ANNEX 7.4.1

Annex A7.4.1 **Development of ELCOM-CAEDYM Model**

(1) ELCOM

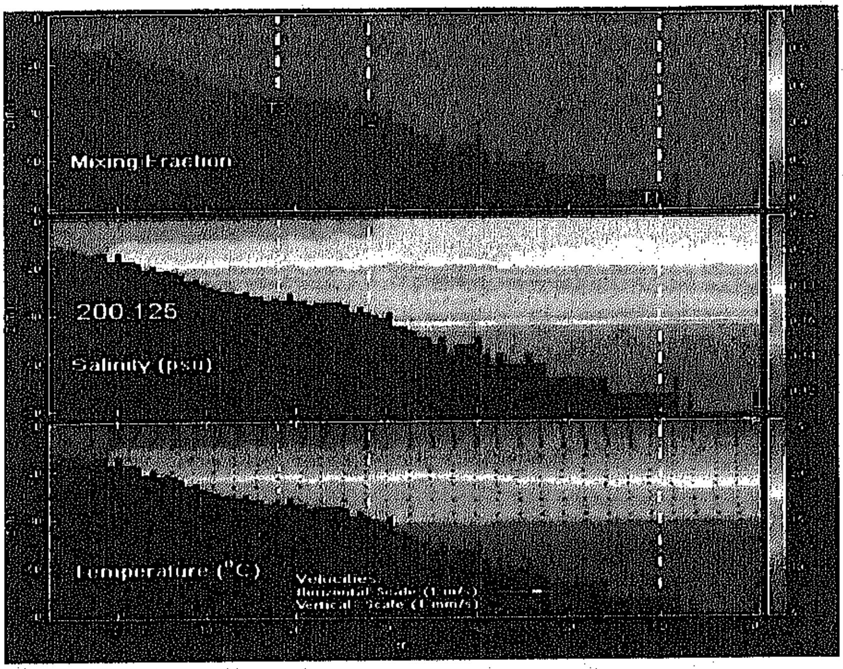


Figure A7.4.1 3D Simulation of Brownlee Reservoir on Snake River, Idaho – EUA. On this study ELCOM was used to investigate the variability of the thickness of the mixing layer as function of the flow regimes.

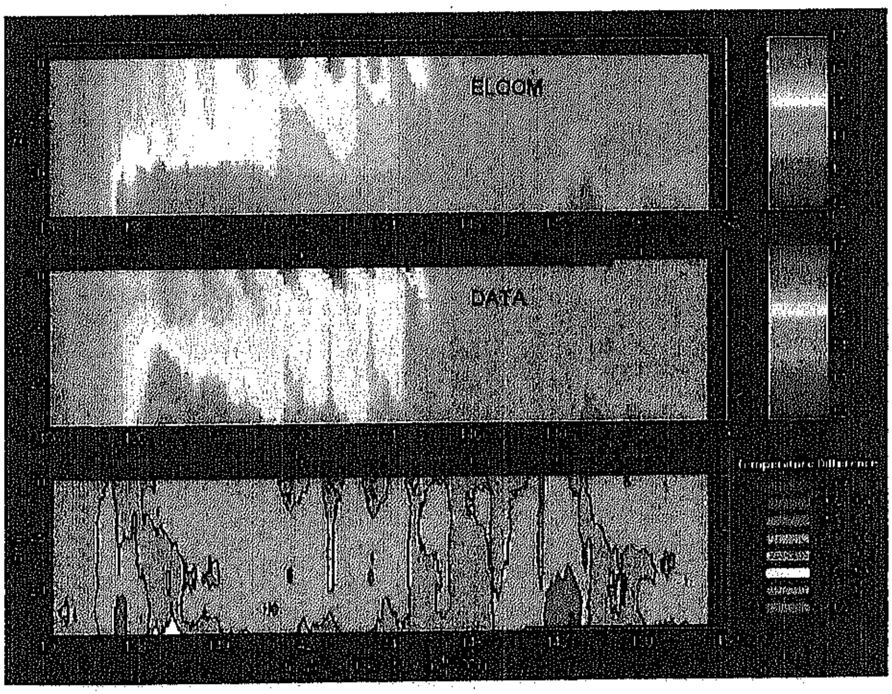


Figure A7.4.2 Simulation of the the thermal structure of Mypong Reservoir, South Australia, showing the even superficial thermoclines over diurnal scales are well represented by the model.

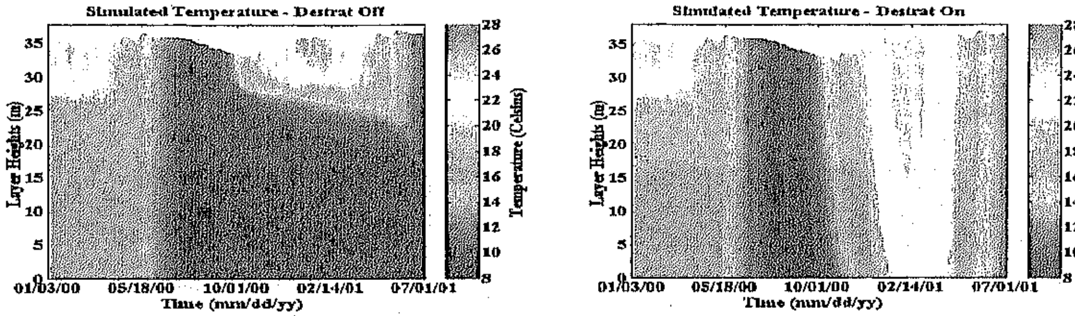


Figure A7.4.3 Simulation of Artificial Destratification on San Roque Reservoir, Argentina.

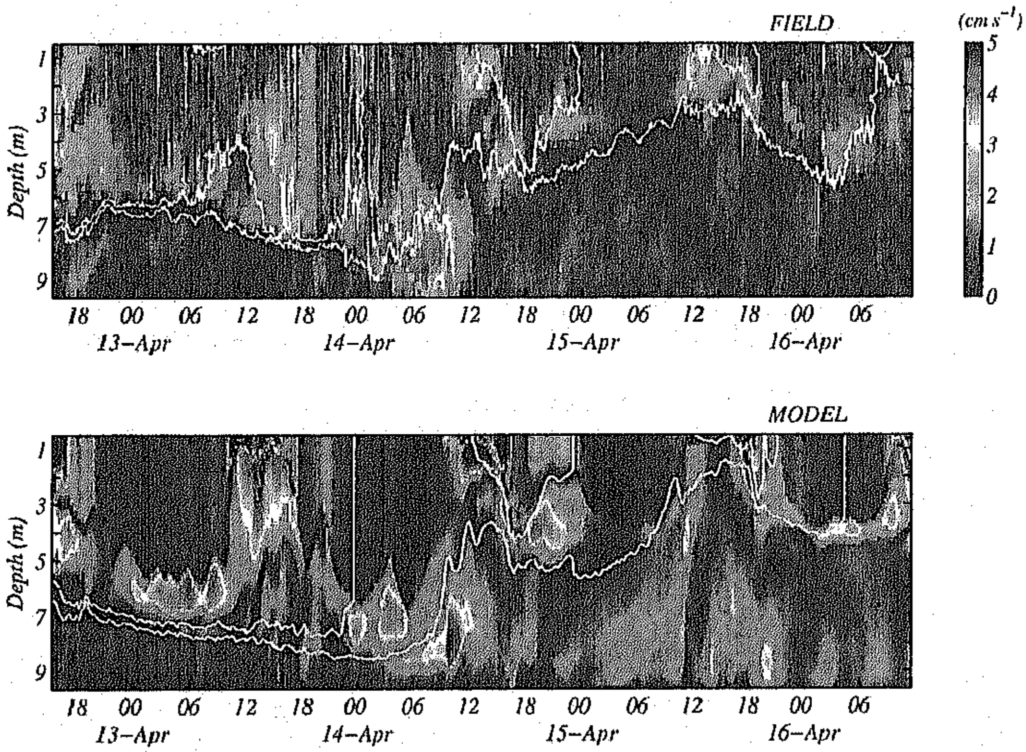


Figure A7.4.4 Comparison of time series of velocity profiles measured at Lobo Reservoir (Brazil) and numerical simulations with ELCOM showing the high precision reached by the model reproducing very short and localized events. The figure also shows on white lines isotherms 26.0 and 25.3°C measured in the field (top panel) and reproduced by ELCOM (bottom panel).

b) CAEDYM

The Computational Aquatic Ecosystem Dynamics Model (CAEDYM) is an aquatic ecological model that may be run independently or coupled with hydrodynamic models DYRESM or ELCOM. CAEDYM consists of a series of mathematical equations representing the major biogeochemical processes influencing water quality. At its most basic, CAEDYM is a set of library subroutines that contain process descriptions for primary production, secondary production, nutrient and metal cycling, and oxygen dynamics. The code is written in modular fashion to support future updates and improvements.

CAEDYM configuration is flexible so that the user can focus on the processes of interest. For example, the model can be configured for a simple set of nutrients-phytoplankton-zooplankton. By simulating several state variables at the species level, CAEDYM can be used to support the understanding and management of a system. In addition, can be coupled to the one-dimensional hydrodynamic model (DYRESM) for studies of the seasonal, annual or decadal variation in water quality. For more detailed spatial information, CAEDYM can be run with the three-dimensional hydrodynamic model ELCOM. To maximize speed and memory requirements CAEDYM shares a common internal data structure with both DYRESM and ELCOM. They also use common output data storage formats, and share common Graphical User Interface (GUI) and visualization routines for configuring the model and displaying the results.

Among the variables simulated by CAEDYM, dissolved oxygen, chlorophyll a, phosphorus (total and filterable), nitrogen (total, ammonia, nitrite, nitrate), carbon (dissolved organic, dissolved inorganic, and particulate organic), iron (total and filterable), manganese, pH, suspended solids, pathogens (such as coliform and Cryptosporidium) and several sediment interactions are the most important to our applications. With CAEDYM is possible to include up to seven groups of phytoplankton as organisms from more elevated trophic levels when there are enough data for model verification. Recently it was included in the model the option to simulate the microbial loop together with the carbon cycle.

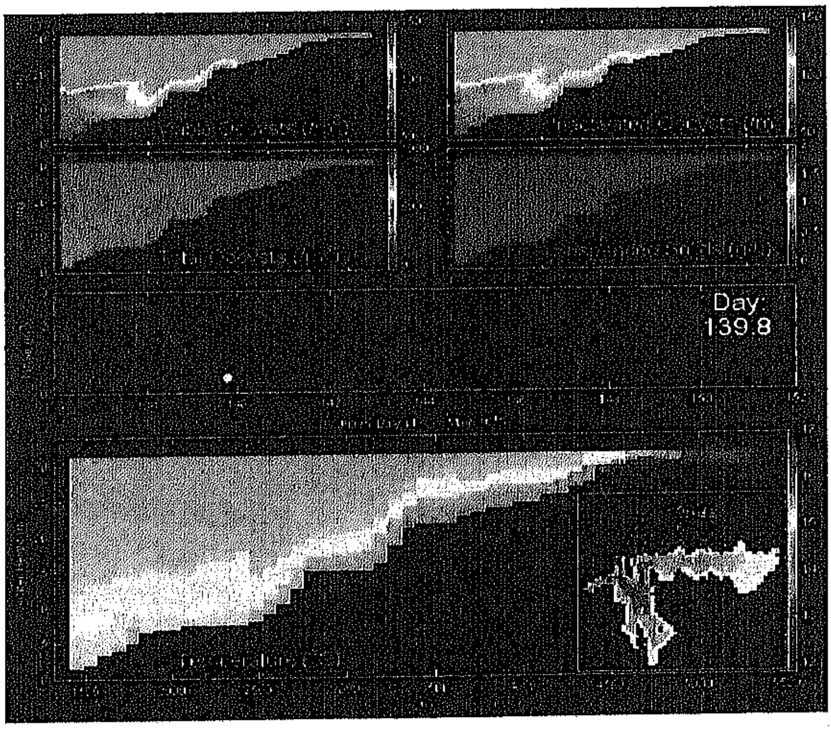


Figure A7.4.5 3D Simulation of Transport and Decay of Pathogens on Mypong Reservoir, South Australia.

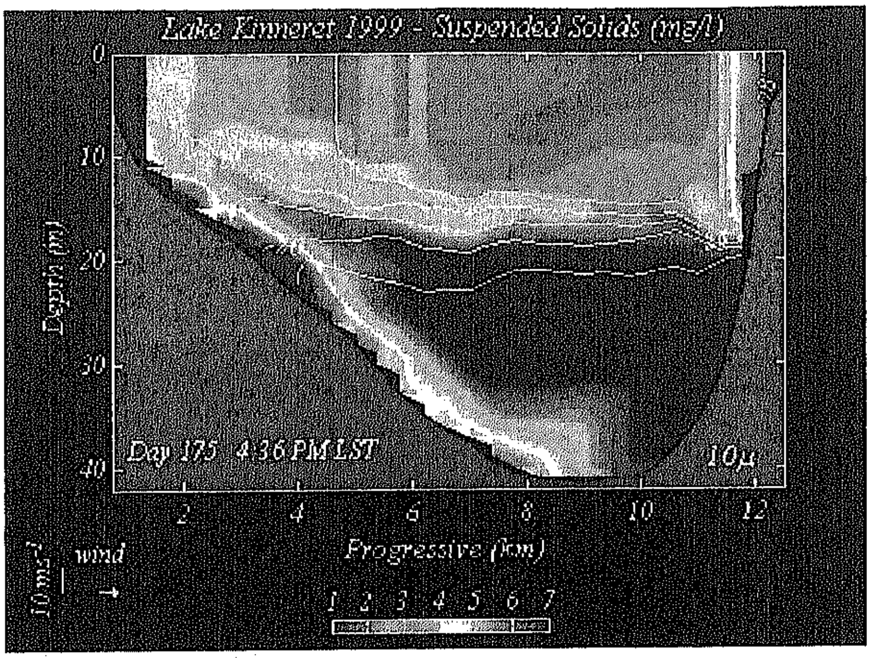


Figure A7.4.6 Frame of Graphic Animation Showing the Turbidity Dynamics on Lake Kinneret, Israel.

