7.9 Institutional Improvement

After the analysis of the current relevant authorities and legislation, the following programs are recommended to be implemented by 2005, covering the whole State.

1) Re-allocation of staff and enhancement of instruction and training during the course of the current re-organization of SEMA, SUCEAM and IAP.

2) Strengthened groundwater management through;
   a) Potential assessment
   b) Strengthened inspection of water use and promotion of registration
   c) Enhanced control of groundwater development and use
   d) Expansion of water source preservation regulation to aquifers

3) Enhanced enforcement of environmental regulations by;
   a) Establishment and enforcement of reporting obligation of operation, effluent discharging and accidents by water user to the competent entity
   b) Effluent standards by type and scale of industry
   c) Phased enhancement of detecting capability of problems and nonconformity to the effluent and water quality standards
   d) Effluent standards for infiltration to the ground
   e) Enhanced control of agrotoxic use

4) Legal arrangement for the control of soil, sand and stone taking in river areas

5) Cost recovery of water environment management regarding;
   a) Cost recovery of resources assessment and environmental monitoring
   b) Cost recovery of water supply and sanitation

6) Promotion of residents participation through information publication

7.10 Project Costs

Costs for the implementation of the Strategy are roughly estimated by major sector and are given in Table-7.6. Prices in August, 1994 and the exchange rate of US$1=R$0.89 were applied for the estimation.

Table-7.6 Costs for the Implementation of the Strategy

Sector		Amount	Project Costs (US$ million)	Remark
Domestic Water Supply		1,183,000 m^3/day	1,294	all urban area, excluding rural areas
Industrial Water Supply		495,000 m^3/day	502	ditto
Agricultural Water Supply		88,000 m^3/day	12	for livestock and fish culture
Sewerage Development		920,000 m^3/day	704	for the major 6 river basins
Flood Control			200 *	structural measures for 4 urban areas
Soil Erosion Control	Terracing	6,021,000 ha	241	
	Non Tillage	3,147,000 ha	202	
	sub-total	9,168,000 ha	443	
Total			3,155	
Hydropower Development		3,095 MW	3,381	
Grand Total			6,536	

(Note) * estimated roughly with the result of the Master Plan Study

7.11 Evaluation of the Strategy

(1) Technical Evaluation

The Strategy in each of the sectors of the Study was formulated with sufficient technical examinations and precision required. Each Strategy was the result of the studies, taking account of the following:

1) analysis of all available basic data and information
2) elaborated comparison and examination of alternatives for both technical and economic aspects
3) technical assessment on safety of proposed plans
4) technical assessment on reliability of proposed plans
5) technical assessment on practicability of proposed plans

(2) Economic and Financial Evaluation

The total cost of US$ 3,155 million is required by 2015 for the implementation of the Strategy for water environment improvement, when the costs for hydropower development, which is financed through different channel, are excluded. At the same time, the cumulative amount of public investment by the State Government will reach US$ 4,400 million. The total cost corresponds to 72 % of the cumulative public investment. The comparison of the total cost might show some feasibility, even though the public investment includes that for development of housing establishments, transportation and telecommunication networks, etc., and substantial parts of the total cost except those for flood control or ecology

conservation, will be invested by relevant State or private companies or entities

Another comparison of past average annual investment of water supply (for domestic and industrial use) sector and hydropower sector with the costs for the implementation of the relevant projects proposed in the Strategy is made in Table-7.7. Annual investment for the proposed water supply projects of US$ 90 million/year is 58 % higher than the past investment for the sector of US$ 57 million/year. Considering that the past investment for the sector was mainly destined for domestic water supply, the required investment for domestic water of US$ 65 million will be almost same as the average of the past investment for domestic water supply. As for sewerage development, the proposed investment of US$ 35 million/year is 84 % higher than the past average investment of US$ 19 million. The reasons of the gap can be: that the past investment was suppressed to lower level than that required, and that the target to meet the Class 2 of the CONAMA's water quality standard as set the Strategy would be considerably high in the current circumstances.

Planned investment amount for hydropower development is judged to be within a reasonable range. In the past external fund has been mobilized for hydropower development in Paraná to cope with the situation that nearly a half of the electricity produced in Paraná is transmitted to neighboring states. The deviation of 80 % as shown below (US$ 169 million per year vs. US$ 94 million per year) is expected to be met by external sources.

