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

MAIN REPORT

October 2003

PACIFIC CONSULTANTS INTERNATIONAL
in association with
NIHON SUIDO CONSULTANTS

Foreign Currency Exchange Rates Applied in the Study

Currency	Exchange Rate/USD
Brazilian Reals (R$)	2.9
Japanese Yen (JPY)	120.0

(Rate as of July 2002)

PREFACE

In response to a request from the Government of the Federative Republic of Brazil, the Government of Japan decided to conduct the Study on Management and Improvement of the Environmental Conditions of Guanabara Bay in Rio de Janeiro, the Federative Republic of Brazil and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team by a joint venture of Pacific Consultants International (PCI) and Nihon Suido Consultants (NSC), headed by Mr. Akira Takechi, to Brazil during May 2002 to August 2003. In addition, JICA set up an Advisory Committee chaired by Mr. Yoji Okayasu, Water Quality Team, Water Environment Research Group, Public Works Research Institute, between March 2002 and August 2003, which examined the study from specialist and technical point of view.

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

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

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

October, 2003

Kazuhisa Matsuoka
Vice-President
Japan International Cooperation Agency

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

October, 2003

Mr. Kazuhisa Matsuoka
Vice - President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "The Study on Management and Improvement of the Environmental Conditions of Guanabara Bay in Rio de Janeiro, the Federative Republic of Brazil". This report has been prepared by the Study Team in accordance with the contracts signed on 13 March 2002, 24 April 2002, and 19 May 2003 (amended on 17 September 2003) between the Japan International Cooperation Agency and the Joint Study Team of Pacific Consultants International and Nihon Suido Consultants.

The report consists of the Summary, Main Report and Supporting Report. The Summary summarizes the results of all studies. The Main Report contains the existing conditions, reviews of existing master plans, the results of the feasibility study, and conclusions and recommendations. The Supporting Report includes technical details of contents of the Main Report.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Land, Infrastructure and Transport, Embassy of Japan in the Republic of Brazil, and also to Brazilian officials and individuals for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study contribute to the environmental improvement of Guanabara Bay, and that friendly relations of both countries be promoted further by this occasion.

Yours faithfully,

Akira Takechi
Team Leader of the Study Team

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ABBREVIATIONS

1. ORGANIZATIONS

ABC	Agência Brasileira de Cooperação (Brazilian Cooperation Agency)
ABNT	Associasão Brasileira de Normas Técnicas (Brazilian Association of Technical Standards)
AFB	Agência Financeira da Bacia (Basin Financial Agency)
BC	Banco Central (Central Bank of Brazil)
BID	Banco Interamericano de Desenvolvimento (Inter-American Development Bank - IDB)
BIRD	Banco Internacional de Reconstrução e Desenvolvimento (International Bank for Reconstruction and Development - IBRD)
BNDES	Banco Nacional de Desenvolvimento Econômico e Social (National Bank for Economic and Social Development)
CECA	Comissão Estadual de Controle Ambiental (State Commission for Environmental Control)
CEDAE	Companhia Estadual de Aguas e Esgoto (State Company of Water and Sewages)
CEF	Caixa Econômica Federal (Federal Savings Bank)
CEHAB	Companhia Estadual de Habitação (State Company of Housing)
CET-Rio	Companhia de Engenharia de Trafego do Rio de Janeiro (Traffic Engineering Corporation of Rio de Janeiro)
CIDE	Centro de Informações e Dados do Rio de Janeiro (Rio de Janeiro Data and Information Center)
CODIN	Companhia Distristos Industriais (Industrial District Companies) (Industrial Districts Company)
CODEC	Comissão Coordenadora para Execução do Programa de Despoluiçãoda Baía de Guanabara (Coordinating Commission for Pollution Control of Guanabara Bay Program)
COFIEX	Comissão de Financiamentos Externos (External Financial Commission)
COMLURB	Companhia Municipal de Limpeza Urbana (Municipal Company of Urban Cleaning)
CONTROL	Secretaria de Estado de Planejamento, Controle e Gestão (State Secretariat of Planning, Control and Management)
CPI	Consumer Price Incex
CMN	Conselho Monetário Nacional (National Monetary Council)
CONAMA	Conselho Nacional de Meio Ambiente (National Environmental Council)

DCON	Divisão de Controle de Industriais (da FEEMA) (Division of Industry Control)
DER	Departamento de Estradas de Rodagem (Department of Roads and Highways)
DHN	Diretoria de Hidrografia e Navegao (da Marinha do Brasil) (Hydrographic and Navigation Board (Brazilian Navy))
DILAB	Divisão de Laboratórios (da FEEMA) (FEEMA's Laboratory Division)
DRM-RJ	Departamento de Recursos Mineirais (Department of Mineral Resources)
DSGME	Diretoria de Serviço Geográfico do Ministerio do Exército (Geographical Services Board, Army Ministry)
EMBASA	Empresa Baiana de Águas e Saneamento SA
EMOP	Empresa de Obras Público do Estado do Rio de Janeiro (Rio de Janeiro State Company of Public Buildings)
FECAM	Fundo Especial para o Controle Ambiental (Special Fund for Environmental Control)
FECP	Fundo Estadual de Combate à Pobreza e às Desigualdades Sociais State Fund for Combat to Poverty and Social Inequality
FEEMA	Fundação Estadual para Engenharia do Meio Ambiente (State Foundation for Environmental Engineering)
GEDEG	Grupo Executivo de Despoluição da Baía de Guanabara (Executive Group for Pollution Control of Guanabara Bay)
GERSOL	Grupo Executivo de Resíduos Sólidos (Executive Group for Solid Residues)
GOB	Government of Brazil
GOJ	Government of Japan
IBRD	International Bank for Reconstruction and Development
IBAMA	Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis (Brazilian Institute of Environment, Natural and Renewable Resources)
IBGE	Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistic)
IDB	Inter-American Development Bank (Banco Interamericano de Desenvolvimento - BID)
IEF	Fundação Estadual de Florestas (State Foundation of Forests)
IMF	International Monetary Fund
IPE INPE	Instituto de Pesquisas Espaciais (Institute of Space Research) (Space Research Institute)
INMET	Instituto Nacional de Meteorologia (Meteorologic National Institute)
INMETRO	Instituto Nacional de Metrologia, Normalização e Qualidade Industrial (National Institute of Metrology, Standardization and Industrial Quality)
INPH	Instituto de Pesquisas Hidroviárias (Institute of Hydro-routes Research) (Hydro-routes Research Institute)
IPEA	Fundação Instituto de Pesquisa Econômica Aplicada (Institute of Applied Economics Research)

