1.1.3 Hydrology and Future of the Basin

(1) Hydrology

1) River discharge

The long-term stream flow observation in the Lake Billings basin is only carried out in RG-1 station of SABESP in Rio Grande (The watershed area; 38.07 km^2, refer to **Figure 1.1.1**).

The observation records were obtained the measured daily water level and calculated discharge rate at 7:00 and 17:00 in January, 1997 - December, 2000 and December, 2001 - June, 2005. It contains a lot of missing value, and the data in 1997-2000 and 2003 are able to use throughout the year.

The secular variation plotted by daily discharge of RG-1 and daily precipitation of E3-149 (Rio Grande Campo) is shown in **Figure 1.1.15**, and the summary table of the annual discharge is shown in **Table 1.1.3**.

The mean annual discharge rate is 0.93-1.34 m^3/s and annual discharge amount is 29.2 million-42.2 million m^3 in RG-1(Rio Grande Campo).

Table 1.1.3 Annual Discharge of RG-1(Rio Grande Campo)

Item	Unit	1997	1998	1999	2000	2003	Mean
Annual discharge amount	m^3	29,170,282	42,245,539	40,216,176	40,576,378	37,692,086	37,980,092
Mean annual discharge	m^3/s	0.925	1.340	1.282	1.283	1.195	1.205
Plentiful discharge	m^3/s	0.932	1.323	1.199	1.248	1.052	1.151
Normal discharge	m^3/s	0.586	0.909	0.722	0.745	0.851	0.763
Low water discharge	m^3/s	0.387	0.654	0.541	0.519	0.722	0.565
Drought water discharge	m^3/s	0.258	0.431	0.409	0.387	0.608	0.419

2) Amount of dam discharge and inflow from Pinheiros waterway by pump-up

EMAE manages stabilization of water level of the Billings Lakes in order to secure water for power generation and normal discharge for downstream, and includes emergency pump-up from the Pinheiros waterway on Tiete river flood.

The daily discharge of the Summit dam and the daily pump-up inflow of the Pedreira dam are recorded.

The monthly and annually variation of discharge and pump-up inflow of 20 years from 1985 to 2004 is shown in **Figure 1.1.16**.

In 1992, the pump-up from Pinheiros waterway to the Lake Billings were prohibited except emergency treatment for the flood of Rio Tietê (discharge 160m^3/s or more) by the state law in order to protection for the progressive pollution of the reservoir though pumping. The pump-up inflow from Pinheiros waterway decreases after 1993, and the discharge from the Summit Control dam also decreases along with it.

Now, the Henry Borden power plant is operated only for the replenishment at time when power is insufficient in power supply for São Paulo urban area and so on. Moreover, the water supply from

Rio Das Pedoras reservoir to Qubatao and Santos is carried out.

The annual discharge and pump-up inflow of 20 years from 1985 to 2004 is shown in **Table 1.1.4**.

(A) E3-149 Daily Precipitation

(B) RG-1 Daily Discharge

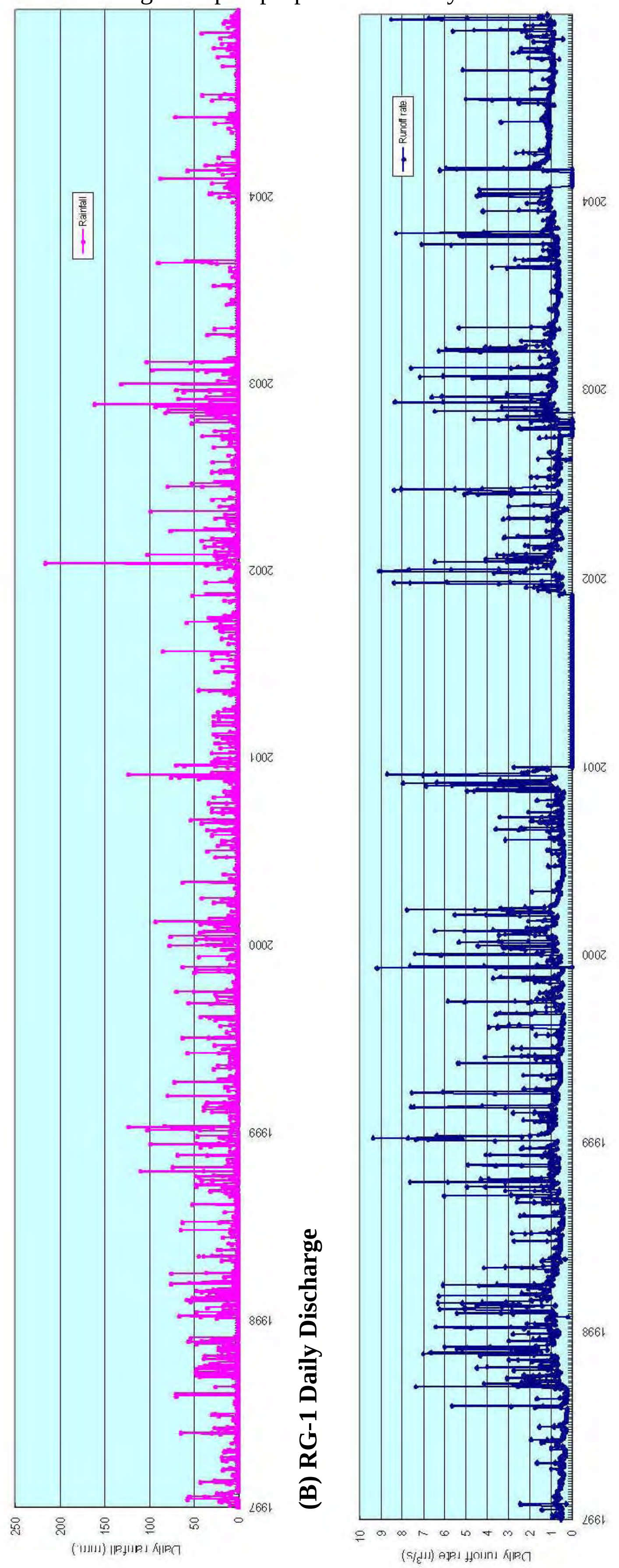
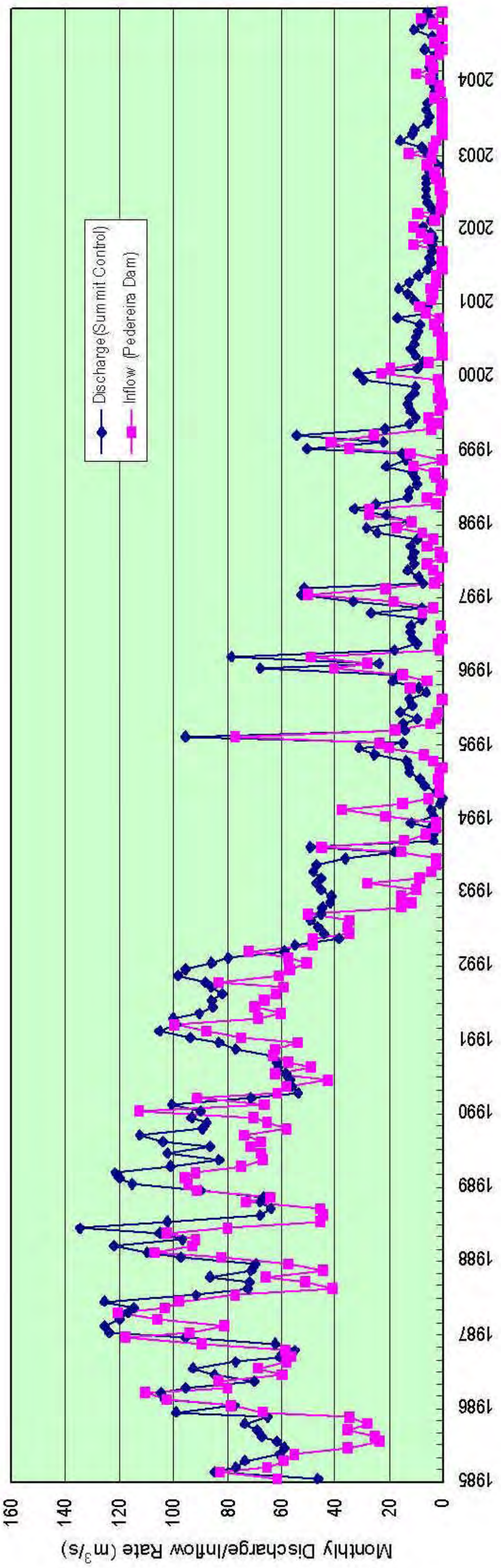


Figure 1.1.15 Annual Variation of RG-1 (Daily Discharge) and E3-149 (Daily Precipitation)

(A) Mean Monthly Discharge and Inflow Rate



(B) Monthly Discharge and Inflow

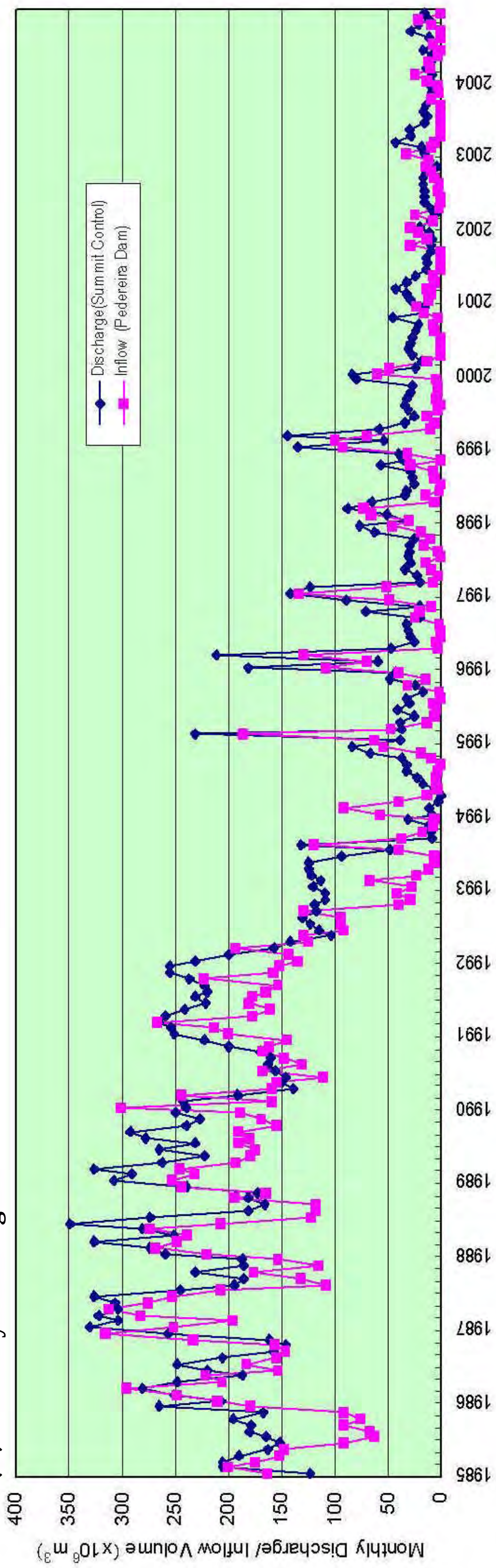


Table 1.1.4 Annual Discharge and Pump-Up Inflow of the Lake Billings

	Discharge		Inflow by pump-up	
	m^3	m^3/s	m^3	m^3/s
1985	2,191,743,360	69.6	1,492,732,800	47.5
1986	2,568,628,800	81.6	2,521,393,920	80.0
1987	3,120,638,400	99.1	2,459,972,160	78.0
1988	2,958,266,880	93.6	2,416,443,840	76.5
1989	3,193,639,488	101.4	2,348,064,288	74.6
1990	2,182,070,016	69.4	2,046,254,400	64.8
1991	2,913,390,720	92.5	2,221,528,032	70.5
1992	1,657,476,000	52.5	1,240,763,616	39.3
1993	941,448,960	29.9	363,230,784	11.6
1994	320,725,440	10.1	292,343,040	9.4
1995	604,488,960	19.7	411,791,040	13.2
1996	817,015,680	25.7	416,798,784	12.4
1997	626,235,840	20.0	309,251,520	9.8
1998	517,233,600	16.4	261,403,200	8.4
1999	684,327,744	21.6	304,266,240	9.8
2000	364,287,456	11.5	175,832,640	5.6
2001	240,736,320	7.7	107,352,000	3.4
2002	157,023,274	5.0	103,956,480	3.3
2003	220,122,551	7.0	59,754,240	1.9
2004	160,761,244	5.1	97,993,152	3.1

3) Withdrawal from the basin

The withdrawal from the Lake Billings basin for municipal water supply is carried out by SABESP in the Rio Grande arm (reservoir), Taquacetuba (reservoir), and Ribeirão da Estiva (river intake).

The daily withdrawal record in Rio Grande arm is obtained after January, 1996, Taquacetuba is from August, 2000 (Beginning of operation), and Ribeirão da Estiva is after August, 1996.

Besides, the intake from the small stream and spring on the north side in the basin for regional water supply is carried out by SEMASA of Santo André, the record of the withdrawal is not carried out.

The monthly and annual variation of withdrawal of three pump station of SABESP is shown in **Figure 1.1.17**.

The withdrawal amount of Rio Grande arm and Taquacetuba shows the tendency to increase every year.

