899	1,294	905	909	912	915	918
	Direct O&M		2743					3,797	9,144	8,772	8,811	8,851	8,890	8,929	9,360	9,004	9,039	9,075	9,110	9,146
	Overhead		50%					1,899	4,572	4,386	4,406	4,425	4,445	4,464	4,680	4,502	4,520	4,537	4,555	4,573
	Total O&M							5,696	13,717	13,158	13,217	13,276	13,335	13,393	14,040	13,506	13,559	13,612	13,666	13,719
	Res Value																			-208,110

SUPPORTING 13

CONSIDERATION OF FAVELAS

TABLE OF CONTENTS

Page

LIST OF TABLES

SUPPORTING 13 CONSIDERATION ON FAVELAS

1. INTRODUCTION

The so-called "Favela" is generally understood to be a settlement that develops spontaneously out of areas that are designated as housing allotment projects, and without proper provision of social infrastructure and public services. According to the last IBGE Census 2000, population living in Favelas accounted for as much as 11.5% of the total population of the municipalities of the Study Area. Favelas, therefore, are not negligible in the sewerage planning of the basin as a potential pollution source, as well as in terms of an equal distribution of social services.

From such viewpoints, the Study made attempts to investigate the actual conditions of Favelas. After reviewing several previous surveys and studies, the Study Team found out that Favelas are not the only manner the low income or destitute population finds to provide for housing (what includes alternatives such as irregular land allotment projects, invasion of land in an organized manner, among others). However, the Study decided to concentrate the analysis only on Favelas considering that their definition is clear according to IBGE: subnormal agglomerations formed by more than 50 residential units disposed in a disorganized and dense manner, on a land belonging to third party, and lacking essential public services. Furthermore, the IBGE Census 2000 covers the entire Study Area (in fact, it covers entire Brazil) while other studies cover only one municipality or parts of the Study Area.

The Study also collected some valuable information about Favelas through the people's awareness survey conducted in this stage and provided in this item.

2. SUBNORMAL AGGLOMERATIONS (FAVELAS) - IBGE 2000 CENSUS

The analysis of the IBGE 2000 Census data was carried out considering the whole population and number of private permanent residences and family heads of the 15 municipalities that compose the Study Area. The municipality of Mesquita was not included because in 2000 it was undivided from Nova Iguaçu. It must be said thought that the analyzed figures refer to the whole municipalities although some of them (Rio de Janeiro, Niterói, Nova Iguaçu, Petrópolis, Cachoeiras de Macacu and Rio Bonito) are only partially included in the Guanabara Bay Basin, our Study Area.

2.1 POPULATION

Population living in Favelas by each municipality, calculated based on the preliminary results of Census 2000, are shown in the *Table 1*.

In the Study Area, Rio de Janeiro city is the one with the highest percentage of its population living in Favelas accounting for not less than 18.7% of the total. In second position, Niterói comes with 11% of its population living in Favelas, closely followed by Magé (8.1%) and Duque de Caxias (7.5%).

2.2 TYPE OF RESIDENCE

The residences in Favelas are mainly single houses (one or two storey houses), although this is the main trend also for other locations in the municipalities of the Study Area. The following comparison table presents the percentage of each type of residence according to location.

	Single Houses	Apartments	Only One Room*
Favelas	92.1%	4.3%	3.7%
Municipalities of the Study Area	73.3%	25.1%	1.5%
Rio de Janeiro State	77.7%	20.9%	1.4%

Note: (*) This means that the family lives in a residence with one room only.

2.3 SOLID WASTE COLLECTION

The solid waste collection rate is, in average, higher than 90% at the Favelas. The lowest coverage rate is observed at the Favelas in São Gonçalo (1.7%), although in absolute figures the number of residences there is also low (58).

However, in Favelas the collection rate from containers represents as much as 37.3% of the solid waste produced by the residences. This means that not a negligible number of residents of Favelas have to take their solid waste to a nearby container to be collected by the municipal collection service what implies that the access of collection trucks is somehow hindered in these locations.

The collection rate from containers is particularly high in Favelas located in Niterói, Cachoeiras do Macacu and Rio de Janeiro (66.4%, 53.3% and 38.7%, respectively) which could be a sign of a highly disorganized and dense land occupation and/or steep topography at the Favelas in these municipalities. More detailed information about solid waste collection in Favelas is provided in *Table 2.*

2.4 WATER SUPPLY

The average rate of water supply through distribution system is higher in Favelas than in the municipalities of the Study Area and RJ State (92.8%, 87.0% and 83.2%, respectively). The only municipalities where the distribution rate exceeds 90% are Rio de Janeiro, Nilópolis and São João de Meriti (97.5%, 96.2% and 95.4%, respectively).

The average figure for the whole municipalities of the Study Area is pushed down by some municipalities that have a very low distribution rate, less than 30%, such as Itaboraí and Tanguá (24.2% and 24.8%, respectively). According to the IBGE 2000 Census though there are no Favelas in Itaboraí nor in Tanguá, thus a comparison of the distribution rate in the whole municipality and in Favelas is not possible.

Among those municipalities where Favelas exist, the lowest water distribution rates in Favelas are observed in Magé and Cachoeiras do Macacu (43.7% and 68.7%, respectively).

As much as in eight (08) municipalities, the water distribution rate in Favelas is higher than in the whole city (Belford Roxo, Duque de Caxias, Nilópolis, Nova Iguaçu, Petrópolis, and São Gonçalo). The highest difference appears in Petrópolis where the difference is of as much as 40.9% (91.9% against 51.0%). For this municipality though the difference is very high and thus believed that no inference is possible without further information.

However, for the other municipalities, a possible inference is that the information for the whole municipality contains a substantial data for other types of low income areas, other than Favelas, which usually also lack basic infrastructure such as water supply through distribution system. These low income areas are not considered as “subnormal agglomerations” according to IBGE classification since their land occupation was carried out in an orderly and not spontaneous manner (straight and relatively large streets, land plots, etc.).

The City of Rio de Janeiro which has the highest number of private permanent residences in Favelas (306,608 out of 348,196 - 88.0%), has a water distribution rate over 90% for both Favelas and the municipality as a whole (97.5% and 94.9%, respectively). For detailed information on water supply please refer to *Table 3.*

2.5 SEWAGE COLLECTION

IBGE Census 2000 presents the information about sewage collection separating the figures for residences *With Bath or Toilet* and those *Without Bath or Toilet.* Figures for residences without bath or toilet are negligible, except for Favelas where these residences represent as much as 1.6% of the total.

Unfortunately, IBGE puts the information of residences discharging their sewage into the sewerage system and into the drainage system together. Nevertheless, this information discloses those residences that somehow manage to dispose off their sewage in a better way not harming their health conditions and living environment. Thus, according to this information, the percentage of residences which sewage is collected either by a sewer or a rainfall drain is as follows: Favelas - 69.7%, Municipalities in the Study Area - 67.0% and RJ State - 62.5%.

Again, the average collection rate is slightly higher for Favelas. However, for them, the second most utilized alternative to discharge the sewage are cesspits, ditches, river, lake or sea or other outlets, generally classified as “Others” (17.3%) in *Table 4.* For the municipalities in the Study Area and RJ State, the second most used alternative in average is the septic tank (20.9% and 21.6%, respectively). This shows that in Favelas when the discharge into a sewer or into a rainfall drain is not possible, the residents tend to discharge the sewage in a precarious manner, not using septic tanks, which can harm their health conditions.

Giving a close look to each municipality (as a whole), it is observed that the lowest sewage collection rates (either through a sewer or a rainfall drain), corresponding to less than 30%, are found in the municipalities of Magé, Itaboraí, São João de Meriti and Guapimirim (29.4%, 27.8%, 24.9% and 21.4%, respectively). The highest ones are found in Nilópolis, followed by Rio de Janeiro City (79.5% and 77.6%, respectively).

As for Favelas, those in the City of Rio de Janeiro present the highest sewage collection rate, as much as 71.5%, closely followed by those in Niterói and Nilópolis (69.2% and 66.9%, respectively). The lowest rates are found in São Gonçalo and Petrópolis (1.7% and 1.0%, respectively). However, the absolute number of permanent private residences in Favelas in these last two municipalities is also the lowest (58 and 210, respectively).

As much as in three (03) municipalities, the sewage collection rate in Favelas is higher than in the whole city (Cachoeiras do Macacu, Duque de Caxias and Magé). In this case, however, no inference is possible since the figures don’t separate those residences connected to a sewer and those connected to a rainfall drain, and thus the service level can not be appraised. Information about treatment is also not provided by IBGE. For detailed information on sewage collection please refer to *Table 4.*

2.6 CHARACTERISTICS OF THE FAMILY HEAD

The difference in terms of average illiteracy rate between family heads in Favelas in one side and those in the municipalities of the Study Area and RJ State in the other side is substantial. Illiterate family heads in Favelas represent as much as 14.0% of the total, while this rate corresponds to 6.5% for the municipalities of the Study Area and 8.0% for RJ State. For the three geographical categories, women are the most illiterate family heads (18.0%, 9.3% and 11.0%, respectively).

IBGE considers illiterate those family heads aged 10 years or more who could not read and write a simple note in the language they knew. Those who had learnt to read and write but had forgotten how to do so and could only sign their own names were also considered illiterate.

The average percentage of family heads with less than one (01) year of study or no instruction at all is the highest for those living in Favelas (13.4%), much higher than the average figures for the municipalities of the Study Area and RJ State (6.8% and 8.2%, respectively). This difference continues for other ranges of years of study. The more the years of study the smaller the percentage of family heads in Favelas that falls on the respective range as shown in the following comparison table.

	Without instruction or less than 1 year of study	1 to 4 years of study	5 to 8 years of study	9 to 11 years of study	12 to 15 years of study	16 years of study or more
Favelas	13.4%	40.8%	31.1%	12.6%	1.1%	1.1%
Study Area in general	6.8%	29.2%	25.7%	22.5%	10.2%	5.6%
Rio de Janeiro State in general	8.2%	31.4%	25.5%	21.1%	8.9%	4.9%

The monthly income of the family head encompasses both the income for the main work plus the income deriving from other works the family head had in the week of reference (23 to 29 of July, 2000). It also encompasses other sources of income such as pension, rental, donation, and other social benefits.

The percentage of family heads in each range of income, calculated in terms of the Brazilian Minimum Wage (hereinafter called only as MW), which at the time was equal to R$ 151.00, is presented in *Table 5*. At that time, the average exchange rate for the American Dollar was approximately US$ 1 = R$ 1.85, thus the MW was equal to approximately US$ 82.

In Favelas, the family head income is considerable lower than in the other geographical categories (municipalities of the Study Area and Rio de Janeiro). Those with *No Income* represent 14.2% of the family heads in contrast to 9.4% and 9.1% for municipalities of the Study Area and RJ State, respectively. Also, those in Favelas receiving something up to 3 MW represent 62.5% while for the municipalities of the Study Area and RJ State this represents 41.4% and 45.1% respectively. On the other hand, family heads receiving more than 10 MW represent only 1.2% in Favelas while for the municipalities of the Study Area and RJ State this represents 15.1% and 13.2%, respectively.

Although there are no Favelas in Guapimirim, Itaboraí, Rio Bonito and Tanguá, according to IBGE 2000 Census, these municipalities also present a high percentage of family heads with income in the range of up to 3 MW (59.2%, 59.2%, 61.4% and 66.1%, respectively). These figures are close to that for the average of the Favelas. Through these figures, it could be inferred that these family heads are living in locations not considered as subnormal agglomerations according to IBGE criteria but that also concentrates low income population.

In the opposite side, considering the municipality as a whole, Niterói and Rio de Janeiro are where the family heads in the range of more than 10 MW concentrates the most (31.9% and 21.2%, respectively).

3. FAVELAS IN THE PEOPLE'S AWARENESS SURVEY

Through the results of the People's Awareness Survey carried out for our Study, some outstanding characteristics of "favelas" could be appraised.

The survey was carried out in 600 residences distributed in the Study Area. The distribution was carried out dividing the samples into three segments of 200. The distribution of the three segments is as follows: Segment 1 - Ordinary settlements (excluding favelas) in the municipalities of Belford Roxo, Duque de Caxias, Magé, Nova Iguaçu and Itaboraí; Segment 2 - Ordinary settlements (excluding favelas) in Rio de Janeiro city; and Segment 3 - Favelas in the municipalities of Magé, São João do Meriti, Nilópolis, Duque de Caxias, Nova Iguaçu and Rio de Janeiro.

Basic infrastructure conditions in Favelas are far behind in relation to the other segments only as for solid waste collection. In Favelas, several residences (42.5%) can not be reached by the collection truck due to the irregularity (straightness and/or steep gradient) of the alleys/streets. Our Survey confirms the information provided by IBGE Census 2000.

On the other hand, streets paving rate (50%) and connection rate to the water distribution system (60%) are very low for the residences in Segment 1. These indices are higher for the Favelas residences (85.5% and 90.5%, respectively). Also the connection rate to the sewerage is higher in Favelas in comparison with residences in Segment 1 (85.0% and 70.5%, respectively) (*Tables 6, 7 and 8*).

As for family income, the higher percentage of families getting less than 3 MW (Minimum Wages) is found in Favelas (58.0%), closely followed by families in Segment 1 municipalities (48.5%). Likewise, families getting more than 10 MW correspond to 5.5% and 5.0% in Segment 1 and Favelas, respectively (*Table 9*).

Considering the similarities in terms of infrastructure problems present in both Favelas' and Segment 1 residences, it is possible to infer that part of the Segment 1 residences could be located in irregular land allotment projects which comprehend land plots sold without proper authorization given by the local government thus without proper provision of infrastructure demanded by the local government. The owners of these land plots usually do not have land ownership documents. In some cases, Favelas residences are provided with better basic infrastructure than the residences in Segment 1.

As for family income, the residents of these irregular land allotment projects are as poor as those living in Favelas and could be characterized as belonging to the same social class.

Respondents in Favelas and Segment 1 are similarly concerned with the lack of infrastructure, mainly sanitation infrastructure, more than the respondents in Rio de Janeiro city for who the main concern is the urban violence problem. The respondents in Favelas and Segment 1 are also concerned with the lack of good medical services which shows their vulnerability in terms of medical assistance (*Tables 10* and *11*)

Despite the similarities in terms of basic infrastructure conditions and income level, respondents in Favelas and Segment 1 differ as for the willingness to pay for improvements in the sewerage system. Respondents in Favelas are more willing to pay for this while those in Segment 1, similarly to those in Rio de Janeiro city, are not. One possible explanation for this difference is that, although part of the respondents in Segment 1 live in not legally recognized allotment projects, they have paid for the land as if for a regular project. They bought it as the only alternative to purchase a piece of land due to the lack of other alternatives provided by the official market or the government. Consequently, they may feel they have the same rights for basic infrastructure as much as the other citizens have. The main reason given by those not willing to pay is that they cannot afford to it. In case of respondents in Rio de Janeiro (excluding Favelas), the willingness to pay rate increases proportionally to the increase of the family income (*Table 10*)

Table 1 Population of Subnormal Agglomerations (Favelas)

Municipality	Total Population	Subnormal Agglomerations	%
Belford Roxo	433,120	2,034	0.47%
Cachoeiras do Macacu	48,460	1,724	3.56%
Duque de Caxias	770,865	57,685	7.48%
Guapimirim	37,940	-	-
Itaboraí	187,127	-	-
Magé	205,699	16,717	8.13%
Nilópolis	153,572	1,700	1.11%
Niterói	458,465	50,632	11.04%
Nova Iguaçu	915,366	5,964	0.65%
Petrópolis	286,348	820	0.29%
Rio Bonito	49,599	-	-
Rio de Janeiro	5,851,914	1,092,958	18.68%
São Gonçalo	889,828	225	0.03%
São João de Meriti	449,229	12,209	2.72%
Tanguá	26,001	-	-
T O T A L	10,763,533	1,240,634	11.53%

Source: Information processed by JICA Study Team (2002) using data of IBGE Census 2000 (Preliminary Results by Census Sectoring).

Note: (1) In IBGE Census 2000, Mesquita was undivided from Nova Iguaçu. Data was available for 15 Municipalities. (2) IBGE Census 2000 shows that there are no Favelas in the municipalities of Guapimirim, Itaboraí, Rio bonito and Tanguá.

Table 2 Solid Waste Collection

Municipality		Total Number of Private Permanent Residences in Favelas	Solid Waste Destination													
			Collected						Not Collected							
			At the door		From a container		Total Collected		Burned	Buried	Disposed in vacant land or public ways	Disposed in river, lake or sea	Others	Total Not Collected	
			N	%	N	%	N	%	N	N	N	N	N	N	%
1	Belford Roxo	541	414	76.5	64	11.8	478	88.4	42	1	20	0	0	63	11.6
2	Cachoeiras do Macacu	518	150	29.0	276	53.3	426	82.2	72	0	20	0	0	92	17.8
3	Duque de Caxias	16,037	12,891	80.4	1,017	6.3	13,908	86.7	682	12	1,212	165	58	2,129	13.3
4	Guapimirim														
5	Itaboraí														
6	Magé	4,708	3,780	80.3	368	7.8	4,148	88.1	389	6	132	29	4	560	11.9
7	Nilópolis	438	392	89.5	43	9.8	435	99.3	3	0	0	0	0	3	0.7
8	Niterói	14,173	3,416	24.1	9,416	66.4	12,832	90.5	697	10	565	45	24	1,341	9.5
9	Nova Iguaçu	1,612	1,237	76.7	23	1.4	1,260	78.2	144	3	17	181	7	352	21.8
10	Petrópolis	210	68	32.4	2	1.0	70	33.3	41	4	2	93	0	140	66.7
11	Rio Bonito														
12	Rio de Janeiro	306,608	179,456	58.5	118,627	38.7	298,083	97.2	2,089	40	4,756	1,196	444	8,525	2.8
13	São Gonçalo	58	1	1.7		0.0	1	1.7	25	1	3	28		57	98.3
14	São João de Meriti	3,293	3,065	93.1	133	4.0	3,198	97.1	62	1	6	26	0	95	2.9
15	Tanguá														
T O T A L		348,196	204,870	58.8	129,969	37.3	334,839	96.2	4,246	78	6,733	1,763	537	13,357	3.8

COMPARISON TABLE

	Collected			Total Not Collected
	At the door	From a container	Total Collected	
Favelas	58.8%	37.3%	96.2%	3.8%
Municipalities in the Study Area	86.6%	8.2%	94.8%	5.2%
Rio de Janeiro State	84.4%	8.4%	92.8%	7.2%

Source: Information processed by JICA Study Team (2002) using data of IBGE Census 2000 ("Censo Demográfico, 2000. Agregado por Setores Censitários dos Resultados do Universo. Volume 3 - Região Sudeste, Rio de Janeiro, 2002").