IPEM	Instituto de Pesos e Medidas (Institute of Weights and Measures)
IPLANRIO	Instituto de Planejamento Municipal (Institute of Municipal Planning) (Municipal Planning Institute)
IPP	Instituto Municipal de Urbanismo Pereira Passos (Pereira Passos Municipal Institute of Urbanism)
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JSWA	Japan Sewage Works Association
MMA	Ministério do Meio Ambiente (Ministry of the Environment)
MPO	Ministério do Planejamento, Orçamento e Gestão (Ministry of Planning, Budget and Management)
MRE	Ministério das Relações Exteriores (Ministry of Foreign Affairs)
NGO	Non-Governmental Organization
OECF	Overseas Economic Cooperation Fund
OIM	Organização Internacional Marítima (International Maritime Organization)
ONG	Organização Não Governamental (Non-Governmental Organization)
SABESP	Companhia de Saeamento Básico do Estado de São Paulo
SEDUR	Secretaria de Estado do Desenvolvimento Urbano (State Secretariat of Urban Development)
SEF	Secretaria de Estado de Fazenda (State Secretariat of Finance)
SEF	Secretaria de Estado de Finanças (State Secretariat of Finance)
SEMADUR	Secretaria de Estado de Meio Ambiente e Desenvolvimento Urbano (State Secretariat of Environment and Urban Development)
SEMAN	Secretaria de Meio Ambiente (State Secretariat of Environment)
SEMAMPE	Secretaria Estadual de Meio Ambiente e Projetos Especiais (State Secretariat of Environment and Special Projects)
SEPDET	Secretaria de Estado de Planejamento, Desenvolvimento Econômico e Turismo (State Secretariat of Planning, Economical Development and Tourism)
SEPURB	Secretaria de Política Urbana - Ministério do Planejamento, Orçamento e Gestão (Secretariat of Urban Policy - Ministry of Planning, Budget and Management)
SERLA	Fundação Superintendência Estadual de Rios e Lagoas (State Authority for Rivers and Lagoons)
SESRH	Secretaria de Saniamento e Recursos Hídricos (State Secretariat of Sanitation and Water Resources)
SINS	Sisitema Nacional de Informações sobre Saneamento (National Information System on Sanitation)

SMH	Secretaria Municipal de Habitação da Cidade do Rio de Janeiro (Municipal Secretariat of Housing of Rio de Janeiro City)
SSPU	Subsecretaria Superintendência de Planejamento (Undersecretariat of Urban Planning)
UERJ	Universidade Estadual do Rio de Janeiro (State University of Rio de Janeiro)
UFRJ	Universidade Federal do Rio de Janeiro (Federal University of Rio de Janeiro)
WB	World Bank

2. TERMINOALOGY

AD	Advection Dispersion Model
As	Arsenic
APM	Área de Proteção de Mananciais (Water Catchment Protection Area)
BOD (5)	Biochemical Oxygen Demand, (5-day, 20ºC)
C	Carbon
Cd	Cadmium
CDL	Chart Datum Level
Chl-a	Chlorophyll-a
CIF	Cost, Insurance and Freight
Cl^-	Chlorine Ion
CN^-	Cyanide Ion
COD	Chemical Oxygen Demand
Coliform	Coliform Group Bacteria
Cr (6+)	Chromium Sexavalent
Cu	Copper
DBOD	Dissolved Biochemical Oxygen Demand
DC	Detritus Carbon
D/D	Detailed Design
DHWL	Design High Water Level
DO	Dissolved Oxygen
DLWL	Design Low Water Level
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EL	Elevation
EU	Eutrophication Model
FC	Foreign Currency
F. coli	Fecal Coliform Bacteria
FIRR	Financial Internal Rate of Return
F/M	Food-to-Microorganisms Ratio
F/S	Feasibility Study
GIS	Geographic Information System
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product

HD	Hydrodynamic Model
H_2S	Hydrogen Sulfide
Hg	Mercury
HHW	Highest High Water
HW	High Water
IL	Ignition Loss
ICMS	Imposto sobre Circulação de Mercadorias (Value Added Taxes on Sales and Services)
INPC	Índice Nacional de Preços ao Consumidor (National Consumer Price Index)
K	Mineralization Constant, 1/day
L_{BOD}	Specific BOD load, kg/km^2/day
L_{TN}	Specific TN load, kg/km^2/day
L_{TP}	Specific TP load, kg/km^2/day
L_{PO4}	Specific PO_4-P load, kg/km^2/day
L_{DIN}	Specific DIN load, kg/km^2/day
L_{TOTAL}	Total pollution before self purification, ton/day
L_{MON}	Monitored load to Bay, ton/day
$L_{WWTP-DIS}$	Load from WWTP, ton/day
$L_{POP. WITHOUT SEWER}$	Load from population without sewer, ton/day
L_I	Load from large industries, ton/day
L_M	Load from small scale treatment units, ton/day
L_{AREAL}	Natural background load, ton/day
L_{RIVER}	Load to river, ton/day
LC	Local Currency
LLW	Lowest Low Water
LW	Low Water
MBAS	Methylene Blue Active Substance
MHWN	Mean High Water Neaps
MHWS	Mean High Water Spring
MIKE 21	Model System from DHI Water and Environment
MLSS	Mixed Liquor Suspended Solids
MLWN	Mean Low water Neaps
MLWS	Mean Low Water
MPN	Most Probable Number
MSL	Mean Sea Level
MW	Minimum Wage
N	Nitrogen
NAM	Precipitation Run-off Model
NH_4- N	Ammonia Nitrogen
NH_2-N	Nitrite Nitrogen
NO_3-N	Nitrate Nitrogen
NPV	Net Present Value
NTU	Nephelometric Turbidity Units
OM or O/M	Operation and Maintenance
P	Phosphorus
PAR	Photosynthetic Active Radiation

Pb	Lead
PC	Phytoplankton Carbon
PCB	Polychlorinated Biphenyls
PDBG	Progama de Despoluição da Baía de Guanabara (Guanabara Bay Pollution Abatement Program)
pH	The Reciprocal of the Logarithm of the Hydrogen-ion Concentration (potential of hydrogen ion)
PIS	Programa de Integração Social (Employees' Profit Participatio Program)
PLANASA	Plano Nacional de Saneamento (National Plan of Sanitation)
PMSS	Plano de Modernização do Setor de Saneamento(do Ministério do Planejamento) (Modernization Plan for the Sanitation Sector [of the Ministry of Planning)
PNB	Programa Nova Baixada (Nova Baixada Program)
PO_4^-P	Phosphate Phosphorus
PPA	Programa Plurianual (4-year Plan)
PROSANEAR	Programa de Saneamento para a População de Baixa Renda (Sanitation Program for the Low Income Population)
PVC	Polyvinyl Chloride
Q_S	Specific Discharge, $l/km^2/sec$
SRT	Solids Retention Time
SS	Suspended Solids
SS (IL)	Ignition Loss of Suspended Solids
SUS	Sistema Único de Saúde (Unified Health System)
TDP	Total Dissolved Phosphorus
TDH	Total Dynamic Head
THg	Total Mercury
TIN	Total Inorganic Nitrogen
TIP	Total Inorganic Phosphorus
TN	Total Nitrogen
TNK	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TON	Total Organic Nitrogen
TOP	Total Organic Phosphorus
TP	Total Phosphorous
TR (IL)	Ignition Loss of Total Residue
TS	Total Solids
Turb.	Turbidity
VTS	Volatile Total Solids
TSS	Total Suspended Solids
UV	Ultra Violet
VSS	Volatile Suspended Solids
VTS	Volatile Total Solids

WTP	Willingness to Pay
WWTP	Wastewater Treatment Plant
WQ	Water Quality Model
Zn	Zinc

3. UNITS

cm	centimeter
cm^2	square centimeter
g	gram
g/m^3	gram per cubic meter
ha	hectare
km^2	Square kilometer
kg	kilogram
kg/d	kilogram per day
km	kilometer
kW	kilowatt
L	liter
L/d	liter per day
Lpcd	liter per capita per day
L/s	liter per second
$L/km^2/sec$	liter per square kilometer per second
m^2	square meter
m^3	cubic meter
m^3/d	cubic meter per day
m^3/h	cubic meter per hour
m^3/m	cubic meter per minute
m^3/s	cubic meter per second
mm^2	square millimeter
$m^3/m^2/d$	cubic meter per square meter per day
m	meter
mg	milligram
mg/L	milligram per liter
ml	milliliter
mm	millimeter
m/s	meter per second
s	second
t	ton (1,000 kg)
W	watt
R$	Brazilian Currency, Real
¥	Japanese Currency, Yen
US$	United States Currency, Dollar
%	Percent

Currency exchange rate adopted is the two digits half currency adjust of monthly average exchange rate in July, 2002, when actual cost estimates work started.