The withdrawal amount of Ribeirão da Estiva shows the annual variation that seems due to influences of stream discharge and almost same amount in 1996 and 2004.

The annual withdrawal amount and mean annual withdrawal rate are shown in **Table 1.1.5**.

The annual withdrawal rate in 2004 is Rio Grande arm 4.73m^3/s, Taquacetuba 4.00m^3/s, and Ribeirão da Estiva 0.097m^3/s.

4) Variation of surface water level and storage volume of the Lake Billings

The water level of the Lake Billings is observed by EMAE in Pedreira dam. The Storage volume is obtained from water level using H (water level) - V (storage volume) table.

The monthly and annual variation of the water level and the storage volume of 20 years from 1985 to 2004 are shown in **Figure 1.1.18**.

The mean monthly water level of 20 years is above sea level 743.09-744.31m, March - May is high, and September - December is low, and the mean annual water level is 743.63 m.

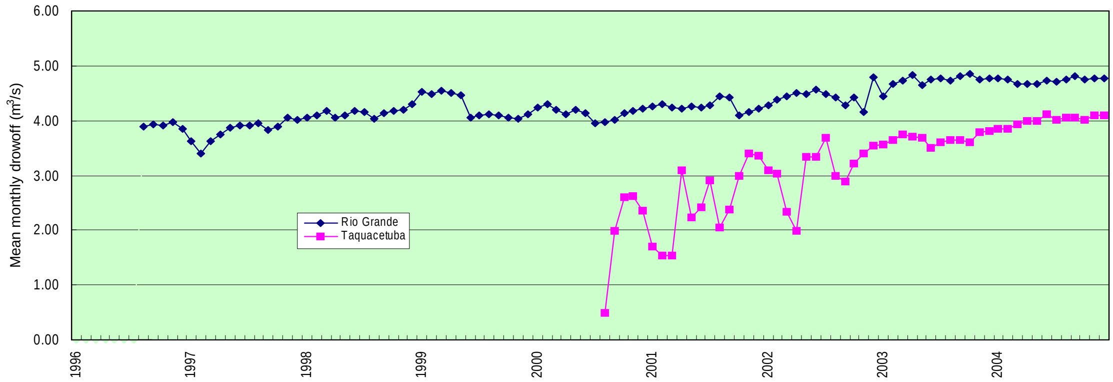
The mean annual water level of 20 years is high in 1987, 1990-1991 and 1995-1999 (744.61-744.98m), and low in 1986, 1993 and 2001 (740.53-42.44m).

The mean annual storage volume is 698 million m^3, and the maximum of mean annual storage volume is 814 millionm^3 and the minimum of mean annual storage volume is 461 million m^3.

In Rio Grande Arm, the three pipes of the diameter 1200mm are installed between the arm and Lake Billings by SABESP. When the surface of the water of the arm seems to exceed 747.20 m, the water-table management of the Rio Grande arm is carried out by portable vacuum pump. The record of the water level observation in Rio Grande arm is not carried out.

Table 1.1.5 Annual Withdrawal from the Lake Billings Basin

	Rio Grand Arm		Taquacetuba		Ribeir'ão da Estiva	
	m^3	m^3/s	m^3	m^3/s	m^3	m^3/s
1996	51,687,072	3.91	-	-	3,058,828	0.097
1997	120,609,216	3.82	-	-	2,614,732	0.083
1998	130,488,192	4.14	-	-	2,684,448	0.085
1999	134,276,832	4.26	-	-	2,309,688	0.07
2000	128,359,296	4.14	26,554,765	2.02	2,459,920	0.078
2001	131,792,832	4.26	80,361,632	2.46	2,275,836	0.072
2002	139,794,336	4.43	100,214,935	3.07	2,235,902	0.071
2003	149,120,352	4.73	119,285,898	3.66	2,963,814	0.094
2004	149,708,736	4.73	130,784,706	4.00	3,082,164	0.097



(B) Ribeirão da Estiva

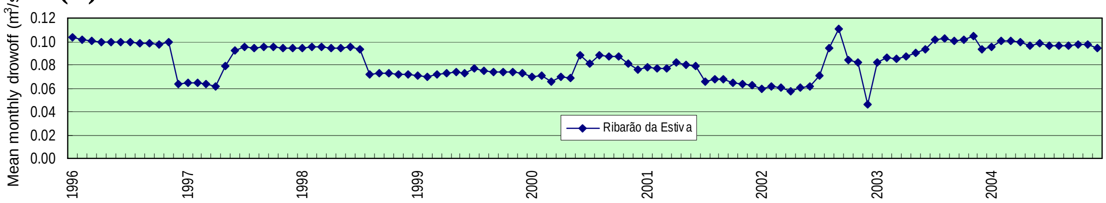
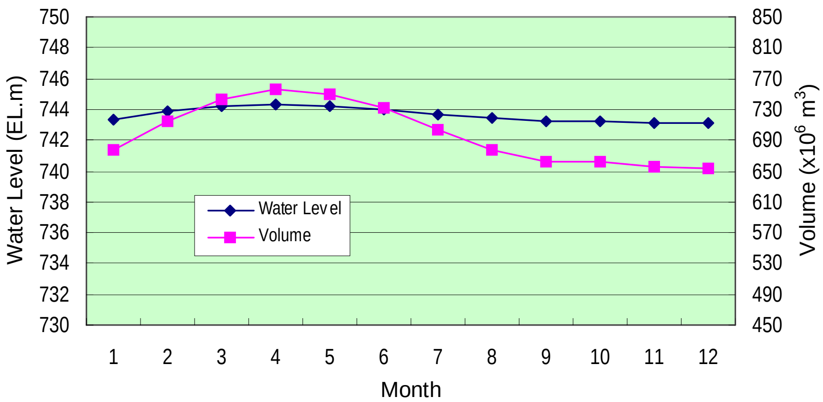


Figure 1.1.17 Annual Variation of Withdrawal from Billings Reservoir

(A) Mean Monthly Water Level and Storage Volume



(B) Mean Annual Water Level and Storage Volume

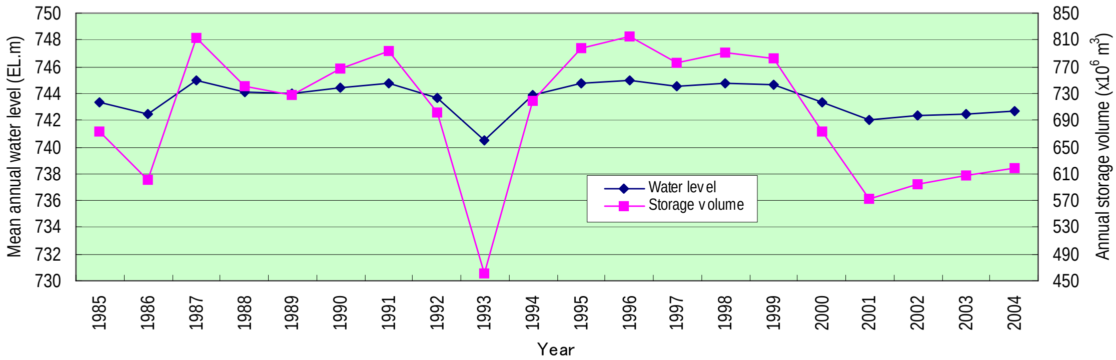


Figure 1.1.18 Water Level and Storage Volume of Billings Reservoir

(2) Future of the basin

1) Stream system of the basin

The stream system of the Lake Billings basin is shown in **Figure 1.1.19**.

The stream system reflects the geological structure, and consists of predominant (long) stream line of west-southwest to east-northeast direction or southwest to northeast direction and second dominant (short) stream line of southeast to northwest direction or south-southeast to north-northeast direction, and drainage network is composed of the polymerized parallelogram pattern.

The main rivers and streams in the Lake Billings basin are as follows;

Rio Grande

Rio Pequeno

Riveirão Reimberg (Cacaia)

Riveirão Varginha (Bororé)

Riveirão Colònia

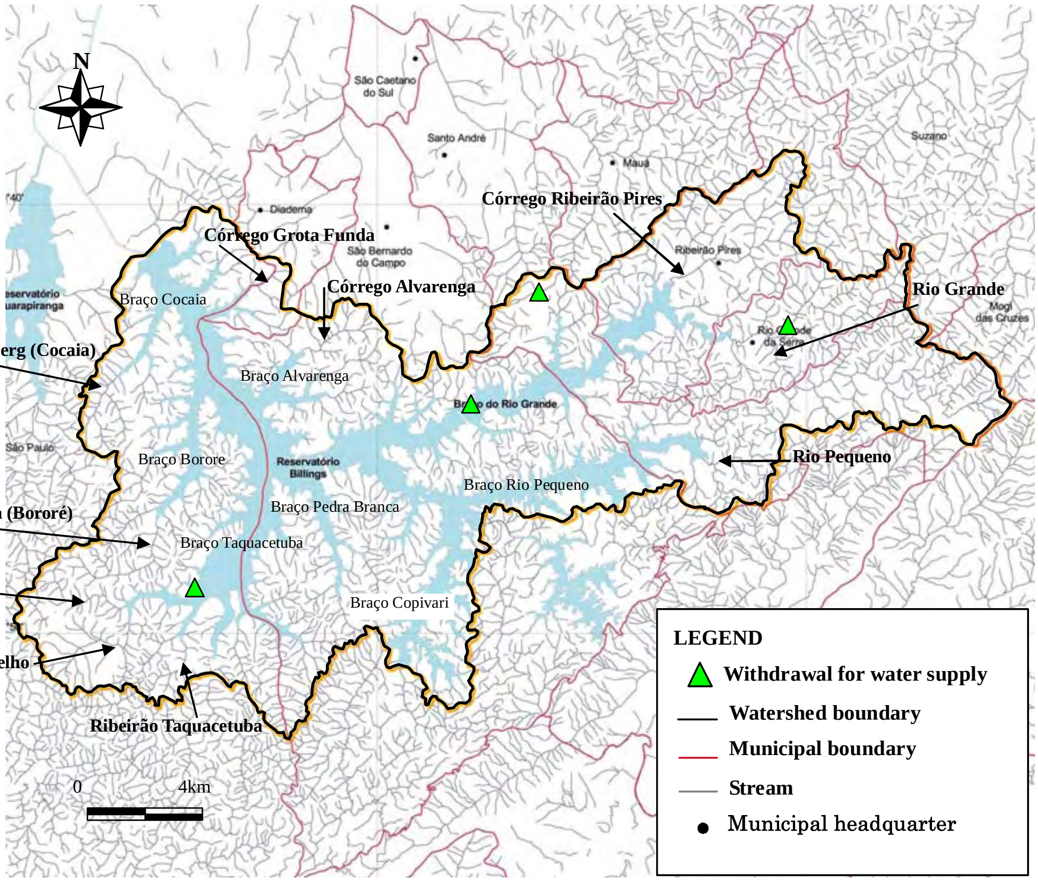
Riveirão Vermelho

Riveirão Taquacetuba

Córrego Ribeirão Pires

Córrego Alvarenga

Córrego Grota Funda



(Source; Billings 2000 João Paulo Ribeiro Capobianco, Marussia Whately 2002 ISA)

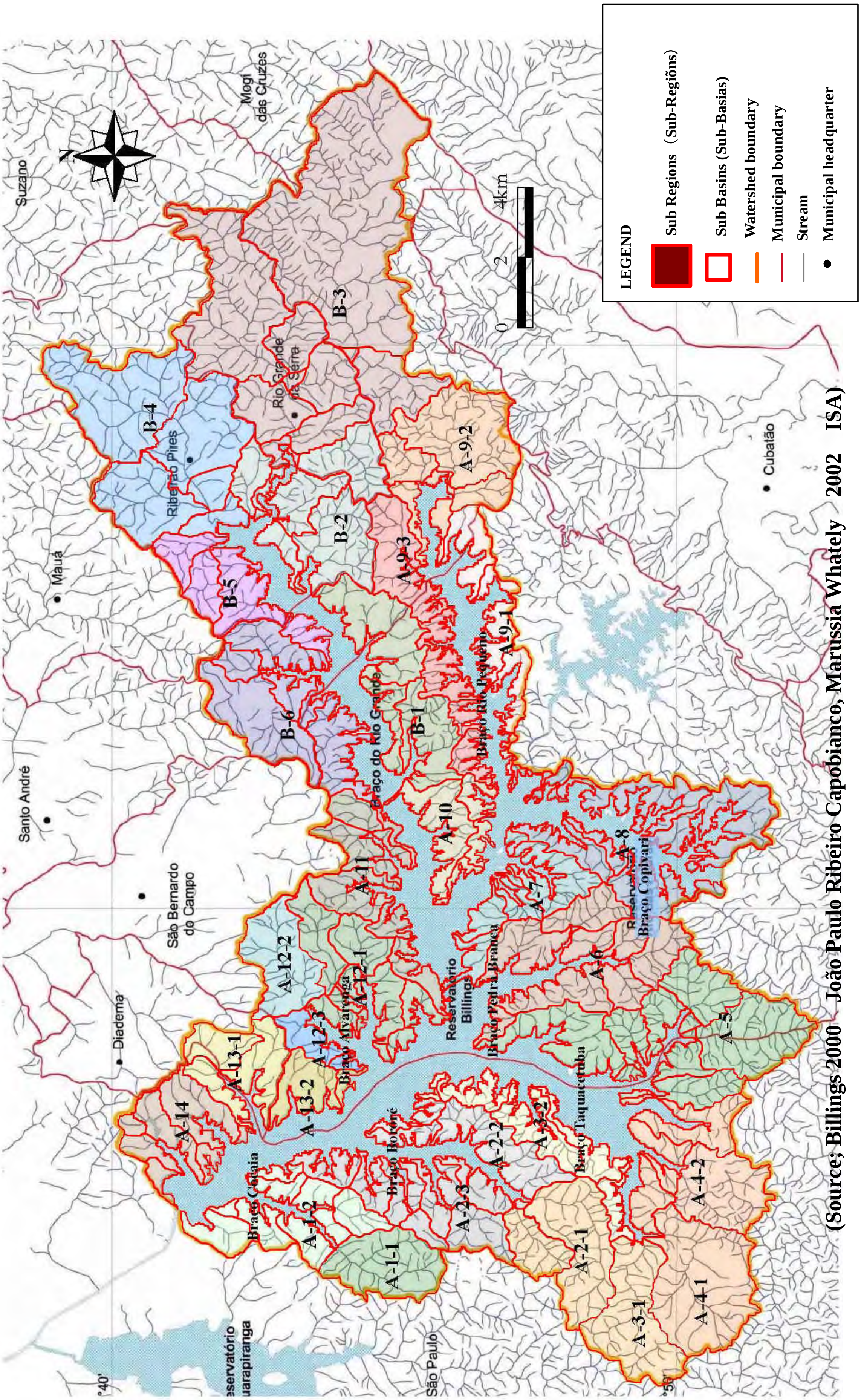
Figure 1.1.19 Map of Channel Stream System in Lake Billings Basin

2) Division of the basin

The division of the basin is shown in **Figure 1.1.20**.

