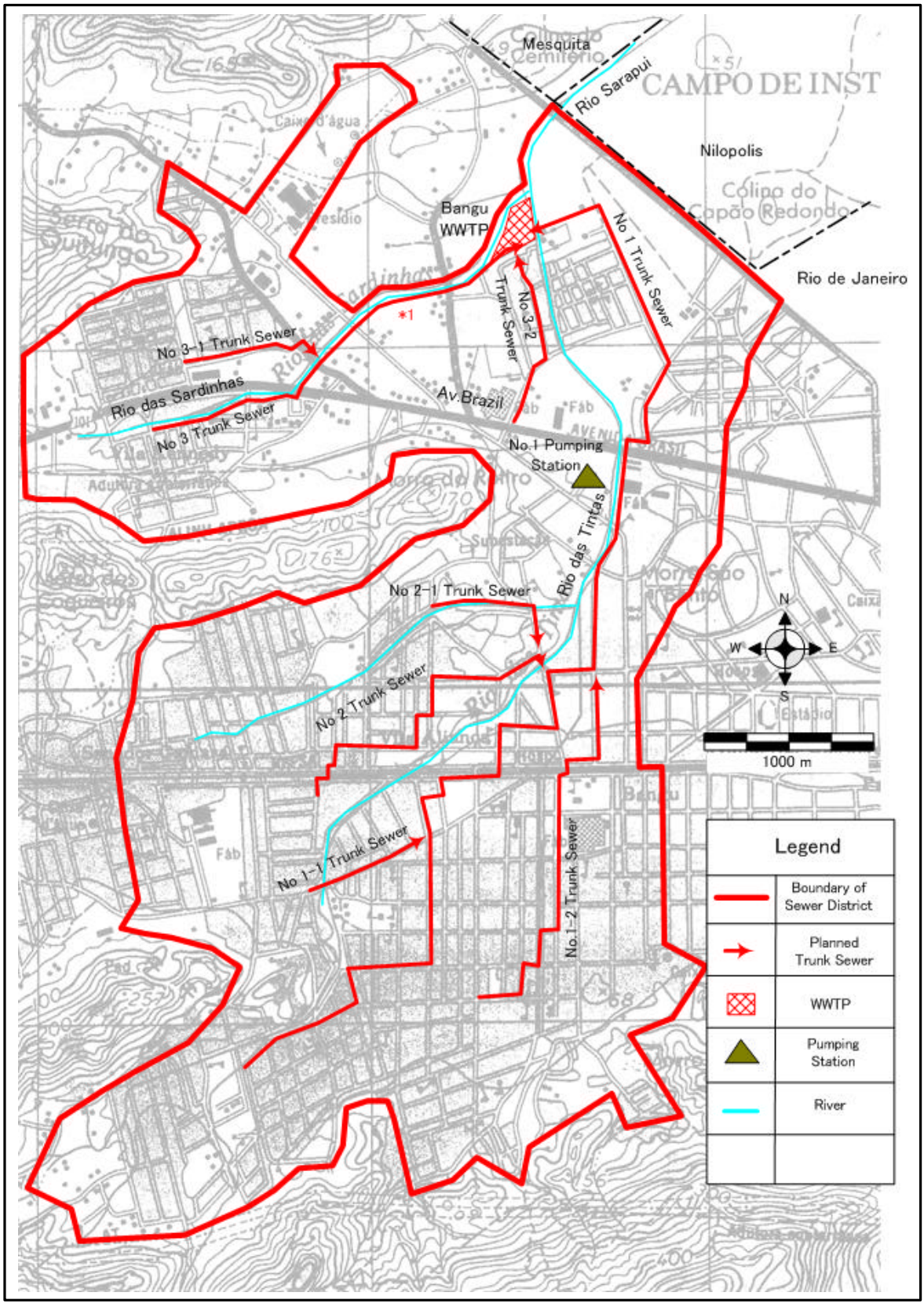


Figure 7.10 Layout Plan of Bangu Sewer District

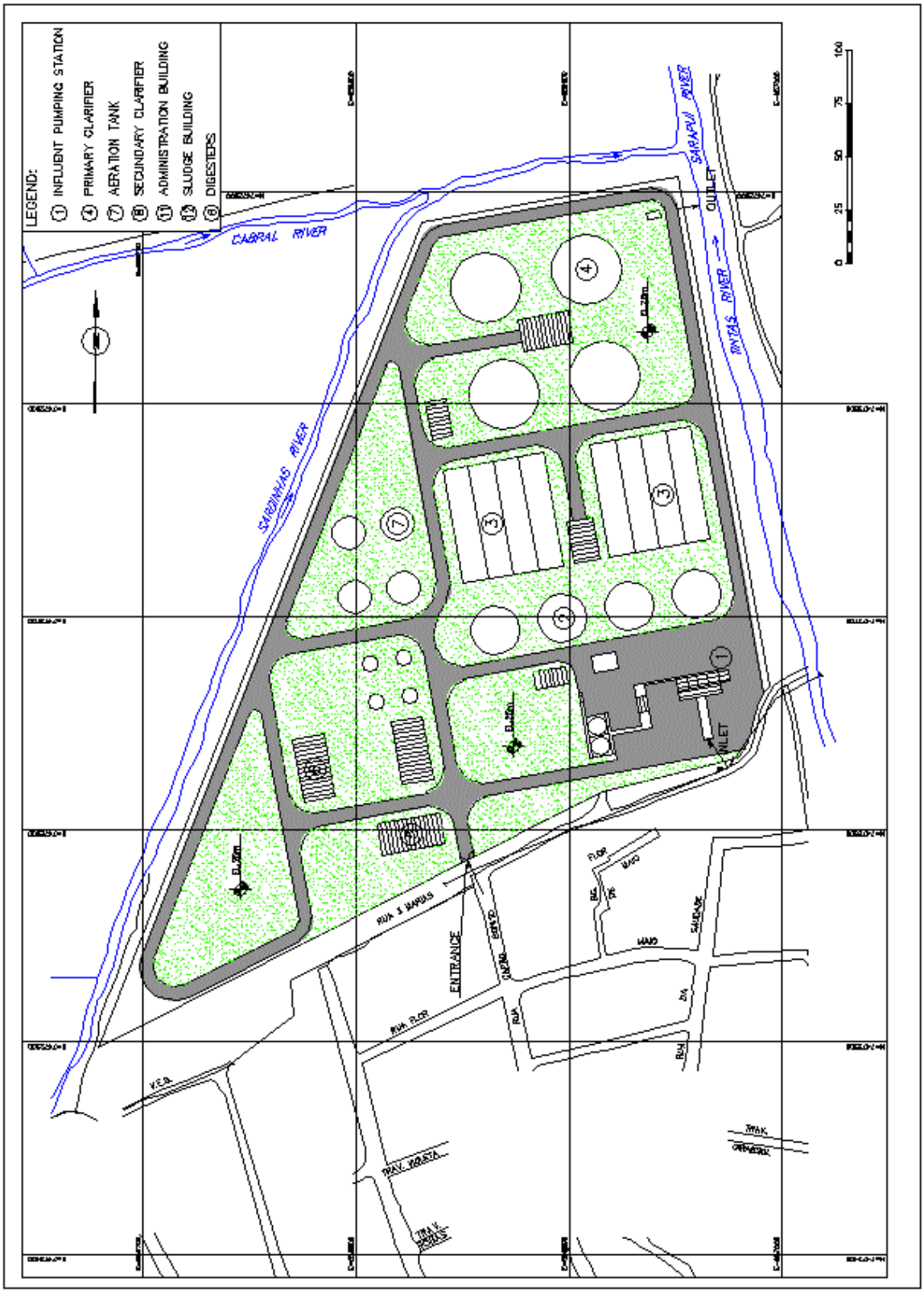


Figure 7.11 Layout Plan of Bangu WWTP

7.3 OPERATION AND MAINTENANCE

7.3.1 GENERAL

Once operation and maintenance of sewerage facilities begin, it cannot be interrupted in order that they fulfill their role of collecting wastewater and treating it. The collected wastewater is treated to the permissible level and discharged to the public water bodies. Furthermore, the byproduct of wastewater treatment or sludge has to be properly treated and disposed of in a safe and acceptable manner.

Maintenance can be categorized into two types: preventive and corrective. The preventive maintenance involves initial inspection of the collection and WWTPs systems and analysis of existing data to identify potential trouble areas. The corrective maintenance refers more to emergency maintenance. This can deal with the failure of facilities and equipment; collapse of an existing sewer; stoppage due to solid waste, roots or grease; or excessive inflow or infiltration.

The sewer maintenance equipment and personnel under the Project may be accommodated preferably in one general yard in the "Metropolitan Center/North Division" for Pavuna and Sarapuí, "West and Green Coast Division" for Acarí and Bangu, both divisions belonging to Operation Directorate, CEDAE." It is desirable 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 conditions, including those of traffic congestion, expansion of sewer network, urban development, etc. Furthermore, prompt investigation of sewer complaints within the shortest possible time is to the credit of the municipality and enhances public relations.

7.3.2 FACILITIES TO BE OPERATED AND MAINTAINED

Under the Project, the sewerage facilities will be consecutively put in operation towards the end of 2009, while some branch sewers will be ready for service by the end of 2005 (refer to *Figure 6.5, Chapter 6*).

The sewerage facilities to be operated and maintained are sewers of 1,832 km, six pumping stations and four WWTPs. Their details are described below:

- Branch/lateral sewers (150 ~ 300 mm diameter.) of 1,760,000 m
- Main/trunk sewers by open cut method (400~ 900 mm diameter) of 22,720 m
- Main/trunk sewers by pipe jacking method (500~ 1500 mm in diameter) of 49,360 m
- Pressure mains (100 ~ 500 mm in diameter) of 1,010 m
- Six pumping stations (capacity of 0.99 ~ 13.4 m^3/min.)
- Pavuna WWTP with the capacity of 1,500 L/s
- Acarí WWTP with the capacity of 1,100 L/s
- Sarapuí WWTP with the capacity of 1,000 L/s
- Bangu WWTPs with the capacity 1,000L/s

O/M works to be practiced are described below.