R$2.9 = US$1 =120 Yen

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 GENERAL

In response to the request of the Government of the Federative Republic of Brazil (GOB) in 2000, the Government of Japan (GOJ) agreed to conduct the Study on Management and Improvement of the Environmental Conditions of Guanabara Bay in Rio de Janeiro, the Federative Republic of Brazil (Study). Accordingly, the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programs of GOJ, was assigned to undertake the Study in close cooperation with the authorities of GOB.

JICA dispatched a preparatory study team to the Federative Republic of Brazil for the preliminary survey as well as discussion of the Scope of Work for the Study. The Scope of Work and the Minutes of Meeting were agreed upon between the State Secretariat of Sanitation and Water Resources, the State of Rio de Janeiro (SESRH) and JICA on November 7, 2001. JICA appointed a joint venture, Pacific Consultants International in association with Nihon Suido Consultants, to conduct the Study and formed the Study Team in March 2002.

The Study Team presented the outlines of the program, methodology and time schedule of the Study as the Inception Report in May 2002. Contents of the Inception Report were agreed upon between the Study Team and SESRH and the study work in Brazil commenced in May 2002.

1.2 BACKGROUND OF THE STUDY

Guanabara Bay in Rio de Janeiro has highly regarded beautiful scenery and is at the base of a national symbol of Brazil (statue of Christ the Redeemer), which elevates the city's value as an international tourist destination. However, in the 1990's, the untreated sewage discharge and illegal solid waste dumping was causing the degradation of water quality in Guanabara Bay.

In order to improve the environment of Guanabara Bay, JICA undertook the "Study on Recuperation of the Guanabara Bay Ecosystem" and formulated the Master Plan (JICA Master Plan) in 1994 responding to the request of GOB. This study recommended improving the water quality of Guanabara Bay with a comprehensive plan of sewerage development, industrial wastewater control, dredging and mangrove reforestation for the target year of 2010.

In parallel with this study and also in 1994, the State Company of Water and Sewage (CEDAE) conducted the "Sewerage Master Plan in Rio de Janeiro Metropolitan Region" (CEDAE Sewerage Master Plan) to cover the 90% of the Rio de Janeiro Metropolitan Area with 32 treatment districts and to treat the collected sewage to secondary level. CEDAE has implemented Guanabara Bay Pollution Abatement Program (PDBG) led by the Inter-American Development Bank (IDB) with co-financing of Japan Bank for International Cooperation (now JBIC, then OECF) at the planning stage of the Sewerage Master Plan. PDBG includes not only the construction of sewerage facilities but also improvement of water supply, solid waste management, stormwater drainage system, strengthening organizational structures and environmental education.

Since PDBG is entering to its final phase, CEDAE is now planning to implement the extension of the sewerage systems as PDBG Phase II and GOB has requested GOJ to conduct the

Feasibility Study for PDBG Phase II projects. After discussion between JICA and SESRH/CEDAE, it was agreed that the study would review JICA Master Plan and CEDAE Sewerage Master Plan to appraise effects of the past and current projects to the bay environment improvement, and to conduct the feasibility study for the projects, of which priority is identified as a result of the review.

1.3 OBJECTIVES OF THE STUDY

The objectives of the Study are:

- To review the Master Plan that was formulated through the "Study on Recuperation of the Guanabara Bay Ecosystem"
- To review the portion related to Guanabara Bay Basin of the "Sewerage Master Plan in Rio de Janeiro Metropolitan Region"
- To conduct a feasibility study (F/S) on priority project(s) selected in the study on sewerage system in Guanabara Bay Basin
- To pursue technology transfer to the counterpart personnel in the course of the Study.

1.4 STUDY AREA

The Study area covers the Guanabara Bay basin which is shown in *Figure 1.1*. The whole basin is located within the Rio de Janeiro State boundary and covers 16 municipalities.

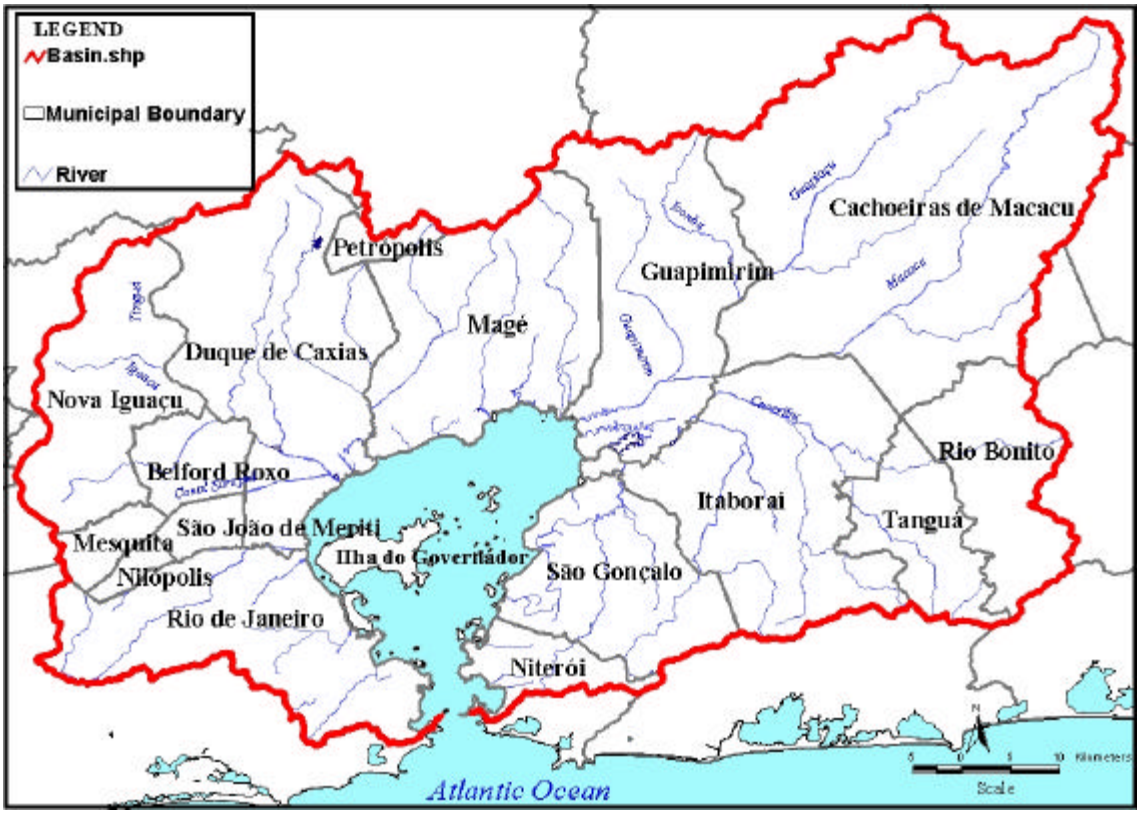


Figure 1.1 Study Area

1.5 STUDY SCHEDULE

The Study was carried out as shown in *Figure 1.2*. The Study is to be completed within 18.5 months between the middle of March 2002 and the end of September 2003, in five work stages. The Study consists of two phases from a viewpoint of outcomes of the study: Phase I: Review on Master Plans and Phase II: Feasibility Study.