Sub basin division (Sub-Bacias, 146 divisions) is taken over from the digital base map (1999) of Secretaria do Meio Ambiante, Govermo do Estado de São Paulo that is used by various reports related to the Lake Billings basin such as Billings2000 series and others.

The sub region division (Sub-Regioes, 32 divisions) is the zonal classifications that hold together sub basins. The sub regional division draws upon the previous Upper Tietê Basin contamination analysis program (Numbering such as A-1), and Rio Grande arm region that had been made one region by the previous analysis is divided into six regions to investigate in detail (Numbering such as B-1). Furthermore, the quasi-regions are set up in important main river regions to investigate contaminate phenomenon of each river in detail (Numbering such as A-3-1).



(Source; Billings 2000 João Paulo Ribeiro Capobianco, Marussia Whately 2002 ISA)

Figure 1.1.20 Partition Map of Billings Reservoir Basin

1.1.4 Natural Environment

(1) Vegetation

The forest distribution map of the Lake Billings basin is shown in **Figure 1.1.21**.

Most of the basin is the secondary forest.

The natural forest or the regenerated forest (forest that cannot be distinguished from the natural forest by the re-grown-up production in the satellite imaging) is extremely few.

The natural forest remains in Paranapiacaba, a stretch of east side of Capivari arm, a part of the upstream of Ribeirão Taquacetuba, a part of the watershed mountainous area of Rio Grande da Serra, a tiny part of northwest side of watershed mountainous area in Ribeirão Pires to Santo André.

The oil resources were insufficient while the world war second, and it is said that many were deforested to obtain the fuel and others. Moreover, the hillside texture becomes baring in the forest zone in the coastal mountain due to the pollution of the industrial region of the Cubatão in the 1970-1980's, damage to which the breakdown and the outflow of soil on the mountainous area slope happen frequently is received, and it has recovered by the subsequent environmental regulation etc. now.

Though the forest regeneration takes usually about 80 years, in the basin, a regeneration forest takes about 60 years is unrecognized with natural forest due to a lot of rainfalls. (remark of the engineer of Instituto Florestal , GESP)

The present range of forestation in the surrounding area of Lake Billings basin is shown in **Figure 1.1.22**. The forestation in the basin is extremely little probably because of rather widely spread existing secondary forest. The eucalyptus and the pine are planting chiefly in the planting lots.

(2) Flora and fauna

The flora and fauna in the surrounding area of Lake Billings basin is shown in **Table 1.1.6** and **Table 1.1.7**. (Source; Programa Rodoanel Mario Covas Trecho Sul Modificado Estudio de Impacto Ambiental (EIA) Volume1 2004, DERSA)

Paranapiacaba in southeast side of the basin is a sanctuary (Rserva Biologica de Paranapiacaba) of SP state.

Santo André municipal bought the square of the town where were prosperous as the strategic intermediate ground of the railway Santos to São Paulo before, and specifies the park of the municipal, maintains as a tourist spot and makes conservation of the watershed area including the square. The natural forest remains comparatively widely, and the plant species is also abundant.

The growing plant species is being investigated by SEMA, GESP and it is as follows.

< Flora of Paranapiacaba >

General species 418 and special species 998 of 118 subjects are affirmed in Paranapiacaba.

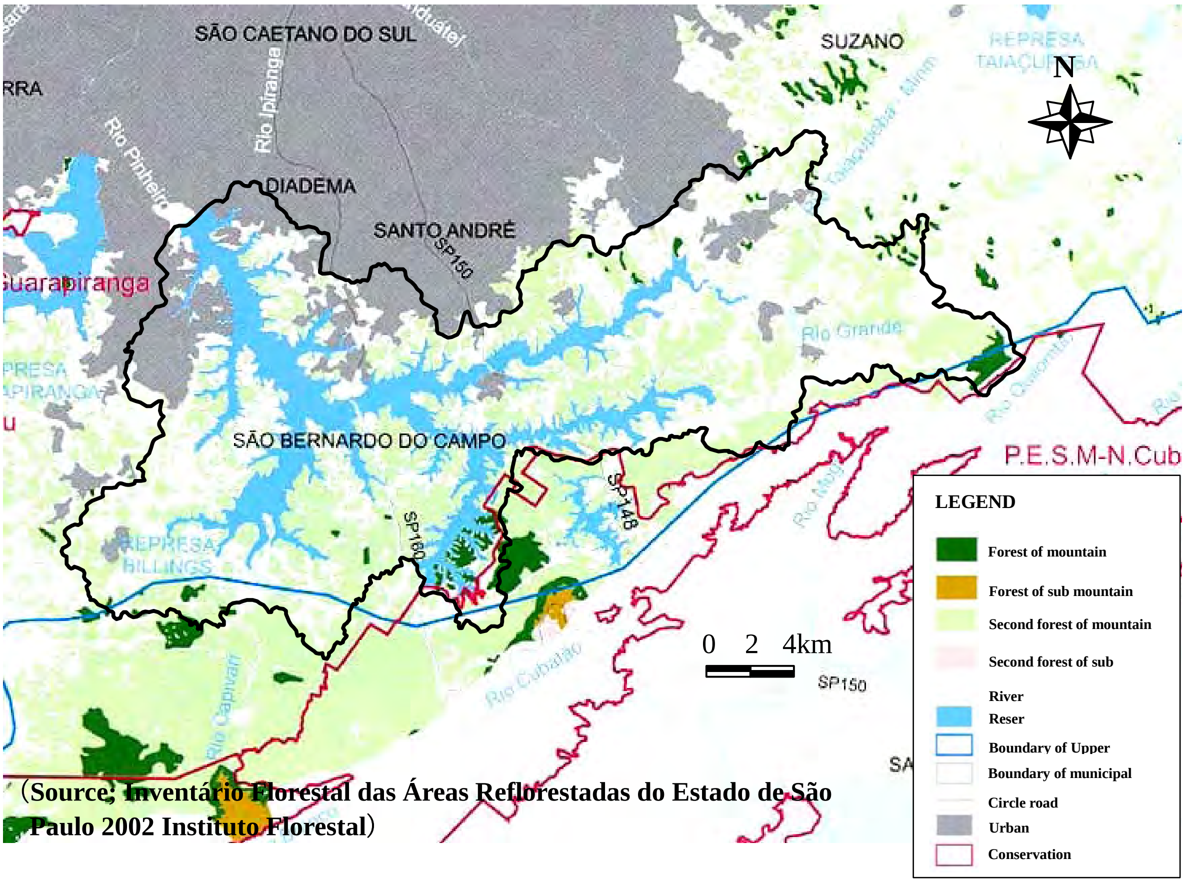
The break-down is as follows. The list of a detailed confirmation species is arranged in the data book.

General Species;

Orchidaceae (56), Poaceae (23), Asteraceae (20), Rubiaceae (20), Leguminosae (18), Myrtaceae (15), Melastomataceae (12), Bromeliaceae (11), Euphorbiaceae (9), Cyperaceae (8).

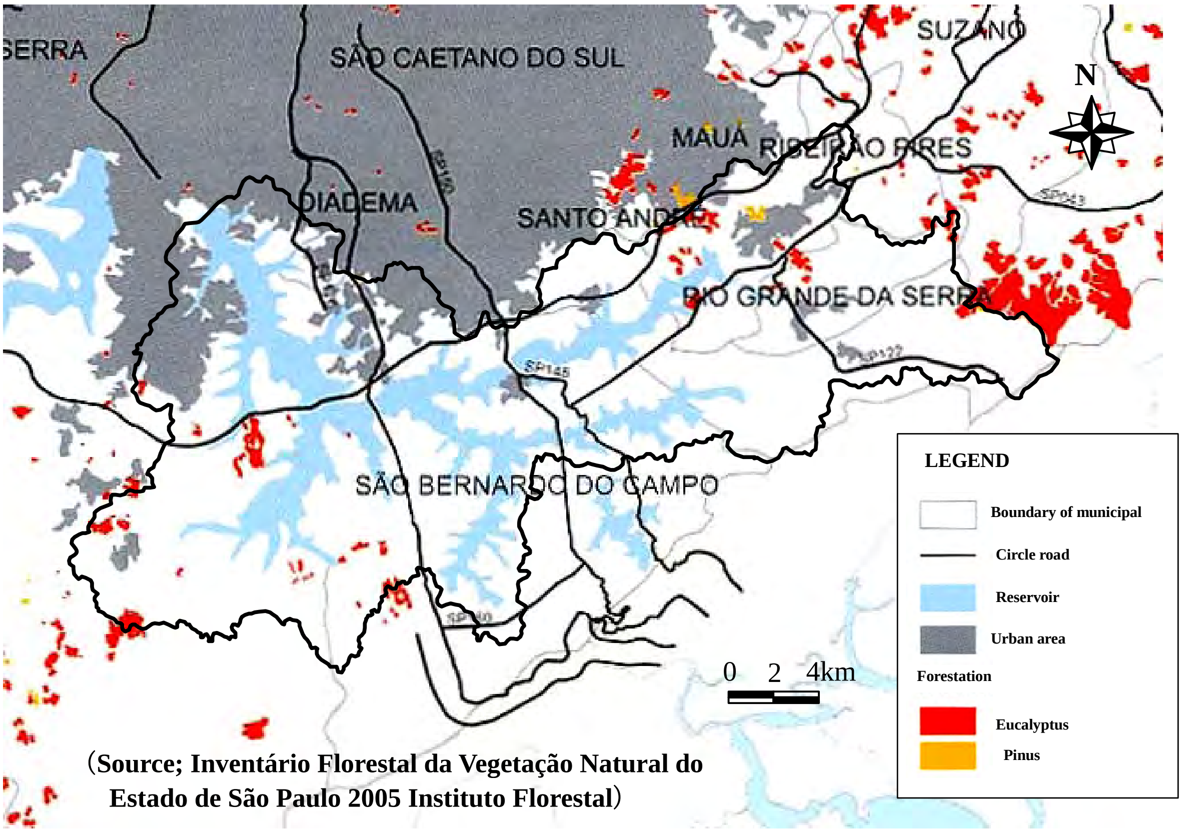
Special Species;

Orchidaceae (153), Myrtaceae (70), Melastomataceae (69), Asteraceae (66), Poaceae (50), Rubiaceae (40), Cyperaceae (38), Bromeliaceae (35), Leguminosae (27), Solanaceae (25), Begoniaceae(19), Piperaceae (18), Lauraceae (17), Araceae (17).



