JAPAN INTERNATIONAL COOPERATION AGENCY

THE STUDY ON INTEGRATED PLAN OF ENVIRONMENTAL IMPROVEMENT IN THE CATCHMENT AREA OF LAKE BILLINGS IN SAO BERNARDO DO CAMPO CITY IN THE FEDERATIVE REPUBLIC OF BRAZIL

Final Report

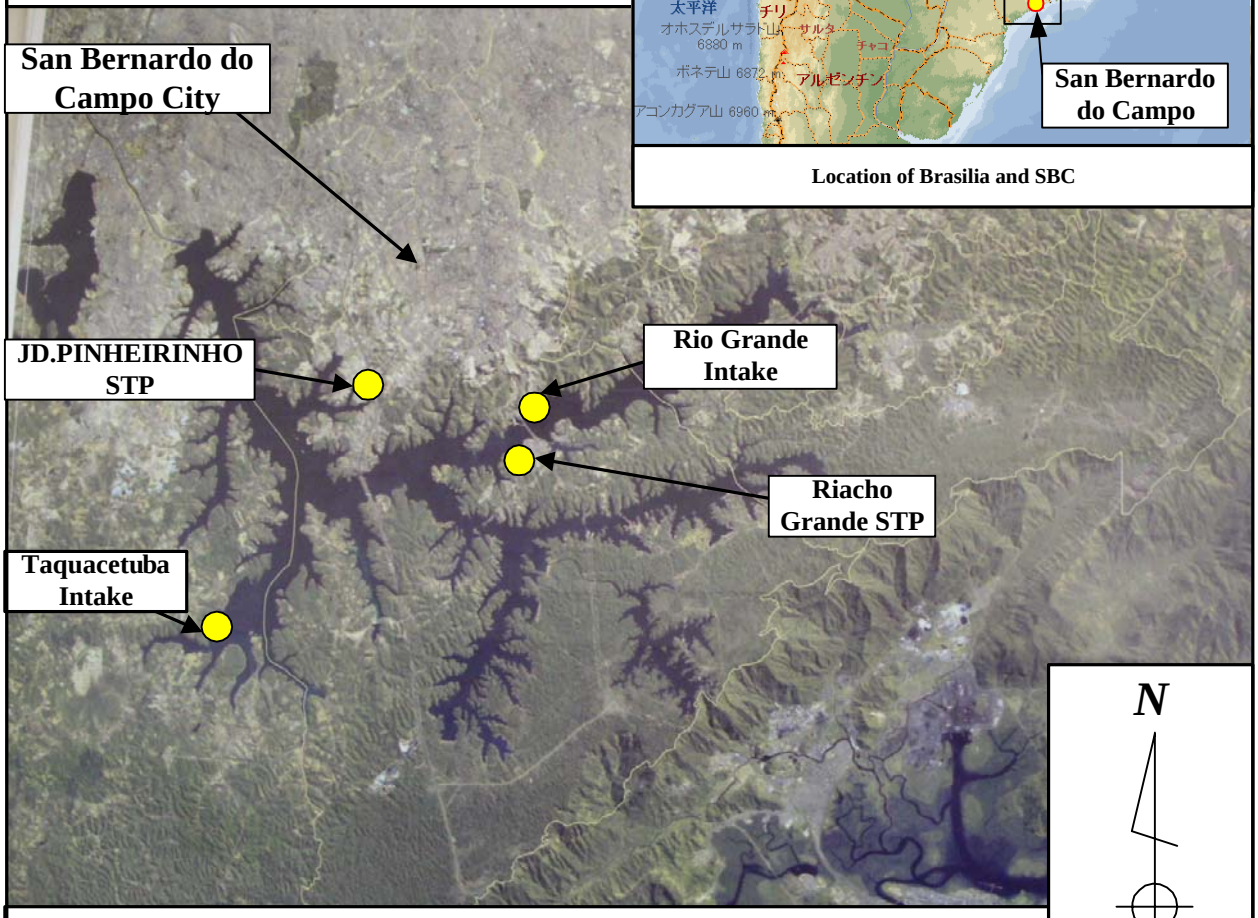
Summary

February 2007

NJS CONSULTANTS CO., LTD.
&
YACHIYO ENGINEERING CO., LTD.

Location Map

Location of Brasilia and SBC



The Billings Lake (satellite photograph）

The Study on Integrated Plan of Environmental Improvement in the Catchment Area of Lake Billings in Sao Bernardo do Campo City, Brazil

PREFACE

In response to a request from the Govemment of Federative Republic of Brazil, the Govemment of Japan decided to conduct 'The Study on Integrated Plan of Environmental Improvement in the Catchment Area of Lake Billings in Sao Bernardo do Campo City in the Federative Republic of Brazil" and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Ikuo Miwa of NJS CONSULTANTS CO., LTD. between July 2005 and October 2006. In addition, JICA set up an advisory committee headed by Mr. Haruo Iwahori, Senior Advisor, Institute for International Cooperation of JICA, which examined the study from specialist and technical points of view.

The team held discussions with the officials concemed of Sao Bernardo do Campo City and the Govemment of Federative Republic of Brazil, and conducted field surveys at the study area. Upon retuming 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 two countries.

Finally, I wish to express my sincere appreciation to the officials concemed of Sao Bernardo do Campo City and the Govemment of Federative Republic of Brazil for their close cooperation extended to the study.

February 2007

Ariyuki Matsumoto

Vice President

Japan International Cooperation Agency

February 2007

Mr. Ariyuki Matsumoto
Vice-President
Japan International Cooperation Agency

Letter of Transmittal

Dear Sir,

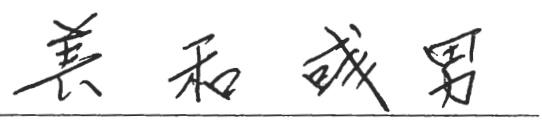
We are pleased to submit herewith the final report for *"The Study on Integrated Plan of Environmental Improvement in The Catchment Area of Lake Billings in Sao Bernardo Do Campo"*.

The Study aims to achieve the environmental inprovement in the Lake Billings, and the Study Team formulated Master Plan in order to improve the water quality, Feasibility Study for priority projects and technology transfer through study activity and seminar/workshop.

The Billings Lake is one of the important water source in the greater San Paulo Region. However the situation is getting worse because of progress of water pollution in the Lake Billings arising from the increase of untreated sewage inflow by population growth and elution of nutrient from the sediment. To encounter these issues, soft measures such as residents education as well as engineering measures such as construction of sewerage and permeable pavement are planned. For the attainment of sustainablity of the project, Environmental Protection Center is also planned. Some of the recommendations made by the Study Team have already been incorporated into the Master Plan of Sao Bernald do Campo city.

We wish to take this opportunity to express the sincere gratitude to the officials of your Agency, the Steering Committee, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, and Japan Bank for International Cooperation for their kind support and advice. We also would like to show the appreciation to the officials of Sao Bernald do Campo city, SABESP(Public company of water supply and sewerage in Sao Paulo State), ABC Consorcium, JICA Brazilia Office, and the Embassy of Japan in Brazil for their kind cooperation and assistance throughout the field survey. Finally, We hope that the recommendations of the Study Team will contribute to further environmental improvement in the Lake Billings.

Very truly yours,



Ikuo Miwa
Team Leader
Study Team for The Study on
Integrated Plan of Environmental Improvement
in The Catchment Area of Lake Billings
in Sao Bernardo Do Campo City

VOLUMES OF FINAL REPORT

"The Study on Integrated Plan of Environmental Improvement in The Catchment Area of Lake Billings in Sao Bernardo do Campo"

FEBRUARY 2007

- SUMMARY REPORT
- MAIN REPORT
- SUPPORTING REPORT
- DATA REPORT

EXECUTIVE SUMMARY

PART I: BASIC STUDY

1 Background

The Lake Billings is a reservoir constructed for power generation at Henry Borden Power Plant at the foot of Coastal Mountains by ducting water over the Ridge of Coastal Mountains. From the beginning, pumping up water from the Tiete River, which runs through Sao Paulo state, to the Lake Billings through the Pinheiros River has been conducted to supplement flowrate for the power generation. Another purpose is to alleviate flooding in Sao Paulo at heavy rains. The Rio Grande Water Treatment Plant of SABESP was commissioned in 1958 by taking water at the Rio Grande Arm for water supply. However, water quality pumped from the Tiete River had got polluted, which has caused the problems such as offensive odor, foaming and algal blooming. Due to this, complete separation of the Rio Grande Arm from the Lake Billings was made in 1982 by SABESP with construction of appurtenant embankment connected to the bank of the Anchieta Highway crossing the Lake Billings. The 1988 Constitution of the Sao Paulo State called for the proper measures not so as to bring polluted water to the Lake Billings within three years. As it was impossible to provide sewerage within such a short period, the condition was changed to allow pumping up of water from the Tiete River to the Lake Billings only when the flow rate of the river exceeded 160 m3/sec, or Sao Paulo enters on alert for flood.

The Lake Billings got an opportunity to improve water quality by this limitation of pumping, but the development of Greater Sao Paulo has already extended to the basin of the Lake Billings and the basin population has expanded from 110,000 in 1970 to 860,000 in 2000, or about eight times. Such domestic sewage has been almost discharged into the Lake Billings without any treatment.

Apart from the intake from the Rio Grande Arm, SABESP has commenced the pumping of water from the Taquacetuba Arm of the Lake Billings to the Lake Guarapiranga for water supply in 2000.

2 Importance of the Lake Billings

Besides the original function as a reservoir for power generation, the Lake Billings has now the important functions such as water source, rich nature and rest place .

The Lake Billings is used for water supply with an intake of 4.7 m^3/sec from the Rio Grande Arm and an intake of 4.0 m^3/sec from the Taquacetuba Arm via the Lake Guarapiranga. A served population by water supply derived from the water of the Lake Billings amounts to approximately 2.7 million people in total.

3 Status of Water Pollution in the Lake Billings

- The concentrations of TN and TP in the Lake Billings and the Rio Grande Arm show a high level of eutrophication in both lakes.
- According to the Vollenwider's eutrophication criteria for chlorophyll-a, those at Pedreira Dam, the confluence with the Taquacetuba Arm and an intake point of the Taquacetuba Arm are categorized into hyper-eutrophication, which suggests a condition that water bloom easily occurs.
- According to the actual measurement of sediment thickness in the Lake Billings and the estimation based thereon, piled sediments reach to volumes of 47 million m^3 in the Lake Billings and 5 million m^3 in the Rio Grande Arm, with thicknesses of 51 cm and 34 cm, respectively.

4 Possible Pollutants Sources and Their Present Status

The biggest pollutant source is domestic sewage, and others are pumping water, storm water and elusion from sediments piled in lake bottom.

PART II: MASTER PLAN

5 Basic Policy for Master Plan

(1) Target year

The target year for water quality conservation goal is set to meet the environmental standards for Class 1 by 2025 for a long-term and the interim goal by 2015 for a middle-term, taking into account the present status of water quality, which is one rank down from the environmental standards for Class 2.

(2) Basic policy for the Master Plan

1) The system as represented by the Association of "Clean the Lake Billings" will be established to make the activities for basin environment improvement sustainable.
2) As the basin environment improvement is attained not only by taking software measures such as infrastructure construction, but also adopting software measures so as to urge the innovation of public awareness towards the establishment of the environmental-friendly life style and business style.
3) The projects for the basin environment improvement of the Lake Billings is studied in the planning framework catching from the viewpoints of water quality improvement, water quality restoration, preservation of growth and habitat environment for aquatic organism, strengthening of combination among water, being and green, and the study and research as shown in **Figure 4**.

6 Socio-economic Planning Framework

(1) Design period

The present means the year of 2005. The design period shall be 20 years later or the year of 2025 with an intermediate year of 2015 for water pollution analysis.

(2) Study area

The study area shall be the basin of the Lake Billings.

(3) Design population

The 2005 population of about 1 million will increase to 1.40 million by 2025, even though such measures to contain the basin population will be taken.

7 Study on Possible Engineering Measures

As the projects for basin environment improvement of the Lake Billings, the following projects are proposed by purpose.

1) Restoration of water quality

   - Sewerage construction in the urban areas
   - Sewerage construction in the isolated communities

2) Restoration of water quantity

   - permeable pavement
   - park provision
   - Remediation of former Alvarenga solid waste dumping site

3) Lake purification

   - Dredging of sediments piled in the lake bottom
   - Installation of a pilot plant using aquatic plants

4) Strengthening of combination among water, human and green

   - Construction of the Environmental Center

5) Study and research

   - Construction of the Water Quality Management Center

8 Study on Possible Software Measures

Many listed as software measures are related to the daily life style or activity of the stakeholders such as the people, schools, NGOs, agricultural associations, housing estate developers, etc., and depend on their cooperation or voluntary activities. Therefore, establishment of the system is main issue for sustainability of the project. In this context, Public enlightenment and environmental education, construction of the Environmental Center

for Experimental Study, and formation of the Association of "Clean the Lake Billings" are proposed in relation to the establishment of organizational and institutional systems.

9 Organizational and Institutional Program

Once the lake or pond is polluted, it is not easy to restore the previous conditions, and requires a long time and accumulation of efforts. This restoration cannot be achieved by the individual stakeholder solely, but can be achieved by sharing the roles among stakeholders in the whole basin and coordinating mutually. For this purpose, it is recommended to organize the "Meeting for Clean the Billings" gathering all the stakeholders concerned with the Billings Lake.

10 Economic and Financial Analysis

The total investment cost for nine projects is 1,101,620 R$, out of which two projects for sewerage construction in the urban areas and isolated communities share 50%.

The economic analysis objects to effect of cost reduction to take and treat water from the Lake Billings. A value of EIRR got 6.3% together with NPV of -57,490,000 R$ and a B/C ratio of 0.92. It is the program that it can carry out economically.

11 Attainability of Water Quality Conservation Targets (WQCTs)

According to the simulation results for the Lake Billings, the parameters of BOD_5, DO, and NH_4-N attain the 2025WQCTs for Class 1 in 2015, but chlorophyll-a just clears the 2015WQCT for Class 2 in 2025 and TP cannot attain the WQCTs.

In the Rio Grande Arm, chlorophyll-a attains the 2015WQCTs for Class 2 in 2015 and BOD_5, DO, NH_4-N and TP meets the 2025WQCTs for Class 1 in 2015, and there is no change in this trend in 2025.

Table 1 Attainability of water quality conservation targets for the Lake Billings

Parameter	Elusion rate	2005	2015		2025		2025WQCT For Class 1
			w/o Project	w/ Project	w/o Project	w/ Project	
With emergency pumping							
Chla	(μg/L)	70.96	75.18	62.76	74.89	59.74	≤30μg/L
BOD_5	(mg/L)	**3.40**	**3.68**	**2.91**	**3.68**	**2.77**	≤5mg/L
DO	(mg/L)	**6.82**	**6.86**	**6.76**	**6.85**	**6.73**	≥5mg/L
NH_4-N	(μg/L)	**27.52**	**29.23**	**24.63**	**28.86**	**23.26**	≤500μg/L
PO_4-P	(μg/L)	3.67	4.32	2.69	4.32	2.43	―
TP	(μg/L)	101.24	110.63	85.23	110.64	80.48	≤30μg/L

Table 2 Attainability of water quality conservation targets for the Rio Grande Arm

Parameter	Elusion rate	2005	2015		2025		2025WQCT For Class 1
			w/o Project	w/ Project	w/o Project	w/ Project	
Chla	(μg/L)	53.80	57.05	***24.34***	59.94	**15.43**	≤30μg/L
BOD_5	(mg/L)	**3.79**	**3.94**	**1.26**	**4.26**	**0.83**	≤5mg/L
DO	(mg/L)	**7.46**	**7.49**	**7.42**	**7.50**	**7.40**	≥5mg/L
NH_4-N	(μg/L)	**44.86**	**45.59**	**16.90**	**48.67**	**11.14**	≤500μg/L
PO_4-P	(μg/L)	1.55	1.70	0.82	1.86	0.70	－
TP	(μg/L)	52.07	55.57	**17.03**	60.57	**10.51**	≤30μg/L

Legend: **1.0** Attain 2025WQCT for Class 1 ES; **1.0** Attain 2025 WQCT for Class 2 ES

Note: Values show the average of water quality at all water surface cells.

PART III: FEASIBILITY STUDY

12 Priority Projects

(1) Sewerage construction in the urban areas

Domestic sewage generated from densely inhabited Alvarenga and Lavras in the northern basin of the Lake Billings is collected for conveyance to the ABC Sewage Treatment Plant (hereinafter STP) outside the basin by pumping to Estrada Takagi Sub-trunk – Couros Trunk running in the Couros River basin which have not yet been constructed. The construction works is accompanied with that of sub-trunk sewers in the Couros River basin as well as a sewage collection system by the public chambers on the roads for house connection.

Trunks and sub- trunks	ø250-1,200 mm	32.9 km
Sewage collection system	Ø250-600 mm m	104.2 km
Main pumping station	3 locations	
Pumping station	6 locations	
Manhole pumping station	72 units	

(2) Sewerage construction in the isolated communities

The existing Riacho Grande Sewage Treatment Plant shall be reconstructed using the oxidation ditch process with phosphorous removal and its service area shall be expanded to the surrounding area, Caperinha, Areiao and Jussara Areas. The construction of sewage collection systems other than the surrounding area, which is constructed by a self-fund of SABESP, is included in the proposed project.

Design population in 2025:	38,200
Design sewage flow:	8,700 m^3/day (Daily Maximum)
Sludge handling:	Transfer to the ABC STP
	after mechanical dewatering

A new STP shall be constructed in Santa Cruz Area with the same process as the Riacho Grande STP. The area has been already sewered, but some sewers currently not available are newly installed.

Design population in 2025:	4,000
Design sewage flow:	1,000 m^3/day (Daily Maximum)

The sludge generated in the Santa Cruz STP shall be conveyed to the above Riacho Grande STP for joint treatment.

(3) Permeable pavement

For the sub-normal residential areas, their regularization is premised on permeable pavement as well as sewerage construction.

Design area:	Lakeside area in the northern basin
Length for permeable pavement:	29.2 km
Drain pit:	202 units
Manhole:	24 units
Length of drains:	2.5 km
Length of housing drains	12.4 km

(4) Construction of the Alvarenga Park

The Alvarenga sub-trunk main in the Alvarenga Area is installed along the Alvarenga Stream which is left naturally and needs river course improvement that will be done in the living environment improvement program (PAT-PROSANEAR). In parallel with the works for sub-trunk main installation and river course improvement, the park along the Alvarenga Stream will be constructed. The effect of storm water runoff containment and groundwater recharge is expected as the secondary function.

Design area:	Alvarenga Area
Park area:	21,121 m^2

(5) Remediation of the former Alvarenga solid waster dumping site

The former solid waster dumping site in Alvarenga discharges leachate through partly exposed waste and it has some risks of collapsing in the steep slopes. For this reason, the remediation work such as embankment, drainage and grass-planting is planned after slope stabilization work. Leachate is collected to a storage tank and then conveyed by a vacuum car to the ABC STP under SABESP for treatment. The roads, fence, observatory and outdoor lightening system is provided for administration.

Design area:	Alvarenga Area
Site area:	25 ha

(6) Construction of the Environmental Center

Environmental Center for Experimental Study and Water Quality Management Center were proposed in the Master Plan in the municipality-owned Estoril Park, then they were integrated as Environmental Center keeping respective functions in the course of discussion with the municipality.

Location:	in the municipality-owned Estoril Park

Structure:	Reinforced concrete with part steel structure
Contents:	exhibition room, experimental study room, library, study room, canteen, dormitory, laboratory, administrative office
Equipment/Instrument	Equipment for water quality analysis, boats for floating school, buses for landing school, administrative vehicles

(7) Installation of a pilot plant for lake purification using aquatic plants

To collect technical know-how for lake purification based on the natural-purification capability by aquatic plants, a pilot plant shall be installed.

Location:	On the waters with an area of 2,250 m^2 in front of the existing Pinheirinho STP
Plant :	Floating aquatic plant such as water hyacinth
Remarks:	A floating fence shall be provided for avoiding wash-out and scattering by water flow

13 Project Evaluation

(1) Financial

The total investment cost of five projects to be undertaken by the Municipality of Sao Bernardo do Campo is 52,913,000 R$, while the annual total O&M cost is 1,619,000 R$, out of which 85.2 % is shared by the Environmental Center.

The total investment cost of two projects to be undertaken by SABESP is 147,585,000 R$, while the annual total O&M cost is 1,962,000 R$. The results of cost-benefit analysis are as follows:

Table 3 Cost-Benefit Analysis for SABESP Projects

	NPV (1000R$)	B/C ratio	FIRR
Sewerage construction in the urban areas	-34,334	0.45	2.6%
Sewerage construction in the isolated communities	-8,529	0.42	0.1%

(2) Socio-economic

It should be noted that the goal of this project is to protect the Lake Billings from further water quality deterioration, and to secure the living of the people in the Greater Sao Paulo who use the lake as a drinking water source through improvement in water quality.

In addition to tangible benefit such as the protection of rich natural environment, safe water supply and provision of the place for rest and relaxation towards "Coexistence Harmonized with Water, Being and Green", the Project will bring the following socio-economic benefit:

(3) Technical

The projects proposed in the Study have been much experienced by the executing agencies involved excluding two projects for construction of the Environmental Center and installation of a pilot plant for lake purification, and there are fewer problems from the viewpoint of safety, reliability and possibility.