(1) Sewers

The O/M works of collection system consist of the following three distinct operations:

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

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, where necessary, repaired.

Sewers maintenance crews, operating throughout the service area, should clean and maintain large sewer lines. Cleaning and flushing to remove blockages or buildup of deposition of grit and wastewater debris will be required from time to time. Regular inspection of sewers must be carried out.

The risk of structural deterioration should be assessed in relation to ground conditions, the quality of the constructed sewer, and the nature and characteristics of the wastewater.

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 year or two years
- Of the non man-entry sewers a visual inspection of the sewer from the manholes should also be carried out once every year or two years
- Detailed inspection of selected sections once every five years.

Groups will be responsible for: i) planned cleaning and the review of retained projects, ii) emergency cleaning, and iii) sewer repairs.

(2) Pumping Stations

Since there are many items of equipment to be inspected, a detailed planned maintenance program should be prepared. 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.

(3) Wastewater Treatment Plants (WWTPs)

Collected sewage is treated at WWTPs. In addition to chemical and biological analysis, it is also important to routinely monitor the quantity and appearance of sewage at various stages. The monitoring points include:

- Pumping stations
- Grit chambers
- Primary clarifiers

- Aeration tanks
- Secondary clarifiers
- Outlet conduit
- Blowers
- Gravity sludge thickeners
- Centrifugal sludge thickeners
- Digesters
- Dewatering equipment
- Sludge dryers

Major parameters for WWTPs O&M are appearance, color, water level, unusual noise and vibration, temperature and so on, and are summarized along with monitoring points in *Supporting 9*.

Results of monitoring and 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.

7.3.3 O/M REQUIREMENTS

Operation and maintenance require equipment, utilities such as electricity and personnel. Each item is described below.

(1) Equipment and Vehicles for Inspection and Cleaning of Sewers

The new sewerage system will require the purchase of cleaning and maintenance equipment and vehicles. Further, for sewer cleaning, cleaning rods and their accessories, and equipment for safety and workshop will be required.

List of standard equipment is shown in *Supporting 9*.

(2) Equipment for WWTP O&M

Tools should include the ordinary hand tools, wood tools, grinding tools, wrecking tools, pipe fitting tools, and such machine tools as may economically be used 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 for a WWTP are shown in *Supporting 9*.

(3) Laboratories

Minimum analytical items in the laboratory in the wastewater treatment plant under the Project will be as follows; appearance, turbidity and pH on daily basis, SS and COD on weekly basis and BOD, nitrogen and phosphorous on monthly basis.

Analysis of some of the above items may be entrusted as necessary to other institutions or laboratories. A laboratory will need to be established in the WWTP. A range of sampling and testing equipment is to be purchased and installed.

Both analytical items and laboratory equipment are summarized in *Supporting 9*.

(4) Utilities

The operation and maintenance of pumping stations and WWTPs requires electricity and mechanical parts for routine repairs. In addition, chemicals are needed for sludge conditioning for WWTPs.

Electricity consumption is estimated based on the operation hours of each equipment in a day, and chemicals consumption by multiplying dry weight of dewatered sludge by unit chemical consumption. Details of utilities in each sewer district are described in "7.4 Cost Estimates" of this chapter as well as in *Supporting 9* and *10*.

(5) Staffing Requirements

1) General

The O&M staffing requirement for the facilities implemented through the Project is estimated for each sewer district. The necessary staff for collection system including pumping stations is separately computed from the existing sewered areas for Pavuna and Sarapuí districts. Since Pavuna and Sarapuí districts have existing WWTPs facilities, the required staff is calculated for the total capacity, namely 3.0 m^3/s for Pavuna WWTP and 2.5 m^3/s for Sarapuí WWTP and is allocated for each additional capacity to be constructed under the Project. As for Acarí and Bangu WWTPs, the staff requirement is calculated for the whole capacity to be constructed under the Project.

2) Sewers

The Sewer O&M Office may be under the control of one Superintendent or Engineer, under which are two separate sections, General Foreman and Office Manager.

The office staff may consist of one employee who keeps a record of the financial operations. 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. A 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 crews should comprise at least three persons, one of whom will be the nominal foreman. Three crews may be able to handle most of the cleaning procedures, build maintenance holes, and make minor repairs and excavations. At least one crew should have the primary job of preventive cleaning. Its members should experience the various cleaning procedures, and make periodic inspections of all lines. A second crew should be equipped to handle the building of maintenance holes, the repair of sewers and maintenance holes, and the customary dig-up jobs.

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.

3) Wastewater Treatment Plants (WWTPs)

For each of Acarí and Bangu WWTPs, totally 49 O&M staff members would be required by the end of 2020; whereas for Sarapuí and Pavuna WWTPs, managers offices are unchanged, but additional O&M staff of 29 and 21 may be required to cope with up to the increased field workload.

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.

A comprehensive, accurate and reliable influent/effluent monitoring is an essential component of the sewerage system O/M. Each of Acarí and Bangu WWTPs will have a new laboratory, while in Pavuna and Sarapuí WWTPs no change is anticipated to staff numbers and jobs of laboratories under the Project.

At least four additional staff members are proposed for each of Acarí and Bangu WWTPs; a chief, a chemist, a microbiologist and a sampling assistant. It is understood that the laboratories have sufficient space to accommodate the technicians who will be performing analyses, and that office space can be found for the section chief.

The standard personnel list for the four sewer districts is shown in *Table 7.33*. This table does not include the existing personnel in the sections related to the wastewater control, but includes only those required for the Project portion.

Further details on the breakdown of required staff members are shown in tables of *Supporting 9*.

Table 7.33 Staffing Requirements under the Project

Facility	Day-shift Staff	Day- and night-shift staff	Total	Remarks
1. Sewers				Including those for pump stations
Pavuna	30	-	30	
Acarí	25	-	25	
Sarapuí	5	-	5	
Bangu	20	-	20	
Subtotal of 1	80	-	80	
2. WWTPs				
Pavuna	21	8	29	For portion of 1,500L/s
Acarí	34	15	49	For total capacity
Sarapuí	15	6	21	For portion of 1,000L/s
Bangu	34	15	49	For total capacity
Subtotal of 2	104	44	148	
Total Staff	184	44	228	

7.3.4 SYSTEM OPERATING PROCEDURES/MANUALS

(1) O&M Manuals

Sewerage system O&M manuals are to be provided. The O&M program should be specified in detailed instruction manuals describing all O&M procedures for each WWTP and each type of sewer. These manuals would normally be provided by those responsible for construction and would be handed over on commissioning.

CEDAE should also have written policies, procedures, and protocols for training O&M personnel and should conduct periodic reviews and revisions of the O&M program. The training program should have established training goals, procedures, and schedules. Classroom training should provide the maintenance personnel with an understanding of the system operations and system characteristics.

Also thorough safety training, in accordance with the occupational safety and health administration standards, is imperative. Safety programs and equipment should be reviewed periodically, and, if necessary, updated.

(2) Record Keeping and Reporting System

The O&M program should include a record-keeping component. The record keeping system should document maintenance procedures through inspection reports. These reports should include information on when the each item in the system was inspected, and, if applicable, what maintenance action was taken, including the equipment used and the personnel involved. Geographical information systems (GIS) and desktop mapping, currently underway, may be useful in storing O&M data on the wastewater system, as well as in developing a database of problem areas.

7.3.5 STAFF TRAINING

(1) General

The O&M program should establish training goals, procedures, and schedules. Training should provide the maintenance personnel with an understanding of the system operations and characteristics. Practical training should illustrate the specific O&M procedure to those directly responsible for performing these activities. In addition, the nature of the O&M work may require employees to work in confined spaces or to be exposed to dangerous gases. Providing proper safety training, in accordance with appropriate state or local standards, is imperative. Safety programs should be reviewed, and if necessary, updated periodically.

(2) Training Program

It is important when starting to build up a workforce for the O&M organization of the collection and WWTP systems that the operators, electricians, mechanics and laboratory chemists are trained through regular planned meetings to understand the overall process of the collection and treatment of wastewater. This will help to define each of their roles and highlight the importance of working together as a team so as to optimize the O&M input.

There will also be a need to conduct planned training courses, both locally and overseas, for the O&M staff. This training would be carried out with the assistance of management and finance experts and technical specialists to include the following topics:

- The establishment and running of training programs for staff (including managers, engineers, technicians, operators, chemists and accountants)
- The operation and maintenance of mechanical and electrical equipment
- Current practices in safety and hygiene
- Current practices and techniques for monitoring, sampling, diagnosis and testing.

It is envisaged that training courses would be scheduled to suit the necessary training for different levels of management. This could entail the following for O&M personnel:

- Senior Staff (Chief Operations Manager and Senior Supervisors) - short duration (up to three weeks) overseas courses on general O&M management, programming and training requirements
- Technical Staff (Operations, Technical Support and Scientific Supervisors) - several short courses (of up to 3-week duration) carried out over an extended period (3 to 6 months) in both local and overseas, on more specific technical requirements for the sewerage system and WWTPs, safety and hygiene practices and techniques for monitoring, testing and sampling
- Day staff (Operators and day-labor staff) - regular courses in Brazil by the Technical Staff based upon their training courses with overseas experts and specialists.

The need for overseas training will be influenced by the availability of suitable experienced and qualified personnel in Brazil. A range of excellent training courses and programs are now offered by various wastewater authorities in other countries too, which could be undertaken by 2 or 3 specialists in Brazil for durations of up to 1 month. The incorporation of at least one of these courses is considered appropriate as part of the present project.

Suggested program for staff training is as follows:

- Overseas study/inspection tours during 2004 by appointed senior and technical staff members (One tour, each comprising 2 persons for up to 1 month)
- Visits to Brazil during 2004 by overseas specialists (2 visits, each comprising 1 or 2 specialists for up to 2 weeks)
- Local training during 2004 to 2005 of technical and day staff, including purchase of training equipment.

(3) Supervisors

Supervisors who are responsible for controlling the day-to-day work activities of the sewerage and wastewater treatment work force should be given training in the planning, organizing and control of work activities associated with their responsibility.

