JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE STATE SECRETARIAT OF ENVIRONMENT AND URBAN DEVELOPMENT (SEMADUR)
THE STATE COMPANY OF WATER AND SEWAGE (CEDAE)

THE STUDY ON MANAGEMENT AND IMPROVEMENT OF THE ENVIRONMENTAL CONDITIONS OF GUANABARA BAY IN RIO DE JANEIRO, THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT

SUPPORTING REPORT VOL I

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1. TOPOGRAPHY

Topographic map of the Guanabara Bay basin is shown in *Figure 1*. The northern part of the Guanabara Bay basin is surrounded by the high mountain range of Serra do Mar. In the northern boundary altitudes varying from 1,000 m to more than 2,000 m with the highest mountain peak of 2,275 m at Serra do Orgaos at the north-center of the basin followed by a mountain peak of 2,219 m at the north-east corner of the basin. The southern part of the basin is surrounded by the coastal mountains of Serra do Bangu, Serra do Carioca and Serra do Mato Grosso with altitude varying from lower than 500 to 1,000 m. The rocky mountains that constrict the mouth of Guanabara Bay are part of this southern mountain range. The central basin is covered with gently undulating hills and plains.

2. GEOLOGY

Geological map of the Guanabara Bay basin is shown in *Figure 2*. The Precambrian basement rocks, forming the mountains and hills covers a large area of the Guanabara Bay basin and consists of zonal gneisses and granitic gneisses, which contain subsidiary intercalated quartzites and marbles. This area is characterized by strong structural lineament, the dominant direction being WSW-ENE and SW-NE. Surui Granite, a late Precambrian granite, intrudes into early Precabrian Gneisses in the northern area adjacent to Guanabara Bay and forms hills with the height of 200 to 300 m. Alkali rocks of early Tertiary are scattered in the east and west sides of the basin. Tertiary alkali rocks also intrude into the Precambrian gneisses around the eastern and western edges of the basin. Pleistocene sediments called Macacu formation are found around Itaboraí. This formation mainly consists of weak consolidated medium to coarse sand with a succession of lenses and thin layers of fine sand. Holocene sediments are distributed over the river and coastal plains.

3. RIVER AND BAY SYSTEM

3.1 RIVER SYSTEM

About 45 rivers flow into Guanabara Bay from each of their catchment areas. All the rivers have their origins at mountain peaks within the catchment boundary. A simplified river system is shown in *Figure 1*. Based on GIS database prepared using 1/50,000 scale map, the total catchment area of the rivers contributing to the flow into Guanabara bay is estimated to be about 4,025 km^2 excluding the islands which have a total area of about 46 km^2. Among the rivers, Rio Guapimirim (flowing from north-east to south-west) has the largest catchment area of about 1,262 km^2 comprising about 31% area of all the river basins (excluding islands). The following two rivers which have large catchment areas are Rio Caceribu (flowing from west to east) and Rio Iguaçu (flowing from south-west to north-east) which have catchment areas of about 811 km^2 and 349 km^2 comprising about 20% and 18% of total river basin area, respectively.

3.2 BAY SYSTEM

Guanabara Bay is a large coastal bay with a total area of about 390 km^2 of which approximately 50 km^2 are occupied by islands. The bay measures 28 km from west to east and 30 km from south to north. Towards the west, north and east the bay is bordered by the Guanabara Bay

Basin and towards the south the bay is connected to the Atlantic Ocean. The entrance of the bay is only 1.6 km wide. About half of the bay area is very shallow with depths below 5 m. The deeper part extends about 20 km in the north-south direction from the bay entrance to the area between the largest island (Ilha do Governador) and Ilha Paquetá, and constitutes a huge channel with average width of 2.5 km and average depth of about 15 m. This channel controls the water exchange between the bay and the ocean.

Guanabara Bay is characterized by high salinities and temperatures. Yearly mean values are approximately 30 ‰ and 25 °C respectively. The freshwater inflow to the bay is mainly focused in the north-eastern and north-western parts of the bay, where the largest rivers of the basin discharge. This inflow, mixed by the bay circulation, gives rise to a salinity distribution in the bay varying from around 34-35 ‰ at the entrance to around 20-25 ‰ at the inner reaches of the bay. Similarly, a weak vertical salinity stratification with typical surface-bed salinity differences of 1-3 ‰ exist in the bay. The salinity distribution varies throughout the year depending primarily on the magnitude and spatial distribution of the freshwater inflow.

The currents of Guanabara Bay are dominated by ebb and flood currents generated by the tide and shaped by the bay bathymetry. The range of the astronomic tide varies from 0.3 m during neap tide to 1.1 m during spring tide and presents diurnal variations of up to 30% of the tidal range. Water level variations along the Atlantic coast (sometimes referred to as meteorological tide, caused by passing weather systems) has typical ranges up to 0.5-0.6 m and periods of several days. Typical maximum current speeds span from 0.6-1.2 m/s at the entrance to 10-30 m/s in the northern part of the bay (Ref. 1). The currents of the bay are to some extent modified by local winds and other factors.

The bay circulation, or the net currents, can be considered a composite of transverse (residual) tidal circulation and gravitational circulation, modified by the effects of the local wind (Ref. 2). The bay circulation is, apart from redistributing the water of the bay, responsible for the transport and spreading of dissolved and suspended substances and organisms such as bacteria, nutrients and phytoplankton.

4. CLIMATE

General meteorological conditions of the Study Area are shown in *Figure 3*. After compiling monthly rainfall data at sixty eight stations collected from SERLA, four stations from INMET and one station from GEO-RIO with data ranging from 1928 to 2002 and utilizing GIS database, historical annual as well as monthly rainfall variation for the total Study Area has been generated. It can be seen that annual total rainfall for the Study Area varies from as low as 891 mm in 1970 to 2,209 mm in 1988. A linear trend line implies an increasing tendency in annual total rainfall. Average monthly total rainfall for the total Study Area varies from 55 mm in July to 228 mm in December. The average annual total rainfall for the Study Area is 1,583 mm. Looking at the monthly rainfall pattern for the Study Area, three seasons can be identified in terms of rainfall:

- Low rainfall/dry season covering there months of June, July and August with total rainfall of 173 mm, representing 11% of annual total rainfall.
- Medium rainfall/transition season covering there months of May, September and October with total rainfall of 298 mm, representing 19% of annual total rainfall.
- High rainfall/wet season covering six months from November to April with total rainfall of 1,112 mm, representing 70% of annual total rainfall.

Using data from all the stations and utilizing GIS database, Isohyetal map of annual total rainfall for the Study Area has been constructed and is shown in *Figure 4*. It can be seen that:

- The general trend of increase in annual total rainfall is from south to north and then from south-west to north-east.
- The southern part, comprising almost half of the Study Area, has a low variation in annual total rainfall which varies from 1,100 to 1,400 mm.
- The northern part has a wide variation in annual total rainfall which varies from 1,400 to 2,800 mm.
- Highest annual total rainfalls of more than 2,800 mm occurs at Posto Garrafao at the mountain peak of Serra do Orgaos (2,275 m) in Magé municipality and next at Apolinário at the north-east mountain peak of the basin (2,219 m) in Cachoeiras de Macacu municipality where annual total rainfall of more than 2,700 mm is observed.

General meteorological conditions at Rio de Janeiro station are also shown in *Figure 3*. The monthly rainfall pattern at Rio de Janeiro station is not the same as that of the total Study Area. Average annual total rainfall and evaporation (by Piche method) at Rio de Janeiro station are 1,173 and 1,199 mm respectively. It can be seen that average monthly total evaporation at Rio de Janeiro station varies from 84 mm in June to 112 mm in January, indicating a low variation which is from low variation in average monthly temperature and relative humidity. Monthly average temperature at Rio de Janeiro station varies from 21.3 °C in July to 26.5 °C in February with average annual temperature of 23.7 °C. Monthly average relative humidity at Rio de Janeiro station varies from 77% in July to 80% in February with average annual relative humidity of 79%.

5. WATER QUALITY OF RIVER

5.1 MONITORING SYSTEM

Water quality monitoring of major rivers and canals in the basin of the Guanabara Bay Basion is carried out by FEEMA. *Figure 5* shows water quality monitoring locations. Presently there are 27 monitoring stations. One stations grab sample is taken every two months for analysis for each river. Generally, samples are taken over two or three consecutive days. Monitoring parameters are listed in *Table 1*.

FEEMA also has another nine stations for sediment quality monitoring where heavy metal pollution is suspected. *Figure 6* shows these stations and *Table 1* shows the monitoring parameters.

5.2 WATER QUALITY OF RIVERS

Water quality monitoring data between 1991-2001 provided by FEEMA was analyzed by the Study Team. *Figure 7* shows the annual average BOD concentration for the year 2000 showing the order of organic pollution level. As expected, pollution level remains very high for the rivers and canals in the densely populated areas of eastern part of the basin around Niterói upto Guaxindiba (GX720) and western part of basin from Canal do Mangue (MN000) to Rio Iguaçú (IA261) due to untreated wastewater discharge. Rivers in the northern part of the basin are of good quality except for Rio Magé and Rio Soberbo.

5.3 NEED TO IMPROVE MONITORING SYSTEM

The present monitoring system is adequate to obtain data on water quality of rivers and canals. However, to obtain data on the pollution load discharged to Guanabara Bay and analyze them, the system is inadequate. To determine pollution load discharged thorough rivers, flow and water quality need to be simultaneously measured. The flow measurements need to be made when and where water samples are obtained for water quality analysis.

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

SERLA has recently established a hydrological monitoring network in the Guanabara Bay basin shown in *Figure 5*, and monitors river flow every day. Almost all of the river gauging stations of the network are located far upstream of the water quality monitoring locations.

It is necessary that monitored information of FEEMA and SERLA are summarized annually and analyzed for trends, etc. using standard formats.

6. WATER QUALITY OF BAY

6.1 MONITORING SYSTEM

Bay water quality monitoring system of FEEMA consists of nine monitoring stations shown in *Figure 8*. Monitoring frequency is monthly for four stations (GN-020, GN-022, GN-040 & GN-043), bimonthly for another four stations (GN-000, GN-026, GN-042 & GN-064) and quarterly for GN-093 which is outside the bay. Monitoring has been fairly regular. Stations where water depth is small (GN-020, GN-040 & GN-042) monitor at upper and lower layers while the stations where water depth is greater monitor at upper, middle and lower layers. On-site measurements are generally made for pH, DO, salinity, and conductivity. *Table 1* shows the monitoring parameters. Generally, sampling is scheduled to be carried out during neap/low tide.

6.2 WATER QUALITY

Water quality monitoring data between 1991-2001 provided by the FEEMA was analyzed by the Study Team. *Figure 9* shows the depth averaged BOD levels (75% of annual data) for the years 1991, 2000 and 2001 arranged according to the pollution level in year 2001, representing overview of two-dimensional distribution and chronological comparison of organic pollution.

The north western part of the bay is mostly polluted in terms of organic pollution, which corresponds to the pollution level of the rivers. Stations GN-064 and GN-026 showed lower BOD concentration in spite of high pollutants discharge, probably because tidal exchange is dominant in these areas and thus sea waters thereremain less polluted. At all the stations, water qualities exceed the water quality standards in terms of BOD except at GN-026 were BOD is just below 5 mg/L for Class 6 water body.

As a long term trend, the pollution level for 2000 increased if compared with that in 1991 at all the stations. In 2001, there seems to be a decrease in pollution level at GN-064, GN-026, GN-000, GN-042 and GN-020 stations. Confirmation of this decrease requires further data analysis.