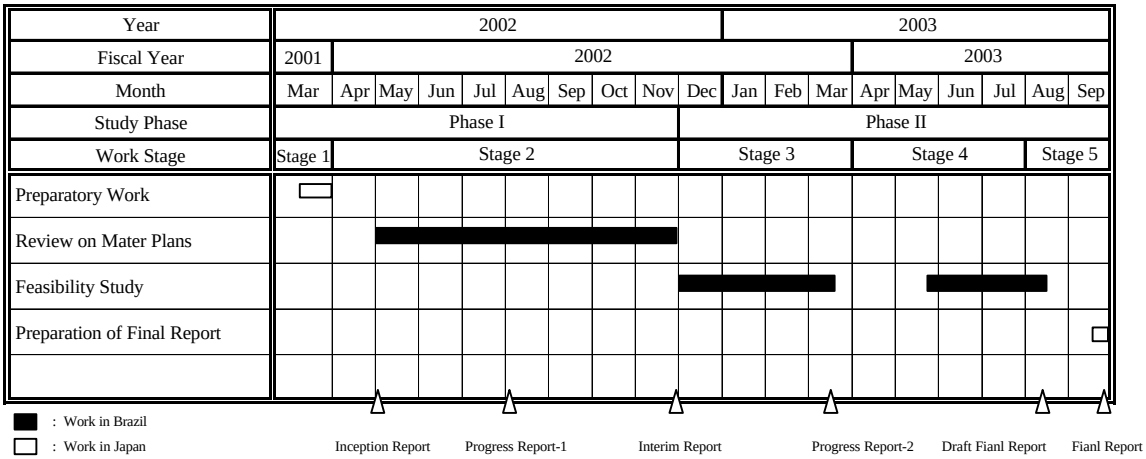


Figure 1.2 Time Schedule of the Study

1.6 STUDY ORGANIZATION

The Study was conducted under the following organizational scheme in *Figure 1.3*.

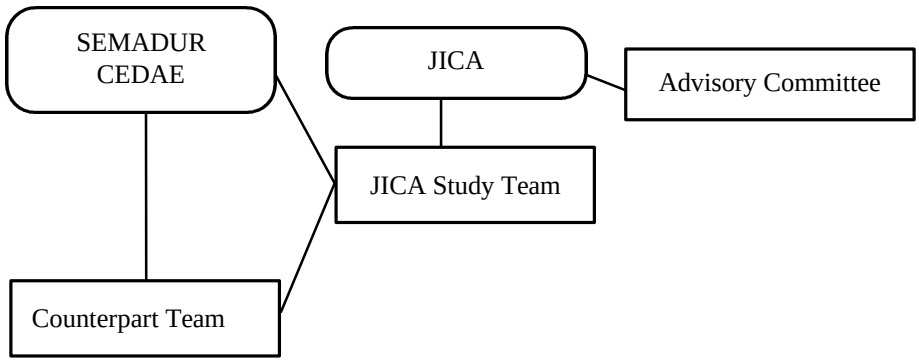


Figure 1.3 Study Organization

JICA organized the Study Team and the Advisory Committee. Their members are shown in *Table 1.1*.

Table 1.1 JICA Study Team and the Advisory Committee Member

JICA STUDY TEAM

Assignments	Name
Team Leader/Water quality restoration	Akira TAKECHI
Pollution analysis A	Erik Kock Rasmussen
Pollution analysis B	Thomas Uhrenholdt
Pollution analysis C	Sivapragasam Kugaprasatham
Hydrological analysis	Sabbir Hassan
Wastewater Planning	Shohei SATA
Sub-Team Leader/Wastewater treatment design	Masakazu NAKAO
Sewer design	Seiichi HANAFUSA
Organization and Institution	Jose Henrique Penido Monteiro
Database	Ryo MATSUMARU
Economic and financial analysis	Yoji SAKAKIBARA
Environment Impact	Tetsuji KAWAMURA
Social consideration	Ione Marisa KOSEKI CORNEJO
Interpreter A	Keiko FUJISAWA
Interpreter B	Cesar MATONO
Social consideration B/Study Coordination	Chiho OCHIAI

JICA ADVISORY COMMITTEE

Assignments	Name
Chairman of the committee	Yuji OKAYASU
Committee member	Masami MIZUGUCHI

SEMADUR acted as an implementing agency and CEDAE as a main counterpart agency. SEMADUR set up a counterpart team at the beginning of the Study and actual study works were carried out by Counterpart Team and Study Team members working together.

Note: At the beginning of the Study, the implementing agency was State Secretariat of Sanitation and Water Resources, the State of Rio de Janeiro (SESRH) and SESRH was reorganized to State Secretariat of Environment and Urban Development (SEMADUR) at the time of a change of the state government administration in January 2003.

Counterpart members consist of personnel from CEDAE, State Foundation for Environmental Engineering (FEEMA: Fundação Estadual para Engenharia do Meio Ambiente), State Authority for Rivers and Lagoons (SELAR: Superintendência Estadual de Rios e Lagoas) and Secretariat of Planning, Economical Development and Tourism (SEPDET: Secretaria de Estado de Planejamento, Desenvolvimento Econômico e Turismo). Counterpart members were reshuffled at the time of the state governmental change. Members of both old and new Counterpart Team are shown in *Table 1.2*.

Table 1.2 Members of Counterpart Team

From January 2003

Assignment	Name	Organization
Chief Counterpart	Rafael Carvalho Oliveira Santos	PDBG, CEDAE
Water Quality Restoration	Fátima de Freitas Lopes Soares	DEP (Water Quality Division), FEEMA
Pollutant Analysis	Elisabeth Lima	DEP (Water Quality Division), FEEMA
Hydrology	André Pinhel	SERLA
Wastewater Planning	Marcos Antonio Coimbra do Nascimento	DRO (West Regional Directory), CEDAE
Wastewater Design	Sérgio Pinheiro de Almeida	PDBG, CEDAE
Sewer Design	Marcos Vinícios M. Fagundes	DRO (East Regional Directory), CEDAE
Database	Vera Lucia de Souza Pinheiro	PDBG, CEDAE
Environmental Impact	Isabel Hirsch de Alcântara	DECON (Non Industrial Activities Division), FEEMA
Social Consideration/ Environmental Education	Dionê Maria Saldanha Marinho	PAC SSA-PA/SEMADUR
Solid Waste	José Maria de Mesquita Jr.	SSA-PA/SEMADUR
Representative of SEMADUR	Alexandre Augusto Furlanetto	Under Secretary of Environment Assistant, SEMADUR
SEMADUR	Alberto José Mendes Gomes	Under Secretary of Environment SEMADUR
Representative of CEDAE	Breno Marinho Junqueira	PDGBG, CEDAE

Former Counterpart Team

Until December 2002

Assignment	Name	Organization
Chief Counterpart	Luis Edmundo Cascão Silva	PDBG, CEDAE
Water Quality Restoration	Celso Bredariol	DEP (Water Quality Division), FEEMA
Pollutant Analysis	Elisabeth Lima	DEP (Water Quality Division), FEEMA
Hydrology	Mônica Miranda Falcão	SERLA
Wastewater Planning	Ciro Lacerda Correia Fillho	DRO (West Regional Directory), CEDAE
Wastewater Design	Rafael Santos	PDBG, CEDAE
Sewer Design	Marcos Vinícios M. Fagundes	DRO (East Regional Directory), CEDAE
Database	Vera Pinheiro	PDBG, CEDAE
Environmental Impact	José M. Mesquita Jr.	DECON (Non Industrial Activities Division), FEEMA
Economic/Financial Analysis and Social Consideration	José Stelberto Porto Soares	SEPDET
Study Administration	Gladstone de Castro	SESRH

1.7 CONTENTS OF THE REPORT

This report was prepared as a draft final report, presenting whole results of the Study. Draft Final Report consists of the following reports:

- Summary
- Main Report
- Supporting Report

All reports are prepared in English except Summary. Summary has Portuguese and Japanese versions, as well as English version.