(4) Organizational and Institutional

The Municipality of Sao Bernardo do Campo has already sufficient experience and staffs for the operation and maintenance of permeable pavement, construction of the Alvarenga Park and remediation of the former Alvarenga solid waste dumping site. Management of the Environmental Center and the study of lake purification using aquatic plants shall be new experiences and need staff recruitment.

SABESP responsible for sewerage construction has been managing efficiently in spite of its great scale and there is no organizational and institutional problem.

(5) Environmental

For the projects proposed in this Study, the screening was conducted in accordance with the Guidelines for Environmental and Social Considerations of JICA, taking into account the environmental impact assessment system currently practiced in Brazil. The results show that there is no Category A project that gives severe affect on the environment and society but almost projects are regarded as Category B which gives less affect than Category A.

(6) Overall Evaluation

Each project proposed has its own problem individually viewing from the financial, socio-economic, technical, operational and institutional and environmental aspects, but they are not fatal in nature. Although careful attention must be paid on the matter pointed out mentioned-above, the projects proposed are justifiable for implementation,.

14 Project Implementation Program

The projects will be initiated by the procedures for the international lending agency and domestic institutions in 2007 with a goal to conclude the loan agreement within the same year. The consultants will be selected in 2008 and start the detailed design of the facilities proposed from its mid-year. The contractors will be decided in 2009 to commence the construction works from 2010 and complete them by 2014.

Table 5 Summary of Project Cost for Priority Projects

Agency	Project		R$	Equivalent JY
SBC	Permeable pavement		25,879,000	1,348,500,000
SBC	Remediation of the former Alvarenga solid waste dumping site		11,965,000	623,400,000
SBC	Construction of the Alvarenga Park		1,168,000	60,800,000
SBC	Construction of the Environmental Centre		8,192,000	426,800,000
SBC	Installation of a pilot plant for lake purification using aquatic plant		665000	34,600,000
	Sub-total		47,869,000	2,494,400,000
SABESP	Sewerage construction in the urban areas		113,446,000	5,911,600,000
SABESP	Sewerage construction in the isolated communities		21,062,000	1,097,500,000
	Total		182,377,000	9,503,600,000
	Consulting services		14,733,000	767,700,000
	Contingency	Construction cost x 0.10	18,238,000	950,300,000
	Land cost		3,388,000	176,500,000
	Grand total		218,736,000	11,398,300,000
SBC	Total		57,700,000	3,006,700,000
SABESP	Total		161,036,000	8,391,600,000
	Grand total		218,736,000	11,398,300,000

R$1=JY 52.11

15 Conclusion and Recommendation

1) Raise of sewerage coverage

2) Promotion of regularization of sub-normal residential areas

3) Early establishment of the Association of “Clean the Lake Billings”

4) Joint management of the Environmental Center

5) Experimental approach for lake purification using aquatic plants

6) Further Study on pollutant loads by elution from sediments and dredging of sediments

7) Importance of public enlightenment and environmental education

BRAZIL
Municipality of Sao Bernardo do Campo

THE STUDY ON INTEGRATED PLAN OF ENVIRONMENTAL IMPROVEMENT IN THE CATCHMENT AREA OF LAKE BILLINGS

CONTENTS

LIST OF FIGURES AND TABLES

List of Abbreviations

ABC	Brazilian agency of Cooperation
ABNT	Brazilian association of Technical Norms
ANA	National agency of the Water
APA	Area of Environmental Protection
APRM	Area of Protection and Recovery of springs
ARA	Area of Environmental Recovery
ARO / APP	Area of Restriction to the occupation / Area of Permanent Protection
BB	Bank of Brasil S/A
BC	Central bank of Brazil
CADES	Municipal Council of Environment and Maintainable Development
CAEDYM	Computacional Model of Ecological Dynamics Aquatic
CEAM	Center of Environmental Education
CEF	Federal savings bank
CESP	Central Electric of Paulo Paulo S.A.
CETESB	Company of Technology of Environmental Sanitation
CONAMA	National Council of the Environment
CONSEMA	State Council of Environment
COT or TOC	Total Organic carbon
CPLEA	Coordination of Strategic Environmental Planning and Environmental Education
CT	Trunk Collector
DAEE	Department of Waters and Electric power
DAIA	Department of Evaluation of Environmental Impact
DBO or BOD	Biochemical Oxygen demand
DEPRN	State department of Protection of the Natural Resources
DNER	National department of Highway
DNPM	National department of the Mineral Production
DOC	Dissolved Organic carbon
DQO or COD	Chemical demand of Oxygen
EEA	Pumping Station of Water
EEE	Pumping Station of sewage
EIA/RIMA	Study of Environmental Impact / Report of Impact of the Environment

EIRR	Rate of Internal Economical Return
ELCOM	Model of Estuary, Lake and Oceanic Costa
EMAE	Metropolitan company of Water and Energia S.A.
EMPLASA	Metropolitan company of Planning of Great São Paulo
ETA	Station of Water Treatment
ETE	Station of Sewage Treatment
FIESP	Federation of the Industries of the State of São Paulo
FIRR	Rates of Financial Intern of Return
FUSP	Foundation of the University of São Paulo
Grande ABC	Santo André, São Bernardo do Campo and São Caetano do Sul
IBAMA	Brazilian institute of the Environment and of the Renewable Natural Resources
IBGE	Brazilian institute of Geography and Statistics
IPT	Institute of Technological Researches of the State of São Paulo
ISA	Environmental institute
JICA	Japan International Cooperation Agency.
M/M	Minutes of Meeting
MMA	Ministry of the Environment
MOD	Dissolved Organic matter
NPV	Net Present value
NT or TN	Total nitrogen
PAT–PROSANEAR	Technical support organization
PDPA	Plan of Development and Environmental Protection
PETROBRÁS	Brazilian petroleum
RMSP	Metropolitan area of São Paulo
SABESP	Company of water supply and sewerage of the State of São Paulo
SBC	São Bernardo do Campo city
SEMASA	Municipal of Environmental Sanitation of Santo André
SHAMA	General office of House and Environment
SIG/ISA	System of Geographical Information of the Partner-environmental Institute
SMA	General office of the Environment of the State of São Paulo
TAC	Term of Adjustment of Conduct
USP	University of São Paulo

PART I: BASIC STUDY

1 Background

The Lake Billings is a reservoir constructed for power generation at Henry Borden Power Plant by dropping water over the Coastal Ridge. From the beginning, pumping of water from the Tiete River, which runs through Sao Paulo, to the Lake Billings through the Pinheiros River has been conducted to supplement a lack of natural runoff therein. This has another purpose to alleviate the occurrence of flood in Sao Paulo. The Rio Grand Water Treatment Plant of SABESP was commissioned in 1958 by taking water at the Rio Grande Arm for water supply. However, water pumped from the Tiete River has changed to polluted water which has caused the problems such as offensive odor, forming and algae growth. Due to this, SABESP was constructed an embankment beneath the Anchieta Highway across the Lake Billings and completely separated the Rio Grande Arm from the Lake Billings in 1982. The 1988 Constitution of the Sao Paulo State called for the proper measures so as not to bring polluted water to the Lake Billings within three years. As it was impossible to provide sewerage within such a period, it was a condition to allow pumping of water from the Tiete River to the Lake Billings at the time when a river flow exceeded 160 m^3/sec, or Sao Paulo entered into on alert for flood.

The Lake Billings got a lead to improve water quality by this limitation of pumping, but the development of Greater Sao Paulo has already extended to the basin of the Lake Billings and the basin population has expanded from 110,000 in 1970 to 860,000 in 2000, or about eight times. Such domestic sewage has been almost discharged into the Lake Billings without any treatment.

Apart from an intake from the Rio Grande Arm, SABESP has commenced pumping of water from the Taquacetuba Arm of the Lake Billings to the Lake Guarapiranga for water supply in 2000.

2 Importance of the Lake Billings

Besides the original function as a reservoir for power generation, the Lake Billings has now the important function as follows:

(1) Valuable water source

- The Lake Billings is used for water supply with an intake of 4.7 m^3/sec from the Rio Grande Arm and an intake of 4.0 m^3/sec from the Taquacetuba Arm via the Lake Guarapiranga. A served population by water supply derived from the water of the Lake Billings amounts to approximately 2.7 million people in total.

- SABESP has a plan to augment a treatment capacity of the Rio Grande Water Treatment Plant by separating the Rio Pequeno Arm from the Lake Billings completely through the construction of an embankment under the Anchieta Highway like the present Rio Grande Arm and connecting the Rio Pequeno Arm to the Rio Grande Arm through tunneling.
- The room for new water resource development has been narrowing in the Greater Sao Paulo Region due to its location of the upstream of the Tiete River at an elevation of 700m to 800 m.

(2) Rich nature

Rich nature is still left around the Lake Billings due to its location at the most upstream of the Tiete River with a watershed at the Coastal Ridge adjoining the coastal area.

(3) Rest place

- Fishing
- Swimming
- Boating
- Rest place

3 Status of Water Pollution in the Lake Billings

(1) Yearly change of water quality of the Lake Billings

CETESB has water quality monitoring points at four locations in the Lake Billings and two locations at the Rio Grande Arm. The water quality during the past ten years for 1995 to 2004 and the year of 2005 is shown in **Table 1** and summarized below:

- The water quality in 2005 has a trend for improvement in comparison with that of the past ten years, that is to say, BOD_5 was improved at four points out of six (4/6), NH_4-N at 4/6, TP at 6/6 and chlorophyll-a at 4/5, while NO_3-N was deteriorated at 5/6.
- The concentrations of BOD_5 do not meet the environmental standards for Class 2 of not more than 4 mg/L at Pedreira Dam and at an intake point of the Taquacetuba Arm.
- All the concentrations of DO clear the environmental standards for Class 1 of not less than 6 mg/L.
- The concentrations of NO_2-N and NO_3-N are below the environmental standards for Class 1 of not more than 1 mg/L and not more than 10 mg/L, respectively at all monitoring points.

- For the concentrations of TP, it attains the environmental standards for Class 2 of not more than 30 μg/L only at an intake point of the Taquacetuba Arm.
- The rate of TN to TP is in a range of 29 to 49 that means the abundant existence of nitrogen component.
- The concentrations of TN and TP in the Lake Billings and the Rio Grande Arm shows a high level of eutrophication in both lakes.
- According to the Vollenwider's eutrophication criteria for chlorophyll-a, those at Pedreira Dam, the confluence with the Taquacetuba Arm and an intake point of the Taquacetuba Arm are categorized into hyper-eutrophication, which suggests a condition that water bloom easily occurs.
- Since 2000, the occurrence of water bloom has been outstanding.
- According to the actual measurement of sediment thickness in the Lake Billings and the estimation based thereon, piled sediments reach to volumes of 47 million m^3 in the Lake Billings and 5 million m^3 in the Rio Grande Arm, with thicknesses of 51 cm and 34 cm, respectively.

Table 1 Water Quality of the Lake Billings and the Rio Grande Arm

		Unit	BILL02100	BILL02500	BILL02900	BITQ00100	RGDE02200	RGDE02900
			Pedreira Dam	Confluence with Taquacetuba Arm	Summit Dam	SABESP's intake	Confluence with Rio Grande river	SABESP's intake
BOD_5	1995-2004	mg/L	7.5	4.9	4.4	6.3	5.1	3.4
	2005	mg/L	5.2	4.5	3.8	4.4	5.2	3.5
DO	1995-2004	mg/L	7.5	7.6	8.0	10.1	8.3	7.4
	2005	mg/L	7.5	8.77	8.7	9.9	8.6	7.5
NH4-N	1995-2004	mg/L	0.26	0.11	0.09	0.12	0.74	0.26
	2005	mg/L	0.22	0.11	0.17	0.09	0.61	0.19
NO_2-N	2005	mg/L	0.12	0.05	0.01	0.03	0.05	0.04
NO_3-N	1995-2004	mg/L	0.98	0.64	0.48	0.36	0.73	0.53
	2005	mg/L	2.63	0.97	0.20	0.48	0.89	0.63
Kjd-N	2005	mg/L	1.64	1.18	0.95	1.31	1.38	0.59
TN	2005	mg/L	4.38	2.20	1.16	1.82	2.81	1.26
TP	1995-2004	mg/L	0.149	0.053	0.064	0.087	0.100	0.066
	2005	mg/L	0.090	0.052	0.040	0.053	0.058	0.027
Chl-a	1995-2004	μg/L	83.4	42.1	20.3	56.8		12.6
	2005	μg/L	67.8	41.3		52.5		7.0
TN/TP	2005		49	42	29	34	48	47

(2) Eutrophication condition of the Lake Billings

The occurrence status of algae is shown in **Table 2**. Chlorophyll-a has a trend lower near to Pedreira Dam and higher away therefrom. That of the Rio Grande Arm is not so high as in the Lake Billings. The dominant species are obviously different between them, or *Cyanobacteria* is dominant in the Lake Billings, while *Chlorophyceae* in the Rio Grande Arm.

Table 2 Occurrence Status of Algae

Monitoring points	Chlorophyll-a (μg/L)		Dominant species
	Average for 1994-2003	Average in 2004	
BILL02100	89.35	54.93	Hyper-eutrophication, *Cyanobacteria* (Microcystis)
BILL02500	42.18	41.93	
BILL02900	20.33		
BITQ00100	58.09	48.22	
RGDE02200			Hyper-eutrophication, *Chlorophyceae* (*Mougeotia*)
RGDE02900	13.01	10.00	

4 Possible Pollutants Sources and Their Present Status

(1) Domestic sewage

The influence of domestic sewage has become bigger, which is expecteded to be the biggest pollutant source in the future.

The basin population of the Lake Billings was expanded from about 110,000 in 1970 to 860,000 in 2000, or eight times with an annual growth rate of 5.5% in the latest ten years (1991-2000) as shown in **Table 3**. The present population in the basin is expected at approximately one million.

The water pollution is outstanding at Alvarenga and Cocaia Areas in the Lake Billings and Ribeirao Pires Area in the Rio Grande Arm, respectively.

Table 3 Population by Municipality Involved in the Basin of the Lake Billings

	1970	1980	1991	1996	2000
Sao Paulo	51,000	160,000	262,087	371,822	469,041
Diadema	8,000	24,000	44,556	49,967	59,804
Sao Bernardo do Campo	16,000	51,000	114,613	158,328	188,181
Santo Andre	4,000	9,000	17,518	23,653	25,283
Ribeirao Pires	24,000	49,000	69,309	77,662	86,470
Rio grande da Serra	8,000	20,000	26,338	29,534	34,225
Basin of the Lake Billings	111,000	313,000	534,421	710,966	863,004

(2) Industrial sewage

The control by CETESB to the factories are very severe and factories conduct industrial sewage treatment in compliance with the regulations. The factories discharging sewage are not so many and sewage stabilization ponds or oxidation ditch processes are used for treatment in general. In most factories, the reuse in the factories or disposal as irrigation water to the land of treated sewage is done so as to minimize the discharge to the lake. Solvay Industry, or the largest sewage discharger in the basin has a plan to discharge its treated sewage to a SABESP's sewer system in the near future.

(3) Agricultural sewage

The large-scale firms so as to require the use of much fertilizer is not found in the basin of the Lake Billings. The small-scale firms are found near the communities, but there is no vegetable plantation in the waters such as lotus demanding fertilizer.

The aquatic plantation is not identified in the basin except for a few fishing ponds.

(4) Livestock industry

Although "Billings 2000" described the presence of pig firms in Diadema and Sao Paulo, only one firm was identified and those in Sao Bernardo do Campo were demolished.

Pasturage of cows and horses are found in some locations, but they are not problematic from the view point of pollutant load.

(5) Tourism sewage

In the basin, only one tourism spot is located in Parana Piacaba at the southeastern end of Santo Andre, but small in scale. Therefore, there is no problem regarding tourism sewage.

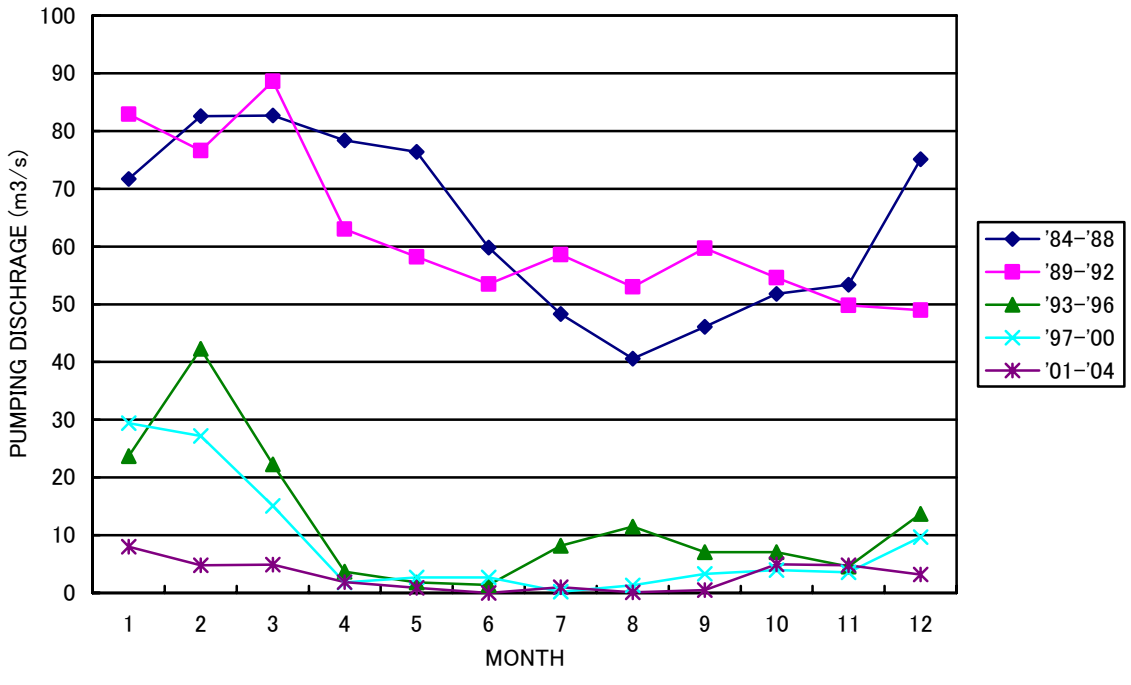
(6) Storm water drain

According to the analysis on the rainfall characteristics, the occurrence probability of rainfall with an intensity of not more than 10 mm/hr is 97% with 177 rainfall days. If it will be cut, the occurrence frequency of surface runoff can be contained within five days.

(7) Pumping to the Lake Billings

The annual average flow by pumping the Tiete River water to the Lake Billings was 70 m^3/sec for 1986 to 1992. Taking into account that a sewage flow discharged by the 17 million people in the Greater Sao Paulo Region was 39 m^3/sec (when assuming a per capita daily sewage flow of 200 L) and the own flow of the Tiete River, it is considered that a substantial flow of sewage has been pumped to the Lake Billings. As shown in **Figure 1**, the pumping flow of the Tiete River water has decreased drastically by the limitation of pumping in 1992 and gradually thereafter.

Figure 1 Change in Pumping Water Flow to the Lake Billings

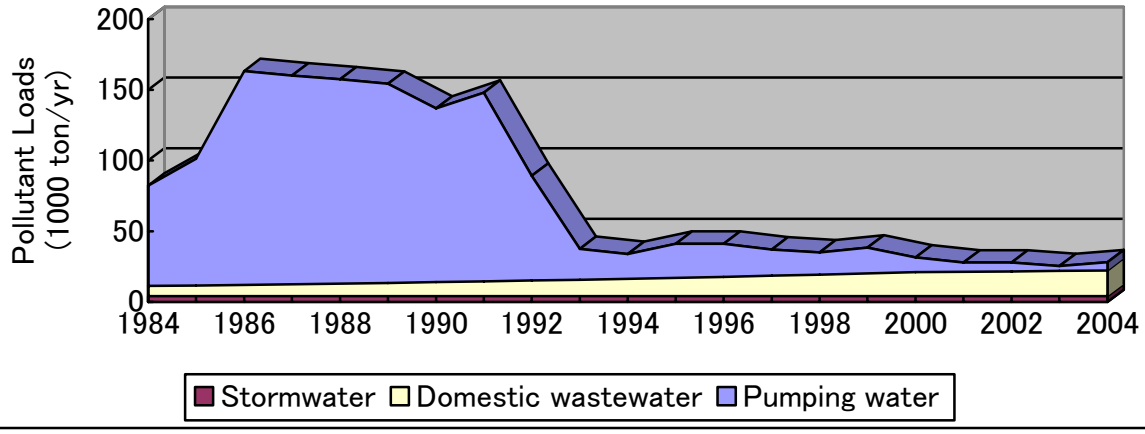


5 Estimation of Pollutant Loads

- As shown in **Figure 2**, the load by domestic sewage has increased and expectedly become a hub among pollution sources.

- The sediments piled in the lake bottom have a possibility to become a potential pollution source, with a fear of elution of nitrogen, phosphorous and heavy metals.
- It is considered that the pumping of the Tiete River water to the Lake Billings is done in the future, whenever Sao Paulo enters into on the alert for flood and depending on its frequency and flow, it still has a possibility to become a big pollution source

Figure 2 Estimated Past Pollutant loads to the Lake Billings



6 Construction Situation of Infrastructure concerned with Water pollution

SABESP, a water supply and sewerage service company of the State of Sao Paulo, provides sewerage services to Sao Bernardo do Campo under the direct management and to Sao Paulo, Ribeirao Pires and Rio Grande da Serra under the concession contract. Although the Municipalities of Diadema and Santo Andre provide sewerage services independently in their own administrative areas, domestic sewage generated in their areas is finally collected to the existing ABC Sewage Treatment Plant managed by SABESP with charge.