(Source; Inventário Florestal das Áreas Reflorestadas do Estado de São Paulo 2002 Instituto Florestal)

Figure 1.1.21 Vegetation Map in Surrounding Area of Billings Reservoir Basin



(Source; Inventário Florestal da Vegetação Natural do Estado de São Paulo 2005 Instituto Florestal)

Figure 1.1.22 Forestation Area Map in Surrounding Area of Billings Reservoir Basin

Table 1.1.6 Flora in the Surrounding Area of Lake Billings Basin

Habitat Area		Species, Genus or Family
Mountainous area	Natural forest (Upper tier)	Newtonia glaziovii, Copaifera trapezifolia, Cedrela fissilis, Meliaceae, Aspidisperma olivaceum, Tabebuia cf. Alba, Hieronima alchorneoides, Cabralea canjerana, Alchornea spp, Pouteri torta, Talauma ovata, Croton spp, Miconia, Leandra, Tibouchina, Roupala sp, Byrnsonina ligustrifolia, Jacaranda spp, Machaerium spp, Cletha scabra, Vantanea compacta, Octonea, Nectandra
	Middle tier	Bathysa spp, Weinmania spp, Inga edulis, Inga marginata, Posoqueria latifolia, Protium kleinii, Lamonia speciosa, Euterpe edulis
	Lower tier	Guarea macrophylla, Psychotria spp, Rudgea jasminoides, Mollinedia triflora, Pipper spp, Heliconia spp, Hedyosmum brasiliense, Geonoma spp, Lithocarium
Low mountainous area and valley	Valley	Pterocarpus violaceus, Aspidosperma olivaceum, Taipirira guaianensis, Sloanea guianensis, Ficus spp, Alchomea triplinervia, Cariniana estrelensis, Ocotea spp, Nectandra spp, Centrolobium robustum, Virola bicuhyba, Cedrela spp, Cabralea canjerana, Hymenaea courbaril, Pseudopiptadenia warmingii, Talauma ovata
	Intermediate area	Pera glabrata, Inga spp, Guarea spp, Gomidesia, Marlierea, Calyptranthes, Myrceugenia spp, Pausandra morisiana, Ocotea teleiandra, Garcinia gardneriana, Syagrus ramanzoffiana, Attalea dubia, Genoma spp, Astrocaryum aculeatissimum, Bactris spp
	Quasi-mountainous area	Euterpe edulis, Philodendron, Scindapsus, Monstera, Anthurium, Tillandsia, Aechmea, Vriesia, Rhipsalis
	Secondary forest	Cecropia spp, Rapanea spp, Croton spp, Inga spp, Schyzollobium parahyba, Tibouchina mutabilis, Miconia cabucu, Tapira guianensis, Hieronima alchorneoides, Alchornea, glandulosa, Alchornea triplinervis, Syagrus romanzoffiana
Low land and alluvial plain area	Wetland	Cyperus, Eleocharis, Rynchospora, Ludwigia spp, Erygium, Xyris spp, Vernonia, Eupathorium, Lantana spp, Mimosa, Crotalaria, Calophyllum brasiliense
	Alluvial forest	Anacardiaceae, Meliaceae, Mirtaceae, Styracaceae, Anonaceae, Clusiaceae, Euphorbiaceae, Ceasalpinaceae
	Alluvial plain	Cedrela odorata, Tapirira guianensis, Styrax pohlii, Rapanea spp, Pera ovata, Hyeronima alchorneoides, Copaifera langsdorfii, Inga spp, Sebastiana serrata, Croton spp, Euterpe edulis

（Source; Programa Rodoanel Mario Covas Trecho Sul Modificado Estudio de Impacto Ambiental (EIA) Volume I 2004 DERSA）

Table 1.1.7 Fauna in the Surrounding Area of Lake Billings Basin

Item	Class	Species, Genus or Family
General species	Mammal	Didelphis albiventris, Didelphis marsupialis, Philander opossum, Micureus cinereus, Monodelphis, Marmosops, Gracilinanus, Metachirus nudicaudatus, Dasypus spp, Euphractus sexcinctus, Cabossous unicinctus, Bradypus variegatus, Coendou villosus, Sciurus aestuans, Kannabateomys, Trinomys, Rhipidomys, Oryzomys, Nectomys, Akadon, Tapitomys, Blarinomys, Cavia aperea, Myoprocta sp, Agouti paca, Hydrochaeris hydrochaeris, Sylvilagus brasiliensis, Pecari tajacu, Tyassu pecari, Mazama spp, Tapirus terrestris, Procyon cancrivorus, Lontra longicaudis, Nasau nasau, Galictis cuja, G.vittata, Eira barbata, Speothos venaticus, Herpailurus yagouaroundi, Leopardus tigrina, Leopardus wiedii, Leopardus pardalis, Puma concolor, Panthera onca, Callithrix aurita, Callicebus personatus, Alouatta fusca, Cebus apella, Brachyteles arachnoides, Myocastor coypus, Bolomys, Oligoryzomis, Akadon, Lutreolina crassicaudata, Cerdocyon thous, Ozotocercus bezoarticus
	Bird	Penelope spp, Procnias nudicolis, Pyroderus scutatus, Trogon spp, Ramphastus spp, Baillonius bailloni, Pionopsitta, Pionus, Forpus, Pyrrhura, Triclaria, Brotogeris, Aratinga spp, Harpia, Morphnus, Spyzaetus, Spysastur, Cariama cristata, Ramphastos toco, Polyborus plancus, Harpyhaliaetus coronatus, Buteo brachyurus, Buteo albiventris, Ardeidae, Phalacrocoridae, Ralidae, Jacamidae
	Reptile and Amphibia	Hydropsalis, Geochelone spp, Tupinambis spp, Ameiva-ameiva, Enyalius, Polychrus, Urostrophus, Liophis, Atractus, Chironius, Phyllodryas, Oxyrrhopus, Pseudoboa, Bothrops spp, Micrurus corallinus, Boa constrictor, Spilotes pullatus, Xenodon, Waglerophis, Caiman latirostris
Special species	Extinct species	Harpia harpyja, Morphnus guianensis, Panthera onca, Tayassu pecari
	Rare species	Callitrhix jaccus, Diopsittaca nobilis, Amazona aestiva, Bulbucus ibis, Felis catus, Cani lupus, Mus musculus, Rattus rattus, Rattus novergicus, Passer domesticus, Columbia livia, Hemydactylus mabouia, Rana spp.

(Source; Programa Rodoanel Mario Covas Trecho Sul Modificado Estudio de Impacto Ambiental (EIA) Volume I 2004 DERSA)

1.2 Social Condition of Lake Billings

1.2.1 Municipalities involved in the Lake Billings Basin

(1) Characteristics

The Lake Billings has a basin area of 58,280.32 ha out of which 10,814.20 ha is the reservoir surface area。 The water level of the reservoir varies significantly due to the pumping from the Tiete River and Pinheiros River. According to the data from IBGE, the highest water level is approximately 747.65 m.

Its basin is situated southeast of the Sao Paulo Metropolitan Area neighbouring the Guarapiranga River basin west and Serra do Mar west and covering the whole of Rio Grande da Serra, and the parts of Diadema, Ribeirão Pires, Santo André, São Bernardo do Campo and São Paulo.

In the Lake Billings basin, the land use and occupation is regulated by the laws such as water resource protection law, permanent protection area law, etc, however, one of the most important mechanism to protect the land actually is to introduce the conservation units by defining the park or environmental protection area. At present, only 2.6% of the Lake Billings basin area is protected in the form of conservation units legally such as Parque Estadual da Serra do Mar, Parque Natural Municipal Nascentes de Paranapiacaba, Parque Regional e Jardim Botânico do Pedroso, Parque Municioal Estoril, Milton Marinho de Moraes and so on. Besides those, Área de Proteção Ambiental Capivari-Monos (25,000 ha) was designated in 1991 with a purpose to make natural protection and sustainable development of water resources compatible.

Table 1.2.1 and **Figure 1.2.1** shows the municipalities involved in the Lake Billings basin with each basin area.

Table 1.2.1 Municipalities Involved in the Lake Billings Basin

Municipality	Municipal Area (ha)	Area within Lake Billings Basin		
		(ha)	(%) *	(%)**
Diadema	3,069.89	726.80	23.68	1.25
Ribeirão Pires	9,900.10	6,367.37	64.32	10.93
Rio Grande da Serra	3,661.45	3,661.45	100.00	6.28
Santo André	17,476.00	9,581.20	54.82	16.44
São Bernardo do Campo	40,597.50	21,384.48	52.67	36.69
São Paulo	152,462.30	16,559.30	10.86	28.41