Seasonal variation of water quality is not readily discernible from the available monitoring data due to missing data, etc. *Figure 10* shows the variation of salinity and BOD for two stations (GN-064 and GN-042) which represent areas of the bay mainly influenced by the tidal exchange and influenced by the freshwater/wastewater discharge, for the 1991 and 2001. Further analysis will be carried out to understand the seasonal pattern.

Table 1 List of Monitoring Parameters for Water Quality and sediment Quality

No.	Water Quality	Sediment Quality
1.	Temperature	Solids Content
2.	pH	Water Content
3.	Conductivity	Chemical Oxygen Demand
4.	Salinity	Chromium
5.	Dissolved Oxygen	Manganese
6.	Secchi depth	Iron
7.	Suspended Solids	Nickel
8.	Total Dissolved Solids	Copper
9.	Biochemical Oxygen Demand (5-day)	Zinc
10.	Chemical Oxygen Demand	Cadmium
11.	Total Kjeldahl Nitrogen	Mercury
12.	Nitrite Nitrogen	Lead
13.	Nitrate Nitrogen	Benzo (a) Pyrene
14.	Ammonium Nitrogen	Polychlorinated Biphenyls (PCBs)
15.	Total Phosphorous	
16.	Soluble Phosphates	
17.	Chlorophyl-a	
18.	Pheophytin	
19.	Cyanide	
20.	Phenols	
21.	Sulphates	
22.	Chlorides	
23.	Polychlorinated Biphenyls (PCBs)	
24.	Benzo (a) Pyrene	
25.	Total Aromatic Hydrocarbons (HPA)	
26.	Total Coliforms	
27.	Fecal Coliforms	
28.	Iron	
29.	Nickel	
30.	Chromium	
31.	Copper	
32.	Zinc	
33.	Cadmium	
34.	Mercury	
35.	Lead	

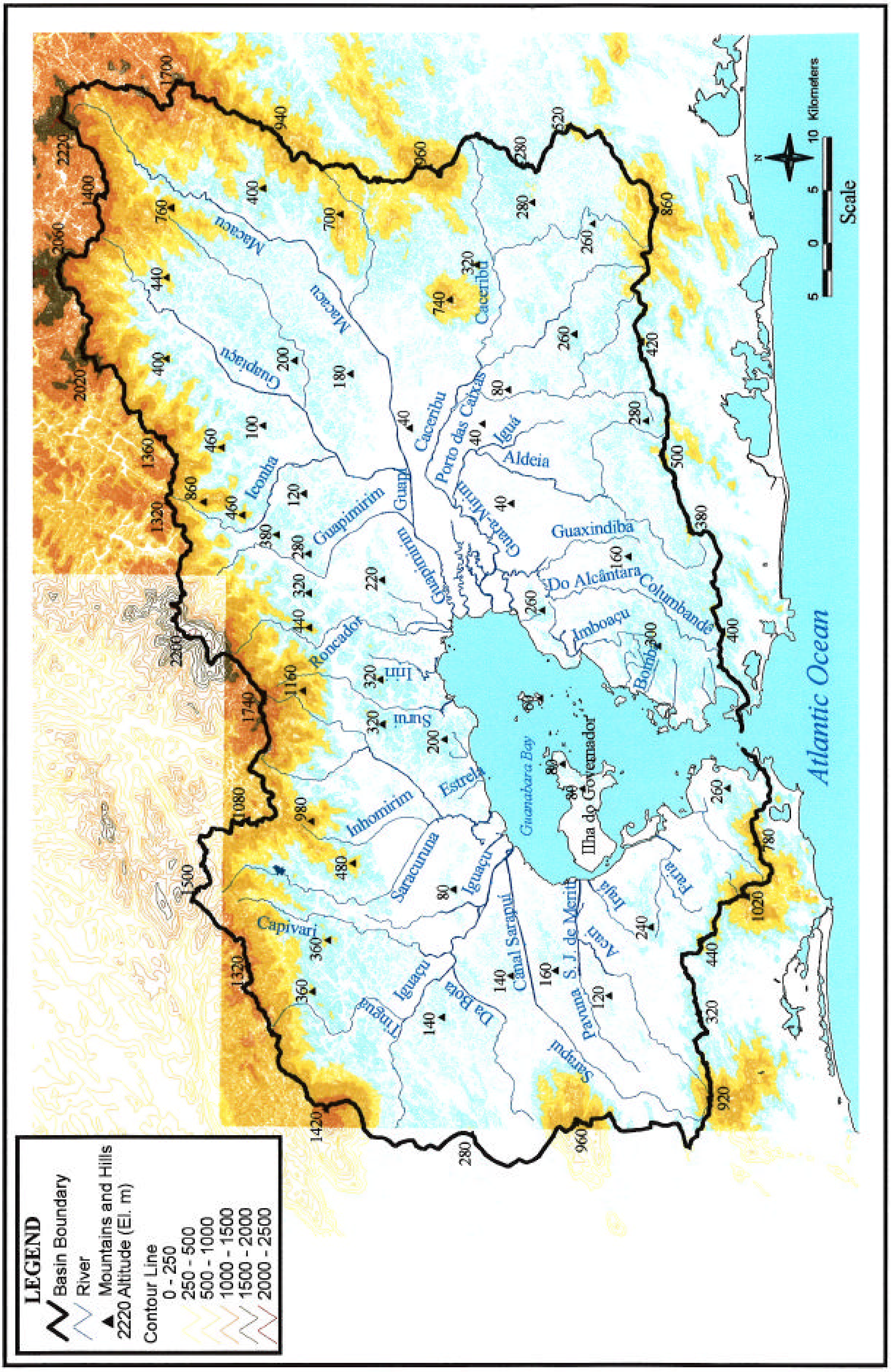
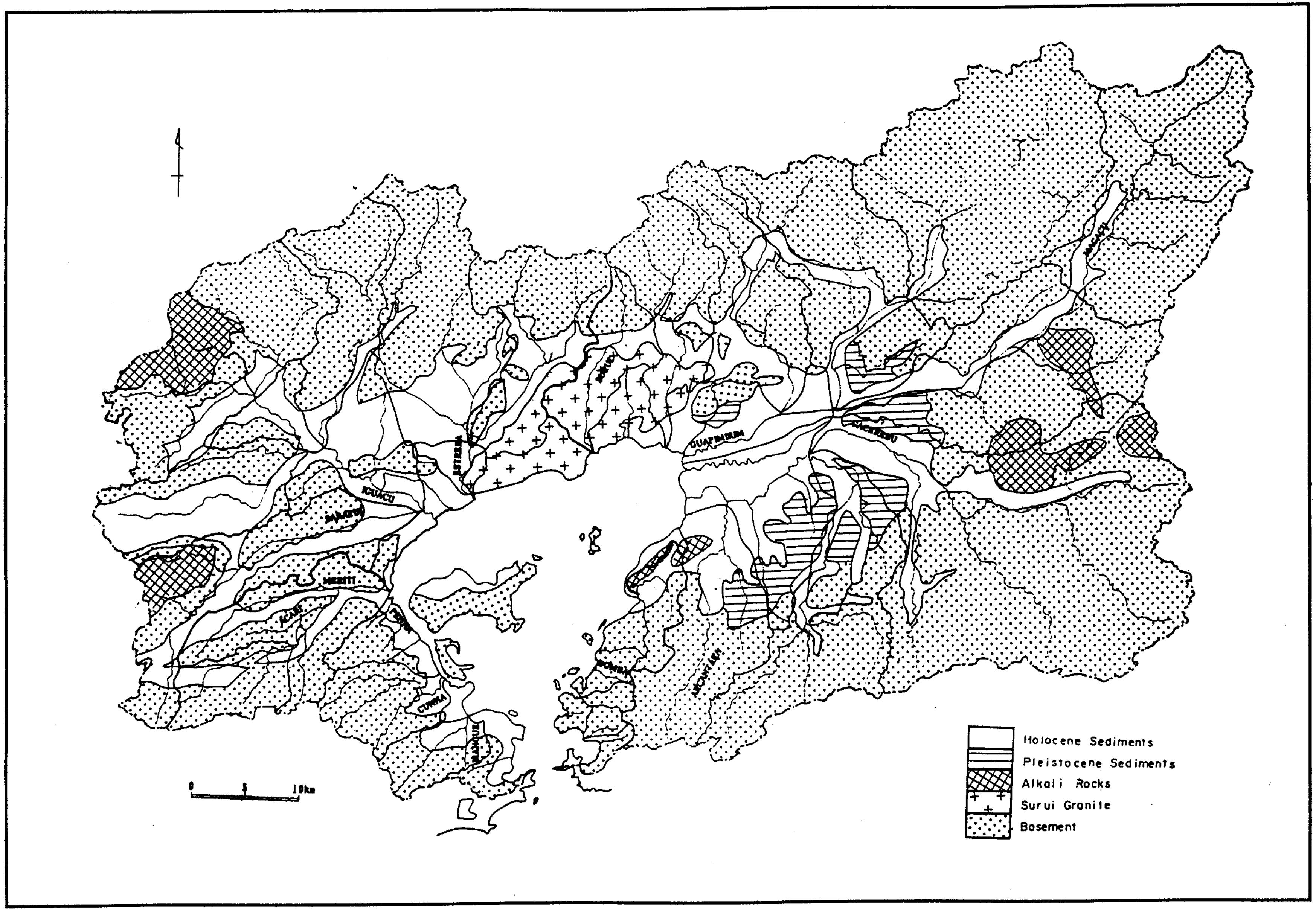
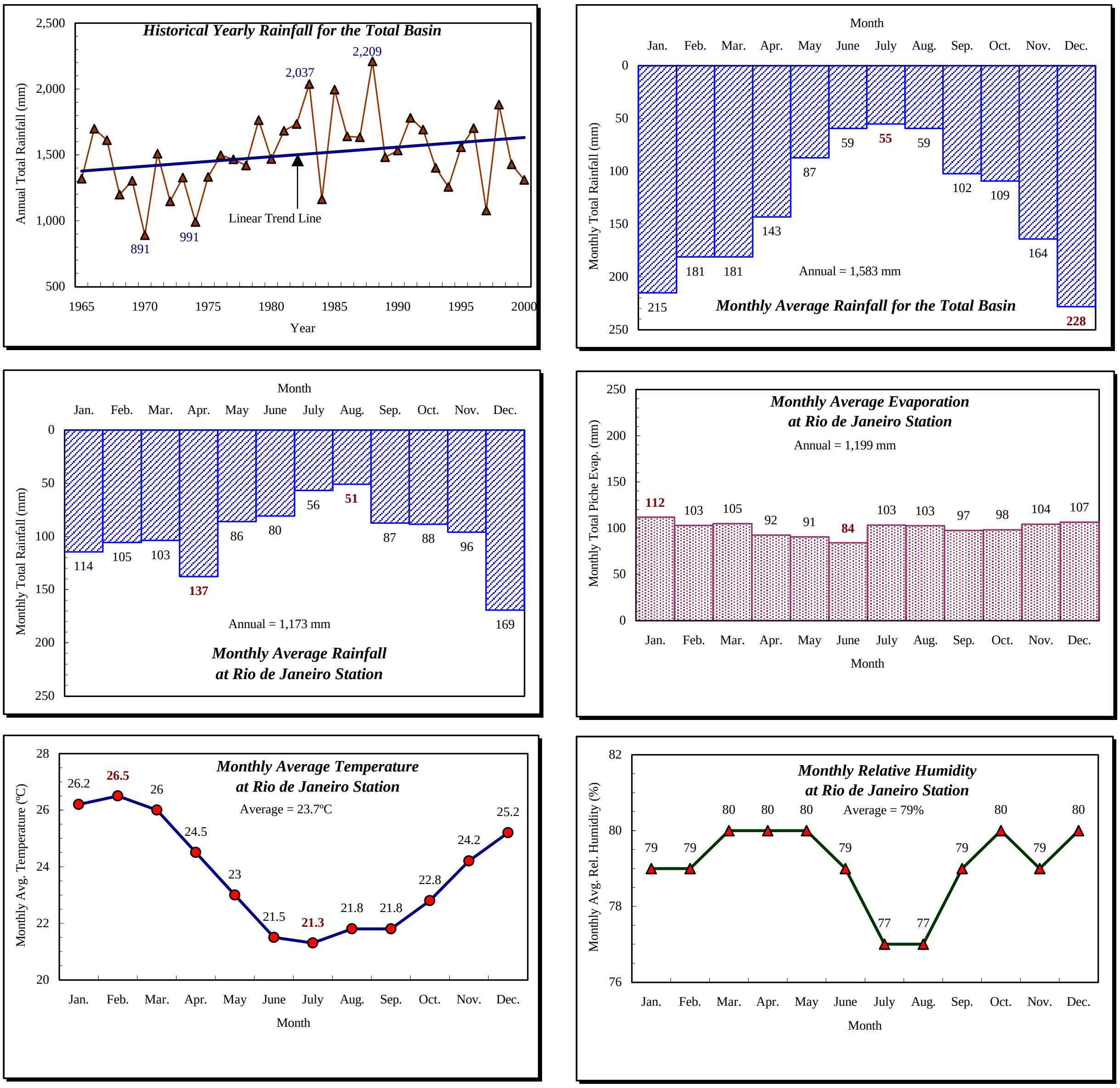