Table-7.7 Comparison of the Planned Investment and Past Investment

(unit: US$10^6)

Sector	Planned Investment		Past Investment	Remark
	Total	Annual Average	Annual Average	
Water Supply				
- domestic water	1,309	65	-	
- industrial water	502	25	-	
sub-total	1,811	90	57	data from the SANEPAR
Sewerage	704	35	19	data from the SANEPAR
Hydropower	3,381	169	94	data from the COPEL

(3) Social and Environmental Evaluation

Strategy is aiming at improvement of water environment such as to supply domestic, industrial and agricultural water, to improve water quality by development of sewerage system, to mitigate flood disaster, to control soil erosion, to conserve ecology etc. Therefore, the positive impacts will be much larger than the negative impacts on the society and the environment. The negative impacts are to be discussed in the section 8.11.

7.12 Selection of the Pilot River Basins

After the formulation of the Strategy for water environment improvement, Pilot River Basins were selected as target basins for the Master Plan Study.

In order to determine the Pilot River Basin(s), six factors were studied: 1) Socio-Economy (Population and Gross Domestic Product), 2) Water Demand, 3) Flood Damage, 4) Water Quality, 5) Soil Erosion, 6) Ecology.

After examination of each of the above factors by each major basin, significance of the factor in each basin was evaluated and classified into five classes from A (Serious Significance) to E (Negligible Significance) in accordance with the degree of significance.

The result of the examination and the classification is shown in Table-7.8. The river basin of the most significance is the Iguaçu River Basin, followed by the Tibagi River Basin. These two river basins were selected as the Pilot River Basins.

Table-7.8 Selection of Pilot River Basins

	River Basin	Cinzas	Iguacu	Itarare	Ivai	Litoranea	Piquiri	Pirapo	Ribeira	Tibagi
Factor	Socio Economy	D	A	E	C	E	D	D	D	B
	Water Demand	D	A	E	C	E	C	D	E	B
	Flood Damage	E	A	E	D	B	E	E	E	D
	Water Quality	C	A	D	D	E	C	D	D	B
	Soil Erosion	A	B	B	A	D	B	C	B	C
	Ecology	E	A	E	C	E	C	C	E	A
	Priority Order for Selection		1							2

CHAPTER 8 WATER ENVIRONMENT MASTER PLAN FOR THE PILOT RIVER BASINS

8.1 Water Supply

(1) Classification of Area

As the purposes and forms of water use are different by areas, the Master Plan was prepared by classified areas. The area was, at first, classified into urban or rural area. The water use in urban area is composed of uses for domestic and industrial purposes. The water use in rural area comprises of uses for domestic and agricultural purposes. According to the projected population in 2015, urban areas are classified as follows:

A) large urban area (population more than 100,000)
B) medium urban area (population more than 50,000)
C) other urban area

Other urban areas (C) are further classified as follows, considering the topographical conditions:

a) urban area located near a main river
b) urban area located near second or third tributary of a main river
c) urban area located on plateau or mountain top

In the Iguaçu River Basin, 17 townships belong to large urban areas (14 townships are located in the Curitiba Metropolitan Region), 6 townships to medium urban areas (B), and 76 townships to other urban areas (C). In the Tibagi River Basin, there are three large urban areas (A), 7 medium urban areas and 26 other urban areas.

(2) Curitiba Metropolitan Region

Water volume to be developed newly for the Curitiba Metropolitan Region by 2015 is estimated at 7.24 m³/second (625,000 m³/day). Water sources to meet this requirement are surface water of the tributaries of the Iguaçu River by dam/reservoir development, and groundwater in the Karst aquifer located 10-50 km north of Curitiba. Ten dam sites around Curitiba and 4 stages of the Karst aquifer development were investigated. Bases on the investigation results, the optimum development plans, comprising of dam construction and borehole drilling, were proposed as shown in Table-8.1. The locations of these project sites are shown in Figure-8.1. The water balance between the estimated demand and the supply with these projects for Curitiba Metropolitan Region is illustrated in Figure-8.2.

Table-8.1 Water Resources Development Plan for Curitiba Metropolitan Region

Type of Development Project	Development Volume (m³/second)	Construction Cost (US$ million)
(1) Irai Dam	1.400	49.3
(2) Piraquara II Dam	0.750	22.0
(3) Pequeno Dam	0.800	28.6
(4) Alto Miringuava Dam	0.600	35.3
(5) Cotio Despique	1.200	43.8
(6) Groundwater Development (Stage-1), 29 wells	1.290	40.3
(7) Groundwater Development (Stage-2), 27 wells	1.195	57.5
< Total >	7.235	276.8

Note: The construction costs include water development and conveyance costs and exclude water treatment and distribution costs.