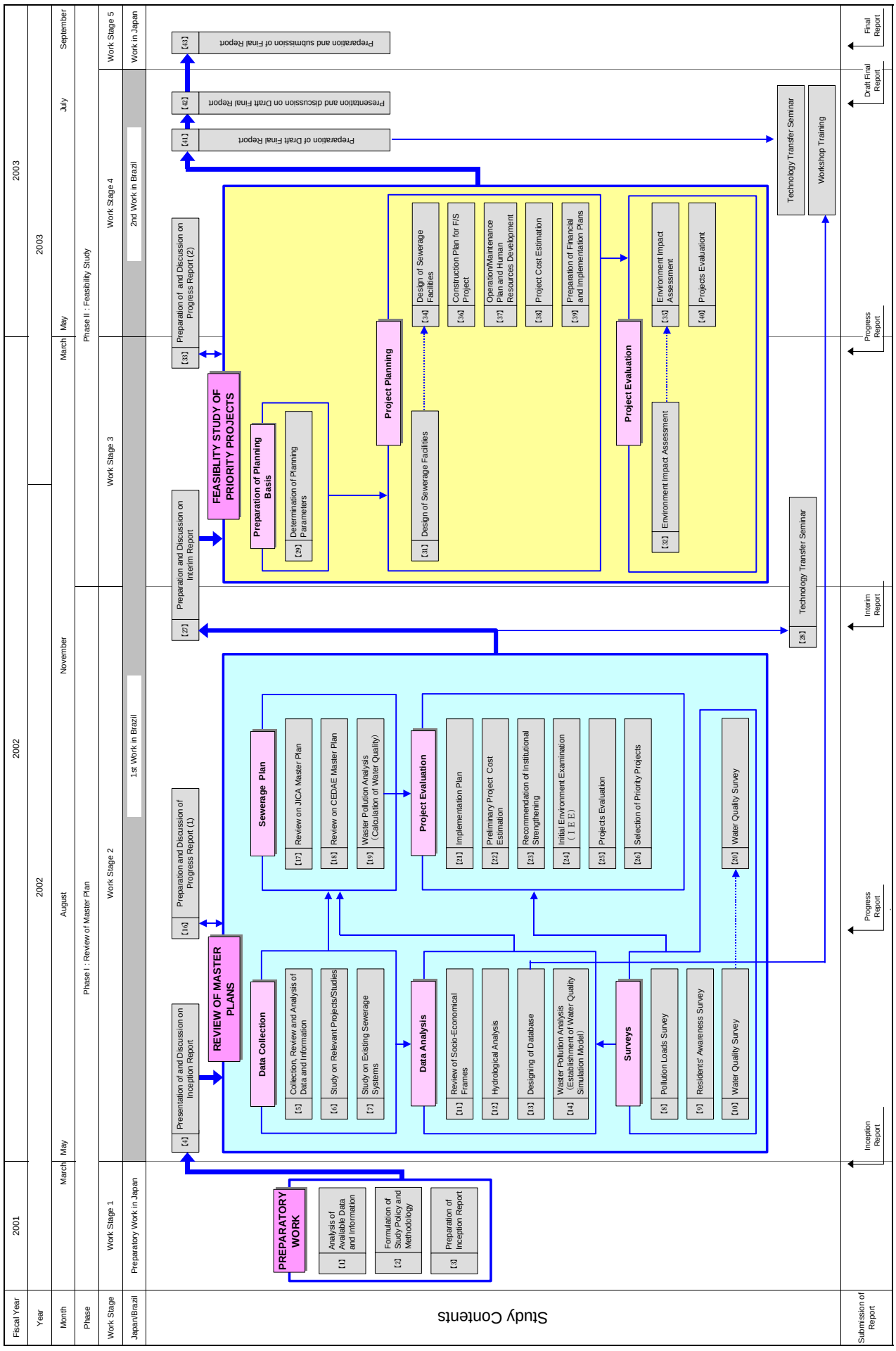


Figure 1.4 Detailed Study Flow

CHAPTER 2

EXISTING CONDITIONS

CHAPTER 2 EXISTING CONDITIONS

2.1 NATURAL CONDITIONS

2.1.1 TOPOGRAPHY AND GEOLOGY

Topographic map of the Guanabara Bay basin is shown in *Figure 2.1*. 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.

Geological map of the Guanabara Bay basin is shown in *Figure 2.2*. The Precambrian basement rock, 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.

2.1.2 RIVER AND BAY SYSTEM

(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 2.1*. 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.

(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.

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.

2.1.3 CLIMATE

General meteorological conditions of the Study Area are shown in *Figure 2.3.* 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.

General meteorological conditions at Rio de Janeiro station are also shown in *Figure 2.3.* 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%.

2.1.4 WATER QUALITY OF RIVER

(1) Monitoring System

Figure 2.4 shows water quality monitoring locations by FEEMA. Presently there are 27 monitoring stations. One station's grab sample is taken every two months for analysis for each river. FEEMA also has another nine stations shown in *Figure 2.4* for sediment quality monitoring where heavy metal pollution is suspected.

(2) Water Quality of Rivers

Figure 2.5 shows the annual average BOD_5 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 Niteroi up to 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.

2.1.5 WATER QUALITY OF BAY

(1) Monitoring System

Bay water quality monitoring system of FEEMA consists of nine monitoring stations shown in *Figure 2.6.* 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.

(2) Water Quality

Figure 2.6 shows the depth averaged BOD_5 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_5 concentration in spite of high pollutants discharge, probably because tidal exchange is dominant in these areas and thus sea waters there remain less polluted. At all the stations, water qualities exceed the water quality standards in terms of BOD_5 except at GN-026 were BOD_5 is just below 5 mg/L for Class 6 water body.