* percentage to administrative area

** percentage to basin area

Fonte: Billings 2000

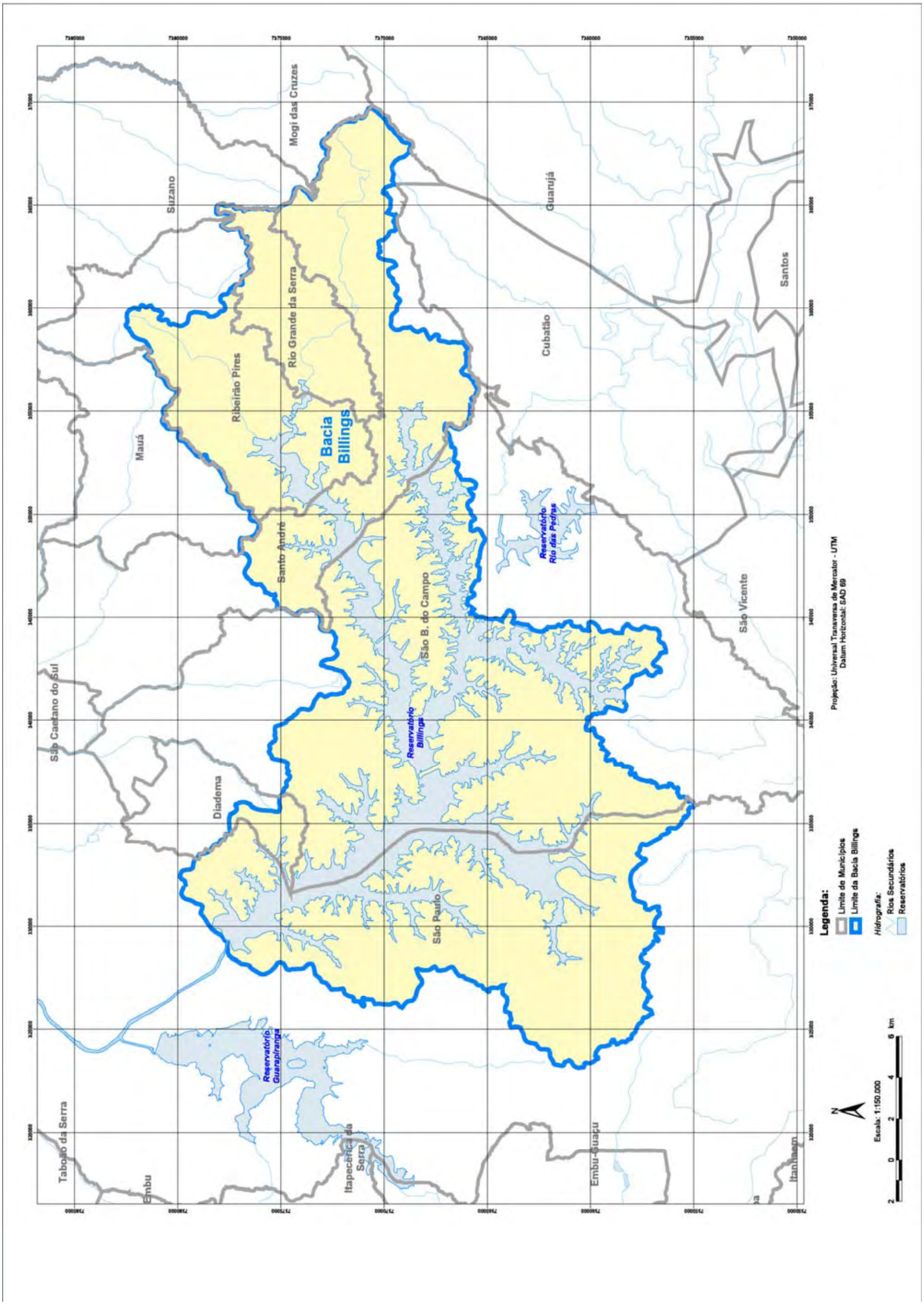


Figure 1.2.1 Municipalities Involved in the Lake Billings Basin

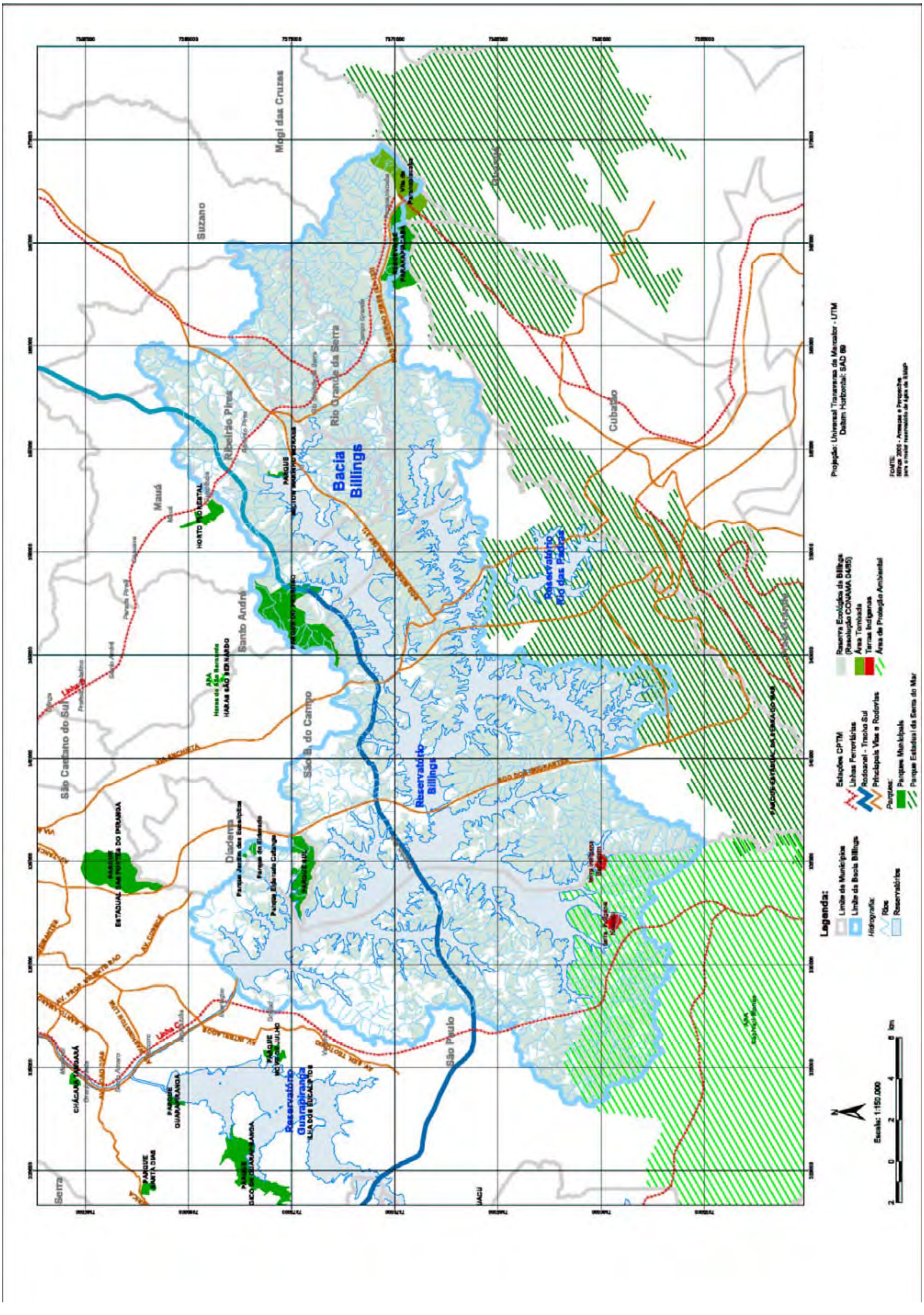


Figure 1.2.2 Environmental protection area in the Lake Billings basin

1.2.2 Population

The change in population by municipality in the Lake Billings basin is shown in **Figure 1.2.3** and **Annex A1.2.1**. The most municipalities have shown the biggest growth in 1970's and gradually lost their pace thereafter, but the population within the Lake Billings basin has exceptionally grown without slowing down and reached 860,000 in 2000 from 110,000 in 1970, or eight times growth for 30 years. It is a problem of time that the population exceeds one million and maybe clears it already at the present moment with a pace above that of San Bernardo do Campo which showed the remarkable growth with a present population of 700,000 from only 30,000 in 1950.

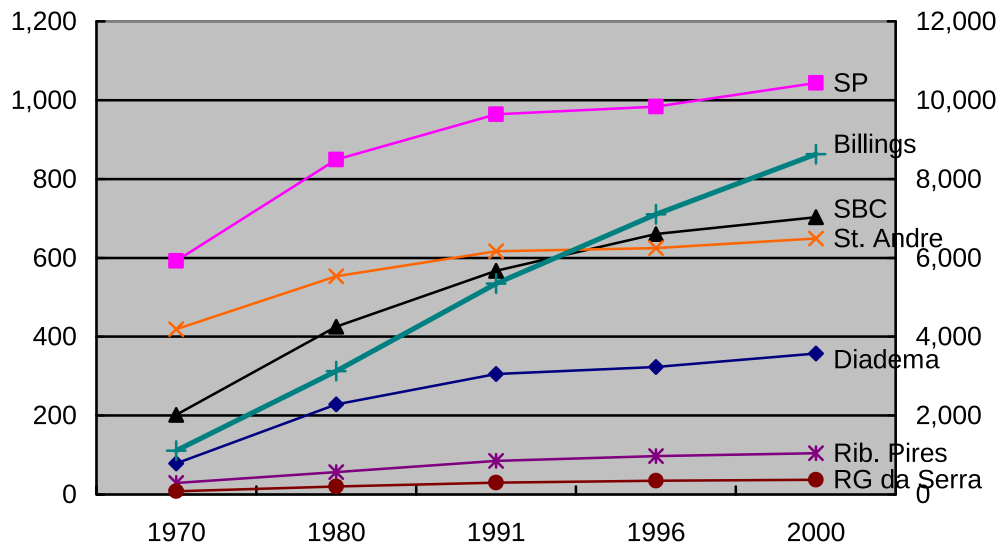


Figure 1.2.3 Transition of Total Population by Municipality and Basin Population

According to the breakdown in **Table 1.2.2**, Sao Paulo shares 54.3% in 2000 rising gradually its percentage from 45.9% in 1970, while Sao Bernardo do Campo rose the percentage to 21.4% in 1991 from 14.4% in 1970 but had almost no change thereafter. Other municipalities show the drop of their percentage affected by the above two municipalities. As a result, the share of Sao Paulo and Sao Bernardo do Campo has reached to 76.1%, when Ribeirao Pires is added to this, it is 86.1%.

The percentages of basin population to total population in each municipality are 100% in Rio Grande da Serra, 82.7% in Ribeirao Pires, 26.8% in Sao Bernardo do Campo and only 4.5% in Sao Paulo, showing that the center of Rio Grande da Serra and Ribeirao Pires are located in the Lake Billings basin.

Table 1.2.2 Population Share by Municipality in the Lake Billings Basin

	1970	1980	1991	1996	2000
Sao Paulo	45.9	51.1	49.0	52.3	54.3
Diadema	7.2	7.7	8.3	7.0	6.9
SBC	14.4	16.3	21.4	22.3	21.8
Santo Andre	3.6	2.9	3.3	3.3	2.9
Ribeirao Pires	21.6	15.7	13.0	10.9	10.0
Rio Grande da Serra	7.2	6.4	4.9	4.2	4.0
Total	100.0	100.0	100.0	100.0	100.0

Fonte: IBGE

The population growth rates within the basin in the major four municipalities involved in Lake Billings during the period of 1970 50 1980 were as high as about 12% in Sabn Paulo, San Bernardo do Campo and Diadema and 8% in Santo Andre. Although their rates dropped down during the period of 1980 to 1991 but showed to be still high in the each administrative area. During the period of 1991 to 2000, these values in three municipalities other than San Paulo further went down, but San Paulo show 6.68% up and San Bernardo do Campo5.66%. As a whole, the overall growth rate of basin population was a high level of 5.47% which is almost equivalent to 5.87% for 1980 to 1991.
Table 1.2.3 shows the number and population of sub-normal settlements. The percentage of population in sub-normal settlements to basin population is near 17%, which is highest in Sao Paulo, followed by San Bernardo do Campo.

Table 1.2.3 Number and Population of Sub-normal Settlements

	No. of Sub-normal Settlement	Population in Sub-normal Settlement	Percentage to Basin Population (%)
Sao Paulo	84	80,474	21.64
Diadema	29	7,636	15.28
SBC	44	29,673	18.74
Santo Andre		2,942	12.44
Ribeirao Pires	6	422	0.54
Rio Grande da Serra			
Total	163	121,147	16.92

1.2.3 Land Use

(1) Existing land use materials

BILLINGS 2000 (Joãn Paulo R. Capobianco, Marussia Whately 2002 ISA) is existing land use material of the Lake Billings basin. The land use change in 1989 and 1999 in the basin is arranged.
The Summary table of land use of the basin is shown in **Table 1.2.4** and land use map of the basin is a shown in **Figures 1.2.4** and **1.2.5**.

The urban area surrounding concentrated area increased greatly in ten years compared with the urban concentrated area itself, and rural inhabited area decreases oppositely though the urban and the urban concentrated area increase. The forest (natural forest), the forest (secondary forest), Agricultural land, bared land and mining land are decrease, especially forest (natural forest)and Agricultural land are largely decrease and Forestation area and Industrial area are slightly increase. .It is very clear that the surrounding area of urban concentrated area is rapidly advanced.

Based on the land use in the basin of the Lake Billings in 2000 in **Figure 1.2.7**, quoted from the report of "Calibração de Sistema Relacional de Correlação do Manejo do Território e da Qualidade Ambiental para o Reservatório Billings Relatório - Final (2004 Prime)" prepared by the Committee for The Upper Tiete River Basin, the land use by sub-basin (sub-regiõnes) is summarized in **Table 1.2.5**.

The land use of the Lake Billings basin in 2000, "Calibração de Sistema Relacional de Correlação do Manejo do Território e da Qualidade Ambiental para o Reservatório Billings Relatório - Final (2004 Prime)" reported by CBH-AT(Comite de Bacia Hidrografica do Alto Tiete), is shown in **Figure 1.2.7**. The land use of sub-regions through the land use classification is shown in **Table 1.2.5**. Moreover, the land use of the sub region divided by the water contamination analysis is shown in **Figure 1.2.6**.

Table 1.2.4 Land Use Change of the Lake Billings Basin from 1989 to 1999

Division item	1989 年		1999 年	
	Area (ha)	(%)	Area (ha)	(%)
Urban Concentrated area	1,485.85	2.55	1,653.66	2.84
Urban area	5,404.61	9.27	6,874.60	11.80
Rural Inhabitation area	3,344.26	5.74	3,263.52	5.60
Empty land	61.59	0.11	57.56	0.10
Mining land	192,90	0.33	156.89	0.27
Agricultural land	4,129.22	7.09	3,541.50	6.08
Secondary forest	699,15	1.20	647.32	1.11
Natural forest	31,825.67	54.61	30,242.02	51.89
Forestation area	188.26	0.32	398.35	0.68
Industrial area	98.55	0.17	109.06	0.19
Artificial development zone	14,722.11	25.27	15,661.92	26.89
Forest zone	32,713.08	56.13	31,287.17	53.68
Others	10,850.25	18.62	11,336.36	19.43

(A) Land use in 1989

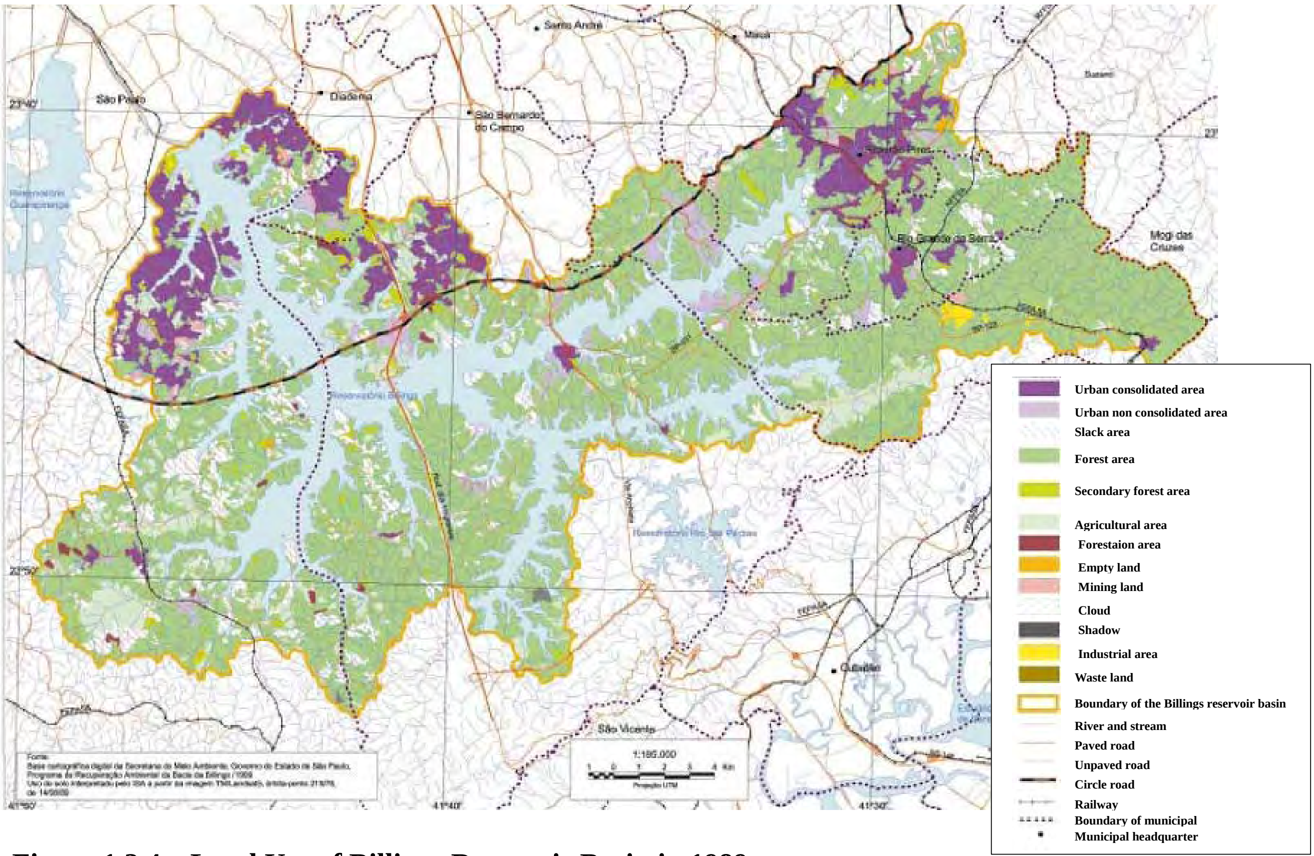
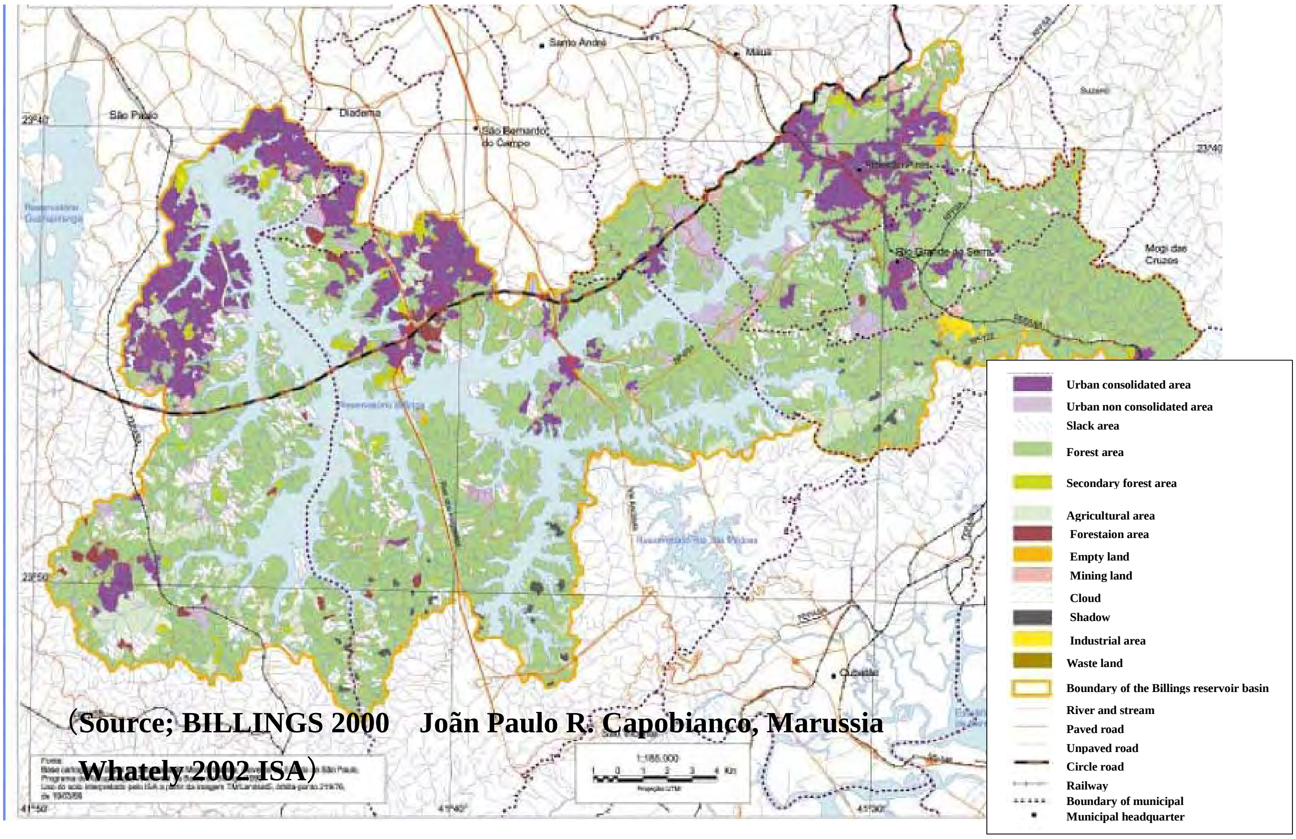