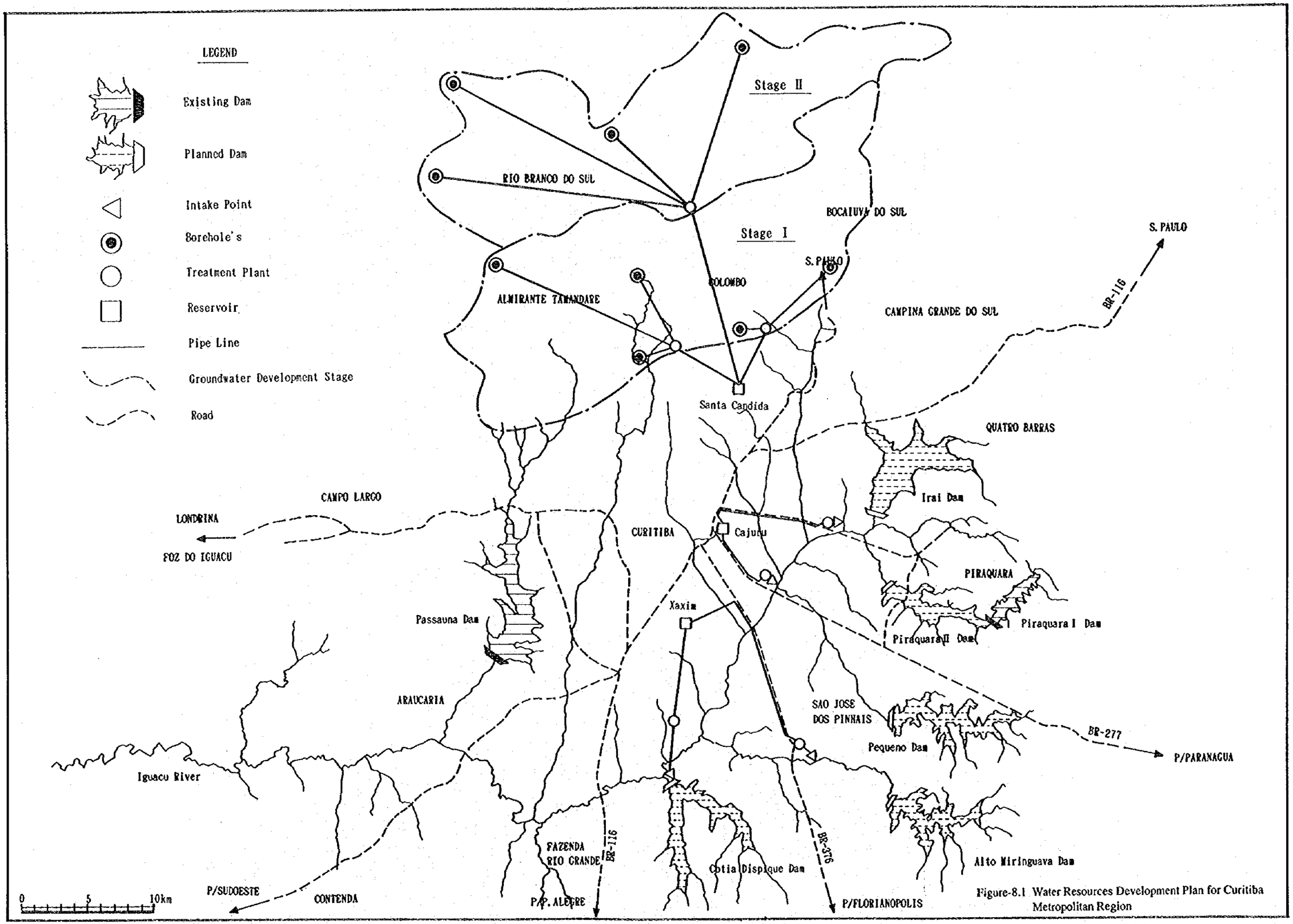

Figure-8.1 Water Resources Development Plan for Curitiba Metropolitan Region

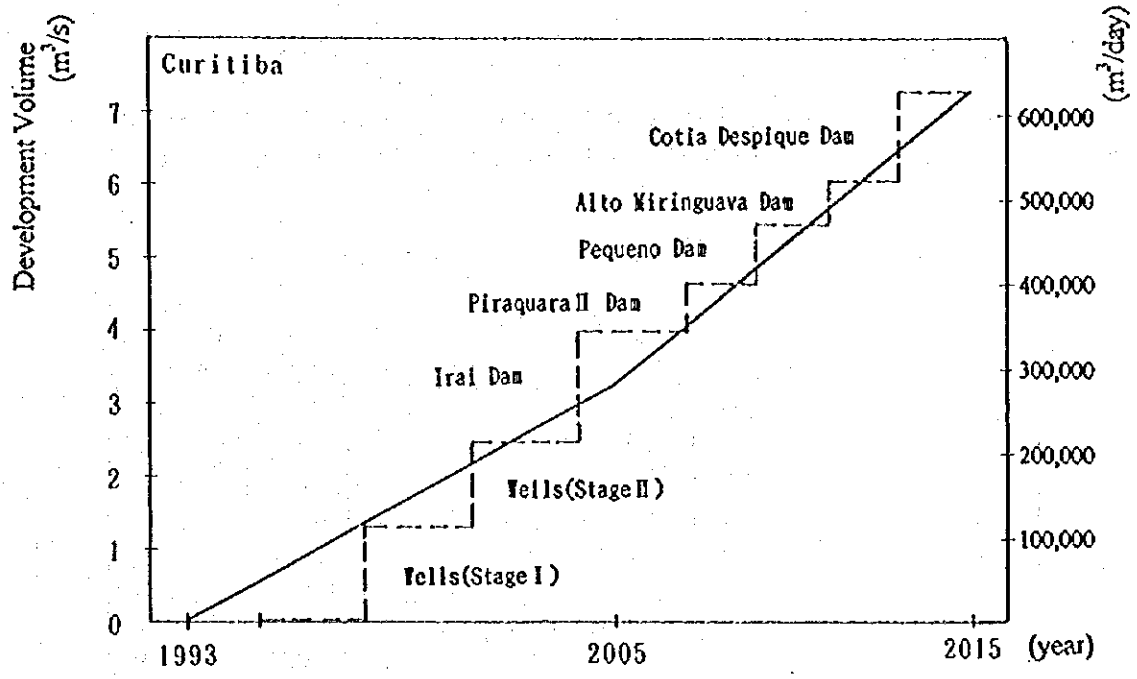

Figure-8.2 Water Demand and Supply Plan for Curitiba Metropolitan Region

(3) Large Urban and Medium Urban Areas

In the Iguaçu River Basin, there are three large urban areas other than Curitiba Metropolitan Region; Cascavel, Foz do Iguaçu and Guarapuava, and six medium urban areas; Francisco Beltrão, Pato Branco, Medianeira, Dois Vizinhos, Palmas and União da Vitoria. In the Tibagi river basin, there are three large urban areas; Ponta Grossa, Londrina-Cambe, and Apucarana, and six medium urban areas; Castro, Telemaco Borba, Comelip Procopio, Arapongas, Ibipora and Irati. To meet the estimated demands in these urban areas, formulation of source development plans, rough facility planning and cost estimation were carried out as shown in Table-8.2 and 8.3.

(4) Other Urban Areas

The water supply plans for the other urban areas (C) are prepared according to the topographical situations of the area. For the areas of Class-a, the required water was planned to be taken directly from the river. For the areas of Class-b and Class-c, the optimum plan was decided comparing groundwater development and direct intake from river, from technical and economic points of view. As construction cost for each urban area was difficult to estimate, the estimation was carried out by an analysis of correlation between the volume of water developed and projects cost in typical models. The results are shown in Table-8.2 and 8.3.

(5) Rural Areas

Water demands for domestic use in rural areas will not increase except in some areas. As the future demands will be met by the improvement or rehabilitation of the existing facilities and by improved operation and maintenance, new development plan seems not to be necessary.

(6) Agricultural Water

Water for livestock and aqua-culture is obtained directly from small rivers to meet the demands. The cost was estimated based on unit cost for domestic water supply in other urban areas.