Table 3 Water Supply

Municipality		FAVELAS						
		Total Number of Private Permanent Residences	Water Supply					
			Distribution System		Well or Spring		Other Sources	
			N	%	N	%	N	%
1	Belford Roxo	541	405	74.9	118	21.8	18	3.3
2	Cachoeiras do Macacu	518	356	68.7	152	29.3	10	1.9
3	Duque de Caxias	16,037	14,059	87.7	1,133	7.1	845	5.3
4	Guapimirim							
5	Itaboraí							
6	Magé	4,708	2,058	43.7	1,970	41.8	680	14.4
7	Nilópolis	438	427	97.5	3	0.7	8	1.8
8	Niterói	14,173	9,961	70.3	1,346	9.5	2,866	20.2
9	Nova Iguaçu	1,612	1,440	89.3	150	9.3	22	1.4
10	Petrópolis	210	193	91.9	17	8.1	0	0.0
11	Rio Bonito							
12	Rio de Janeiro	306,608	291,092	94.9	4,695	1.5	10,821	3.5
13	São Gonçalo	58	54	93.1	-	-	4	6.9
14	São João de Meriti	3,293	3,055	92.8	110	3.3	128	3.9
15	Tanguá							
TOTAL		348,196	323,100	92.8	9,694	2.8	15,402	4.4

Municipality		MUNICIPALITIES IN THE STUDY AREA						
		Total Number of Private Permanent Residences	Water Supply					
			Distribution System		Well or Spring		Other Sources	
			N	%	N	%	N	%
1	Belford Roxo	121,619	87,847	72.2	28,305	23.3	5,467	4.5
2	Cachoeiras do Macacu	13,898	9,657	69.5	3,880	27.9	361	2.6
3	Duque de Caxias	219,974	152,546	69.3	61,466	27.9	5,962	2.7
4	Guapimirim	10,621	4,836	45.5	5,195	48.9	590	5.6
5	Itaboraí	53,341	12,892	24.2	37,039	69.4	3,410	6.4
6	Magé	58,097	27,113	46.7	27,687	47.7	3,297	5.7
7	Nilópolis	44,428	42,731	96.2	1,429	3.2	268	0.6
8	Niterói	143,924	112,747	78.3	21,208	14.7	9,969	6.9
9	Nova Iguaçu	260,648	210,894	80.9	42,609	16.3	7,145	2.7
10	Petrópolis	84,461	43,065	51.0	33,125	39.2	8,271	9.8
11	Rio Bonito	13,557	6,912	51.0	6,401	47.2	244	1.8
12	Rio de Janeiro	1,815,858	1,769,729	97.5	24,536	1.4	21,593	1.2
13	São Gonçalo	262,887	211,329	80.4	35,871	13.6	15,687	6.0
14	São João de Meriti	129,390	123,467	95.4	3,654	2.8	2,269	1.8
15	Tanguá	7,286	1,807	24.8	5,303	72.8	176	2.4
TOTAL		3,239,989	2,817,572	87.0	337,708	10.4	84,709	2.6

RIO DE JANEIRO STATE	4,253,611	3,540,106	83.2	587,833	13.8	125,672	3.0

COMPARISON TABLE			
	Distribution System	Well or Spring	Other Sources
Favelas	92.8%	2.8%	4.4%
Municipalities in the Study Area	87.0%	10.4%	2.6%
Rio de Janeiro State	83.2%	13.8%	3.0%

Source: Information processed by JICA Study Team (2002) using data of IBGE Census 2000 ("Censo Demográfico, 2000. Agregado por Setores Censitários dos Resultados do Universo. Volume 3 - Região Sudeste, Rio de Janeiro, 2002").

Table 4 Sewage Destination

No.	Municipality	Total Number of Private Permanent Residences in Favelas	SEWAGE DESTINATION IN FAVELAS – With Bath or Toilet – Sewerage or Drainage System (1) N	(1) %	Septic Tank (2) N	(2) %	Cesspit (3) N	Ditch (4) N	Rio, Lake or Sea (5) N	Other Outlet (6) N	Sub-total (3)+(4)+(5)+(6) (7) N	(7) %	Without Bath or Toilet (8) N	(8) %
1	Belford Roxo	541	182	33.6	61	11.3	45	243	0	5	293	54.2	5	0.9
2	Cachoeiras do Macacu	518	296	57.1	14	2.7	75	129	0	1	205	39.6	3	0.6
3	Duque de Caxias	16,037	9,905	61.8	1,701	10.6	592	2,253	927	232	4,004	25.0	427	2.7
4	Guapimirim													
5	Itaboraí													
6	Magé	4,708	1,625	34.5	1,362	28.9	155	1,287	189	14	1,645	34.9	76	1.6
7	Nilópolis	438	293	66.9	99	22.6	37	0	3	2	42	9.6	4	0.9
8	Niterói	14,173	9,801	69.2	970	6.8	861	1,230	761	94	2,946	20.8	456	3.2
9	Nova Iguaçu	1,612	106	6.6	443	27.5	29	111	891	2	1,033	64.1	30	1.9
10	Petrópolis	210	2	1.0	3	1.4	11	0	178	1	190	90.5	15	7.1
11	Rio Bonito													
12	Rio de Janeiro	306,608	219,169	71.5	34,552	11.3	6,844	25,749	14,347	1,517	48,457	15.8	4430	1.4
13	São Gonçalo	58	1	1.7	1	1.7		5	49	1	55	94.8	1	1.7
14	São João de Meriti	3,293	1,467	44.5	275	8.4	26	528	858	66	1,478	44.9	73	2.2
15	Tanguá													
	TOTAL	348,196	242,847	69.7	39,481	11.3	8,675	31,535	18,203	1,935	60,348	17.3	5,520	1.6

No.	Municipalities	Total Number of Private Permanent Residences in the Study Area	SEWAGE DESTINATION IN THE MUNICIPALITIES OF THE STUDY AREA – With Bath or Toilet – Sewerage or Drainage System (1) N	(1) %	Septic Tank (2) N	(2) %	Cesspit (3) N	Ditch (4) N	Rio, Lake or Sea (5) N	Other Outlet (6) N	Sub-total (3)+(4)+(5)+(6) (7) N	(7) %	Without Bath Or Toilet (8) N	(8) %
1	Belford Roxo	121,619	65,019	53.5	30,907	25.4	5,299	16,308	1,477	1,124	24,208	19.9	1,485	1.2
2	Cachoeiras do Macacu	13,898	6,412	46.1	2,508	18.0	2,707	1,019	986	66	4,778	34.4	200	1.4
3	Duque de Caxias	219,974	124,030	56.4	45,487	20.7	9,415	28,599	7,638	2,181	47,833	21.7	2,624	1.2
4	Guapimirim	10,621	2,276	21.4	4,918	46.3	1,284	1,662	249	65	3,260	30.7	167	1.6
5	Itaboraí	53,341	14,821	27.8	21,933	41.1	5,047	8,448	1,546	758	15,799	29.6	788	1.5
6	Magé	58,097	17,097	29.4	18,860	32.5	5,114	12,675	2,898	637	21,324	36.7	816	1.4
7	Nilópolis	44,428	35,310	79.5	7,646	17.2	265	101	917	26	1,309	2.9	163	0.4
8	Niterói	143,924	105,129	73.0	20,151	14.0	6,636	5,010	4,055	1,549	17,250	12.0	1,394	1.0
9	Nova Iguaçu	260,648	133,855	51.4	75,618	29.0	8,805	31,756	6,692	1,545	48,798	18.7	2,377	0.9
10	Petrópolis	84,461	58,414	69.2	11,294	13.4	4,039	1,629	8,174	372	14,214	16.8	539	0.6
11	Rio Bonito	13,557	3,641	26.9	6,791	50.1	644	1,694	466	76	2,880	21.2	245	1.8
12	Rio de Janeiro	1,815,858	1,409,223	77.6	287,635	15.8	23,371	50,009	30,200	5,812	109,392	6.0	9,608	0.5
13	São Gonçalo	262,887	105,936	40.3	106,818	40.6	12,370	21,426	11,627	2,794	48,217	18.3	1,916	0.7
14	São João de Meriti	129,390	86,284	66.7	32,516	25.1	2,029	4,698	2,422	650	9,799	7.6	791	0.6
15	Tanguá	7,286	1,812	24.9	3,040	41.7	690	1,314	261	24	2,289	31.4	145	2.0
	TOTAL	3,239,989	2,169,259	67.0	676,122	20.9	87,715	186,348	79,608	17,679	371,350	11.5	23,258	0.7
	RIO DE JANEIRO STATE	4,253,611	2,659,046	62.5	920,506	21.6	209,200	262,063	139,938	24,555	635,756	14.9	38,303	0.9

COMPARISON TABLE

	SEWAGE DESTINATION – With Bath or Toilet – Sewerage	Septic Tank	Others	Without Bath or Toilet
Favelas	69.7%	11.3%	17.3%	1.6%
Municipalities of the Study Area	67.0%	20.9%	11.5%	0.7%
Rio de Janeiro State	62.5%	21.6%	14.9%	0.9%

Source: Information processed by JICA Study Team (2002) using data of IBGE Census 2000 ("Censo Demográfico, 2000. Agregado por Setores Censitários dos Resultados do Universo. Volume 3 - Região Sudeste, Rio de Janeiro, 2002").

Table 5 Family Heads according to Monthly Income

	Municipalities	Total Number of Family Heads in Favelas	FAMILY HEADS ACCORDING TO AVERAGE INCOME IN FAVELAS							
			up to 3 MW		more than 3 to 10 MW		more than 10 MW		without income	
			N	%	N	%	N	%	N	%
1	Belford Roxo	541	383	70.8	80	14.8	4	0.7	74	13.7
2	Cachoeiras do Macacu	518	373	72.0	58	11.2	5	1.0	82	15.8
3	Duque de Caxias	16,037	10,430	65.0	2716	16.9	105	0.7	2,786	17.4
4	Guapimirim									
5	Itaboraí									
6	Magé	4,708	2,899	61.6	1091	23.2	73	1.6	645	13.7
7	Nilópolis	438	295	67.4	96	21.9	0	0.0	47	10.7
8	Niterói	14,173	9,616	67.8	2620	18.5	166	1.2	1,771	12.5
9	Nova Iguaçu	1,612	1,120	69.5	269	16.7	12	0.7	211	13.1
10	Petrópolis	210	133	63.3	45	21.4	4	1.9	28	13.3
11	Rio Bonito									
12	Rio de Janeiro	306,608	190,383	62.1	69513	22.7	3679	1.2	43,033	14.0
13	São Gonçalo	58	33	56.9	4	6.9	1	1.7	20	34.5
14	São João de Meriti	3,293	2,029	61.6	537	16.3	8	0.2	719	21.8
15	Tanguá									
	T O T A L	348,196	217,694	62.5	77029	22.1	4057	1.2	49,416	14.2

	Municipalities	Total Number of Family Heads in the Study Area	**FAMILY HEADS ACCORDING TO AVERAGE INCOME IN MUNICIPALITIES OF THE STUDY AREA**							
			up to 3 MW		more than 3 to 10 MW		more than 10 MW		without income	
			N	%	N	%	N	%	N	%
1	Belford Roxo	121,619	68,326	56.2	32,328	26.6	2,332	1.9	18,633	15.3
2	Cachoeiras do Macacu	13,898	8,646	62.2	3,473	25.0	596	4.3	1,183	8.5
3	Duque de Caxias	219,974	117,543	53.4	64,309	29.2	7,694	3.5	30,428	13.8
4	Guapimirim	10,621	6,289	59.2	2,702	25.4	488	4.6	1,142	10.8
5	Itaboraí	53,341	31,559	59.2	12,526	23.5	1,621	3.0	7,635	14.3
6	Magé	58,097	33,729	58.1	15,472	26.6	1,876	3.2	7,020	12.1
7	Nilópolis	44,428	19,714	44.4	17,469	39.3	3,298	7.4	3,947	8.9
8	Niterói	143,924	41,705	29.0	47,606	33.1	45,884	31.9	8,729	6.1
9	Nova Iguaçu	260,648	136,552	52.4	80,164	30.8	11,221	4.3	32,711	12.5
10	Petrópolis	84,461	40,747	48.2	28,324	33.5	10,004	11.8	5,386	6.4
11	Rio Bonito	13,531	8,310	61.4	3,413	25.2	808	6.0	1,000	7.4
12	Rio de Janeiro	1,801,912	620,082	34.4	655,866	36.4	382,476	21.2	143,488	8.0
13	São Gonçalo	262,887	131,836	50.1	89,393	34.0	14,696	5.6	26,962	10.3
14	São João de Meriti	129,390	66,755	51.6	42,736	33.0	4,504	3.5	15,395	11.9
15	Tanguá	7,286	4,813	66.1	1,386	19.0	165	2.3	922	12.7
	T O T A L	3,226,017	1,336,606	41.4	1,097,167	34.0	487,663	15.1	304,581	9.4
RIO DE JANEIRO STATE		4,253,611	1,919,240	45.1	1,386,861	32.6	559,870	13.2	387,640	9.1

COMPARISON TABLE				
	Up to 3 MW	more than 3 to 10 MW	more than 10 MW	without income
Favelas	62.5%	22.1%	1.2%	14.2%
Municipalities in the Study Area	41.4%	34.0%	15.1%	9.4%
Rio de Janeiro State	45.1%	32.6%	13.2%	9.1%

Source: Information processed by JICA Study Team (2002) using data of IBGE Census 2000 ("Censo Demográfico, 2000. Agregado por Setores Censitários dos Resultados do Universo. Volume 3 - Região Sudeste, Rio de Janeiro, 2002").

Table 6 Infrastructure and Basic Services Available at the Residences

Basic services		Segment 1		Rio de Janeiro City		Favelas	
		n	%	n	%	n	%
Electric Energy	Do have	197	98.5	200	100.0	200	100.0
	Do not have	3	1.5	-	-	-	-
	Total	**200**	**100.0**	**200**	**100.0**	**200**	**100.0**
Street Paving	Do have	100	50.0	199	99.5	171	85.5
	Do not have	100	50.0	1	0.5	29	14.5
	Total	**200**	**100.0**	**200**	**100.0**	**200**	**100.0**
Street Lighting	Do have	179	89.5	200	100.0	192	96.0
	Do not have	21	10.5	-	-	8	4.0
	Total	**200**	**100.0**	**200**	**100.0**	**200**	**100.0**
Solid Waste Collection	Do have, at their doors	179	89.5	188	89.5	112	56.0
	Do have, in collective bins	4	2.0	22	10.5	63	31.5
	Do have, in neighboring streets	7	3.5	-	-	19	9.5
	Do not have	10	5.0	-	-	3	1.5
	Did not respond	-	-	-	-	3	1.5
	Total	**200**	**100.0**	**210**	**100.0**	**200**	**100.0**

Source: People's Awareness Survey carried out by JICA Study Team, 2002

Note: Segment 1 encompasses the municipalities of Belford Roxo, Duque de Caxias, Magé, Nova Iguaçu and Itaboraí.

Table 7 Connection Rate to Water Supply System

	Segment 1		Rio de Janeiro City		Favelas	
Status	**n**	**%**	**n**	**%**	**n**	**%**
Connected	120	60.0	196	98.0	181	90.5
Not Connected	80	40.0	4	2.0	19	9.5
Total	200	100.0	200	100.0	200	100.0

Source: People's Awareness Survey carried out by JICA Study Team, 2002

Table 8 Method of Sewage Disposal

Method		Segment 1		Rio de Janeiro City		Favelas	
		n	%	n	%	n	%
Connected to sewerage		**141**	**70.5**	**195**	**97.5**	**170**	**85.0**
Not connected to sewerage		**59**	**29.5**	**5**	**2.5**	**30**	**15.0**
a	Disposed off into the drainage system	2	1.0	2	1.0	1	0.5
b	Septic tank without outlet	5	2.5	-	-	-	-
c	Septic tank + drainage system	4	2.0	-	-	-	-
	Sub-total 1	**11**	**5.5**	**2**	**1.0**	**1**	**0.5**
d	Septic tank + open ditch	13	6.5	-	-	2	1.0
e	Rudimentary cesspit	4	2.0	-	-	3	1.5
f	Disposed off or channeled straight into the river, stream or the sea	17	8.5	3	1.5	19	9.5
g	Discharged into open ditches	13	6.5	-	-	5	2.5
h	Others	1	0.5	-	-	-	-
	Sub-total 2	**48**	**24**	**3**	**1.5**	**29**	**14.5**
Total		**200**	**100**	**200**	**100**	**200**	**100**

Source: People's Awareness Survey carried out by JICA Study Team, 2002

Table 9 Characterization of Residence according to Family Income (per month)

Family Income (in Minimum Wages - MW)*	Segment 1		Rio de Janeiro City		Favelas	
	n	%	n	%	n	%
< MW	14	7.0	11	5.5	21	10.5
1 MW to < 2 MW	44	22.0	12	6.0	50	25.0
2 MW to < 3 MW	39	19.5	18	9.0	45	22.5
Sub-total (< 3 MW)	**97**	**48.5**	**41**	**20.5**	**116**	**58**
3 MW to < 4 MW	30	15.0	23	11.5	27	13.5
4 MW to < 5 MW	14	7.0	14	7.0	19	9.5
5 MW to < 7.5 MW	35	17.5	38	19.0	20	10.0
7.5 MW to < 10 MW	13	6.5	22	11.0	8	4.0
10 MW or more	11	5.5	62	31.0	10	5.0
Total	**200**	**100.0**	**200**	**100.0**	**200**	**100.0**

Family Income (in American Dollars - US$)**	Segment 1		Rio de Janeiro City		Favelas	
	n	%	n	%	n	%
< US$ 63.9	14	7.0	11	5.5	21	10.5
US$ 63.9 to < US$ 127.8	44	22.0	12	6.0	50	25.0
US$ 127.8 to < US$ 191.7	39	19.5	18	9.0	45	22.5
US$ 191.7 to < US$ 255.6	30	15.0	23	11.5	27	13.5
US$ 255.6 to < US$ 319.5	14	7.0	14	7.0	19	9.5
US$ 319.5 to < US$ 479.2	35	17.5	38	19.0	20	10.0
US$ 479.2 to < US$ 639.0	13	6.5	22	11.0	8	4.0
US$ 639.0 or more	11	5.5	62	31.0	10	5.0
Total	**200**	**100.0**	**200**	**100.0**	**200**	**100.0**

Source: People's Awareness Survey carried out by JICA Study Team, 2002

Note: (*) National Minimum Wage (MW) per month as of September, 2002 = 200 Reais

(**) American Dollar exchange rate as of September, 2002: US$ 1 = 3.13 Reais

Table 10 Top 10 Problems or Needs within the Community

Problems	Segment 1		Rio de Janeiro City		Favelas	
	n	%	n	%	n	%
Basic sanitation infrastructure	133	66.5	76	38.0	100	50.0
Urban infrastructure in general (except basic sanitation infrastructure)	98	49.0	60	30.0	71	35.5
Security, violence	35	17.5	89	44.5	32	16.0
Health	15	7.5	20	10.0	15	7.5
Education	9	4.5	9	4.5	19	9.5
Poverty, unemployment	5	2.5	5	2.5	9	4.5
Lack of urban equipment	2	1.0	10	5.0	5	2.5
Others	4	2.0	18	9.0	12	6.0
There is no problem	11	5.5	20	10.0	22	11.0
Did not respond	13	6.5	14	7.0	17	8.5

Source: People's Awareness Survey carried out by JICA Study Team, 2002

Note: The total of absolute and relative figures exceeds the number of respondents and 100%, respectively, because the question admits more than one answer.