SABESP has operated and maintained the existing four sewage treatment plants, or two in Sao Bernardo do Campo, and one in Ribeirao Pires and Rio Grande da Serra, respectively, but has a basic policy to pump all the sewage generated in the urban area of the Lake Billings basin to the north outside the basin, or to the Barueri WWTP for Sao Paulo and the ABC WWTP for others.

The construction works of relevant facilities such as trunk sewers and pumping stations to pump sewage outside the basin has been already done by SABESP in Sao Paulo and Ribeirao Pires. The Municipalities of Diadema and Santo Andre have also conducted the sewerage construction in the basin.

There is no sewerage plan covering the Lake Billings basin of Sao Bernardo do Campo and no construction works has done in these years due to the confusion accompanied with the

transfer of water supply and sewerage facilities from the Municipality of Sao Bernardo do Campo to SABESP. As a result, the sewerage construction in Sao Bernardo do Campo is rather behind those in other municipalities. Therefore, it is an urgent matter to formulate a sewerage plan and to start its construction works.

PART II: MASTER PLAN

7 Basic Policy for Master Plan

(1) Water quality conservation target

In consideration of the background of the Lake Billings abovementioned, the goals of the water quality conservation plan are set so as to reclaim the environment blessed with rich water and green that were existent at the Lake Billings and its surrounding area previously, or "clean water surrounded by green" and "habitats for diverse living tings" for long-term, and "achievement of environmental standards" and "coexistence of water, human and green" for middle-term (**Figure 3**).

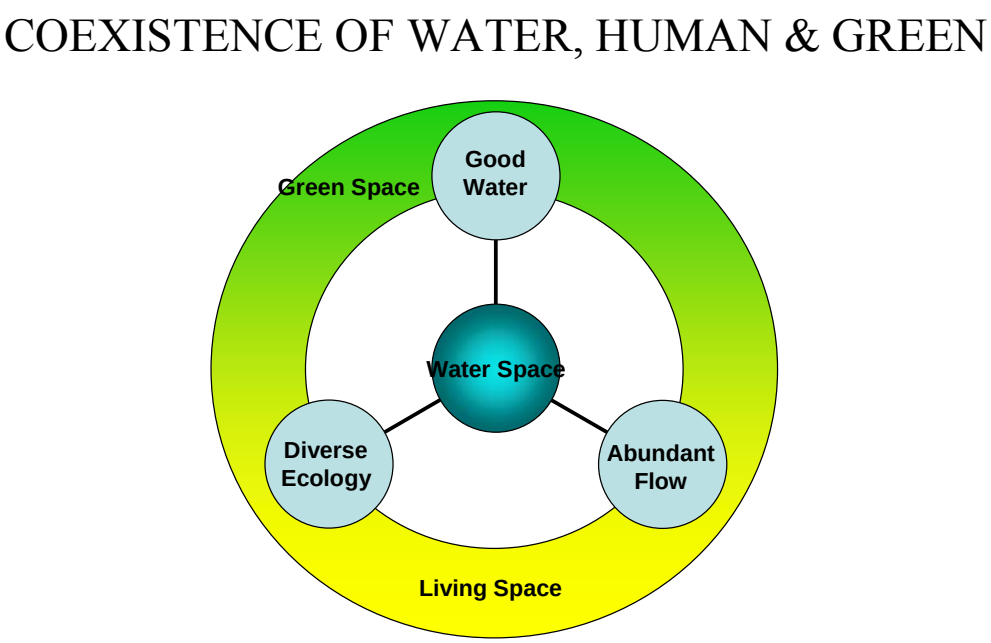


Figure 3 Concept for Basin Environment Improvement of the Lake Billings

1) Target year

Taking into the scale of the lake and basin, current situation of environmental administration in the basin, and the schedule of the Emergency Plan which the State Government of Sao Paulo has a plan to implement under the assistance from the World Bank, the target years are set in 2015 for the middle-term and in 2025 for the long-term.

2) Target level

The water quality conservation target is set so as to meet the environmental standards by 2025 with the interim target for the intermediate year or 2015 as shown in **Table 4**, considering the pollution status of the Lake Billings and the Rio Grande Arm, requests from the people, scale of measures required for solution and the time required for the effect appearance.

Table 4 Water quality Conservation Target

Parameter		Middle-term target（2015）			Long-term target（2025）		
		Billings (Interim 1)	Billings (Interim 2)	Rio Grande (Interim 2)	Billings (Class 1)	Billings (Class 2)	Rio Grande (Class 2)
E. Coli	(MPN/100mL)						
BOD	(mg/L)	5	8	8	3	5	5
DO	(mg/L)	5	4	4	6	5	5
pH		6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0
Chl-a	(mg/L)	30	60	60	0.01	0.03	0.03
TN	(mg/L)	1.5	2.5	2.5	0.8	1.2	1.2
TP	(mg/L)	0.03	0.05	0.05	0.02	003	0.03

(2) Basic policy of master plan

The basin environment improvement of the Lake Billings shall be promoted under the following policies:

1) The lake has a character that water is retained therein. From such hydraulic characteristics of a closed water body, the pollutant loads incoming to the lake is apt to settle for accumulation resulting in water pollution. It is not easy to restore its previous water quality, once the lake has been polluted. For this reason, such endeavor is not finished only by taking engineering measures, but requires a long-term approach.

2) As the basin environment improvement is attained not only by taking engineering measures such as infrastructure construction, but also adopting software measures so as to urge the innovation of public awareness towards the establishment of the environmental-friendly life style and business style, because it is important that a resident or entrepreneur has an environmental-friendly mind one by one and positively acts for water purification in his daily life.

3) For the conservation of water environment in a lake, it is important to have the comprehensive viewpoint such as restoration of hydrologic cycle and securement of growth and habitat environment for aquatic organisms including water quality improvement, water

quantity restoration, and conservation of water fronts and so on so as to control the whole lake. In the implementation of measures, the public involvement including NGOs and NPOs should be encouraged. In addition to the conventional role of the lake, the people want the formation of rich landscape, provision of water front with amenity and recreational place and strengthening of combination among water, being and green, resulted from the elevation in awareness and diversification of needs for water environment. It is also necessary to establish a system to measure the effect through the pollutant load survey and water quality monitoring in the basin, to provide the information on the actual status of the lake with plain description to the people, and to get the understanding of the people for the basin environment improvement, Therefore, the measures to be taken should be considered in the planning framework for the basin environment improvement, but not limited to only the pollutant load reduction.

4) All the stakeholders including the people are responsible for sharing the measures for water quality conservation of the lake and for evaluating their results. Therefore, the presentation of a whole lake image is dispensable to correspond to such diverse viewpoints.

As the precondition in promotion of the measures for water quality conservation of the lake, the provision of information on the details of a whole lake image in the form of plain understanding is required for all the stakeholders to have the common concern and awareness. Sharing of problem recognition and reconstruction of cooperative framework is the basis to support the whole of policy. For example, it is important to make a stronghold of environmental information and education for production of common awareness and sharing of problem recognition.

(3) Measures to be taken

1) Establishment of the Association of “Clean the Lake Billings”

It is not easy to restore the lake, once polluted, but requires a long time and steady accumulation of little endeavor. There are six municipalities involved in the basin of the Lake Billings and state agencies, the people, community associations, schools, NGOs, agricultural association, housing estate developers, sewage dischargers and universities are also concerned with the Lake Billings. The improvement of basin environment is not attained, if an individual stakeholder acts independently, but attained by sharing the roles among stakeholders and acting in combination with each other. For this purpose, it is recommended to establish the Association of “Clean the Lake Billings” gathering all stakeholders as early as possible.

2) Public enlightenment and environmental education

According to the survey on public enlightenment and environmental education, the people living in the basin of the Lake Billings has less awareness on their contribution of water

pollution of the lake, and low willingness-to pay for sewage charge, which suggest the awareness of the people on the basin environment improvement. To make a plan surer, public enlightenment and environmental education are very important to elevate their awareness on the basin environment, and urge the people to connect to a sewer system immediately and make a payment for sewage charge, when it will be completed, and to participate in the activities for the basin environment.

3) Selection of projects from the comprehensive viewpoint

The projects for the basin environment improvement of the Lake Billings is studied in the planning framework catching from the viewpoints of water quality improvement, water quantity restoration, securement of growth and habitat environment for aquatic organisms, strengthening of combination among water, being and green, and the study and research as shown in **Figure 4**.

Figure 4 is composed of engineering measures to construct facilities and software measures to innovate the people's awareness and to urge the people to participate in the activities for the basin environment improvement. The software measures is essentially in nature to urge each stakeholder's awareness for action, which are the activities for public enlightenment and environmental education as a means of the administrative side to produce such awareness, or the issues to be tackled by the Association of "Clean the Lake Billings".

Viewpoint	Approach	Software measures (Target year: sustainable)	Hardware measures (Target year: see the right col.)	M/P Target Year
Restoration of water quantity	Groundwater recgarge		Permeable pavement	2007-2025
			Const. of public parks & greens	2007-2015
		Restoration of natural forest		
		Proper use of land		
	Reduction of water consumption	Proper use of groundwater		
		Reduction of water consumption		
Improvement of water quality	Reduction of incoming pollutant loads		Sewerage const.	2007-2015
			Introduction of advanced treatment	2010-2012
			Installation of septic tanks	Sustainable
		Reduction of domestic wastewater load at the source		
			Direct treatment in streams	Not adopted
		Cleaning of the riverside		
		Cleaning of the lakeside		
			Measures for spesified pollutant sources	2010-2012
		Proper application of fertilizer		
		Protection of firms from soil errosion		
	Measures for internal pollutant sources		Aeration in the lake	Not adopted
			Dredging of sediments piled in lake bottom	after 2016
			Culture & collection of aquatic plants	Inst.:2010、Op.: 2011-2015
		Removal of water bloom		
Securement of growth & habitat environ. for aquatic org.	Conservation of water front	Conservation of bird sanctuary		
Strengthening of combination among water, being & green	Public enlightenment & environmental education	Information provision to the public	Const. of the Environ. Centre	2010-2011
		Awareness enlightenment on water management		
		Capacity building for community management		
	Formation of landscape	Proper management of forest & reforestration		
	Raise in water front amenity		Const. of water front parks	Not adopted
Study & research	Water quality monitoring	Utilization of water quality databse	Const. of the Water Quality Management Centre	2010-2011
	Promotion of research	Implementation of environmental survey		

Figure 4 Planning Framework for Basin Environment Improvement of the Lake Billings

8 Socio-economic Planning Framework

(1) Design period

The present means the year of 2005. The design period shall be 20 years later or the year of 2025 with an intermediate year of 2015 for water pollution analysis.

(2) Study area

The study area shall be the basin of the Lake Billings.

(3) Design population

The population in the basin of the Lake Billings is projected every five years by 2025 starting from the year of 2005, as shown in **Table 5**. This projection is based on the assumption that measures to contain the population growth are applied in various forms to the whole basin of the water source protection area for the Lake Billings. The 2005 population of about 1 million will increase to 1.40 million by 2025, even though such measures to contain the basin population will be taken.

Table 5 Population Projection in the Basin of the Lake Billings

	2000 [1)]	2005 [2)] (present)	2010	2015	2020	2025
Population	865,870	989,970	1,096,462	1,205,486	1,294,475	1,393,398
Growth rate (%)		1.027	1.021	1.019	1.014	1.015

1) Based on the 2000 census
2) Projected using an actual growth rate

(4) Land Use

The basin area of the Lake Billings of 582.8 km^2 is composed of 475.5 km^2 (81.6%) for land and 107.3 km^2 (18.4%) for water surface. Out of a land of 475 km^2, grassland and forestry is 346 km^2 (approximately 73%), relatively densely inhabited area 87 km^2 (including commercial and industrial area, 19%), agricultural area 9 km^2 (1.9%), commercial and industrial area 3 km^2 (0.65%) and others are villas called “Chacara”. By municipality, Sao Bernardo do Campo has a biggest share of 32%, followed by Sao Paulo (29%) and these two municipalities share 61% of land in total.

The land use is featured by the preserved grassland and forestry and the low percentage of agricultural, commercial and industrial areas. The agricultural land has reduced year by year, on the contrary, the residential area has increased as well as population growth. The development of residential estates and site preparation has been done at present, although some seems to be illegal

(5) Economy

The whole basin area of the Lake Billings is designated as the water source protection area and there are three categories regarding the land use over there as follows:

- No occupational area
- Occupation-regulated area
- Environmental restoration area

Out of the above, "no occupational area" is designated to the southern part of the Coastal Ridge outside the basin of the Lake Billings. Occupation-regulated area is designated in the southern basin of the Lake Billings where land use form with no affect on water pollution on the Lake Billings is allowable including residential use with conditions and use for tourism and leisure concerned with the lake. "Environmental restoration area" is defined as the area to make environmental measures possible to restore the water quality.

The western, northern and eastern part of the Lake Billings is expected to develop mainly as the normal residential area accompanying small-scale commercial and industrial locations, due to the legal provisions mentioned above and strict control to the appearance of the sub-normal residential area and favela. In the basin of Sao Bernardo do Campo, the industries of furniture making, metal processing and mechanics are relatively many. The new location of a large-scale factory is difficult except for those that were located in the old days.

It is considered that the southern part of the Lake Billings will keep the present scale as the agricultural firms in the future. The livestock industry has a trend to disappear from the basin, although there is almost no keeping of cattle, pigs and chickens.

9 Study on Possible Engineering Measures

(1) Sewerage construction in the urban areas

1) Basic policies of SABESP (see **Figure 5**)

- Domestic sewage generated in the basin of the Lake Billings in Sao Paulo is treated at the Barueri WWTP.
- Domestic sewage generated in the basin of the Lake Billings in other municipalities involved than Sao Paulo is treated at the ABC WWTP.
- Domestic sewage generated in the southern basin of the Lake Billings in Sao Bernardo do Campo and Santo Andre is coped with on the case-by-case basis.

2) Present situation of sewerage construction

- The construction works of pumping stations to convey domestic sewage generated in

the basin of the Lake Billings outside the basin have been done in Sao Paulo and Ribeirao Pires.

- The Municipality of Diadema has already operated a pumping station to convey a part of domestic sewage generated in the basin of the Lake Billings outside the basin.
- The Municipality of Santo Andre has progressed sewerage construction independently in the basin of the Lake Billings.
- SABESP has a plan to expand a service area and improve the existing Riacho Grande WWTP located in Sao Bernardo do Campo with a self-fund in 2006.
- For the Alvarenga District in the basin of the Lake Billings in Sao Bernardo do Campo, the Municipal Department of Housing and Environment (SHAMA) has completed a sewerage plan using a subsidy for PAT-PROSANEAR from the Ministry of Urban Development, the Federal Government.

3) Agreements between the Municipality of Sao Bernardo do Campo and SABESP

- SABESP will improve a connection rate of domestic sewage from 79% to 95% by 2009.
- SABESP will receive 90% of domestic sewage collected at the WWTP for treatment by 2011.

4) Sewerage Plan for Sao Bernardo do Campo (see **Figure 6**)

At present, there are two trunk mains to cover Sao Bernardo do Campo, or the Meninos Trunk for the eastern part and the Couros Trunk for the western part. Out of them, almost part of the Meninos Trunk has been already completed, but the Couros Trunk has been completed only from the confluence with the Menino Trunk to Curral Grande. Recently, the Municipality has decided improvement of the Couros River and road construction from Curral Grande to the confluence with the Jurubatuba Watercourse under the IDB-financed Urban Transportation Program for 2006 to 2009.

But to perform the commitments with the Municipality, SABESP is required to extend the Couros Trunk and to receive sewage to be generated in the basin of the Lake Billings. At the time of construction of the Meninos Trunk and the Jurubatuba Sub-trunk, as there was no idea to receive sewage to be generated in the basin of the Lake Billings, they have enough capacities therefor. The construction of the Couros Trunk is, therefore, required to convey sewage to the ABC Sewage Treatment Plant.

From the situation mentioned above, the plan to collect sewage from not only the Alvarenga District but also other urban areas in the basin of the Lake Billings for pumping to the Couros Trunk outside the basin and to convey it to the ABC WWTP for treatment is proposed. This plan also includes the construction of several sub-trunks connecting to the Couros Trunk to

promote sewerage coverage in the municipal eastern area.

(2) Sewerage construction in the isolated communities

As of 2005, there are 16 isolated communities from the urban area. The alternatives such as all sewage conveyance outside the basin, independent treatment at each community, integrated treatment of adjoining communities and treatment by septic tanks were studied. The plan to construct a WWTP in Riacho Grande and Santa Cruz District, respectively, collecting sewage from neighboring communities was finally selected.

Other areas to be not sewered shall be covered by septic tanks.

(3) Permeable pavement

The permeable pavement is effective to an increase of runoff coefficients accompanied with population growth in the future, which storm water by an intensity of 10 mm/hr precipitating on the roads can be treated by infiltration. As the road area in the densely inhabited area is about 25%, an overall runoff coefficient can be reduced by 75% by introduction of the permeable pavement. This is applied to the densely inhabited area such as Alvarenga District.

(4) Construction of parks and greens

The functions of parks and greens are to contain storm water runoff and to recharge groundwater, through improving vacant spaces. As a secondary effect, creation of streams is expected from the viewpoint of amenity.

Although there are the large lands in the basin of the Lake Billings, parks and greens are better to locate the place where storm water infiltration is required in the urban area, a certain level of flat area can be secured, the people closely feel the effect of water quality improvement through sewerage construction, adjoining a waterfront, if possible, and where the people easily get to.

(5) Remediation of the former Alvarenga solid waste dumping site

For the former solid waste dumping site in Alvarenga District, it is improved so as to raise safety through earth coverage, measures for leachate and storm water, and slope protection from collapse. Leachate is collected for storage on-site and treatment at the ABC WWTP therafter and a safety fence is provided to protect from invaders' entrance. As the solid waste reclaimed has a high compressibility, it is considered that settlement will last in the future and its utilization will be limited to parks and greens.

(6) Dredging of sediments piled in the lake bottom

There are possibly sediments piled in the lake bottom for a long time, especially massively near Pedreira Dam with a fear of adverse affect on water quality of the lake by elution from sediments for a long-term. As measures against this, dredging of sediments or earth cover on

sediments by sand is considered.

(7) Installation of a pilot plant using aquatic plants

Natural water hyacinth with a high growth rate, productivity and nitrogen and phosphorous contents, as a typical aquatic plant, is also observed in places in the Lake Billings. As it is floated with roots extended into water, water hyacinth is easily cultured and collected. By using such features, it is notable as a means of removal of nitrogen and phosphorous. However, when it overgrows in the lake due to its high growth rate and covers fully the water surface of the lake and rivers, it obstructs water flow and sunlight radiation resulting in the oxygen shortage in water and deterioration of water quality. Therefore, its adaptability to the Lake Billings should be studied carefully.

(8) Construction of the Environmental Centre for Experimental Study

Schools have the obligation of environmental education that is substantially done in the educational practice using the prints such as pamphlets, however it cannot be said that environmental education based on experimental study has not yet been fully established. For this reason, it is proposed to construct the Environmental Centre for Experimental Study in Sao Bernardo do Campo locating in the basin center of the Lake Billings to understand/experience environmental issues focusing on water pollution problems with the following functions:

- Environmental education
- Exchange and information sending
- Cooperation with and support to civic activities

(9) Construction of the Water Quality Management Centre

The current water quality monitoring of the Lake Billings is done by CETESB and SABESP. The former is the state regulatory agency on water quality covering the whole state with four monitoring points in the Lake Billings and two in the Rio Grande Arm, respectively, but has, in fact, no capacity to cover the arms and rivers that is affected at first by the inflow of pollutant loads. SABESP has a strong concern in the Lake Billings as drinking water source and its targets for monitoring are concentrated to the Central Channel reaching to an intake point. Since the water quality variation in the arms and rivers results in the effect on the Central Channel, and it facilitates to make a measure by monitoring water quality therein and identifying its cause. Also, it is possible to show the direction for population through the confirmation of effects of the water quality improvement activities from the viewpoint of water quality. For this reason, the establishment of the Water Quality Management Centre is proposed to cover the water quality monitoring at the arms and rivers and to carry out the study and research for lake purification.