Table-8.2 Water Resources Development Plan for Iguaçu River Basin

Area	Project	Water Resource	Development Volume (m^3/day)	Project Cost (US$ million)
<Curitiba Metropolitan Area>				
		29 Wells (Stage I)	111,000	110.6
		27 Wells (Stage II)	103,000	157.9
		Irai Dam	121,000	135.4
		Piraquara II Dam	65,000	60.4
		Pequeno Dam	69,000	78.5
		Alto Miringuava Dam	52,000	96.9
		Cotia Despique Dam	104,000	120.3
Sub-total			625,000	760.0
<Large Urban Areas>				
	Cascavel	São Jose River (I)	13,000	7.1
		São Jose River (II)	13,000	7.1
		9 Wells (Stage I)	16,000	17.7
		1 Well (Stage II)	10,000	7.0
	Foz do Iguaçu	Parana River (I)	30,000	3.7
		Parana River (II)	30,000	3.7
		Parana River (III)	30,000	3.7
	Guarapuava	Bananas River (I)	13,000	4.6
		Bananas River (II)	12,000	4.5
Sub-total			167,000	59.1
<Medium Urban Areas>				
	Francisco Beltrão	Marrecas River (I)	10,000	2.4
		Marrecas River (II)	10,000	2.3
	Pato Branco	Chopim River	10,000	9.1
	Mediancira	1 Well (Stage II)	11,000	4.3
	Dois Vizinhos	Chopim River	12,000	9.1
	Palmas	Caldeiras River	6,000	4.9
	União da Vitoria	Iguaçu River	3,000	3.7
	Sub-total		62,000	35.8
<Other Urban Areas>	Surface Water & Wells			
	Sub-total		72,000	102.9
<Agricultural Water>	Surface Water			
	Sub-total		33,000	4.6
Total			959,000	962.4

Table-8.3 Water Resources Development Plan for Tibagi River Basin

Area	Project	Water Resource	Development Volume (m^3/day)	Project Cost (US$ million)
<Large Urban Areas>				
	Ponta Grossa	Tibagi River (I)	18,000	6.7
		Tibagi River (II)	19,000	6.8
	Londrina & Cambe	Tibagi River (I)	35,000	15.5
		Tibagi River (II)	35,000	15.5
		Tibagi River (III)	36,000	15.5
	Apucarana	4 Wells (Stage I)	22,000	7.3
		4 Wells (Stage II)	23,000	7.6
	Sub-total		188,000	74.9
<Medium Urban Areas>				
	Castro	Iapo River (I)	11,000	2.8
		Iapo River (II)	11,000	2.7
	Telemaco Borba	Tibagi River (I)	9,000	3.4
		Tibagi River (II)	9,000	3.4
	Cornelio Procopio	Congonhas River	6,000	7.4
	Arapongas	1 Well (Stage I)	11,000	7.2
		Pirapo River	9,000	8.7
	Ibipora	Tibagi River	9,000	7.4
	Irati	Imbituvinha River	6,000	9.0
	Sub-total		81,000	52.0
<Other Urban Areas>		Surface Water & Wells		
	Sub-total		30,000	32.9
<Agricultural Water>		Surface Water		
	Sub-total		8,000	1.0
Total			307,000	160.8

8.2 Hydropower Development

Planned hydropower stations in the Iguaçu and the Tibagi River Basins are listed in Table-8.4, and their locations are shown in Figure-7.2. Planned capacity installed at 3 stations in the Iguaçu River Basins is 1,400 MW, and 1,096 MW at the 5 stations in Tibagi River Basin.

Table- 8.4 Planned Hydropower Stations in the Iguaçu and Tibagi River Basins

Location No.	Name of Power Station	Basin	River System	Installed Capacity (MW)	Firm Energy (GWh)	Planned Start-up Year
1	Jordão Diversion	Iguaçu	Jordão	6.5	499	Mar. 96
2	Salto Caxias	Iguaçu	Iguaçu	1,240	4,853	Dec. 98
4	Jataizinho	Tibagi	Tibagi	156	758	Sep. 02
5	Cebolão	Tibagi	Tibagi	156	757	Sep. 03
	Sub-total (up to 2005)			1,559	6,867	
3	São Jeronimo	Tibagi	Tibagi	284	1,386	2006
6	Maua	Tibagi	Tibagi	388	1,617	2007
7	Telemaco Borba	Tibagi	Tibagi	112	541	2008
12	Fundão	Iguaçu	Jordão	154	640	2005-09
	Sub-total (2005 to 2015)			938	4,184	
Total	Iguaçu River Basin		16 stations	1,400	5,992	
			7 stations	1,096	5,059	

8.3 Flood Control

(1) General

Flood damage is concentrated in the Iguaçu River Basin. Even though floods in Irati and Ipiranga were reported, the flood damage was small. To prevent or minimize flood damage, two types of countermeasures, non-structural measures and structural measures, were proposed for the areas as shown in Table-8.6 and 8.7.