Figure 1 Topography



Source: JICA 1994
The Study on Recuperation of the Guanabara Bay Ecosystem, Volume 3, Supporting Report I

Figure 2 Geology of the Guanabara Bay Basin



Source :	Rainfall of Total Basin :	Monthly data from 68 rainfall stations of SERLA ranging from 1928 - 2000; Monthly data from 4 rainfall Stations of INMET ranging from 1975 - 2000; Monthly data from 1 rainfall station of GEO-RIO ranging from 1997 - 2002.
	Rio de Janeiro Station :	Monthly data from CIDE ranging from 1973 to 1990.

Figure 3 General Meteorological Condition

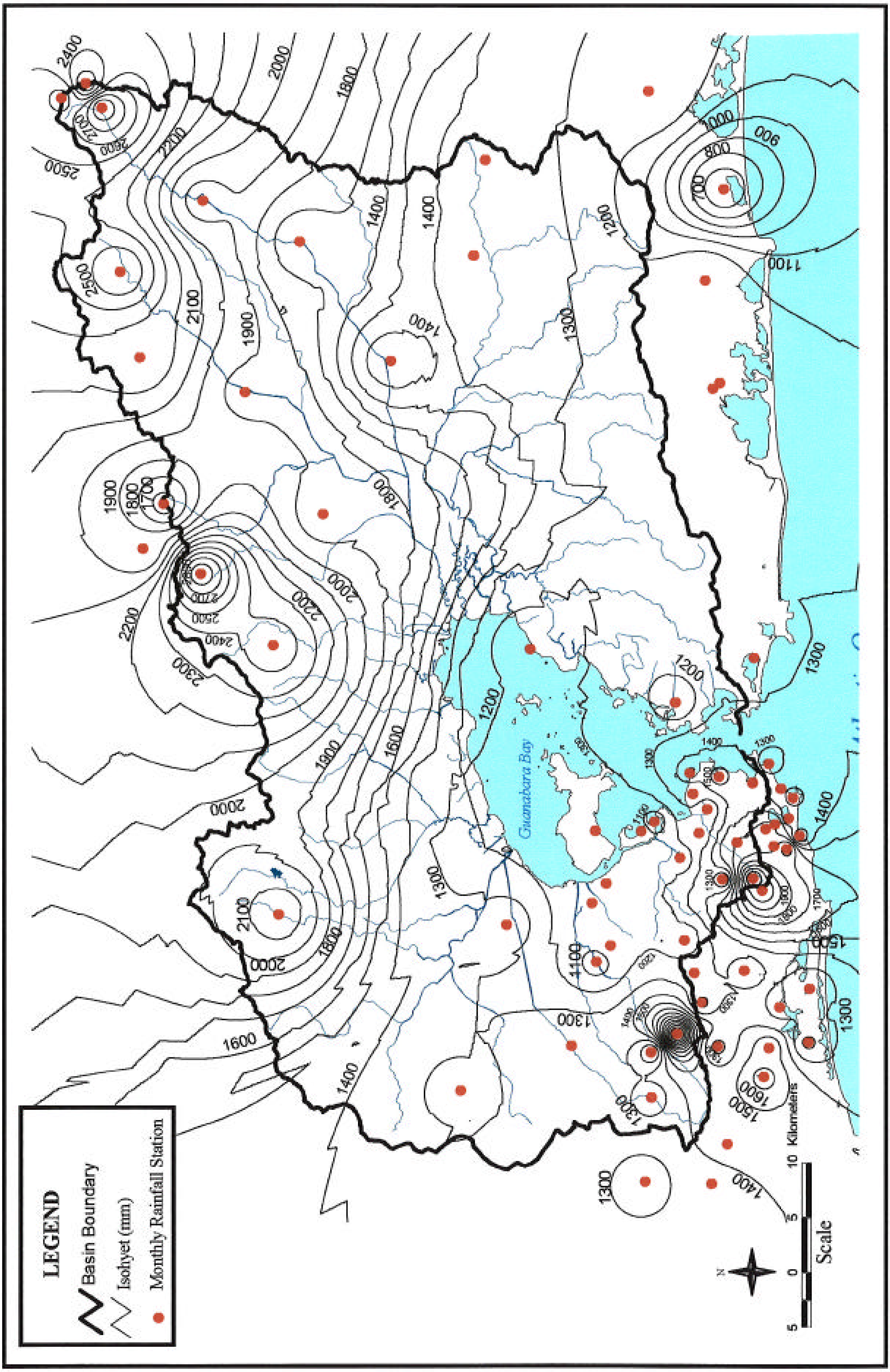
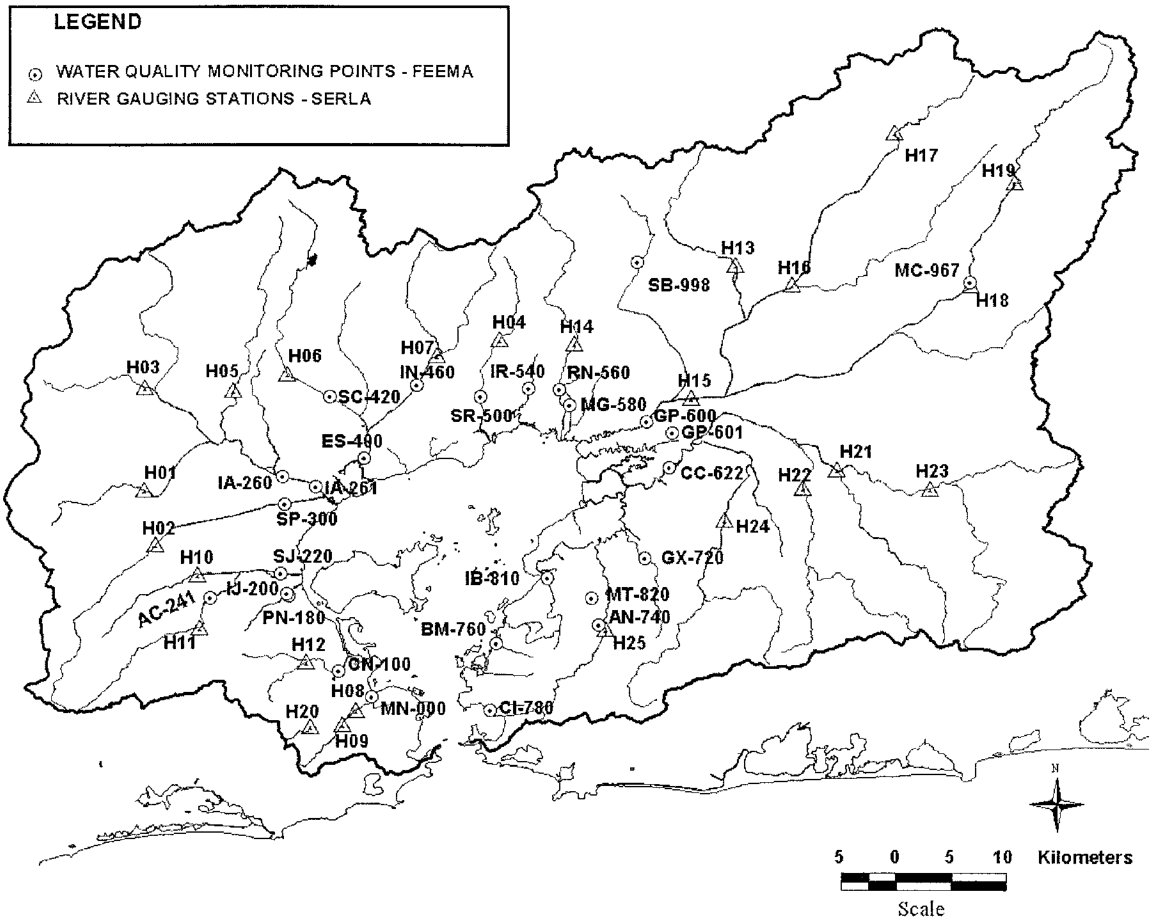
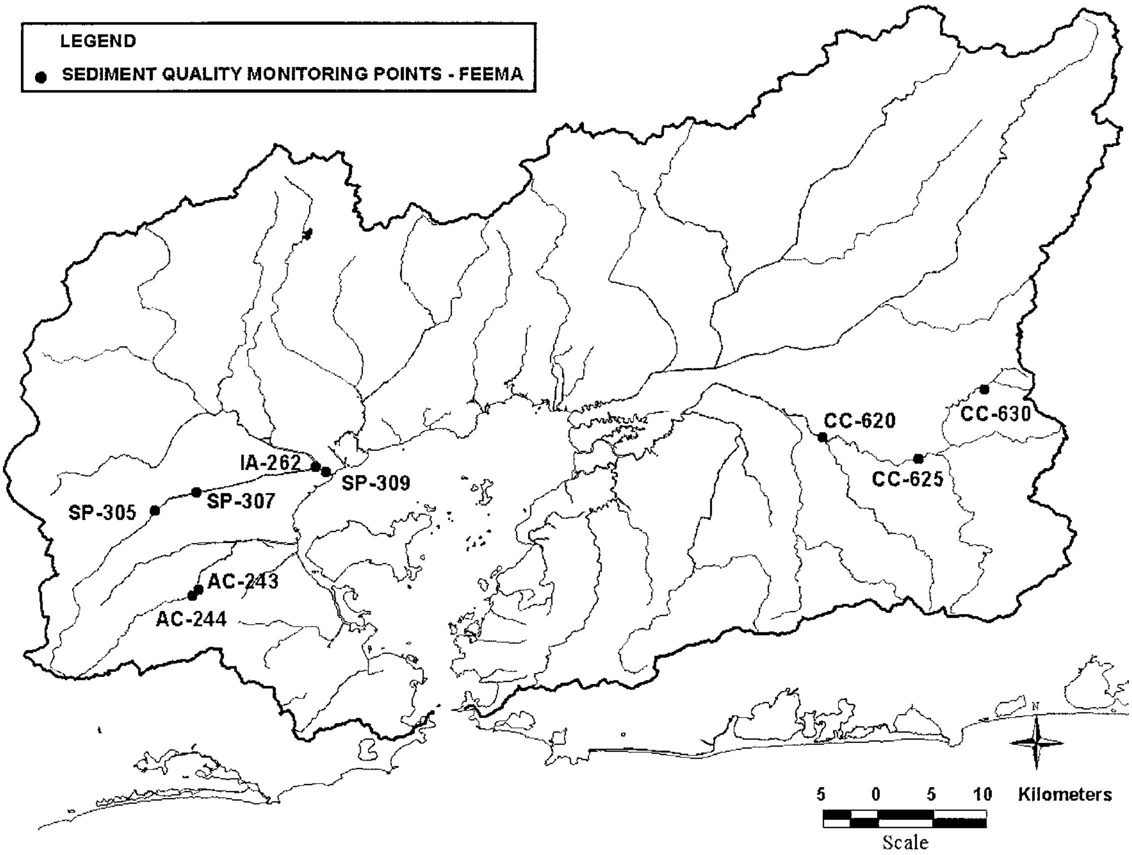