Table 11 Top 10 Health Problems for the Family and the Community

Health Problems	Segment 1		Rio de Janeiro City		Favelas	
	n	%	n	%	n	%
Diseases which affect the population	63	31.5	66	33.0	58	29.0
Lack of basic health and hospital units (not for emergencies)	28	14.0	19	9.5	32	16.0
Lack of professionals in basic health and hospital units	35	17.5	10	5.0	22	11.0
Lack of basic sanitation infrastructure	6	3.0	11	5.5	14	7.0
Lack of medication/material in basic health and hospital units	10	5.0	6	3.0	11	5.5
The access to health services is difficult	3	1.5	14	7.0	7	3.5
Lack of emergency services	14	7.0	2	1.0	3	1.5
Lack of urban equipment	3	1.5	1	0.5	2	1.0
Difficulty in obtaining laboratory tests and exams	3	1.5	1	0.5	1	0.5
Other health problems	-	-	2	1.0	2	1.0
Mentioned economic, environment and educational problems	3	1.5	5	2.5	2	1.0
Sub-total 1	*168*	*84.0*	*137*	*68.5*	*154*	*77.0*
There is no problem	25	12.5	39	19.5	48	24.0
Did not respond	49	24.5	43	21.5	28	14.0
Sub-total 2	*74*	*37.0*	*82*	*41.0*	*76*	*38.0*

Source: People’s Awareness Survey carried out by JICA Study Team, 2002

Note: The total of absolute and relative figures exceeds the number of respondents and 100%, respectively, because the question admits more than one answer.

SUPPORTING 14

ENCOURAGEMENT OF ENVIRONMENTAL AWARENESS

TABLE OF CONTENTS

Page

SUPPORTING 14 ENCOURAGEMENT OF ENVIRONMENTAL AWARENESS

LIST OF TABLES

LIST OF TABLES

SUPPORTING 14 ENCOURAGEMENT OF ENVIRONMENTAL AWARENESS

1. BACKGROUND

According to the Residents' Awareness Survey carried out on the course of this Study, the Guanabara Bay basin residents' awareness level about the environmental conditions of the bay is low and need to be raised. This is very important to achieve the water quality targets established for the bay and to increase the awareness level on water environment, either by waking up the residents about the importance of the sewerage works, and thus they will demand these services from the responsible agencies, or by changing their water consumption and solid waste disposal patterns by environmental friendly ones.

In this context, the Study Team consider Environmental Education Programs (EEPs) and information dissemination through Website as measures to encourage the people' awareness to the environmental issues. As result of the consideration, the Study;

- proposes the Environmental Education Programs, and
- has opened Website to introduce current environmental conditions of Guanabara Bay

2. ENVIRONMENTAL EDUCATION PROJECTS (EEPS) IN GUANABARA BAY

2.1 EXISTING ENVIRONMENTAL EDUCATION PROJECTS (EEPS)

The importance of EEPs has already been recognized in Guanabara Bay basin at Rio de Janeiro State, and thus many environmental related projects at different levels have been implemented or are in progress at present. During the third phase of the Study, the Study team has interviewed several organizations to get a better understanding of the existing EEPs. As a result, we collected information about representative projects of different levels of organizations/programs currently being carried out in Guanabara Bay basin. These 4 projects started due to the initiative of different level organizations / programs: Federal, State level, Municipality and Private. The following table presents same characteristics of these projects such as name, target population, etc.

Table 1 List of Environmental Education Projects

Project Name	Initiative	Sponsor	Target Population	Duration	Executing Organization
Movement of Life Protection and the Guanabara Bay Revitalization Program	Federal	• Ministry of Environment - Federal Government of Brazil	12 municipalities of the Guanabara Bay Basin	Oct/2000 to Oct/2001	CIMA - Culture, Information and Environment (NGO) under agreement with Ministry of Environment
Environmental Education Project of the Guanabara Bay Depollution Program (PEA - PDBG)	State	• IDB (PDBG) Interamerican Development Bank portion for PDBG	Teachers of the Rio de Janeiro State educational system within Guanabara Bay Basin (main).	1998 - 2002	UERJ - University of Rio de Janeiro State under agreement with FEEMA (PDBG co-executor agency)
São Gonçalo Clean City	Municipality	• National Health Fund (FUNASA) - Federal Government • Municipal Government of São Gonçalo	Municipality of São Gonçalo	1997 - 1999	ABES-RJ - Brazilian Association of Sanitary Engineers - Rio de Janeiro section (Professional Association) under agreement with the municipal government of São Gonçalo
Estação Mauá Project	Private / NGO	• PETROBRAS • Magé municipal government	Population of Mauá Community in the municipality of Magé	Feb/2002 to June/2003	CIMA - Culture, Information and Environment (NGO) under agreement with PETROBRAS

However, the common characteristic of all the projects is that they target the improvement of the environmental conditions of the Guanabara Bay, through the increase of the bay basin residents' awareness about the Bay current environmental conditions and necessary countermeasures to improve it. These projects are being carried out through educational activities (courses, seminars, workshops, etc.), practical activities (recycling), cultural activities (theater plays) and/or income generation activities (women cooperative for sewing recycled cloth) what shows a wide variety of options to implement an EEP.

(1) Movement of Life Protection and the Guanabara Bay Revitalization Program

1) Fundamental

In 1999, the Ministry of Environment conceived a nation-wide Environmental Education Program in which students from all over Brazil would gather in Brasília to discuss an agenda to deal with the environmental problems in their home states. During this meeting, a letter was written and was called "Letter of Life Protection Principles".

Concurrently, the Federal Government was implementing the Program of Environmental Revitalization of the Guanabara Bay Basin. This Program was implemented with the resources derived from the fine applied to Petrobrás due to a major oil spill occurred in 2000, and comprised complementary actions to the already existing PDBG.

The Federal Government then decided that the Life Protection Movement would lead the Environmental Education Project within the before mentioned revitalization program. This was carried out within the Sub-program of solid waste management and, at the time, 12 municipalities of the Guanabara Bay basin participated.

2) Objectives

- to sensitize and mobilize the governmental, private and community sectors of each municipality in order to reduce, recycle or reutilize solid waste;
- to provide an appropriate handling and destination to solid waste.

3) Activities

Aiming at the above objective, the project carried out several activities. In the first stage of the Project, 1,200 Public, Private and Community organizations were visited and listed up. Through this activity it was possible to get to know each organization characteristics and activities, their projects and actions; verify the interviewees perception about the main socio-environmental problems in their respective municipality and in the Guanabara Bay; and list up the diseases and events of improper disposal of solid waste. This information was organized in a Data Bank and is available in the project website (http://www.protetoresdavida.org.br/bg.htm).

The main actions of each of the 12 participant municipal prefectures for the preservation of ecosystems, social inclusion of scavengers' families and implementation of selective collection of solid waste (for recycling purposes) were surveyed and compiled into a book aiming at publicizing, exchange and multiplying positive experiences that contribute for the environmental revitalization of Guanabara Bay.

Each participant organization received a set of educational material including those on the Life Protection Movement (Life Protection Principles Book, Environmental Agenda at Schools, and a videotape about the Movement National Meeting), and another videotape and book elaborated with the support of specialized consultants, about Guanabara Bay (history of the basin occupation, cultural patrimony, ecosystems and environmental problems) and about the Revitalization Program.

From April to August, 2001, the Project carried out 100 courses, qualifying 2,188 Life Protectors. Half of the Protectors are teachers and students of 467 schools and day care centers, mostly belonging to the municipal schools system. The number of courses participants is presented as follows:

Table 2 Numbers of Participant

Participant	Number
Teachers and Students	1,082
Municipal officials	267
Public sector representatives	93
Community leaders	746
TOTAL	2,188

During the courses, the Project themes were discussed (Guanabara Bay, Environmental Revitalization Program, Solid Waste and the Life Protection Movement) through workshops, exhibitions, guided studies with the educational material and sensitization activities. The representatives of each of the 890 organizations that took part in the course elaborated action proposals for the implementation of the Life Protectors Project in each respective school, community, public agency, company or association.

The action proposals elaborated during the courses were followed-up and supported by the project through the following:

- 13 (thirteen) mini-courses on selective collection for recycling for approximately 196 schools and community organizations interested in developing this kind of activity. In some cases, they already have the support of the municipal prefecture or of the private sector;
- articulation of partnerships among different sectors for the implementation of various actions and projects (planting of riverside forests, cleaning activities, campaigns, recuperation and/or preservation of parks, waterfalls and other environmental patrimony, publicizing the Life Protectors Principles, etc.);
- technical support from CIMA and NUMA (another NGO) teams during meetings and courses organized by Life Protectors, multiplying the Project, and forming new Life Protectors;
- support to the implementation of the Environmental Agenda at Schools and organization of Forums.

4) Implementation period and Funding

The implementation period was from October 2000 to October 2001. The project was not continued and there are no plans for its continuation.

The project total cost was R$ 2,600,000 (two million and six hundred thousand Reais) totally disbursed by the Ministry of Environment.

(2) Environmental Education Project of the Guanabara Bay Depollution Program PEA - PDBG

1) Fundamental

This Environmental Education Project (PEA - PDBG) is one of the components of the PDBG that is being carried out through an agreement between the State government and UERJ (University of Rio de Janeiro State). This component is funded with IDB resources and corresponds to approximately 0.4 % of the total IDB portion for PDBG. The project was staged into 3 phases.

2) Objectives

- to provide instruments for the education system professionals, community leaders and governmental policy makers for an eco-political praxis;

- to mobilize the community;
- to organize knowledge; and
- to produce didactic material.

3) Activities

The main activities so far carried out within the PEA were as follows:

a) Production of educational material (text books, maps, manuals, etc.).
b) Implementation of courses: (1) specialization course on environmental management education targeting mainly the teachers of the Rio de Janeiro State government educational system (middle-high and high schools) within the coverage area. The final work of this course is an Action Plan elaborated by the students in cooperation with the community. This course is officially recognized as a post-graduation course; (2) Implementation of a qualification course of environmental management education targeting mainly community leaders of the coverage area that receive a certificate.
c) Support in the elaboration of the above mentioned Action Plans by the specialization course students and follow-up of this activity.
d) Implementation of Environmental Education Reference Centers (EE Centers) in municipalities located within the Bay Basin, assisting them with materials and technical support.

Production of Educational Material

Throughout the PEA implementation, the following didactic material was produced:

- Pedagogic Books I, II, III and IV;
- Manual of Theoretico-Methodological Fundaments for the activities of the Environmental Education Reference Centers;
- Manual - Guidance for the integration of the project contents to the Rio de Janeiro State middle-high and high schools curriculum (in elaboration);
- Tabloids “Caminhos da Guanabara” (Ways of Guanabara);
- Summary books about the Action Plans;
- Land use and vegetal coverage Map and PDBG intervention Map;
- Videos and documents.

Implementation of Courses

These courses were implemented having the Guanabara Bay basin as the study area and were sub-divided in several disciplines about the PDBG, environmental conditions of the bay, sewerage system, water environment, among others. They also comprised seminars and workshops, apart from field visits such as to a WWTP, a Sanitary Landfill and to the Bay.

1) Specialization Course of Environmental Management Education

This course is given within 390 hours of classes/activities during approximately 8 months at the UERJ facilities in Rio de Janeiro City. The course is divided into: (1) Seminars for the presentation of themes-concepts; (2) Classes on several matters; and (3) Workshops to supply instruments for the development of the Action Plans. The Action Plans, produced by groups of students, is the actual final graduation work presented 6 months after the classes are finished.

2) Qualification Course of Environmental Management Education

This course follows a similar curriculum as of the specialization course. However, it is summarized and has 60 hours of classes/activities) and does not set as pre-requisite to be college graduate. This course was carried out at the UERJ facilities as well as at the Environmental Education Reference Centers.

The number of graduates of the specialization course and of the qualification course is presented in the following table:

Table 3 Number of Participants in Specialization and Qualification Courses

	Specialization Course	Qualification Course
Phase I	392	65
Phase II	277	27
Phase III	227	208
Total	896	300

Apart from the above graduates, another 404 persons were qualified as Environmental Agents at the EE Centers (during phases II and III) and 26 were qualified through the Methodology of the "Teatro do Oprimido" (Theater of the Oppressed) developed by a Brazilian theater director to express through a theater play the social problems (in this case the environmental problems).

Support in the elaboration of Action Plans

1) Elaboration

The Action Plan is a plan aiming to deal with the environmental issues at the grassroots level. The teachers who are the specialization course participants are trained and oriented to work together with the community where their school is located and to produce an Action Plan. The first step for the construction of an Action Plan is to make a diagnosis of the local conditions, based on the sub-basin geographical division. This is also carried out jointly with the community. After that, the teachers and the community members outline an Action Plan to deal with the environmental issue they regarded as the most important one for the community.

As a result of the Specialization Courses on Environmental Management Education, 238 Action Plans were implemented by the specialization course participants. Depending on the Action Plan, the target population varies from around 50 persons (a classroom) to 5,000 (sub-basin community). One of the main advantages of these plans is that their implementation is carried out by teachers and community leaders who have a great potential of spreading information and gathering participants.

A summary of the 10 (ten) best Action Plans among those produced during the first phase of the PEA is provided in the following table. These Action Plans were selected through criteria that took into consideration the following aspects: (1) Coverage/Community Participation; (2) Harmony with the Action Plan Project objectives; (3) Results/Products; and (4) Partnerships/Perspectives.

These ten Action Plans were rewarded with an amount of R$ 30,000 each funded by IDB, through an amendment in the original Project contract.

2) Evaluation of Implementation

In 2003, the first evaluation of the Action Plans shall be compiled in a report currently being elaborated by the UERJ coordination staff. This evaluation comprised an interview with the teachers at their schools (280 schools) and visits to the Action Plans locations. The interviews were carried out using a pre-established questionnaire. However, the interviewer was free to open the question when necessary thus the result is a qualitative text about the Action Plan, and not a multiple choice questionnaire for statistic purposes. The major evaluation items were as follows: (1) follow-up of the primary plan, (2) continuity and (3) self-sustainability.

Table 4 (1/2) Ten (10) Awarded Action Plans

No.	Name of the Action Plan	Municipality	Targeted Population	Results / Products	Partnerships / Perspectives
1	"Atmospheric Pollution, the Number ONE Enemy"	São João de Meriti	400 students	• Implementation of SOS Planet Space where workshops on writing texts, drawing cartoons, making newspapers are carried out, besides seminars and campaigns.	Partnership SEMADS, FEEMA, IBAMA, FIOCRUZ, Municipal Secretariats of Environment, Health, Culture, Sport, and Leisure. Perspectives Mobilization of Community Associations and Association of Parents, technical visits to factories, continuation of activities, identification of new important activities to be carried out, strengthening of partnerships.
2	"Solid Waste - Environmental Degradation Factor around the School at Nova Iguaçú Region"	Nova Iguaçu	1600 students	• Adoption of the themes Environment and Health as the integrating axis of the school pedagogical activities in 2000; • Realization of the Environment Fair; • Creation of the Environmental Studies Group; • Creation of the Fashion Show Workshop (recyclables); • Participation of students in the Environment Education Course promoted through a partnership between PUC-Rio (Catholic University of Rio de Janeiro) and Municipal Prefecture of Nova Iguaçu; • Participation of students in the Environment Agents Formation course promoted by the Environment Education Reference Center in Nova Iguaçu, in July 2002.	Partnership Several schools, NGO "Protectors of Live", Municipal Secretariat of Urbanism and Environment of Nova Iguaçu, State Institute of Hematology, Environment Education Reference Center of Nova Iguaçu. Perspectives Integration of other municipal schools of the region in the environmental education activities carried out at the Alberto Pasqualini school.
3	"Nursery Project: Fundamentals and Perspectives"	Nova Iguaçu	2500 students	• Construction of a nursery for production of rain forest species seedlings in order to recuperate degraded areas.	This Action Plan depends on the community participation for its concretization.
4	"Irregular Domestic Solid Waste Disposal - Play "For Love of Guanabara Bay"	São Gonçalo	10.000 (general public)	• The theater play "For Love of Guanabara Bay" is being performed in cultural centers, community centers, theaters, with the attendance of the communities.	Partnership High school "Walter Orlandini" students participation. Perspectives The theater group intends to remake the scenary and costumes and to increase the number of performances in different schools and communities
5	"The Environmental Education at schools as a systemic manner to preserve the environment"	Duque de Caxias	4500 students	• Set up of the Environmental Studies Center to: (1) Identify socio-environmental problems; (2) Support the process of organization and representation of local communities; (3) Stimulate educative practices and political participation of the community.	Partnership Public Education Unities Perspectives Implementation of new partnerships with the region private sector in order to become self-sustainable.

Table 4 (2/2) Ten (10) Awarded Action Plans

No.	Name of the Action Plan	Municipality	Targeted Population	Results / Products	Partnerships / Perspectives
6	"The Environmental Education and the Construction of the Student -Citizen"	Niterói	5000 (2000 students and 3000 community members)	• Construction of a Permanent Environmental Education Space - EPEA, with the implementation of a video library and library, two editions of an environmental newspaper called "Eureka" and workshops about various subjects; • The professionals involved in this Action Plan participated as teachers in the Project Qualification Courses. • Presentation of this Action Plan in the Regional Meeting of Biology Teaching - Rio de Janeiro/Espírito Santo, 2001.	Partnerships Municipal Secretariat of Environment; State University of Rio de Janeiro - UERJ; Fluminense Federal University. Perspectives To continue and to expand the activities of school-community integration, keeping the same team and integrating new professionals.
7	"The School as space of knowledge building to transform the reality - Laboratory of Social Environment (LAMAS)"	Niterói	4500 (students, teachers and school workers)	• "Coração de Estudante" Project - Scientific Initiation for High school students; • Project of School Environment Preservation; • Gardening Project; • I Round of Lectures/Debates on pedagogic and socio-environmental issues. • II Round of Lectures/Debates on pedagogic and socio-environmental issues. • Political-Pedagogical Project. • Other projects involving the school community that became possible because of this Action Plan but are not necessarily directly related to the environment.	Partnerships State University of Rio de Janeiro - UERJ, Fluminense Federal University, State Secretariat of Education. Perspectives The partnerships organized for the Action Plan implementation are important tools to assure the Plan continuation, extending its benefits to other schools and communities.
8	"Bota River - Birth and Death"	Belford Roxo	Students of the State Highschool Santa Amélia	• Elaboration of a Manual for Environmental Education Practices Guidance.	Partnerships River margin communities, school communities and the High school Santa Amélia.
9	"Pollution and Environment: society awareness building through solid waste recycling"	São Gonçalo	1500 (students)	• Collection of recycles produced at the school; • Laboratory of solid waste recycling; • Elaboration of newspapers about the relationship between diseases and improper solid waste disposal.	
10	"Environmental Education Theory and Practice at the School Community - Logical Sanitation"	Rio de Janeiro	4500 (children and teenagers)	• Public debate about the relationship among Water Resources, Basic Sanitation and Human Health (1998); • Participation of 25 community members in courses for the formation of Environmental Agents; • Contribution in the implementation of the "Bairrinho Program" (Slums urbanization) of the Municipal Prefecture of Rio de Janeiro City. • Creation of a Parasitological Control Center for kids and teenagers of 13 homeless communities in the Ricardo de Albuquerque neighborhood.	Partnership Municipal Prefecture of Rio de Janeiro. Perspectives In the Parasitological Center, those with parasites will be sent to the Guadalupe Health Post. There will be a continuous guidance about the importance of water for the population health.

Environmental Education Reference Centers (EE Centers)

The main objectives of the EE Centers are:

- to raise the awareness and to qualify the professionals that will act as multiplying agents of socio-environmental practices;
- to develop activities integrated with the community (grassroots level); and
- to make available to the community videos, books, specialized magazines, maps and other materials regarding the socio-environmental issue.
- to support graduates of the program or communities to be independent in implementing the projects.