(2) Flood Control for União da Vitoria

As flood control measure for União da Vitoria, a combination of resettlement and dike construction is recommendable. The contents of both measures are as follows:

<Resettlement>

- Prohibition of public and private buildings and houses in zones lower than elevation 746.5 m and transfer and resettlement of them to safe zones
- Prohibition of construction of public and private new buildings and houses in the zones with elevation between 746.5 m and 748.5 m excluding buildings and houses heightened for flood resistance

<Dike Construction>

- design flood discharge : 4,980 m^3/second (actual flood in 1983, 1/120 year probability)
- design water level : 750.0 m (actual flood water level in 1983)
- design dike top level : 751.2 m (freeboard allowance : 1.2 m)
- total length of dike : 17 km
- design max. height : 5 m (dike bottom level > 746.5 m)
- Sluices including pumping facilities : 8 sets

(3) Flood Water Level at União da Vitoria

The flood backwater from the Foz do Areia reservoir to São Mateus do Sul through União da Vitoria was studied by non-uniform flow calculation based on various assumptions, employing floods in 1983 and 1992. The starting water levels of reservoir are 744.0 m, 742.0 m and 739.0 m. The employed river cross sections are the survey result carried out by JICA Study Team and COPEL. The calculation results are shown in Table-8.5 and Figure-8.3. The river water level fluctuation corresponding to the reservoir water level seems to be very small at União da Vitoria rather than water level flactuation corresponding to flood discharge.

Table-8.5 Flood Backwater from Foz do Areia Reservoir

Case	Flood	Foz do Areia	Porto Vitoria	União da Vitoria	Fluviopolis	São Mateus do Sul
A1	1983	744.0 m	746.7 m	750.1 m	759.0 m	764.3 m
A2	1983	742.0 m	746.3 m	750.0 m	759.0 m	764.3 m
A3	1983	739.0 m	746.1 m	749.9 m	759.0 m	764.3 m
A4	1992	742.0 m	745.4 m	748.7 m	757.7 m	763.4 m
A5	1992	739.0 m	745.3 m	748.7 m	757.7 m	763.3 m

Note: (1) Flood discharges are 4,980 m^3/sec and 3,810 m^3/sec for 1983 flood and 1992 flood respectively.
(2) H.W.L. of the Foz do Areia reservoir is 742.0.

Table-8.6 Proposed Non-structural Flood Control Measures

River Basin	Region	Municipalities	Non-structural Flood Control Measures	Implementation Schedule 1st. Stage present-2005	Implementation Schedule 2nd. Stage 2006 - 2015
Iguaçu River	1	Curitiba Metropolitan	Zoning	Δ	Δ
			FFWS	O	◎
			Evacuation	O	O
			Proofing	O	O
			Operation Rule	O	◎
	2	São Mateus do Sul	Zoning	Δ	Δ
			FFWS	O	◎
			Evacuation	Δ	O
			Proofing	O	O
		Porto Amazonas	Zoning	Δ	Δ
			FFWS	O	◎
			Evacuation	Δ	O
			Proofing	O	O
	3	Reboucas, Guarapuava	Zoning	Δ	Δ
			FFWS	O	O
			Evacuation	Δ	O
	4	União da Vitoria	Zoning	O	O
			FFWS	O	◎
			Evacuation	Δ	O
			Proofing	O	O
			Operation Rule	O	◎
	5	Rio Negro	Zoning	Δ	Δ
			FFWS	O	◎
			Evacuation	Δ	O
			Proofing	O	O
	6	Foz do Iguaçu	Zoning	O	O
			FFWS	O	◎
			Evacuation	O	O
			Proofing	O	O
			Operation Rule	O	◎
	8	Capanema	Zoning	Δ	Δ
			FFWS	Δ	Δ
			Evacuation	Δ	O
Tibagi River		Irati	Zoning	O	O
			FFWS	Δ	O
		Ipiranga	Zoning	O	O
			FFWS	Δ	O

(Note) (1) Non-structural Measures

Zoning : Zoning for land use control with resettlement and parks
FFWS : Flood forecasting and warning systems
Evacuation : Evacuation and rescue activities
Proofing : Raising of ground level and building, etc.
Operation Rule : Operation rules for reservoir, flood control facilities, etc.