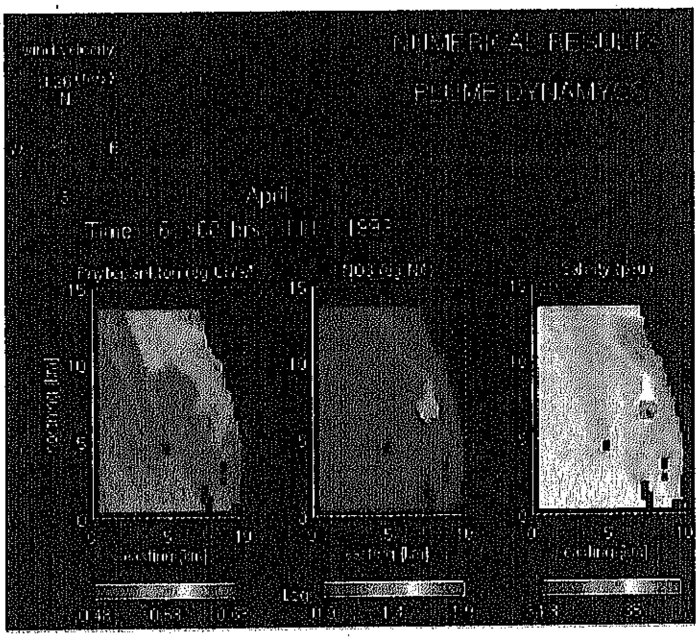


Figure A7.4.7 3D Numerical Results Illustrating the Dispersion of Effluents over Perth Coastal Waters (Australia).

ANNEX 7.4.2

Annex A7.4.2 Sequence of CTD profiles obtained along transect T1, T2 and T3

A recent intensive experiment conducted by *Universidade Federal de Sao Carlos* and CETESB confirms such horizontal heterogeneity on Billings Reservoir and demonstrates the occurrence of vertical gradients equally important. **Figures A7.4.8 to A7.4.10** illustrate these gradients on several CTD surveys conducted between 29 and 30 September, 2004, during a passage of a cold front over the reservoir.

The complete series of these surveys will be presented on a scientific article (under preparation); however, the authors already confirmed that the main components determinant the horizontal gradients along Billings Reservoir are: (i) obstructions between reservoir arms (Imigrantes bridge – see conductivity gradients along transects T1), (ii) contribution of sub-catchments (see Rio Pequeno and Rio Grande arms – conductivity profiles and turbidity along transects T3), and (iii) the orientation of the reservoir's arms regarding the main winds (see main water body and Taquacetuba – thermal stratification more accentuated along arms of shorter fetch on transects T2). As we follow the evolution of the profiles along the main water body becomes clear the dynamical character of the stratification by the thermocline tilting and "pilling" of water from the epilimnion downstream the wind direction – important results for the plankton distribution in the reservoir (Rio, 2003).

The short considerations above show that the numerical simulations of the system Billings/Rio Grand should be based on detailed estimative of the loads (external and internal), as the requirement of 3D capability of the models.

During the last months, under the scope of the current project, several campaigns of water quality sampling in the reservoirs as more detailed estimative of the loads over a large number of tributaries has been producing a rich data set for model calibration and improvement of the load model.

Regarding the hydrodynamics and water quality, most of the conducted work was conducted in a new discretization which should imply on minimal loss of spatial representativeness as make feasible the use of these 3D models for the simulation of long periods.

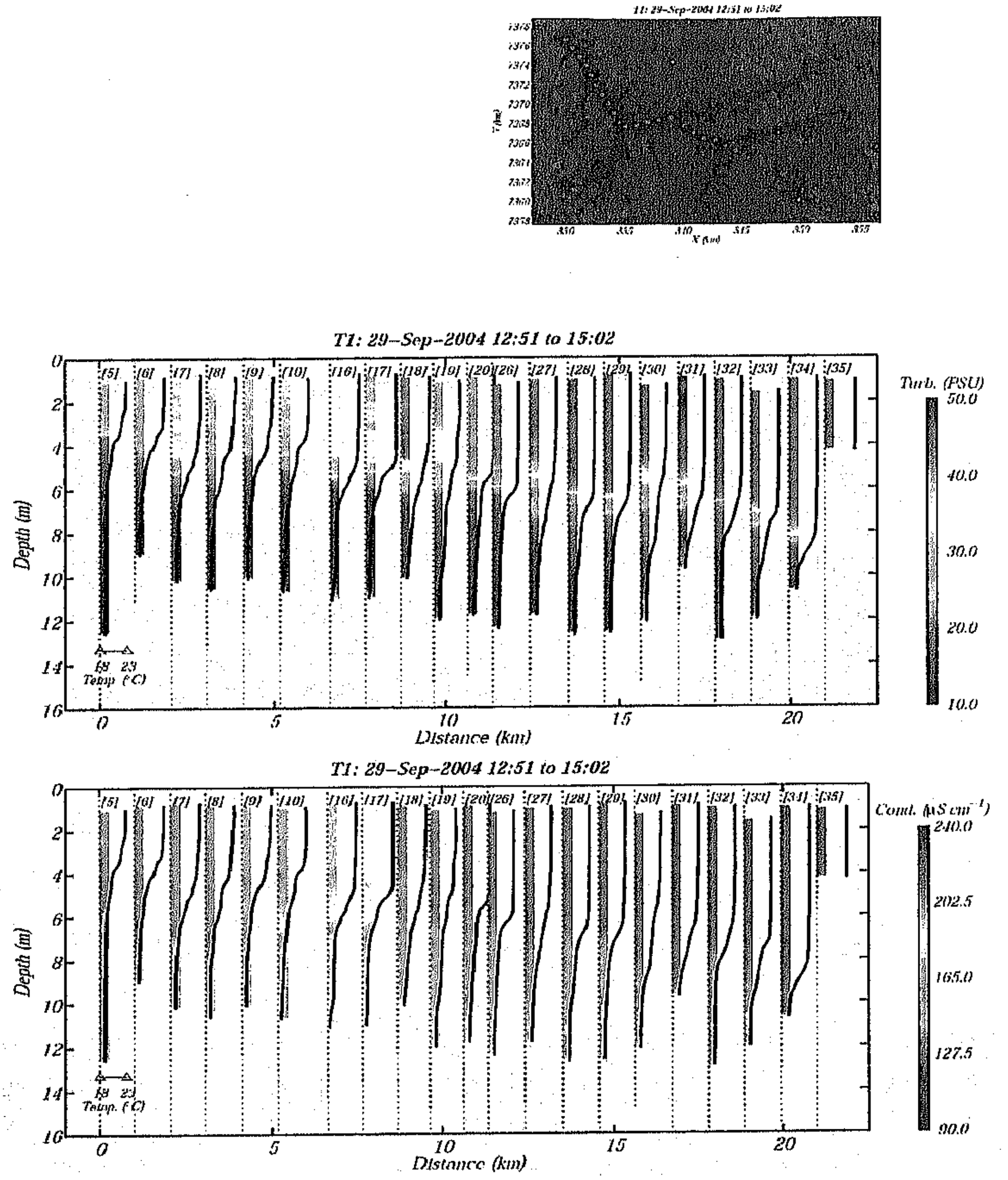


Figure A7.4.8 Sequence of CTD profiles obtained during a survey on 29 September 2004 along transect T1 – Summit up to Pedreira as shown in the top panel. The transect name, the sampling interval and a map showing the profiles location are presented together with the CTD results in the figure. The CTD variables shown are turbidity and electrical conductivity color coded in accordance with the plots side bar. Each panel also show the temperature profiles as black lines.

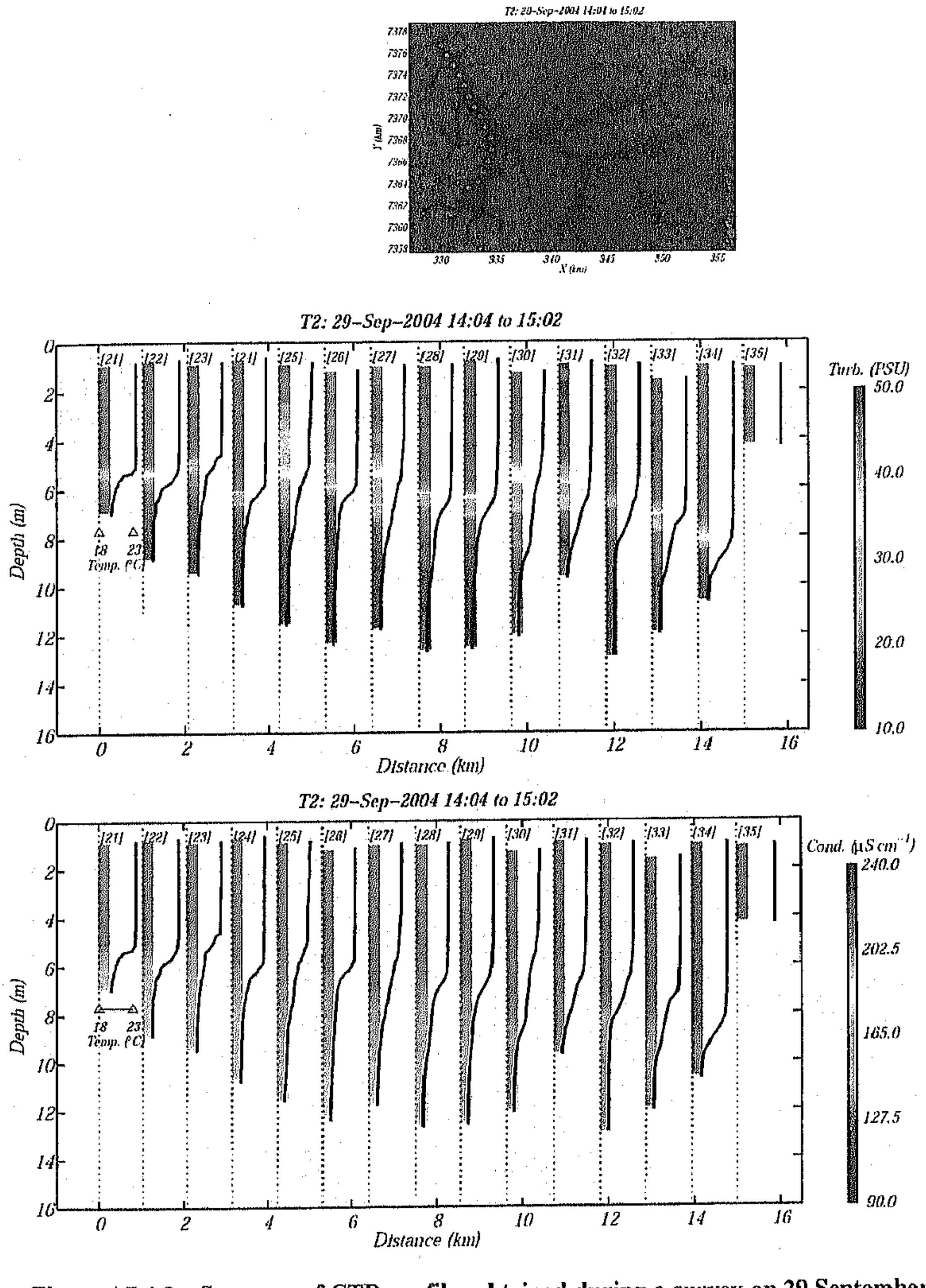


Figure A7.4.9 Sequence of CTD profiles obtained during a survey on 29 September 2004 along transect T2 – Taquacetuba to Pedreira (see Figure 5.2.19 a description of the panels).

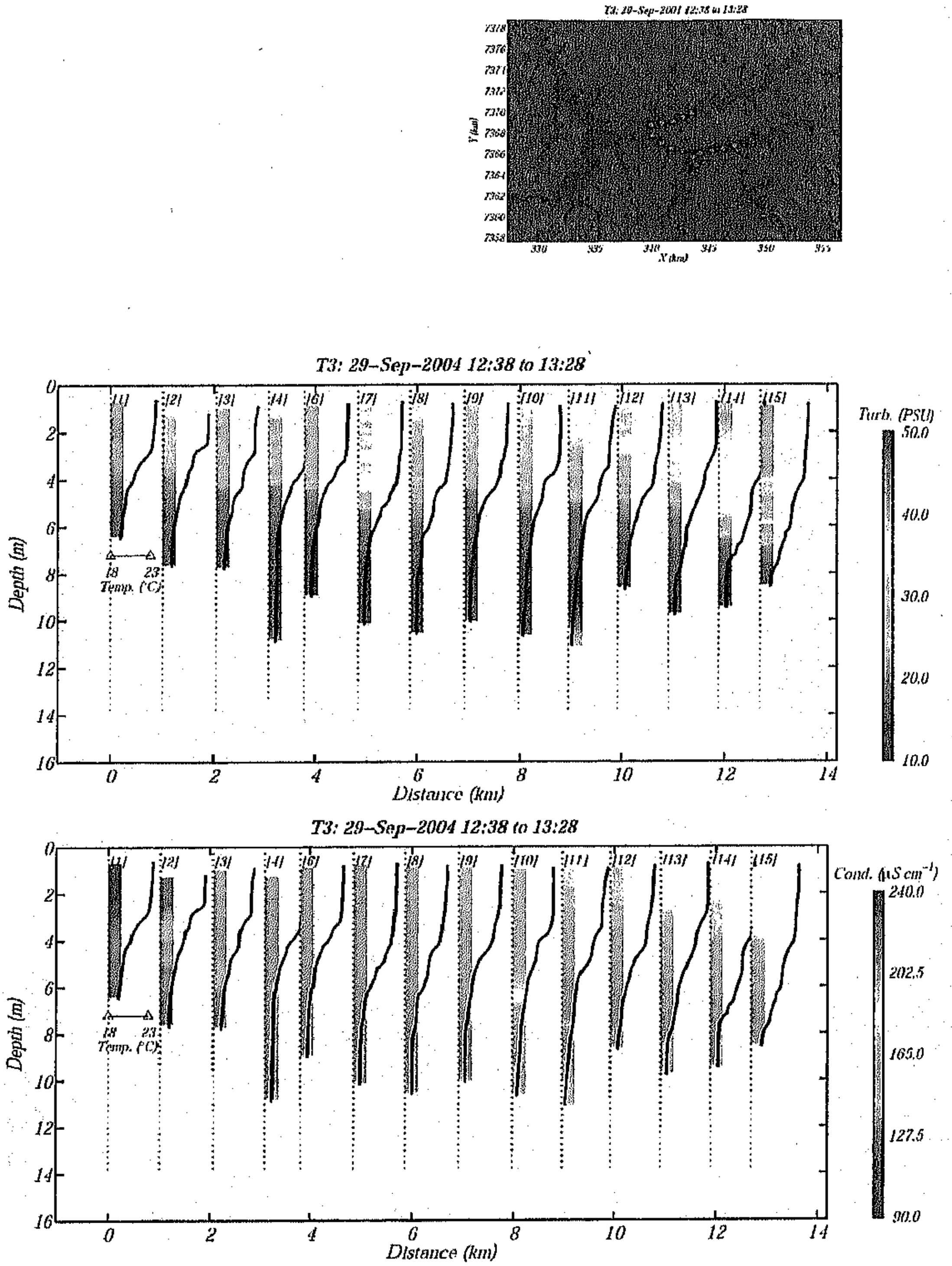


Figure A7.4.10 Sequence of CTD profiles obtained during a survey on 29 September 2004 along transect T3 – Rio Pequeno to Rio Grande (see Figure 5.2.19 for panels description)