Figure 4 Isohyetal Map of Annual Total Rainfall



STATION	LATITUDE	LONGITUDE	RIVER NAME
MN-000	22° 54' 1"	43° 12' 36"	Canal do Mangue
CN-100	22° 52' 46"	43° 14' 22"	Canal do Cunha
PN-180	22° 49' 10"	43° 16' 59"	Canal do Penha
IJ-200	22° 49' 5"	43° 17' 6"	Rio Irajá
AC-241	22° 49' 19"	43° 21' 3"	Rio Acari
SJ-220	22° 48' 9"	43° 17' 24"	Rio S. João de Meriti
SP-300	22° 44' 48"	43° 17' 15"	Rio Sarapuí
IA-260	22° 43' 28"	43° 17' 22"	Rio Iguacú
IA-261	22° 43' 55"	43° 15' 38"	Rio Iguacú
SC-420	22° 39' 33"	43° 14' 57"	Rio Saracuruna
IN-460	22° 38' 56"	43° 10' 28"	Rio Inhomirim
ES-400	22° 42' 31"	43° 13' 8"	Rio Estrela
SR-500	22° 39' 26"	43° 7' 5"	Rio Surui
IR-540	22° 39' 2"	43° 4' 36"	Rio Iriri
RN-560	22° 39' 2"	43° 2' 58"	Rio Roncador
MG-580	22° 39' 47"	43° 2' 25"	Rio Magé
SB-998	22° 32' 50"	42° 58' 58"	Rio Soberbo
GP-600	22° 40' 32"	42° 58' 23"	Rio Guapimirim
GP-601	22° 41' 4"	42° 57' 1"	Rio Guapimirim
MC-967	22° 33' 36"	42° 41' 38"	Rio Macacu
CC-622	22° 42' 47"	42° 57' 11"	Rio Cacerebu
GX-720	22° 47' 9"	42° 58' 23"	Rio Guaxindiba
MT-820	22° 49' 6"	43° 1' 9"	Rio Mutondo
AN-740	22° 50' 24"	43° 0' 47"	Rio Alcântara
IB-810	22° 48' 12"	43° 3' 29"	Rio Imboassú
BM-760	22° 51' 20"	43° 6' 9"	Rio Bomba
CI-780	22° 54' 37"	43° 6' 24"	Canal Canto do Rio

Figure 5 River Water Quality Monitoring Locations and River Gauging Stations



Location ID	LATITUDE	LONGITUDE	RIVER NAME
AC-243	22° 50' 30"	43° 21' 32"	Rio Acari
AC-244	22° 50' 50"	43° 21' 52"	Rio Acari
CC-620	22° 42' 40"	43° 48' 35"	Rio Cacerebu
CC-625	22° 43' 36"	43° 43' 32"	Rio Cacerebu
CC-630	22° 40' 10"	43° 40' 6"	Rio Cacerebu
IA-262	22° 44' 40"	43° 14' 54"	Rio Iguacú
SP-305	22° 46' 38"	43° 23' 53"	Rio Sarapuí
SP-307	22° 45' 42"	43° 21' 44"	Rio Sarapuí
SP-309	22° 44' 26"	43° 15' 26"	Rio Sarapuí

Figure 6 River Sediment Quality Monitoring Locations (Additional)

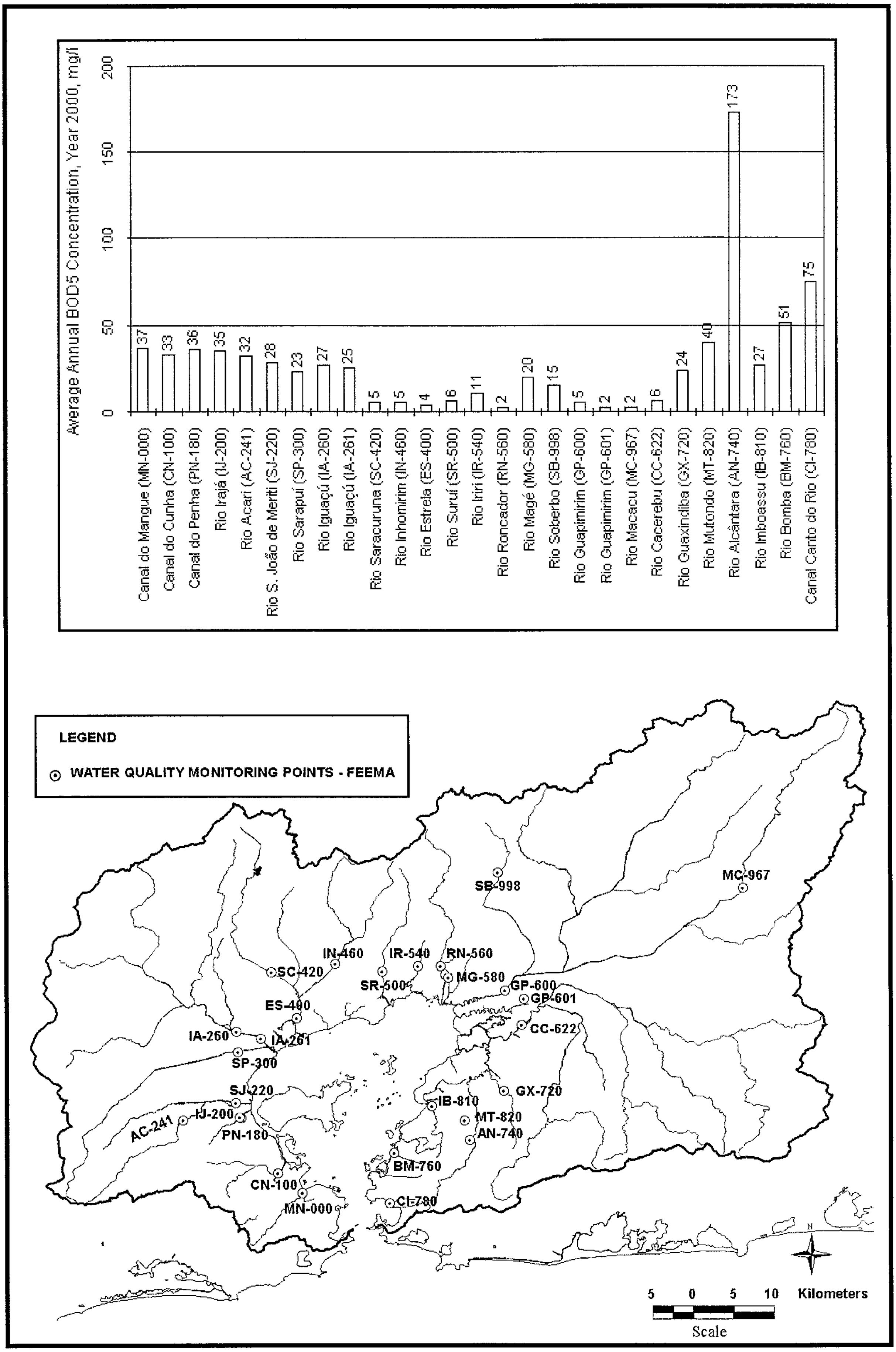
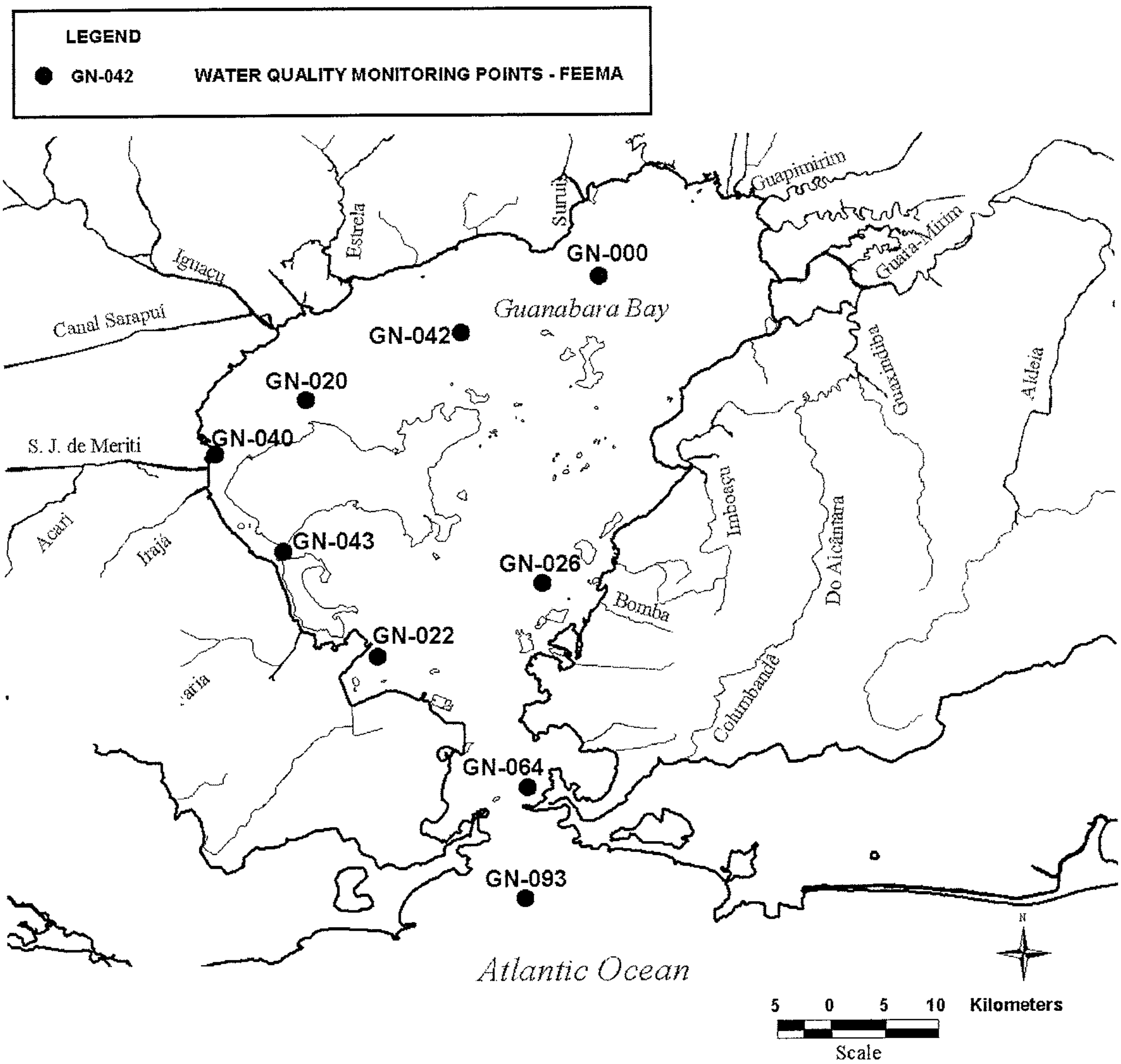