(2) Implementation Methods

Δ : Extension of present method
O : Improvement of present method
◎ : Employment of new method

Table 8-7 Proposed Structural Flood Control Measures

Region	Municipalities	Structural Flood Control Measures	Project Cost (US$million)	Implementation Schedule	
				1st. Stage present-2005	2nd. Stage 2006 - 2015
1	Curitiba Metropolitan	<Continuation of PROSAM> - Channel Excavation (15 km, 1.3 million.m³) - Landscape restoration and park development of river bank area - Irai dam for flood control and to guarantee 1.8 m³/s to Curitiba - Relocation and resettlement of 1,400 houses located in risky areas including occupying river flood plain - Expropriation of 7,000 plots of lands and rights required for environment protection along river and environmentally sensitive areas	Total 34.3 (excluding Irai dam)	O	-
		<Extension of PROSAM> - Channel Excavation by Curitiba municipality - Piraquara II, Pequeno, Alto Miringuava dams for water supply with flood control function		O Δ	O
2	São Mateus do Sul	- dikes	11.1	-	O
4	União da Vitoria	- Dike system in União daVitoria, 17 km	85.9	O	

(Note) Δ : Partial operation O : Full operation

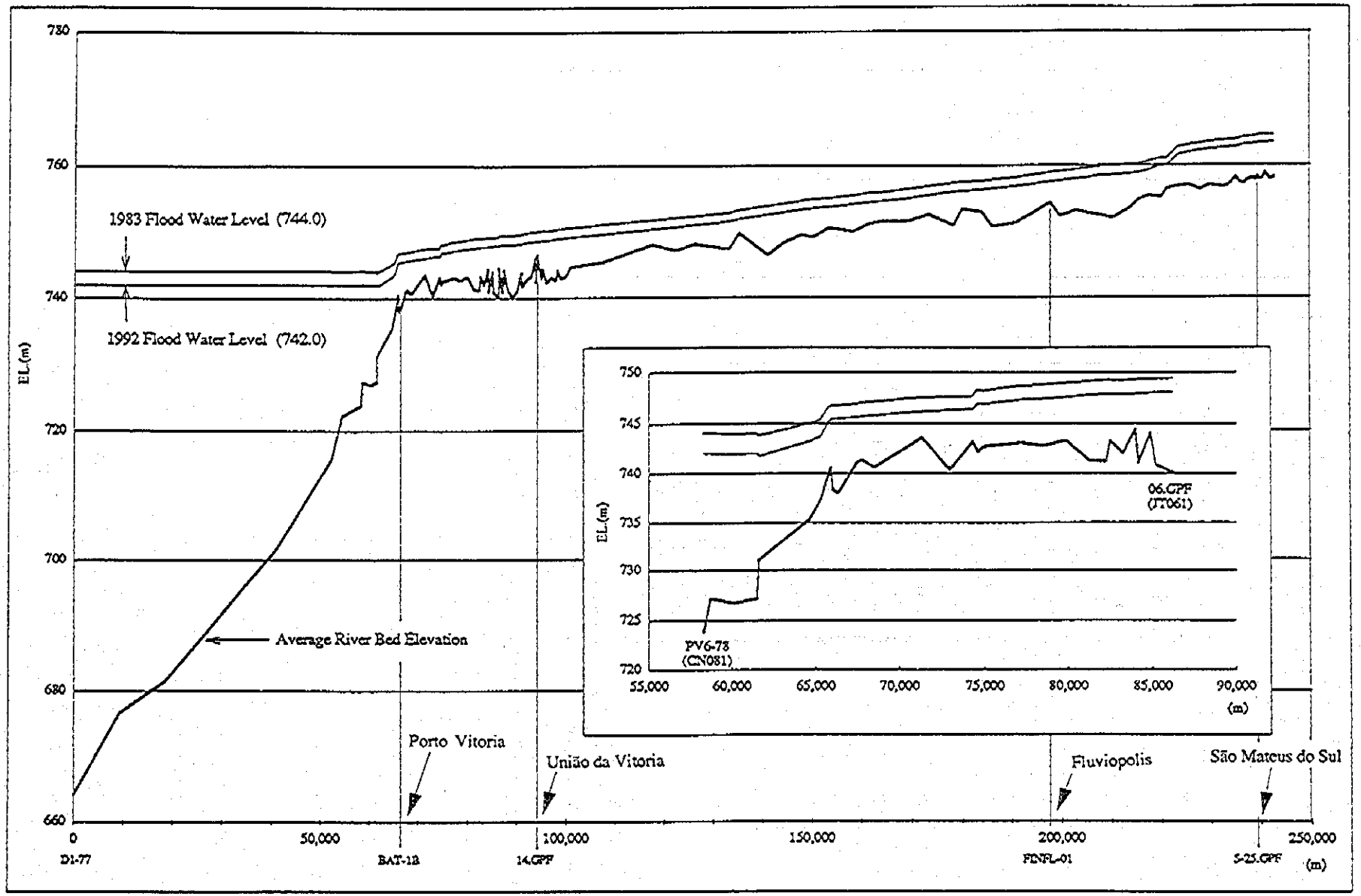

Figure 8-3 Flood Backwater from Foz do Areia Reservoir

8.4 Water Quality Improvement and Sewerage Development

(1) Large Urban Areas

Main causes of contaminated water are assumed to be domestic waste effluent from large urban areas. Curitiba Metropolitan Area and Cascavel for the Iguaçu River Basin, Ponta Grossa and Londrina for Tibagi River Basin were selected as target areas for the estimation of current and future water contamination, as well as for formulation of sewerage development plans to improve water quality.