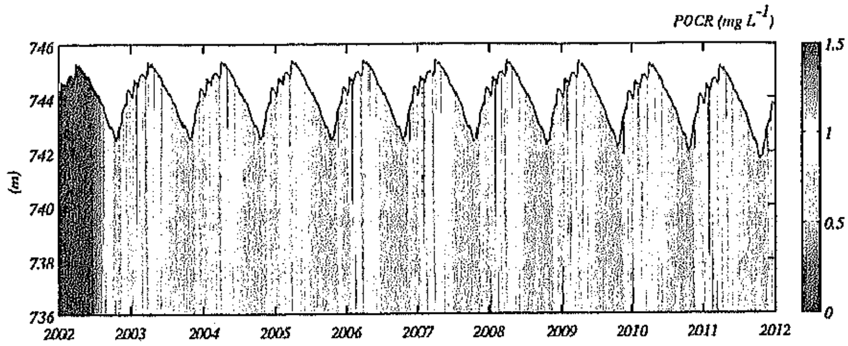
ANNEX 7.4.3

Annex A7.4.3 Simulated time series at BL101

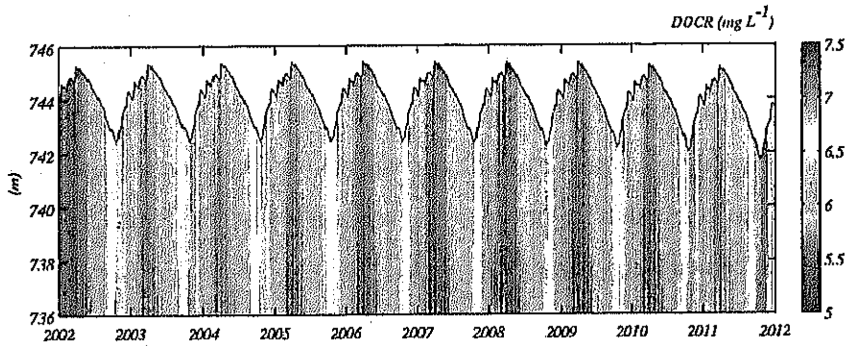
As discussed on the last report, the new setup for Billings is very computationally efficient and the first long term 10 years runs have been conducted. A simulation example is illustrated below through time series at site BL101 – junction of Taquacetuba and the main branch of Billings. **Figures A7.4.1** to **A7.4.5**, with these results, show the more equilibrated balances on carbon as also the algae dynamics discussed above. The hydraulic and meteorological environmental conditions of 2002 were repeated to generate synthetic boundary conditions for 10 years period for this example simulation. The general tendency of water quality deterioration in this example is partially attributed to the fact that 2002 was a dry year. On the following synthetic environment forcing time series generation for the scenarios runs different conditions can be easily generated by the Load Model - on which not only the probability of a dry or wet year can be exploited, but also the several loads conditions will be included (i.e. population grown, remediation strategies).

For the scenarios discussion, outputs like the time series at specific sites can be combined with layers snapshots as shown on **Figure A7.4.6**, that illustrates the evolution of a numerical tracer on Billings after a short pumping of the polluted waters of Pinheiros River into the reservoir.

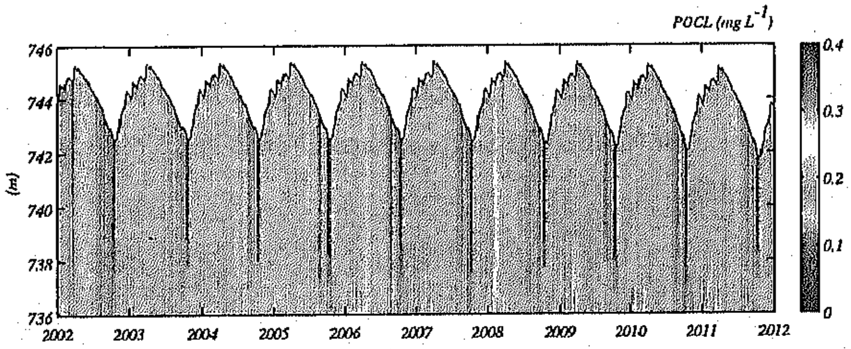
The calibrated model coefficients are presented on **Annex A.7.4.4** and the meaning of each coefficient is explained on "CAEDYM Science Manual" and CAEDYM User's Manual", both included in the appendix.



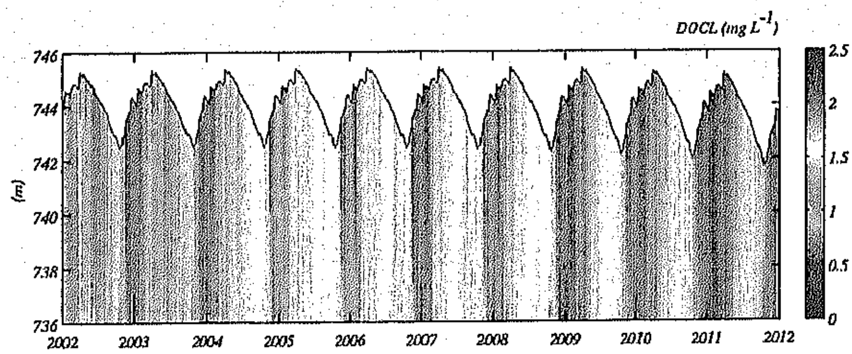
(a)



(b)



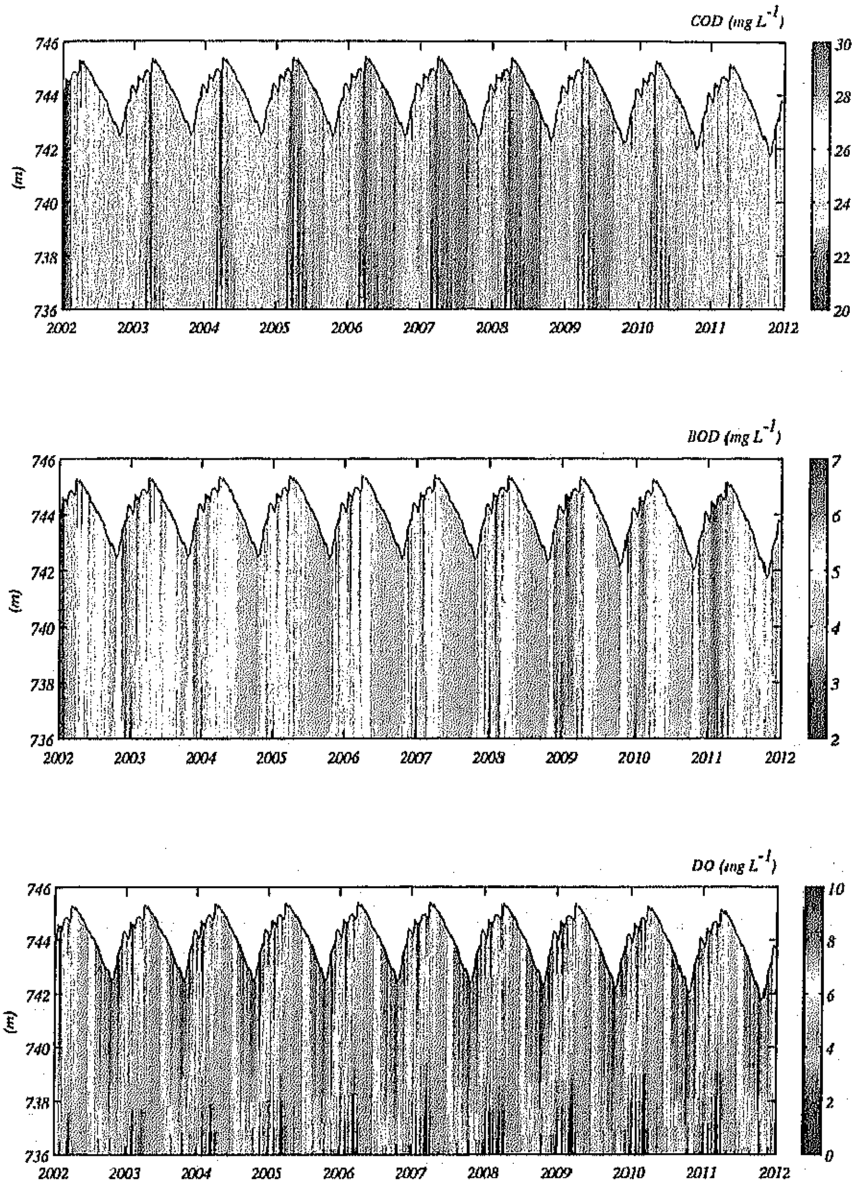
(c)



(d)

Figure A7.4.11(1) Simulated time series at BL101 of (a) particulate organic carbon refractory, (b) dissolved organic carbon refractory, (c) particulate organic carbon labil and (d) dissolved organic carbon labil.

These carbon species are important internal variables determining the chemical and biochemical oxygen demand in the water column and, as seen in the plots, reach a reasonable equilibrium despite deviations introduced in the initial values.



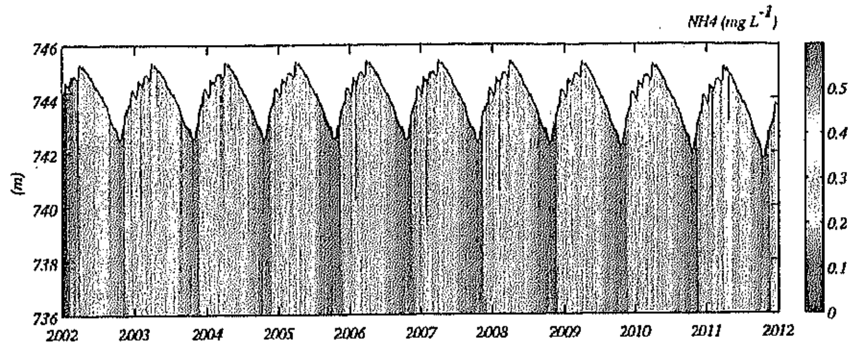
(a)

(b)

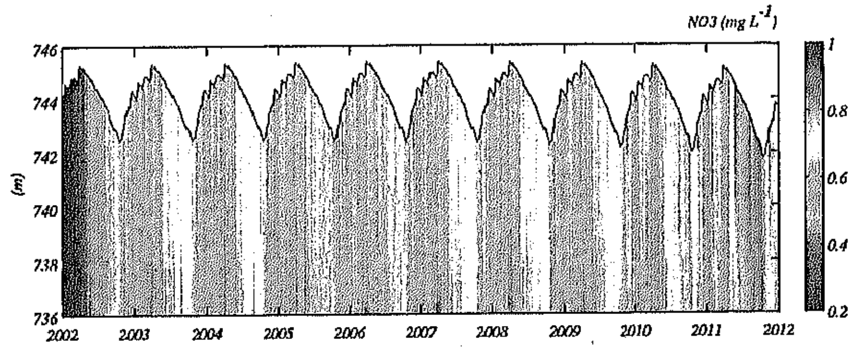
(c)

Figure A7.4.11(2) Simulated time series at BL101 of (a) chemical oxygen demand, (b) biochemical oxygen demand and (c) dissolved oxygen concentration in the water column

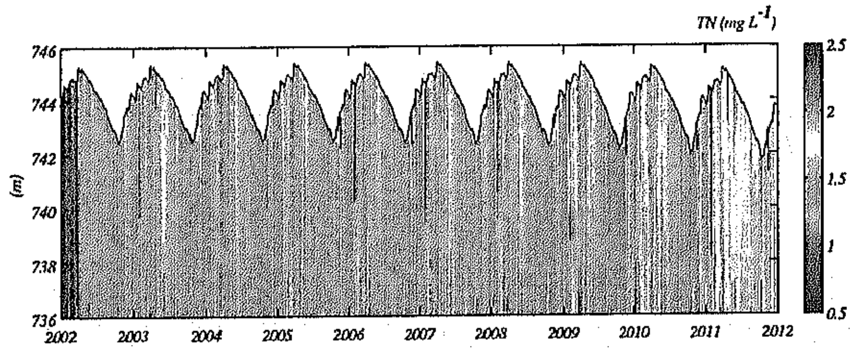
– possible the main variables to be discussed on the scenarios evaluation. COD and BOD are derived variables of the carbon balance in the model and again clearly show the perturbation of the initial conditions following by an equilibrated evolution of their states along the 10 years simulation.



(a)



(b)



(c)

Figure A7.4.11(3) Simulated time series at BL101 of (a) ammonium, (b) nitrate and (c) total nitrogen concentration in the water column.

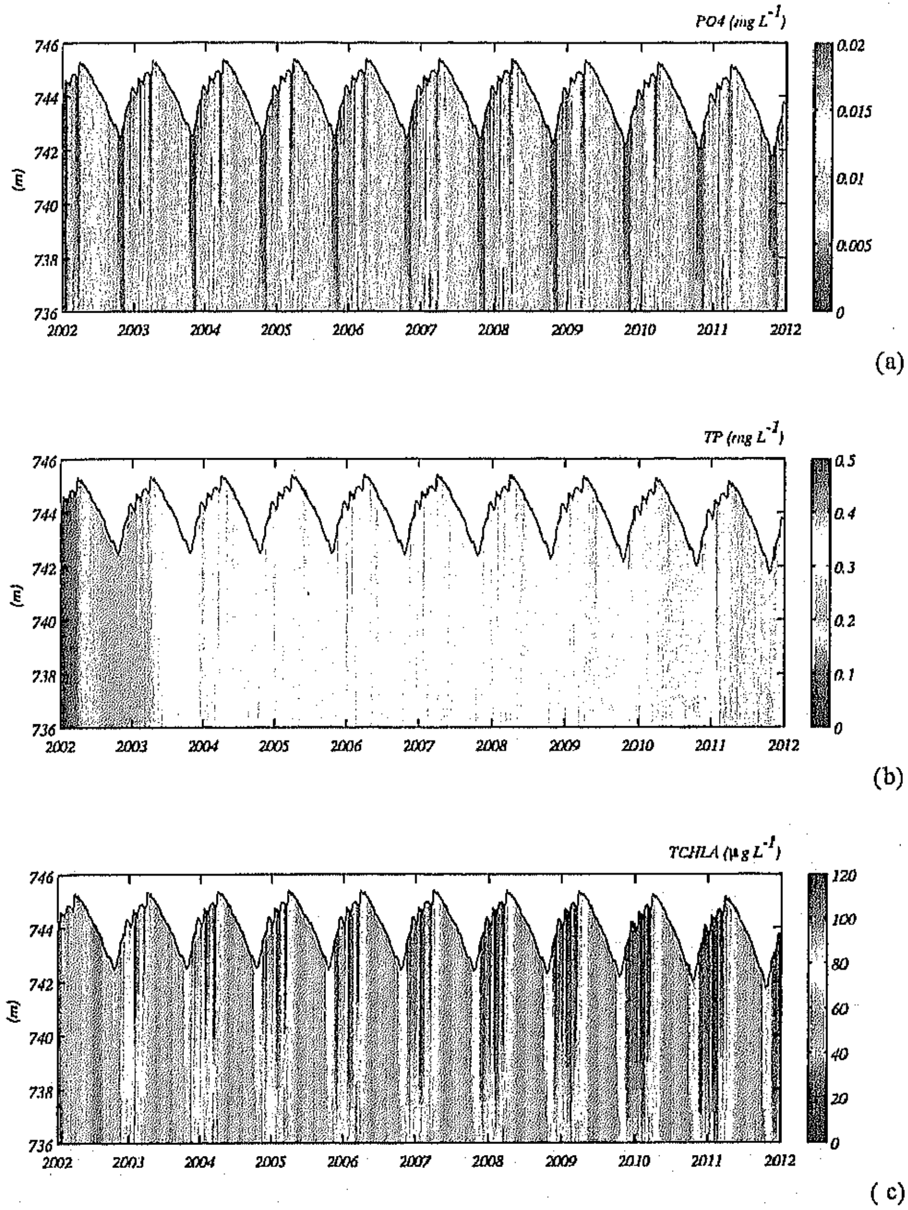


Figure A7.4.11(4) Simulated time series at BL101 of (a) phosphate, (b) total phosphorus and (c) total chlorophyll a concentration in the water column

– among the main variables to evaluate the evolution of the eutrofication process in the reservoir or its recovery.As the sediment elusion experiments will be concluded a finner calibration of the phosphorus cycle will be possible.