Figure 7 Average BOD_5 Concentration of Rivers, Year 2000



STATION	LATITUDE	LONGITUDE
GN-000	22° 43' 27"	43° 6' 15"
GN-020	22° 46' 30"	43° 13' 50"
GN-022	22° 52' 40"	43° 11' 57"
GN-026	22° 50' 52"	43° 7' 39"
GN-040	22° 47' 50"	43° 16' 10"
GN-042	22° 44' 50"	43° 9' 50"
GN-043	22° 50' 9"	43° 14' 24"
GN-064	22° 55' 48"	43° 8' 0"
GN-093	22° 58' 28"	43° 8' 2"

Figure 8 Locations of Bay Water Quality Monitoring

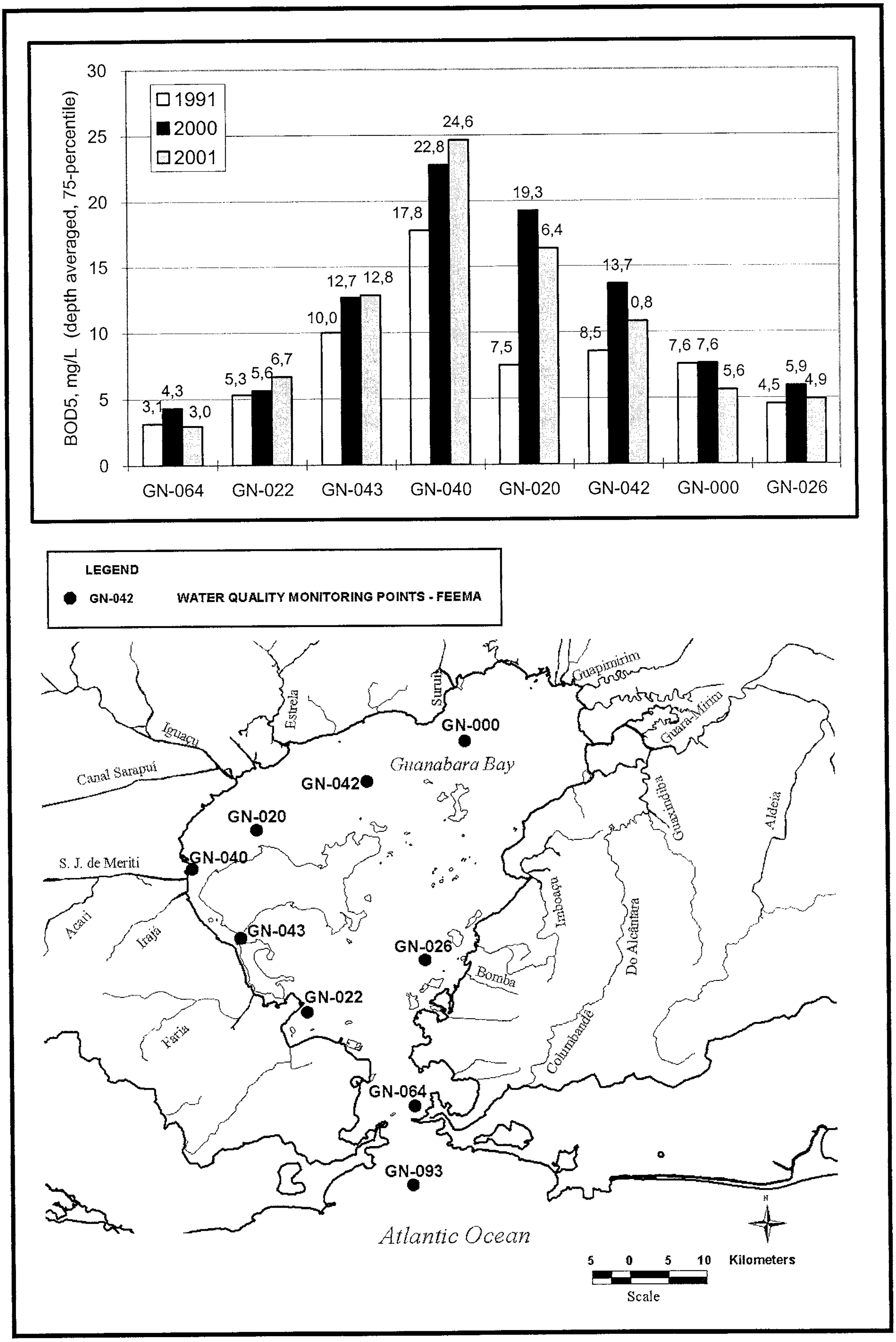


Figure 9 Variation of Water Quality of Bay

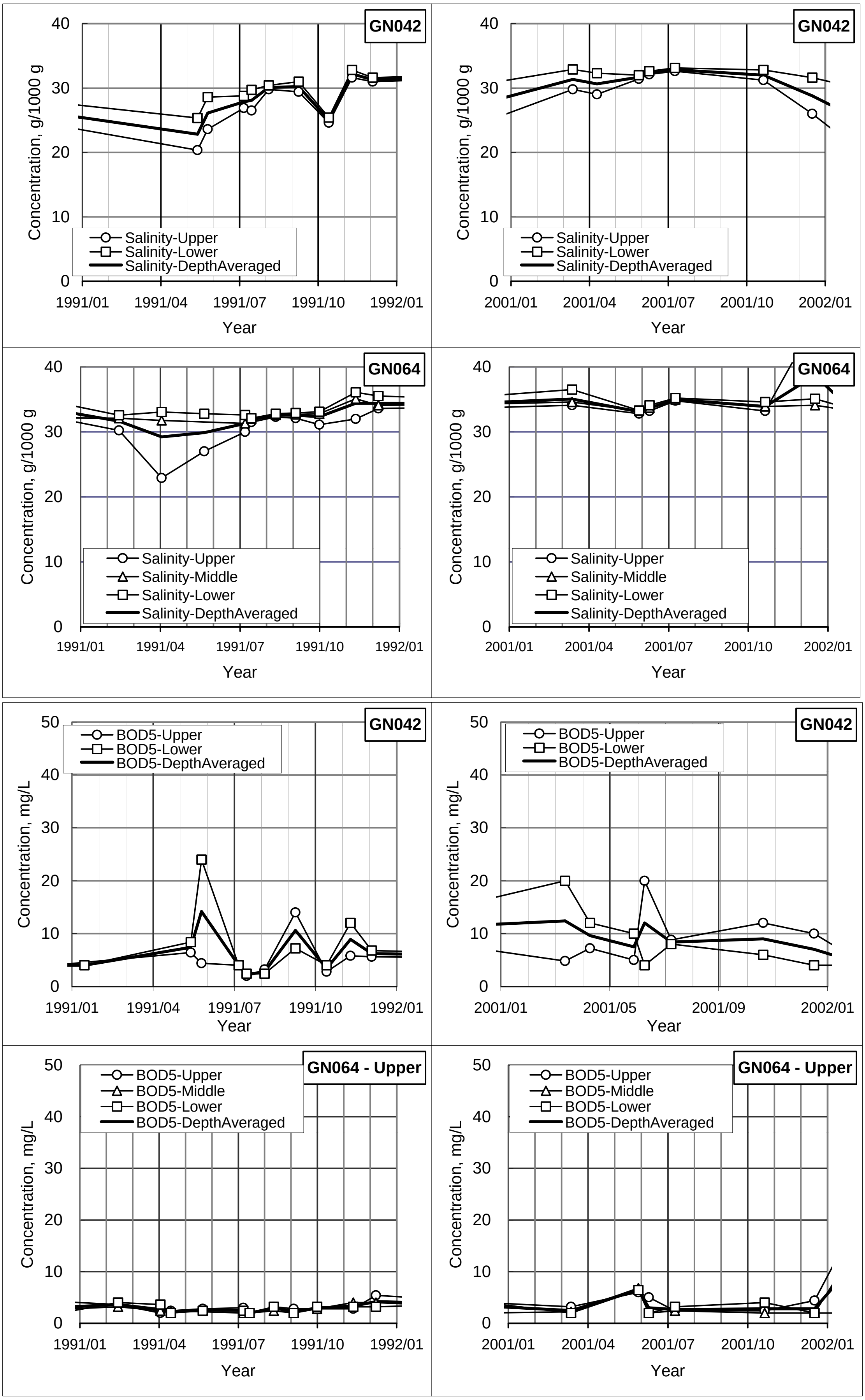


Figure 10 Variation of Water Quality at GN-064 and GN-042 Stations

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SOCIO-ECONOMIC CONDITIONS

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1. POPULATION

1.1 PRESENT POPULATION

Table 1 shows population, area and population density of 16 municipalities in Guanabara Bay basin in 2000. Total population of 16 municipalities was about 11 million, and occupied 75% of the Rio de Janeiro State (RJ State) in year 2000.

Table 1 Population, Area and Population Density of 16 Municipalities in 2000

	Population (persons)	Share in RJ State (%)	Share in Total (%)	Area (km^2)	Population density ($persons/km^2$)
Rio de Janeiro	*5,851,914*	*40.7*	*54.4*	*1,205.8*	*4,853.1*
Belford Roxo	433,120	3.0	4.0	79.0	5,482.5
Duque de Caxias	770,865	5.4	7.2	468.3	1,646.1
Guapimirim	37,940	0.3	0.4	361.9	104.8
Itaborai	187,127	1.3	1.7	429.2	436.0
Magé	205,699	1.4	1.9	386.8	531.8
Nilópolis	153,572	1.1	1.4	19.4	7,916.1
Niterói	*458,465*	*3.2*	*4.3*	*134.5*	*3,408.7*
Nova Iguaçu	*750,487*	*5.2*	*7.0*	*520.5*	*1,441.9*
Mesquita	*164,879*	*1.1*	*1.5*	*41.6*	*3,963.4*
São Gonçalo	889,828	6.2	8.3	248.7	3,577.9
São João de Meriti	449,229	3.1	4.2	34.7	12,946.1
Tanguá	26,001	0.2	0.2	142.8	182.1
Petrópolis	*286,348*	*2.0*	*2.7*	*797.1*	*359.2*
Cachoeiras de Macacu	*48,460*	*0.3*	*0.5*	*956.8*	50.6
Rio Bonito	*49,599*	*0.3*	*0.5*	*463.1*	107.1
Total of Municipalities	10,763,533	74.9	100.0	6,290.2	1,711.2
RJ State	14,367,083	100.0	-	43,864.3	327.5
Brazil	170,143,121	-	-	8,514,213.5	20.0

Note: In municipalities written in italic figure, parts of territory are included in the Study Area
Source: Informações Gerais Estado do Rio de Janeiro, CIDE
Brasil em números 2001, IBGE

Population of the Rio de Janeiro Municipality (RJ Municipality) was 5.9 million, and occupied 55% of the 16 municipalities. São Gonçalo (8%), Duque Caxias (7%), and Nova Iguaçu (7%) followed it. Some municipalities which are located on the west side of Guanabara Bay had high population density. Especially the three municipalities, São João de Meriti (12,946 $persons/km^2$), Nilópolis (7,916 $persons/km^2$) and Belford Roxo (5,482 $persons/km^2$), had higher population density than that of the Rio de Janeiro Municipality (4,853 $persons/km^2$).