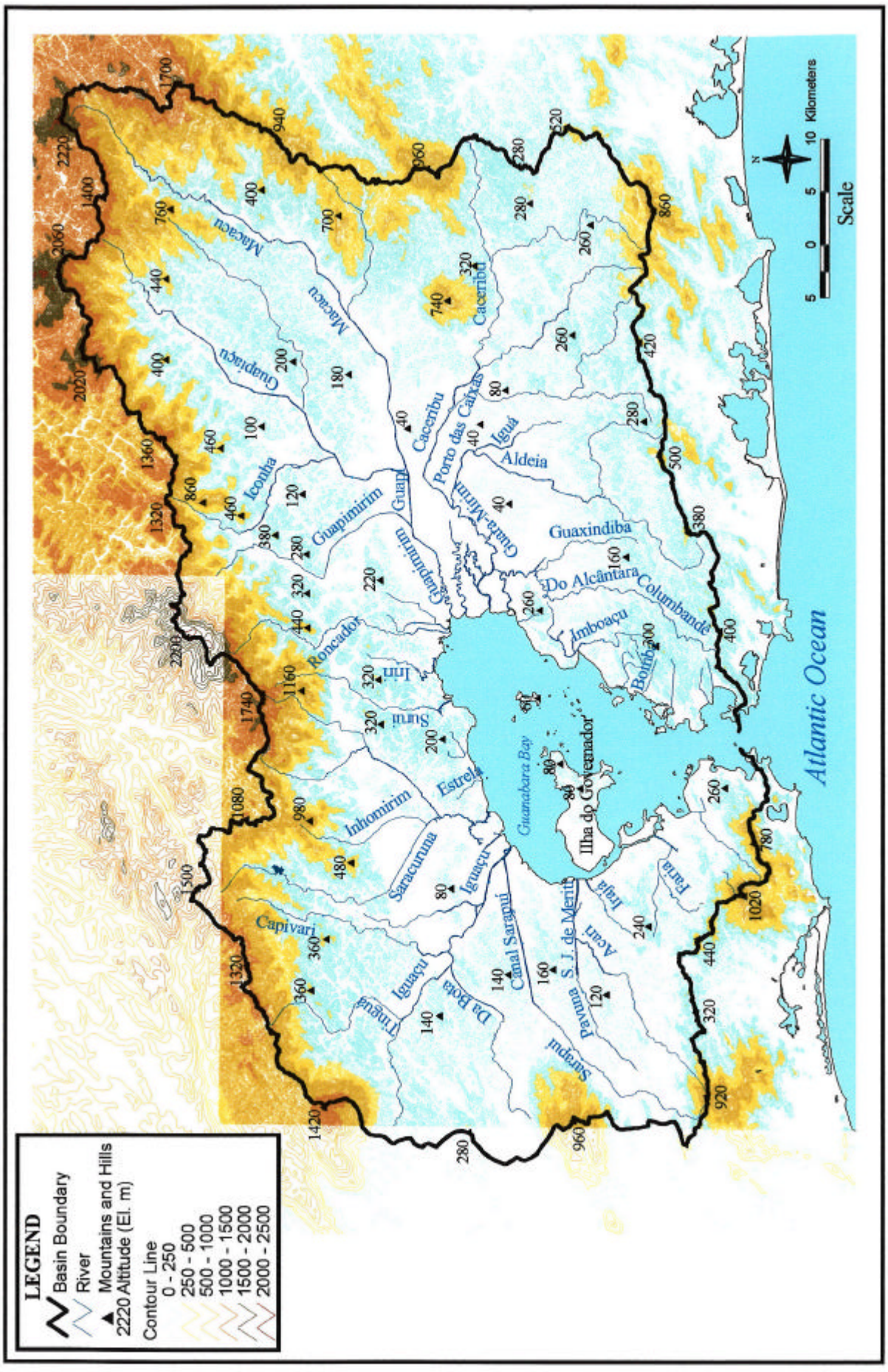


Figure 2.1 Topography

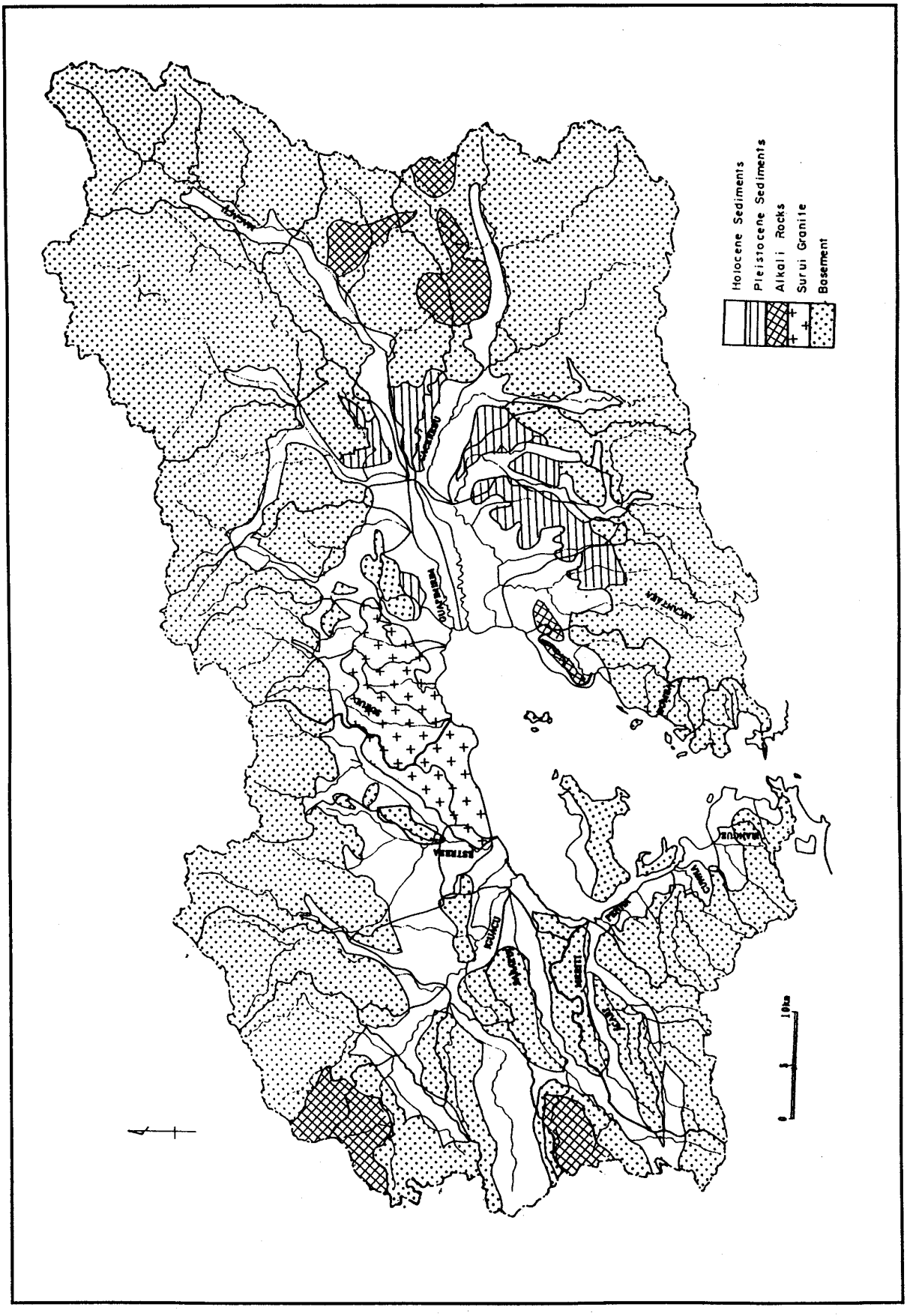
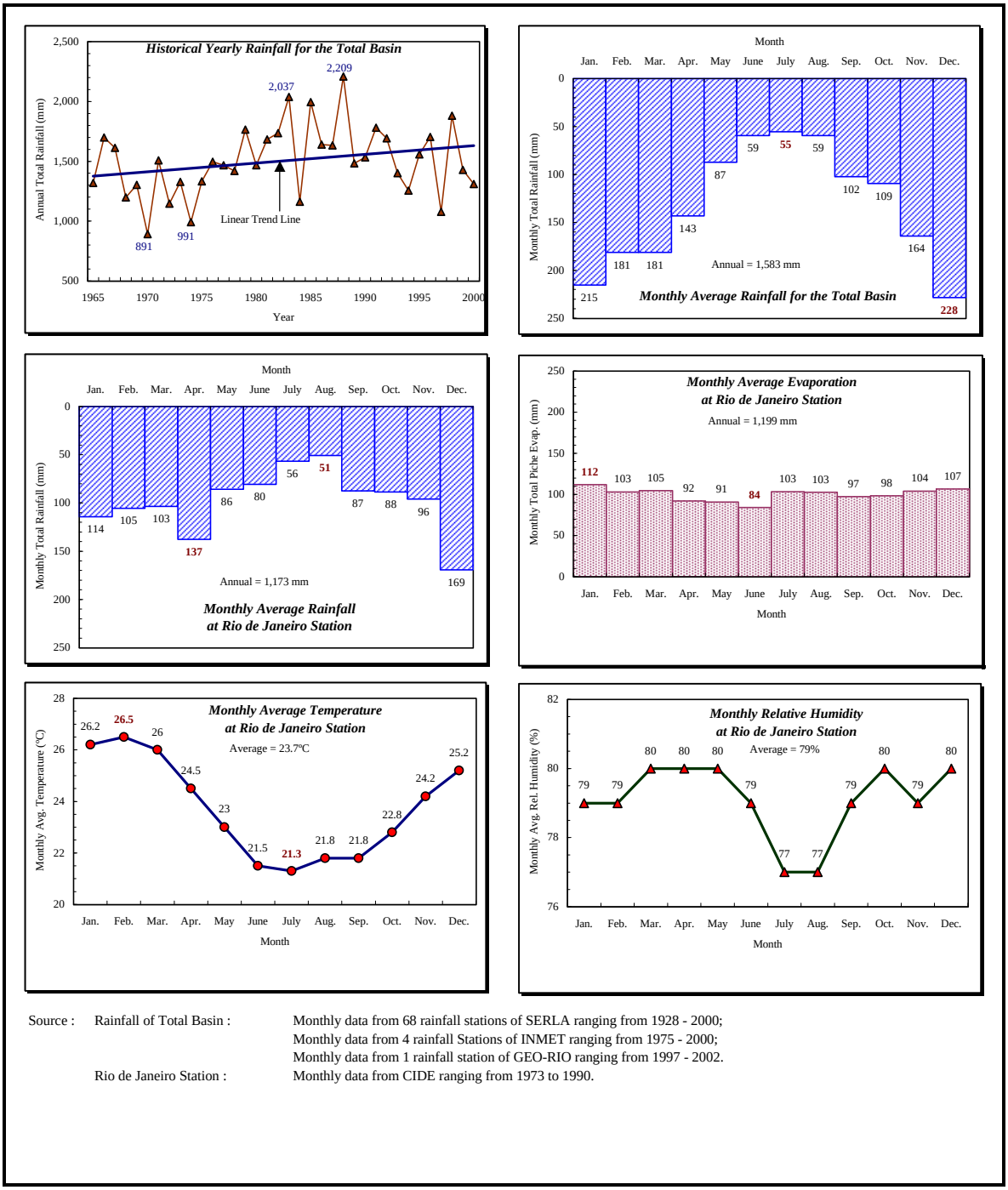