(4) Scientific Staff

Qualified chemists with a minimum understanding of sewerage and wastewater treatment processes should be provided with a knowledge of obtaining representative samples of wastewater and sludge and also to the mechanics, optimization and control of wastewater treatment together with the problems associated with the various processes.

(5) Operators

In order to be able to delegate responsibility to the lowest possible level there is a need to train operational personnel so as to shorten the line of communication and so attempt to optimize manpower management. For example where a fitter would be needed to stuff glands on a pump, an operator could be trained to carry out this type of function.

Also where an electrician would change fuses in connection with electrical equipment, this action could, through training, be carried out by an operator. Such training increases the flexibility of the workforce and therefore provides greater scope for management.

A technical introduction should also be given to operators on the basics of sewerage and wastewater treatment. The purpose would be to give a broad understanding of the sources and nature of wastewater and the treatment processes used to prevent water pollution. Subsequently this introduction could be further developed by knowledge of the fundamental mechanisms involved in the treatment of wastewater.

(6) Training Equipment

In addition to the operations and maintenance equipment described in the previous sections, it is likely that equipment will also need to be purchased to facilitate training programs for staff in Brazil, and in particular for safety-related courses. This equipment could be purchased directly by the wastewater authority or could be provided by specialists as part of the training program:

- VTR, playback screen and videotapes
- Projector and slides
- Relevant publications on health and safety in design, construction and operation.

7.4 COST ESTIMATES

7.4.1 CAPITAL COSTS

The cost estimates for the recommended Project facilities have many factors peculiar to the time and the sewer districts, including local topographic characteristics, soil conditions, and existing sewerage system also plays distinct parts in estimate of capital costs.

Most of the materials for civil works are locally available with qualities complying with internationally acceptable standards, whereas those for the certain types of electrical and mechanical equipment are to be imported

The estimated capital costs include labor, material, overhead and profit, plus contingency for pavement replacement, minor relocation of existing facilities, and other unforeseeable matters. The expense of traffic maintenance is not included in the costs because of the many variables involved.

Capital costs have been estimated for the preliminary engineering purpose and, while these are sufficiently accurate for the feasibility study purpose, need to be reviewed at the time of detailed design and contracting.

(1) Compositions of Capital Costs

The estimated capital costs comprise the following components:

- Direct or construction costs
- Land acquisition and compensation
- Administration expenses
- Engineering services
- Physical contingencies.

(2) Conditions and Assumptions for Cost Estimates

In many instances, where items of work are not available directly from the unit costs as provided in EMOP, necessary costs have been determined on the basis of the data from obtained similar construction and known costs that have been established by the CEDAE counterpart and the Study Team.

The direct construction costs of major facilities, such as WWTPs and pipe jacking works, have been estimated with unit price bases in reference to the recently contracted Bills of Quantities for the similar projects under the PDGB Project, including those for materials, labor, equipment and contractors profits to complete the facilities.

The labor and equipment rates have been estimated at the price level of July 2003 and converted to US Dollars using the current exchange rate as shown below:

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

Labor and equipment costs, and the major unit costs obtained from EMOP and recently contracted prices are presented in *Supporting 11* "Cost Estimates," in Supporting Report.

(3) Foreign and Local Currency Portions

Capital costs are estimated both for foreign currency (F.C.) and local currency (L.C.) portions depending upon construction items.

Direct costs of sewers, pumping stations and WWTPs are summarized in *Tables 7.34*, *7.35* and *7.36*.

Table 7.34 Construction Costs of Sewers

Items	Dia.(mm)	Unit Cost (US$/m)	Pavuna	Acarí	Sarapuí	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$1,000)

Table 7.35 Construction Costs of Pumping Stations

	Pavuna	Acarí	Sarapuí	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)

Table 7.36 Construction Costs of WWTPs

Compornents	Pavuna	Acarí	Sarapuí	Bangu	Total
Civil & Architectural 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 Portion	3,320	4,483	2,586	4,463	14,852

Note: Foreign Currency portions are included in mechanical work cost. (Unit:US$1,000)

The direct costs in each sewer district are further summarized in *Table 7.37*.

Table 7.37 Overall Construction Costs in Each Sewer District

Items	Pavuna	Acarí	Sarapuí	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$1,000)

(4) Land Acquisition and Compensation

The acquisition of about 6.5 hectares land for the Bangu WWTP is estimated at US$ 650,000 in view of the current land unit prices advised by CEDAE and of possible ground leveling. As neither residential nor agricultural properties exist within the selected site, no compensation for such purposes will be needed. For practical purposes, the cost is assumed that all the land will be acquired at the current prevailing price.

(5) Administrative Expenses

The administrative expense directly required for the Project implementation is estimated at 5% of the direct cost.

(6) Engineering Services

Engineering services cost is estimated at 10% of the direct cost, which includes those for basic design, detail design, tender documentation, and construction supervision services. The technical assistance for seminars and staff training programs are also included in the engineering services.

(7) Physical Contingency

The overall physical contingency is estimated at 10% of the direct cost.

7.4.2 PROJECT COSTS

The First Stage Project, to be undertaken over the period from 2004 through 2009, will require a total capital cost of US$393.68 million (at mid-July 2003 price level, without cost escalation). *Table 7.38* shows the breakdown of the capital costs into component items:

Table 7.38 Summary of Capital Costs (US$ 1,000)

Item	F.C.	L.C.	Total
I. Direct Cost			
1.1 Wastewater Treatment Plants			
Pavuna WWTP	3,320	11,552	14,872
Acarí WWTP	4,483	23,810	28,293
Sarapuí WWTP	2,586	9,155	11,741
Bangu WWTP	4,463	22,472	26,935
Subtotal of WWTPs	14,852	66,989	81,841
1.2 Collection Systems			
Pavuna District	-	90,374	90,374
Acarí District	-	72,548	72,548
Sarapuí District	-	14,416	14,416
Bangu District	-	54,745	54,745
Pumping Stations	-	495	495
Subtotal of Collection System	-	232,578	232,578
Total of Direct Costs	**14,852**	**299,567**	**314,419**
II. Indirect Costs			
Land Acquisition (Bangu WWTP)	-	650	650
Administrative Expense (5%)	-	15,722	15,722
Engineering Services (10%)	-	31,443	31,443
Physical Contingencies (10%)	-	31,443	31,443
Total of Indirect Cost	**-**	**79,258**	**79,258**
Total of Capital Costs	**14,852**	**378,825**	**393,677**

Note: Estimated by the JICA Study Team in consultation with CEDAE. More details of the breakdown of direct construction cost are shown in *Supporting 10 "Cost Estimates,"* in Supporting Report. .

7.4.3 OPERATION AND MAINTENANCE COSTS

The operation and maintenance costs for the Project facilities consist of those for administrative and operational personnel, power for WWTPs, chemicals for sludge conditioning, sludge disposal and sewer inspection/cleaning and routine repairs of WWTPs mechanical and electrical equipment. The annual operation and maintenance costs by category, estimated for the design capacity, are estimated at approximately US$11,350,000 as summarized in *Table 7.39.*

Table 7.39 Summary of Annual O&M Costs for Each Sewer District

Facility	Item	Pavuna	Acarí	Sarapuí	Bangu	Total
Sewers	Personnel for sewers	621,000	517,500	103,500	414,000	1,656,000
WWTP	Personnel for WWTP	600,300	1,014,300	434,700	1,014,300	3,063,600
	Electricity	1,226,711	832,666	778,745	783,354	3,621,476
	Chemicals	989,646	447,265	659,771	406,581	2,503,263
	Sludge disposal	79,920	30,059	53,341	27,280	190,600
	Routine repairs	65,461	98,677	53,250	97,933	315,321
	Total	2,962,038	2,422,967	1,979,807	2,329,448	9,694,260
Total		3,583,038	2,940,467	2,083,307	2,743,448	11,350,260

(Unit: US$)

7.5 PROJECT IMPLEMENTATION

7.5.1 IMPLEMENTATION SCHEDULE

(1) General

After the Feasibility Study is conducted, engineering services can be initiated in mid 2004 if necessary financial arrangements are done. Upon authorization of the financial arrangement, engineering consultants are to be selected to undertake the detailed design and documentation for the project construction packages.

The design work should be conducted according to the implementation priority. Considering that Pavuna and Sarapuí districts have existing facilities for both collection and treatment, the implementation for these two districts can be started earlier than Acarí and Bangu Districts. The design of sewerage facilities of this magnitude will require extensive site investigations, surveys and documentations; hence, a considerable time to complete is needed.

The design work for the collection and WWTP systems is scheduled to complete within 6 months (sewers) and 12 months (WWTPs) for each Sewer District, including bid documents preparation for each contract package, then, the selection and award of contractor(s) for the works will be made. Sewers construction will be divided into several lots and the design works will be made accordingly. The construction supervision services will start in early 2005 when the construction works in Pavuna and Sarapuí Districts begin and in early 2006 for Acarí and Bangu Districts.

The construction works of both "Collection System" and "Wastewater Treatment Plants" are scheduled to commence in early 2005 (Pavuna and Sarapuí) and early 2006 (Acarí and Bangu), lasting four years until the end of 2008 or 2009. The engineering services will last until mid 2009 or mid 2010 including acclimation period of WWTPs and the construction supervision of collection systems and WWTPs.

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

(2) Collection Systems

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.

(3) WWTPs

All of the construction sites are located at low-lying areas adjacent to rivers. 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 within the site. Therefore, no significant land improvement and preparatory works will be required except for vegetation and topsoil removal, and grading before the construction work starts.

Since general facilities, security fences and gates, roads, parking, and administration buildings are to be built, some types of mechanical equipment may be imported (For further details see *Supporting 8* "Facility Planning and Design", Supporting Report).

Detailed implementation and disbursement plans of each of four sewer districts are described in *Supporting 11*, Supporting Report.

7.5.2 OVERALL IMPLEMENTATION SCHEDULE

(1) Construction Schedule

Figure 7.12 shows overall implementation schedule for Pavuna, Acarí, Sarapuí and Bangu Sewer Districts.