So far, EE Centers were set up in 05 (five) municipalities of the Guanabara Bay Basin: São Gonçalo, Nova Iguaçu, Belford Roxo, Niterói and Rio de Janeiro. Out of these, (03) of these centers were shut off: São Gonçalo, Belford Roxo and Nova Iguaçu. The Niterói center is continuing its activities in a facility provided by the municipal government and with its own staff. The Rio de Janeiro center is operating within UERJ facilities also with the university own staff.

For the set up of this center, basically three requisites were necessary: (1) a facility provided by the local government or another organization; (2) staff also provided by the local government or another organization; and (3) material resources such as TV sets, video cameras, computer sets, and others provided with IDB funds. The organization of the centers was carried out under the coordination of the PEA coordination staff.

When a center is shut off, the material provided with IDB funds has to be returned to FEEMA that becomes in charge of this material. At present, only the Nova Iguaçu center hasn’t returned their material yet.

Implementation period and Funding

The financial resources used so far by the PEA-PDBG are listed as follows:

Phase I	R$ 1,474,778
Phase II	R$ 1,319,183
Phase III	R$ 1,396,000
Total	R$ 4,189,961

As already mentioned, the funds were provided through the IDB portion of the PDBG. As of June 2003, considering an exchange rate of US$ 1 ≅ R$ 2.90, the total cost of the PEA-PDBG cost is US$ 1,396,600.

(3) São Gonçalo Clean City

1) Fundamental

This project aimed at enhancing the urban cleaning and solid waste collection services of the Municipality of São Gonçalo. At the time, the Dengue fever was spreading and the main concern was to reduce the locations where the mosquitoes could reproduce, and that meant litter (inside of littered cans, bottles, pneumatic tires, and so on). The educational aspect was mainly carried out by teenagers trained for explaining the population about the importance of the proper disposal of solid waste. The services were also enhanced.

2) Objectives

- to reduce Dengue fever transmitting mosquitoes and to control leachate from solid waste;
- to inform about the importance of a proper behavior as for solid waste disposal before collection;
- to increase the population awareness and to promote better sanitary conditions.

3) Activities

This program comprised the remodeling of the city urban cleaning services. The basic idea was to: a) organize an awareness up campaign, b) change the institutional image of the services to make it more appealing to the general public, c) settle a telephone hotline service for denouncing littering, d) other awareness raising activities.

Organization of awareness up campaign

The awareness up campaign was mainly based on a door-to-door explanation to be carried out by students (teenagers). For that, they received training in how to explain the São Gonçalo citizens the proper manner to dispose of solid waste, the importance to prevent litter to accumulate water that could be the birthplace for the dengue transmitting mosquitoes, and other important information concerning solid waste management. This door-to-door explanation was very important because it reached the person in charge for solid waste disposal at the residence, mainly mothers/wives, also explaining the relation between Dengue fever and solid waste.

Approximately 400 students took part in this training project. The selection of students was carried out according to their grades at school and location in the municipality, i.e. students from all over the municipality were selected. They received an allowance of R$3/day not in cash but in tickets to buy food, plus a cardboard box containing basic staple food supplies. They were also provided with a uniform.

Change the institutional image

A new logo was created for the company in charge of the urban cleaning and solid waste collection services, the uniforms of the solid waste collecting employees were changed accordingly, as well as the collecting trucks painting.

Settle telephone hotline service

A telephone hotline service was settled for the citizens to denounce littering. The complaints were sent to a computerized system. This system was responsible for contacting the responsible organization to take care of the problem according to the incoming calls and needs.

Other awareness raising activities

Partnerships allowed the painting of walls (for erasing graphiting), the formation of a Carnival parading group (“Bloco de Carnaval”), a theater play, creation of characters to perform campaigns (Ms. Gonçalina family), among others.

Implementation period and Funding

The project was developed during 3 (three) years, from 1997 to 1999. In the first year, it was funded with FUNASA (National Fund of Health) resources, from federal government. In the second and third years, the Municipal Prefecture of São Gonçalo funded the project. Apart from these funds, the project managed to establish partnerships with the private sector. For instance, cardboard boxes with food supplies were provided by a Supermarket Chain (SENDAS), while uniforms were provided by a Cosmetic Factory (Boticário).

The total cost of the project, excluding the partnerships with the private sector, was of approximately R$ 400,000/year amounting to RS$ 1,200,000 in three years. This included the payment of the ABES-RJ (Brazilian Association of Sanitary Engineers - Rio de Janeiro section) staff that was in charge of the project concept and implementation.

The project was interrupted because of a political decision when the new Mayor took office after the 2000 elections.

(4) Environment Project carried out by CIMA (Culture, Information and Environment Center)

1) Fundamental / Introduction

This project is carried out at the Mauá community, at the margins of the Guanabara Bay, in the municipality of Magé. It is sponsored by a Private company (PETROBRAS) as part of their social contribution policy.

2) Objectives / Components

Estação Mauá Project has three main components: social, environmental and economic.

- The environmental component is the collection of PET bottles and the educational effect it has once preventing the littering of PET bottles into the drainage system and the Guanabara Bay.
- The social component is the integration of the community women in productive activities, so that they understand their important role in the society.
- The economic component is the self-sustainability of the cooperative business. Income and job opportunity generation at low income area through recycle materials.

3) Activities

The local government as well as the local schools are contacted to allow the mobilization of citizens for the importance of depositing PET bottles in appropriate containers. In the course of this activity, the NGO CIMA staff gave lectures about the importance of collecting PET bottles and other components in 13 different schools at Magé.

The collection of PET bottles is particularly important to avoid littering in the nearby creeks and rivers that will eventually reach the Bay, polluting its waters and harming the beautiful scenary of the Bay. Furthermore, PET bottles can get into the drainage system producing clogging and thus allowing the occurrence of floods during the rainy season.

The containers for the deposit of PET bottles by the residents were located in 23 places around the community and their collection from theses locations is carried out by the municipal government.

The cooperative women sew T-shirts made of recycled PET bottles material and sell them. The revenue from the selling of PET bottles is negligible, and the collection of bottles itself has more an environmental education effect than an economic effect.

The cooperative is still not self-sustainable, lacking rotation capital. The sewing machines and other equipment were acquired with PETROBRAS funds (grant). The workshop is operating in a small building rented by the Cooperative with municipal funds.

CIMA is a NGO that started its activities in 1985 with the main purpose of organizing the Rio Film Festival. Nowadays, applying their knowledge and skills in organizing large events, CIMA has expanded its range of activities and has already earned experience by doing Environmental Education related projects contracted out by federal and private companies.

In this project, CIMA worked on the mobilization of citizens for the collection of PET bottles, organization of women’s cooperative, organization of the business itself including studies and surveys for the commercialization of the cooperative products.

4) Implementation period and Funding

The project was implemented into two phases: Phase I (2001-2002) comprised the research and community organization, and Phase II (2002-2003) comprised the actual implementation of activities. There had been an interruption of 4 months between the two phases due to the delay in the contract renewal process with PETROBRAS.

The Estação Mauá Project total cost is the sum of the PETROBRAS portion plus the Municipal Government expenses with the collection of PET bottles and rental of the workshop facility.

2.2 SUMMARY OF EXISTING PROJECTS

The following table shows a summary of the existing projects according to some evaluation items such as coverage, subjects, self-sustainability and son on.

Table 5 Summary of Existing Projects

Evaluation Items	Project			
	Movement of Life Protection and the Guanabara Bay Revitalization Program	**Environmental Education Project of the Guanabara Bay Depollution Program (PEA - PDBG)**	**São Gonçalo Clean City**	**Estação Mauá Project**
Coverage	12 municipalities of Guanabara Bay basin. Wide participation of government officials, NGOs and private sector.	Guanabara Bay basin municipalities. Teacher/students for the specialization course are selected from all over the basin. So far, effective Action Plans don't cover the whole basin area. Teachers have a high potential to spread coverage through their students and the school community.	São Gonçalo municipality. During implementation, teenagers were selected from all over the municipality to act as environmental agents. House to house informative work was carried out by them covering the whole municipality.	Community of Mauá at Magé municipality. Small scale thus good coverage of PET bottles collection activities (23 collection points). Number of cooperative members: 25 persons
Subject	Environment, solid waste management.	Natural conditions, sewerage and others. Dealing with the whole environment scheme.	Dengue fever-health, solid waste management.	Environment and solid waste management, social and economic aspects.
Funds Management	No information about this.	Disbursement schedule from State government is unstable. PEA-PDBG team has not presented a funds management planning for the 4th Phase.	ABES-RIO professionals were very able in establishing partnerships with the private sector to allow the expansion of the original project scope. Due to political changes, the last payment due to ABES-RIO was not paid by the municipal government.	Without the support of CIMA, the Women's cooperative was not able to handle the cooperative management. More expertise is demanded for when CIMA works finished and the cooperative has to deal it alone.
Sustainability	During implementation, supplied funds came from the Ministry of Environment. Not self-sustainable.	Specialization and Qualification courses: not self-sustainable and not searching for self-sustainability since the courses are offered for free. EER Centers: not self-sustainable but searching for methods to assure self-sustainability.	During implementation, the main portion was from FUNASA (National Health Fund) and Local Government. Though, a good partnership policy with the private sector allowed the inflow of significant resources for complementary activities.	Not yet self-sustainable but searching for methods to assure self-sustainability. Need of rotation capital.
Achievements	Implementation of various short-term courses on matters related mainly to Solid Waste management and Guanabara Bay. Production of various educational materials. Establishment of a home page still on-line.	Reasonable number of graduates of both courses and a long waiting list for the specialization course (high demand). As for EER centers, only two from the original five centers managed to continue activities.	Change of the São Gonçalo municipality residents' solid waste disposal patterns to more environmental friendly ones. Actual engagement of teenagers in productive activities preventing them to engage in drug dealing activities.	Engagement of Magé residents in PET bottles collection thus preventing their disposal on the bay or in the drainage system, also preventing the occurrence of floods caused by drainage system clogging. Actual establishment of an income generation cooperative for the community's women

Evaluation Items	Project			
	Movement of Life Protection and the Guanabara Bay Revitalization Program	**Environmental Education Project of the Guanabara Bay Depollution Program (PEA - PDBG)**	**São Gonçalo Clean City**	**Estação Mauá Project**
Self-evaluation	Inexistent since the project finished	An evaluation report on the Action Plans is currently in elaboration by PEA-PDBG team.	Inexistent since the project was interrupted.	Cooperative members periodically gather in General Meetings to discuss the cooperative issues. As for the PET bottles collection, evaluation is carried out according to the increase of collected material.
Feed-backing	Inexistent since the project finished	Dependent on the finalization of the evaluation report. Lacking the establishment of evaluation tools for seminars, action plans, among others.	Inexistent since the project was interrupted.	The adhesion of the community is increasing. Thus, the collection points had to be increased accordingly.
Future Perspectives	There will be no continuation.	Dependent on the extension of the IDB funding agreement for continuation.	Interrupted due to political reasons.	Self-sustainability is not yet assured. Dependent on rotation capital for continuation. Good perspectives for cooperative's sells. The increase of the cooperative members number depends on the increase of products sells.

The Study suggests the continuation of PDBG works for the improvement of Guanabara Bay water environment, therefore the Environmental Education Project carried out by PDBG is recommended for continuation. However, as a result of our review, many necessary and important possible improvements are recognized. In order to continue the project, it is important to disclose the bottlenecks and to point out improvement measures.

Apart from this, the Study by reviewing some existing projects also came to the conclusion of the importance of the community level projects that though still face many difficulties. The Study evaluated the Estação Mauá project carried out by CIMA as having a good potential of self-sustainability and possible to get good results with limited funding sources. Thus, necessary improvements to lead to even better results are recommended and proposed.

2.3 RECOMMENDATIONS FOR THE IMPROVEMENT OF EXISTING PROJECTS

The following table presents the identified main bottlenecks and recommendations for improvement for the two projects described above.

Table 6 Bottlenecks and Recommendations

Project Name	Bottlenecks	Recommendations
Environmental Education Project of the Guanabara Bay Depollution Program PEA - PDBG	(1) The continuation of Action Plans is not assured.	(1) Existing Action Plan should be the starting point for the subsequent courses students. In this manner, the new group of students should analyze the existing Action Plan, and propose methods to improve, to expand, or to actually implement it, in case the implementation hadn't yet being carried out.
	(2) There is a lack of experiences exchange among the students.	(2) (2.1) The elaboration of Action Plans, actually elaborated by the Specialization Course students, should also count on the participation of the Qualification Course students to allow a better cooperation and exchange of experiences among them. (2.2) Set up of a Website for the Project. This could allow the download of textbooks and others only for enrolled students with a login and a password, for example.

Project Name	Bottlenecks	Recommendations
	(3) Continuation of teachers' environmental activities at schools after graduation is not assured. (4) EER Centers are not self-sustainable.	(3) The graduates of the Specialization Course, mostly State educational system teachers, should be bound to the commitment of applying the knowledge acquired during the course in their activities back at school, for a pre-determined period. The Specialization Course is rendered for free for those teachers and thus they should have the obligation of somehow return this investment to the society. (4) (4.1) EER centers should associate to existing NGOs with an already organized structure. These two organizations could them join their strength. It is though worthy to say that a sound research on existing NGOs, their actual activities and coverage, as well as their actual commitment to the environment cause, is a pre-requisite for such an action. (4.2) College students should be invited to work at these centers, for a pre-determined period, applying the knowledge learnt at school, implementing various activities related to environmental education. Through an agreement with the EER Centers coordination, the college institutions could determine this internship period and also that one activity developed at the EER Center becomes the final graduation work. Apart from the financial advantages of this initiative, an important outcome is the early commitment of future professionals with the Guanabara Bay basin environment.
Estação Mauá Project	(1) Cooperative is not self-sustainable yet. (2) Support from municipal government is unstable.	(1) (1.1) Building-up capacity training is necessary to increase the cooperative members skills in managing their business. (1.2) The funding should include a rotation capital to maintain the cooperative business until acquiring self-sufficiency. (1.3) Cooperative should search for agreements with institutions for the production of institutional use T-shirts (schools, soccer team supporters, etc.) (2) (2.1) Municipal governments should be involved through a sound explanation work, considering that this work, after all, is beneficial for all the citizens. (2.2) Search for other partnerships with the private sector in order not to be so dependent on the municipal government.

(1) Improvement of EEP by PDBG

The major issue of EEP by PDBG is the lack of an evaluation system for the project. Because of that, its contribution to the society and the number of influenced people are hard to grasp. Their main concept of educating/creating educators to influence/teach a large coverage of educated students and community is the strongest advantage of this project. However, at present, there are no indicators that show its great contribution in improving the awareness about the water environment of Guanabara Bay. Developing a quantitative and qualitative evaluation system will help teachers and students to increase their confidence and will encourage the recognition of the important role the environmental educators have, as well as also increasing decision makers understanding about the project effectiveness.

Financial sustainability is another important factor to reconsider in this project. The initial financial planning should be elaborated so that to adjust to the actual funding conditions. Apart from this, other financial sources and/or partnerships should be sought. In case of the EER Centers, partnerships with NGOs or colleges in order to have college students of various fields (engineering, geography, geology, biology, sociology, etc.) working as interns at the centers could be a good alternative for the lack of financial resources. These are only some examples but other alternatives can be sought through the creative participation of the project participants.

(2) Recommendation of possible Pilot Projects of EEP

To work with experienced NGO is one of the good ways to implement a pilot project. NGO's knowledge, skills and intensive research together with marketing sense can lead the project to self-sustainability. Some possible pilot projects suggested by CIMA are listed as follows.

1) Environmental Education and Sustainability at Guanabara Bay

The successful example of the Estação Mauá project could be applied in different communities of the Guanabara Bay basin.

This project joins two very important activities that are the environmental protection (through the collection of PET bottles) and the income generation for communities in need (cooperative).

The collection of PET bottles is particularly important to avoid littering in the nearby creeks and rivers that will eventually reach the Bay, polluting its waters and harming the beautiful scenary of the Bay. Furthermore, PET bottles can get into the drainage system producing clogging and thus allowing the occurrence of floods during the rainy season.

The development of cooperatives with the aim of income and employment generation together with environmental preservation and education is very important not only from the economic point of view but also from the socialization point of view: the cooperative members, specially women, can recognize their important role in the society.

The focuses on the production of T-shirts and clothing made of recycled PET bottles that will be collected within the community. Besides the production of clothes, the qualification of cooperative members in various fields is also important to be carried out through qualification courses such as: cut and sewing, production, administration and management and environmental education.

Together with the PET bottles collection, other activities should be carried out with the cooperative members so that they become multiplying agents in spreading the environmental awareness, mobilizing the community, and allowing the collection to be carried out in several community sectors such as schools, residences, commerce, churches, etc.

2) Environmental Education and Art at Guanabara Bay

<u>Description</u>

This project aims at developing an activity that unites education, art and environmental sustainability together with the Guanabara Bay surroundings population.

Students from public schools of the 16 municipalities of the Guanabara Bay basin will be called to take part in a Theater Script Competition, and the winning text will be used for the set up of an itinerant Theater Play.

The intention of this project is to disclose the teenagers’ position about the environmental reality of Guanabara Bay, and to make their impressions, suggestions and commitment level known in order to help the recuperation of that environment.

Everyday, actions to mobilize the teenagers increase, valorizing their participation in everyday life issues. Surpassing the limits of only denouncing problems, the teenagers’ contribution in the identification of the problems causes and the search for alternatives to solve them are also increasing.

The set up of this theater play will broaden these teenagers vision towards the public dimension, with the support of art. The audience, the general public in all the municipalities of the Guanabara Bay basin, will also have their vision broaden in regard to environmental issues.

<u>Objectives</u>

- To give the opportunity to the public schools students, located at the Guanabara Bay basin, to depict that socio-environmental reality, with emphasis at the sustainability, through a theater script competition.

- To present to the public living at the municipalities a good quality Theater Play that is also committed to the Guanabara Bay sustainability, aiming at sensitizing the population for conscious actions towards the environmental preservation.

Methodology

The awarded script will be transformed by a professional into an actual theater play script.

The play will be set up with professional actors from these municipalities.

The stage decoration will be made of recyclable materials and will be produced by teenagers that participate in social inclusion projects existing in the municipalities. Furthermore, the play will be developed so that it can be itinerant.

The play will be presented 76 times, 16 times in Rio de Janeiro and 60 times in the other 15 municipalities, according to the municipal secretariats of Education and Culture of each municipality.

In addition, a report-video of the project as well as a video of the whole play will be produced for future use.

3) Community Radio Station

Description

The creation of a Community Radio Station in Bangu, western zone of Rio de Janeiro municipality, aims at the creation of a broadcasting center of knowledge and information about health, sanitation and environment, in partnership with local community organizations. Apart from this information, the radio station will also spread information on local cultural activities. This is particularly important considering the broad geographic coverage and high population density of Bangu, besides the great environmental sanitation and violence problems faced by the community. This activity will strengthen the community self-esteem and cultural identity. In the medium term, the radio shall become self-sustainable through partnerships with local partners (for instance, through the transmitting of commercials of the local enterprises). Furthermore, its operation will also become independent, i.e., the radio station will be operated by community members, mainly youngsters formed as environmental reporters and that received on-job training by specialized technicians hired for the project.