Figure 1.2.4　Land Use of Billings Reservoir Basin in 1989



（Source; BILLINGS 2000　Joãn Paulo R. Capobianco, Marussia Whately 2002 ISA）

Figure1.2.5　Land Use of Billings Reservoir Basin in 1999

The Land use of the whole basin in 2000 is as follows: agricultural land;1.9%, forestation area; 2.9%, Forest; 45.7% , grass land ; 23.7%, rural inhabitaion area; 7.3%, Urban concentrated area; 1.4%, Urban area; 16.4% and industrial area; 0.7%.

The urban concentrated area is only about20% in B-4(Ribeirão Pires). The urban area exceeds 50% in A-1 (Soccoro, SP), A-12 (Alvarenga, SBC), A-14 (Pedreira, SP), and 20% in A-10(SBC), A-13 (Diadema), B-2 (Santo, André), B-4 (Ribeirão Pires). The forest area exceeds 50% in A-3, A-5, A-6, A-7, A-8, A-9, B-1, B-3, B-6.

Table 1.2.5 Land Use of Sub-Region in the Billings Reservoir Basin in 2000

Sub Region	Area of land use (ha)								
	1 Agricultural land	2 Forestation area	3 Forest	4 Grass land	5 Rural inhabited area	6 Uban Area (Concentrated)	7 Uban Area	8 Industrial Area	Total
A-1	0.00	0.00	84.56	465.23	59.78	0.00	1471.11	17.18	2097.86
A-2	190.54	30.86	1363.99	949.49	717.81	0.00	532.97	0.67	3786.33
A-3	99.24	89.24	1044.31	492.60	158.45	0.00	168.17	0.00	2052.02
A-4	242.15	36.52	1278.16	969.49	404.89	0.00	220.01	0.00	3151.23
A-5	103.11	308.85	1525.77	680.06	310.29	0.00	0.00	0.00	2928.08
A-6	56.47	109.70	1072.65	557.04	212.65	0.00	41.67	0.00	2050.18
A-7	0.00	0.00	551.48	245.70	78.06	0.00	73.75	0.00	948.99
A-8	8.00	0.00	1611.43	379.51	14.53	0.00	3.01	0.00	2016.48
A-9	3.10	24.10	2414.84	1200.76	214.79	0.00	18.84	0.00	3876.42
A-10	6.87	23.12	262.87	212.71	61.36	0.00	214.24	0.00	781.16
A-11	5.32	161.23	440.25	280.55	178.35	0.00	186.07	21.81	1273.58
A-12	139.67	148.53	261.24	509.54	33.70	0.00	1312.06	54.75	2459.50
A-13	6.02	83.54	347.92	257.24	197.36	0.00	426.25	12.02	1330.34
A-14	0.00	19.18	44.69	225.83	51.69	0.00	678.52	18.44	1038.35
B-1	22.10	17.10	945.97	239.72	51.69	0.00	307.50	0.00	1584.10
B-2	0.00	32.64	842.77	565.87	151.87	0.00	442.28	0.00	2035.44
B-3	0.00	141.67	4663.42	1875.34	312.40	0.00	426.38	145.62	7564.83
B-4	0.00	48.05	834.23	840.14	146.10	661.85	796.77	38.10	3365.23
B-5	11.33	63.48	680.72	155.98	60.25	0.00	108.83	0.00	1080.59
B-6	1.63	59.79	1427.49	142.98	37.62	0.00	373.08	0.00	2042.59
Total	895.57	1397.59	21698.75	11245.79	3453.64	661.85	7801.52	308.58	47463.30

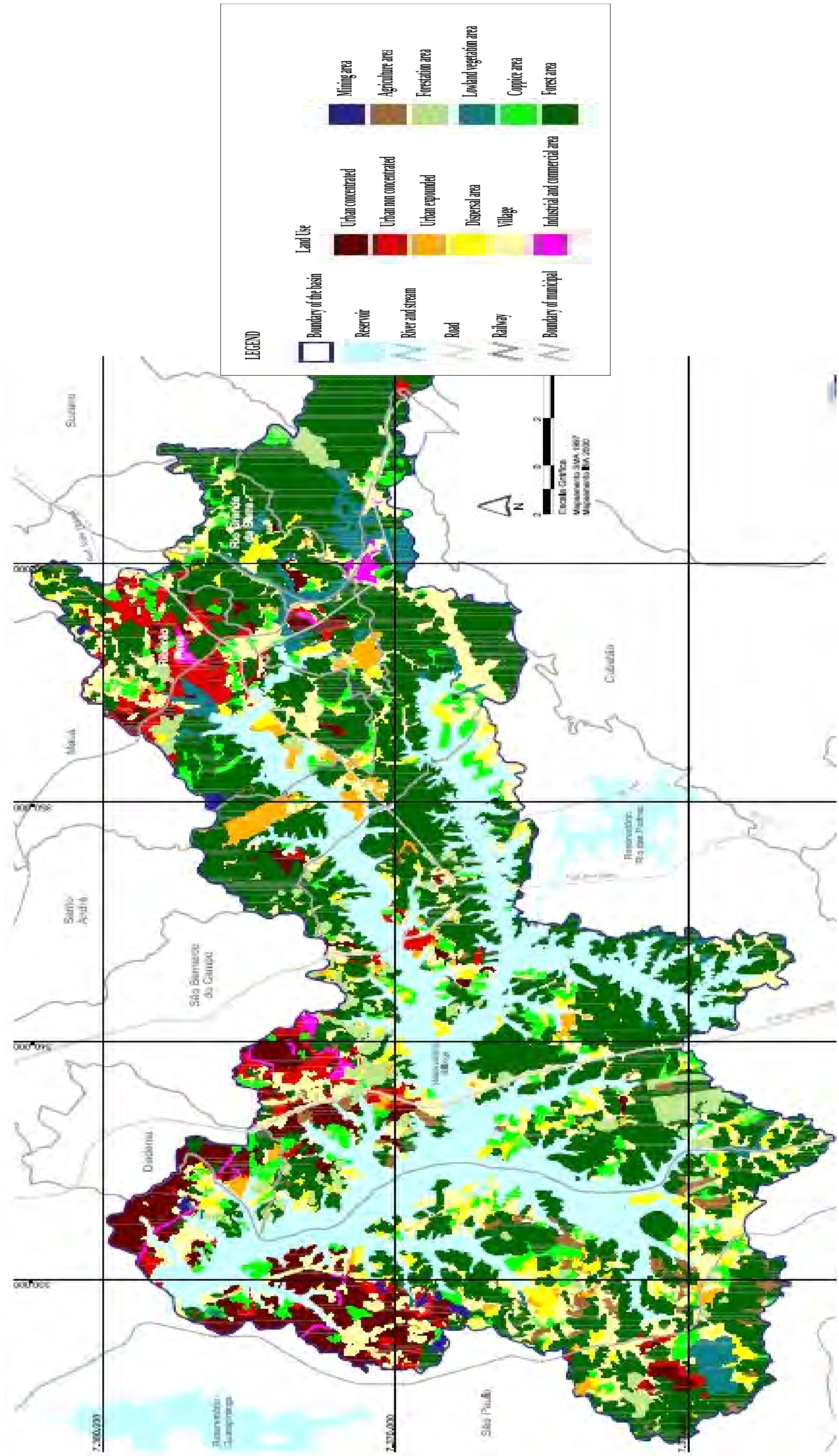
Sub Region	Percentage of land use (%)								
	1 Agricultural land	2 Forestation area	3 Forest	4 Grass land	5 Rural inhabited area	6 Uban Area (Concentrated)	7 Uban Area	8 Industrial Area	Total
A-1	0.0	0.0	4.0	22.2	2.8	0.0	70.1	0.8	100.0
A-2	5.0	0.8	36.0	25.1	19.0	0.0	14.1	0.0	100.0
A-3	4.8	4.3	50.9	24.0	7.7	0.0	8.2	0.0	100.0
A-4	7.7	1.2	40.6	30.8	12.8	0.0	7.0	0.0	100.0
A-5	3.5	10.5	52.1	23.2	10.6	0.0	0.0	0.0	100.0
A-6	2.8	5.4	52.3	27.2	10.4	0.0	2.0	0.0	100.0
A-7	0.0	0.0	58.1	25.9	8.2	0.0	7.8	0.0	100.0
A-8	0.4	0.0	79.9	18.8	0.7	0.0	0.1	0.0	100.0
A-9	0.1	0.6	62.3	31.0	5.5	0.0	0.5	0.0	100.0
A-10	0.9	3.0	33.7	27.2	7.9	0.0	27.4	0.0	100.0
A-11	0.4	12.7	34.6	22.0	14.0	0.0	14.6	1.7	100.0
A-12	5.7	6.0	10.6	20.7	1.4	0.0	53.3	2.2	100.0
A-13	0.5	6.3	26.2	19.3	14.8	0.0	32.0	0.9	100.0
A-14	0.0	1.8	4.3	21.7	5.0	0.0	65.3	1.8	100.0
B-1	1.4	1.1	59.7	15.1	3.3	0.0	19.4	0.0	100.0
B-2	0.0	1.6	41.4	27.8	7.5	0.0	21.7	0.0	100.0
B-3	0.0	1.9	61.6	24.8	4.1	0.0	5.6	1.9	100.0
B-4	0.0	1.4	24.8	25.0	4.3	19.7	23.7	1.1	100.0
B-5	1.0	5.9	63.0	14.4	5.6	0.0	10.1	0.0	100.0
B-6	0.1	2.9	69.9	7.0	1.8	0.0	18.3	0.0	100.0
Total	1.9	2.9	45.7	23.7	7.3	1.4	16.4	0.7	100.0

Source: CALIBRAÇÃO DE SISTEMA RELACIONAL DE CORRELAÇÃO DO MANEJO DO TERRITÓRIO E DA QUALIDADE AMBIENTAL PARA O RESERVATÓRIO BILLINGS RELATÓRIO FINAL 2004 PRIME

(2) Land use in 2004

Land use of 2004 is under arranging according to each sub region division and each sub basin division (Sub-Bacias) from UpperTiete Basin land-use map 1:25,000 made with EMPLASA. This text is retouched as soon as it completes it. Moreover, the change of the land use of the basin shall be discussed.