Table 2 shows changes of the population growth rate in 16 municipalities. Population of the 16 municipalities is still growing, but average annual growth rates have been decreasing since 1970s. In 1940, total population of the 16 municipalities was 2.3 million. It increased three times in 30 years (1940-1970), but increased only 1.5 times in next 30 years (1970-2000). Such change is as same as the RJ State and Brazil.

The population growth in 16 municipalities is much greater than that of the RJ State. Average annual population growth rate in 16 municipalities was greater than that of RJ State until 1970s, but the growth rate in RJ State has been greater than that of 16 municipalities since 1980s.

Table 2 Average Annual Population Growth Rate in 16 Municipalities

	1950-60	1960-70	1970-80	1980-91	1991-2000
Rio de Janeiro	*3.36*	*2.54*	*1.82*	*0.67*	0.73
Belford Roxo	11.91	9.00	5.01	2.25	2.05
Duque de Caxias	10.17	5.88	2.93	1.36	1.61
Guapimirim	2.08	5.30	4.83	1.73	3.43
Itaborai	5.08	5.49	5.79	3.48	3.32
Magé	5.42	6.93	3.82	1.21	2.57
Nilópolis	7.60	2.86	1.70	0.38	-0.32
Niterói	*2.80*	*2.82*	*2.05*	*0.86*	0.56
Nova Iguaçu	*9.34*	*7.13*	*4.03*	*1.48*	1.96
Mesquita	*7.39*	*4.76*	*2.95*	*1.15*	1.67
São Gonçalo	6.89	5.67	3.64	2.18	1.48
São João de Meriti	9.63	4.66	2.81	0.60	0.60
Tanguá	-0.94	1.51	5.17	1.94	1.25
Petrópolis	*3.51*	*2.58*	*2.56*	*0.98*	1.28
Cachoeiras de Macacu	*5.22*	*2.25*	*0.60*	*1.04*	2.10
Rio Bonito	*0.97*	*2.20*	*1.52*	*1.10*	1.05
Total of 16 municipalities	4.31	3.43	2.38	1.00	1.07
RJ State	3.68	2.97	2.30	1.15	1.28
Brazil	3.06	2.87	2.48	1.93	1.65

Note: Municipalities in Italic Figures means parts of territories are included in the Study Area
Source: Informações Gerais Estado do Rio de Janeiro, CIDE
Brasil em números 2001, IBGE
Annual Statistic Yearbook 1999, IBGE

The RJ Municipality experienced an annual population growth of about 3% which was higher than a national population growth rate in 1940s and 50s. But average annual growth rate in recent 11 years (1990-2001) declined to 0.73%. Some municipalities located to the north of the RJ Municipality also experienced population growth more than 10% in 1940s and 50s. But the recent annual growth rate in such municipalities also dropped to 1 to 2%.

Guapimirim, Itaborai and Magé municipalities, in which population density is still low and face Guanabara Bay, are now having high population growth rates of 2.5 to 3%.

1.2 POPULATION UNTIL 2020

The Study Team forecasted future population in 16 municipalities. The population of each municipality was estimated by the workflow shown in the *Figure 1*.

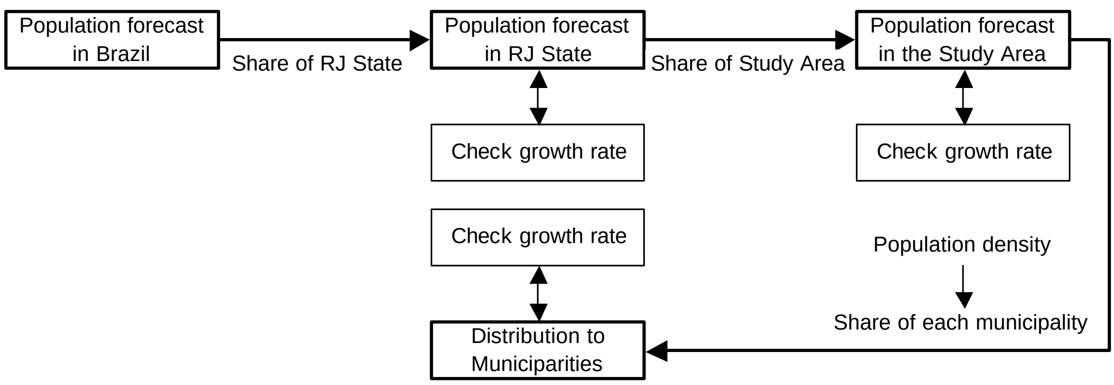

Figure 1 Workflow of Population Forecast in the Study Area

Source: JICA Study Team

IBGE (Instituto Brasileiro de Geografia e Estatística) has submitted a national population forecast of Brazil until 2020. The Study Team assigned the share of population in the RJ State to the national population, considering historical change since 1940s, and calculated the population of the RJ State. Next the Study Team checked population growth rates, which were derived from the population forecast. In case the calculated growth rate differed from the historical trend a lot, the Study Team reset the share of the RJ State again and recalculated.

Table 3 shows the population forecast, share and growth rates in RJ the State together with the population forecast in Brazil by IBGE.

The share of the RJ State has been declining consistently since 1970. Therefore the Study Team assumed that the share from 2005 to 2020 continued to decline from 8.30% to 8.00. In this assumption, population growth rate will decrease from 0.94% to 0.60%, which is consistent with historical changes.

Table 3 Population Forecast in Brazil and RJ State

	1991	2000	2005	2010	2015	2020
Brazil (persons)	146,825,475	170,143,121	181,341,499	192,040,996	201,517,470	209,705,328
Share (%)	8.72	8.44	**8.30**	**8.18**	**8.08**	**8.00**
Growth rate (%)	1.15	1.28	**0.94**	**0.86**	**0.72**	**0.60**
RJ State (persons)	12,807,706	14,367,083	**15,058,809**	**15,716,858**	**16,290,907**	**16,785,058**

Note: Bold figures means forecast by the JICA Study Team
Source: Brasil em números 2001 (Brazil in figures 2001), by IBGE.
JICA Study Team

Population forecast of 16 municipalities was calculated from the population forecast of the RJ State in the same way. The *Table 4.2* shows rates of changes in share of population in 16 municipalities. In Rio de Janeiro, the share in 1991 was 56.06% and that in 2000 was 54.37%. The Study Team assumed that the share would continue decreasing and set the figures shown in the *Table 4.* Rate of change of population share in the last 20 years was -3.5%, and that in next 20 years will be - 3.74%.

Table 4 Share of Population in 16 Municipalities

	Population Share of Each Municipality (%)						Population Desnity (Persns/km^2)	Rate of population share change	
	1991	2000	**2005**	**2010**	**2015**	**2020**		1980-2000	2000-2020
Rio de Janeiro	56.06	54.37	**53.25**	**52.25**	**51.47**	**50.80**	4,853.1	-3.74	-3.57
Belford Roxo	3.69	4.02	**4.22**	**4.40**	**4.50**	**4.58**	5,482.5	0.80	0.56
Duque de Caxias	6.83	7.16	**7.39**	**7.64**	**7.89**	**8.14**	1,646.1	0.59	0.98
Guapimirim	0.29	0.35	**0.38**	**0.42**	**0.45**	**0.47**	104.8	0.09	0.12
Itaborai	1.43	1.74	**1.94**	**2.09**	**2.19**	**2.27**	436.0	0.65	0.53
Magé	1.67	1.91	**2.09**	**2.26**	**2.36**	**2.44**	531.8	0.27	0.53
Nilópolis	1.62	1.43	**1.38**	**1.35**	**1.32**	**1.30**	7,916.1	-0.30	-0.13
Niterói	4.46	4.26	**4.18**	**4.14**	**4.12**	**4.11**	3,408.7	-0.27	-0.15
Nova Iguaçu	6.45	6.97	**7.25**	**7.42**	**7.54**	**7.61**	1,441.9	0.85	0.64
Mesquita	1.45	1.53	**1.55**	**1.57**	**1.59**	**1.61**	3,963.4	0.10	0.08
São Gonçalo	7.98	8.27	**8.52**	**8.74**	**8.94**	**9.13**	3,577.9	1.24	0.86
São João de Meriti	4.35	4.17	**4.04**	**3.91**	**3.80**	**3.71**	12,946.1	-0.38	-0.46
Tanguá	0.24	0.24	**0.24**	**0.24**	**0.25**	**0.25**	182.1	0.03	0.01
Petrópolis	2.61	2.66	**2.64**	**2.62**	**2.60**	**2.58**	359.2	0.04	-0.08
Cachoeiras de Macacu	0.41	0.45	**0.45**	**0.47**	**0.49**	**0.51**	50.6	0.04	0.06
Rio Bonito	0.46	0.46	**0.47**	**0.47**	**0.48**	**0.48**	107.1	0.00	0.02

Source: JICA Study Team

When the Study Team set share of each municipality, population density in 2000 Census is also considered. Even if a municipality has a high population growth ratio, the Study Team set shares so that the municipality, which has a high population density, will not keep such high population growth ratio. In Belford Roxo, the Study Team assumed that the share would continue increasing, but the change in 20 years would be limited. Because population density is higher level, 5,482.5 persons/km^2 there.

The Study Team also assumed that the share in São Gonçalo would increase with higher change than that in Belford Roxo, because the population density isn't so high there.

The *Table 5* shows the population forecast until 2020 in each municipality. Population in 16 municipalities will reach at 12 million in 2020. Net increase will account for 1.5 million persons, and average annual growth rate will be 0.67% in 20 years.

In Rio de Janeiro, population will be 6.2 million in 2020. Average annual growth ratio in 20 years will decrease from 0.70% to 0.33%. The growth ratio will decrease in most municipalities excluding Magé. In São João de Meriti, the growth ratio will be only 0.08% because population density has already reached an extremely high level, 12,946.1 persons/km^2 in 2000.