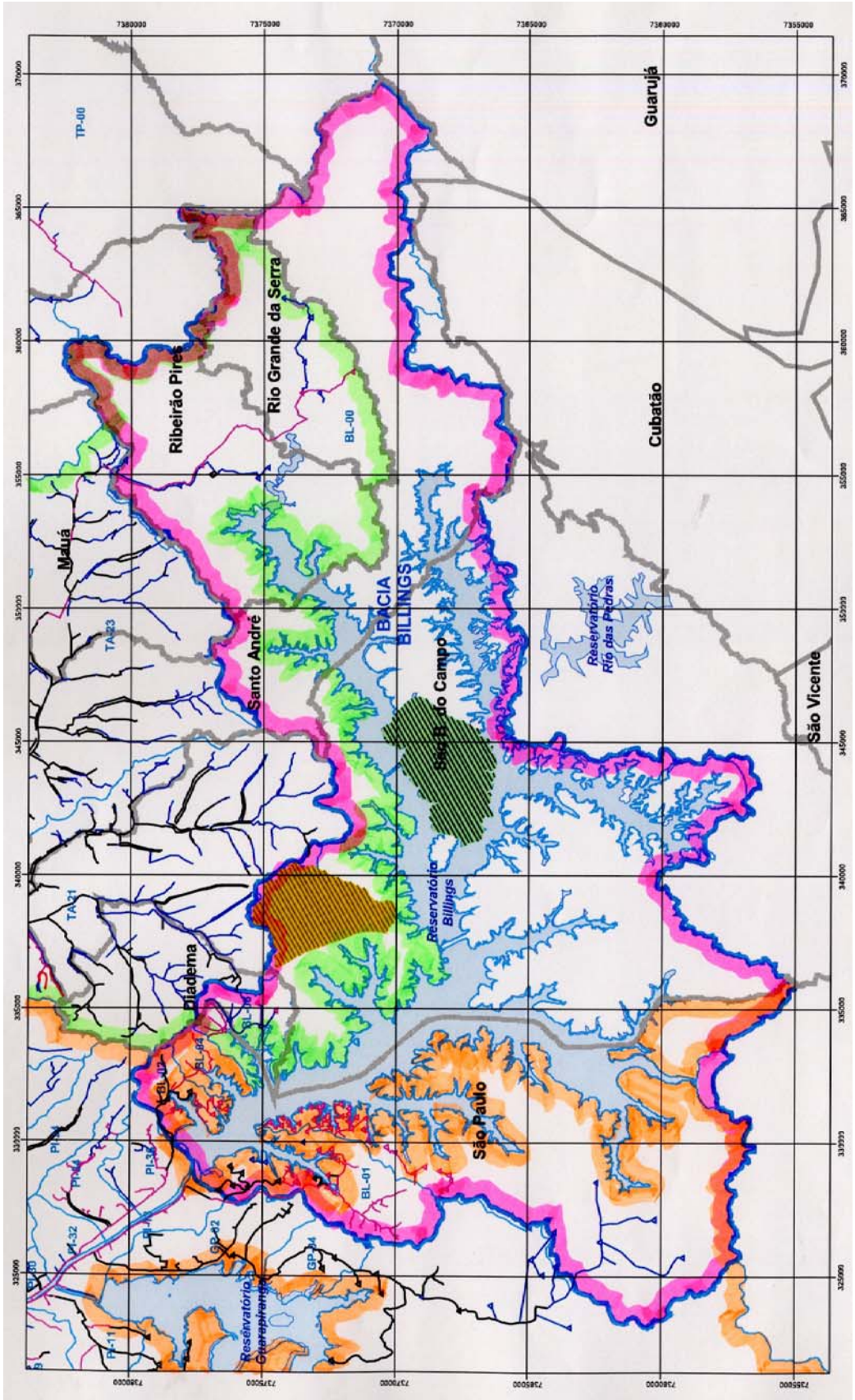


Figure 5 Sewerage Plan of SABESP for the basin of the Lake Billings

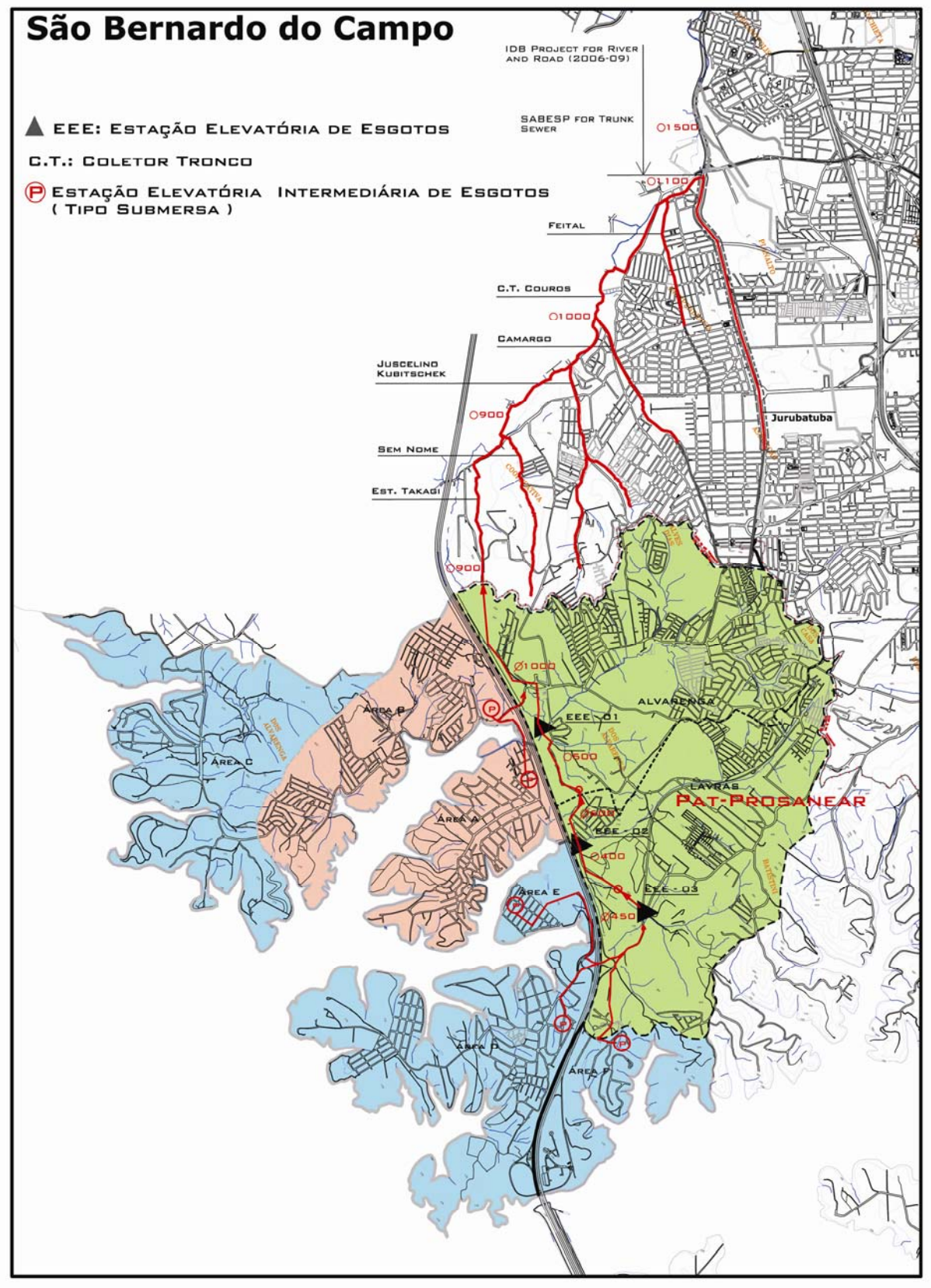


Figure 6 Sewerage Plan for Sao Bernardo do Campo

10 Study on Possible Software Measures

Many listed as software measures is concerned with the daily life style or action of the stakeholders such as the people, schools, NGOs, agricultural associations, housing estate developers, etc., or rely on their cooperation or voluntary activities. Therefore, the formation of a system, not as the project, that is able to maintain such activities is a problem. Public enlightenment and environmental education, construction of the Environmental Centre for Experimental Study, and formation of the Association of "Clean the Lake Billings" proposed in relation to the establishment of organizational and institutional systems are all concerned with this.

Although some of software measures have already conducted at present, it is advised that all will be developed as the basin-wide movement without waiting for the completion of projects proposed.

(1) Concerned with the life style/business style of the people/entrepreneurs

- Proper use of groundwater
- Reduction of water consumption
- Reduction of pollutant loads by domestic sewage generated at the kitchen, etc.

Out of pollutant loads, that from domestic sewage has the biggest contribution at present and increasing tendency in the future due to the increase of population in the basin. It still takes much time to complete the provision of a sewerage system in the basin. For this reason, it is necessary to reduce the pollutant load generated in the basin. However, as the pollutant loads derived from industrial and livestock sewage have been already not in a problem level, the main target is domestic sewage. Since the pollutant loads are calculated by the following equation, the basis is "No Pollution, No Discharge" for sewage.

[Pollutant loads] = [Concentration of sewage] x [Sewage flow generated]

As this may require the people to change the life style, it is recommended to enlighten the people repeatedly through a variety of channels such as public relation to the people, works on communities, school education (from children to families) and so on.

(2) Concerned with the participation in the activities for the basin environment improvement

- Restoration of natural forest

The restoration of natural forest that was lost during the World War II has been fruitful, but the current problem depends on how such forest will be protected from the wave of urbanization and extended in the future

- Cleaning of the lakeside
- Cleaning of the streams

The garbage spread along the lakeside and riverside is visually unpleasant and causes heavy damage to the lake and streams, all the more in case that it is used for a water source. The lake and streams are used for a dumping site of garbage in some cases and the garbage placed on somewhere is washed out by the storm water during rainfall in other cases. The both cases are apt to occur at the area where a garbage truck has no access over there. In such an area, it is effective to work on the people through community association.

- Removal of water bloom and algae

SABESP has been forced to remove the water bloom and algae in the Rio Grande Arm for operation and maintenance of the intake works and water treatment plant. Even though they die in the lake, as they become a new internal pollutant source in the lake, it is the best way to remove them from the lake as SABESP has conducted.

(3) Concerned with legal compliance or administrative guide

- Proper land use

It is important to require the housing estate developers for the strict compliance with the law, and to monitor and regulate what they have done actually, so as not to increase the sub-normal houses any more. The order of improvement for illegal building should be issued in the earliest time, before they have the floor with a progress of building on the loose.

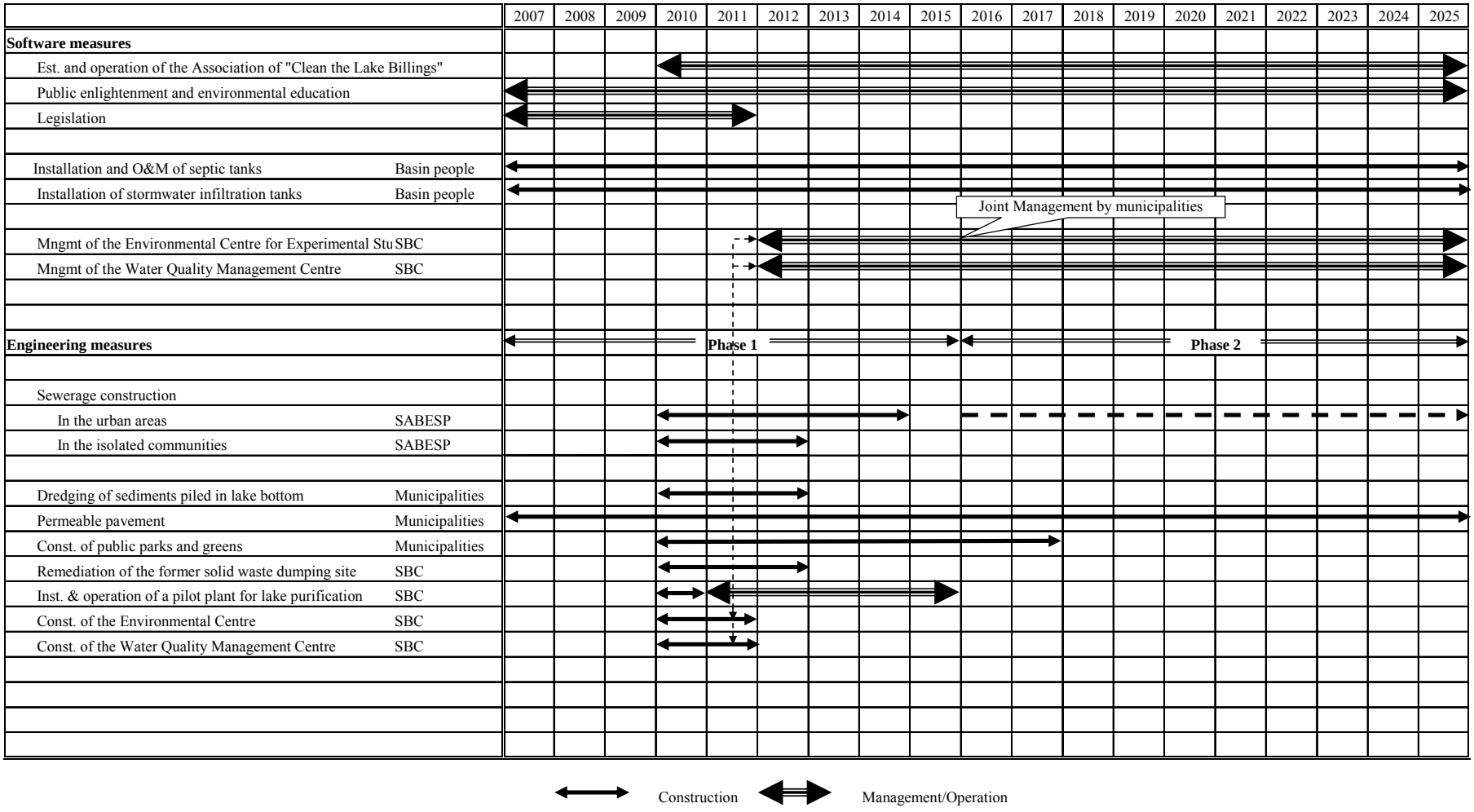
- Improvement of fertilizer application
- Soil erosion from firms

In the basin of the Lake Billings, the firms are found in the basin of Borore Arm and Taquacetuba Arm where vineyards and Christmas tree plantations are managed in a small-scale. As the fertilizer applied to those crops has a fear to be washed out together with soil, the farmers should take measures for such soil erosion, especially at the slope. As there is an intake works of SABESP in the Taquacetuba Arm, it is recommended to work on actively the farmers for proper fertilizer application and minimization of naked land.

11 Implementation Program for master Plan

The implementation program is shown in **Figure 7**.

Figure 7 Implementation Program of Master Plan



12 Organizational and Institutional Programm

Once the lake or lagoon was polluted, it is not easy to restore the previous conditions, requiring a long time and accumulation of little efforts. This restoration cannot be done by the individual stakeholder solely, but can be achieved by sharing the roles among stakeholders in the whole basin and coordinating mutually. For this purpose, it is recommended to organize the Association for "Clean the Lake Billings" gathering all the stakeholders concerned with the Lake Billings as shown in **Figure 8**.

As the Association for "Clean the Lake Billings" is the place for agreement formation and decision making basically, the stakeholders often make discussions and, in accordance with the decisions over there, should take action hopefully. The relationship between the association and stakeholders are as follows:

(1) Association for "Clean the Lake Billings"

- Progressive promotion of programs
- Evaluation of tackling status and target achievement situation
- Forwarding of information
- Review of programs

(2) From the Association to each stakeholder

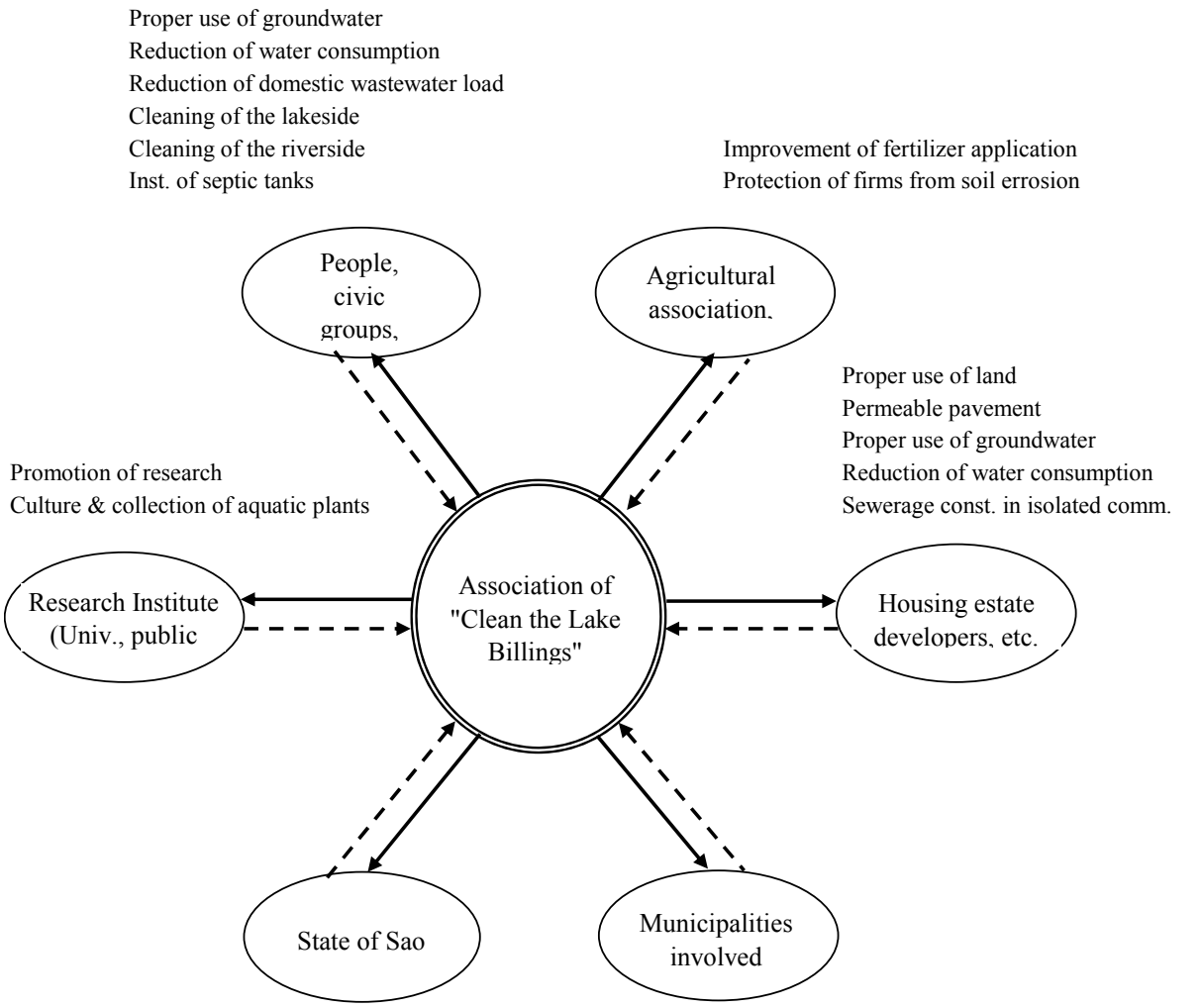
- Provision of information on target achievement situation
- Recommendation of tackling promotion

(3) From each stakeholder to the Association

- Report on tackling situation
- Report on monitoring results
- Idea and proposal

Figure 8 shows the construction of the Association and the examples of role sharing.

It is expected that the Association for "Clean the Lake Billings" will encounter the various twists and turns till it will be managed smoothly. During such period, the Municipality of Sao Bernardo do Campo shall take a leadership for its organization as secretariats.



State/ EMAE	Aeration in the lake	Permeable pavement
	Dredging of sediments piled in lake bottom	Const. of public parks & greens
		Restoration of natural forest
SABESP	Sewerage const. in urban areas	Direct treatment in the streams
	Sewerage const. in isolated comm.	Remediation of the former dumping site
	measures for water bloom	Conservation of ecology
		Conservation of natural landscape & water front
CETESB	Water quality management	Const. of the Environmental centre
	Promotion of research	Const. of the Water Quality Management Centre
		Research on treatment using aquatic plants
Common	Inf. provision & support to civic activities	Inf. provision & support to civic activities
	Environmental education	Environmental education
		Const. of water front parks

Figure 8 Association of Clean the Billings and Role Sharing among Stakeholders

13 Initial environmental Examination

The result of screening for the proposed projects in the master plan study is shown in **Table 6** based on IEE results and taking the recipient country's environmental impact assessment (EIA) requirement into consideration. Almost all proposed projects are estimated to be categorized as "B", which means that they may not cause significant adverse impact on the surrounding environment and society compared to "A". On the other hand, according to the recipient's country's requirement on EIA, any project proposed in Master Plan does not require Environmental Impact Assessment (EIA/RIMA) except the dredging of sediments piled in the Lake Billings, since they does not cause significant adverse impact on the surrounding environment according to the interview with the reviewing authority.

Table 6 Screening Results for Proposed Projects in the Master Plan

No.	Name of Project	Category based on IEE Results	EIA Requirement in Recipient's Country	Final Screening
1	Sewerage construction in the urban areas	B	The project which transports the sewage to existing sewage networks require neither preparation of EIA/RIMA nor LP (Preliminary License) and it only requires the procedures commencing LI (Installation License).	B
2	Sewerage construction in the isolated communities	B	The project needs to prepare only RAP (Preliminary Environmental Report), and it requires LP and LI.	B
3	Permeable Pavement	B	The project does not require EIA/RIMA.	B
4	Construction of public parks and greens t	B	The project does not require EIA/RIMA.	B
5	Remediation of the former Alvarenga solid waste dumping site	B	The project does not require EIA/RIMA.	B
6	Dredging of sediments piled in the lake bottom	B	The project requires the preparation of EIA/RIMA and the environmental authorization procedures commencing at LP. The acquisition of the licenses for treatment, transportation and disposal of lake bottom sediment is necessary.	A
7	Water Purification Pilot Project Using Water Plants	B	The project does not require the preparation of EIA/RIMA, but it will require the procedures after LP.	B
8	Environmental Centre for Experimental Study	C	The project does not require EIA/RIMA.	C
9	Water Quality Management Centre	C	The project does not require EIA/RIMA.	C

14 Economic and Financial Analysis

The total investment cost for nine projects is 1,101,620 R$, out of which two projects for sewerage construction in the urban areas and isolated communities share 50% as shown in **Table 7**.