Objectives

- To build a permanent relationship between the project and the main local community organizations, during the whole process of implementation, administration and operation of the radio station;
- To daily broadcast to the community a radio program with educational contents (sanitation, health, environment and environmental education, information, project activities and community organizations activities) and cultural contents (divulgation of local cultural groups);
- To create a forum for discussion and proposition of solutions for the community problems;
- To divulge and strengthen the community self-esteem and cultural identity.

Methodology

1st year

In the 1st year of the project, a survey on local organizations will be carried out, after what these organizations will be visited and the leaders will be instructed about the project objectives. A workshop for the creation of the Community Radio will be carried out with the interested community members.

For the radio station operation, an Association has to be created and thus meetings will be held for the discussion of its Statute as well as a General meeting for its constitution, followed by all the legal registrations required.

The radio station implementation will require the elaboration of a technical project. This will be followed by the selection of best locations for the installation of the radio station and of the antenna. The best location will be rented, and equipment and furniture will be acquired.

While the radio station is installed, the operation team will be selected and contracted. Meanwhile, courses on sanitation, health and environment will be rendered to the community council formed during the Association creation and to the technical team to allow the creation of the radio programming.

The whole process will culminate with the radio opening event and the start of the pilot operation (4 hours per day).

2nd and 3rd years

Courses will be rendered to community youngsters for their formation as environmental reporters, qualifying them to identify and to propose alternatives for the solution of environmental sanitation problems. The activities of the students will be divulged and debated in the community radio programming.

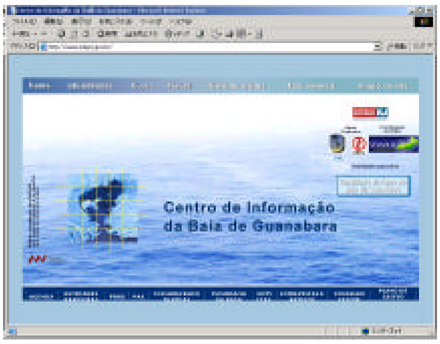
Gradually, the radio programming will be expanded to 8 hours per day, and then finally to 10 hours per day. Meanwhile, the radio station self-sustainability will be searched through partnerships with local enterprises and others. As for radio station operation, gradually the operation will be transferred to the community. First, this operation will be jointly carried out by hired technicians and community youngsters and, in a following state, it will be wholly carried out by community members.

3. HOME PAGE

Main tasks of putting Home page(HP) at Web site is to disseminate information to the views to increase their understandings and awareness about water quality in Guanabara Bay.

3.1 BACKGROUND

Currently there are several Websites introducing the Guanabara bay, some of them are school works by high school students and others are updating news about PDBG project.



There is an official home page (http://www.cibg.rj.gov.br) of the government, presenting information about Guanabara Bay provided by various governmental organizations such as SEMADUR, CIDE, FEEMA, SERLA and others. This Homepage has created in purpose of exchanging and sharing the data and information regarding the Guanabara bay. Users can find out which department and organization is responsible for certain types of information and down load interesting data. However, this Website does not give general picture or water quality of Ganabara bay but rather explaining the roles of each government offices and their works. In other words, the contents of the existing Website does not attract general views and do not encourage the awareness of residents.

In order to encourage the resident awareness of the Guanabara bay, the Study has added a new section which shows and explains the overview of the Guanabara bay as a trial. This home page has been designed so as to attract people who are not interested in the Guanabara bay and so as to provide people who has already interested in with further and various information. Since the home page has been set up as a trial base, it is expected that the concerned organization should update the homepage and develop to make better information distributing tool to improve people's awareness.

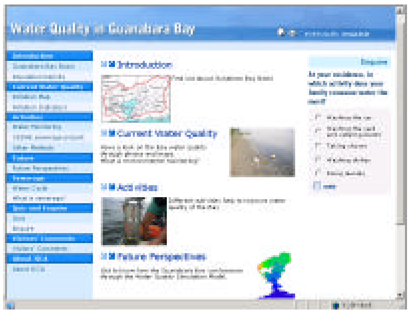
3.2 OBJECTIVES

The main objectives of HP are:

- to disseminate information about Guanabara Bay to bring the awareness and understandings about water quality of the Bay.
- to reach all different levels of public viewers from school student to government officials to inform the current water quality of the Bay, improvement methods and future perspective of improvement effort so that public could understand the importance of the projects and activities that currently carried out.

3.3 CONTENTS OF HOME PAGE

In order for general public to understand and get interested in the subject, many photos and maps have used to describe and explain water quality of Guanabara bay and several actives that have been carried out in the bay basin. Organization of the home page is shown in *Figure 1*.

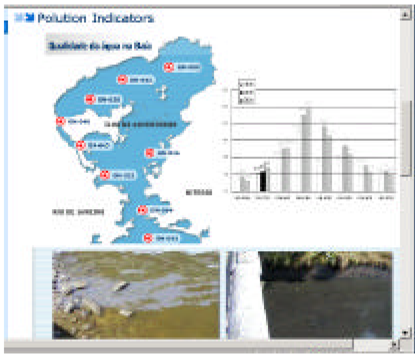


(1) Introduction

Introduction shows the Guanabara Bay basin and its basic information such as population distribution and Landuse.

This helps to understand the location of the Bay, physical relationship between the bay and basin, and deviation of population that is a potential pollution source.

(2) Current Water Quality



Pollution Map indicates the water quality of the Guanabara Bay by color measurement and BOD measurement. This color indicator helps easy understanding and grasping of the general image of where the water is polluted and where is not. Another BOD indicator using FEEMA's sampling points and BOD chart gives rough locations and images of water quality. Photo images of sampling points and its landscape could help viewers easily understand the water quality at their familiar location. If knowing its location, they could even sense its smell and be able to relate to their everyday life.

(3) Activities

This section introduces different methods and effort to improving the water quality of the Guanabara Bay. All the different methods would contribute to the improvement of water quality, for example, preservation and re-forestation to help natural eco-system, implement technical methods directly improve the water quality, and other education or legislation methods could encourage the government and community's environmental awareness. Major topics of this section are:

- Water Monitoring
- Sewerage works
- Other Technical methods
- Environmental education

(4) Sewerage

This section is for kids.

Using landscape interactive image with various photos showing water cycle with highlighting the sewerage system; discharging from houses, transmitting to WWTP, treating at WWTP and finally returning to the Bay.

(5) Quiz, enquire and visitor's comments

Playing games, answering enquire, writing visitor's comments and updating photos; though those activates, viewers get interested in and can understand more about the water quality and knowing more about Guanabara Bay. Also it can expect repeaters.

- Water Quality of Guanabara Bay Home Page
  - English
    - Introduction (1)
      - Guanabara Bay Basin (1-1)
      - Population density (1-2)
    - Current water quality (2)
      - Pollution Map (2-1)
      - Pollution indicators (2-2)
    - Activities (3)
      - Water monitoring (3-1)
      - CEDAE Sewerage Project (3-2)
      - Other methods (3-3)
    - Future (4)
      - Future perspective (4-1)
    - Sewerage (5)
      - Water cycle (5-1)
      - What is sewerage? (5-2)
    - Quiz and Enquire (6)
      - Quiz (6-1)
      - Enquire (6-2)
    - Visitors' comments (7)
    - About JICA (8)
  - Portuguese
    - Follows same organization as English

Figure 1 Organization of the Homepage

SUPPORTING 15

DATABASE AND DECISION SUPPORT SYSTEM

TABLE OF CONTENTS

Page

SUPPORTING 15 DATABASE AND DECISION SUPPORT SYSTEM

LIST OF TABLES

LIST OF FIGURES

SUPPORTING 15 DATABASE AND DECISION SUPPORT SYSTEM

1. INTRODUCTION

In order to formulate effective plans for improvement of natural environment, it is necessary to process and analyze large amount with wide range of information rationally. In general, the information are not unified, not managed properly and not ready for use for decision making. Since, the Guanabara Bay Basin covers several municipalities and a lot of organizations related to the environmental management are engaged, the information for formulating the environmental management plan are scattered.

To improve this situation, a database with a system of decision support has been established by the Study by unifying the scattered data/information.

2. DATABASE SYSTEM

2.1 BASIC CONCEPT OF DATABASE

(1) Concept for Database Design

Since the database is a part of decision support system of Guanabara Bay improvement, the roles of the database are as follows:

- To create an input data for water quality simulation of the Bay;
- To show the pollution load in various conditions.

In order to achieve the roles mentioned above, it is necessary to integrate the data/information scattered in various organizations and to arrange it in order for utilization for estimating the pollution load and decision-making.

As mentioned above, most of the data/information to achieve the roles has already been prepared in the various entities. It is, therefore, decided that the database is to be built by integrating the existing scattered data/information.

On the other hand, the value of database would be increased by accumulation of the data/information and continuous periodical update and utilization of the database. The followings are taking into account for easy accumulation of the data/information and the database maintenance:

- Simplified database/layer structures are applied in order to maintain the database with less knowledge of database operation.
- Sources of the data/information are clearly referred in the database to reach them easily.
- The areas for the data/information, which are currently not available but required in the future, are reserved in the database to avoid further construction work.

Since the database acts as a part of the decision support system, it is better to have capabilities of processing and analyzing the special (graphic) data/information. In this context, the database is proposed to be constructed as a Geographic Information System (GIS) based database.

In addition, construction of the database with clarified strategy and structure would decrease the degree of dependency to database software and would make it easier to transfer the database to other software. It makes the database easier for sustainable use.

(2) Database and GIS

Relation between Database and GIS is shown in *Figure 1*.

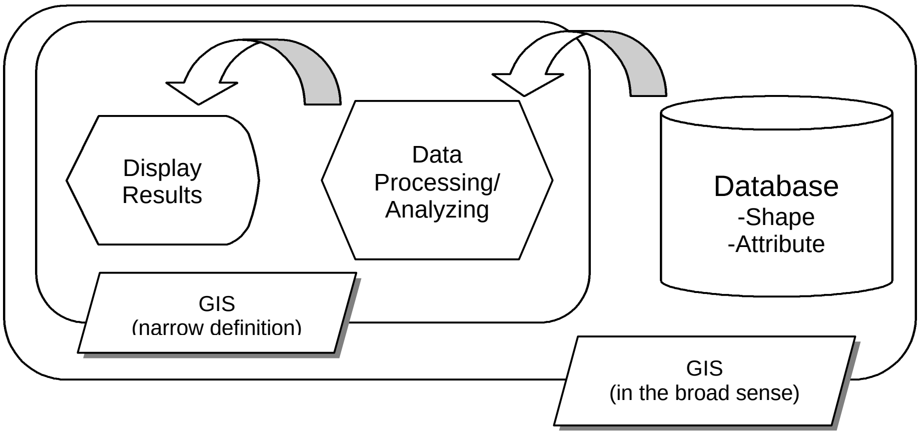


Figure 1 Relations between Database and GIS

As shown in *Figure 1*, GIS and database are different when saying strictly, however, in most cases, the GIS software has a function of database. The database is decided to be constructed by using the database function of GIS software of ArcView with following considerations:

- Amount of data handling in the database;
- Popularization of Software;
- Easiness of operation for data processing/analyzing;
- Easiness of conversion of the database file to other database format.

2.2 MAPS AND INFORMATION FOR DATABASE

(1) Base Map for GIS

1) Topographic Map

A base topographic map for the database has been prepared mainly based on digital topographic map with a scale of 1/50,000 prepared by CIDE as a part of PDBG project (for the index map, refer to *Figure 2* at the end of *Supporting 15*). Digital topographic maps with a scale of 1/400,000 prepared by CIDE has been utilized for some small parts in the fringe areas of the Study Area, which are not covered by the PDBG maps. The projection and other information of geographic features for the system are as follows:

➢ Projection:	Cônica Conforme de Lambert
➢ Datum:	Córrego Alegre
➢ Unit:	Meters
➢ Standard Parallel 1:	-20° 40’
➢ Standard Parallel 2:	-23° 20’
➢ Central Meridian:	-45° 00’
➢ Reference Latitude:	-19° 30’
➢ False Northing:	0.0
➢ False Easting:	0.0

2) Administration Boundary

Latest spatial information prepared by CIDE and IBGE have been imported to the database as administration boundaries.

3) Basin Boundary

Basis of the basin boundary and the boundary of the Study Area, which is equal to the Guanabara Bay Basin, is from the latest information of CIDE. The information have been examined in detail and modified and determined through the Study.

4) Landuse

Landuse map prepared by CIDE in 1998 with a scale of 1/100,000 using 1996 SPOT satellite image is the latest landuse map available for the Study area and is stored in the GIS database. Even though, landuse map with a scale of 1/50,000 was also available from CIDE but the map was divided into many parts. Considering integrity of data, 1/100,000 scale landuse map was finally used in this Study.

5) Population

Population data by sector for year 2000 is from IBGE with a scale of 1/10,000. The data comprise population of the municipalities intersected by the Guanabara Bay basin. There were some missing data which have been updated by this Study using landuse map overlayed with sector map to make the population data complete and ready for analyzing using GIS. Based on the sector population data, population by municipalities and by river basin have been generated using geo-processing utility of ArcView GIS.

(2) Information for Database

There are two kinds of data/information stored in the database; one is the data/information prepared based on existing information and the other is created by this Study. Examples are shown in *Table 1* below:

Table 1 Information for Database

Based on Existing Information	Established by this Study
Natural Conditions (Topography, Geology, River, etc.) Geographical Information (Road, Railway, Building, etc.) Socio-Economic Condition (Population, Landuse, etc.) Monitoring Information (Meteo-Hydrology, Water Quality, etc.)	Wastewater Planning Information (Sewer District, Wastewater Treatment Plant, Pumping Station, Sewer Pipe, etc.)

2.3 STRUCTURE OF DATABASE

(1) Structure of Database

As expressed in the section of "Basic Concept", the structure of the database is made to be simple and easily understandable. The database structure is shown in *Figure 3* (at the end of *Supporting 15*).

(2) Layer Structure

1) General

Since the database is constructed as a GIS based one, the database is organized in layer structure. Each layer consists of three information namely feature, location and attribute. The layer structure and attribute data for each layer are shown in *Table 2 to 4* at the end of *Supporting 15*.

2) Composition of Files

There are two types of data in GIS. One is the spatial map data and the other is the text base attribute. The spatial map data keep information on location of features such as line, polygon, point and grid with their XY coordinates. Spatial maps have only information on location, area or length. These spatial data are saved in a shape file format in the world of ArcView 3. Each shape files has a single type of feature.

Another type of data is the text base attribute such as name of river, observation data of monitoring station and statistical figures etc. Any kind of text data that explain the spatial data can be added to the attribute table. These attribute data are saved as dbf file format (attribute table) in ArcView 3.

Each shape file is dynamically linked with its attribute table. For example, the color of a feature of shape file will automatically change based on the specified legend when attribute data is modified. Specific features of shape file are automatically selected when they are queried in the attribute table. On the other hand, the attributes will be automatically queried when the features on the map are selected by the mouse. The relationship between shape file and attribute table is shown in *Figure 4* at the end of *Supporting 15*. A shape file corresponds to an attribute table one by one.

3. DECISION SUPPORT SYSTEM (DSS)

3.1 BACKGROUND

The GIS based database for the environmental management of Guanabara Bay has been built during the Study. On the other hand, water quality of the bay has been simulated by MIKE 21, a package software for water quality simulation developed by Danish Hydraulic Institute (DHI).

Input data, such as pollution load for MIKE 21 simulation was calculated using information stored in the database and input to MIKE 21 manually, because the GIS database itself dose not have a function to generate the data.

Operation of GIS database, data preparation and operation of MIKE 21, and analysis of simulation results are currently carried out separately and special skills for each program is required. Such a complicated process hinders the efficient use of these systems for decision-making process of environmental management, and it is, therefore, necessary to link between the systems and provide seamless environment of system operation.

3.2 OBJECTIVE OF SYSTEM DEVELOPMENT

The objectives of the system development are:

- to develop a Graphical User Interface (GUI) for easy operation of GIS database and MIKE 21,
- to develop interface and data exchange tools between GIS database and MIKE 21, and
- to create a seamless environment of system operation.

3.3 DSS FUNCTIONS

(1) General

Based on decision-making process considerations, the following functions are required for this system:

- GUI for viewing and editing the GIS database (Stage 0);
- Calculation of pollution load and preparation of input data file for water quality simulation by MIKE 21 (Stage I);
- Simulation of Guanabara Bay water quality by MIKE 21 (Stage II); and
- Display and evaluation of the results of water quality simulation based on pre-set criteria (StageIII).

Since water quality simulation process will be carried out by MIKE 21 and source code of MIKE 21 cannot be modified, system development requirements related to this process are not included.

The GUI for the system has been developed as an interactive one using ESRI's MapObjects LT 2.0 software. MapObjects is a collection of mapping components for application developers that works under Visual Basic programming language environment. Using MapOjects LT 2.0 and Visual Basic 6, the DSS has been developed as a stand-alone executable software such that no other software is needed to run the DSS. However, to make pollution load calculation and to run water quality simulation, Microsoft Excel and MIKE 21 software are pre-requisite. The DSS comes with a setup file that has to be installed in the user's computer.

(2) GUI for Viewing and Editing the GIS Database (Stage 0)

As special skills are required for operation of ArcView GIS database, frequent update of the database is not carried out. To improve this situation, an interactive GUI into which the users can view and edit the database easily, is provided in this system development. Same shape and dbf (dBASE) files developed in the GIS database are shared by the DSS. Maps can be viewed and data (attribute tables) can be edited in the DSS. Even though, geometry or shape of the map objects can't be directly modified from the DSS but any modification or updating of the shape files using a GIS software like ArcInfo or AutoCAD Map will be reflected in the DSS since the system uses the same file system stored in the GIS database. This makes the DSS a powerful tool for GIS data visualization and editing.

(3) Calculation of Pollution Load to the Bay (Stage I)

Process diagram of this stage is shown in *Figure 5* at the end of *Supporting 15*. In this process, pollution load to the bay is calculated using data stored in the GIS database and some coefficients to be inputted manually. The calculation result is exported to MIKE 21 time series data using a visual basic macro program from within the DSS. Same pollution load calculation methodology that has been applied in this Study has been used in the DSS. There are three interfaces for basic data input which are:

- Basic Basin Data: where the user has to input population and sewage treatment ratio and industrial/non-industrial pollution load data by river basin (under GIS environment);
- Basic WWTP Data: where the user has to input population and sewered ratio for each waste water treatment plant (under GIS environment);
- Basic Load Parameters: where the user view and edit general load parameters applicable for all river basins and wastewater treatment plants.

As a pre-set condition, population for year 2000 and sewage treatment ratio used by this Study have been set up. There are also three interfaces for detailed data input which have several other pre-set data and parameters used for pollution load calculation. The user can see and edit the data and parameters as needed. Based on the input data and parameters, the DSS automatically calculates pollution load by river basin and by WWTP. The calculated pollution loads can be viewed within the DSS on separate basin and WWTP load calculation windows. Summary of pollution loads for creating time series data of MIKE 21 eutrophication model can also be viewed on separate constant and discharge dependent load windows. Complete time series of pollution loads by river basin and by WWTP can be viewed from original load calculation excel file. The calculated pollution loads are exported to MIKE 21 time series files by using a visual basic macro program integrated with the DSS.