Table 5 Population Forecast of Municipalities

	1991	2000	**2005**	**2010**	**2015**	**2020**	AAGR* 1980-2000	**AAGR* 2000-2020**
Rio de Janairo	5,480,768	5,851,914	**5,951,178**	**6,057,637**	**6,159,998**	**6,247,174**	0.70	**0.33**
Belford Roxo	360,714	433,120	**472,084**	**510,595**	**539,061**	**563,739**	2.16	**1.33**
Duque de Caxias	667,821	770,865	**826,136**	**885,994**	**944,541**	**1,001,288**	1.47	**1.32**
Guapimirim	28,001	37,940	**42,748**	**48,983**	**54,156**	**58,107**	2.49	**2.15**
Itaborai	139,493	187,127	**216,657**	**242,144**	**261,936**	**278,985**	3.41	**2.02**
Magé	163,733	205,699	**233,706**	**262,149**	**282,588**	**300,205**	1.82	**1.91**
Nilópolis	158,092	153,572	**153,874**	**156,146**	**157,600**	**159,479**	0.07	**0.19**
Niterói	436,155	458,465	**467,108**	**479,926**	**493,038**	**505,381**	0.72	**0.49**
Nova Iguaçu	630,384	750,487	**810,564**	**860,565**	**902,732**	**936,191**	1.69	**1.11**
Mesquita	142,058	164,879	**173,438**	**182,238**	**190,520**	**198,224**	1.38	**0.93**
São Gonçalo	779,832	889,828	**951,897**	**1,012,976**	**1,069,642**	**1,122,453**	1.86	**1.17**
São João de Meriti	425,772	449,229	**451,929**	**453,746**	**455,240**	**456,704**	0.60	**0.08**
Tanguá	23,249	26,001	**26,998**	**28,007**	**30,109**	**30,938**	1.63	**0.87**
Petrópolis	255468	286,348	**295,095**	**303,804**	**311,226**	**317,334**	1.11	**0.52**
Cachoeiras de Macacu	40,208	48,460	**50,319**	**54,518**	**58,673**	**62,748**	1.52	**1.30**
Rio Bonito	45,161	49,599	**52,619**	**54,585**	**57,546**	**59,130**	1.08	**0.88**
Total in the Study Area	9,776,909	10,763,533	**11,176,349**	**11,594,014**	**11,968,605**	**12,298,079**	1.04	**0.67**

(Unit: persons)

Note: * Average Annual Growth Ratio (%)
Bold figures shows the forecast by the JICA Study Team.
Source: JICA Study Team

1.3 BASIN POPULATION

Some municipalities protrude from the Bay basin and some municipalities expand over the two or more river basins. Population 2000 by basin were calculated by counting the population in census sectors of Census 2000.

The census sector is the smallest unit of the census survey. Each municipality is divided into about 50 to 8000 sectors mainly depending on population density as shown in *Table 6.* In case one sector expands over different river basins, population of the sector is distributed to the basins proportionally to covering area sizes.

Table 6 Numbers of Census Sectors in Census 2000

Name of Municipality	No. of Census Sectors
Belford Roxo	619
Cachoeiras do Macacu	79
Duque de Caxias	1,065
Guapimirim	53
Itaboraí	248
Magé	254
Nilópolis	208
Niterói	705
Nova Iguaçu	1,108
Petrópolis	386
Rio Bonito	74
Rio de Janeiro	8,145
São Gonçalo	1,220
São João de Meriti	577
Tanguá	40
TOTAL	**14,781**

Note: MESQUITA is not included because it was created in 2001
Source: IBGE Census 2000

Populations in 2010 and 2020 are estimated by applying to each sector the population growth rate (refer *to Table 5*) of the municipality to which the sector belongs. Population by the river basin in 2000, 2010 and 2020 are shown in the *Supporting 5.*

2. ECONOMIC ACTIVITIES

2.1 PRESENT ECONOMIC CONDITIONS

Table 7 shows Nominal Gross Regional Domestic Products (GRDP) of the RJ State and the 16 municipalities. GRDP of the 16 municipalities totaled R$109 billion, and accounted for 75.7% of the RJ State and 10.0% of Brazil. Among the 16 municipalities, the largest GRDPwas generated in the RJ Municipality (76%), followed by Duque de Caxias (6.1%), Niterói (4.1%), São Gonçalo (3.4%) and Nova Iguaçu (2.9%). The shares of the other municipalities were quite low.

Table 8 shows performance of Real GRDP of the RJ State and Brazil from 1994 to 2000. Average annual growth rate of the RJ State is 4.1%, 1.5% higher than that of Brazil. Annual growth rate of the RJ State since 1994 is higher than that of Brazil, except in 1996 and 1997.

Table 7 GRDP and GRDP per Capita in 2000

	GRDP (R$1,000)	Share in RJ State (%)	Share in 16 municipal-ities (%)	GRDP per Capita (R$)
Rio de Janairo	*82,647,268*	*58.8*	*75.7*	*14,123*
Belford Roxo	1,436,188	1.0	1.3	3,316
Duque de Caxias	6,672,459	4.7	6.1	8,656
Guapimirim	154,814	0.1	0.1	4,080
Itaborai	701,609	0.5	0.6	3,749
Magé	633,267	0.5	0.6	3,079
Nilópolis	661,760	0.5	0.6	4,309
Niterói	*4,511,258*	*3.2*	*4.1*	*9,840*
Nova Iguaçu	*3,171,338*	*2.3*	*2.9*	*4,226*
Mesquita	*343,717*	*0.2*	*0.3*	*2,085*
São Gonçalo	3,696,020	2.6	3.4	4,154
São João de Meriti	1,831,941	1.3	1.7	4,078
Tanguá	109,940	0.1	0.1	4,228
Petrópolis	*2,172,852*	*1.5*	*2.0*	*7,588*
Cachoeiras de Macacu	*173,222*	*0.1*	*0.2*	*3,575*
Rio Bonito	*234,459*	*0.2*	*0.2*	*4,727*
Total of 16 municipalities	109,152,112	77.7	100.0	10,141
RJ State	140,496,766	100.0	-	9,779
Brazil	1,086,700,000	-	-	6,387

Note: Municipalities in Italic Figures means parts of territories are included in the Study Area
Source: Informações Gerais Estado do Rio de Janeiro, CIDE
International Financial Statistics (IFS), International Monetary Fund (IMF)

Table 8 Real GRDP of RJ State and Real GDP of Brazil

	Unit	1994	1995	1996	1997	1998	1999	2000
Real GRDP index of RJ State	1995=100	95.17	100.00	107.17	109.00	112.03	115.61	121.05
Annual growth rate	%	5.08	7.17	1.71	2.78	3.20	4.71	5.08
Average annual growth rate	%	-	-	-	-	-	-	4.09
Real GDP index of Brazil	1995=100	95.90	100.00	102.70	106.00	106.30	107.10	111.90
Annual growth rate	%	-	4.28	2.70	3.21	0.28	0.75	4.48
Average annual growth rate	%	-	-	-	-	-	-	2.61

Source: Anuário Estatísco do Estado do Rio de Janeiro 2001, CIDE, FIS, IMF

In 1998 and 1999, Brazil economy experienced recession. It came from a financial shock due to the Asian Financial Crisis, and the economy experienced nearly 0% growth,. The RJ State economy, however, didn't experience such economic recession, and kept high GRDP growth rate at that time. Such strong economic performance comes from booming in petroleum industry[1]. *Table 9* shows production index of the mining (representing the petroleum industry), manufacturing and sales index in the RJ State. While the production index of the mining and manufacturing increased by 31% in 10 years, most of the increase came from an increase of mining production (126%). The RJ State and some municipalities received benefit, royalty revenue from petroleum. In 2001 Royalty of the RJ State and some municipalities amounted to R$1,812 million, and of which R$1,078 million is revenue for the State Government.

On the other hand, manufacturing production decreased 9% at the same time. And more, sales index (retail trade in the metropolitan area) dropped 30% in 1990s. Only petroleum industry led the RJ economy in 1990s.

[1] According to the Report, "BOLETIM ECONÔMICO DA SEF", prepared by Secretaria de Estado de Fazenda, production of petroleum and LGN in RJ State occupies 79% of production in Brazil.

Table 9 Indexes of Mining, Manufacturing and Retail Trade

	Unit	1998	1999	01/2000	02/2000	03/2000
Production index						
Mining and Manufacturing	Average of 1991 = 100	118.65	125.83	121.97	130.57	131.14
Mining	Average of 1991 = 100	177.14	207.80	223.94	233.65	226.55
Manufacturing	Average of 1991 = 100	94.60	92.12	80.04	88.17	91.89
Sales index						
Retail trade in metropolitan area (16 municipalities)	01/1995=100	77.295	74.85	68.92	68.84	70.57

Source: A Economia Fluminense (CD-ROM), CIDE

2.2 PRESENT FINANCIAL CONDITIONS OF THE RIO DE JANEIRO STATE

(1) Financial Responsibility Law

The Financial Responsibility Law enacted in April 2000, sets budgetary planning, execution and reporting of the Governments in Brazil. The law is applied to all levels of government, and it regulates the following matters relating to the state and municipality governments:

- The Federal Government shall withhold federal transfers to the states and municipalities that do not effectively collect their own taxes.
- Permanent spending mandates shall be created with corresponding increase in permanent revenues or cuts in other permanent spending items.
- Annual credit disbursements cannot exceed capital spending.
- Personnel spending by the state and municipal governments are limited 60% of net revenue, and the law sets separate ceilings on the personnel spending of the executive, legislative and judicial branches. If state and municipal governments cannot stay within the limit, they cannot receive transfers from the Central Government and credit guarantees from the federal government.
- Each government have to prepare and disclose balance sheet (in every two months) and fiscal report (in every four months).

State and municipal governments have to conduct budget operations under the supervision of the Federal Government.

(2) Public Finance of the State Government of Rio de Janeiro

Table 10 shows revenue and expenditure of the RJ State from 1998 to 2001. The State Government had been reducing budget deficit until 2000, and the deficit recorded R$-605 million. However it increased to -1,264 million, and the proportion of budget deficit to GRDP recorded - 0.7% in 2001.

Tax revenue accounted 60% of the total revenue in four years (from 1998 to 2001). ICMS (value added taxes on sales and services) was the most important component in taxes, and accounted 90% of the total tax revenue. Capital revenue, which almost consists of borrowings from banks, and financing by State Treasure Bond, has decreased a lot from 20% to 2 - 3%. Financing by State Treasure Bonds stopped in 1999 by the agreement between the State Government and the Federal Government, under the Financial Responsibility Law.

Table 10 Public Finance of RJ State

	1998	1999	2000	2001
Revenue (R$ 1000)	11,460,726	11,979,901	15,950,011	16,694,253
Of which				
Tax	59.6	64.4	55.3	60.6
ICMS	54.7	60.0	50.7	55.3
Transfer	15.5	11.0	20.1	9.8
Capital Revenue	22.6	21.5	1.9	3.0
State Treasure Bonds	14.5	17.9	0.0	0.0
Expenditure (R$ 1000)	13,820,065	13,052,217	16,555,766	17,958,649
Of which				
Current Expenditure	75.7	76.0	88.6	87.5
Transfer	41.8	36.9	47.2	47.5
Charges due to Debt	3.7	2.7	5.0	6.6
Capital Expenditure	24.3	24.0	11.4	12.5
Investment	10.6	5.1	9.3	10.0
By State Government Secretariat				
State Secretariat of Sanitation and Water Resources	0.0	1.4	0.7	7.0

Source: Anuário Estatísco do Estado do Rio de Janeiro 2001, CIDE (Unit: percent)

In the expenditure, the share of current expenditure has increased from 76% to 88% in four years. Transfer to municipal government accounted for 40 - 50% of total expenditure, and investment 5 to 10% of total expenditure, respectively.

In the distribution of government secretariats, share of SEMADUR (State Secretariat of Environment and Urban Development) has increased rapidly from 1% to 7.0% in 2002. It seems to disburse for sewerage development in PDBG.

(3) Fiscal Sustainability

1) Federal Government

Table 11 shows the changes of figures on financial sustainability; Real GDP growth rate, Dollar-Real exchange rate, percentage of public sector[2] primary balance to GDP, net public debt ratio, and gross external public debt ratio. The percentage of Net Public Debt in GDP has been increasing consistently, from 34.4% in 1996 to 58.9% in 2002.

One of reasons of such rapid increase comes from depreciation of Brazilian Real against US Dollar. The value of Real has dropped less than one-half in five years, from US$1=R$1.005 in 1996 to US$1=R$2.358 in 2001. Shown in the *Table 11*, percentage of Gross External Public Debt ratio has increased from 10.6% in 1997 to 17.7% in 2001 in accordance with the depreciation of Real.