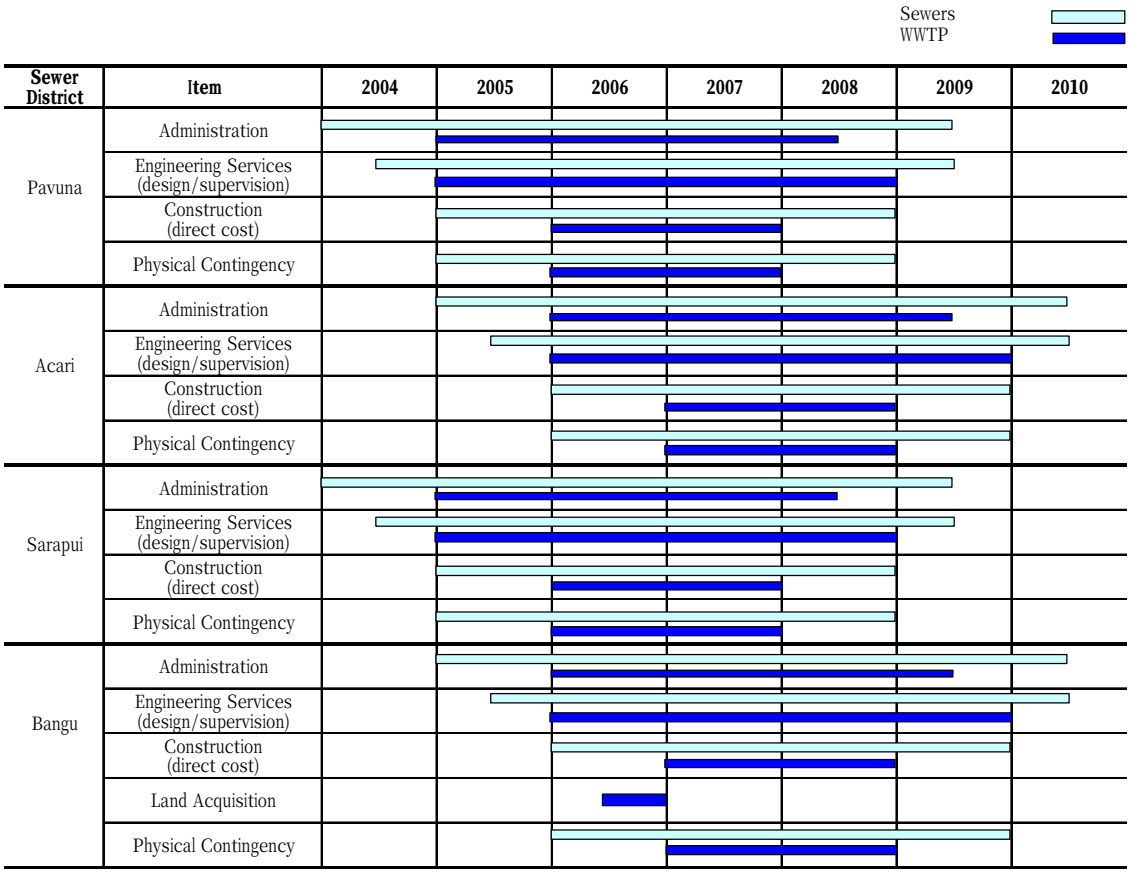


Figure 7.12 Overall Implementation Schedule

(2) Disbursement Plan

The estimated total project capital cost and disbursement schedule are summarized in *Table 7.40*. The disbursement plan is worked out in view of the construction schedule by sewer district.

Table 7.40 Summary of the Capital Costs and Disbursement Plan by Sewer District

Sewer District	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		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
Acarí	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			18,230	32,377	32,376	18,228		101,211
	Land Acquisition								
	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
Sarapuí	Administration(5%)	130	294	294	294	225	71		1,308
	Engineering Services(10%)	144	582	582	582	580	146		2,616
	Construction		3,604	9,475	9,474	3,604			26,157
	Land Acquisition								
	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			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		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
Foreign Currency	Ravuna			1,660	1,660				3,320
	Acarí				2,242	2,242			4,483
	Sarapuí			1,293	1,293				2,586
	Bangu				2,232	2,232			4,463
	Total			2,953	7,426	4,473			14,852

(Unit: US$1,000)

7.6 PROJECT EVALUATION

7.6.1 OUTLINE

The proposed Project will help alleviate the present Bay water contamination and unsanitary conditions prevailing in the urban districts within the Project Area. The situation has led to an overall deterioration in general public health through increasing incidences of water and sanitation-related diseases, as well as considerable losses of image as the world most reputable tourism resort.

At present, a large portion of the raw wastewaters find their way either to nearby drains or rivers and finally flow into Guanabara Bay. Many communities not served by the sewerage system instead rely on inappropriate and poorly functioning on-site systems as sanitation systems. Without the immediate implementation of a comprehensive sewerage system improvement program, further environmental degradation and public health deterioration will be unavoidable.

The Project will provide an affordable and technically sound solution to the current pollution problems resulting in substantially improved wastewater services for communities and a noticeably cleaner environment. The Project represents a major step toward improving the environment in the Project Area.

7.6.2 TECHNICAL EVALUATION

(1) General

The proposed sewerage project, serving high priority sewer districts, is selected as the optimum short-term program because:

- It represents the least-cost solution
- It could achieve the desired water quality objectives
- It has minimal negative environmental and social/socio-economic impacts
- It is financially viable and affordable.

(2) Pollutant Loads Reduction

The Project forms sewerage improvement plan in Guanabara Bay Basin up to 2020 and will serve 9270 ha of Rio de Janeiro's built-up and urban districts and their surrounding areas. The project will encompass 1.4 million people and treat the wastewater of 3,360 L/s in 2020.

The BOD loading in F/S area in 2020 will be 76,000 kg/day. Upon completion of proposed sewerage facilities in the Project, the BOD loading will be reduced by 90% or the discharge to the environment will be 10% of the generated amount.

The pollutants reduction will surely contribute to the Bay water environment improvement. The proposed collection and treatment systems are at present the best available option from technical and economic viewpoints to alleviate the organic loading flowing into the Bay.

(3) Proposed Sewerage Facilities

1) Wastewater Collection System

The sewer system is designed in principle to flow the wastewater by gravity, reducing the energy need to pump up wastewater to the maximum extent practicable. In view of such planning principle, the existing sewer district boundaries have been reviewed and necessary modifications are made, thus making the system operation and maintenance easy and reducing energy requirements.

All the sewers are designed to have hydraulic capacities to flow the peak flows with some allowance (maximum 75% of pipe depth). This will allow interior of sewers to supply sufficient ventilation to avoid anaerobic conditions of the wastewaters in the sewers, thereby preventing possible sulfide buildup and corrosion of the sewers.

2) Wastewater Treatment Plants (WWTPs)

The WWTPs use the conventional activated sludge process, that is the best technology option currently available for organic pollutants removal to produce the treated effluents that could meet the stringent effluent discharge standards to the Bay water.

Moreover, the process can easily be upgraded to advanced processes when needed to further remove wastewater nutrients such as nitrogen and phosphorous by adding chemicals and/or applying biological nitrification and denitrification processes operation, when more stringent effluent quality control become desireable.

The whole excess sludge, after being stabilized and dewatered, will be disposed of to solid waste disposal site. Although the quantity of simply dewatered sludge to the level of 25% solids content could be relatively small in quantity, an effort is further made to reduce the volume by thermal-dryers. Thus, the sludge production will be as low as 110 ton/day, which could in turn significantly reduce the disposal cost and may offer the opportunity for sludge recycling.

(4) Implementation Schedule

The Project will be implemented over a period of seven years with full completion being achieved by the end of 2010. The interim commissioning of the project facilities may be carried out during the period to enable earliest possible utilization of the new facilities and early introduction of cost recovery measures.

It is envisaged that the implementation of the Project will proceed efficiently and quickly, since the major construction works are planned to concurrently proceed under separate contracts throughout the period.

(5) Land Acquisition

The project contracts are to be awarded through international competitive biddings under the categories of sewers, pumping stations and WWTPs, while small sewer constructions may be split-up to the smaller contracts for local contractors. These procedures can significantly shorten the overall construction period.

The sewers and pumping stations will be constructed within the right-of-ways or on government-owned lands.

The candidate Bangu WWTP site is a vacant wasteland next to which several houses were built. It is urgent to secure the land before it is occupied by houses. The official procedure of site acquisition is in progress as of July 2003.

(6) Overall Technical Evaluation

The proposed project will help improve the existing deteriorated quality of the bay water, and in particular the sanitary conditions in the Project Area.

The Project will provide cost-effective wastewater collection and treatment facilities to serve the most densely developed and severely degraded urban districts, which are compatible with the long-term strategy.

From the foregoing facts and discussions, it is evident that the proposed Project is justified technically sound and will contribute to a large extent to the improvement of currently deteriorated environmental and sanitary conditions of the Project Area and its surrounding districts.

7.6.3 ACHIEVEMENT OF WATER QUALITY TARGET

As discussed in 6.6.3, it has been confirmed that Priority Project achieves the short-term target.

7.6.4 FINANCIAL ANALYSIS

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 be clarified after this financial analysis, in Financial Plan. Project period is set as 25 years, from 2004 to 2028, considering the assumption of 25-year 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.

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 used for administration, and issuance and collection of water bill. It costs 50% of direct O&M cost[1].
- These O&M costs from 2021 to 2028 are assumed to apply the costs in 2020.

3) Residual Value

Llifetime of sewerage facilities is calculated under the assumption in *Table7.41*. 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 accounts for 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 respectively.

Table 7.41 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

[1] 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 equation:

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

Construction of sewer network consists of only civil works, and lifetime of sewer is estimated to be 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, construction cost per year, is accumulated for 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 after 2009. Total residual value calculated under these lifetimes is US$181.2 million.

(2) Cash Inflow

Cash inflow comes from operation revenue. It will be generated from 2008 when WWTP and sewer network starts operation[2]. The Study Team set the following assumptions for the operational revenue:

- CEDAE can collect user charge which is R$1.14 (US$0.39) per 1 m^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
- Volume of wastewater follows the analysis in the *Supporting 7*.