(4) Water Quality Simulation (Stage II)

Water quality of the Guanabara Bay is simulated by Eutrophication Module of MIKE 21 in this process. MIKE 21 is a stand-alone software that works separately and no modification of the program can be done. Therefore, no special development work has been carried out in this stage. However, to ease the simulation process, pre-set files have been included in the DSS. The users have to open MIKE 21 setup file, then view and modify the pre-set data according to need and run the simulation. If the users of the DSS don't change the pre-set model parameters and input file name or path, then the users only need to initiate running of the simulation. As a pre-set condition, in the hydrodynamic model, basin runoff for average year and in the eutrophication model, pollution load corresponding to basin population for year 2000 have been set up. The users of the DSS are expected not to change the basin runoff but update basin population and therefore, basin load. Since, updated time series of pollution load data for MIKE 21 is automatically generated in Stage II, therefore, the users can directly run the eutrophication model without any editing of the MIKE 21 setup file. This makes simulation process of MIKE 21 very simple and straightforward. Since, export of the MIKE 21 2D time series result files require some sort of post-processing within MIKE 21, therefore, the users of the DSS have to view the 2D result files from within MIKE 21. However, the users can view results at the bay water quality monitoring points which are zero-dimension time series files, from within the DSS as explained in Stage III below. Process diagram of this stage is shown in *Figure 6* at the end of *Supporting 15*.

(5) Display of Simulation Result (Stage III)

In this process, simulation results at the bay water quality monitoring points can be viewed and evaluated against pre-set criteria. The process involves importing MIKE 21 time series simulation results to the DSS by using a visual basic macro program integrated with the DSS. Process diagram of this stage is shown in *Figure 7* at the end of *Supporting 15*.

This completes the decision making process: starting from viewing and updating of the GIS database using the DSS, pollution load calculation within the DSS, exporting updated pollution load data from DSS to MIKE 21, simulation of water quality by MIKE 21, importing simulation results from MIKE 21 to the DSS and finally evaluation of bay water quality using the DSS and decision making.

Table 2 Layer Structure and Attributes of GIS Database (1 of 6)

Category	Classification	Name of Layer		Layer Code	Original Data	Attribute 1	ok	Attribute 2	ok	Attribute 3	ok	Attribute 4	ok	Attribute 5	ok	Attribute 6	ok	Attribute 7	ok	Attribute 8	ok
Natural Conditions (01)	**Topography (11)**	**Contour Line**	**field**	**LNC01**	CIDE	elevation (m)	x														
			field name	**XLNC01**	X	ELEVACAO	x														
			format		T-20	N-10,2	x														
		Point Elevation	**field**	**PNC01**	CIDE_JICA	elevation (m)	x														
			field name	**XPNC01**	X	ELEVACAO	x														
			format		T-20	N-10,2	x														
	Coastal Line (12)	**Coastal Line**	**field**	**LNC02**	CIDE	code(1)															
			field name	**XLNC02**	X	COD_01															
			format		T-20	T-5															
	Bay/Sea (13)	**Bay**	**field**	**ANC01**	CIDE_JICA	name	x	Area (sq. km)	x												
			field name	**XANC01**	X	NOME	x	AREA	x												
			format		T-20	T-70	x	N-20,2	x												
		Sea	**field**	**ANC02**	CIDE	name	x	Area (sq. km)	x												
			field name	**XANC02**	X	NOME	x	AREA	x												
			format		T-20	T-70	x	N-20,2	x												
	Geology (14)	**Geology**	**field**	**ANC03**		ID		geo. classification		area (sq. km)											
			field name	**XANC03**	X	ID		GEO_CLASS		AREA											
			format		T-20	T-20		T-60		N-20,4											
		Fault	**field**	**LNC03**		name		ID-JICA		ID-BR		level of fault									
			field name	**XLNC03**	X	NOME		ID_JICA		ID_BR		NIVEL									
			format		T-20	T-70		T-20		T-20		T-60									
	Ground Water Table (15)	**Ground Water Table**	**field**	**LNC04**		elevation (m)															
			field name	**XLNC04**	X	ELEVACAO															
			format		T-20	N-10,2															
	Vegetation (16)	**Vegetation**	**field**	**ANC04**		ID		veg. classification		area (sq. km)											
			field name	**XANC04**	X	ID		VEG_CLASS		AREA											
			format		T-20	T-20		T-60		N-20,4											
River and Basin (02)	**River (21)**	**River (stream line - simplified)**	**field**	**LRB01**	CIDE	name		ID-JICA		ID-BR		mgt. agency		flow direction		length (m)					
			field name	**XLRB01**	X	NOME		ID_JICA		ID_BR		ORGAO		DIRECAO		DISTANCIA					
			format		T-20	T-70		T-20		T-20		T-60		T-60		N-20,4					
		River (area)	**field**	**ARB01**	CIDE_JICA	name		ID-JICA		ID-BR		mgt. agency		flow direction		area (sq. km)	x				
			field name	**XARB01**	X	NOME		ID_JICA		ID_BR		ORGAO		DIRACAO		AREA	x				
			format		T-20	T-70		T-20		T-20		T-60		T-60		N-20,4	x				
	Lakes (22)	**Lakes**	**field**	**ARB02**	CIDE	name	x	ID-JICA		ID-BR		area (sq. km)	x								
			field name	**XARB02**	X	NOME	x	ID_JICA		ID_BR		AREA	x								
			format		T-20	T-70	x	T-20		T-20		N-20,4	x								
	Guanabara Bay Basin (23)	**Guanabara Bay Basin**	**field**	**ARB03**	CIDE_JICA	name	x	area (sq. km)	x	pop. 1991		pop.1996		pop. 2000	x	pop.2005		pop. 2010	x	pop. 2015	
			field name	**XARB03**	X	NOME	x	AREA	x	POP1991		POP1996		POP2000	x	POP2005		POP2010	x	POP2015	
			format		T-20	T-70	x	N-20,4	x	N-10,0		N-10,0		N-10,0	x	N-10,0		N-10,0	x	N-10,0	
	River Basin (24)	**River Basin (major)**	**field**	**ARB04**	CIDE_JICA	name	x	ID-JICA	x	ID-BR		area (sq. km)	x	Base Flow Zone	x	Average Elevation (m)	x	Average Slope (degree)	x	pop. 1991	
			field name	**XARB04**	X	NOME	x	ID_JICA	x	ID_BR		AREA	x	BF_ZONA	x	ELEV_MED	x	INCL_MED	x	POP1991	
			format		T-20	T-70	x	T-20	x	T-20		N-20,4	x	T-5	x	N-20,2	x	N-20,2	x	N-10,0	
		River Basin (sub)	**field**	**ARB05**	CIDE_JICA	name	x	ID-JICA	x	ID-BR		area (sq. km)	x	Base Flow Zone	x	Average Elevation (m)	x	Average Slope (degree)	x	pop. 1991	
			field name	**XARB05**	X	NOME	x	ID_JICA	x	ID_BR		AREA	x	BF_ZONA	x	ELEV_MED	x	INCL_MED	x	POP1991	
			format		T-20	T-70	x	T-20	x	T-20		N-20,4	x	T-5	x	N-20,2	x	N-20,2	x	N-10,0	
Road/Railway/ Buildings (03)	**Road (31)**	**Principal Road**	**field**	**LRR01**	CIDE	name		ID-JICA		ID-BR		code(4)		mgt. agency		width (m)		nos. of lane			
			field name	**XLRB01**	X	NOME		ID_JICA		ID_BR		COD_04		ORGAO		LARGURA		FAIXAS			
			format		T-20	T-70		T-20		T-20		T-5		T-60		N-20,4		T-60			
		Secondary Road	**field**	**LRR11**		name		ID-JICA		ID-BR		code(4)		mgt. agency		width (m)		nos. of lane			
			field name	**XLRB11**	X	NOME		ID_JICA		ID_BR		COD_04		ORGAO		LARGURA		FAIXAS			
			format		T-20	T-70		T-20		T-20		T-5		T-60		N-20,4		T-60			
	Railway (32)	**Railway**	**field**	**LRR02**	CIDE	name	x	ID-JICA		ID-BR		mgt. agency									
			field name	**XLRB02**	X	NOME	x	ID_JICA		ID_BR		ORGAO									
			format		T-20	T-70	x	T-20		T-20		T-60									
	Facilities/Buildings (33)	**Public Facilities/Buildings**	**field**	**PRR01**		name		ID-JICA		ID-BR		code(5)		use of bdg.		building area (sq. m)		nos. of stories			
			field name	**XPRB01**	X	NOME		ID_JICA		ID_BR		COD_05		USO_EDIF		AREA_EDIF		ANDARES			
			format		T-20	T-70		T-20		T-20		T-5		T-60		N-20,4		N-3,0			
		Major Facilities/Buildings (private)	**field**	**PRR02**		name		ID-JICA		ID-BR		code(6)		use of bdg.		building area (sq. m)		nos. of stories			
			field name	**XPRB02**	X	NOME		ID_JICA		ID_BR		COD_06		USO_EDIF		AREA_EDIF		ANDARES			
			format		T-20	T-70		T-20		T-20		T-5		T-60		N-20,4		N-3,0			
Monitoring Station (04)	**Meteorological Observation (41)**	**Meteorological Observation**	**field**	**PMS01**	INMET, SERLA	name	x	ID-JICA	x	ID-BR	x	location (municipality name)	x	latitude (S)	x	longitude (W)	x	elevation (m)	x	mgt. agency	x
			field name	**XPMS01**	X	NOME	x	ID_JICA	x	ID_BR	x	LOCAL	x	LATITUDE	x	LONGITUDE	x	ELEVACAO	x	ORGAO	x
			format		T-20	T-70	x	T-20	x	T-20	x	T-60	x	T-20	x	T-20	x	N-10,2	x	T-60	x
	Stream Gauge (42)	**Stream Gauge Station**	**field**	**PMS02**	SERLA	name	x	ID-JICA	x	ID-BR	x	location (municipality name)	x	latitude (S)	x	longitude (W)	x	mgt. agency	x	river name	x
			field name	**XPMS02**	X	NOME	x	ID_JICA	x	ID_BR	x	LOCAL	x	LATITUDE	x	LONGITUDE	x	ORGAO	x	RIO	x
			format		T-20	T-70	x	T-20	x	T-20	x	T-60	x	T-20	x	T-20	x	T-60	x	T-60	x
	Tidal Station (43)	**Tidal Station**	**field**	**PMS03**	DHN	name	x	ID-JICA		ID-BR		location (name)		latitude (S)	x	longitude (W)	x	mgt. agency	x	install year	
			field name	**XPMS03**	X	NOME	x	ID_JICA		ID_BR		LOCAL		LATITUDE	x	LONGITUDE	x	ORGAO	x	ANO	
			format		T-20	T-70	x	T-20		T-20		T-60		T-20	x	T-20	x	T-60	x	T-10	
	Wind (44)	**Wind Station**	**field**	**PMS04**	DHN	name	x	ID-JICA		ID-BR		location (name)	x	latitude (S)		longitude (W)		mgt. agency	x	install year	
			field name	**XPMS04**	X	NOME	x	ID_JICA		ID_BR		LOCAL	x	LATITUDE		LONGITUDE		ORGAO	x	ANO	
			format		T-20	T-70	x	T-20		T-20		T-60	x	T-20		T-20		T-60	x	T-10	
Water Quality (05)	**Water Quality (51)**	**Stream Water Quality Monitoring**	**field**	**PWQ01**	FEEMA	name	x	ID-JICA		ID-BR	x	location (name)	x	latitude (S)	x	longitude (W)	x	mgt. agency	x	install year	
			field name	**XPWQ01**	X	NOME	x	ID_JICA		ID_BR	x	LOCAL	x	LATITUDE	x	LONGITUD	x	ORGAO	x	ANO	
			format		T-20	T-70	x	T-20		T-20	x	T-60	x	T-20	x	T-20	x	T-60	x	T-10	

Table 2 Layer Structure and Attributes of GIS Database (2 of 6)

Category	Classification	Name of Layer		Layer Code	Original Data	Attribute 1	ok	Attribute 2	ok	Attribute 3	ok	Attribute 4	ok	Attribute 5	ok	Attribute 6	ok	Attribute 7	ok	Attribute 8	ok
		Bay Water Quality Monitoring	**field**	**PWQ02**	FEEMA	name	x	ID-JICA		ID-BR		location (name)	x	latitude (S)	x	longitude (W)	x	mgt. agency	x	commencement year	
			field name	**XPWQ02**	X	NOME	x	ID_JICA		ID_BR		LOCAL	x	LATITUDE	x	LONGITUD	x	ORGAO	x	ANO_INI	
			format		T-20	T-70	x	T-20		T-20		T-120	x	T-20	x	T-20	x	T-60	x	T-4	
	Areal Classification of	**Bay Water Classification**	**field**	**AWQ01**	FEEMA (CONAMA)	ID-BR	x	location		code(10)		area (sq. km)	x								
	Bay Water Quality (52)	**by BR**	**field name**	**XAWQ01**	X	ID_BR	x	LOCAL		CODIGO		AREA	x								
			format		T-20	T-20	x	T-60		T-20		N-20,4	x								
		Bay Water Classification	**field**	**AWQ02**		ID-MP		location		code(11)		area (sq. km)									
		by JICA M/P	**field name**	**XAWQ02**	X	ID_MP		LOCAL		CODIGO		AREA									
			format		T-20	T-20		T-60		T-20		N-20,4									
		Bay Water Classification	**field**	**AWQ03**		ID-JICA		location		area (sq. km)		existing (code(10))		short term (code(12))		mid. term (code(12))		long term (code(12))			
		by this Study	**field name**	**XAWQ03**	X	ID_JICA		LOCAL		AREA		CODE_10		COD_12_S		COD_12_M		COD_12_L			
			format		T-20	T-20		T-60		N-20,4		T-60		T-60		T-60		T-60			
Socio	**Administrative Boundary (61)**	**Administrative Area**	**field**	**ASE01**	CIDE_IBGE	name	x	ID-JICA		ID-BR	x	area (sq. km)	x	pop. 1991		pop.1996		pop. 2000	x	pop.2005	
Economy		**(municipality -**	**field name**	**XASE01**	X	NOME	x	ID_JICA		ID_BR	x	AREA	x	POP1991		POP1996		POP2000	x	POP2005	
(06)		**Guanabara Bay basin)**	**format**		T-20	T-70	x	T-20		T-20	x	N-20,4	x	N-10,0		N-10,0		N-10,0	x	N-10,0	
		Administrative Level 2	**field**	**ASE11**	IBGE	name	x	ID-JICA		ID-BR		area (sq. km)	x	pop. 1991		pop.1996		pop. 2000		pop.2005	
		(District/Sub-District -	**field name**	**XASE11**	X	NOME	x	ID_JICA		ID_BR		AREA	x	POP1991		POP1996		POP2000		POP2005	
		Guanabara Bay basin)	**format**		T-20	T-70	x	T-20		T-20		N-20,4	x	N-10,0		N-10,0		N-10,0		N-10,0	
		Administrative Level 3	**field**	**ASE12**		name		ID-JICA		ID-BR		area (sq. km)		pop. 1991		pop.1996		pop. 2000		pop.2005	
		(Neighborhood/Bairio)	**field name**	**XASE12**	X	NOME		ID_JICA		ID_BR		AREA		POP1991		POP1996		POP2000		POP2005	
			format		T-20	T-70		T-20		T-20		N-20,4		N-10,0		N-10,0		N-10,0		N-10,0	
	Landuse (62)	**Landuse 1998**	**field**	**ASE31**	CIDE_JICA	ID		landuse classification	x	landuse name	x	landuse code	x	municipality code	x	municipality name	x	area (sq. km)	x		
		by Municipality	**field name**	**XASE31**	X	ID		CLASSIF	x	USO_NOME	x	USO_CODE	x	MUN_CODE	x	MUN_NOME	x	AREA	x		
		(Guanabara Bay basin)	**format**		T-20	T-20		T-60	x	T-60	x	N-20	x	N-20	x	T-60	x	N-20,4	x		
		Landuse 2001	**field**	**ASE32**		ID		landuse classification		landuse name		landuse code		picture ID		area (sq. km)					
			field name	**XASE32**	X	ID		CLASSIF		USO_NOME		USO_CODE		PICT_ID		AREA					
			format		T-20	T-20		T-60		T-60		N-20		N-20		N-20,4					
		Landuse 2010	**field**	**ASE33**		ID		landuse classification		landuse name		landuse code		picture ID		area (sq. km)					
			field name	**XASE33**	X	ID		CLASSIF		USO_NOME		USO_CODE		PICT_ID		AREA					
			format		T-20	T-20		T-60		T-60		N-20		N-20		N-20,4					
		Landuse 2020	**field**	**ASE34**		ID		landuse classification		landuse name		landuse code		picture ID		area (sq. km)					
			field name	**XASE34**	X	ID		CLASSIF		USO_NOME		USO_CODE		PICT_ID		AREA					
			format		T-20	T-20		T-60		T-60		N-20		N-20		N-20,4					
	Social Class (63)	**Social Class**	**field**	**ASE04**		name		ID		area (sq. km)		no. of Sub-normal		population in sub-nomal							
			field name	**XASE04**	X	NOME		ID		AREA		SUB_NORM		POP_SUBN							
			format		T-20	T-20		T-20		N-20,4		N-10,0		N-10,0							
	Water Supply (64)	**Water Supply**	**field**	**ASE05**		name		ID		area (sq. km)		method of supply (code(15))		total amount of water supply (m3/day)		domestic use (%)		public use (%)		commercial use (%)	
			field name	**XASE05**	X	NOME		ID		AREA		COD_15		TOT_WATE		PERC_DOM		PERC_PUB		PERC_COM	
			format		T-20	T-20		T-20		N-20,4		T-60		N-20,4		N-6,2		N-6,2		N-6,2	
	Electricity (65)	**Electricity Line**	**field**	**LSE01**		ID		classification (code(16))		voltage											
			field name	**XLSE01**	X	ID		COD_16		VOLTAGEM											
			format		T-20	T-20		T-60		T-60											
Wastewater	**Sewer District (71)**	**Sewer System**	**field**	**AWW01**	JICA	name	x	ID-JICA	x	ID-BR	x	area (ha)	x	Status	x	population (2000)	x	population (2005)	x	population (2010)	x
System		**(area)**	**field name**	**XAWW01**	X	NOME	x	ID_JICA	x	ID_BR	x	AREA	x	STATUS	x	POP2000	x	POP2005	x	POP2010	x
(07)			**format**		T-20	T-70	x	T-20	x	T-20	x	N-20,4	x	T-60	x	N-10,0	x	N-10,0	x	N-10,0	x
	Sewage Outlet (72)	**Sewage Outlet**	**field**	**PWW01**		name		ID-JICA		ID-BR		area (sq. km)		diameter (mm)		location		longitude		latitude	
			field name	**XPWW01**	X	NOME		ID_JICA		ID_BR		AREA		DIAMETRO		LOCAL		LONGITUD		LATITUDE	
			format		T-20	T-70		T-20		T-20		N-20,4		N-20,4		T-60		T-20		T-20	
	Sewerage Facilities (73)	**Wastewater Treatment Plant**	**field**	**PWW02**	JICA	name	x	ID-JICA		ID-BR	x	location	x	const. year		area treated (sq. km)		pop. treated	x	Existing capacity (L/s)	x
			field name	**XPWW02**	X	NOME	x	ID_JICA		ID_BR	x	LOCAL	x	ANO		AREA		POP	x	EXIST_CAP	x
			format		T-20	T-70	x	T-20		T-20	x	T-60	x	T-4		N-20,4		N-10,0	x	N-20,4	x
		Pumping Station	**field**	**PWW03**		name		ID-JICA		ID-BR		location		const. year		pumping method (code(19))		capacity (qu. m/min)		inflow pipe btm. el. (m)	
			field name	**XPWW03**	X	NOME		ID_JICA		ID_BR		LOCAL		ANO		COD_19		CAPAC		INF_PIPE	
			format		T-20	T-70		T-20		T-20		T-60		T-4		T-60		N-20,4		N-20,4	
		Manhole	**field**	**PWW04**		name		ID-JICA		ID-BR		location		const. year		type (code(20))		material (code(21))		upstream btm. el. (m)	
			field name	**XPWW04**	X	NOME		ID_JICA		ID_BR		LOCAL		ANO		COD_20		COD_21		UPSTREAM	
			format		T-20	T-70		T-20		T-20		T-60		T-4		T-60		T-60		N-20,4	
		Pipe	**field**	**LWW01**		name		ID-JICA		ID-BR		const. year		diameter (mm)		length (km)		material (code(22))		upstream btm. el. (m)	
			field name	**XLWW01**	X	NOME		ID_JICA		ID_BR		ANO		DIAMETRO		DISTANCIA		COD_22		UPSTREAM	
			format		T-20	T-70		T-20		T-20		T-4		N-20,4		N-20,4		T-60		N-20,4	
Pollutant	**Non-point Source (81)**	**Non-point Source**	**field**	**PPS01**		ID-JICA		type (code(23))		location		latitude (S)		longitude (W)		name of receiving water body		discharge rate (m3/day)		discharge quality-1	
Source			**field name**	**XPPS01**	X	ID_JICA		COD_23		LOCAL		LATITUDE		LONGITUD		NOME_W		DISCHARG		DIS_Q_1	
(08)			**format**		T-20	T-20		T-60		T-60		T-20		T-20		T-60		N-20,4		T-60	
	Point Source (82)	**Industrial Point Source**	**field**	**PPS02**		name		ID-JICA		ID-BR		type (code(24))		location		latitude (S)		longitude (W)		year commencement of operation	
			field name	**XPPS02**	X	NOME		ID_JICA		ID_BR		COD_24		LOCAL		LATITUDE		LONGITUD		ANO_INI	
			format		T-20	T-70		T-20		T-20		T-60		T-60		T-20		T-20		T-4	
		Non-industrial Point Source	**field**	**PPS03**		name		ID-JICA		ID-BR		type (code(24))		location		latitude (S)		longitude (W)		year commencement of operation	
			field name	**XPPS03**	X	NOME		ID_JICA		ID_BR		COD_24		LOCAL		LATITUDE		LONGITUD		ANO_INI	
			format		T-20	T-70		T-20		T-20		T-60		T-60		T-20		T-20		T-4	
Data File	**Meteorological (91)**																				
(09)	**Hydrological (92)**																				
	Tide (93)																				
	Water Quality (94)																				