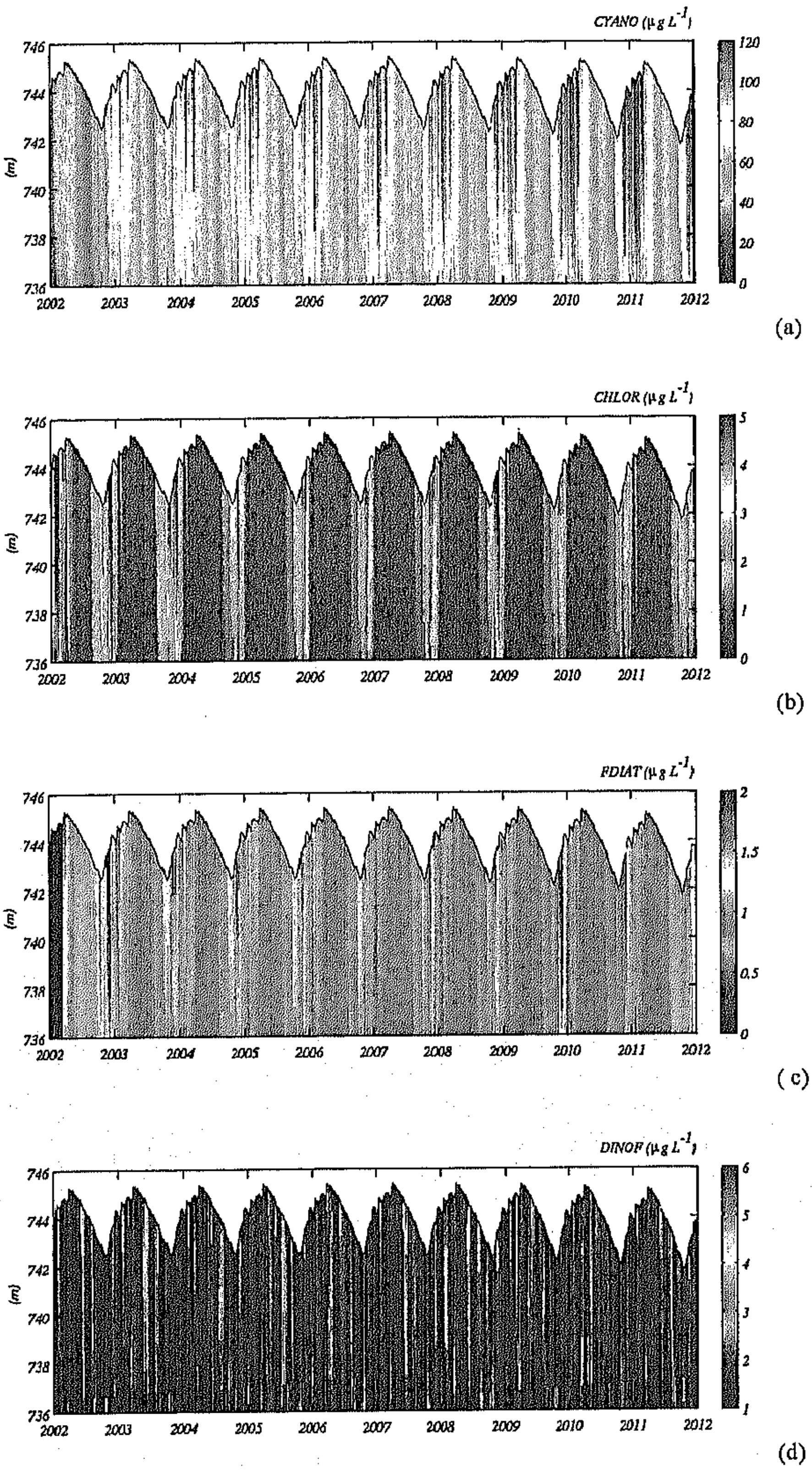


Figure A7.4.11(5) Simulated time series at BL101 of the concentration of the main algae groups in the water column: (a) cyanobacteria, (b) chlorophytes, (c) diatoms and (d) dinoflagellates.

The representation of their sazonality and relative dominance are of the the main improvements of the current calibration and this capability of the new setup is very important for the scenarios evaluation as a shift of the the cyanobacteria dominance by the remediation strategies will reduce the large problem of taste and odor in both reservoirs.

ANNEX 7.4.4

Annex A7.4.4 Biogeochemical coefficients in water quality model CAEDYM

PHYTOPLANKTON CONSTANTS

Phytoplankton group 1: dinoflagellates	*(DINOF)*
- Minimum biomass threshold	0.500 (mg/L)
- Average C:Chla ratio	300 (mg C)/(mg Chla)
- Growth rate	0.200 /day
- Respiration rate	0.070 /day
- Fraction of respiration relative to total loss	0.5
- Temperature multiplier for respiration	1.04
- Temperature multiplier for growth	1.06
- Standard temperature	20.000 deg C
- Optimum temperature	22.000 deg C
- Maximum temperature	28.000 deg C
- Optimum salinity	18
- Salinity limitation at S	36.0 : 1.000
- Optimum light saturation	390.0 uE/m^2/s
- Half saturation constant for phosphorus	0.004 mg P/L
- Half saturation constant for nitrogen	0.020 mg N/L
- Maximum nitrogen uptake	3.000 mg N/mg Chla/day
- Minimum internal nitrogen ratio	36.000 (mg N)/(mg Chla)
- Maximum internal nitrogen ratio	45.000 (mg N)/(mg Chla)
- Specific attenuation coefficient	0.01400 ug Chla/L/m
- Rate coefficient for light dependent migration	0.600 m/hr
- Rate coefficient for nutrient dependent migration	0.600 m/hr
- DO threshold for vertical migration	1.000 mg/L
- Critical shear stress for resuspension	0.020 N/m^2
- Resuspension rate	0.000E+00 mg/m^2/sec
- Half saturation constant for resuspension	0.000 mg/m^2
- Sediment survival time	2.000 days

Phytoplankton group 2: cyanobacteria	*(CYANO)*
- Minimum biomass threshold	0.500 (mg/L)
- Average C:Chla ratio	40.000 (mg C)/(mg Chla)
- Growth rate	1.200 /day
- Respiration rate	0.060 /day
- Fraction of respiration relative to total loss	0.9
- Temperature multiplier for respiration	1.03
- Temperature multiplier for growth	1.06
- Standard temperature	20.000 deg C
- Optimum temperature	28.000 deg C
- Maximum temperature	35.000 deg C

- Optimum salinity	3
- Salinity limitation at S	36.0 : 1.000
- Photosynthesis-irradiance curve parameter	130.0 uE/m^2/s
- Half saturation constant for phosphorus	0.003 mg P/L
- Half saturation constant for nitrogen	0.040 mg N/L
- Specific attenuation coefficient	0.01400 ug Chla/L/m
- Settling velocity	-.230E-06 m/s
- Critical shear stress for resuspension	0.001 N/m^2
- Resuspension rate	0.000E+00 mg/m^2/sec
- Half saturation constant for resuspension	0.010 mg/m^2
- Sediment survival time	2.000 days
Phytoplankton group 4: chlorophytes	*(CHLOR)*
- Minimum biomass threshold	0.500 (mg/L)
- Average C:Chla ratio	40.000 (mg C)/(mg Chla)
- Growth rate	2.000 /day
- Respiration rate	0.140 /day
- Fraction of respiration relative to total loss	0.6
- Temperature multiplier for respiration	1.08
- Temperature multiplier for growth	1.06
- Standard temperature	20.000 deg C
- Optimum temperature	27.000 deg C
- Maximum temperature	33.050 deg C
- Optimum salinity	14
- Salinity limitation at S	36.0 : 1.000
- Photosynthesis-irradiance curve parameter	80.0 uE/m^2/s
- Half saturation constant for phosphorus	0.003 mg P/L
- Half saturation constant for nitrogen	0.060 mg N/L
- Specific attenuation coefficient	0.01400 ug Chla/L/m
- Settling velocity	-.230E-06 m/s
- Critical shear stress for resuspension	0.001 N/m^2
- Resuspension rate	0.000E+00 mg/m^2/sec
- Half saturation constant for resuspension	0.010 mg/m^2
- Sediment survival time	2.000 days
Phytoplankton group 7: diatoms	*(FDIAT)*
- Minimum biomass threshold	0.500 (mg/L)
- Average C:Chla ratio	40.000 (mg C)/(mg Chla)
- Growth rate	1.300 /day
- Respiration rate	0.060 /day
- Fraction of respiration relative to total loss	0.6
- Temperature multiplier for respiration	1.07
- Temperature multiplier for growth	1.06
- Standard temperature	20.000 deg C

- Optimum temperature	25.000 deg C
- Maximum temperature	32.000 deg C
- Optimum salinity	1
- Salinity limitation at S	36.0 : 1.000
- Photosynthesis-irradiance curve parameter	60.0 uE/m^2/s
- Half saturation constant for phosphorus	0.006 mg P/L
- Half saturation constant for nitrogen	0.050 mg N/L
- Constant internal silica concentration	120 mg Si/mg Chla
- Half saturation constant for silica	0.000 mg Si/L
- Specific attenuation coefficient	0.01400 ug Chla/L/m
- Settling velocity	-.120E-05 m/s
- Critical shear stress for resuspension	0.001 N/m^2
- Resuspension rate	0.000E+00 mg/m^2/sec
- Half saturation constant for resuspension	0.010 mg/m^2
- Sediment survival time	2.000 days

DISSOLVED OXYGEN CONSTANTS

- Static sediment exchange rate	2.000 gm^2/day
- Half sat const for DO sed flux	0.500 cm^2/day
- Carbon:Oxygen stoichiometric ratio	2.667 (mg C)/(mg DO)
- Seagrass biomass:oxygen ratio	2.667 (mg seag. C)/(mg DO)
- Photo-respiration planktonic phyto loss	0.01
- Fraction of oxygen production allocated to seagrass roots	0.1

MICROBIAL DECOMPOSITION PARAMETERS

- Half sat for DO effect on bacteria	3
- Aerobic/Anaerobic factor for decomp	0.3

DISSOLVED ORGANIC PARAMETERS

GROUP 1: LABILE DOM	
- Specific attenuation coefficient	0.001 mg/L/m
- Max Rate of DOC Metabolism	0.012 /day
- Max Rate of DOP Mineralization	0.006 /day
- Max Rate of DON Mineralization	0.012 /day
GROUP 2: REFRACTORY DOM	
- Specific attenuation coefficient	0.001 mg/L/m
- Max Rate of DOC Metabolism	0.001 /day
- Max Rate of DOP Mineralization	0.001 /day

- Max Rate of DON Mineralization	0.006 /day
- Min Salinty bound for DOCR floc	1
- Max Salinty bound for DOCR floc	10
- Flocculation rate constant	0.500 /day
- Photolytic decay constant	0.000 /day

ORGANIC PARTICLE PARAMETERS

GROUP 1: LABILE POM	
- Mean particle density	0.105E+04 kg/m^3
- Mean particle diameter	0.180E-04 m
- Critical shear stress	0.010 N/m^2
- Specific attenuation coefficient	0.005 mg/L/m
- Max Rate of POC Decomposition	0.009 /day
- Max Rate of POP Decomposition	0.001 /day
- Max Rate of PON Decomposition	0.001 /day
GROUP 2: REFRACTORY POM	
- Mean particle density	0.105E+04 kg/m^3
- Mean particle diameter	0.600E-05 m
- Critical shear stress	0.500 N/m^2
- Specific attenuation coefficient	0.005 mg/L/m
- Max Rate of POC Decomposition	0.001 /day
- Max Rate of POP Decomposition	0.000 /day
- Max Rate of PON Decomposition	0.000 /day

DISSOLVED INORGANIC PARAMETERS

- PO4 Adsorption/Desorption const 1	-80
- PO4 Adsorption/Desorption const 2	0
- NH4 Adsorption/Desorption const 1	0
- NH4 Adsorption/Desorption const 2	0
- Temp multiplier for denitrifiation	1.08
- Denitrifiation rate coefficient	0.060 /day
- Half saturation for denitrifiation	0.500 mg/L
- Temp multiplier for nitrifiation	1.08
- Nitrifiation rate coefficient	0.020 /day
- Half saturation for nitrifiation	2.000 mg O/L
- Ration of O2 to N for nitrification	3.429 mg N/mg O

INORGANIC PARTICLE PARAMETERS

GROUP 1: Colloidal solids	
- Mean particle density	0.160E+04 kg/m^3
- Mean particle diameter	0.100E-05 m
- Critical shear stress	0.050 N/m^2
- Specific attenuation coefficient	0.040 mg/L/m
GROUP 2: Non-colloidal solids	
- Mean particle density	0.160E+04 kg/m^3
- Mean particle diameter	0.100E-04 m
- Critical shear stress	0.060 N/m^2
- Specific attenuation coefficient	0.040 mg/L/m

SEDIMENT NUTRIENT FLUX PARAMETERS

- Temp multiplier for sediment fluxes	1.05
- Release rate of PO_4	0.002 g/m^2/day
- DO dependence for PO_4 release	0.500 g/m^3
- Release rate of NH_4	0.020 g/m^2/day
- DO dependence for NH_4 release	0.500 g/m^3
- Release rate of NO_3	0.000 g/m^2/day
- DO dependence for NO_3 release	0.500 g/m^3
- Release rate of Reactive Si	0.038 g/m^2/day
- DO dependence for Si release	0.500 g/m^3
- Release rate of DOCL	0.000 g/m^2/day
- Release rate of DOCR	0.001 g/m^2/day
- DO dependence for DOC release	0.500 g/m^3
- Release rate of DOPL	0.001 g/m^2/day
- Release rate of DOPR	0.000 g/m^2/day
- DO dependence for DOP release	0.500 g/m^3
- Release rate of DONL	0.001 g/m^2/day
- Release rate of DONR	0.000 g/m^2/day
- DO dependence for DON release	0.500 g/m^3

SEDIMENT COMPOSITION PARAMETERS

- Sediment Organic Fraction	0.15
- Sediment Porosity	0.1
- Composite Resuspension rate	0.000 g/m^2/day

ANNEX 10.1.1

10 FUTURE PROJECTION OF SEWAGE FLOW RATE

10.1 Target Year

15 to 20 years is adopted as planned target year in Brazil as well as many foreign countries. According to confirmation of other reports of various plans, target year of 2015 were found in the many of planning. In this study, year of 2025 is set as target year in consideration of the completion of this study in 2006.