(3) Net Cash Flow

Table 7.42 presents cash outflow, cash inflow and net cash flow. FIRR, which is calculated from net cash flow, is 6.3%.

[2] In 2008 Pavuna WWTP and Sarapuí 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 7.42 Net Cash Flow

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

(4) Impacts of other financial sources on the Priority Projects

The Study Team examined the following impacts on the Priority Projects. The first one is investment expenditure of the State Government. The second one is bank loans. The Study Team will calculate FIRR of the Projects under combination these conditions.

1) Investment Expenditure

Investment expenditure consists of the following three cases:

- Case 1: No Investment Expenditure from the State Government
- Case 2: Investment Expenditure from the State Government
- Case 3: More Investment Expenditure from the State Government.

Case 1: No Investment Expenditure from the State Government

In Case 1, the State Government doesn't disburse any investment expenditure for the priority projects. Thurs, net cash flow would not change, and be as same as *Table 7.43*.

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. The State Government will have to continue disbursing the

same amount in 2004 and 2005, in order to fulfill the all amount of local portion. Therefore, disbursement for the feasibility study starts in 2006.

Financial resource of the disbursement comes from FECP (State Fund for Combating 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 to 2009. This 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.

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.

2) Bank Loans

As for bank loans, the Study Team prepares the following four loan patterns:

- Case a: No bank loans
- Case b: 60% of construction cost is financed by low interest rate (2.5%) with 7-year grace period and 25-year of loan period (Low interest rate)
- Case c: 60% of construction cost is financed by international market interest rate (5.5%) with 7-year grace period and 25-year of loan period (International market interest rate)
- Case d: 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 (Combination of Case b and Case d).

3) Combination of two impacts

Table 7.43 shows patterns of additional cash flows outside the Priority Projects. The table "Case 1a" means the combination of "Case 1 (non public investment)" and "Case a (non bank loans)." FIRR is calculated in each pattern, and evaluated in the section "(6) Evaluation and Conclusion."

Table 7.43 Combination of Two Impacts

	Case 1: Non invest expenditure	Case 2: Investment expenditure	Case 3: More investment expenditure
Case a: Non bank loans	Case 1a	Case 2a	Case 3a
Case b: Low interest rate	Case 1b	Case 2b	Case 3b
Case c: International market interest rate	Case 1c	Case 2c	Case 3c
Case d: Combination of Case b and Case c	Case 1d	Case 2d	Case 3d

Source: JICA Study Team

(5) User Affordability

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

(6) 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 7.44 shows FIRR of the feasibility study in 12 cases. In the following 8 cases, FIRR exceeds 8%:

- All cases in Case 3 (Case3a, Case3b, Case3c and Case3d)
- Case 2b and Case 2d
- Case 1b and Case 1d.

Table 7.44 Comparison of FIRR

	Case 1: Non invest expenditure	Case 2: Investment expenditure	Case 3: More investment expenditure
Case a: Non bank loans	6.3	6.8	8.1
Case b: Low interest rate	8.9	10.4	12.8
Case c: International market interest rate	6.5	7.6	9.6
Case d: Combination of Case b and Case c	8.2	9.7	11.2

Source: JICA Study Team (Unit: %)

Considering assurance of conditions, CEDAE and the State Government will 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 a proportion of sewerage development in the 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 make a loan, the loan amount will exceed US$217 million. In case of low interest rate, it is difficult for almost all banks to lend such a big amount; therefore, it is realistic that a bank with lower interest rate will co-finance with a bank at 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 these projects.

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 cannot disburse investment expenditure at all, FIRR would be 8.2%.

(7) Financial Plan

In the financial analysis of the priority project, CEDAE and the State Government are treated as a single project implementation body for simplification. This section clarifies the demarcation

of these organizations. This section also reports loan conditions and financing methodology when net cash flow is minus in each year.

1) Roles of CEDAE and the State Government for the priority project

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
- 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
- Disburse investment expenditure for the priority project
- Transfer bank loans to CEDAE
- Disburse interest payment and principal refund.

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 year
- Loan period is 25 years, from 2004 to 2028
- Grace period is 7 years from 2004 to 2010.

In the other side, loan condition is:

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

3) Financing Method

From 2004 to 2009, net cash flow will be negative as shown in *Table 7.45*. 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 7.45 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 7.46 presents the relation between decrease of these rates and generated cash inflow from decrease of unearned water bill rate and non-revenue water rate. If CEDAE is successful in decreasing unearned water bill rate to 10%, it would have US$18 million of cash inflow every year. If CEDAE is successful in decreasing non-revenue water rate

to 30%, 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 maintain the current level.

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

Table 7.46 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
** performance in 2001
(Unit: US$1,000)

Source: JICA Study Team

7.6.5 ECONOMIC ANALYSIS

Economic benefit is evaluated from the result of Economic Internal Rate of Return, and it is calculated by 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

First, land acquisition cost necessary in Bangu Sewer District is excluded, because the prepared land is not used for production activity, and opportunity cost of the land is zero now.

Second, taxation imposed in the cost is excluded. As shown *Table 7.47*, construction cost of WWTP is divided into the three components: civil and architectural work, mechanical equipment and electrical equipment. Construction of sewer network consists of only civil and architectural work. The following taxes are imposed in each component:

- Customs duty for imported goods (20%)
- IDT[3] for civil and architectural work (5%)
- ICMS[4] and IPI[5] for mechanical equipment and electrical equipment, which are produced in Brazil (12%+7%).

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

And shown in *Table 7.47,* only mechanical equipment involves imported goods, percentage of which is 40%.

Table 7.47 Cost Structure and Tax Ratio

		Cost share	Share of imported goods
WWTP	Civil and architectural works	40	0
	Mechanical equipment	50	40
	Elwctrical equipment	10	0
Sewer	Civil and architectural works	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 for sewer network is 95 units. Economic cost of WWTPs is calculated in the following equation:

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

Third, unskilled labor cost is calculated by opportunity cost. According to existing data, unskilled labors working in PDBG receive R$336 per month, 60% higher than minimum wage at that time, but its opportunity cost was less than minimum wage, R$200 per 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.

2) O&M Costs

The same as financial analysis, the Study Team set the following assumptions:

- 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 used for administration, and issuance and collection of water bill. It costs 50% of direct O&M cost[6].

3) Residual Value

Residual value is calculated from the lifetime of WWTP and sewer. The methodology is the 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 for the rest of the lifetime.

The residual value, calculated from these conditions, amounts to US$208 million.

[6] 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.

(2) Cash Inflow

In this economic analysis, economic benefit was defined as "the value Guanabara Bay with improved water quality", the 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: residents (people living in Rio de Janeiro State), Brazilian tourists, and international tourists. Willingness to pay of a person is based on 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 Niteroi, Copacabana, Ipanema, and Leblon). People won't doubt water quality.*
- *Eco-system in Guanabara Bay will recover and people can see more fishes and marine creatures in the bay.*
- *People won't smell bad odors and won't see dirty seawater."*

Results of the survey indicate that willingness of pay per a person is R$8 (residents), R$13 (Brazilian tourists), and R$25 (international tourists). Detailed methodology and results of the survey are indicated in *Supporting 17.*

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 persons" assumed economic benefit if water quality of Guanabara Bay were improved to the same level as 2020 in each year. However it is impossible to achieve the target before 2020, 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.

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

Cash inflow, cash outflow and net cash flow of the priority projects are summarized as shown in *Table 7.48*, and Economic Internal Rate of Return (EIRR) is 12.9 %.

Table 7.48 Cash Flow of the Priority Projects

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 7.49 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 7.49 Results of Sensitivity Analysis

Cases	EIRR
Case1: 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 rate 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.

7.6.5 SOCIAL EVALUATION

Social impacts of the proposed project was evaluated by focusing the possible impacts to Favelas from view points of fair distribution of the project benefit and residents affordability of the sewerage services.

(1) Consideration in Sewerage Planning

At the beginning of the Study, Favelas were envisaged as receiving poorer public services compared to average people living in normal areas and thus special consideration to Favelas was considered necessary in planning the sewerage development.

However, the analysis of IBGE Census 2000 and the people's awareness survey conducted in this Study revealed that ratios of public services coverage in Favelas, such as water supply, sewerage and solid waste collection, are somewhat higher than the averages of Rio de Janeiro State and 15 municipalities in the Study Area. This is probably because Favelas are concentrated in more urbanized areas where naturally public service covering ratios are high and also because there are many intervention programs in Favelas, which often have the implementation of the basic infrastructures as its components. However, one negative characteristic of Favelas regarding public services is recognized: disordered and narrow streets.

Therefore, the proposed priority projects adopted following concepts for the development of the sewer system in Favelas

Considering the above mentioned situation, the strategic plan adopted the following concepts for the sewerage development in Favelas:

- Since sewers cannot be installed in disordered streets, intervention programs shall install sewers when they improve streets.
- New intervention programs shall collect sewage and discharge it into CEDAE's trunk sewers.

(2) Affordability

Another concern for the sewerage development in Favelas is affordability of the residents for the sewerage service. There are two categories related to the sewerage service in CEDAE water bill system; water billing rate with and without sewerage service. The application of the categories does not necessarily depend on whether users are actually receiving the service or not. It depends on the areas where users live. Users living in areas designated by CEDAE as "with sewerage" are paying the with-sewerage rate regardless if they are connected to a sewer or not.

Therefore, the sewerage development by the strategic plan can not directly affect the people living in "with sewerage areas". On the other hand, if the sewerage development takes place in "without sewerage" areas, people in these areas would be newly charged "with sewerage rate". Supposing their water consumption rate is less than 15 m^3/month (Minimum consumption rate in the tariff system), their monthly water charge including sewerage service will be 20.78 R$.

Most sanitation projects financed by the World Bank adopt 4% of monthly household income as criterion for the affordability. Employing this criterion, if the monthly household income is over

518 R$, the family is judged to afford the service. However, according to IBGE Census 2000, households with monthly income less than 2MW and 3MW (400 and 600 R$ at the time of this Study) account for 75% and 58%, respectively, and thus sewerage service charge does not seem affordable to them.