Table 11 Changes of Figures on Financial Sustainability

	1996	1997	1998	1999	2000	2001	2002
Real GDP growth rate	2.7	3.3	0.1	0.8	4.4	1.4	1.5
Dollar-real exchange rate	1.005	1.708	1.161	1.815	1.357	2.358	2.930
Primary Balance of Public Sector	0.4	-1.0	0.0	2.2	3.5	3.7	3.9
Net Public Debt ratio	34.4	35.2	43.4	49.4	49.3	53.3	58.9
Gross External Public Debt ratio	-	10.6	12.4	17.1	15.9	17.7	24.7

Source: Press Releases on the Article IV consultation, IMF (Unit: %)
Banco Central do Brasil

2 Primary Balance is a budget balance of which interest payment in expenditure, and public debt in revenue is excluded.

Primary balance records surplus in recent years, and fiscal deficit is not a cause of the increase of Net Public Debt. Primary Balance which is a basis for policy discussion between the Federal Government and the IMF had been increasing gradually, and it exceeded targets decided by the agreement between two organizations.

The Central Bank of Brazil publishes a report, named "Are there Reasons to doubt Fiscal Sustainability in Brazil?" in June 2002. According to this report, another main reason of debt increase is accumulation of hidden liabilities in the state companies and state banks, etc. The report estimates that Net Public Debt-GDP ratio was 56.0% in 2002. However if exchange rate were constant, it would be 42.5 percent, and if there were no hidden liabilities, it would be 43.2 percent, according to the report.

Table 12 shows figures on Public Debt in the same development-level countries as Brazil. The table shows that level of Net Public Debt-GDP ratio in Brazil is not so high as other countries, and annual public finance is well managed. Net Public Debt-GDP ratio in Brazil is almost same level as Malaysia, and Net Public External Debt is also almost same level as Mexico until 2001[3]. But GDP growth rate is different. Brazil economy is weak, and the econimy did not experience GDP growth more than 5 percent in recent years. This is the reason why Public Debt is one of the major economic issues in Brazil.

Table 12 Public Debt in the Upper-Middle Income Countries* in 2000

	GDP growth rate	Net Public Debt-GDP ratio	Net Public External Debt-GDP ratio
Argentina	1.3	49.4	-
Malaysia	8.3	61.4	-
Mexico	6.6	-	15.9

Source: Press Releases on Article IV consultation, IMF (Unit: percent)
Note: * Classified by the World Bank

In order to solve the Public Debt difficulties, it is necessary to carry out three policies. The first one is to keep surplus of primary balance. The Federal Government submitted the Budget Guideline Law to the Congress. The law aim to increase the medium term primary surplus to 4.25% of GDP from 3.9% in 2003[4]. The current administration also submitted laws about pension and tax reform to the Congress. If the laws were approved, it would contribute to reducing fiscal imbalances and remove inefficiencies that hinder growth.

The second one is to unveil hidden liabilities. Public sector has already conducted some policies such as;

- Debt agreements among the Federal, State and Municipal Governments since 1997,
- Fiscal Stabilization Program since 1998,
- Fiscal Responsibility Law in 2000

The third one is to stabilize macro economic environment in order to avoid depreciation of Real. Especially it is needed to maintain low inflation rate, to reduce trade deficit[5], and to avoid depression .

[3] Though US Dollar-Brazil Real rate recorded 3.9 in September 2002, Brazil Real was appreciated after that and arrived at 2.8 per 1 US Dollar in July 2003. Therefore Net Public Debt ratio would decrease around 20% in 2003

[4] The Federal Government has been achieving the primary surplus target with the IMF since 1996, the beginning of the Real Plan. The Federal Government has already achieved the primary surplus target in the first half of 2003 until May, arrived at R$37 billion at that time.

[5] In the first half of 2003, Brazil economy recorded US$10.4 billion of trade surplus. Export amount increased 131.3% from the same term last year.

2) Rio de Janeiro State

Table 13 shows percentage of Public Debt-GDP ratio of the Rio de Janeiro State. It had increased 9.7 point rapidly, from 7.9% in 1995 to 17.6% in 1998, and started to decrease a little after 1999. Financing from state financial institutions, such as Banco do Brasil and Central Bank of Brazil, are major financing source, and the borrowing amount-GDP ratio increased 13.0 point, from 2.3% in 1995 to 15.3% in 2000.

Treasury bond was a major financing source before 1997. However Rio de Janeiro State and the Federal Government made an agreement that re-organizes Public Debt of the State. Consequently treasury bond of the state is substituted with borrowing from the state bank, almost Banco do Brasil. That is why percentage of treasury bond changed from 7.7% to 0% suddenly, and internal borrowing increased rapidly from 9.3% to 15.3% in 1999.

Table 13 Public Debt-GDP Ratio of Rio de Janeiro State

	1995	1996	1997	1998	1999	2000
Total	7.9	7.9	12.1	17.6	16.3	16.1
Internal debt	7.9	7.8	11.9	17.1	15.5	15.3
Treasury bond	5.5	5.6	6.5	7.7	0.0	0.0
Borrowing	2.3	2.2	5.4	9.3	15.5	15.3
External debt	0.0	0.1	0.2	0.5	0.8	0.8
Treasury bond	0.0	0.0	0.0	0.0	0.0	0.0
Borrowing	0.0	0.1	0.2	0.5	0.8	0.8

Source: Secretaria de Estado da Fezenda (Unit: percent)

External debt is very limited . It consists of treasury bond (R$3.5 million in 2001), borrowing from international financial institutions such as IDB, World Bank and JBIC.

Table 14 shows the fiscal plan from 2002 to 2017, prepared by the Secretaria de Estado da Fezenda (Former State Secretariat of Finance). According to the plan, borrowing from public domestic and international financial institutions will finish in 2004. And the State Government disburse R$800-1,300 million for interest payment, and R$500-600 million for capital refund every year. The plan has budget surplus will be generated every year. In 2002 it will be R$118 million (0.8% of revenue), and increase to R$1,022 million (4.9%of revenue) in 2017. Increase of investment expenditure is limited in the plan, therefore percentage of investment payment in expenditure will decrease from 11% in 2002 to 9% in 2017. The State Government have to conduct public investment in limited financial resource.

The State Government prepares such fiscal plan, and discuss with the Federal Government regularly. If the State Government couldn't achieve target in the plan, the Federal Government would institute a sanction, such as prevention or reduction of fiscal transfer.

Table 14 Fiscal Plan from 2002 to 2017

	2002	2007	2012	2017
Revenue	14,960	16,729	18,654	20,963
Tax	10,592	12,640	14,848	17,034
Transfer	1,629	1,728	2,090	2,618
Borrowing	746	0	0	0
Expenditure	14,843	16,381	18,052	19,941
Personnel payment	5,573	6,305	7,134	8,071
Interest payment	1,323	1,099	976	874
Capital repayment	532	617	534	471
Investment	1,633	1,695	1,760	1,827
Balance	118	347	601	1,022

Source: Secretaria de Estado de Fezenda (Unit: R$ million)

2.3 GRDP UNTIL 2020

Economy in the RJ State experienced higher development than the national average. The average annual growth rate of the RJ State was 4.09% from 1994 to 2000. But an economic projection by Secretaria de Estad de Fazenda (SEF) is not optimistic.

SEF is preparing a projection of public finance until 2017. In the projection, the average annual growth rate of GRDP is forecasted based on the following assumptions:

- Average annual growth rate until 2010 is 2.5 percent, and
- It will decrease to 1.5 percent from 2011 to 2017.

As described in the Section 2.1, high and stable economic development of the RJ economy came from a rapid production increase in the petroleum industry. The economic projection until 2010 is almost the same level as the national average annual growth rate from 1994 to 2000. It means that the rapid increase of the petroleum industry will stop in coming 10 years, and the economy of the RJ State will perform as same as the national average.

The *Table 15* and the *Figure 2* show the projection of GRDP in the RJ State until 2020. "Trend growth" in the Table and Figure means that the economic development path at an average growth rate of 4.09%. In this case the volume of GRDP in 2020 will be R$363 billion, 2.2 times of GRDP in 2000. But in case of SEF's projection, the volume of GRDP will be limited to R$242 billion, only 1.5 times of the level in 2000.

The Study Team judges that the adoption of the SEF's projection in estimating future economic conditions of the Study Area is more realistic, because SEF has set a projection on the public finance under this projection, and public investment plans will follow such projection. The Study Team will set up the GRDP projection finally after further discussions with Counterpart Team.

Table 15 Projection of GRDP in RJ State

	2000	2005	2010	2015	2017	2020
Projection of GRDP by SEF	162,600	**183,967**	**208,142**	**224,228**	**231,006**	**241,558**
Trend growth (AAGR: 4.09%)	162,600	**198,702**	**242,819**	**296,731**	**321,510**	**362,612**

Note: Projection of GRDP is calculated by the Study Team based on the assumption of SEF.

Source: Secretaria de Estado de Fazenda

Anúario Estatísco do Estado do Rio de Janeiro 2001. CIDE

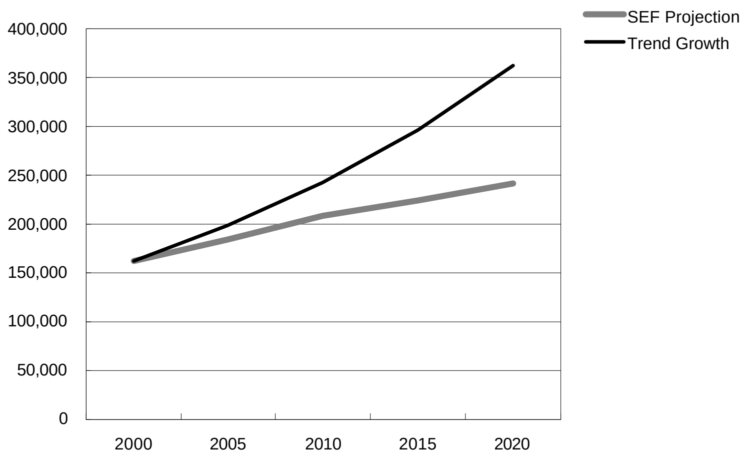

Figure 2 Projection of GRDP

Source: JICA Study Team

2.4 PUBLIC FINANCE UNTIL 2020

Described in the 2.3, SEF prepares the projection of the public finance until 2017. In the projection, it adopted the following assumptions to estimate public revenues and expenditures:

- ICMS: Increase by 1% per a year
- IPVA: Increase by 5% per a year
- Royalties of the oil production: Oil price would be US$25 per barrel
- Public expenditure: Personnel expenses would increase by 2.5% per a year, and other expenses would increase by 2% per a year

In the projection, SEF projected that share of the public expenditure in GRDP will increase twice, from 6.6% in 2000 to 12.2% in 2017. And SEF expects that a budget surplus, which is around 5% of GRDP would continue until 2017. *Table 16* shows projection of GRDP and public finance in the RJ state.

Table 16 Projection of GRDP and Public Finance in the RJ State

	2000	2005	2010	2015	2017	2020
Projection of GRDP	162,600	**183,967**	**208,142**	**224,228**	**231,006**	**241,558**
Projection of Revenue	11,473	16,007	17,921	19,868	20,962	-
Projection of Expenditure	10,668	15,860	17,367	19,136	19,940	-

Note: Projection of GRDP is calculated by the Study Team based on the assumption of SEF.
Source: Secretaria de Estado de Fazenda
Anúario Estatísco do Estado do Rio de Janeiro 2001, CIDE