Table 7 Project Cost for the SBC Projects

	Investment Cost (1000R$)	Share	O&M cost in 2015 (1000R$)	Share
Sewerage construction in the urban areas	527,862	48%	4,687	60%
Sewerage construction in the isolated communities	22,752	2%	837	11%
Permeable Pavement	498,045	45%	449	6%
Construction of public parks and greens	19,638	2%	199	3%
Remediation of the former Alvarenga solid waste dumping site	12,803	1%	129	2%
Dredging of sediments piled in the lake bottom	11,042	1%	0	0%
Installation of a pilot plant for lake purification using aquatic plants	712	0%	98	1%
Construction of the Environmental Center	4,383	0%	690	9%
Construction of the Water quality management Center	4,383	0%	690	9%
Total	1,101,620	100%	7,778	100%

From a nation economical point of view, economic price is calculated from market price in the economic analysis. Economic price excludes tax and subsidy. Standard Conversion Factor (SCF) converts market price to economic price usually. Because the breakdown of cost for the economic cost calculation was not set, the conversion was not adopted this time. 31% was subtracted as a tax / subsidy equivalency from market price to make it with an economic price.

Various types of effects will be expected with the program for the Lake Billings to improve water quality: effect of cost reduction, effect of industry promotion, effect of sanitary improvement, effect of environment protection, and effect of living environment improvement. Because some of them are difficult to be measured, this study objects to effect of cost reduction to take and treat water from the Lake Billings.

In the above-mentioned condition, economic evaluation index were calculated..

A value of EIRR got 6.3% together with NPV of -57,490,000 R$ and a B/C ratio of 0.92. It is the program that it can carry out economically.

15 Attainment Status of the Water Quality Conservation Targets (WQCTs)

(1) Lake Billings

How to see the figures showing the simulation results is described in **Figure 9**.

The WQCT attainment status by project implementation is shown in **Figure 10** and **Table 8** by parameter. The WQCTs as shown in **Table 4** for the year of 2025 are same as those of the environmental standards.

According to the simulation results, the improvement effect of water quality is shown in all parameters of Chlorophyll-a, BOD_5, NH_4-N, PO_4-P and TP except for DO between the years of 2005 (before sewered) and 2015 (after sewered). However, the parameters of Chlorophyll-a and TP cannot attain the WQCTs. The extent of water quality improvement depends on parameter in which the improvement rate of water quality in 2015 to that in 2005 is biggest in PO_4-P by 35%, followed by TP (22%) and BOD_5 (20%).

At the moderate elution rate:

Chlorophyll-a

- The concentration distribution on the water surface is improved moderately for 2005 to 2015, but slightly for 2015 to 2025.
- The concentration of Chlorophyll-a just clears the 2015 WQCT for Class 2 in 2025.
- Chlorophyll-a exceeds an environmental standard of 30 μg/L except for the remotest area such as Rio Pequeno and Rio Capivari from Pedreira Dam, especially at the deepest portion of Alvarenga and Pedra Blanca with a concentration of around 80 μg/L.

BOD_5

- The concentration distribution on the water surface is improved moderately for 2005 to 2015, but slightly for 2015 to 2025.
- The concentration of BOD_5 clears the 2025 WQCT for Class 1 in 2015.
- Watching the profiles for the simulation period, the concentration in Summit Dam is stable at 2 to 4 mg/L throughout a year.

DO

- As for DO, higher concentration is better, but the concentration distribution on the water surface is gradually dropping in 2005, 2015 and 2025.
- The median of the DO concentrations meets the 2025 WQCT for Class 1 since 2005.

NH_4-N

- The concentration distribution on the water surface is stable at less than 30 μg/L all in 2005, 2015 and 2025.
- The 2005 new environmental standard of NH_4-N varies by pH, that is to say, the lower pH the higher the standard. For a pH of more than 8.5, an environmental standard of

NH_4-N for Class 1 is less than 500 μg/L that is cleared since 2005

- At Summit Dam, the elution of NH_4-N from bottom sediments is observed during January to April and September to December.
- The median of NH_4-N drops to 23.2 μg/L in 2025 due to the remarkable progress of homogenization as a whole of the lake.

PO_4-P

- The concentration distribution on the water surface is improved moderately for 2005 to 2015, but slightly for 2015 to 2025.
- There is no environmental standard for PO_4-P, but its median is in a low level of 2.4 μg/L.
- At Summit Dam, the elution of NH_4-N from bottom sediments is observed during January to April and August to December.
- Watching the profiles for the simulation period, the concentration in the Taquacetuba Arm is stable at zero to 5 mg/L throughout a year.

TP

- The concentration distribution on the water surface is improved moderately for 2005 to 2015, but slightly for 2015 to 2025.
- The concentration of TP is in a level of 80 μg/L even in 2025, far from the 2015 WQCT of 30μg/L for Class 2.

It should be noted that the attainment status of water quality conservation targets for the Lake Billings in **Table 8** already reflects the influence of emergency pumping in the concentrations. For example, the improvement effect of BOD_5 by sewerage construction is from 3.40 mg/L to 2.77 mg/L, or 0.63 mg/L with emergency pumping, but from 2.38 mg/L to 1.34 mg/L, or 1.04 mg/L without emergency pumping. That is to say, emergency pumping reduces the effect of sewerage construction.

Table 8 Attainment status of **WQCTs** for the Lake Billings

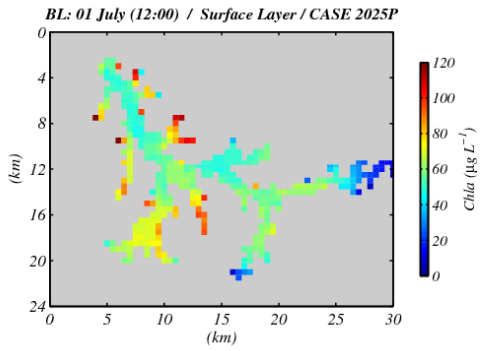
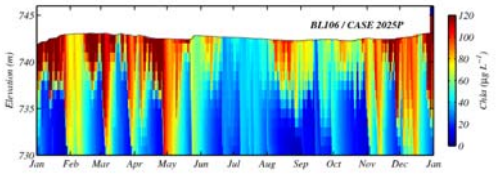
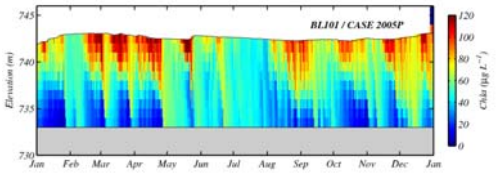
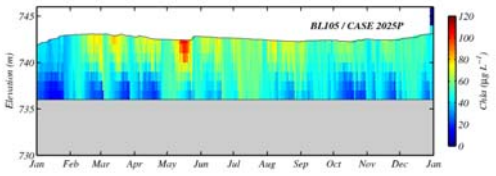
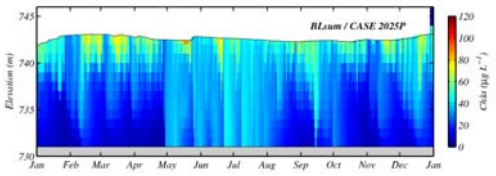
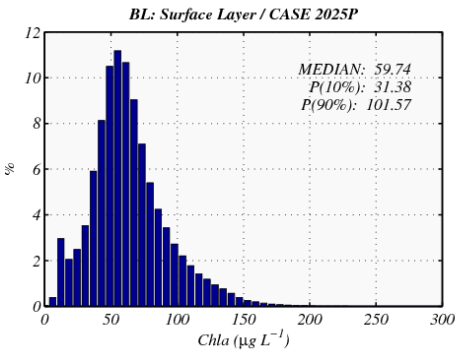
Parameter	Elusion rate	2005	2015		2025		2025 WQCT
			w/o Project	w/ Project	w/o Project	w/ Project	
With emergency pumping							
Chla (μg/L)	Moderate	70.96	75.18	62.76	74.89	59.74	≤30μg/L
	High	92.70	93.24	88.19	92.89	86.09	≤10μg/L
BOD_5 (mg/L)	Moderate	**3.40**	**3.68**	**2.91**	**3.68**	**2.77**	≤5mg/L
	High	6.17	6.28	5.59	6.27	5.43	≤3mg/L
DO (mg/L)	Moderate	**6.82**	**6.86**	**6.76**	**6.85**	**6.73**	≥5mg/L
	High	**7.04**	**7.02**	**7.05**	**7.02**	**7.04**	≥6mg/L
NH_4-N (μg/L)	Moderate	**27.52**	**29.23**	**24.63**	**28.86**	**23.26**	≤500μg/L
	High	**45.18**	**46.64**	**39.14**	**46.42**	**37.35**	≤500μg/L
PO_4-P (μg/L)	Moderate	3.67	4.32	2.69	4.32	2.43	―
	High	6.84	7.28	4.97	7.27	4.56	―
TP (μg/L)	Moderate	101.24	110.63	85.23	110.64	80.48	≤30μg/L
	High	143.01	148.90	118.67	149.19	113.39	≤20μg/L
Without emergency pumping (for reference)							
Chla (μg/L)	Moderate	48.52		31.02		**25.35**	≤30μg/L
	High	97.41		73.50		65.80	≤10μg/L
BOD_5 (mg/L)	Moderate	**2.38**		**1.60**		**1.34**	≤5mg/L
	High	5.79		**4.39**		**3.96**	≤3mg/L
DO (mg/L)	Moderate	**6.53**		**6.34**		**6.27**	≥5mg/L
	High	**7.09**		**6.84**		**6.74**	≥6mg/L
NH_4-N (μg/L)	Moderate	**26.84**		**20.60**		**17.36**	≤500μg/L
	High	**46.48**		**35.86**		**32.44**	≤500μg/L
PO_4-P (μg/L)	Moderate	1.38		0.93		0.82	―
	High	3.12		1.49		1.24	―
TP (μg/L)	Moderate	61.27		38.62		31.31	≤30μg/L
	High	97.48		66.96		59.73	≤20μg/L

Legend: **1.0** Attain WQCT for Class 1 **1.0** Attain WQCT for Class 2

Note: Values show the average of water quality at all water surface cells (every three hours for one year).

In a column for the WQCT, the upper shows Class 1 and the lower Class 2.

Figure 9 How to See the Figures Showing the Simulation Results

	Figures Showing the Simulation Results	Description
		• This figure shows the concentration distribution on the water surface at a certain time (in this case at 12:00 on July 1) and varies momentarily.
BL106 Pedreira		・This figure shows the profile at each monitoring point during the simulation period of one year. ・The monitoring points are shown in **Figure 17.1.1**. ・The grey zone in the lower portion indicates that the bed is shallower the datum level.
BL101 Confluência		
BL105 Taquacetuba		
BLsum Summit		
Class 1 ≤10 µg/L ***Class 2 ≤30 µg/L***		• This histogram shows the occurrence frequency distribution in % every three hours during a simulation period of one year with a horizontal axis of concentration and a vertical axis of frequency. • "Class" in the left shows the 2025 WQCT for Class 1 for the particular parameter. • The figures on the right top show the median, 10% value and 90% value, respectively.

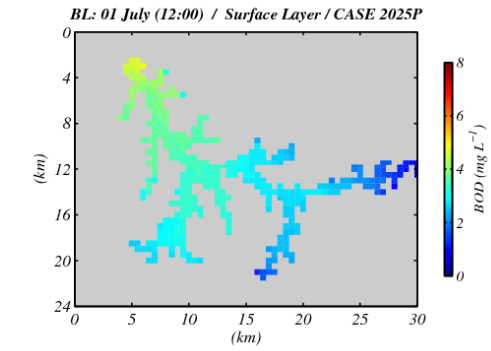
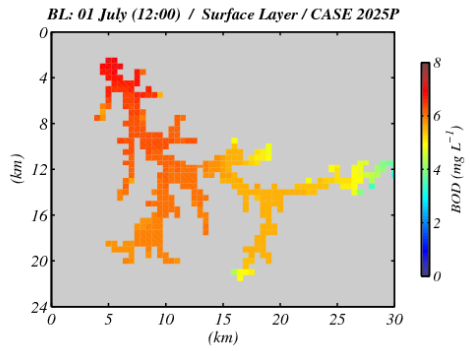
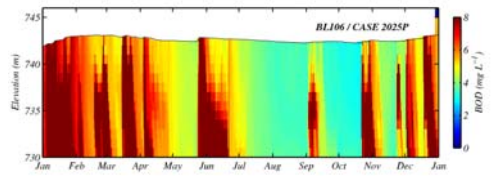
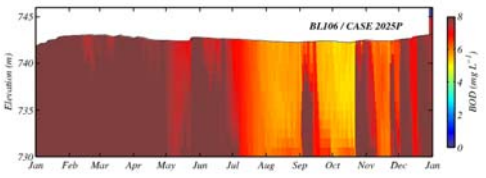
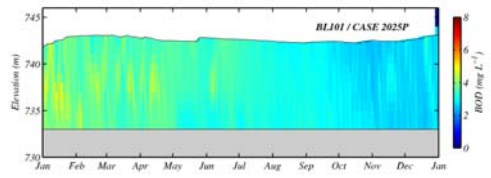
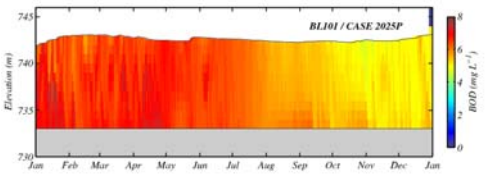
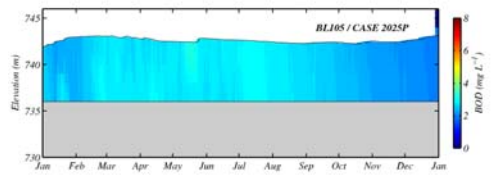
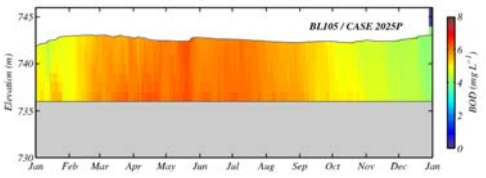
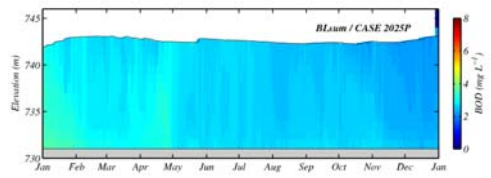
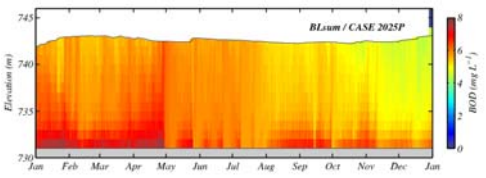
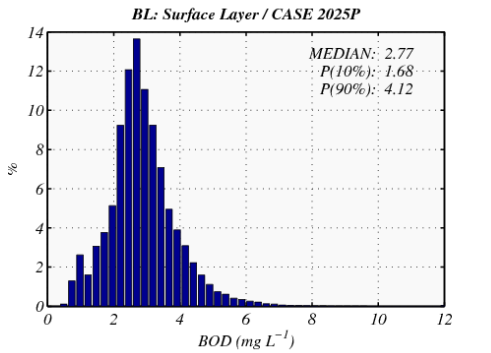
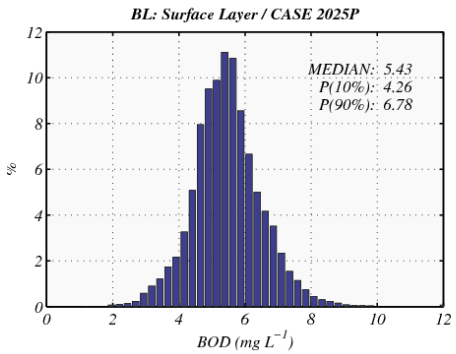
	Moderate Elution	***High Elution***
		
Pedreira		
Confluência		
Taquacetuba		
Summit		
Class 1 ***≤ 3 mg/L*** ***Class 2*** ***≤ 5 mg/L***		
Watching the profiles for the simulation period at the moderate elution rate, the concentration in the Taquacetuba Arm and Summit Dam is stable at 2 to 4 mg/L throughout a year.		

Figure 10(1) Attainment status of **WQCTs** for the Lake Billings

(BOD_5 in 2025 with sewerage construction)

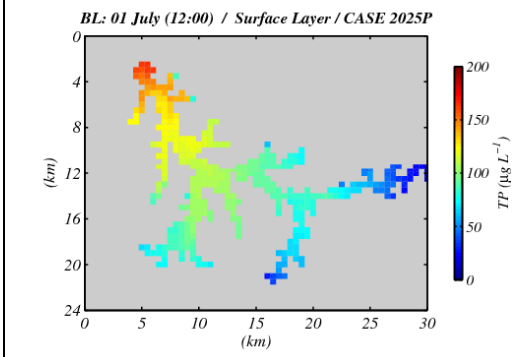
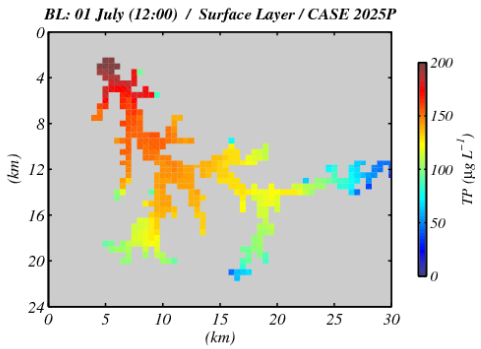
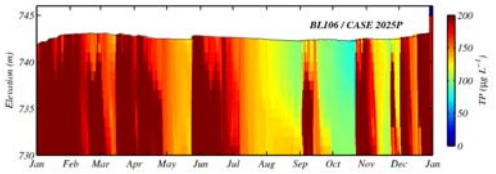
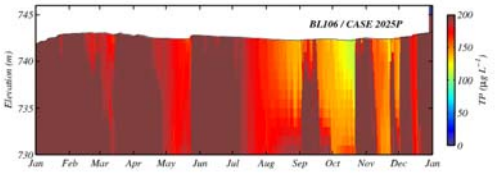
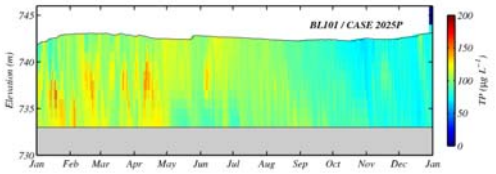
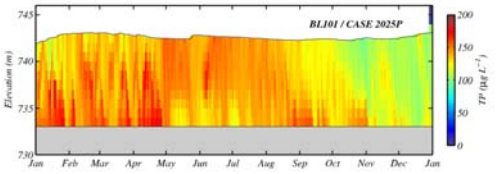
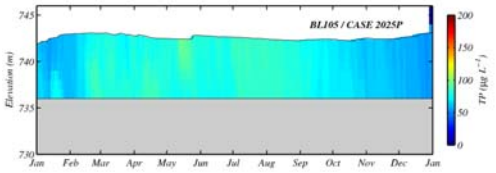
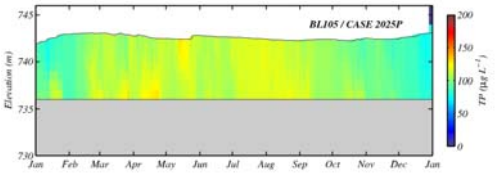
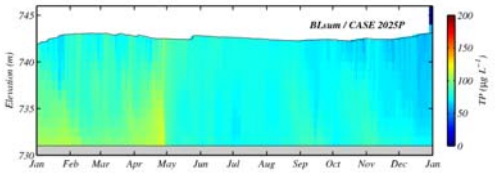
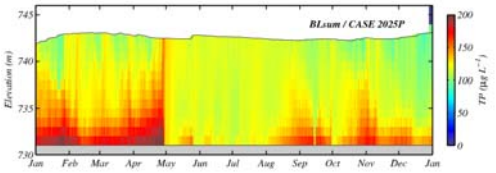
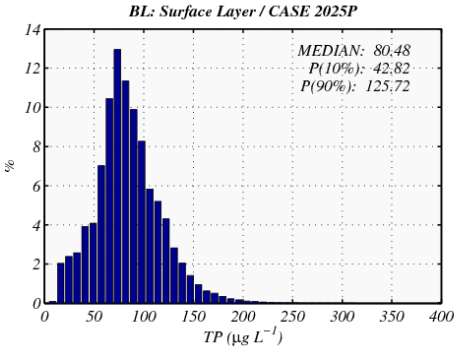
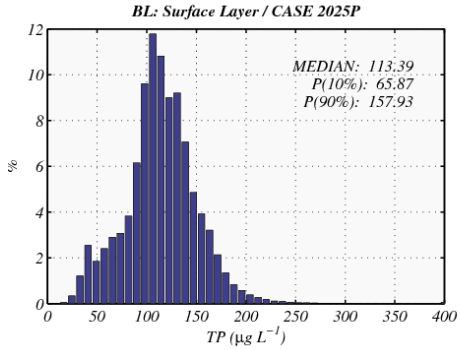
	Moderate Elution	***High Elution***
		
Pedreira		
Confluência		
Taquacetuba		
Summit		
Class 1 ***≥ 20 µg/L*** ***Class 2*** ***≥ 30 µg/L***		
The concentration of TP is in a level of 80 µg/L even in 2025, far from the 2015 WQCT of 30µg/L for Class 2.		