Figure 2.2 Geology of Guanabara Bay Basin

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



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 2.3 General Meteorological Condition

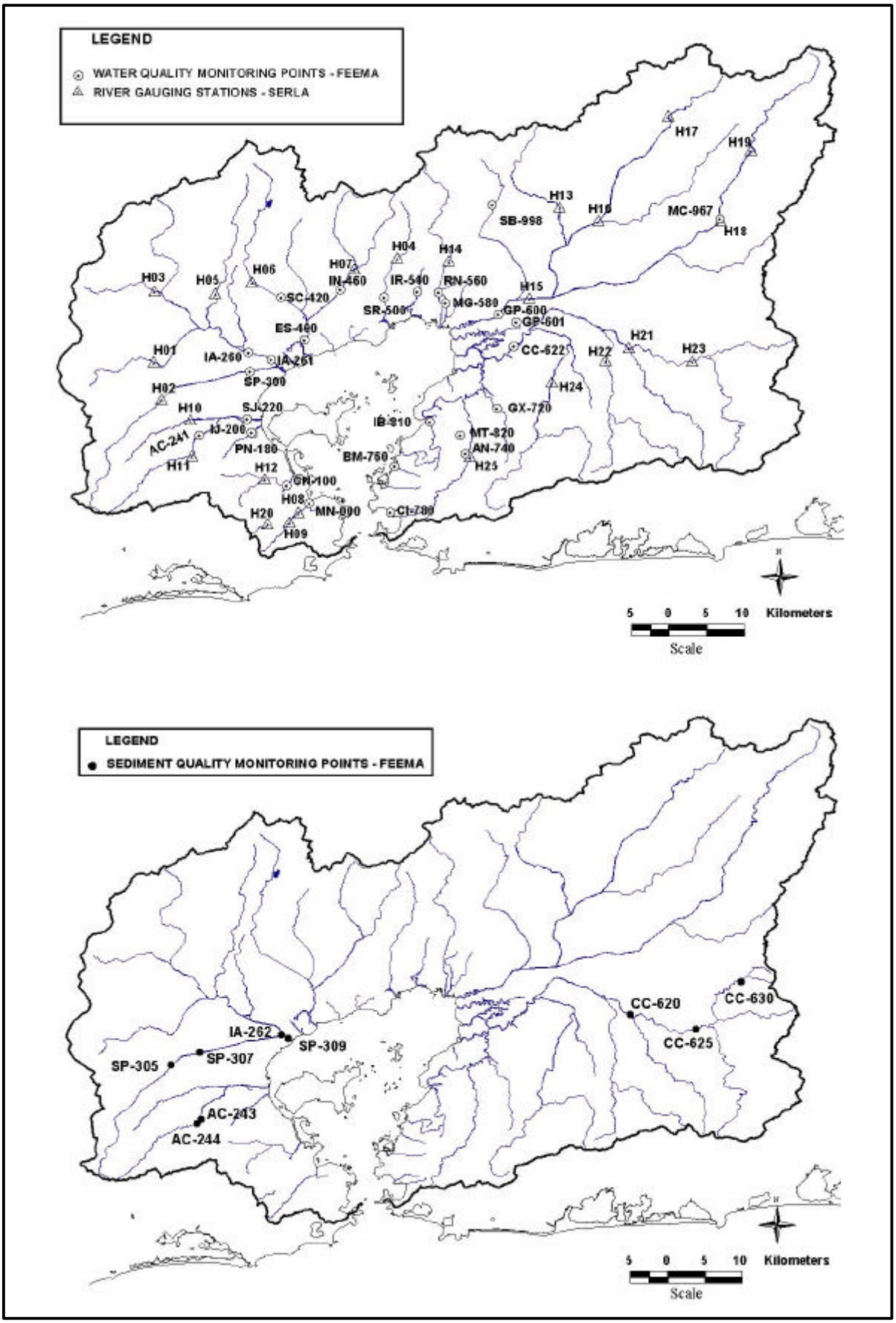


Figure 2.4 River Water Quality Monitoring Locations, River Gauging Stations and River Sediment Quality Monitoring Locations