On the other hand, CEDAE has a *de facto* special tariff system that reduces water charge of poor households with less than 5 MW of monthly income. In this tariff system, water charge is calculated proportionally to the consumption at a rate of 0.691 R$/m^3 while a fixed rate of 20.78 R$ is charged up to 15 m^3 under the normal tariff system.

Therefore, sewerage charge is considered to be affordable to Favela residents by applying the special tariff system.

7.6.6 ENVIRONMENTAL EVALUATION

The EIA study was carried out in accordance with the relevant laws and regulations in Brazil with reference to JICA's Environmental Consideration Guidelines and JBIC Environmental Guidelines for ODA Loans.

The EIA study identified possible negative/positive impacts and proposed mitigation/optimization measures as shown in *Table 7.50*. These measures will be taken into consideration in detailed design stage to prepare technical specification of the proposed projects. This mitigation/optimization measure will be a guideline for proposing concrete PBA (Plano de Basica Ambiental: Basic Environmental Plan), which includes procedure, time schedule and estimated cost.

Therefore, it is concluded that the proposed project is environmentally feasible.

Table 7.50 Summary of Possible Impacts and its Mitigation/Optimization Measures

Possible Impacts	Evaluation	Proposed Mitigating / Optimizing Measures
During Planning / Design Stage		
Resettlement caused by land acquisition	Negligible	-
Disturbance caused by geotechnical survey	Negative but temporary and can be minimized	• Distribution of information leaflets • Arrangement of contact desk for residents
During Construction Stage		
Impacts on fauna and flora	Negative but temporary and can be minimized	• Applying protection measure for trees to minimize cutting • Reuse of cut and removed raw vegetal material • Adequate disposal of vegetal material • Consideration for transplantation of trees or nest
Erosion	Negative but temporary and can be minimized	• Avoid earth movement close to rivers • Applying preventive measures against erosion especially in rainy season
Impacts on traffic	Negative but temporary and can be minimized	• Submission of transport plan for the work by the contractor of civil work • Mutual agreement and coordination with relevant competent department responsible for traffic. • Arrangement of adequate precaution and safety measures • Appropriate repair and reinstatement work
Impacts on health of workmen and residents near construction site	Negative but temporary and can be minimized	• Periodical health examination for labors • Arrangement of contact desk for residents • Conducting opinion inquiry to residents to monitor degree of satisfaction • Preparation of prevention program for possible accident
Impacts on daily life of residents near construction site	Negative but temporary and can be minimized	• Publicize construction schedule to residents, especially for mobilization of heavy-equipment • Education program to maintain discipline of labors in order to avoid confliction with local residents • Arrangement of contact desk for residents • Conducting opinion inquiry to residents to monitor degree of satisfaction
Increase of employment opportunities	Positive	• Collecting information on eligible local labor • Giving priority for employment to the labor living in the nearby communities
Impacts on public utilities	Negative but temporary and can be minimized	• Collecting information on existing public facility • Preparation of repair work plan when/where disturbance of public utilities cannot be avoided
Dust and noise	Negative but temporary and can be minimized	• Sprinkling of water to avoid generation of dust • Respect of work hours • Avoid noise levels above 85 dB close to dwelling according to the guideline stipulated in ABNT, MB-268
During Operation Stage		
Public health improvement	Positive	• Appropriate operation and treatment • Regular Monitoring
Water quality improvement	Positive	• Improvement of current monitoring system
Impacts on traffic	Negligible	-
Increase of employment opportunities	Positive	• Collecting information on eligible local labor • Giving priority for employment to the labor living in the nearby communities
Noise and odor	Negative and continuous but can be minimized	• Appropriate operation and maintenance • Regular Monitoring
Sludge disposal	Negative and continuous but can be minimized	• Appropriate operation and treatment • Regular Monitoring of the quality of sludge

7.6.7 OVERALL PROJECT EVALUATION

- The proposed Project forms the least-cost and short-term strategic plan for the Project Area up to the year 2020, and will service the built-up urban districts.
- The WWTPs expanded and newly constructed under the Project would treat by the year 2020 the average daily wastewater of 626,136 m3/day, including portion of industrial wastewater. When all the WWTPs are properly operated, about 30,430kg of BOD5 (at 90% removal efficiency) will be removed daily, which would otherwise be discharged directly to the rivers and Bay.
- Althrough the planned sludge heat-drying process, the estimated First Stage excess sludge generation can be reduced as low as 109.7m3/d in 2020. This will facilitate the sludge handling and disposal, and minimize pathogens in sludge, vectors attraction, and contamination in the disposal site.
- The reduction of waste loads reaching Guanabara Bay will achieve the short-term improvement target, which eliminates unpleasant conditions currently prevailing the western parts of the Bay.
- The project is judged to be viable from financial and economic viewpoints.
- The Project assures social equality in the distribution of the projects benefit and residents financial affordability.
- Possible negative impacts of the Project are judged to be controlled by proper mitigation countermeasures,
- The Project will provide an affordable and technically sound solution to the current pollution problems resulting in substantially improved wastewater services for the communities and a noticeably cleaner environment. The Project represents a major step toward improving the environment in the Guanabara Bay Basin, resulting in considerable improvement of water environment and sanitation conditions.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

8.1.1 SOUNDNESS OF THE PROJECT

The Feasibility Study (F/S) proposes the construction of sewers and WWTPs to collect and treat the wastewater from the four high priority sewer districts.

Technically, the proposed system will handle the estimated quantity of the wastewater from 2009 through 2020 in accordance with generally accepted engineering practice. The collected wastewater will be treated with the conventional activated sludge process, which is currently the best available secondary treatment process.

The quality level of WWTPs effluent will comply with the National/State effluent discharge quality standards as set forth for Guanabara Bay and its tributaries. The Project as detailed is sound and urgently needed for the improvement of water pollution in the Bay tributaries and rivers, and unsanitary conditions in the built-up urban districts.

The F/S has verified the technical, economic, institutional and environmental feasibility of the proposed priority Project; however, F/S has also revealed that the Project implementation is financially difficult without appropriate financial support. At the beginning of the Project, the investment costs for the construction works of this magnitude would be a financial burden to the present CEDAE.

In view of the situation, F/S evaluated the financial feasibility for the financial and institutional support from the State and international lending agencies. The Project is logically related to present and proposed plans for Rio de Janeiro's growth and development, and is financially self-supporting; therefore, its funding and execution is recommended.

8.1.2 BENEFITS OF THE PROJECT

Significant benefits to the environment, public health, and economy can be derived from the proposed Project, covering both direct and indirect benefits. In particular, the proposed Project will achieve the short-term target of the strategic plan, eliminating unpleasant conditions of the western part of the Bay. This will greatly contribute to the improvement of the living conditions of nearby residents as well as to the mitigation of disagreeable conditions around the international airport that is a gateway to the world.

Economic analysis from quantification of such benefit indicated economic soundness with 12.9% EIRR. Also financial analysis indicated financial soundness with 9.7% FIRR.

If no sewerage and sanitation systems were installed in the Area, the water pollution and public sanitary conditions, which already have reached a deplorable level in many districts, will become progressively worse.

8.2 RECOMMENDATIONS

As mentioned above, the Priority Project is sound and profitable. However it is only possible when the project is steadily implemented and the sewerage system is properly operated.

The Study revealed that the situations of the environmental and sewerage administrations of Rio de Janeiro State do not necessarily assure such preconditions. This section presents general recommendations for the enforcement of the environmental administration and specific recommendations for the implementation and operation of the Project. Some of recommendations are attached with practical proposals to overcome the issues involved.

8.2.1 FOR THE BETTER ENVIRONMENTAL ADMINISTRATION

For the enforcement of the environmental administration, effective administrative functions and political or public support to policies attaching importance to the environment are necessary.

(1) Integration of Functions

Currently in the State of Rio de Janeiro, SEMADUR is a responsible organization for the Guanabara Bay environment. It has several State organizations under it, such as FEEMA and SERLA, which are responsible for the environmental control and such as CEDAE, which is responsible for the implementation of structural projects. From these structures, SEMADUR could be an ideal organization for environmental administration since it can coordinate the control function and the implementation function.

However, in reality, SEMADUR has not fully utilized its advantageous position. This is because it does not have a function within its own organization to integrate and/or coordinate the function of organizations under it. For example, FEEMA has been conducting water quality monitoring of the Guanabara Bay regularly, but there is no procedure to report the results to SEMADUR. There is no way to utilize the information obtained by the monitoring to the Bay improvement activities. Moreover, while this Study itself is just a study on environmental administration, no department or section that is capable to act as a counterpart of the study exists in SEMADUR.

This is a weak side of the environmental administration in the State of Rio de Janeiro. There is no organization that takes initiative for the Bay improvement activities. SEMADUR should take the initiative. To do so, SEMADUR should organize such a department or section in their own organization which is equipped with following functions:

- Information pool of activities and plans related to the Bay environmental improvement
- Preparation of scenarios for the Bay environmental improvement through analysis on collected data and information
- Selection of the optimal scenario
- Revision of Strategic plan which is technically, economically and financially feasible
- Implementation of Strategic plan
- Coordination of budget allocation to activities for Bay improvement

Figure 8.1 shows concept of the organization that coordinates the functions of the present organizations under it and integrates the policy related to the Bay improvement. Water quality simulation model (WQSM) and Decision Support System (DSS) developed in this Study can be used as tools for integration of the policy for selecting the optimal scenario.

It is also recommended to enforce the current water quality monitoring program by FEEMA to make it the information source for the proposed organization. Required features of the monitoring program for the purposes are presented in item (3) below in this subsection.

(2) Encouragement of Environmental Awareness

The Bay improvement activities could be supported by the environmental policies and residents daily activities. The environmental policies can progress by support of the residents through the State parliament. Thus awareness of the environment of the residents is a key factor of the Bay improvement.

The study revealed relatively low awareness of the residents of the study area. The state should encourage residents awareness of the environment in order to obtain residents support of the sound environmental policy.

Study provided two tools for the encouragement of the residents awareness as shown below: namely, environmental education programs and Home page for the Guanabara Bay water quality. The study recommends that the State realize the proposed environmental education programs, and update and develop the Home page (for details, refer to *Supporting 14*.).