Figure 10(2) Attainment status of **WQCTs** for the Lake Billings

(TP in 2025 with sewerage construction)

(2) Rio Grande Arm

The simulation results by parameter such as BOD_5, DO, chlorophyll-a, NH_4-N、PO_4-P and TP) is shown in **Table 9** and summarized below.

Table 9 Attainment status of **WQCTs** for the Rio Grande Arm

Parameter	Elusion rate	2005	2015		2025		2025 WQCT
			w/o Project	w/ Project	w/o Project	w/ Project	
Chla	Moderate	53.80	57.05	***24.34***	59.94	**15.43**	≤30μg/L
(μg/L)	High	52.05	52.01	***27.15***	54.09	**20.78**	≤10μg/L
BOD_5	Moderate	**3.79**	**3.94**	**1.26**	**4.26**	**0.83**	≤5mg/L
(mg/L)	High	5.84	5.56	**2.39**	5.89	**1.79**	≤3mg/L
DO	Moderate	**7.46**	**7.49**	**7.42**	**7.50**	**7.40**	≥5mg/L
(mg/L)	High	**7.18**	**7.21**	**7.12**	**7.21**	**7.09**	≥6mg/L
NH_4-N	Moderate	**44.86**	**45.59**	**16.90**	**48.67**	**11.14**	≤500μg/L
(μg/L)	High	**52.05**	**53.55**	**27.15**	**56.91**	**20.78**	≤500μg/L
PO_4-P	Moderate	1.55	1.70	0.82	1.86	0.70	—
(μg/L)	High	1.42	1.44	0.77	1.54	0.68	—
TP	Moderate	52.07	55.57	**17.03**	60.57	**10.51**	≤30μg/L
(μg/L)	High	77.02	75.30	**28.88**	81.41	**21.23**	≤20μg/L

Legend: **1.0** Attain WQCT for Class 1 **1.0** Attain WQCT for Class 2

Note: Values show the average of water quality at all water surface cells (every three hours for one year).

In a column for the WQCT, the upper shows Class 1 and the lower Class 2.

At the moderate elution rate:

Chlorophyll-a

- The concentration distribution on the water surface is considerably improved in the year of 2005, 2015 and 2025 stepwise.
- The concentration clears the 2015 WQCT for Class 2 and an environmental standard for Class 2 in 2015 and is very close to 10 μg/L for Class 1 in 2025
- The daily fluctuation shows high values of 80 to 100μg/L at RG03 for April to September but drops to 30μg/L for January to June at RG01.

BOD_5

- The pollution is outstanding near the estuary of the Ribeirao Pires.
- The concentration distribution on the water surface is considerably improved in the year of 2005, 2015 and 2025 stepwise.
- The distribution width on the histograms becomes narrower showing homogeneous improvement of the lake as a whole.
- The 2025 WQCT for Class 1 is cleared in 2015.
- The daily fluctuation shows high values of 8mg/L at RG03 except for May to June but drops to 2mg/L at RG01.

DO

- Although the higher concentration is better in terms of DO, the concentration distribution drops gradually in the year of 2005, 2015 and 2025 stepwise.
- The median of DO clears the 2025 WQCT for Class 1 since 2005.

NH_4-N

- The concentration distribution is always stable as below 100μg/L for the year of 2005,
- The elution from bottom sediments is observed for January to April and September to December at all monitoring points, which shows a high value of 500μg/L at the highest.
- The median of DO clears the environmental standard for Class 1since 2005.
- The median of DO drops to 11.14μg/L in 2025 by the progress of homogeneity as a whole.

PO_4-P

- The concentration distribution is improved in 2005, 2015 and 2025 stepwise, but the water quality of the downstream is worse.
- The elution from bottom sediments is observed for January to April and August to December at all monitoring points, which shows a high value of 20μg/L at the highest.
- The daily fluctuation shows high values of 80 to 100μg/L at RG03 for April to September but drops to 30μg/L at RG01 for January to June.

TP

- The concentration distribution is improved in 2005, 2015 and 2025 stepwise,
- The TP concentration clears the 2025 WQCT for Class 1 in 2015.

(3) Affect on water quality of the Lake Billings by continuous pumping of the Pinheiros River water

The purpose of the present Study is to control the water pollution in the Lake Billings and to maintain the use of lake water as a source for water supply. The plan for continuous

pumping of the Pinheiros River water after treatment is expected to lead to the result against the purpose with the following fear:

- The simulation result for continuous pumping of the Pinheiros River water shows a big influence on the water quality at the intake point in the Taquacetuba Arm.
- The Pinheiros River water is categorized into treated sewage. There is a fear of safety when it is used for a drinking water source with a mixing rate of about 78%.
- The BOD_5 load to be brought into the Lake Billings through continuous pumping of the Pinheiros River water is almost equal to the load by domestic sewage currently discharged therein. Therefore, it is doubtful of its improvement effect, since there is almost no change in BOD_5 load reduction, even though the sewerage will be provided and almost sewage will be conveyed to the outside of the lake basin.
- The floatation treatment is definitive in pollutant removal.

Hence, it is desirable to be fully discussed in Brazil regarding the issue on continuous pumping of the Pinheiros River water from the viewpoint of risk and safety as a drinking water source.

The simulation results are shown in **Figure 11** and **Table 10**, which are summarized below.

Watching the concentration of BOD_5 representing the magnitude of pollutant load into the Lake Billings and situation of water pollution therein, it is found that the case of emergency pumping plus continuous pumping worsens the water quality of the lake.

- The BOD_5 concentration in the case of emergency pumping plus continuous pumping is approximately 1.6 times that in the case of emergency pumping all in 2005, 2015 and 2025.
- In the case of emergency pumping, BOD_5 is over the 2025 WQCT for Class 2 in 2005, but clears that for Class 1 both in 2015 and 2025 by the effect of sewerage construction.
- In the case of emergency pumping plus continuous pumping, BOD_5 cannot attain the WQCT for Class 1 all in 2005, 2015 and 2025 in spite of sewerage construction.
- The BOD_5 concentration of 4.84 mg/L in 2015 and 4.71 mg/L in 2025 in the case of emergency pumping plus continuous pumping exceed that of 3.40 mg/L in 2005 not sewered. In other words, it means that the effect of sewerage construction is offset in the case of emergency pumping plus continuous pumping.

Other parameters are evaluated as follows:

Chlorophyll-a

- The concentration distribution on the water surface, annual water quality fluctuation at the monitoring points and the distribution width on a histogram show that the case of emergency pumping plus continuous pumping brings the stabler and better results than that of emergency pumping.
- In the case of continuous pumping, the setting of Chlorophyll-a at zero works effectively.
- In the case of emergency pumping plus continuous pumping, the concentration is slightly over the 2025 WQCT for Class 1.

DO

- In case of DO, the higher the better and the case of emergency pumping plus continuous pumping bring adverse effect on water quality.
- The Do concentration is 0.1mg/L in the case of emergency pumping and 4.8mg/L in the case of emergency pumping plus continuous pumping and the latter is rather better. However, the simulation results show that the case of emergency pumping brings the better results than the case of emergency pumping plus continuous pumping. This is presumably caused by the big DO supply by the waves in the Lake Billings, while, in the case of emergency pumping plus continuous pumping, the rise in Do is very slow due to its huge volume
- The both cases meet the 2025 WQCT for Class 1.

NH_4-N

- The difference in water quality pattern of both cases well appears at Pedreira Dam.
- The distribution width on the histograms is remarkably narrower in the case of emergency pumping that the case of emergency pumping plus continuous pumping that suggests the progress of homogeneity as shown in the water surface.
- The case of emergency pumping plus continuous pumping worsens the water quality of the lake obviously.
- As long as the concentration distribution on the water surface is observed, both cases clear the the environmental standards for Class 1.
- The elution from bottom sediments is observed during September to April.

PO_4-P

- The concentration distribution on the water surface, annual water quality fluctuation at the monitoring points and the distribution width on a histogram show that the case of emergency pumping plus continuous pumping brings the stabler and better results than that of emergency pumping.

- The elution from bottom sediments is observed during September to April.

TP

- Although the loading by emergency pumping is same in both cases, the TP concentration is lower in emergency pumping plus continuous pumping due to dilution effect by continuous pumping.
- The concentration distribution on the water surface, annual water quality fluctuation at the monitoring points and the distribution width on a histogram show that the case of emergency pumping plus continuous pumping brings the stabler and better results than that of emergency pumping.
- Even in the case of emergency pumping plus continuous pumping with better water quality, the TP concentration is high as 80 μg/L and far from the 2025 WQCT for Class 2.

Billings - BOD_5 - 2025

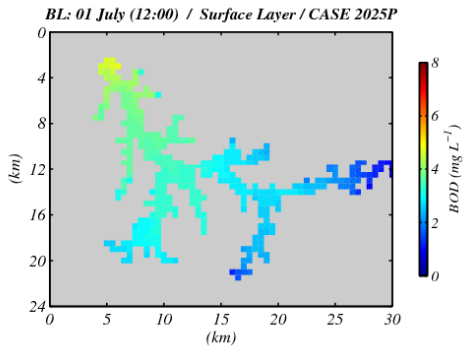
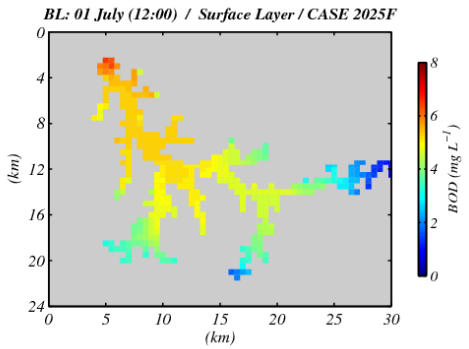
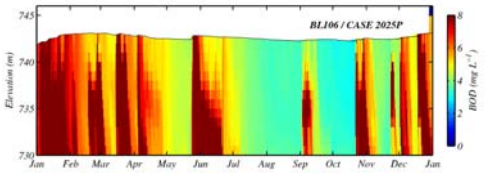
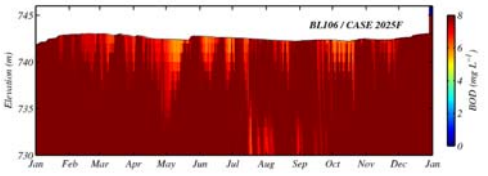
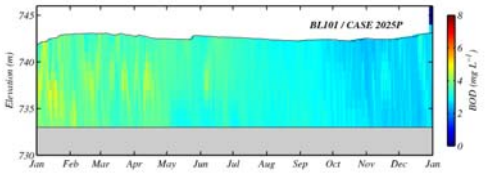
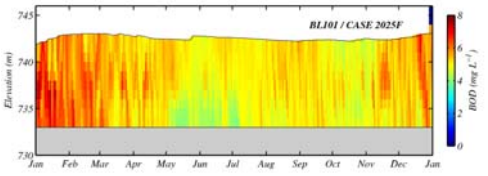
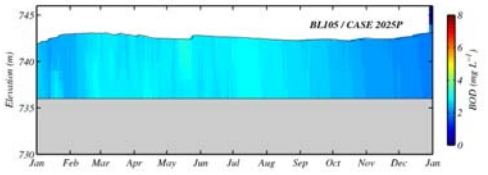
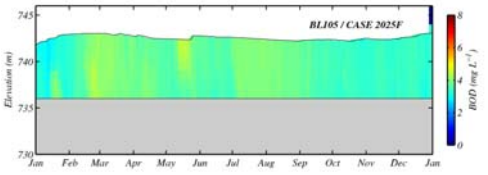
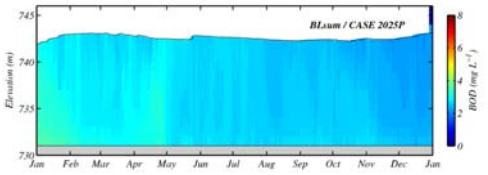
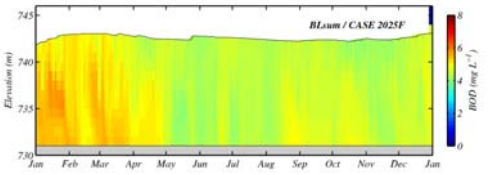
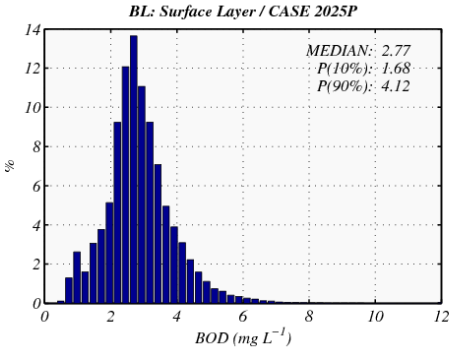
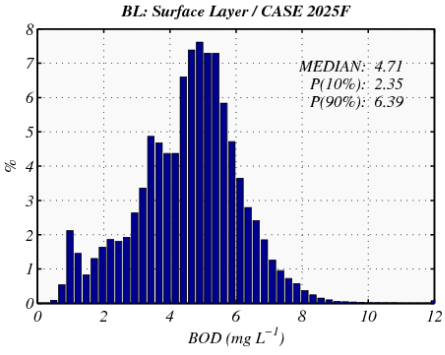
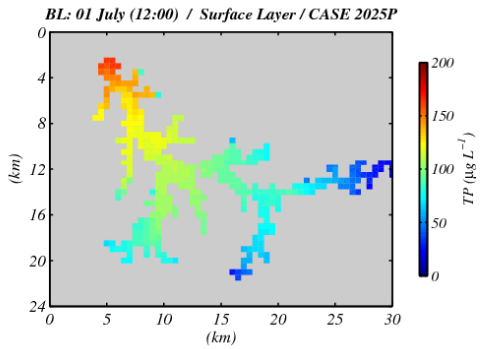
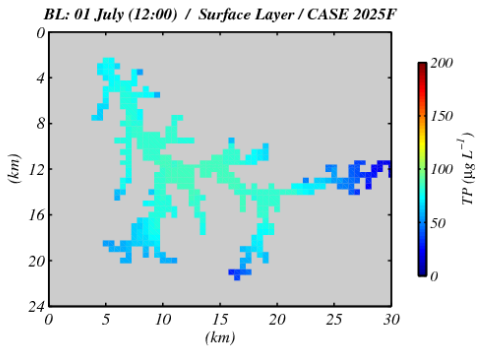
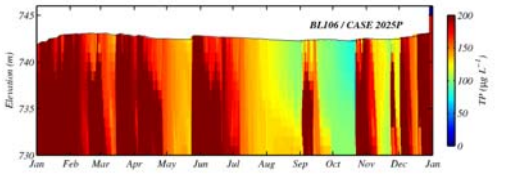
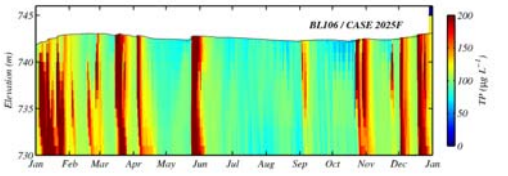
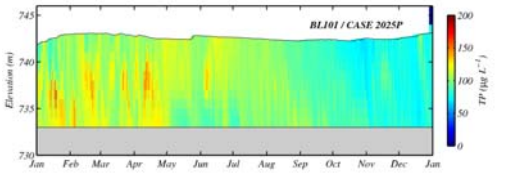
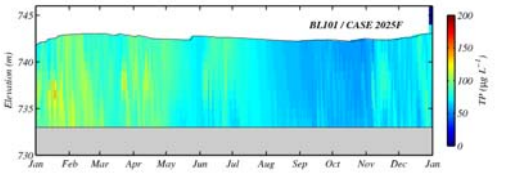
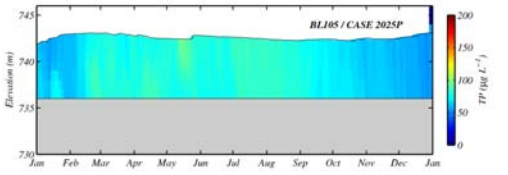
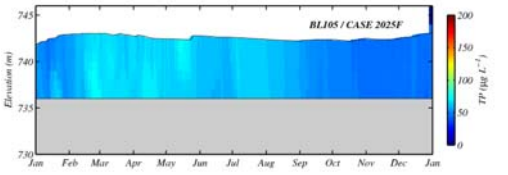
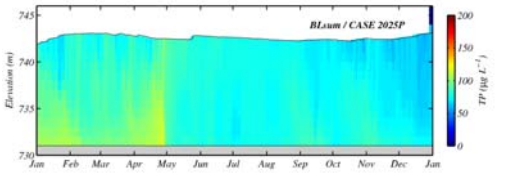
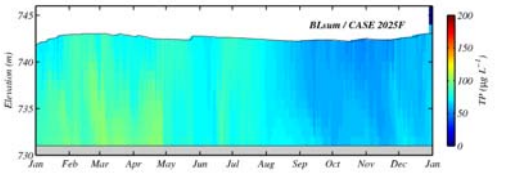
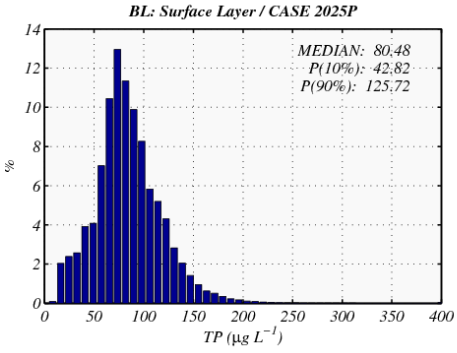
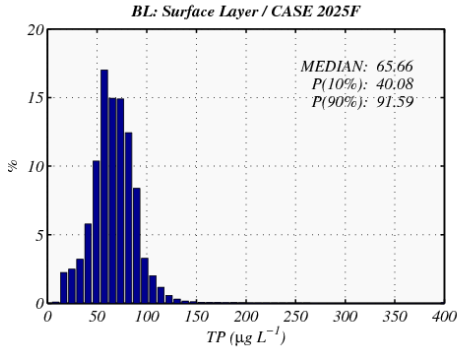
	Emergency pumping	Emergency pumping + Continuous pumping
		
Pedreira		
Confluência		
Taquacetuba		
Summit		
Class 1 ***≤ 3 mg/L*** ***Class 2*** ***≤ 5 mg/L***		
The difference of water quality between both cases is clear especially at Pedreira Dam where the high concentration of BOD_5 appears intermittently in the case of emergency pumping and continuously in the case of emergency pumping plus continuous pumping		

Figure 11(1) Attainment status of WQCTs for the Lake Billings (BOD_5)

Billings - TP - 2025

	Emergency pumping	Emergency pumping + Continuous pumping
		
Pedreira		
Confluência		
Taquacetuba		
Summit		
Class 1 ***≥ 20 µg/L*** ***Class 2*** ***≥ 30 µg/L***		

The concentration distribution on the water surface, annual water quality fluctuation at the monitoring points and the distribution width on a histogram show that the case of emergency pumping plus continuous pumping brings the stabler and better results than that of emergency pumping.

Figure 11(2) Attainment status of WQCTs for the Lake Billings (TP)

Table 10 Attainment status of WQCTs

	Pumping pattern	Concentration			2025 WQCT
		2005 Unsewered	2015 Sewered	2025 Sewered	
Chl-a	Emergency pumping	70.96	62.76	59.74	≤30μg/L
	Emergency pumping + Continuous pumping	33.34	31.53	30.66	≤10μg/L
BOD_5	Emergency pumping	**3.40**	**2.91**	**2.77**	≤5mg/L
	Emergency pumping + Continuous pumping	5.32	**4.84**	**4.71**	≤3mg/L
OD	Emergency pumping	**6.82**	**6.76**	**6.73**	≥5mg/L
	Emergency pumping + Continuous pumping	**6.16**	**6.11**	**6.10**	≥6mg/L
NH_4-N	Emergency pumping	**27.52**	**24.63**	**23.26**	≤500μg/L
	Emergency pumping + Continuous pumping	**106.06**	**103.01**	**101.54**	≤500μg/L
PO_4-P	Emergency pumping	3.67	2.69	2.43	—
	Emergency pumping + Continuous pumping	1.61	1.48	1.42	—
TP	Emergency pumping	101.24	85.23	80.48	≤30μg/L
	Emergency pumping + Continuous pumping	77.25	68.39	65.66	≤20μg/L

Legend: **1.0** Attain WQCT for Class 1 **1.0** Attain WQCT for Class 2

Note: Values show the average of water quality at all water surface cells (every three hours for one year).

In a column for the WQCT, the upper shows Class 1 and the lower Class 2.

16 Project Evaluation

The projects proposed for basin improvement of the Lake Billings are evaluated from the viewpoints of financial, socioeconomic, technical, organizational and institutional, and environmental aspects.

(1) Financial

The projects that can expect the income out of all the projects proposed in the M/P are only the sewerage construction in the urban areas and the isolated communities which share 89% of the total project cost. For this reason, financial analysis is conducted only for sewerage projects. The FIRRs calculated are 2.0% for the urban areas, 0.1% for the isolated

communities and 1.9% for their integration. The sewerage construction in the isolated communities has less financial viability, but that in the urban areas has viability by taking measures such the raise in sewage charge. The key for business success is to maintain a high collection rate of sewage charge through the improvement of the people's awareness.