The results are shown in **Table 1.2.6** and **Figure 1.2.6**.



(Source: CALIBRAÇÃO DE SISTEMA RELACIONAL DE CORRELAÇÃO DO MANEJO DO TERRITÓRIO E DA QUALIDADE AMBIENTAL PARA O RESERVATÓRIO BILLINGS RELATÓRIO FINAL 2004 PRIME)

Figure 1.2.6 Land Use of Billings Reservoir Basin in 2000

Table 1.2.6 Land Use in the Billings Reservoir Basin in 2000 (Sub-Region and Sub-Basin)

Sub Region	Area of land use (ha)									Percentage of land use (%)								
	1 Agricultural land	2 Forestation area	3 Forest	4 Grass land	5 Rural inhabited area	6 Uban Area (Concentrated)	7 Uban Area	8 Industrial Area	Total	1 Agricultural land	2 Forestation area	3 Forest	4 Grass land	5 Rural inhabited area	6 Uban Area (Concentrated)	7 Uban Area	8 Industrial Area	Total
A-1-1	0.00	0.00	49.82	185.00	46.83	0.00	545.87	0.34	827.86	0.0	0.0	6.0	22.3	5.7	0.0	65.9	0.0	100.0
A-1-2	0.00	0.00	34.74	280.23	12.95	0.00	925.24	16.84	1270.00	0.0	0.0	2.7	22.1	1.0	0.0	72.9	1.3	100.0
A-1	0.00	0.00	84.56	465.23	59.78	0.00	1471.11	17.18	2097.86	0.0	0.0	4.0	22.2	2.8	0.0	70.1	0.8	100.0
A-2-1	156.25	22.30	397.66	413.88	243.42	0.00	124.86	0.00	1358.38	11.5	1.6	29.3	30.5	17.9	0.0	9.2	0.0	100.0
A-2-2	31.37	8.55	403.74	228.03	231.52	0.00	9.77	0.00	912.98	3.4	0.9	44.2	25.0	25.4	0.0	1.1	0.0	100.0
A-2-3	2.92	0.00	562.59	307.58	242.86	0.00	398.34	0.67	1514.97	0.2	0.0	37.1	20.3	16.0	0.0	26.3	0.0	100.0
A-2	190.54	30.86	1363.99	949.49	717.81	0.00	532.97	0.67	3786.33	5.0	0.8	36.0	25.1	19.0	0.0	14.1	0.0	100.0
A-3-1	11.30	80.99	556.87	214.32	39.49	0.00	149.40	0.00	1052.38	1.1	7.7	52.9	20.4	3.8	0.0	14.2	0.0	100.0
A-3-2	87.94	8.25	487.44	278.28	118.96	0.00	18.77	0.00	999.64	8.8	0.8	48.8	27.8	11.9	0.0	1.9	0.0	100.0
A-3	99.24	89.24	1044.31	492.60	158.45	0.00	168.17	0.00	2052.02	4.8	4.3	50.9	24.0	7.7	0.0	8.2	0.0	100.0
A-4-1	108.76	10.31	703.25	539.61	190.26	0.00	155.64	0.00	1707.83	6.4	0.6	41.2	31.6	11.1	0.0	9.1	0.0	100.0
A-4-2	133.39	26.21	574.92	429.89	214.63	0.00	64.37	0.00	1443.40	9.2	1.8	39.8	29.8	14.9	0.0	4.5	0.0	100.0
A-4	242.15	36.52	1278.16	969.49	404.89	0.00	220.01	0.00	3151.23	7.7	1.2	40.6	30.8	12.8	0.0	7.0	0.0	100.0
A-5	103.11	308.85	1525.77	680.06	310.29	0.00	0.00	0.00	2928.08	3.5	10.5	52.1	23.2	10.6	0.0	0.0	0.0	100.0
A-6	56.47	109.70	1072.65	557.04	212.65	0.00	41.67	0.00	2050.18	2.8	5.4	52.3	27.2	10.4	0.0	2.0	0.0	100.0
A-7	0.00	0.00	551.48	245.70	78.06	0.00	73.75	0.00	948.99	0.0	0.0	58.1	25.9	8.2	0.0	7.8	0.0	100.0
A-8	8.00	0.00	1611.43	379.51	14.53	0.00	3.01	0.00	2016.48	0.4	0.0	79.9	18.8	0.7	0.0	0.1	0.0	100.0
A-9-1	0.00	0.00	265.46	495.00	88.67	0.00	0.00	0.00	849.13	0.0	0.0	31.3	58.3	10.4	0.0	0.0	0.0	100.0
A-9-2	0.00	0.00	1158.83	562.97	51.69	0.00	10.13	0.00	1783.62	0.0	0.0	65.0	31.6	2.9	0.0	0.6	0.0	100.0
A-9-3	3.10	24.10	990.55	142.79	74.43	0.00	8.71	0.00	1243.67	0.2	1.9	79.6	11.5	6.0	0.0	0.7	0.0	100.0
A-9	3.10	24.10	2414.84	1200.76	214.79	0.00	18.84	0.00	3876.42	0.1	0.6	62.3	31.0	5.5	0.0	0.5	0.0	100.0
A-10	6.87	23.12	262.87	212.71	61.36	0.00	214.24	0.00	781.16	0.9	3.0	33.7	27.2	7.9	0.0	27.4	0.0	100.0
A-11	5.32	161.23	440.25	280.55	178.35	0.00	186.07	21.81	1273.58	0.4	12.7	34.6	22.0	14.0	0.0	14.6	1.7	100.0
A-12-1	106.87	129.71	183.91	260.41	16.84	0.00	672.18	41.37	1411.28	7.6	9.2	13.0	18.5	1.2	0.0	47.6	2.9	100.0
A-12-2	32.80	5.14	22.22	192.67	0.00	0.00	499.70	13.38	765.91	4.3	0.7	2.9	25.2	0.0	0.0	65.2	1.7	100.0
A-12-3	0.00	13.68	55.11	56.47	16.86	0.00	140.19	0.00	282.31	0.0	4.8	19.5	20.0	6.0	0.0	49.7	0.0	100.0
A-12	139.67	148.53	261.24	509.54	33.70	0.00	1312.06	54.75	2459.50	5.7	6.0	10.6	20.7	1.4	0.0	53.3	2.2	100.0
A-13-1	0.00	28.71	121.19	200.43	101.35	0.00	420.47	12.02	884.16	0.0	3.2	13.7	22.7	11.5	0.0	47.6	1.4	100.0
A-13-12	6.02	54.83	226.73	56.80	96.01	0.00	5.78	0.00	446.18	1.3	12.3	50.8	12.7	21.5	0.0	1.3	0.0	100.0
A-13	6.02	83.54	347.92	257.24	197.36	0.00	426.25	12.02	1330.34	0.5	6.3	26.2	19.3	14.8	0.0	32.0	0.9	100.0
A-14	0.00	19.18	44.69	225.83	51.69	0.00	678.52	18.44	1038.35	0.0	1.8	4.3	21.7	5.0	0.0	65.3	1.8	100.0
B-1	22.10	17.10	945.97	239.72	51.69	0.00	307.50	0.00	1584.10	1.4	1.1	59.7	15.1	3.3	0.0	19.4	0.0	100.0
B-2	0.00	32.64	842.77	565.87	151.87	0.00	442.28	0.00	2035.44	0.0	1.6	41.4	27.8	7.5	0.0	21.7	0.0	100.0
B-3	0.00	141.67	4663.42	1875.34	312.40	0.00	426.38	145.62	7564.83	0.0	1.9	61.6	24.8	4.1	0.0	5.6	1.9	100.0
B-4	0.00	48.05	834.23	840.14	146.10	661.85	796.77	38.10	3365.23	0.0	1.4	24.8	25.0	4.3	19.7	23.7	1.1	100.0
B-5	11.33	63.48	680.72	155.98	60.25	0.00	108.83	0.00	1080.59	1.0	5.9	63.0	14.4	5.6	0.0	10.1	0.0	100.0
B-6	1.63	59.79	1427.49	142.98	37.62	0.00	373.08	0.00	2042.59	0.1	2.9	69.9	7.0	1.8	0.0	18.3	0.0	100.0
Total	895.57	1397.59	21698.75	11245.79	3453.64	661.85	7801.52	308.58	47463.30	1.9	2.9	45.7	23.7	7.3	1.4	16.4	0.7	100.0

Source: CALIBRAÇÃO DE SISTEMA RELACIONAL DE CORRELAÇÃO DO MANEJO DO TERRITÓRIO E DA QUALIDADE AMBIENTAL PARA O RESERVATÓRIO BILLINGS RELATÓRIO FINAL 2004 PRIME

1.3 Water Use and History of the Lake Billings

1.3.1 Water Use and History of the Lake Billings

The Lake Billings has a water surface area of 100.8 km^2 at a water level of 746 m with a water volume of 1,150 x 106 m^3 and an average water depth of 9 m.

The reservoir was constructed by Light and Power Company Ltd. (Canadian) in 1937 by damming the Rio Grande River with a flow of 13 m^3/s flowing in the Serra do Mar (sea mountain ridge) to generate electricity at Cubatao (Henry Borden Power Plant) by using a drop of approximately 400 m.

Thereafter, Henry Borden Power Plant expanded its power generation capacity in 1940's to cope with an increase in power demand by pumping up the river water (60 m^3/s) of the Tiete River and its tributary, the Juqueri River at Edgard de Souza, Traicao and Pedreira Pump Stations (see **Figure 1.3.1**).

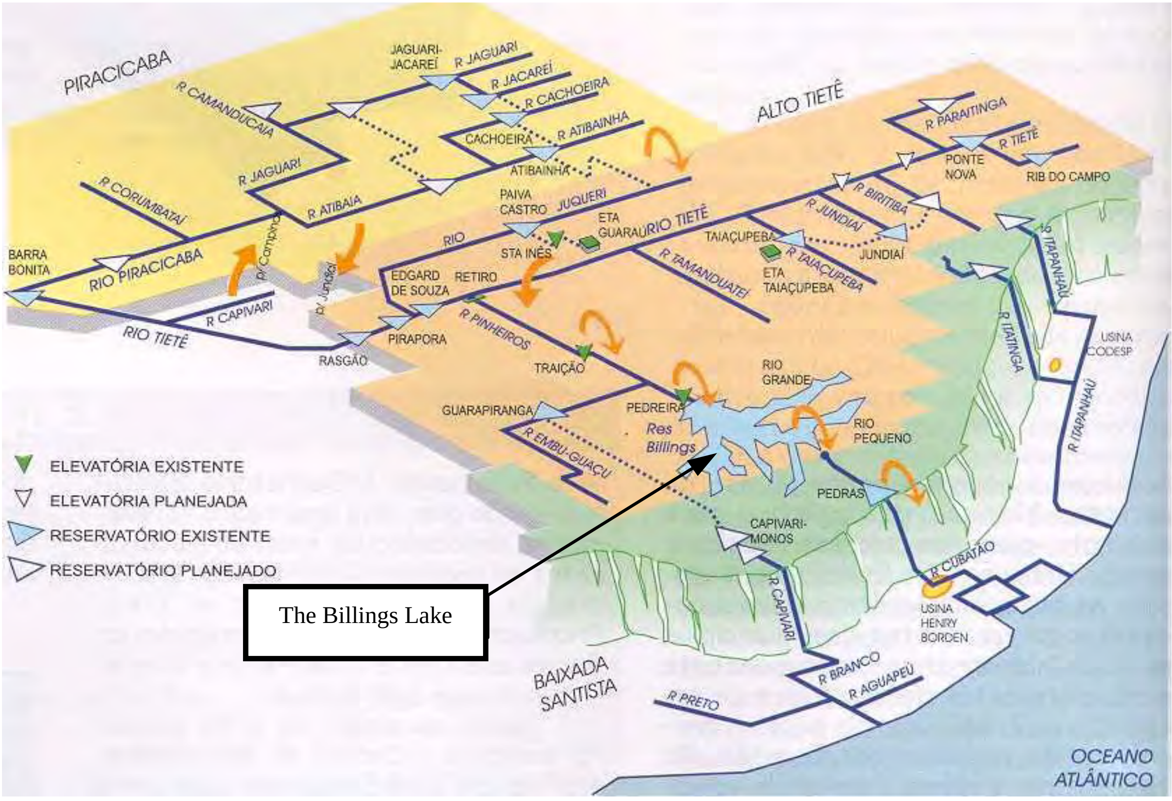


Figure 1.3.1 Pumping-up of Tiete River Water to the Lake Billings

However, starting from this point, the water quality of the Tiete River has deteriorated by the increase in population and industrial activities resulting in the worsening of water quality in the Lake Billings as time passes. SABESP commissioned the Rio Grande Water Treatment Plant (present actual capacity: 4.7 m^3/s) for water supply in 1958 taking water from the Rio Grande Arm which is the biggest arm in the Lake Billings. In 1982, the Rio Grande Arm is completely separated by an embankment construction below the Anchieta Highway from the main body of the Lake Billings to protect the Arm from the inflow of polluted water.