1) Environmental Education Programs

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: namely, environmental protection (through the collection of PET bottles) and the income generation for communities in need (cooperatives).

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 scenery 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 focus is 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.

Environmental Education and Art at Guanabara Bay

Description

This project aims at developing an activity that unites education, art and environmental sustainability together with the Guanabara Bay surrounding 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 increase teenagers awareness 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 will increase, valorizing their participation in everyday life issues. By surpassing the limits of only denouncing problems, the teenagers contribution in the identification of the problem causes and the search for alternatives to solve them are also increasing.

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

Objectives

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

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 receive on-the-job training by specialized technicians hired for the project).

Objectives

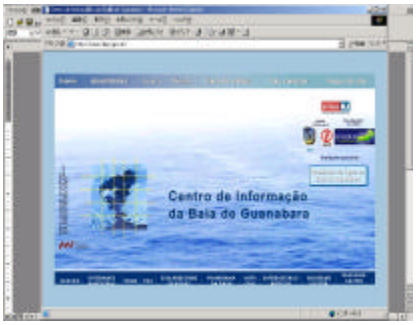
- To build a permanent relationship between the project and the main local community organizations, during the whole process of implementation, administration and operation of the radio station.
- To daily broadcast to the community a radio program with educational contents (sanitation, health, environment 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 community problems.
- To divulge and strengthen community self-esteem and cultural identity.

Apart from this, the Study also recommends the continuation of the Environmental Education Project (PEA – PDBG) that is one of the components of the PDBG I and is being carried out through an agreement between the State government and UERJ (University of Rio de Janeiro State). This Project objectives are as follows: to provide instruments for the educational system professionals, community leaders and government policy makers for an eco-political praxis; to mobilize the community; to organize knowledge and to produce didactic material about environment.

2) Home page

Main objective 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.



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. This Home page was created for the purpose of exchanging and sharing the data and information regarding the Guanabara bay. However, this Website does not give a general picture or water quality of Ganabara bay, but rather explains the roles of each government office and their work. In other words, the contents of the existing Website do not attract general views and do not encourage the awareness of residents.

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

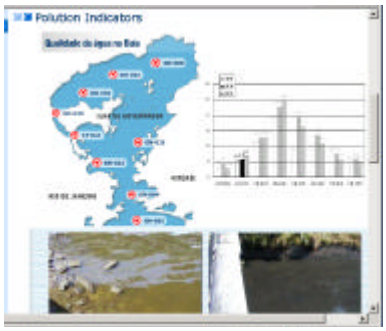
Major contents of the home page are as follows:

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 the population that is a potential pollution source.

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 point and BOD chart gives rough location and image of water quality. Photo images of sampling points and its landscape could help viewers easily understand the water quality at their familiar location. By knowing its location, they could even sense its smell and be able to relate it to their everyday life.

Activities

This section introduces different methods and efforts 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, implementing technical methods directly to improve the water quality, and other education or legislation methods that could encourage the government and raise community's environmental awareness. Major topics of this section are:

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

Sewerage

Using landscape interactive image showing the hydrological cycle, this page highlights the sewerage system such as sewage discharging from houses, sewage transmitting to WWTP, treatment at WWTP and final discharge to the Bay.

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 repeat visitors to the website.

(3) Comprehensive Environmental Monitoring Plan in Guanabara Bay Basin

Based on the review of current monitoring system conducted by FEEMA, the following remarks and recommendations can be made to promote adequate environmental monitoring program.

1) Monitoring Items

Monitoring items for analysis and frequency in current monitoring system conducted by FEEMA is considered to be adequate.

2) Monitoring of Bay Water Quality

For the bay water quality monitoring, it is recommended that 2 more sampling points should be added, near river mouths of Rio Iraja and Rio Cunha (GN-048 and GN-050), where water sampling and analysis were conducted in the Study.

3) Monitoring of River Water Quality

To determine pollution load discharged through a river, flow measurements need to be made at the time when water samples are obtained for water quality analysis.

Most of the existing water quality monitoring locations are influenced by tide, and flow measurement at these locations is not desirable for pollutant load estimation. Since flow measurements are not made by FEEMA, advantage can be taken if water quality monitoring is carried out at the same location as SERLA's river gauging stations where river flow is monitored daily. Additional monitoring locations on major rivers will facilitate determination of pollution load thorough measurements.

It is necessary that monitoring information of FEEMA and SERLA are summarized annually and analyzed for trend etc. using standard formats.

4) Public Transparency

All data should be summarized with raw data, and released to public by publishing annual or monthly report and uploading to webpage to promote public transparency and awareness. It is recommended that the following items should be included in the report:

- Reports should show the year-to-year trend of general analysis items regarding organic pollution (BOD, TSS, TN, TP, F. coli etc.) so that anyone can compare the relationship between progress of project and its effect.
- Reports should show the year-to-year or annual trend of general index regarding public health (rate of waterborne-disease, infant mortality rate, etc.) so that anyone can compare the relationship between progress of project and its effect.
- Special task force should be organized, with participation of competent organizations (e.g., FEEMA, SERLA and CEDAE), regarding publication of annual or monthly report.

8.2.2 FOR THE SOUND IMPLEMENTATION AND OPERATION OF THE PROJECT

(1) Implementation of Priority Project

CEDAE should take the first action to realize the Project, which is to make decisions on implementation of the Project, especially in areas enumerated below.

- Implementation of the Priority Project is dependant on financing being arranged and on final design to enable the contract documents to be prepared. The Priority Project's construction program presented in Chapter 7 has a total estimated cost of US$ 393.7 million, including allowances for engineering, contingencies, legal, and administrative costs.
- It is envisaged that this constitutes a seven-year program (2004 through 2010), which should be financed from Government resources, employing the funds which have already been used by the Government on sewerage system improvement. Because the Project would cause a heavy financial burden on CEDAE and affect other new projects, every effort should be exercised to the maximum extent to squeeze out self-financing sources.

- Application for a loan should therefore be made now to international lending agencies since approval of the loan could take about one year. In order to save time, final design studies should also be performed as soon as possible consistent with the timing of the loan. Ideally, the financing and contract documents should be ready at the same time so as to allow construction of the Priority Project to proceed immediately at that time. In this way, it is envisaged that Priority Project construction could be completed some six years from now.
- Acquisition of the lands for Bangu WWTP as soon as after the decision is made to proceed to the Priority Project.
- Some important institutional arrangements will need to be established in CEDAE so that the new Sewerage Department can assume full control and responsibility for the planning, construction and operation of the wastewater collection and treatment facilities.
- The support and technical cooperation of other governments and municipalities, particularly the Rio de Janeiro Municipality to CEDAE, will be essential for the success of the Project, and will ensure that users of the new wastewater system are provided with a reliable, efficient and effective service.
- It is assumed that the Priority Project would be implemented as the second phase of PDBG. The second phase of PDBG may be able to comprise more components as the current PDBG does. In this line, it is desired that it include the supplemental measures for the Bay improvement such as dredging of bottom sediment, removal of garbage on the sea surface, preservation and restoration of mangrove and wetland conservation.
- The Study has concluded that the Priority Project is financially viable on condition of 30% low interest loan, 30% medium interest loan and 40% of local financing. However, in the actual loan application, it would be negotiable to decrease ratio of local financing by increasing ratios of loan. For example, 44.1% and 37.1% of a total project cost were covered by IDB and JBIC respectively, resulting in 18.8% of local financing in present PDBG Phase I. Considering some delay in the implementation of the current PDBG supposing due to unstable local financing, it would be recommendable to increase ratios of the loan in order to secure more smooth project implementation.

(2) Financial Improvement of CEDAE

According to annual report of SNIS (National Information System on Sanitation) program, annual operational revenue per 1 m^3 of invoiced volume is smaller than annual cost without principal repayment (DTS). Thus, the more CEDAE provide water service, the more it receives deficit. Under such a circumstance, CEDAE and the State Government cannot sustain the priority project. The Study Team recommends the following actions, in order to increase operational revenue, and to decrease cost.

CEDAE should continue monitoring indicators in SNIS program report, analyzing the difference of indicators with other water supply companies. It should set targets, and prepare an action plan.

The following sections describes examples of such activities.

1) Increase of Operation Revenue

As stated in the previous section, decrease of unearned water bill rate and non-revenue water rate will generate cash inflow, and produce increase of operational revenue. Non-revenue water rate decreased by 9% from April to March in 2003, and it is estimated to be about 48% this year if CEDAE can maintain the current level.

In the long run, CEDAE should achieve 10% for unearned water bill rate, and 30% for non-revenue water rate. Because SABESP and EMBASA, which are state water companies of Sao São Paulo State and Bahia State respectively, have already arrived at that level. If CEDAE can achieve the target, it will receive new cash flow of US$175 million (R$508 million). This is 40% of current operational revenue of CEDAE per a year.

In order to decrease unearned water bill rate and non-revenue water rate, CEDAE can carry out the following actions:

- Commercial approach, which consists of replacement of meters for accurate measurement, special water bill rate for poor residents, negotiation with unpaid residents, etc.
- Technical approach which consists of renovation of water supply and sewer pipes, introduction of pressure control system by use of Information Technology, etc.

The Study Team recommends starting with the commercial approach first. Therefore CEDAE should continue its effort on re-registration of users and replacement of new meters[1].

2) Decrease of O&M Expenditure

Table 8.1 presents cost structure of CEDAE, SABESP and EMBASA. CEDAE's operation cost of per 1 m^3 of produced/treated water is 0.2 points higher than SABESP. Two items, "tax payment," "depreciation," "personnel expense" of CEDAE is much higher than the other two companies.

As for tax payment, the State Government should consider treating CEDAE as an exempt or tax-reduction coorporation, because the State Government would have to support CEDAE financially in case of management crisis.