10.2 Planning Area and Population Projection

(1) Methodology

Planning area for pollution load reduction is set in the core of the Billings Lake basin. This is constituted by the basin of the main lake and the Rio Grande arm. It is thought that there is no inflow of the load from outside of the basin boundary. Since there have been many unknown factors about transition of the population of the Billings Lake basin, a lot of studies were conducted in the past years. It is thought that the reliability of the following 2 information is high as a result of examination. An existing-condition description is made based on these for future projection.

1) : "CALIBRACAO DE SISTEMA RELACIONAL DE CORRELACAO DO MANEJO DO TERRITORIO E DA QUALIDADE AMBIENTAL PARA O RESERVATORIO BILLINGS" 2004 Oct by SMA/CPLEA (by Prime Engenharia)

2) : "Indicação de Áreas de Intervenção e Respectivas Diretrizes e Normas Ambientais e Urbanísticas de Interesse Regional na Bacia Hidrográfica do Reservatório Billings" (by Prime Engenharia)

(2) Past population transition and current distribution of population

The past population transition based on the above-mentioned data (1) is shown in **TableA10.2.1**. The population in the basin in 2000 is presumed to be 866,000 persons. The rate of the population increase which uses 1970 as base year is high rate, 7% - 8%. Distribution of population of existing-condition population is shown in **TableA10.2.2**. in terms of middle size catchment area. According to this information, regarding to the main lake, population concentrates on the Pedereira Dam and the Alvarenga Cocaia area, and population concentration is shown near the mouth of the river Pires and the river Rio Grande of Rio Grande Arm .

Table A10.2.1 Population transition of the-Billings-Lake basin

	1970	1980	1991	1996	2000			
					Total	Favela	City area part	Rural
Population	111,000	313,000	534,421	710,965	865,870	161,115	683,103	21,652
Sao Paulo	51,000	160,000	262,087	371,822	469,041	107,056	351,93	10,555
Diadema	8,000	24,000	44,556	49,967	59,804	9,148	50,171	485
SBC	16,000	51,000	114,613	158,328	188,181	38,411	144,377	5,393
Santo Andre	4,000	9,000	17,518	23,653	31,015	4,886	21,439	1,824
Ribeirao Pires	24,000	49,000	69,309	77,662	86,470	1,614	83,613	1,243
Rio Grande da Serra	8,000	20,000	26,338	29,534	34,225	0	31,573	2,652

Table A10.2.2 Distribution of population (2000) in the sub basins

	Favelas No.	Urban No.	Rural No.	Total No.	Remarks
A1.1	5,068	66,808	127	72,003	
A1.2	0	2,904	966	3,870	
A1.2	41,161	122,682	158	164,001	
A2.2	0	124	1,035	1,159	
A2.3	13,833	38,155	1,132	53,120	
A3.1	0	9,470	490	9,960	
A3.2	0	458	593	1,051	
A4.1	0	13,919	533	14,452	
A4.2	0	2,400	2,087	4,487	
A5	0	0	2,359	2,359	
A6	0	3,100	1,063	4,163	
A7	0	1,974	603	2,577	
A8	0	501	102	603	
A9.1	0	0	203	203	
A9.2	0	313	361	674	
A9.3	0	361	519	880	
A10	650	11,252	579	12,481	
A11	8,112	5,296	361	13,769	
A12.1	10,581	48,132	148	58,861	
A12.2	14,577	48,551	4	63,132	
A12.3	2,687	15,070	103	17,860	
A13.2	12,459	54,012	1,819	68,290	
A13.2	0	605	928	1,533	
A14	45,487	83,081	237	128,805	
Main Lake	154,615	529,168	16,510	700,293	
B1	0	8,359	215	8,574	
B2	0	14,029	732	14,761	
B3	0	33,194	2,960	36,154	
B4	590	72,292	715	73,597	
B5	1,024	2,530	23	3,577	
B6	4,886	23,531	497	28,914	
Rio Grande Arm	6,500	153,935	5,142	165,577	
Total	161,115	683,103	21,652	865,870	

(3) Projection of future population

The future projection of the Billings-Lake-basin population is shown by data (2). The projection of population in the municipalities in the basin in 2015 is based on SEADE of the state, and its prediction of the population in 2015 was made assuming the share of the basin population in the future. In the process of this result, adjustment with higher rank plans and other related plans of the state, and consent/approval of each municipality have been obtained as an appropriate future plan. From this reason, the projection by (2) was adopted also in this study. However, for the years from 2016 to 2025, projection was independently conducted by study team.

(4) Expandable area for housing

Expandable area is required for increase of households and population. Although the Billings Lake basin has a area of 475km^2, existing residential area is119.1km^2 (among those, urbanized-area 84.6km^2, Chacala area 34.5km^2), and, as for the part of the white washed area of 65.73km in the **Figure A10.2.1** is inhabitable area in the report

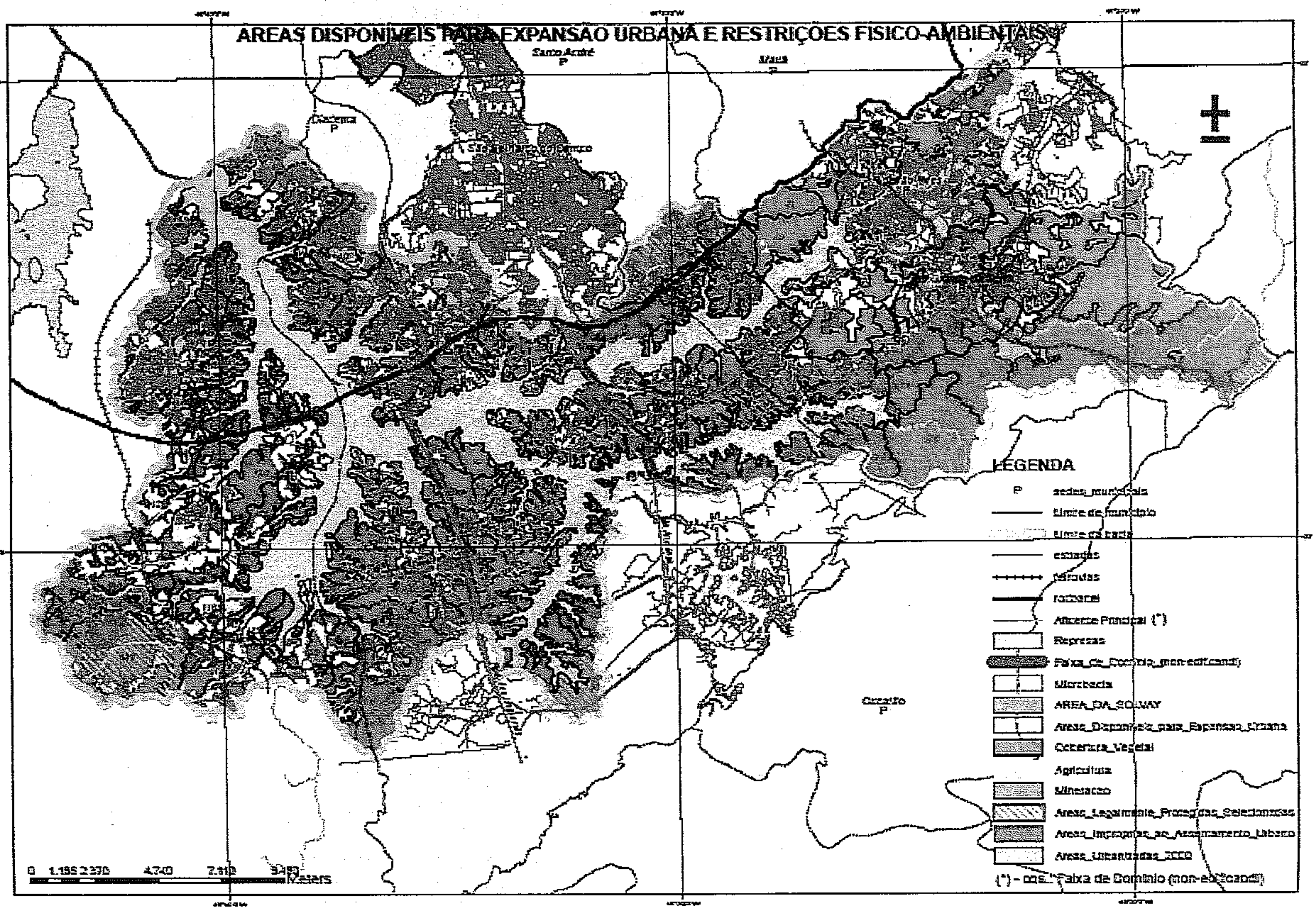


Figure A10.2.1 Inhabitable area (white washed area in the map)

(5) Future projection of population

Projection was made for the following two cases, although it is based on the result of information (2) by 2015.

CASE 1: Refer to **Figure A10.2.4**. The population growth rate for every small basin by 2025 is the same with the "Prime Report" in which projection is made by the year of 2015. Although the rate is 4% or more in SBC and the Santo Andre area, that of Cocaia area and Diadema etc. is held to 0.4% and 1.8% as the areas are already densely populated.

CASE 2: Refer to **Figure A10.2.2**. Population growth rate in the whole basin by the year 2015 is the same with Case 1. However, that of after 2015 is held lower than Case 1 by referring the growth rate of Master Plan of San Bernaldo do Campo or densely inhabited area such as Cocaia.

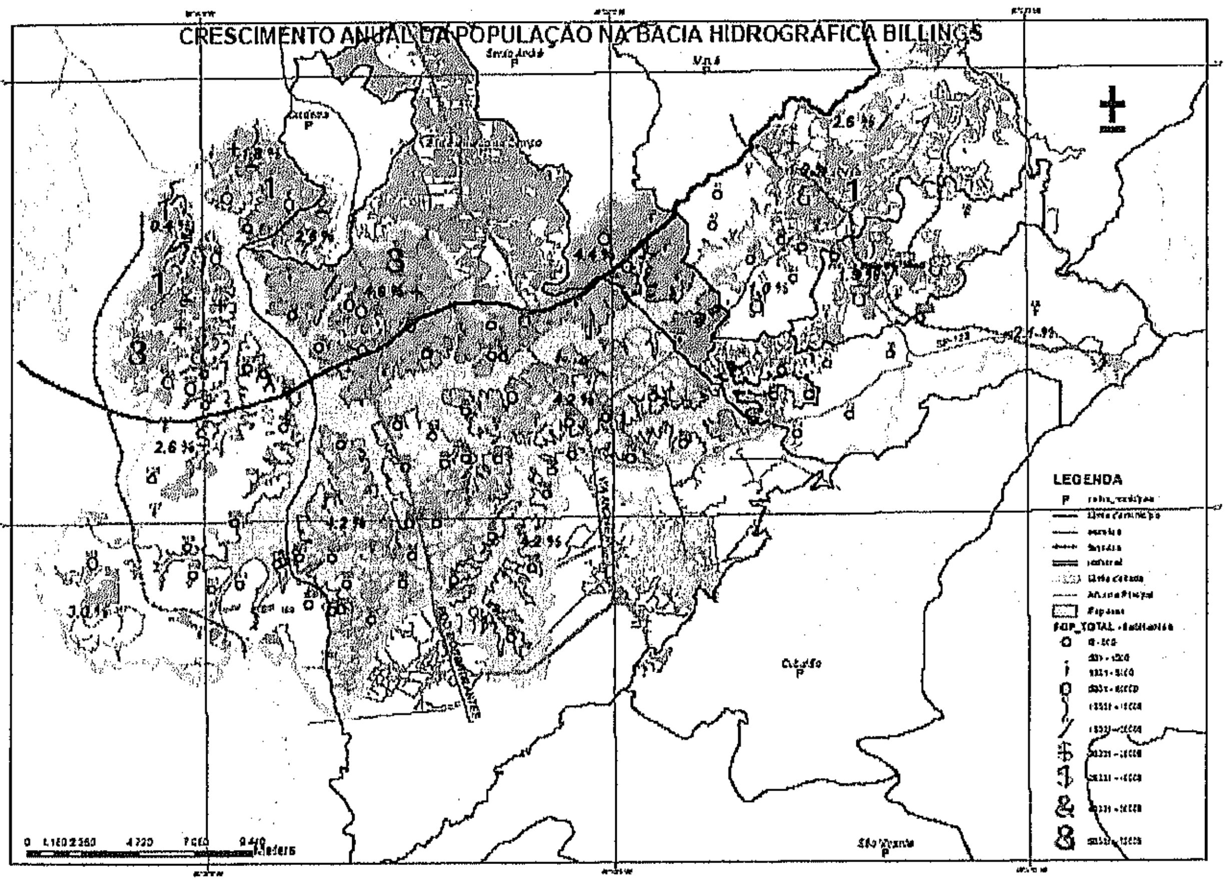


Figure A10.2.2 Future population growth rate

In CASE1, population will be doubled from 866,000 in 2000 to 1,756,000 in 2025. **(Figure A10.2.3)** Population of Case 2 is a lowered figure to 1,393,000 people due to the difference of growth rate. **(Figure A10.2.4)**