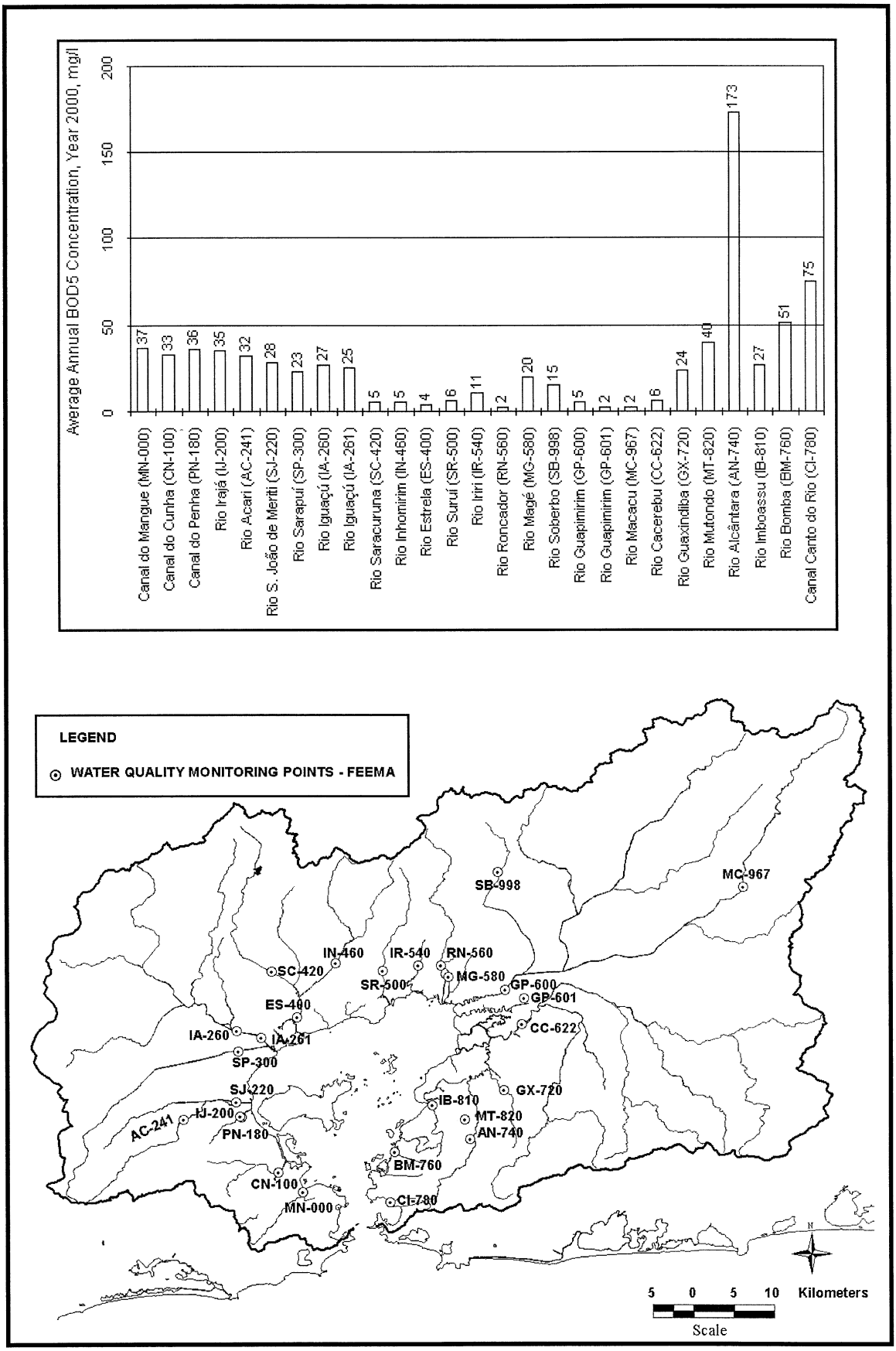


Figure 2.5 Average BOD_5 Concentration of Rivers, Year 2000

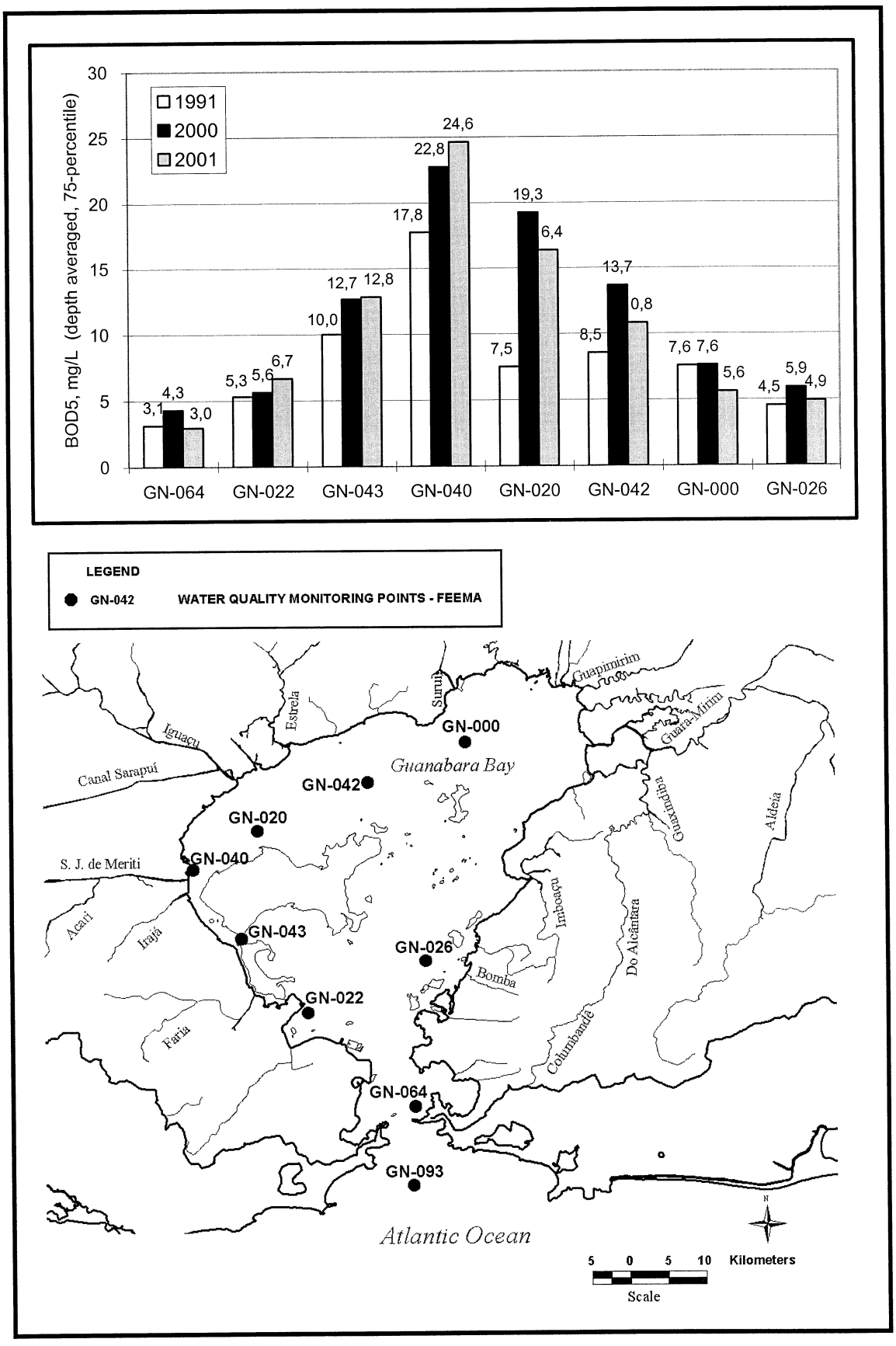


Figure 2.6 Locations of Bay Water Quality Monitoring and Variation of Water Quality of Bay