When the performance of the Rio Grande Water Treatment Plant with an intake from the Rio Grande Arm is compared with that of the Guarau Water Treatment Plant with an intake from the different river basin of which the water quality is relatively good, it is found that the chemical consumption at Rio Grande is approximately two times that at Guarau according to the data of chemicals including oxidizing reagent and algaecide and clear water production volume. From this fact, it is assumed that the worse the water quality the more the production cost, or the annual unit cost of production will increase from the present 0.5 R$/$m^3$ to double or 1.0 R$/$m^3$ in 2025 in case of "without Project", while will be 40% down to 0.3 R$/$m^3$ in case of "with Project". The EIRR calculated is 6.3% and the project can be said to be economically viable.

(2) Socioeconomic

The implementation of the projects proposed in the present study bring the following obvious socioeconomic benefit in addition to the protection of rich nature, supply of safe water and the provision of rest place through the improvement of basin environment of the Lake Billings towards "Coexistence of Water, Human and Green":

- Increase in employment opportunity
- Reduction in water treatment cost for supply
- Reduction in removal cost of algae and aquatic plants
- Rise of land cost

It should be noted that the project intends to protect the living of 2.7 million people in the Greater Sao Paulo Region relying their water source on the Lake Billings by protecting its water quality from further deterioration.

(3) Technical

In the present study, as for sewage largely affecting the water quality of the Lake Billings through its discharge without any treatment except for the very limited area within the basin, the optimum sewerage plan was selected through the alternative comparison from the viewpoints of treatment inside the basin or conveyance outside the basin of sewage, layout of facilities, construction method and so on, dividing the study area into the urban areas, isolated communities and others and taking into account the consistency with related programs and superior plans. The water quality requirement to the effluent discharged into the Lake Billings, construction and O&M costs, easiness in O&M are also reviewed. Therefore, the projects proposed in the M/P are technically feasible.

The projects other than sewerage construction are undertaken by the municipalities involved in the basin, but there is less constructional problem in permeable pavement, park provision,

remediation of the former Alvarenga solid waste dumping site, building of the Environmental Centre for Experimental Study and construction of the Water Quality Management Centre. However, due to almost no technical experience in purification of the lake using aquatic plants and dredging of sediments piled in the lake bottom, it is better to advance the study steadily, starting from a pilot or small scale and accumulating the knowledge.

(4) Organizational and Institutional

Out of projects proposed in the M/P, the sewerage construction is undertaken by SABESP of which the State of Sao Paulo is the biggest stockholder. Notwithstanding of its giant scale, SABESP has efficiently operated the facilities in the equivalent level of Japan and Korea internationally. There is, therefore, no problem.

Other projects than sewerage construction such as permeable pavement, park provision, remediation of the former Alvarenga solid waste dumping site, building of the environmental centre for experimental study and construction of the water quality management centre are undertaken by the municipalities involved in the basin such as Sao Bernordo do Campo. The municipality has already sufficient experience and organization to implement the projects for permeable pavement, park provision and remediation of the former Alvarenga solid waste dumping site.

The operation of the environmental center for experimental study and the water quality management center is the quite new projects and need the staff recruitment. As various people have concerns for the Lake Billings as represented in the “Seminário Billings 2002”, the preservation of human resources will be possible, if opening positions extensively, and to obtain the cooperation of volunteers. It is recommended to collect the public opinion widely in constructing and operating these facilities as the activity base for basin environment improvement of the Lake Billings.

Although the lake purification using aquatic plants is also a new experience, it is possible to manage it, starting from an experimental unit to study the know-how in cooperation with the university and institution step-by-step

It is expected that the dredging of sediments piled in the lake bottom requires a huge amount of cost and time, therefore the start from limited implementation is recommended in order to study the experience.

(5) Environmental

In the present study, the screening was conducted in line with the JICA Guideline for Environment taking into account the requirements in the environmental impact assessment licensing system in the Brazilian side. As a result, each project is not classified into Category A (The project gives serious affect on the environment and society.), but into Category B (The project gives a little affect on the environment and society in comparison with Category A.).

Under the EIA system in Brazil, the preparation of EIA/RIMA, procedures after preliminary environment license, and acquisition of environmental license for treatment, conveyance and disposal of dredged sediments are required for the dredging of sediments piled in the lake

bottom. For other projects than the above, there is no necessity to prepare the EIA/RIMA.

As this projects aim at improving the basin environment of the Lake Billings, the projects accompanied with works is mainly undertaken by the administrative sides and the activities for environmental improvement is done by stakeholders such as community and civic associations, schools, etc. in cooperation with the administrative sides. It goes without saying that such projects and activities will be done so as to minimize the environmental impact.

(6) Overall Evaluation

Based on the reviews above-mentioned, the projects proposed are considered reasonable for implementation in light of financial, socioeconomic, technical, organizational and institutional and environmental aspects.

PART III: FEASIBILITY STUDY

17 Selection of Priority Project

As the projects for basin environment improvement of the Lake Billings, the following projects are proposed by purpose.

1) Improvement of water quality

   - Sewerage construction in the urban areas

   - Sewerage construction in the isolated communities

2) Restoration of water quantity

   - Permeable pavement

   - Park provision

   - Remediation of former Alvarenga solid waste dumping site

   Note: The remediation of the former Alvarenga solid waste dumping site has initially a fear of inclusion of heavy metals in its leachate

3) Lake purification

   - Dredging of sediments piled in the lake bottom

   - Installation of a pilot plant using aquatic plants

4) Strengthening of combination among water, human and green

   - Construction of the Environmental Centre

5) Study and research

   - Construction of the Water Quality Management Centre

The selection of priority projects shall be done with the following three steps. That is to say, each project is evaluated from the viewpoint of emergency, effect and response to negative impact at the first step and possibility of realization at the second step. If the project passes both steps, it shall be acknowledged as a priority project, even though the evaluation score in each stage is low.

1) First step: Evaluation based on emergency, effect and response to negative impact

2) Second step: Evaluation based on possibility of realization, or acquisition of site and EIA/RIMA)

3) Third step: To pass both steps

The evaluation results to select the priority projects are shown in **Tables 11 and 12**.

Table 11 Selection of Prioriyu Projects for the Feasibility Study (F/S)

	First stage					Second stage				Third stage
	Emer.	Effect	Neg. impact	Sub-total	Eval. (≥5)	Land acquis.	Environ. lisence	Sub-total	Eval. (≥4)	Overall judg.
Permeable pavement	1	2	2	5	○	2	3	5	○	◎
Prov. of the Alvarenga Park	2	1	2	5	○	3	3	6	○	◎
Imp. of the former Alvarenga solid waste dumping site	2	1	2	5	○	3	3	6	○	◎
Sewerage prov. in the urban areas	3	3	2	7	○	2	3	5	○	◎
Sewerage prov. in the isolated comm.	2	3	2	7	○	3	2	5	○	◎
Dredging of sediments	2	2	1	5	○	1	1	2		
Lake purification	2	1	2	5	○	2	2	4	○	◎
Environ. center for exp. study	3	3	3	9	○	3	3	6	○	◎
Water quality management centre	2	3	3	8	○	2	2	4	○	◎

Note: The meaning of scores is as follows: 3: high or easy, 2: moderate, 1: low or difficult
The evaluation for emergency and effect is based on the relative evaluation within the identical purpose.

From **Table 11**, the priority projects selected are as follows:

1) Sewerage construction in the urban areas
2) Sewerage construction in the isolated communities
3) Permeable pavement
4) Park provision
5) Remediation of former Alvarenga solid waste dumping site
6) Installation of a pilot plant using aquatic plants
7) Construction of the Environmental Centre
8) Construction of the Water Quality Management Centre

Table 12 Evaluation of emergency, effect and possibility of realization by project

Project	First step: emergency & effect		Second step: possibility of realization	
	emergency	effect	Land acquisition	Environmental license
Restoration of water quality				
Sewerage construction in the urban areas	Urban domestic sewage is the biggest pollution source.	Very effective due to conveyance of sewage outside the basin that makes a load zero in the basin. Load reduction: 15.95 ton/day[1)]	Condemnation and use of private land is required along the Couros Trunk Sewer.	Not necessary for EIA/RIMA, but requires procedures after application of construction license (LI)
Sewerage construction in the isolated communities	Domestic sewage in the isolated communities is the secondly biggest pollution source.	Effective due to phosphorous-removable secondary treatment. Load reduction: 2.07 ton/day[2)]	No problem in land acquisition for reconstruction of Riacho Grande WWTP and construction of Santa Cruz WWTP.	Not necessary for EIA/RIMA, but requirs submission of RAP to DAIA or CETESB that issues the licenses such as LP, LI and LO.
Restoration of water quantity				
Permeable pavement		Big effect for groundwater recharge Reduction of runoff Protection of unpaved roads from erosion	No condemnation for permeable pavement.	Not necessary for EIA/RIMA
Construction of Parks and Greens	If it is left as it is, there is a fear of formation of a favera.	Effective for groundwater recharge	No problem in land acquisition.	Not necessary for EIA/RIMA
Inprovement of the former Alvarenga solid waste dumping site	If it is left as it is, there is a fear of formation of a favera. The slope has a risk of collapse	Effective for groundwater recharge	The present favela is included in the existing relocation progarmme. No relocation of residents	Not necessary for EIA/RIMA The particular area is designated as a polluted area requiring a survey for pollution area management by CETESB.
Lake purification				
Dredging of sediments piled in the lake bottom	Sediments have piled with a thickness of 30 to 50 cm over the whole area.	The effect is not clear by partial dredging. Emergency pumping is continued in the future.	Necessary for the EMAE' approval	Necessary for EIA/RIMA and procedures after application of construction license (LI) as well as a license for treatment, conveyance and disposal of dredged sediments.
Installation of a pilot plant for lake purification using aquatic plants	Necessary for an experimental approach	Ideal due to use of natural purification function, if it works well.	Necessary for the EMAE' approval	Not necessary for EIA/RIMA but requires confirmation at the implementation stage.
Strengthening of combination				

among water, human and green				
Construction of the Environmental Center	The earlier public enlightenment and environmental calculation, the better	Effective as the place for public enlightenment and environmental calculation. Expected to be a symbol for the basin of the Lake Billings.	No problem due to construction at the municipality-owned park.	Not necessary for EIA/RIMA.
Study and Research				
Construction of the Water Quality Management Centre	No check of the pollution status in arms and streams at present.	Effective to check the conditions of arms and streams. Make studies for lake purification possible.	No problem due to construction at the municipality-owned park.	Not necessary for EIA/RIMA.

1) Design population of Sao Bernardo do Campo in 2025: 295,331, per capita pollutant load: 54 g/capita/day

295,331 x 54 = 15.948 ton/day

2) Design population of Riacho Grande (SBC) in 2025: 37,159 (7,135 m^3/day) and Santa Cruz (SBC): 4,041 (776 m^3/日), per capita pollutant load: 54 g/capita/day, target effluent BOD_5: 20 mg/L

(37,159 + 4,041) x 54 - (7,135 + 776) x 20 = 2.225 - 0.158 = 2.067 ton/day

18 Priority Projects

(1) Sewerage construction in the urban areas

Domestic sewage generated from densely inhabited Alvarenga and Lavras Districts in the northern basin of the Lake Billings is collected for conveyance to the ABC Sewage Treatment Plant outside the basin by pumping to Estrada Takagi – Couros Trunk Sewers running in the Couros River basin which have not yet been constructed. The construction works include that of sub-trunk sewers in the Couros River basin as well as a sewage collection system by the public chambers on the roads for house connection in the lake basin.

Imigrantes Sub-trunk	ø400-1,000 mm	4.4 km
Estrada Takagi Sub-trunk	ø250-900 mm	2.3 km
Couros Trunk	ø250-1,200 mm	4.4 km
Sub- trunk mains connected to the Couros Trunk		
	Ø250-500 mm	21.8 km
Sewage collection system	Ø250-600 mm m	104.2 km
Main pumping station	3 locations	
Pumping station	6 locations	
Manhole pumping station	72 units	

(2) Sewerage construction in the isolated communities

The existing Riacho Grande Sewage Treatment Plant is reconstructed using the oxidation ditch process with phosphorous removal and its service area is expanded to the surrounding area, Caperinya, Areiao and Jussara Districts. The construction of sewage collection systems other than the surrounding area, of which a sewer system is constructed by a self-fund of SABESP, are included in the proposed project.

Design population in 2025:	38,200
Design sewage flow:	8,700 m^3/day
Sludge handling:	conveyance to the ABC WWTP
	after mechanical dewatering and

A new WWTP is constructed in Santa Cruz District with the same process as that of the Riacho Grande WWTP. The area has been already sewered, but some sewers currently not available are newly installed.

Design population in 2025: 4,000

Design sewage flow: 1,000 m^3/day

The sludge generated in the Santa Cruz WWTP is conveyed to the above Riacho Grande WWTP for joint treatment.

(3) Permeable pavement

For the sub-normal residential areas, their regularization is premised on permeable pavement as well as sewerage construction.

Design area: Lakeside area in the northern basin

Length for permeable pavement: 29.2 km

Drain pit: 202 units

Manhole: 24 units

Length of drains: 2.5 km

Length of housing drains 12.4 km

(4) Construction of the Alvarenga Park

The Alvarenga Sub-trunk in the Alvarenga District is installed along the Alvarenga Stream which is left naturally and needs river course improvement that will be done in the living environment improvement program (PAT-PROSANEAR). In parallel with the works for sub-trunk installation and river course improvement, the park along the Alvarenga Stream will be constructed. The effect of storm water runoff containment and groundwater recharge is expected as the secondary function.

Design area: Alvarenga District

Park area: 21,121 m^2

(5) Remediation of the former Alvarenga solid waster dumping site

The former solid waster dumping site in Alvarenga discharges leachate through partly exposed garbage and with a risk of collapse. For this reason, the remediation work such as embankment, drainage and grass-planting is planned after slope stabilization work. Leachate is collected to a storage tank and then conveyed by a vacuum car to the ABC WWTP under SABESP for treatment. The roads, fence, observatory and outdoor lightening system is provided for maintenance.

Design area:	Alvarenga District
Site area:	25 ha

(6) Construction of the Environmental Centre

Although the Environmental Centre for Experimental Study and the Water Quality Management Centre proposed in the Master Plan are planned to locate adjoiningly in the municipality-owned Estoril Park, but integrated keeping respective functions in the course of discussion with the municipality.

Location:	In the municipality-owned Estoril Park
Structure:	Made of reinforced concrete with partly steel structure
Contents:	Exhibition room, experimental study room, library, study room, canteen, dormitory, laboratory, administrative office, etc.
Instrument	Water quality instrument, ship for floating school, bus for landing school, maintenance vehicles, etc.

(7) Installation of a pilot plant for lake purification using aquatic plants

To collect technical know-how for lake purification based on the natural purification function by aquatic plants, a pilot plant is installed.

Location:	Waters with an area of 2,250 m^2 in front of the existing Pinheirinho WWTP
Material:	Suspended plant such as water hyacinth
Remarks:	A floating fence is provided for protection of plants from scattering.

19 Financial Analysis

The priority projects for basin environment improvement of the Lake Billings are carried out by the Municipality of Sao Bernardo do Campo and SABESP.

Projects to be undertaken by the Municipality of Sao Bernardo do Campo

1) Environmental Center
2) Permeable Pavement

3) Remediation of the former Alvarenga solid waste dumping site

4) Installation of a pilot plant for lake purification using aquatic plants

5) Construction of the Alvarenga Park

Projects to be undertaken by SABESP

1) Sewerage construction in the urban areas

2) Sewerage construction in the isolated communities

(1) Projects to be undertaken by the Municipality of Sao Bernardo do Campo (see **Table 13**)

Table 13 Project Cost for the SBC Projects

	Investment Cost (1000R$)	Share (%)	O&M cost (1000R$)	Share (%)
Environmental Center	8,766	16.6	1,379	85.2
Permeable Pavement	27,691	52.3	2	0.1
Remediation of the former Alvarenga solid waste dumping site	12,803	24.2	128	7.9
Installation of a pilot plant for lake purification using aquatic plants	712	1.3	98	6.1
Construction of the Alvarenga Park	2,942	5.6	11	0.7
Total	52,913	100.0	1,619	100.0

Although application of Yen loan is not decided, assuming the condition of Yen loan, finance source of the projects is sorted. When project cost was estimated, that was divided into Local Currency Potion and Foreign Currency Potion. The foreign currency potion assumed 100% JBIC fund and Local Currency Potion assumed self-fund of SBC 25% and JBIC fund 75%.

The Municipality of Sao Bernardo do Campo has credibility of direct loan based on financial responsibility law according to financial data in 2004. In other words a basic condition to request Yen loan satisfies it.

Table 14 Fund Plan for the SBC Projects

	Investment Cost (1000R$)	SBC fund (1000R$)	Yen loan (1000R$)	Yen loan (1000Yen)
Environmental Center	8,766	1,938	6,827	355,767
Permeable Pavement	27,691	6,470	21,221	1,105,815
Remediation of the former Alvarenga solid waste dumping site	12,803	2,991	9,811	511,267
Installation of a pilot plant for lake purification using aquatic plants	712	166	545	28,416
Construction of the Alvarenga Park	2,942	1,984	958	49,928
Total	52,913	13,550	39,363	2,051,193

(2) Projects to be undertaken by SABESP

1) Sewerage construction in the urban areas

The investment cost is estimated in total at 124,833,000 R$. As for the breakdown, construction cost for Lot-1 54,571,000 R$ (44%), Lot-2 21,660,000 R$ (17%), Lot-3 37,215,000 R$ (30%), consulting fee 9,907,000 R$ (8%), and land cost 1,480,000 R$ (1%).

O&M cost is 1,140,000 R$ every year.

2) Sewerage construction in the isolated communities

The investment cost is estimated in total at 22,752,000 R$. As for the breakdown, Santa Cruz construction cost (including consulting fee, site expropriation cost) is 4,956,000 R$ (22%), and Riacho Grande construction cost (the same as above) is 17,796,000 R$ (78%).

O&M cost increases gradually after operation in 2013, as first year 822,000 R$.

Table 15 Project Cost for SABESP Projects

	Investment Cost (1000R$)	Share (%)	O&M cost (1000R$)	Share (%)
Sewerage construction in the urban areas	124,833	85%	1,140	58%
Sewerage construction in the isolated communities	22,752	15%	822	42%
Total	147,585	100%	1,962	100%

The investment cost of two projects is 147,585,000 R$, and it is served 33,809,000 R$ (23%) by SABESP self-fund and 113,776,000 R$ (5,929,000,000 yen) (77%) by JBIC fund. O&M

cost is funded by only self-fund of SABESP.

Table 16 Fund Plan for SABESP Projects

	Investment Cost (1000R$)	SBC fund (1000R$)	Yen loan (1000R$)	Yen loan (1000Yen)
Sewerage construction in the urban areas	124,833	29,842	94,992	4,950,020
Sewerage construction in the isolated communities	22,752	3,968	18,784	978,833
Total	147,585 100%	33,809 23%	113,776 77%	5,928,852

Cost-Benefit Analysis

Table 17 shows the result of cost-benefit analysis of SABESP projects, assuming 2006 as the base year and project period for 25 years from 2008 as project start to 2033 and 12% as a discount rate.

Table 17 Cost-Benefit Analysis for SABESP Projects

	NPV (1000R$)	B/C ratio	FIRR
Sewerage construction in the urban areas	-34,334	0.45	2.6%
Sewerage construction in the isolated communities	-8,529	0.42	0.1%

For sewerage construction in the urban areas, net present value (NPV) is a minus, and, cost coverage ratio (B/C ratio) is under 1, and financial internal rate of return (FIRR) is 2.6% that means not financially feasible, but exceeds an interest rate of Yen loan. It is necessary to make effort to increase incomes at a higher collection percentage than the assumed collection rate, and to reduce investment cost and O&M cost.

For sewerage construction in the isolated communities, net present value (NPV) is a minus, and, cost coverage ratio (B/C ratio) is under 1, and financial internal rate of return (FIRR) is 0.1% that means worse than sewerage construction in the urban areas. It is necessary to make effort to increase incomes at a higher collection percentage than the assumed collection rate, and to reduce investment cost and O&M cost.

20 Support to the Environmental Impact Assessment

(1) Necessity on Environmental Licenses for Priority Projects

The necessity on environmental licenses based on Sao Paulo State environmental impact assessment legislation and other institutional requirements related to the proposed priority projects was examined through the confirmation with DAIA of SMA and the Division of Environmental License and Evaluation (Departamento de Licenciamento e Avaliacao Ambiental) of SHAMA in SBC. **Table 18** shows the results of above confirmation.

Table 18 Necessity on Environmental Licenses for Priority Projects

Name of Project	Necessity on EIA/RIMA	Requirement on Procedures other than EIA/RIMA
Sewage Treatment Project in Urban Areas	EIA/RIMA is not necessary.	Procedure following upon the application for LI is necessary. Project proponent should submit necessary documents to CETESB, DUSM and DEPRAM who are Sao Paulo state government relevant authorities.
Sewage Treatment Project in Isolated Communities	EIA/RIMA is not necessary.	Project proponent should submit RAP to DAIA or CETESB. DAIA or CETESB shall examine for its approval and licenses for LP, LI and LO.
Permeable Pavement Project	EIA/RIMA is not necessary.	Project proponent should give notice to DUSM and submit necessary documents.
Public Parks and Green Space Development Project	EIA/RIMA is not necessary.	Project proponent should give notice to DUSM and submit necessary documents.
Environmental Remediation Project of Former Alvarenga Open Dumping Site	EIA/RIMA is not necessary.	The project site is designated as contaminated area by CETESB and project proponent should require the survey / study which should follow CETESB's management regulation or the environmental remediation of the contaminated areas.
Pilot Project for Water Purification using Water Plants	EIA/RIMA is not necessary.	The proposed project should require LP, LI and LO. Furthermore, the application procedure with the relevant administration authorities including EMAE is necessary.
Installation of Environmental Protection Center	EIA/RIMA is not necessary.	Project proponent should give notice to DUSM and submit necessary documents.