Table 2 Layer Structure and Attributes of GIS Database (3 of 6)

Category	Classification	Name of Layer		Layer Code	Attribute 9	ok	Attribute 10	ok	Attribute 11	ok	Attribute 12	ok	Attribute 13	ok	Attribute 14	ok
Natural Conditions (01)	Topography (11)	Contour Line	field	LNC01												
			field name	XLNC01												
			format													
		Point Elevation	field	PNC01												
			field name	XPNC01												
			format													
	Coastal Line (12)	Coastal Line	field	LNC02												
			field name	XLNC02												
			format													
	Bay/Sea (13)	Bay	field	ANC01												
			field name	XANC01												
			format													
		Sea	field	ANC02												
			field name	XANC02												
			format													
	Geology (14)	Geology	field	ANC03												
			field name	XANC03												
			format													
		Fault	field	LNC03												
			field name	XLNC03												
			format													
	Ground Water Table (15)	Ground Water Table	field	LNC04												
			field name	XLNC04												
			format													
	Vegetation (16)	Vegetation	field	ANC04												
			field name	XANC04												
			format													
River and Basin (02)	River (21)	River (stream line - simplified)	field	LRB01												
			field name	XLRB01												
			format													
		River (area)	field	ARB01												
			field name	XARB01												
			format													
	Lakes (22)	Lakes	field	ARB02												
			field name	XARB02												
			format													
	Guanabara Bay Basin (23)	Guanabara Bay Basin	field	ARB03	pop. 2020	x	pop. density 2000 (persons/km2)	x	pop. density 2010 (persons/km2)	x	pop. density 2020 (persons/km2)	x				
			field name	XARB03	POP2020	x	DENS2000	x	DENS2010	x	DENS2020	x				
			format		N-10,0	x	N-10,2	x	N-10,2	x	N-10,2	x				
	River Basin (24)	River Basin (major)	field	ARB04	pop.1996		pop. 2000	x	pop.2005		pop. 2010	x	pop. 2015		pop. 2020	x
			field name	XARB04	POP1996		POP2000	x	POP2005		POP2010	x	POP2015		POP2020	x
			format		N-10,0		N-10,0	x	N-10,0		N-10,0	x	N-10,0		N-10,0	x
		River Basin (sub)	field	ARB05	pop.1996		pop. 2000	x	pop.2005		pop. 2010	x	pop. 2015		pop. 2020	x
			field name	XARB05	POP1996		POP2000	x	POP2005		POP2010	x	POP2015		POP2020	x
			format		N-10,0		N-10,0	x	N-10,0		N-10,0	x	N-10,0		N-10,0	x
Road/Railway/ Buildings (03)	Road (31)	Principal Road	field	LRR01												
			field name	XLRB01												
			format													
		Secondary Road	field	LRR11												
			field name	XLRB11												
			format													
	Railway (32)	Railway	field	LRR02												
			field name	XLRB02												
			format													
	Facilities/Buildings (33)	Public Facilities/Buildings	field	PRR01												
			field name	XPRB01												
			format													
		Major Facilities/Buildings (private)	field	PRR02												
			field name	XPRB02												
			format													
Monitoring Station (04)	Meteorological Observation (41)	Meteorological Observation	field	PMS01	install year	x	recording method (code(7))	x	transmitting method (code(8))		item-1	x	obs. frequency	x	item-2	x
			field name	XPMS01	ANO	x	CODE_07	x	CODE_08		ITEM_1	x	OBS_FRE1	x	ITEM_2	x
			format		T-10	x	T-60	x	T-60		T-60	x	T-200	x	T-60	x
	Stream Gauge (42)	Stream Gauge Station	field	PMS02	gauged area (sq. km)	x	install year	x	datum level (elevation in m)		recording method (code(7))	x	transmitting method (code(8))	x	item-1	x
			field name	XPMS02	AREA	x	ANO	x	DATUM		COD_07	x	COD_08	x	ITEM_1	x
			format		N-20,4	x	T-10	x	T-60		T-60	x	T-60	x	T-60	x
	Tidal Station (43)	Tidal Station	field	PMS03	recording method (code(7))		transmitting method (code(8))		obs. frequency	x	name of data file					
			field name	XPMS03	COD_07		COD_08		OBS_FREQ	x	NOME_ARQ					
			format		T-60		T-60		T-200	x	T-60					
	Wind (44)	Wind Station	field	PMS04	recording method (code(7))		transmitting method (code(8))		obs. frequency	x	name of data file					
			field name	XPMS04	COD_07		COD_08		OBS_FREQ	x	NOME_ARQ					
			format		T-60		T-60		T-200	x	T-60					
Water Quality (05)	Water Quality (51)	Stream Water Quality Monitoring	field	PWQ01	recording method (code(7))		transmitting method (code(8))		obs. frequency	x	Type	x	Avg. BOD5 2000 (mg/l)	x	Depth 1	x
			field name	XPWQ01	COD_07		COD_08		OBS_FREQ	x	TIPO	x	BOD5_00	x	DEPTH_1	x
			format		T-60		T-60		T-200	x	T-60	x	N-20,2	x	T-60	x

Table 2 Layer Structure and Attributes of GIS Database (4 of 6)

Category	Classification	Name of Layer		Layer Code	Attribute 9	ok	Attribute 10	ok	Attribute 11	ok	Attribute 12	ok	Attribute 13	ok	Attribute 14	ok
		Bay Water Quality Monitoring	field	PWQ02	obs. frequency	x	sampling depth (code(9))		Type	x	Avg. BOD5 1991 (mg/l)	x	Avg. BOD5 2000 (mg/l)	x	Avg. BOD5 2001 (mg/l)	x
			field name	XPWQ02	OBS_FREQ	x	COD_09		TIPO	x	BOD5_91	x	BOD5_00	x	BOD5_01	x
			format		T-200	x	T-60		T-60	x	N-20,2	x	N-20,2	x	N-20,2	x
	Areal Classification of	Bay Water Classification	field	AWQ01												
	Bay Water Quality (52)	by BR	field name	XAWQ01												
			format													
		Bay Water Classification	field	AWQ02												
		by JICA M/P	field name	XAWQ02												
			format													
		Bay Water Classification	field	AWQ03												
		by this Study	field name	XAWQ03												
			format													
Socio	Administrative Boundary (61)	Administrative Area	field	ASE01	pop. 2010	x	pop. 2015		pop. 2020	x	pop. density 2000 (persons/km2)	x	pop. density 2010 (persons/km2)	x	pop. density 2020 (persons/km2)	x
Economy		(municipality -	field name	XASE01	POP2010	x	POP2015		POP2020	x	DENS2000	x	DENS2010	x	DENS2020	x
(06)		Guanabara Bay basin)	format		N-10,0	x	N-10,0		N-10,0	x	N-10,2	x	N-10,2	x	N-10,2	x
		Administrative Level 2	field	ASE11	pop. 2010		pop. 2015		pop. 2020		pop. density 2000 (persons/km2)		pop. density 2010 (persons/km2)		pop. density 2020 (persons/km2)	
		(District/Sub-District -	field name	XASE11	POP2010		POP2015		POP2020		DENS2000		DENS2010		DENS2020	
		Guanabara Bay basin)	format		N-10,0		N-10,0		N-10,0		N-10,2		N-10,2		N-10,2	
		Administrative Level 3	field	ASE12	pop. 2010		pop. 2015		pop. 2020		pop. density 2000 (persons/km2)		pop. density 2010 (persons/km2)		pop. density 2020 (persons/km2)	
		(Neighborhood/Bairio)	field name	XASE12	POP2010		POP2015		POP2020		DENS2000		DENS2010		DENS2020	
			format		N-10,0		N-10,0		N-10,0		N-10,2		N-10,2		N-10,2	
	Landuse (62)	Landuse 1998	field	ASE31												
		by Municipality	field name	XASE31												
		(Guanabara Bay basin)	format													
		Landuse 2001	field	ASE32												
			field name	XASE32												
			format													
		Landuse 2010	field	ASE33												
			field name	XASE33												
			format													
		Landuse 2020	field	ASE34												
			field name	XASE34												
			format													
	Social Class (63)	Social Class	field	ASE04												
			field name	XASE04												
			format													
	Water Supply (64)	Water Supply	field	ASE05	industrial use (%)		others (%)									
			field name	XASE05	PERC_IND		PERC_OUT									
			format		N-6,2		N-6,2									
	Electricity (65)	Electricity Line	field	LSE01												
			field name	XLSE01												
			format													
Wastewater	Sewer District (71)	Sewer System	field	AWW01	population (2015)	x	population (2020)	x	pop. density 2020 (persons/ha)	x						
System		(area)	field name	XAWW01	POP2015	x	POP2020	x	DENS2020	x						
(07)			format		N-10,0	x	N-10,0	x	N-10,2	x						
	Sewage Outlet (72)	Sewage Outlet	field	PWW01	name of receiving water body											
			field name	XPWW01	NOME_W											
			format		T-60											
	Sewerage Facilities (73)	Wastewater Treatment Plant	field	PWW02	Planned capacity (L/s)	x	actual flow rate (qu. m/day)	x	treatment process (code(17))		method of sludge dewatering (code(18))		effluent disc. (lat)		effluent disc. (long.)	
			field name	XPWW02	PLAN_CAP	x	ACT_FLOW	x	COD_17		COD_18		LAT_EFF		LONG_EFF	
			format		N-20,4	x	N-20,4	x	T-60		T-60		T-20		T-20	
		Pumping Station	field	PWW03	discharge pipe btm. el. (m)		head (m)		ground el. (m)							
			field name	XPWW03	DIS_PIPE		HEAD		GROUND							
			format		N-20,4		N-20,4		N-20,4							
		Manhole	field	PWW04	downstream btm. el. (m)											
			field name	XPWW04	DOWNSTRE											
			format		N-20,4											
		Pipe	field	LWW01	downstream btm. el. (m)		year of repair									
			field name	XLWW01	DOWNSTRE		ANO_REPA									
			format		N-20,4		T-4									
Pollutant	Non-point Source (81)	Non-point Source	field	PPS01	discharge quality-2		discharge quality-3									
Source			field name	XPPS01	DIS_Q_2		DIS_Q_3									
(08)			format		T-60		T-60									
	Point Source (82)	Industrial Point Source	field	PPS02	effluent disc. (latitude)		effluent disc. (longitude.)		name of receiving water body		discharge rate (qu. m/day)		discharge quality-1		discharge quality-2	
			field name	XPPS02	LAT_EFF		LONG_EFF		NOME_W		DISCHARG		DIS_Q_1		DIS_Q_2	
			format		T-20		T-20		T-60		N-20,4		T-60		T-60	
		Non-industrial Point Source	field	PPS03	effluent disc. (latitude)		effluent disc. (longitude.)		name of receiving water body		discharge rate (qu. m/day)		discharge quality-1		discharge quality-2	
			field name	XPPS03	LAT_EFF		LONG_EFF		NOME_W		DISCHARG		DIS_Q_1		DIS_Q_2	
			format		T-20		T-20		T-60		N-20,4		T-60		T-60	
Data File	Meteorological (91)															
(09)	Hydrological (92)															
	Tide (93)															
	Water Quality (94)															

Table 2 Layer Structure and Attributes of GIS Database (5 of 6)

Category	Classification	Name of Layer		Layer Code	Attribute 15	ok	Attribute 16	ok	Attribute 17	ok	Attribute 18	ok	Attribute 19	ok	Attribute 20	ok	Attribute 21	ok	Attribute 22	ok
Natural Conditions (01)	Topography (11)	Contour Line	field field name format	LNC01 XLNC01																
		Point Elevation	field field name format	PNC01 XPNC01																
	Coastal Line (12)	Coastal Line	field field name format	LNC02 XLNC02																
	Bay/Sea (13)	Bay	field field name format	ANC01 XANC01																
		Sea	field field name format	ANC02 XANC02																
	Geology (14)	Geology	field field name format	ANC03 XANC03																
		Fault	field field name format	LNC03 XLNC03																
	Ground Water Table (15)	Ground Water Table	field field name format	LNC04 XLNC04																
	Vegetation (16)	Vegetation	field field name format	ANC04 XANC04																
River and Basin (02)	River (21)	River (stream line - simplified)	field field name format	LRB01 XLRB01																
		River (area)	field field name format	ARB01 XARB01																
	Lakes (22)	Lakes	field field name format	ARB02 XARB02																
	Guanabara Bay Basin (23)	Guanabara Bay Basin	field field name format	ARB03 XARB03																
	River Basin (24)	River Basin (major)	field field name format	ARB04 XARB04	pop. density 2000 (persons/km2) DENS2000 N-10,2	x x x	pop. density 2010 (persons/km2) DENS2010 N-10,2	x x x	pop. density 2020 (persons/km2) DENS2020 N-10,2	x x x										
		River Basin (sub)	field field name format	ARB05 XARB05	pop. density 2000 (persons/km2) DENS2000 N-10,2	x x x	pop. density 2010 (persons/km2) DENS2010 N-10,2	x x x	pop. density 2020 (persons/km2) DENS2020 N-10,2	x x x										
Road/Railway/ Buildings (03)	Road (31)	Principal Road	field field name format	LRR01 XLRB01																
		Secondary Road	field field name format	LRR11 XLRB11																
	Railway (32)	Railway	field field name format	LRR02 XLRB02																
	Facilities/Buildings (33)	Public Facilities/Buildings	field field name format	PRR01 XPRB01																
		Major Facilities/Buildings (private)	field field name format	PRR02 XPRB02																
Monitoring Station (04)	Meteorological Observation (41)	Meteorological Observation	field field name format	PMS01 XPMS01	obs. frequency OBS_FRE2 T-200	x x x	item-3 ITEM_3 T-60	x x x	obs. frequency OBS_FRE3 T-200	x x x	item-4 ITEM_4 T-60	x x x	obs. frequency OBS_FRE4 T-200	x x x	avg. annual rainfall (mm) CHU_ANU N-20,2	x x x	status STATUS T-60	x x x	name of data file NOME_ARQ T-60	
	Stream Gauge (42)	Stream Gauge Station	field field name format	PMS02 XPMS02	obs. frequency OBS_FRE1 T-200	x x x	item-2 ITEM_2 T-60	x x x	obs. frequency OBS_FRE2 T-200		item-3 ITEM_3 T-60	x x x	obs. frequency OBS_FRE3 T-200	x x x	avg. discharge 2000 (m3/s) VAZ_00 N-20,2	x x x	status STATUS T-60	x x x	name of data file NOME_ARQ T-60	
	Tidal Station (43)	Tidal Station	field field name format	PMS03 XPMS03																
	Wind (44)	Wind Station	field field name format	PMS04 XPMS04																
Water Quality (05)	Water Quality (51)	Stream Water Quality Monitoring	field field name format	PWQ01 XPWQ01	Depth 2 DEPTH_2 T-60		Depth 3 DEPTH_3 T-60		item-1 ITEM_1 T-60		item-2 ITEM_2 T-60		item-3 ITEM_3 T-60		status STATUS T-60	x x x	name of data file NOME_ARQ T-60			

Table 2 Layer Structure and Attributes of GIS Database (6 of 6)