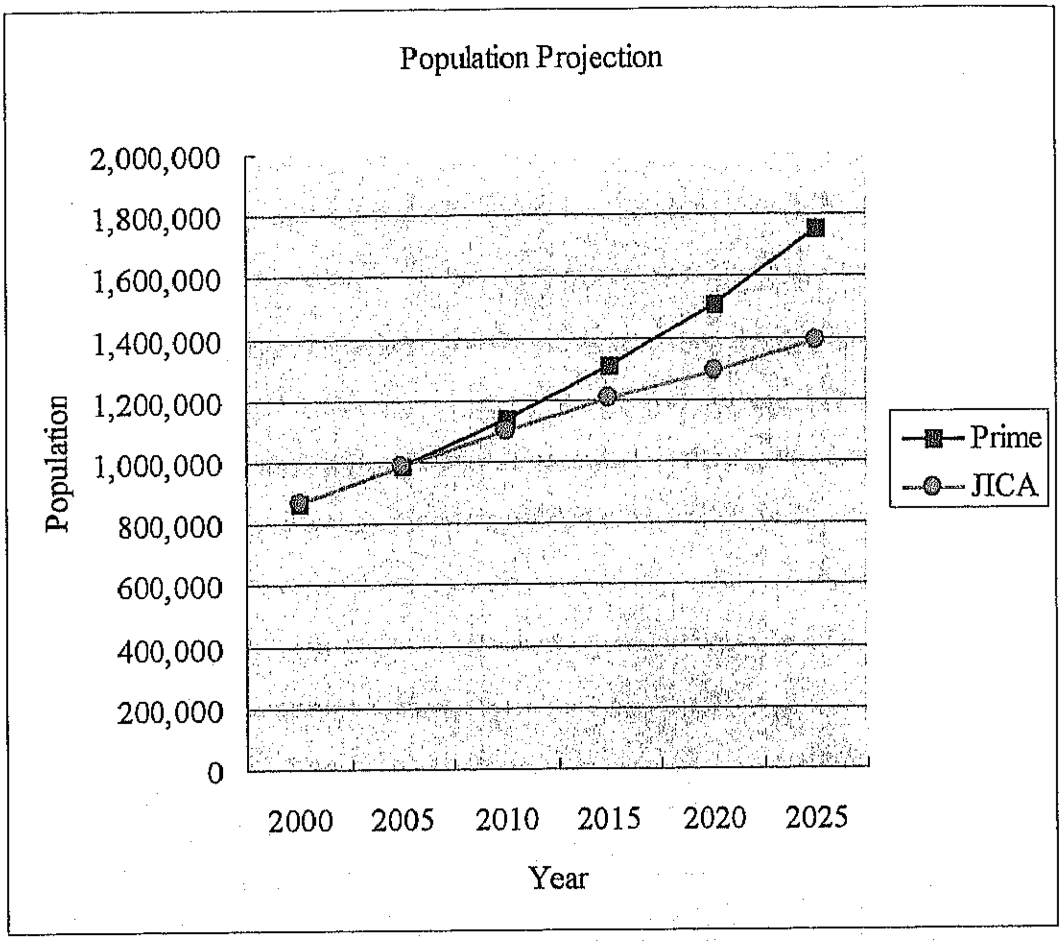


Figure A10.2.3 Future population projection CASE1

Result of Population Projection

		2000	2005	2010	2015	2020	2025
Prime(Case1)	Population	865,870	989,970	1,136,101	1,308,684	1,513,107	1,755,949
	Growth Rate		1.027	1.028	1.029	1.029	1.030
JICA(Case2)	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

Figure A10.2.4 Future population projection

According to reference 2), this population increase shall be absorbed by the expandable area for residential area and increase of the population density. The population density in the projection is assumed to be increasing about 30 persons / ha plus for the existing condition, and that of extensible area is calculated as 56-61 persons / ha. Habitable population with this manner is calculated in **Table A10.2.3.** The future population density of established urban area shall follow information 2).

Table A10.2.3 Future habitable population and population projection (the methodology with Prime)

	Established city area	Extensible area	total	Note
Area (ha)	11,917	6,573	18,490	
Population (nos.)	865,870	—	865,870	
Existing population density (pop/ha)	72.7	—	72.7	
Assumed population density (nos./ha)	100	60		
Habitable population (nos.)	1,191,700	394,380	1,586,080	
Projection case1	1,191,700	564,300	1,756,000	NG
Assumed population density (nos./ha)	100	86	>1,586,080	
Projection case2	1,191,700	201,700	1,393,400	OK
Assumed population density (nos./ha)	100	54	<1,586,080	

The result is as follows.

(CASE1): Supposing that trend of increase-in-population of existing condition is maintained, population density of habitable area will become about 90 persons / ha in 2025. Increase of the population is as big as the existing population of 890,000 people.

(CASE2): Although resistance to expansion of population is considered, about 520,000 increase population shall occur in 2025.

It is quite rapid increase and application of political control and restriction to expansion of population promptly shall be needed.

(6) Adopted projection of population

In this study, the result of CASE2 which considers some control to the expansion of population is adopted. Refer to **Table A10.2.4.**

In the year 2025 population increase in the main lake basin will become 326,000 compared with the year 2005, and that of the branch lake in the year 2025 will come to increase of 78,000. Total population in 2025 will come to 1,400,000 in the whole basin.

Table A10.2.4 The Billings Lake basin Future projection of population Unit (nos.)

Year	(2000)	2005	2010	2015	2020	2025	Remarks
Billings	(700,293)	805,417	891,866	978,328	1,051,726	1,131,151	
Rio Grande Arm	(165,577)	184,553	204,596	227,158	242,749	262,247	
Total	(865,870)	989,970	1,096,462	1,205,486	1,294,475	1,393,398	

10.3 Sewage flow rate and pollution load

(1) The current status of water supply and sewerage

1) Water consumption track record

The track record of water consumption before handover of water supply and sewerage facility from SBC city to SABESP is shown in **Figure A10.3.1**. Average water consumption per household is calculated according to this data. For both of regular and irregular residence, examination was made by using average family number in the census.

According to the result, average unit water consumption rate of favela was far larger than regular residence, but both came to close from 1998. Average water consumption per capita of a regular residence is rather stable during 131 - 140 L / day/capita for 16 years in 1987 - 2002 except for the year 1997.

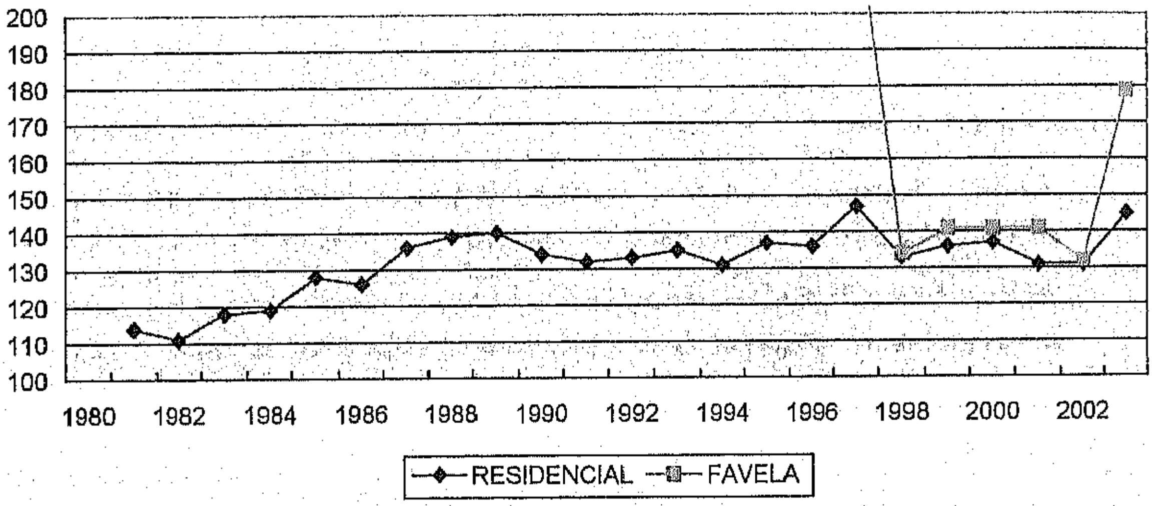


Figure A10.3.1 Transition of daily average water consumption rate per capita (SBC)

2) Water consumption rate of commercial use and industrial

In addition to the above, there is commercial and industrial usage for water supply. There is fixed need equivalent to 10 - 12% of total water consumption in commercial use water, and daily average water consumption rate has been constant to 0.71m^3-/home/tap in 1998 and afterwards. Although the industrial water occupied 30% of total water consumption in the late 1970s, it was below 18.2% and 20% in 1991, and lowered the share quickly to 2.8% in recent years 8.3% in 1997. Since the big change to the number of hydrants is not seen, this is probably because that use of ground water is increasing while measures against water saving, such as circulation use in factories and conversion to water conserving type process from water consuming process, have taken effect. But about the rate of flow, its current status is still not clear. In fact, in the hearing of factories, measures against water conservation were conspicuous, such as zero emission to the environment with perfect water recycling.

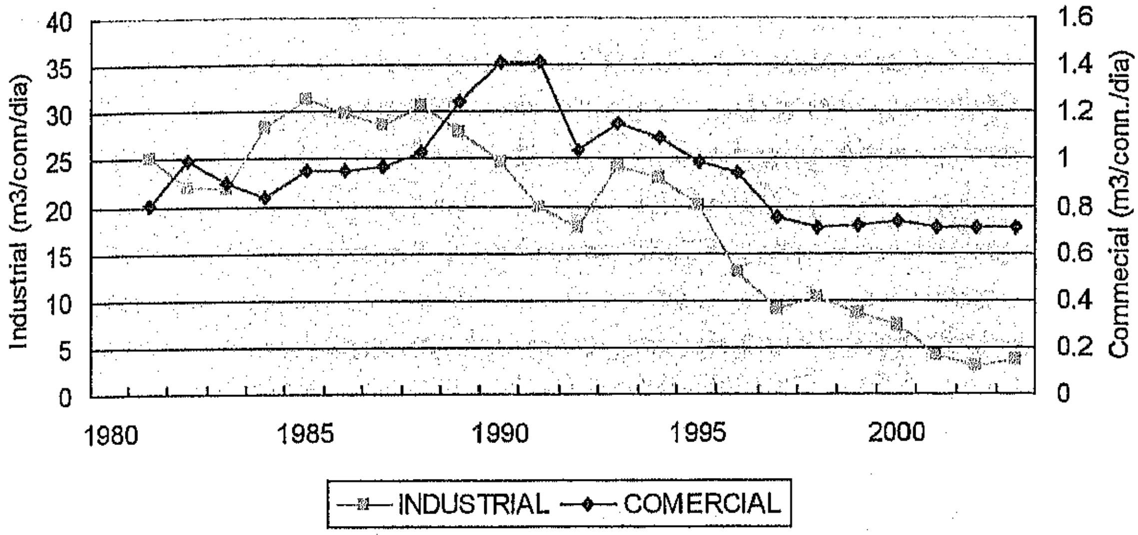


Figure A10.3.2 Commercial use and industrial use for the water consumption per faucet

A part of such industrial water conservation seems to have been covering the increase in the domestic use with increase in population, and is considered to have controlled the need of the whole water SBC in 1988 and afterwards.

(2) Study on the unit rate of sewage flow and pollution load

1) Objective

The unit rate for sewerage planning was confirmed in SBESP information. But it became clear that it was transferred from Europe, set as design criteria long before and it has been used without verification. It is thought that the study on various unit rates in current status has significance for future facilities planning by clarifying the variation of the unit rate in the area, season and time.

2) The unit rate measurement survey on sewage

24 hours site studies of the sanitary sewage flowrate and water quality at the point of a exposed sewer pipe of Alvarenga area Jardim Laura in San Bernard do Campo city were conducted on 2nd and 3rd September, 2005. (No rain fall was observed over 1 week before the survey)

Drainage area and population were also investigated by confirmation of the basin boundary and that of sewers simultaneously. Large-scale apartment, factory, large-scale restaurant and shopping center, are not located in the area, and it is almost dominated by individual residences. Half of the area is favela (Jardin Laura II). In this area, there is no well for potable water. (A shallow well for irrigation was confirmed), and water supply depends for the whole quantity on SABESP mostly. Sewage of the regular house was connected to sanitary sewer. Illegal connection to sewers by independent construction in favela was confirmed as well.

i) 24-hour study on sanitary-sewage flowrate

Sanitary-sewage flowrate change is shown below. It becomes the minimum flowrate near at 6:00 a.m., and a trend for flowrate to increase toward noon is seen. Mean discharge from the area is 7.6 L/sec (=656.6m^3/day). Since this flowrate includes permeation of ground water, it needs to be taken into consideration in examination.

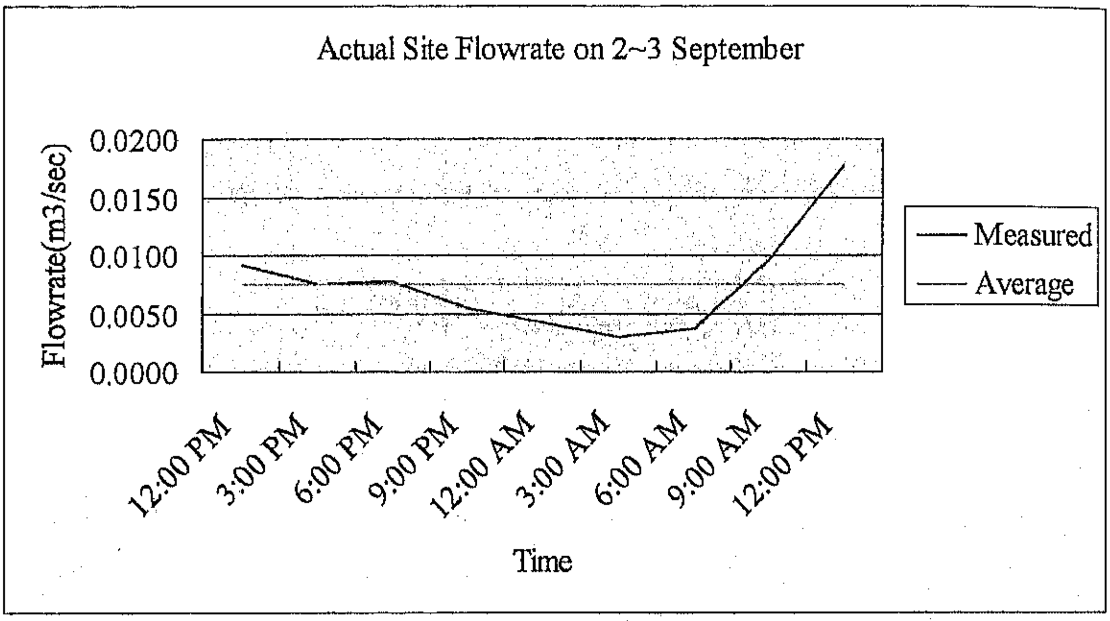


Figure A10.3.3 Flowrate change in Alvarenga

Rate of flowrate fluctuation at the time of final sampling, rate of change shows the numerical value beyond 2.0. Since the day was on Saturday, this may have been influenced by increased at-home rate. The value of the previous day is about 1.2 to daily average flowrate.