The deterioration of water quality in the Lake Billings has grabbed the public, NGO and mass media and the movement for water quality improvement has risen. By responding the pressure of the public, the state constitution enforced in 1988 included the article to ban the inflow of polluted water to the Lake Billings from 1992. While the sewerage facilities has less progress due to the huge investment requirement for the construction of wastewater treatment plants by 1992 when the construction works has commenced under the IDB finance and the worsening of river water quality has advanced by then. To perform the article of environmental conservation for the Lake Billings, the Bureau of Environment of the Sao Paulo State issued the operation rule of the Tiete River to forbid the pumping of river water from the Tiete and Juqueri Rivers except for the emergency that the river flow increase so as to occur the flood during the wet season and the resolution to discharge the river flow to the downstream of the Tiete River was passed. This change in discharge direction of polluted water has resulted in the environmental destruction of the downstream of the Tiete River with beautiful natural environment by not only the water pollution but also offensive odor caused by hydrogen sulfide and a great deal of foaming by detergent, which have lasted until now.

Beside the above, the stoppage of pumping at Pedreira Dam brings a variety of political and economic ripples such as stoppage of power generation at Henry Borden Power Plant in fact and reduction of water supply to the Cubatao Industrial Zone and so on in Sanxista Baisada.

Additionally, SABESP started to take water with an amount of 2.0 to 4.0 m^3/s at the Taquacetuba Arm in 2000 to convey to the Guarapiranga Reservoir for water supply to supplement the recent water shortage in the Metropolitan Region.

The measures to ban the pumping to the Lake Billings except for an emergency when the flood may expectedly occur in the Metropolitan Region leads to the considerable reduction in water pumping discharge. That is to say, before the banning of pumping, the pumping is done routinely regardless of rainfall but after the banning of pumping, as shown in **Figure** average amounts of water pumped were yearly reduced from 63.9 m^3/s (set at 100%) for 1984 to 1988 and 62.3 m^3/s (98%) for 1989 to 1992 to 11.6 m^3/s (18%) for 1993 to 1996, 8.4 m^3/s (13%) for 1997 to 2000 and 2.9 m^3/s (5%) for 2001 to 2004 by 1/20 to the peak.

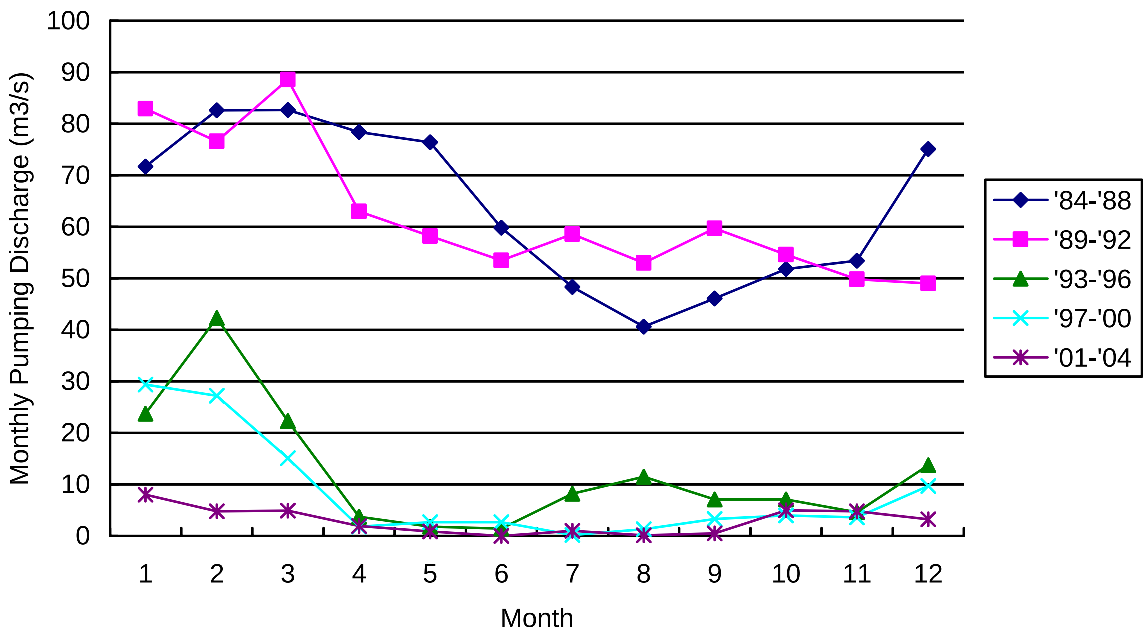


Figure 1.3.2 Pumping Discharge of River Water at Pedreira Dam to the Lake Billings

Immediately after the banning of pumping, the pumping has been strictly done only when the flow of the Tiete River expectedly exceed 160 m^3/s but it seems that the pumping has been done with somewhat more moderate way in the recent years. The pumping operation is concentrated to the period of December to March. For reference, an average flowrate of 63.9 m^3/s during the period of 1984 to 1988 equals to an amount to exchange water in the Reservoir 2.1 times a year, based on a nominal storage capacity of 95 billion m^3 of the Lake Billings excluding that of the Rio Grande Arm. While, average runoff to the Lake Billings in longer years is 9.2 m^3/s or an exchange years of reservoir water is 3.3 years.

1.3.2 Multipurpose Water Use of Lake Billings

The long-term average runoff from the basin of the Lake Billings is estimated as shown in **Table 1.3.2**.

Table 1.3.2 Long-term Average Runoff from the Natural Basin of the Lake Billings

	Long-term Average Runoff (m^3/s)
Lake Billings	9.2
Boloré	0.51
Taquacetuba	1.75
Pedra Branca	0.41
Capivari	1.57
Rio Pequeno	3.02
Others	1.94
Rio Grande Arm	4.9
Total	14.1

The situation of water use in the Lake Billings (see **Figure 1.3.3**) is summarized as described below.

(1) Water Supply

Water of the Lake Billings is used as sources for water supply at the following three systems. (see **Figure 1.3.4**)

1) Rio Grande System

Water is taken from the Rio Grande Arm and treated at the Rio Grande Water Treatment Plant to supply to San Bernardo do Campo (100% of population), Santo Andre (25%) and Diadema (100%) with an amount of 4.7 m^3/s.

2) Taquacetuba/Guarapiranga System

Water is conveyed fro the Taquacetuba Arm to the Guarapiranga Reservoir with an amount of 4.0 m^3/s and treated at the Alto da Boa Vista Water Treatment Plant where treatment is done for algal toxicity, offensive odor and taste.

3) Cubatao/Baixada Santista System

The system takes water from the Cubatao River and drain from Henry Borden Power Plant after power generation with a total amount of 4.0 m^3/s (1.5 m^3/s from power plant drain during dry season) to supply water to the coastal municipalities.

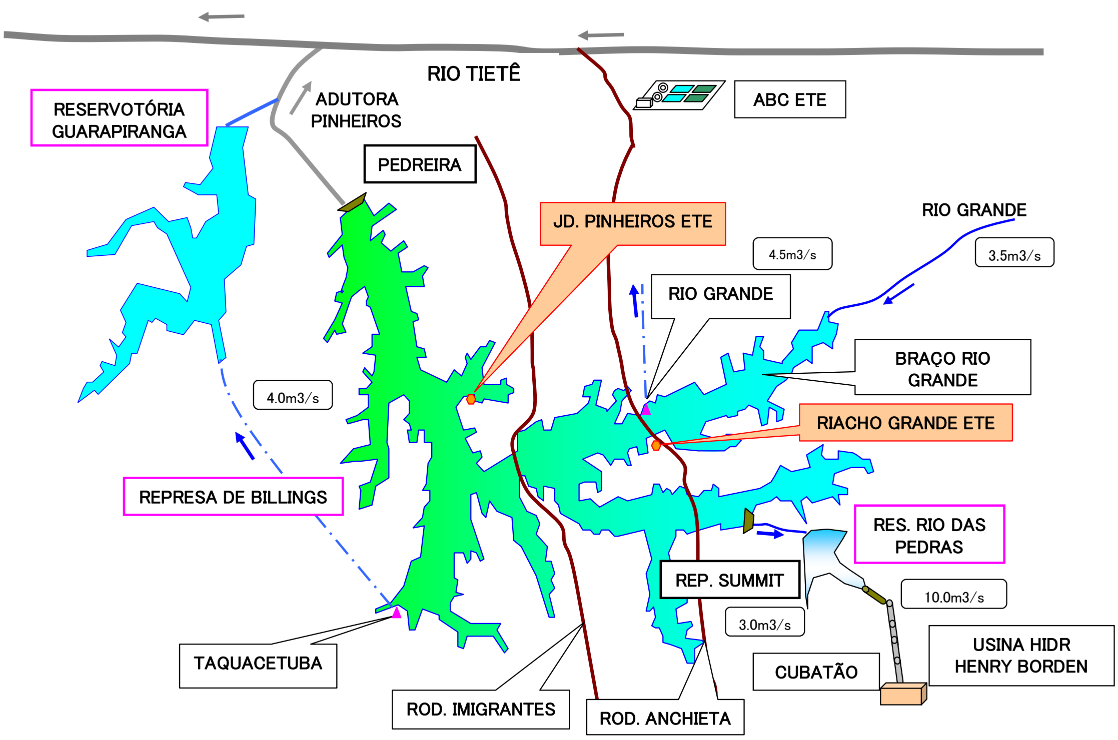


Figure1.3.3 Water Use in the Lake Billings

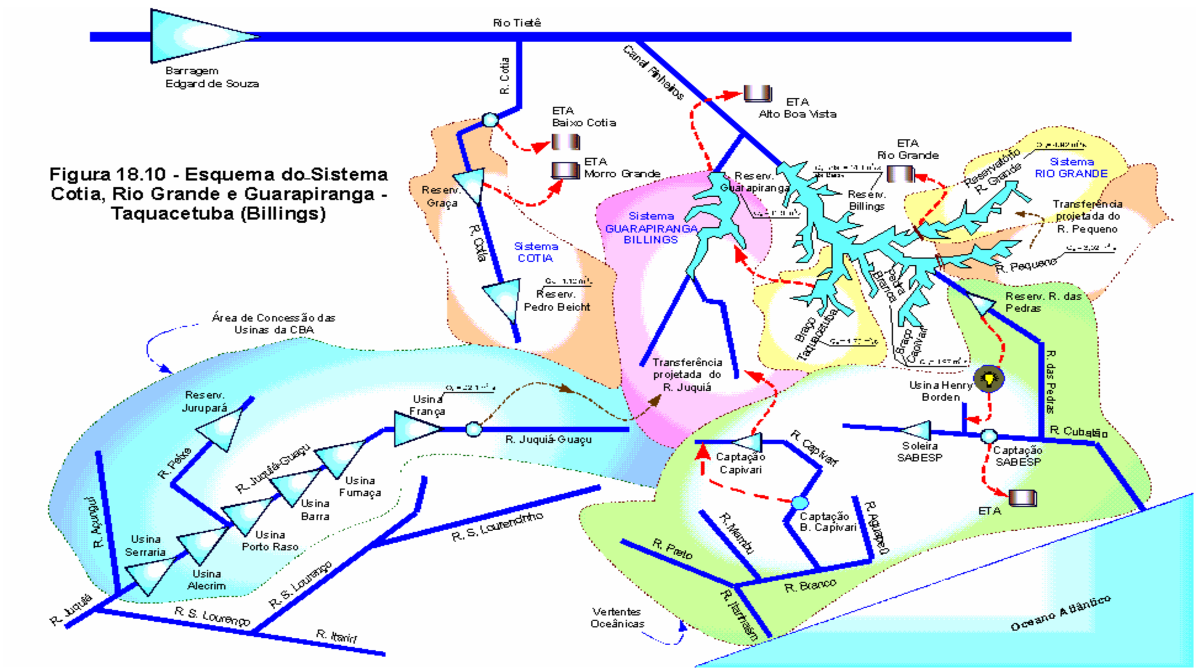


Figure 1.3.4 Water Use in the Lake Billings for Water Supply

(2) Industrial Water supply

Water taken from the Cubatao River is supplied to the Cubatao Industrial Complex as industrial water.

(3) Hydropower Generation

Although the Lake Billings was originally constructed for hydropower generation, the present water use for power generation is considerably reduced from 90 m^3/s to approximately 25 m^3/s for the water demand peak since the ban on pumping to the Lake Billings at the Pedreira Dam.

(4) Flood Control

When the flow of the Tiete River exceeds 160 m^3/s, the pumping at Pedreira Dam is implemented to mitigate the flood in Sao Paulo.

(5) Recreation

Water skiing is done especially concentrated to the Rio Grande Arm and Taquacetuba Arm and fishing is the most popular recreation seen in the above two Arms. While swimming and recreation accompanied with a direct contact with water is generally avoided from a fear of water pollution.

1.3.3 Importance of the Billings Lake as the sources of drinking water

Both of the Billings Lake and the Guarapiranga Lake are located in the suburbs of Sao-Paulo, and they supply 18.1m^3/s of water which becomes about 28.2% of the overall rate of consumption. The share of the Billings Lake alone is 13.5% (8.7 m^3/s) including the water transmission to the Guarapiranga Lake.

Although the use as the source of drinking water was started in 1958 as for the Rio Grande arm, the water supply to the Guarapiranga Lake from Taquacetuba arm was implemented as the countermeasure against the large drought which continued 1999/2000/2001. In case this water transmission did not exist, Sao-Paulo citizen's water shortage was considered to have aggravated further, and this incident proved how the Billings Lake would be important as the source of drinking water in those days.

SABESP needs further water resource development in the Lake Billings for expansion of the Rio Grande Water Treatment Plant. The Lake Billings shall be more important as 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.