Table 8.1Cost Structure of CEDAE, SABESP and EMBASA

Expense item per 1m^3 of produced/treated water	CEDAE	SABESP	EMBASA
	2001	2001	2001
Total (DTS)	1.25	1.05	1.20
Personnel expense	0.30	0.27	0.26
Chemical expense	0.02	0.02	0.04
Electrical expense	0.06	0.07	0.08
Outsourcing expense	0.12	0.11	0.08
Interest payment	0.08	0.23	0.22
Depreciation and reserve for unpaid bill	0.36	0.23	0.22
Tax payment	0.15	0.01	0.07

Source: DIAGNÓSTICO DOS SERVIÇOS DE ÁGUA E ESGOTOS 2000, 2001, SISTEMA NACIONAL DE INFORMAÇÕES SOBRE SANEAMENTO (SNIS)

Difference of depreciation and reserve for unpaid bills between CEDAE and other two companies is the largest, but CEDAE's investment amount per production/treated water volume (0.08 in 2001) is much lower than SABESP (R$0.17 in 2000 and 0.21 in 2001) and EMBASA (R$0.31 in 2000 and 0.26). Therefore most of the difference comes from reserves for unpaid water bills. If CEDAE were successful in decreasing the unpaid water bill rate, it can also decrease the reserve, and can decrease average operation cost.

[1] 20% of water meter has replaced to new one to date. CEDAE should continue this action.

CEDAE's personnel expense is a little higher than the other two companies, but reduction of tax payment and depreciation and reserve should be considered first.

3) Others

Before CEDAE collects sewerage bills from all residents in service area, but it collects the bill only from the residents which had connected with sewer network since this year. When a resident wants to use sewer service, he has to bear the burden of connection cost himself[2]. Therefore residents which have not connected sewer network may lose the incentive to connect sewer network.

CEDAE and the State should consider supporting the residents who can't pay connection cost at one time. For example they should introduce a loan system with no/low interest rate, and a divided payment system. If they can't introduce such systems, unearned water bill rate would not increase, and CEDAE couldn't collect enough user charge. It will worsen financial feasibility of the priority project.

(3) Operation and Maintenance Improvement of CEDAE

Some parts of the Rio de Janeiro's collection systems were constructed as long ago as in 1880s mainly in the central builtup urban districts, and new works were gradually expanded. In 1885 and 1890, the old private company (RIC) constructed the area's first sewers. During 1950 to 1960, the areas rapidly developed as a result of completion of the bridge linking Ilha do Governador, Alegria and other the bay coastal zones, and so too were sewer systems devloped.

The old central urban districts have so far mostly been covered by old sewers (some of them are as old as 100 years), which have apparently caused sewage overflows at many locations, creating unsanitary conditions. However, the exact extent of sewer deteriorations in such old parts of the Rio de Janeiro is yet to be known.

So far, no comprehensive sewer rehabilitation program has been established yet to identify the real situation. Under the circumstances, it is apparent that there is an urgent need for sewer rehabilitation and retrofitting. It is recommended to establish a sewer renovation program involving preparation of sewer network inventory, and to establish the program of inspections, cleanings and rehabilitations of sewers. These should be responsibility of the newly established Sewerage Department in CEDAE.

(4) Implications of Future Actions and Studies

Because of the recommended plan for the positive control of water quality in the Bay and waterways in the Study Area, several special actions and investigations are necessary to provide a sound basis for detailed planning and system design. Specifically, urgent studies and actions should be undertaken for the continued protection and improvement of the environment of the Area.

In order to execute the program for the wastewater discussed in this report, it will be necessary to have an expertly managed system of authority, responsibility and control over all aspects of the Project. This program execution should incorporate management techniques most current and suitable to Rio de Janeiro.

[2] Connection cost depends on diameter and material of pipe, pavement material of road, etc. A resident has to pay R$52-700 per 1m.

The Study concluded that the Project is feasible and that the state support is essential. The success of the project strategy for the sewerage system improvement and environmental protection in Guanabara Bay Basin and its surrounding areas requires the implementation of a range of actions, including:

- Following the implementation of Priority Project, subsequent stages of the program should be implemented in a similar manner to Priority Project. Updating of basic data should be performed prior to each construction stage to ensure that changes unforeseen at the present time are taken into account.
- Enforcement of controls over what enters the river and groundwater particularly from industrial and commercial activities, which need to enhance their wastewater pre- treatment practices.
- Strengthening of CEDAE to take responsibility for the management, implementation and operation of the Project.
- Construction of new sewers to collect wastewater from the peripheral urban areas, followed by full connection of property wastewater discharges to them.
- Further construction and rehabilitation of WWTP facilities to serve areas of the Rio de Janeiro and its surrounding areas, to provide conventional activated sludge treatment to all wastewater flows.
- Introduction of public education programs to promote community participation and understanding of the importance and benefits of public sanitation works.
- Training of personnel in project management, financial management, operation and maintenance of wastewater facilities, and testing and monitoring, techniques.
- Planning for the future to ensure that future urban developments are provided with wastewater/sanitation facilities.

(5) Monitoring of WWTP Operation

Based on the review of current relevant regulation regarding to wastewater effluent monitoring (such as State Decree No. NT-202 and DZ-215), the following remarks and recommendations are made.

This kind of monitoring plan should target not only the Priority projects, but also all existing/future sewerage concerning projects in the Guanabara Bay Basin.

1) Monitoring of Effluent and Receiving River

In addition to effluent monitoring, water quality in receiving water body should be monitored on a regular basis. Sampling should be conducted from at least 3 points, namely, proximate upstream of discharge point, proximate downstream of discharge point and the downstream of discharge point where effluent and river flux completely mix together.

2) Monitoring of Sludge

In addition to effluent, sludge generated from WWTP should be analyzed in regular basis. Analysis items should include at least, Solid Content, Cd, Cr(6+), Cu, Hg, Pb and Zn.

3) Monitoring of Odor

It is necessary to conduct monitoring for odor level in/around WWTP during the operation stage.

- Sampling should be conducted at least twice a year, considering temperature, humidity and prevailing wind direction at the time when sampling is conducted.
- It is recommended to conduct sampling in January and July (temperature and humidity is high in January, and southwest wind is prevailing in January and northeast wind is prevailing in July).

4) Monitoring of Noise

It is necessary to conduct monitoring for noise level in/around WWTP during the operation stage.

- Noise level should be monitored at least twice a year and measured both in daytime and nighttime.
- Measuring should be conducted at the boundary fence of WWTP. Measuring should be from at least 2 points.

5) Public Transparency

All data should be summarized with raw data and released to the public by publishing annual report or uploading to webpage to promote public transparency.

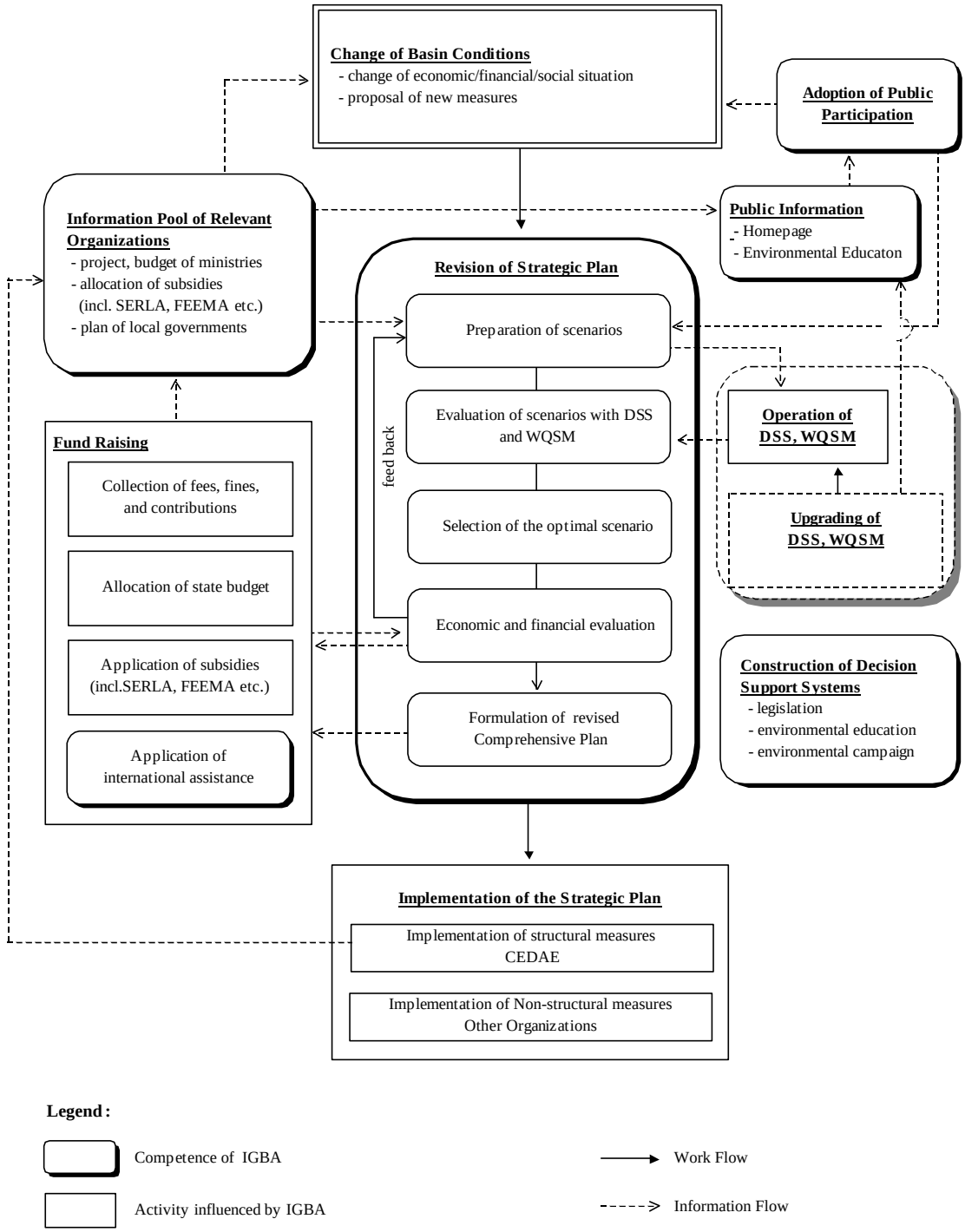


Figure 8.1 Conceptual Diagram of Functions of Integrated Guanabara Bay Environmental Administration (IGBA)