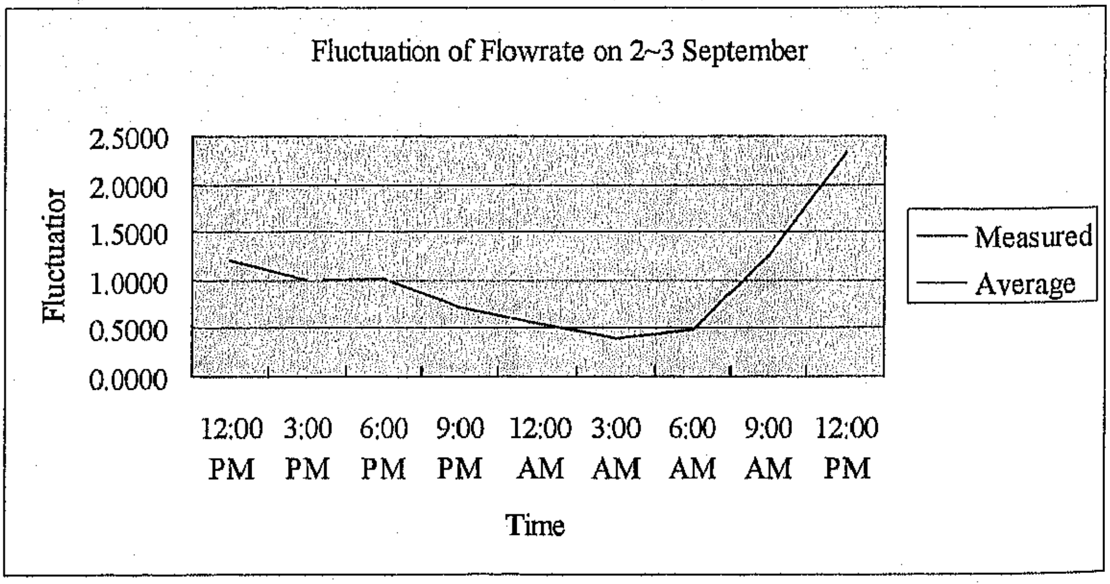


Figure A10.3.4 Fluctuation of flow rate in Alvarenga

ii) Calculation of the unit rate of sewage

Drainage area of the community was confirmed by site investigation as follows; **(Figure A10.3.5)**

Table A10.3.1 Fundamentals for sewage unit rate study

Item	Unit	Numerical value	Note
Drainage area	ha	10.9	Measured on the drawing
Households in the area	Nos.	629	-ditto-
Population	Nos.	3,422	Home nos x 5.44pop
Sewer extension	km	2.0	Measured on the drawing
Sewers extension per ha.	m/ha	183	2.0km/10.9ha

The population in the drainage area was calculated by households and 5.44 persons per house (by SABESP). In the study by the SABASP charge collection table shown in another section, they were 5.1 persons/house. Since results of SABESP investigation were close to our study, and it is based on much more data than this study, the value of SABESP was used for analysis. About permeation of ground water, 0.5 L/km/sec of the permeation is used in SABESP. The same value shall be used for examination and prediction.

According to the on-site measurement and the fundamentals of the area, the unit rate of sanitary sewage was assumed below. According to this, the unit rate is 166 L/capita/day which is close to the unit rate of SABESP (150 L/capita/day).

The amount of ground water infiltration becomes 13.2% to the amount of sanitary sewage in this example, and it is also close value which is used in Japan currently. Taking into consideration that unit sewer length per ha is about 200 m/ha (they are 183 m/ha from **Table A10.3.2**) in the densely inhabited area like the Jardim Laura, it will be possible to estimate an average of 15% infiltration from ground water in the basin.

Table A10.3.2 Flowrate unit-rate examination of sewage

Hour	Weather	Air Temp. (°C)	Discharge (m^3/s)	Remarks
12PM	cloudy	19	0.0091	
3PM	foggy/cloudy	18	0.0075	
6PM	foggy/cloudy	16	0.0077	
9PM	foggy/cloudy	12	0.0055	
12AM	fine	11	0.0042	
3AM	fine	8	0.0030	
6AM	foggy/cloudy	11	0.0036	
9AM	fine	18	0.0096	
12PM	cloudy	20	0.0177	
Average		14.8	0.0076	
Infiltration		l/sec	0.0010	
Actual flowrate		l/sec	0.0066	
		m3/sec	567.0	
Residents		Households	629	
		Population	3,422	
Unit Rate		l/capita/sec	166	

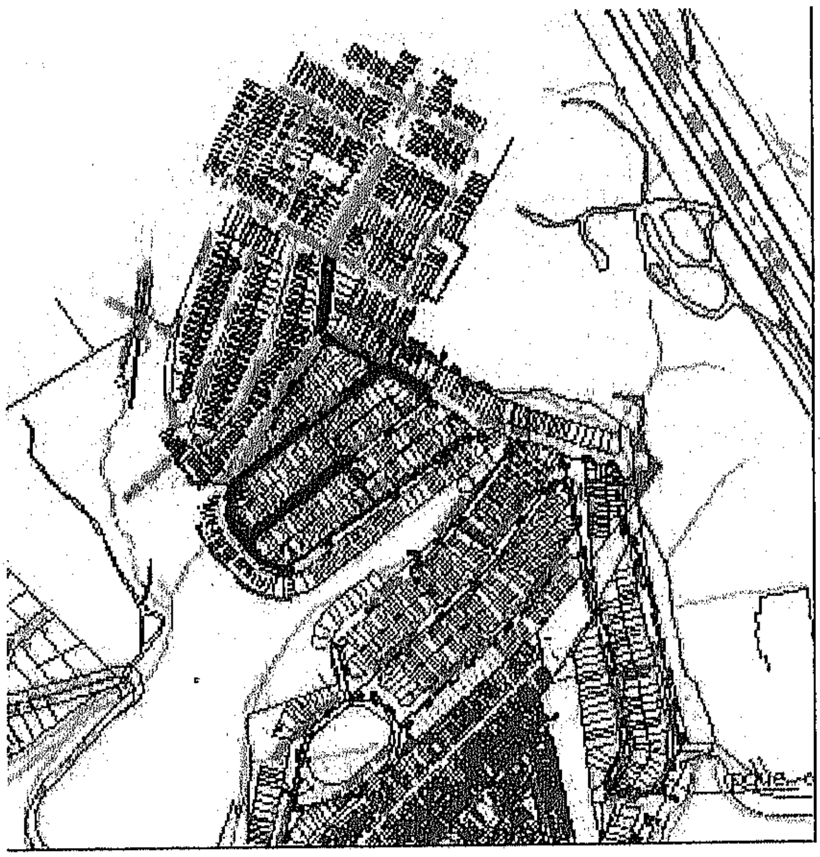


Figure A10.3.5 Jardim Laura

iii) Hearing survey of unit rate of sanitary sewage

A hearing survey was performed in the Jardim Laura area to get the information of the number of residents in a house and water consumption per month. It was implemented by confirmation of the charge collection slip of SABESP. This work also enabled to check the validity of the measurement survey result from different point of view. Results of the investigation are shown in **Table A10.3.3**. As for the number of houses subject to the study, 14 houses were chosen. Calculated average unit rate per capita was 138 L/capita/day with about 5.1 persons per house in October, 2005. The annual average value is indicated by the collection slip and this average value is 114 L/capita/day.

Table A10.3.3 Unit rate survey - sanitary sewage 1

Date 2005. Nov. 24th

Number	Street	Household data	Water Consumption (m3/month)		Resident	Unit Rate per capita		Remarks
		No. etc.	Latest monthly	Yearly average	(people)	Latest monthly	Yearly average	
1	Av.1001	89027	19		6	0.106	0	
2	Av.1001	31	13		4	0.108	0	
3	Rua Sylvio	45	18		6	0.100	0	
4	Av.1001	20	38	27	6	0.211	0.150	
5	Av.1001	19	23	19	5	0.153	0.127	
6	Rua Amadeu	26	32	25	7	0.152	0.119	
7	Rua Ribeiro	82	18	17	4	0.150	0.142	
8	Rua Ribeiro	163	20	16	4	0.167	0.133	
9	Rua Ribeiro	160	33	25	8	0.138	0.104	
10	Rua Ribeiro	38	12		2	0.200	0	
11	Rua Sylvio	70	6	5	2	0.100	0.083	
12	Rua Sylvio	174	9	7	2	0.150	0.117	
13	Rua Tangaras	Bar	27	19	6	0.150	0.106	
14	Avenida Laura	Loja	13	15	9	0.048	0.056	2 invoices
Average			20.1	17.5	5.07	0.138	0.114	
Standard Deviation			9.5	7.3	2.2	0.043	0.028	
75% percentile value			29.6	24.8	7.3	0.181	0.142	
95% percentile value			39.1	32.1	9.5	0.224	0.170	

iv) Unit-rate hearing survey 2

This study investigated the unit rate of the urbanized area outside of the basin, and tried comparison with the area inside of the basin, or containing favela. The large-scale apartment of Costa brava area in Sao Bernardo do Campo was selected for the study. This was also made by the charge collection slip of SABESP. Well water is used together for cost saving in the apartment. It was due to the problem of the water quality of well water.

According to this, the Jardim Laura areas differ clearly and are the results of about twice called 311 L/capita/day. This is considered to mean that the type of usage of water differs.

In Jardim Laura, although there occurs sometimes suspension of water supply, this apartment is coping with the problem by storing well water in preparation for suspension of water supply etc. Probably, increase of the water consumption by cleaning / wash water in swimming pool, car-washing, and residential area cleaning etc. has been taking place.

Table A10.3.4 Unit rate of sanitary sewage in large scale apartment in the outside of the basin

Monitoring Stations	month	Water consumption					Unit Rate	Seasonal Fluctuation
		water supply	well	(m³/month)	(m³/day)	(l/day/resident)	(l/day/capita)	
costa brava	April	447	1165	1612.0	53.7	1119.4	279.9	0.90
	May	477	1272	1749.0	58.3	1214.6	303.6	0.97
	Jun	473	1450	1923.0	64.1	1335.4	333.9	1.07
	Jul	607	1167	1774.0	59.1	1231.9	308.0	0.99
	Aug	666	1247	1913.0	63.8	1328.5	332.1	1.07
	Sept	879	966	1845.0	61.5	1281.3	320.3	1.03
	Oct	877	877	1754.0	58.5	1218.1	304.5	0.98

Average	311.7560	l/day/capita
Stddev	18.823	l/day/capita
75%value	330.579	l/day/capita

Seasonal variation in the apartment is shown below. Although the data of the time of midsummer are lacking, it is thought that big seasonal change is not seen.

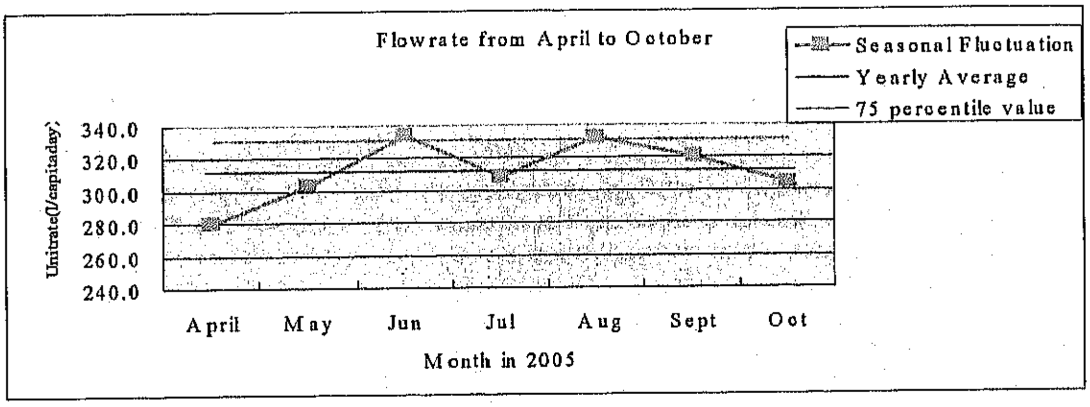


Figure A10.3.6 Seasonal variation of unit rate of sewage of large-scale apartment

v) The projected unit rate of SABESP and the adopted value in this study

The water consumption unit rate and sanitary-sewage scale factor (2006. Jan. confirmation) of SABESP are as follows.

Table A10.3.5 Unit rate of SABESP

Item	Classification	Unit	Value	Remarks
Unit Rate	Daily Average	L/capita/day	150	At present
		L/capita/day	160	For the year 2006
		L/capita/day	180	-ditto- 2015
		L/capita/day	200	-ditto- 2025
	Infiltration to sewer	L/sec/km	0.5	For the pipeline distance
Coefficient	Sewage/water consumption	-	0.8	
	Daily Max/Daily Average	-	1.2	
	Hourly Max/Daily Average	-	1.5	

In the Jardim Laura area, it was admitted that the unit rate and actual measurement of SABESP of an existing condition are close as stated above. Thus, the unit rate of SABESP seems expressing the current status well. In the future, as the example of a large-scale apartment shows, trend of increase on the average shall be seen, and the amount of unit rate of sanitary sewage will increase gradually. From such results, the planned value of SABESP is judged appropriate to adopt as an amount unit rate for sanitary sewage in this plan.

vi) Unit rate of pollutant load

In 24hrs measurement survey, water quality was also simultaneously measured for the purpose of calculation of pollutant load per unit. It can be said that all values are smaller than those of many reference values including Japanese standard. Making a plan using this value may leads to the plan by the side of underestimating. In this study, the value of CETESB is chosen. The values for future are set constant with the value in table.

Table A10.3.6 Pollution-load unit rate and Measurement survey result

Domestic Load Unit Rate						
	time zone	g/ 3 hours				
		BOD	SS	COD	TN	TP
Site-Survey	1	32,118	10,065	45,784	4,430	427
	2	23,514	12,855	39,014	2,632	411
	3	22,163	12,211	41,273	3,120	448
	4	12,475	5,732	18,504	1,859	219
	5	4,025	1,160	5,435	896	81
	6	1,482	1,123	3,273	853	70
	7	8,333	4,508	16,490	2,049	288
	8	35,494	10,430	73,168	5,062	1,077
	Total	139,604	58,084	242,941	20,901	3,021
	Ave.conc	246	102	428	37	5
	g/Capita/day	40.8	17.0	71.0	6.1	0.9
Design Standard etc.(g/capita/day)						
Brasil	Sabesp	54			10	3
	SMA	56.16	55		11.904	1.514
	CETESB	54	60	108	10	1.2
Japan	JSWA	58	45	27	11	1.3
Adopted Value (g/capita/day)						
Adopted Value		54	60	108	10	1.2

vi) Assumption of inflow sewage water quality of sewage treatment plant

Each water quality in an existing condition (2005) and the future (2025) is calculated below. 15% of infiltration to the sewage is considered in this case.