Category	Classification	Name of Layer		Layer Code	Attribute 15	ok	Attribute 16	ok	Attribute 17	ok	Attribute 18	ok	Attribute 19	ok	Attribute 20	ok	Attribute 21	ok	Attribute 22	ok
		Bay Water Quality Monitoring	**field field name format**	**PWQ02 XPWQ02**	Depth 1 DEPTH_1 T-60	x x x	Depth 2 DEPTH_2 T-60	x x x	Depth 3 DEPTH_3 T-60	x x x	item-1 ITEM_1 T-60		item-2 ITEM_2 T-60		item-3 ITEM_3 T-60		status STATUS T-60	x x x	name of data file NOME_ARQ T-60	
	Areal Classification of Bay Water Quality (52)	**Bay Water Classification by BR**	**field field name format**	**AWQ01 XAWQ01**																
		Bay Water Classification by JICA M/P	**field field name format**	**AWQ02 XAWQ02**																
		Bay Water Classification by this Study	**field field name format**	**AWQ03 XAWQ03**																
Socio Economy (06)	**Administrative Boundary (61)**	**Administrative Area (municipality - Guanabara Bay basin)**	**field field name format**	**ASE01 XASE01**	water supply/sewage by (code(13)) COD_13 T-60															
		Administrative Level 2 (District/Sub-District - Guanabara Bay basin)	**field field name format**	**ASE11 XASE11**																
		Administrative Level 3 (Neighborhood/Bairio)	**field field name format**	**ASE12 XASE12**	income level (code(14)) COD_14 T-60															
	Landuse (62)	**Landuse 1998 by Municipality (Guanabara Bay basin)**	**field field name format**	**ASE31 XASE31**																
		Landuse 2001	**field field name format**	**ASE32 XASE32**																
		Landuse 2010	**field field name format**	**ASE33 XASE33**																
		Landuse 2020	**field field name format**	**ASE34 XASE34**																
	Social Class (63)	**Social Class**	**field field name format**	**ASE04 XASE04**																
	Water Supply (64)	**Water Supply**	**field field name format**	**ASE05 XASE05**																
	Electricity (65)	**Electricity Line**	**field field name format**	**LSE01 XLSE01**																
Wastewater System (07)	**Sewer District (71)**	**Sewer System (area)**	**field field name format**	**AWW01 XAWW01**																
	Sewage Outlet (72)	**Sewage Outlet**	**field field name format**	**PWW01 XPWW01**																
	Sewerage Facilities (73)	**Wastewater Treatment Plant**	**field field name format**	**PWW02 XPWW02**	influent (BOD) INFL_BOD T-60	x x x	influent (SS) INFL_SS T-60	x x x	effluent (BOD) EFF_BOD T-60	x x x	effluent (SS) EFF_SS T-60	x x x	Status STATUS T-60	x x x						
		Pumping Station	**field field name format**	**PWW03 XPWW03**																
		Manhole	**field field name format**	**PWW04 XPWW04**																
		Pipe	**field field name format**	**LWW01 XLWW01**																
Pollutant Source (08)	**Non-point Source (81)**	**Non-point Source**	**field field name format**	**PPS01 XPPS01**																
	Point Source (82)	**Industrial Point Source**	**field field name format**	**PPS02 XPPS02**	discharge quality-3 DIS_Q_3 T-60															
		Non-industrial Point Source	**field field name format**	**PPS03 XPPS03**	discharge quality-3 DIS_Q_3 T-60															
Data File	**Meteorological (91)**																			
(09)	**Hydrological (92)**																			
	Tide (93)																			
	Water Quality (94)																			

Table 3 Code for Layer Structure (1 of 2)

Code No.	Item	No.	Classification
code(1)	Coastal Line	1	sea locates right side
		2	sea locates left side
		99	unknown
code(2)	Bay/Sea/Lake	1	water body
		2	island
		99	unknown
code(3)	River Basin	1	major river basin
		2	sub river basin
		3	sub-sub river basin
code(4)	Roads	1	federal road
		2	state road
		3	municipal road
		99	others/unknown
code(5)	Public Facilities/Buildings	1	gov. office building
		2	private office building
		3	commercial building
		4	
		5	
		6	
		7	
		8	
		9	
		10	
		99	others/unknown
code(6)	Private Facilities/Buildings	1	
		2	
		3	
		4	
		5	
		6	
		7	
		8	
		9	
		10	
		99	others/unknown
code(7)	Recording Method	1	automatic
		2	manual
		99	others/unknown
code(8)	Transmitting Method	1	telemeter
		2	offline
		99	others/unknown
code(9)	Bay Water Quality Sampling Depth	1	top
		2	middle
		3	bottom
		99	others/unknown
code(10)	Areal Classification of Bay Water Quality by Brazil (see Reference Table 1)	1	Class 1
		2	Class 2
		3	Class 3
		4	Class 4
		5	Class 5
		6	Class 6
code(11)	Areal Classification of Bay Water Quality by JICA M/P (see Reference Table 2)	1	
		2	
		3	
code(12)	Areal Classification of Bay Water Quality by This Study (see Reference Table 3)	1	
		2	
		3	

Table 3 Code for Layer Structure (2 of 2)

Code No.	Item	No.	Classification
code(13)	Water Supply/Sewage by Directoria	1	Directoria regional baia de Guanabara Leste
		2	Directoria regional baia de Guanabara Oeste
		3	Directoria regional das baias de Septiba e Ilha Grande
		4	Directoria regional interior
		5	Directoria regional oceanica
		6	Saneament a cargo do Municipio
		7	Saneament a cergo da empresa privada
		8	Atuacao parcial
		99	others/unknown
code(14)	Income Level (Ratio against Minimum Wage (m.m.))	1	up to 3 m.w.
		2	3 - 10 m.w.
		3	10 - 15 m.w.
		4	15 - 20 m.w.
		5	more than 20 m.w.
		99	others/unknown
code(15)	Method of Water Supply	1	house connection
		2	public tap
		3	supply by tank truck by public service
		4	others by public service
		5	no service by public
		99	unknown
code(16)	Electricity Line	1	high voltage transmission line
		2	high voltage distribution line
		3	low voltage distribution line
		99	others/unknown
code(17)	Treatment Process	1	primary only
		2	activated sludge process
		3	oxidation ditch
		4	oxidation pond
		99	others/unknown
code(18)	Method of Sludge Dewatering	1	belt press
		2	centrifuge
		99	others/unknown
code(19)	Pumping Method	1	screw pump
		2	centrifugal
		99	others/unknown
code(20)	Manhole Type	1	Type A
		2	Type B
		3	Type C
		99	others/unknown
code(21)	Manhole Material	1	PVC
		2	concrete
		3	steel
		99	others/unknown
code(22)	Pipe Material	1	PVC
		2	concrete
		3	steel
		99	others/unknown
code(23)	Type of Non-point Source	1	farmland
		2	pasture
		99	others/unknown
code(24)	Type of Point Source	1	food industry
		2	chemical industry
		3	textile
		4	shipping industry
		5	pharmaceutical industry
		6	petrochemical industry
		7	soft drink bottling
		8	paper industry
		9	metallurgical industry
		10	wastewater treatment plant (public)
		99	others/unknown

Table 4 Reference Tables

Reference Table 1

Standard of Water Quality by CONAMA

Item	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Fecal Coliform (MPN/100ml)	<200	<1,000	<4,000	---	<1,000	<4,000	<1,000	<4,000
Total Coliform (MPN/100ml)	<1,000	<5,000	<20,000	---	<5,000	<20,000	<5,000	<20,000
BOD (mg/l)	<3	<5	<10	---	<5	<10	<5	---
DO (mg/l)	>6	>5	>4	>2	>6	>4	>5	>3
Suspended Substance	VA	VA	VA	VA	VA	VA	VA	VA
PH	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Remark	for freshwater	for freshwater	for freshwater	for freshwater	for seawater	for seawater	for brackish water	for brackish water

Reference Table 2

Standard of Water Quality by JICA MP

	Class 1	Class 2	Class 3

Refernce Table 3

Standard of Water Quality by this Study

	Class 1	Class 2	Class 3

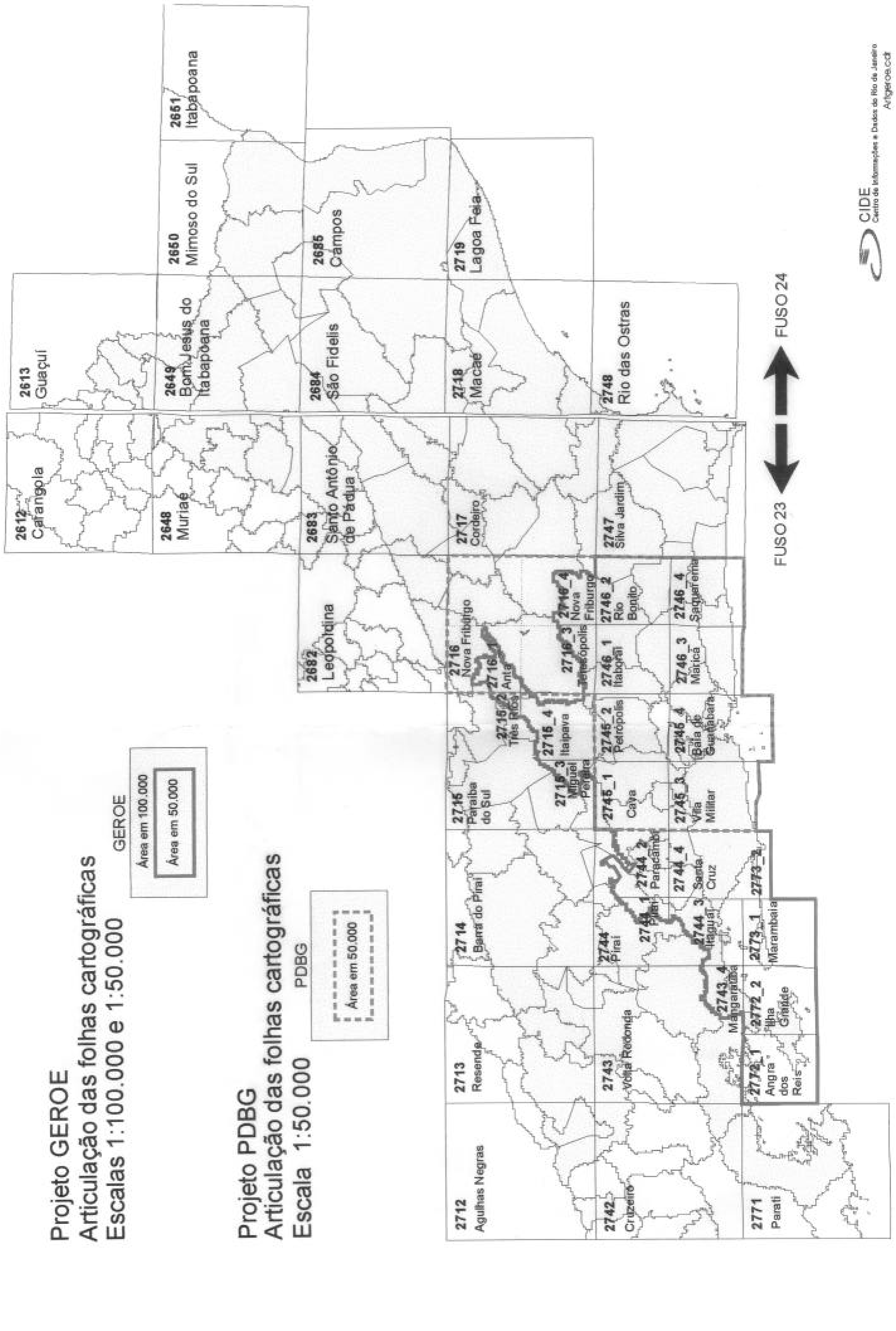


Figure 2 Index Map for Base Map

Data	Attribute
Natural Condition	
Topography	Contour Line, Spot Elevation
Geology	Kind of Soil, Area
Groundwater Table	Contour Level
Vegetation	Classification Area
Rivers	Name, Flow Direction, Length, Width, Flow Rate
Catchment Boundary	Name, Area, ID
Meteorological Observation	
Station	No. Code, Place, Lat. & Long., Data
Stream Gauge Station	No. Code, River Name, Lat. & Long., Gauged Area
Tidal Station	No. Code, Lat. & Long., Data
Social Condition	
Administrative Boundary	Name, Area, Population, No. of Household
Roads	Classification, Width
Major Buildings	Name, Use of Building
Existing Landuse	
Future Landuse 1	Classification, Area
Future Landuse 2	Classification, Area
Social Class	Classification, Area
Income Level	Classification, Area
Water Supply Area	Method of Supply, Classification, Area
Wastewater Planning/Management	
Drainage District Boundary	Name, Area
Pipe	Existing, Planning, Diameter, Material, Ground Elevation, Depth, Year of Construction
Manhole	Existing, Planning, Type, Year of Construction
Pumping Station	Name, Existing, Planning, Year of Construction, Capacity, Pump Type
Wastewater Treatment Plant	Name, Existing, Planning, Capacity, Flow Rate (Design, Existing), Treatment Process, Inf./Eff. Qualities, Year of Construction

Figure 3 Database Structure

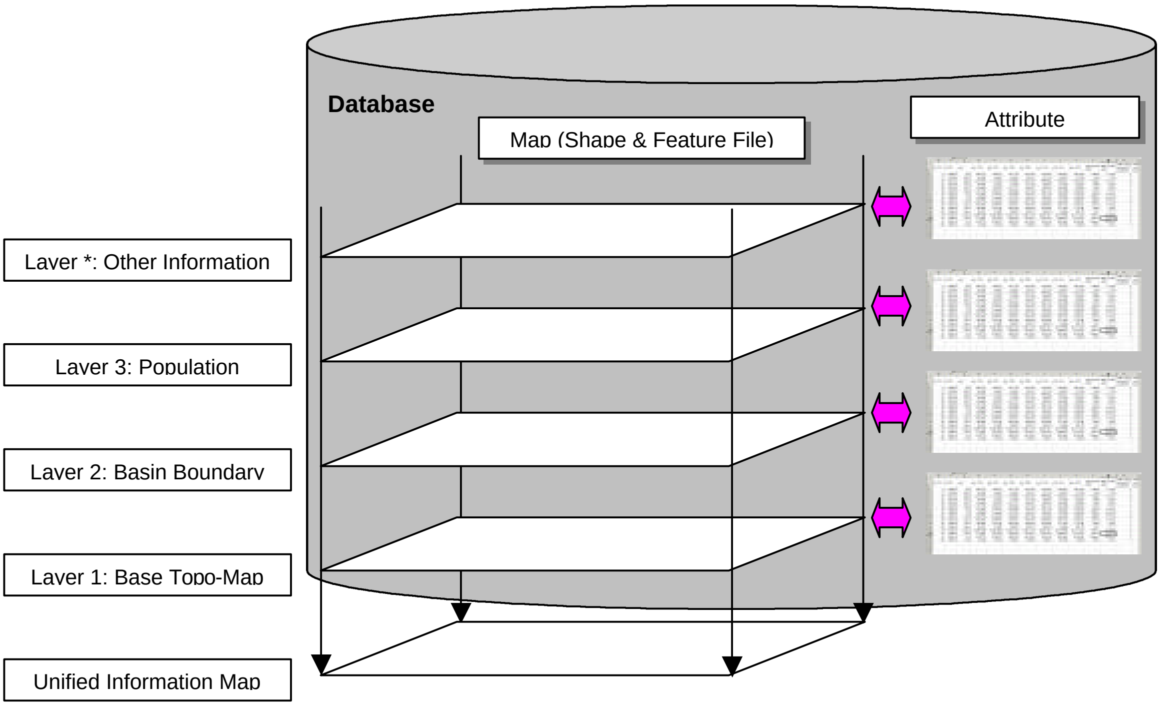


Figure 4 Relation between Shape File and Attribute Table

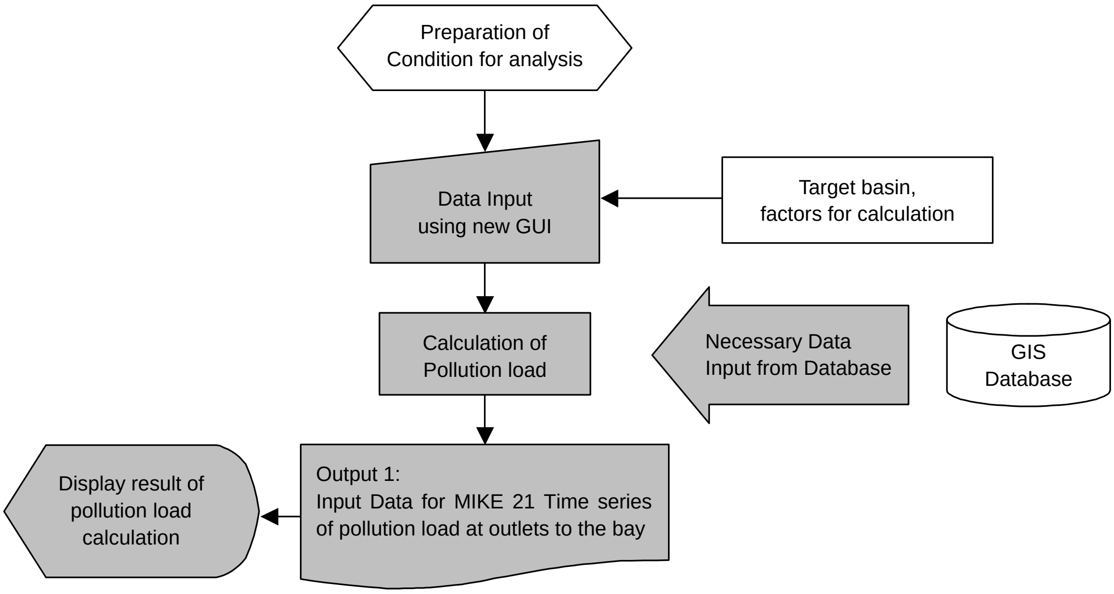


Figure 5 Process Diagram for Calculation of Pollution Load to the Bay (Stage I)

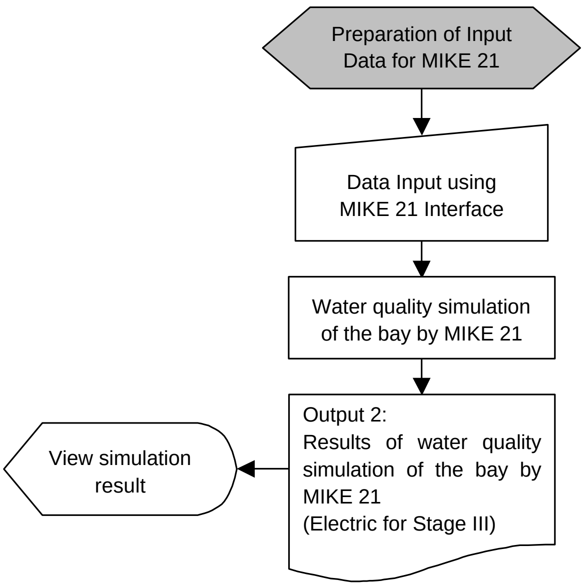


Figure 6 Process Diagram for Water Quality Simulation (Stage II)

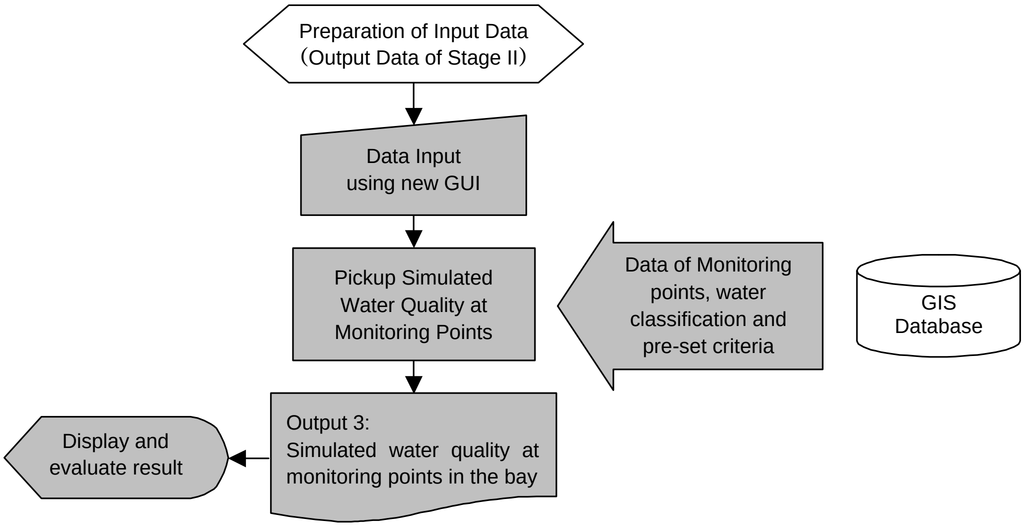


Figure 7 Process Diagram for Display of Simulation Result (Stage III)