(2) Possible Environmental and Social Impact caused by Priority Projects

The environmental and social impacts for the priority projects are estimated as shown in **Table 19** which shows the impact level not more significant than category A. The

Environmental Center project, which will not cause significant impact from IEE studies, was excluded for the scoping study.

Table 19 Possible Environmental and Social Impact caused by Priority Projects

No.	Name of Project	Possible Environmental and Social Impact		
		Before Construction	During Construction	During Operation
1	Sewerage construction in the urban areas （Alternative 1）	• Resettlement / land Issue	• Traffic / public infrastructure • Hazard (Accidents caused by construction works)	• Local economy • Noise
2	Sewerage construction in the isolated communities	• Land issue	• Hazard (Accidents caused by construction works)	• Local economy • Solid waste • Odor
3	Permeable Pavement		• Traffic / public infrastructure • Solid waste	
4	Construction of the Alvarenga Park	• Land issue		
5	Remediation of the former Alvarenga dumping site	• Resettlement / land issue	• Hazard (Accidents caused by construction works)	• Hazard
6	Installation of a pilot plant for lake purification using aquatic plants	• Right of use of water area		• Public health • Solid waste • Flora and fauna • Water pollution • Odor

21 Project Evaluation

In the Study on the Environment Improvement in the Catchment Area of the Lake Billings, the following eight projects are selected as the priority projects

(1) Projects to be undertaken by the Municipality of Sao Bernardo do Campo

1) Construction of the Environmental Centre
2) Permeable pavement
3) Park provision
4) Remediation of the former Alvarenga solid waste dumping site
5) Installation of a pilot plant using aquatic plants

(2) Projects to be undertaken by SABESP

1) Sewerage construction in the urban areas
2) Sewerage construction in the isolated communities

Out of the above, the Environmental Centre is an integration of the Environmental Centre for Experimental Study and the Water Quality Management Centre which were proposed in the Master Plan, but combined through a discussion with the Department of Housing and Environment (SHAMA) of the Municipality, since they are planned in adjoining in the municipality-owned Estoril Park.

The priority projects are evaluated from the financial, socio-economic, technical, organizational and institutional and environmental aspects below.

(1) Financial

1) Projects to be undertaken by the Municipality of Sao Bernardo do Campo

The investment cost of five projects is 52,913,000 R$, and it is served 13,550,000 R$ (26%) by SBC self-fund and 39,363,000 R$ (2,050,000,000 yen) (74%) by JBIC fund. O&M cost 1,690,000 R$ per year is funded by only self-fund of SBC.

The Municipality of Sao Bernardo do Campo has credibility of direct loan based on financial responsibility law according to financial data in 2004. In other words a basic condition to request Yen loan satisfies it.

The Environmental Centre has a possibility to get an income. In case of taking it into account, it is not feasible financially, but it may be said that it is possible to carry out if introduced low-interest fund and effective administration.

2) Projects to be undertaken by SABESP

For sewerage construction in the urban areas, net present value (NPV) is a minus, and, cost coverage ratio (B/C ratio) is under 1, and financial internal rate of return (FIRR) is 2.6% that means not financially feasible, but exceeds an interest rate of Yen loan. It is necessary to make effort to increase incomes at a higher collection percentage than the assumed collection rate, and to reduce investment cost and O&M cost.

For sewerage construction in the isolated communities, net present value (NPV) is a minus, and, cost coverage ratio (B/C ratio) is under 1, and financial internal rate of return (FIRR) is 0.1% that means worse than sewerage construction in the urban areas. It is necessary to make effort to increase incomes at a higher collection percentage than the assumed collection rate, and to reduce investment cost and O&M cost.

Sensitivity of an income is high both in sewerage construction in the urban areas and isolated communities. In other words, financial soundness of project is improved by income increasing by environmental educations.

(2) Socio-economic

It should be noted that the goal of this project is to protect the Lake Billings from further water quality deterioration, and to secure the living of the people in the Greater Sao Paulo Region who use the lake as a drinking water source through improvement in water quality. At present, SABESP takes water of 4.7 m^3/sec from the Rio Grande Arm for water supply to 1.60 million people mainly in the ABC Region of the Greater Sao Paulo, and water of 4.0 m^3/sec from the Taquacetuba Arm for 1.14 million people. The water taken from the Taquacetuba Arm is pumped up to the Lake Guarapiranga from which the Alto da Vista Water Treatment Plant takes water of 13.38 m3/sec including 4.0 m3/sec from the above Taquacetuba Arm for water supply to 3.60 million people. Accordingly, the Lake Billings including the Rio Grande Arm is the water source for 2.68 [= 1.60 + 3.60 x (4.0/13.38)] million people. To respond an increase of water demand, SABESP has an expansion plan in which the Rio Pequeno Arm is separated completely from the Lake Billings by the construction of an embankment similar to the Rio Grande Arm and connected by a tunnel to the Rio Grande Arm as well as the augmentation of the Rio Grande Water Treatment Plant. The importance of the Lake Billings as a water source has been even greater now.

In addition to the obvious benefit such as the protection of rich natural environment, supply of safe water and provision of the rest place towards “Coexistence Harmonized with Water, Being and Green”, the Project brings the following socio-economic benefit:

	Executing agency	
	SBC	SABESP
• Increase in employment opportunity	Yes	Yes
• Reduction of treatment cost	No	Yes
• Cost reduction for removal of algae and aquatic plants	No	Yes
• Raise in land cost	Yes	Yes

(3) Technical

1) Projects to be undertaken by the Municipality of Sao Bernardo do Campo

As the biggest pollutant source in the basin of the Lake Billings is domestic sewage which is left to SABESP responsible for the sewerage construction, the Municipality undertakes the project putting an emphasis on the restoration of water quantity, strengthening of combination among water, being and green, and the study and research. The Municipality has much experience in the similar works for permeable pavement, construction of the Alvarenga Park, remediation of the former Alvarenga solid waste dumping site, and the construction of the Environmental Center, without any problem in the construction stage

For the installation of a pilot plant using aquatic plants, it is better to collect overseas and domestic knowledge, and design and construct the facility with scrupulous care. Attention be paid for that aquatic plants is not scattered and lost under construction.

2) Projects to be undertaken by SABESP

For domestic sewage that is currently discharged into the Lake Billings without treatment except for that in the very limited area and give a great affect on water quality of the Lake Billings, the optimum system solution is formulated, taking into account the consistency with the relevant and superior plans, dividing the study area into the urban areas, isolated communities and others, studying a various alternatives including sewage treatment inside and outside the basin (sewage conveyance to the existing ABC WWTP in the Tamanuduatei River basin), arrangement of sewerage facilities, construction method and so on.

For the sewerage construction in the urban areas, the plan to convey sewage in the basin to the existing ABC WWTP is adopted, which makes a runoff load into the lake zero.

For the sewerage construction in the isolated communities, the issues on sewage conveyance outside the basin, independent treatment at each community or some integrated communities, on-site treatment by septic tanks are studied and the plan composed of reconstruction of the Riacho Grande WWTP with an expansion of service area and construction of the Santa Cruz

WWTP is adopted. Through the study on the water quality requirement for the Lake Billings, costs for construction and O&M, easiness in O&M, etc., the oxidation ditch process with phosphorous removal is finally selected.

The attainment status of the water quality conservation targets through measures the sewerage construction in both the urban area and isolated communities was verified using the mathematical model. The results shows that the parameters of BOD_5, DO and NH_4-N meet the 2025 water quality conservation targets for Class 1, but Chlorophyll-a and TP does no meet even that for Class 2, although they have a possibility to clear it in case of no pumping of the Tiete River water to the Lake Billing. In the Rio Grande Arm, the parameters of BOD_5, DO, NH_4-N and TP meet the 2025 water quality conservation targets for Class 1 and Chlorophyll-a that for Class 2.

Therefore, the projects proposed in the present study are technically feasible.

(4) Organizational and Institutional

1) Projects to be undertaken by the Municipality of Sao Bernardo do Campo

The Municipality of Sao Bernardo do Campo has already sufficient experience and staff for the operation and maintenance of permeable pavement, construction of the Alvarenga Park and remediation of the former Alvarenga solid waste dumping site, while for the management of the Environmental Centre and the study of lake purification using aquatic plants were new experiences. The many people have concern about the Lake Billings, as represented by "Seminario Billings 2002" and it is considered to be possible to secure the human resources, if recruiting extensively, and to get the cooperation of volunteers. For the construction and management of the Environmental Centre as the base of activities for the basin environment improvement of the Lake Billings, it is recommended to gather the wisdom of many people widely as well as the recruitment of professional staff for the study and research.

2) Projects to be undertaken by SABESP

The sewerage construction is undertaken by SABESP, a ware supply and sewerage service provider, of which the State Government of Sao Paulo is the biggest stockholder. SABESP has been managed efficiently in spite of its great scale and its operation and maintenance is in an almost equivalent level to those of Japan and Korea. Therefore, there is no organizational and institutional problem.

(5) Environmental

The Study aims at basin environment improvement of the Lake Billings and the

implementation of the projects including their construction works is undertaken by the administrative side mainly. But for the activities of basin environment improvement, the cooperation of all stakeholders such as the people, NGOs, schools etc. including the administrative side is proposed in which it goes without saying that attention is paid for to minimize an affect on the environment.

For the projects proposed in this Study, the screening was conducted in accordance with the Guidelines for Environmental and Social Considerations of JICA, taking into account the environmental impact assessment system currently practiced in Brazil. The results show that there is no Category A project that gives severe affect on the environment and society but almost projects are regarded as Category B which gives less affect than Category A.

1) Projects to be undertaken by the Municipality of Sao Bernardo do Campo

The remediation of the former Alvarenga solid waste dumping site requires consideration for slope collapse under construction.

For the installation of a pilot plant for lake purification using aquatic plants, the necessity to get a consent of the EMAE as an owner of the Lake Billings, breeding possibility of dengue-transmitting mosquito at a pilot plant, scattering and growing possibility of water hyacinth to be used at a pilot plant, and reaction of CETESB for the above issues have not been unknown and need confirmation thereon in the future.

2) Projects to be undertaken by SABESP

The installation of the Couros Trunk Sewer along the Couros River avoiding the existing underground utilities and the special construction method adopted in order to detour the existing storm water retarding pond and to change the route from along the Couros River to on the existing road are the most careful portion in the construction work. Other works such as pipe installation and construction of pumping stations are in a category of ordinary works.

As the present Riacho Grande WWTP has been operated using one module out of two, it is possible to reconstruct it without a stoppage of its operation.

(6) Overall Evaluation

Each project proposed has its own problem individually viewing from the financial, socio-economic, technical, operational and institutional and environmental aspects, but they are not fatal in nature. Therefore, the project proposed are justifiable for implementation, if they will be constructed with an attention on the matter pointed out mentioned above.

22 Project Implementation Program

(1) Project implementation program

The implementation schedule is shown in **Figure 12**. The projects will be initiated by the procedures for the international lending agency and domestic institutions in 2007 with a goal to conclude the loan agreement within the same year. The consultants will be selected in 2008 and start the detailed design of the facilities proposed from its mid-year. The contractors will be decided in 2009 to commence the construction works from 2010 and complete them by 2014.

Negotiation with the international lending agency	12 months
Application for COFIEX's approval	12 months
	(parallel works with the above)
Selection of consultants	6 months
Detailed Design	42 months
Construction supervision	60 months
	(parallel works with the detailed design partially)
Selection of contractors	12 months
Construction works	60 months

The reason to take 42 months for the detailed design is attributed to the assumption to start the detailed design for sewerage construction in the urban areas and permeable pavement, watching the progress of the regularization work of sub-normal residential areas included in the study area located in the northern basin of the Lake Billings.

(2) Cost Estimates

The cost estimates are summarized in **Table 20**.

Table 20 Summary of Project Cost for Priority Projects

Agency	Project		R$	Equivalent JY
SBC	Permeable pavement		25,879,000	1,348,500,000
SBC	Remediation of the former Alvarenga solid waste dumping site		11,965,000	623,400,000
SBC	Construction of the Alvarenga Park		1,168,000	60,800,000
SBC	Construction of the Environmental Centre		8,192,000	426,800,000
SBC	Installation of a pilot plant for lake purification using aquatic plant		665000	34,600,000
	Sub-total		47,869,000	2,494,400,000
SABESP	Sewerage construction in the urban areas			
	trunk sewer system		54,571,000	2,843,600,000
	pumping stations and force mains in Area A·		21,660,000	1,128,700,000
	Sewage collection network in Area A-F		37,215,000	1,939,200,000
	Sub-total		113,446,000	5,911,600,000
SABESP	Sewerage construction in the isolated communities			
	Riacho Grande system		16,632,000	866,600,000
	Santa Cruz system		4,430,000	230,800,000
	Sub-total		21,062,000	1,097,500,000
	Sub-total		134,508,000	7,009,200,000
	Total		182,377,000	9,503,600,000
	Consulting services		14,733,000	767,700,000
	Contingency	Construction cost x 0.10	18,238,000	950,300,000
	Land cost		3,388,000	176,500,000
	Grand total		218,736,000	11,398,300,000
SBC	Construction cost		47,869,000	2,494,500,000
	Consulting services		3,352,000	174,700,000
	Contingency	Construction cost x 0.10	4,787,000	249,500,000
	Land cost		1,692,000	88,200,000
	Total		57,700,000	3,006,700,000
SABESP	Construction cost		134,508,000	7,009,200,000
	Consulting services		11,381,000	593,100,000
	Contingency	Construction cost x 0.10	13,451,000	700,900,000
	Land cost		1,696,000	88,400,000
	Total		161,036,000	8,391,600,000
	Grand total		218,736,000	11,398,300,000

R$1=JY 52.11

Figure 12 Project Implementation Program for Basin Environment Improvement of the Lake Billings

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Loan negotiation with an international lending agency		L/A Conclusion							
Domestic procedure including COFIEX's approval									
Procedure for private land use/condemnation									
Regularization of sub-normal residential areas									
Selection of consultants									
Preparation of a shortlist									
Preparation of invitation letters									
Preparation of proposals (45-60 days)									
Evaluation of proposals									
Selection of consultants									
Contract negotiation									
Application for approval of Consultants' contract									
Consulting services									
Detailed design									
Procedure for RAP/EIA approval									
Construction supervision									
Selection of contractors									
Declaration									
Preparation of prequalification documents									
Evaluation of prequalification documents									
Announcement for bidding									
Preparation of bidding documents (more than 45 days)									
Evaluation of bidding documents									
Selection of contractors									
Contract negotiation									
Application for approval of Contractor's contract									
Construction works									
SBC projects									
Permeable pavement									
Construction of the Alvarenga Park									
Remediation of the former solid waste dumping site									
Construction of the Enviromental Centre									
Installation of a pilot plant for lake purification									
SABESP projects									
Installation of Imigrantes-Couros Trunk sewers incl. P/Ss									
Construction of sewage collection system in A-F areas									
Construction of Riacho Grande & Santa Cruz Systems									

23 Conclusion and Recommendation

(1) Raise of sewerage coverage

The biggest pollutant source in the basin of the Lake Billings is domestic sewage, of which only 8% is treated at the sewage treatment plants and the remainder is discharged into the lake without any treatment. Therefore, the first priority should be given to reduce the pollutant loads by domestic sewage in the basin of the Lake Billings. For this reason, the project for sewerage construction in the urban areas and isolated communities is planned so as to connect their laterals to a sewer system immediately, if the residents want, by providing the public inlets in front of their houses.

The subject after project implementation relies on to what extent the sewerage coverage can be raised in the basin of the Lake Billings. According to the environmental and social awareness survey, the people in the basin has less awareness on their contribution to water pollution and low willingness-to-pay for sewage charge, while high concern on their involvement in the activities for basin environment improvement. It suggests the possibility that the people's awareness can be changed if any prompt is given. For this purpose, it is very important for them to feel that they are also ones of polluters and have motivation that they have to connect their lines to a sewer system in the earliest time through the public enlightenment, environmental education and activities of the Association of "Clean the Lake Billings".

It is considered as an effective means to require their connection to a sewer system and payment of sewage charge in the course of regularization of sub-normal residential areas, as described later.

The execution agency of sewerage construction is SABESP, but the public health centre is responsible for the promotion of sewerage coverage. It is recommended, however, that the agencies concerned with such as SABESP, municipalities and the public health centre will cooperate together in the campaign for promotion of the people's connection to a sewer system.

(2) Promotion of regularization of sub-normal residential areas

There is no doubt that the biggest pollutant source in the basin of the Lake Billings is domestic sewage. If the sub-normal residential areas mostly located along the lake are left as they are, the proposed sewerage construction lack finishing touch. For these sub-normal residential areas, their regularization should be promoted with conditions of their connection to a sewer system and payment of sewage charge. The agreement (called TAC) among third parties composed of the community, municipality and environmental prosecutor defines each

responsibility for regularization. But the implementation of sewerage construction by SABESP will alleviate the burden accompanied with each responsibility. Instead, the conditions of their connection to a sewer system and payment of sewage charge is, therefore, fully justifiable and the essential requirements directly concerned with the basin environment improvement of the Lake Billings.

(3) Early establishment of the Association of "Clean the Lake Billings"

Since the basin environment improvement of the Lake Billings is not attainable by the effort of Sao Bernardo do Campo only, it is indispensable for all the stakeholders in the basin to cooperate, share the responsibility and act together toward the goal. For this purpose, the early establishment of the Association of "Clean the Lake Billings" and action of all the stakeholders in a body is required. The ABC Consortium or the regional intercity association is expected to play a role as the base for the Association of "Clean the Lake Billings". Five out of six municipalities involved in the basin excluding Sao Paulo belong to the Consortium as well as other two municipalities such as Caetano de Sur and Maua and also the members of the committee to discuss what the basin of the Lake Billings should be. The mayor of Sao Bernardo do Campo is the present president of the Consortium and in a position to get cooperation easily from other members.

The key for success depends on the participation of Sao Paulo. The Municipality of Sao Bernardo do Campo has the biggest administrative area and water surface area in the basin of the Lake Billings, but Sao Paulo shares 54.3% of the basin population and is the biggest pollutant source in the basin. As no participation of Sao Paulo reduces the effect by half, it is recommended to strongly work Sao Paulo to participate in the activities of the Association of "Clean the Lake Billings".

(4) Joint management of the Environmental Centre

All five projects proposed for the Municipality of Sao Bernardo do Campo produce no income at present and, even though obtaining the loan from international assisting agency, the Municipality has to bear the own burden and repayment of loan and interest for the loan in the investment cost, and operation and maintenance cost for a long term. Among others, the operation and maintenance cost for the Environmental Centre shares 64% in the total O&M cost. The Environmental Centre is able to have an income by its management manner. One approach is to transfer the sole management by the Municipality of Sao Bernardo do Campo to the joint management by the municipalities involved in the basin and to share the expenditures, by opening the use of the Environmental Centre to the basin people. The participation in such a joint management is expected to grow an awareness of solidarity and to

elevate sustainability for basin environment improvement among municipalities.

(5) Experimental approach for lake purification using aquatic plants

According to the experiences in lake purification in Japan, there is sometime less water quality improvement of the lake than expected in spite of the progress of sewerage coverage. Although it may be too early to start the study of lake purification using aquatic plants at a level of 8% in sewerage coverage, such study is not almost done in Brazil and the experimental approach is proposed to collect the know-how thereof in the early stage. The cause that water hyacinth, which is found here and there in the Lake Billings, does not grow explosively, breeding possibility of dengue-transmitting mosquito in the pilot plant, absorption rate of nitrogen and phosphorous by aquatic plants, harvest amount of water hyacinth and its final disposal method will be the possible themes for the study.

(6) Further study on pollutant loads by elution from sediments and dredging of sediments

It is found that a large quantity of sediments piled in the bottom of the Lake Billings. However, the actual situation of pollutant loads by elution from sediments is not clear, since the studies on elution from sediments in the lake have little done in Brazil, which makes it difficult to predict the pollutant loads by elution from sediments accurately. It is a probable result that nitrogen and phosphorous will not attain the water conservation targets, even though constructing sewerage facilities in the basin of the Lake Billings. For this reason, it is indispensable to exert for studying elution from sediments in the lake and for grasping pollutant loads by elution accurately. As the dredging of sediments piled in the lake bottom requires a huge investment and a long time, it should be reviewed based on the results of elution from sediments.

(7) Importance of public enlightenment and environmental education

Once the lake has been polluted, it is difficult to restore its previous water quality. In parallel with implementing the engineering measures, the people in the basin, understanding the importance of the Lake Billings, are required to order their lives according to the rigid rules, or “No discharge, No pollution” so as to share in the bounty of nature. For this reason, it is recommended to conduct public enlightenment and environmental education more than ever sustainably to the people through various channels such as school, community, media, etc.