Table A10.3.7 Assumption of sewage water quality unit: mg/L

	BOD	SS	COD	TN	TP
2005	391	435	782	72.4	8.7
	Q=150x0.8x1.15=138 L/capita/day				
2025	294	326	587	54.3	6.5
	Q=200x0.8x1.15=184 L/capita/day				
2005 Pereira	339	168	661	76	8.0
	Site measurement in Pereira channel				

According to comparison with sewage water quality assumption, it turns out that water in the Pereira channels is in the status of sewage itself. Furthermore, this channel water quality shows that assumption of the above-mentioned unit rates is appropriate in general. It turns out that SS is lower compared with unit rate like the survey result in Jardim Laura.

In this study the quality of influent sewage to the sewage treatment plant shall be determined on the basis of the above-mentioned water quality.

(3) Other unit rates

Except for the unit rate of domestic sewage, it shall be set as follows.

i) Industrial waste water

Point discharging shall be carried out with the office management list of CETESB. However, except Solvay Indupa. of Santo Andre, no other industry has substantial influence.

ii) Water for commercial use

Although the amount of water which should be counted for commercial use includes restaurants etc., such amount of water is considered to be leveled and contained in the amount unit rate of home sanitary sewage. There are not much large-scale facilities seen in the basin. From these, unit rate of sanitary sewage can be inclusive such sewage.

iii) Tourism drainage

In this basin, Paranapiacaba area is a famous sightseeing area in the basin and it should be included in the sewage treatment area as tourism sanitary sewage. Sight seeing population and caretakers for the lodgings and restaurants shall be considered. For this reason, the unit rate for tourists is required.

As an amount unit rate of sanitary sewage for tourists, it shall be set from the rate over a domestic-sewage unit rate by referring to an example of Japan. Refer to **Table A10.3.8**.

Table A10.3.8 Tourist sanitary-sewage unit rate

	Domestic sewage	Lodging tourism sanitary sewage	Day trip tourism sanitary sewage
1) The ratio of the unit rate of sanitary sewage	100%	50%	15%
Unit rate(L/capita/day)	150	75	22.5
2) The ratio of the unit rate of pollution load			
BOD	100%	85%	24%
COD	100%	85%	24%
SS	100%	84%	23%
T-N	100%	95%	40%
T-P	100%	86%	27%
3) Pollution load unit rate(g/capita/day)			
BOD	54	46	13
COD	108	92	26
SS	60	51	14
T-N	10	9.5	4.0
T-P	1.2	1.0	0.3

Source: Sewerage facility guideline (Japan Sewage Works Association)

10.4 Projected sewage flow rate and pollution load

(1) The methodology of projection of sewage

The amount of sewage shall be calculated for 2 classifications of generated sewage, and discharged sewage. The generated sewage is an amount of polluter's load generated at the origin. The amount of discharged sewage is the amount of sewage which arrives at the closest public water body. For example, in case of septic tank, generated sewage is just the same with sewerage, but discharged pollution load is zero, because the liquid is infiltrated to the under ground and sludge is removed by contractor periodically to the sludge treatment plant.

i)The generated sewage :

$Q_{xy} = \Sigma (P_{xy} \times q_{xy})$

Where Qxy : Load X generated in the year y

Pxy: Projected value X in the year y,

qxy: unit rate of X generation in the year y

ii)The discharged sewage :

$Q'_{xy} = \Sigma (P_{xy} \times q'_{xy})$

Where Q'_{xy} : Load X discharged in the year y

Pxy: Projected value X in the year y,

q'xy : unit rate of X discharged in the year y

Ground water infiltration shall be considered in treatment plant facilities and pollution analysis respectively. The methodology of pollution load projection is the same as the methodology of the projection of sewage flow rate.

(2) Common condition for projection

i) Frame value

- CASE2 JICA

ii) The unit rate of sewage and pollution load unit rate

- Although the unit rate of sanitary sewage increases, pollution load unit rate is considered as constant.

iii) Generation and discharge

a) Generation shall be calculated value x 1.0.

b) Discharge shall be calculated as follows.

- Discharge loads are roughly classified into three items such as direct run off, sewerage (discharge without treatment and with sewage treatment), and septic tank. Regarding this share of three discharge, it turned out that the shares changes by areas. The Billings Lake basin shall roughly be divided into eight areas according to modes of residents. The ratio of the 3 above-mentioned shall be defined for every area to examine discharge load. The classification and percentage are shown in the following table. The basic data of this figure is the same as **Table 3.4.1**. In case that the areas are adjoined, and condition of sanitary facilities is close, the same numerical value is used in order to avoid complication.

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Table A10.4.1 Distribution in basin of sanitary facilities **Unit (%)**

A municipality/area	Sewerage	Septic tank	Direct run off	Note
Sao Paulo 1	40	50	10	Circumference of Pedereira
Sao Paulo 2	0	70	30	District of Parereilhos
Diadema	65	30	5	Whole district
SBC1	65	30	5	Alvarenga high density area
SBC2	40	50	10	The opposite shore of a lake
Santo Andre	5	40	55	Whole district
Ribeirao Pires	65	30	5	Whole district
Rio Grande arm	65	30	5	Whole district

- Direct run off: Discharge rate 1.0 to water body.
- Sewage: In sewage untreated zone, the discharge rate is 1.0 to water area. It is 0 in sewage treated zone.
- Sewage treatment: In case of anaerobic treatment, such as UASB, treatment efficiency shall be 65%. In case of oxidation ditch method, 90% of treatment efficiency shall be used. In

case of advanced sewage treatment, discharge water quality is fixed to BOD=5 mg/L.

- Both of excretory waste and used washing water shall be treated in the septic tank. And treated water shall permeate or be discharged to channel after treatment. From the result of hearing survey, 25% of septic tanks are considered discharging to the area of water for public use. However, since this percentage changes according to maintenance and operation, infiltration of 100% in the pollution analysis.
- The rate of installation of septic tank is considered to be constant in the analysis. If sewerage is constructed in the neighborhood, the residents are obliged to connect to sewer from septic tank. However, such areas are limited to several places in the basin in order to control population growth, the rate as of now shall be used even for future projection.
- About industrial waste water, the discharge rate of 1.0 shall be applied to data of CETESB information. It was confirmed that many companies don't discharge effluent by the water spraying to woods or cultivated fields. However, for the safety factor, discharge rate shall be taken as 1.0.

(3) Cases of examination

Two (2) cases were examined for discharged sewage, and the pollution load as shown in **Table A10.4.2.**

Table 10.4.2 Cases of Examination for discharge of sewage and pollution load

	Facility construction plan	Note
Scenario 1	• The case of a zero option • Assuming the SABESP trunk for the direction of Ribeirao Pires will be done in 2010. Sewage will be transferred to the ABC treatment plant.	
	• No constructions for other facility including Alvarenga area and Cocaia area	
Scenario 2	• The direction of a Ribeirao Pires is the same as scenario 1.	
	• Sao Paulo and a SBC Alvarenga Diadema shall advance construction according to the plan of SABESP. • Sewage of Parelheiros and Grajau in Sao Paulo shall be transmitted to Barueri treatment plant. Facility shall be completed in 2010 - 2015. • Regarding in-lake area of SBC, construction shall be advanced according to master plan. The enterprising body is set to SABESP. Sewerage system with independent STP shall be constructed in Riacho Grande area and Santa cruz area.	
	• It shall be fixed by the city sewerage planning about Santo Andre.	

(4) Result of examination

Scenario1: The case of zero option. In 2025, the total amount of discharge sewage of the basin is 101,000m³/day, about 84,000m³/day flows into main lake, and the rest of 17,000m³/day will go to Rio Grande arm. Since sewage of Ribeirao Pires treatment plant and Rio Grande da Serra treatment plant is transferred to the ABC treatment plant before 2010, the amount of sewage falls a little bit in 2010. Although there is not much increase of sewage and pollution load in the Rio Grande arm, that of main lake will be doubled.

Scenario2: A calculation result is shown in **Figures A10.4.3** and **A10.4.4**. In 2025, the total amount of discharge sewage of the basin is approximately 10,000m³/day, among those 8,500m³-/day flows into main lake, and the rest go to Rio Grande arm. Compared with scenario1, the amount of sewage and pollution load will decrease sharply by SABESP and the measure against each municipalities in 2015.

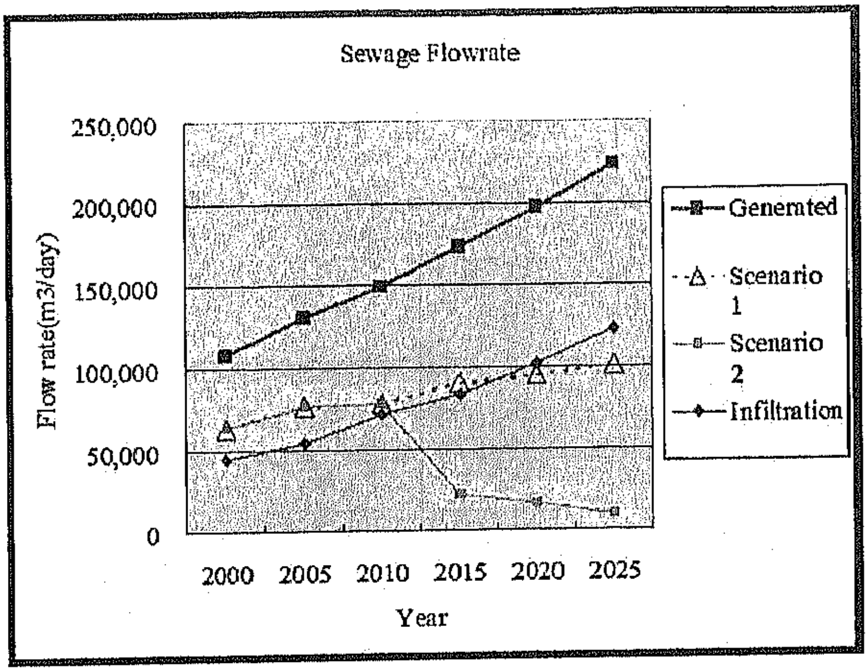

Figure A10.4.1 Generation and discharge of sewage

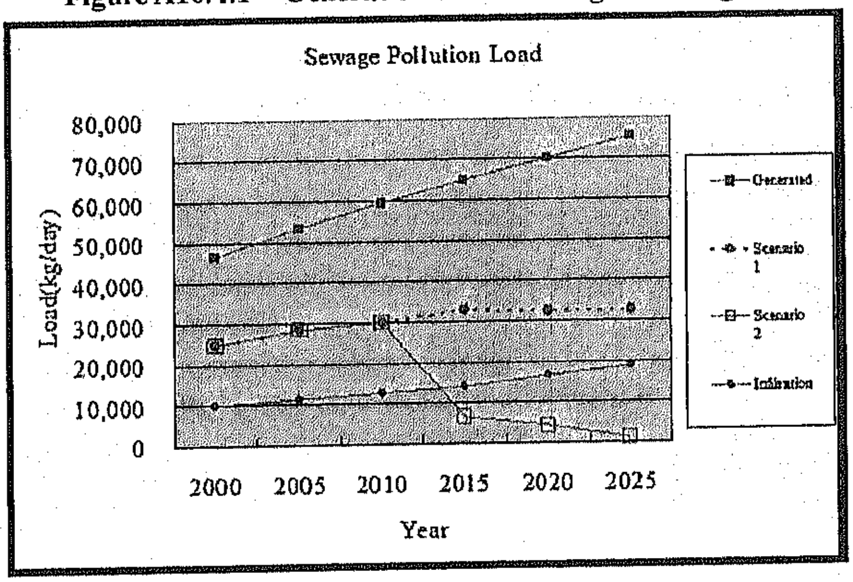

Figure A10.4.2 Generation and discharge pollution load

10.5 Design influent sewage quality and effluent water quality

(1) Design influent sewage quality

Comparison of the track record in ABC treatment plant with the examples of Japan is shown in the following table. Quite high influent concentration in Billings basin and Suzano STP is shown. The reason of this is that unit rate of sewage is comparatively smaller than that of Japan in the basin. Though influent concentration in ABC STP is very low, this may be because of mixing of various drainages to the sewage. Nagoya-city was used for the example of Japanese unit flow rate and sewerage-facility guideline as pollutant loading unit.

Table A10.5.1 Comparison of influent water quality of the-Billings-Lake basin and Japan

	BOD	SS	COD	TN	TP	Remarks
Billings Basin	300～400	330～440	600～800	54～72	6～9	mg/L
	Q=150～200x0.8x1.15=138～184 L/capita/day					
Suzano STP	309	341	796	—	—	—
ABC STP	107	162	265	—	—	—
Japan	58	27	45	11	1.3	g/capita/day
	144	67	112	27	3.2	mg/L
	Q=350x1.15=402.5 L/capita/day					Nagoya

Source: About Suzano and the quality of an ABC influent water, it is from SABESP Annual Report 2002-2003.

(2) Design effluent water quality

The following regulations by Ministry of Environment 2005 shall be applied in discharging effluent to the Billings Lake basin,

a) Sewage final effluent water quality standard

It is regulated by the criteria of the federation and states as shown in **Chapter 2** and **Table 2.3.3**. Additional control exists by the type of water body and location of discharge.

- The number of fecal-coliform-bacteria groups: No description
- BOD: below 60 mg/L
- ammonia nitrogen: No description
- Kjerdahal nitrogen: No description
- Nitrate nitrogen: No description
- Nitrite nitrogen: No description
- Phosphorus: No description

There are no regulations about phosphorus and nitrogen shown in the above, and BOD concentration is not good enough to improve water quality. There is no description about SS as well.

b) Effluent water quality in this project

In addition to effluent water quality standard in Andreense STP by guidance and instructions, effluent water quality is determined as follows;

- The number of fecal-coliform-bacteria groups: below 1,000 MPN / 100mL Following
- BOD removal rate : over 90%
- DO: over 2mg/L
- Total nitrogen removal rate : over 50%
- Total phosphorus: over 50%
- SS: over 90%

As a result, effluent water quality exceeds general secondary treatment water quality, and it needs advanced wastewater treatment. Effluent water quality is determined as follows.

Table A10.5.2 Design effluent water quality

Item	BOD	SS	COD	TN	TP	Coli.
Unit	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL
Billings Basin	20	20	40	15	1.0	1000

Note 1) SS is determined as the same value of BOD from removal rate .

2) As chromium method is used for water analysis, COD is set as twice of BOD.

3) Phosphorus is set referring the examples in Japan.

With employing the conventional technology in this design condition, effluent water quality is difficult to achieve and advanced sewage treatment system is required for it. As advanced sewage treatment, a system which is combined with advanced SS removal is needed for nitrogen and phosphorus removal. Four existing treatment plants in the Billings Lake do not have enough treatment capability judging from these criteria.