Target water quality for target areas is set as Class-3 (BOD: 5-10 mg/liter) except for Cascavel to Class-2 (BOD: 3-5 mg/liter) considering reasonably attainable water quality target. Current contamination in these areas is substantially worse than the target, being at Class-4 or worse, and BOD is estimated to reach 30 mg/liter or higher.

Based on the estimates of the current volume of pollutant loads from domestic and industrial effluent, amount of diluting water (base flow of the river-$Q_{10,7}$+domestic sewage discharge+industrial waste water discharge) and present water quality (BOD), purification-residual ratio was analyzed assuming run-off ratio. Applying these ratios, and the water quality target, targeted volume of pollutant load reduction and required sewerage treatment, and the costs for sewerage development by 2005 and 2015 were estimated as shown in Table-8.8.

(2) River Basins

The Iguaçu and the Tibagi River Basins were divided into 20 and 17 blocks, respectively. Pollutant loads from sources such as domestic sewage, industrial and livestock waste water, and natural pollutant loads, as well as future water quality were estimated by each block, assuming required sewerage development estimated above and applying Streeter-Phelps formula.

The result of the estimation shows that the water quality in immediate downstream of the Curitiba Metropolitan Region will meet the target of Class-3, its BOD being 6 mg/liter, and that in all other rivers of the two basins will remain within Class-2, clearing that target.

With implementation of proposed sewerage development in Curitiba Metropolitan Region, Cascavel, Ponta Grossa, and Londrina, water quality in both the Iguaçu and the Tibagi Rivers will meet the target standards. Sewerage development in other urban areas may be required in response to future pollutant loads in order to control the water quality in the area and immediate downstream of the rivers.

Table-8.8 Sewerage Development in Large Urban Areas (2015)

	Iguaçu River Basin		Tibagi River Basin	
	Curitiba	Cascavel	Ponta Grossa	Londrina
Population in Urban Area (thousand persons)	3,040	303	306	580
Diluting Water (thousand m^3/day)	1,143	144	163	255
BOD Loads Discharged (kg/day)				
- Domestic Sewage	164,200	16,400	16,500	31,300
- Industrial Waste Water	23,200	400	2,900	11,800
Flow-out BOD Loads (kg/day)	45,000	4,300	4,500	9,800
Target Water Quality (BOD, mg/liter)	10	5	10	10
Permissible Runoff BOD (kg/day)	11,400	720	1,600	2,500
Target BOD Reduction (kg/day)	122,700	11,400	8,900	20,800
Targeted Population (thousand persons)	2,392	264	206	270
Treated Sewerage (m^3/day)	420,000	45,000	30,000	70,000
Project Cost (million US$)	294.0	50.0	29.2	59.4

8.5 Soil Erosion Control

In the Strategy study (Section 7.5) gross soil loss was calculated by the EMATER's division. For the Master Plan study, gross soil loss was computed by municipality.

Average soil loss from the Iguaçu River Basin is 18 ton/ha·year, and the maximum loss is found along the left side in the downstream of the river. Municipalities with high rates of soil loss in that area are Nova Esperança do Sudoeste, Boa Esperança do Iguaçu, Barracao and Itapejara D'oeste and the losses reach 57 - 86 ton/ha·year. From the Tibagi River Basin, the average soil loss is 10.9 ton/ha·year. The highest figure was found along the right side in the downstream of the river. Municipalities with high rates in that area are, São Jeronimo da Serra, Sapopema, Jataizinho and Santa Cecilia do Pavao, and the losses range 32-93 ton/ha·year. These figures are significantly higher than the target, 11 ton/ha·year.

For soil erosion control, two main measures, 1) complete implementation of terracing in all crop land and 2) 50% implementation of non tillage to beans, maize and soybean fields, were proposed with complementary measures, such as improvement of farm roads, agronomic measures and soil management. Through the implementation of these measures, the average soil loss from the Iguaçu and the Tibagi River Basins will decrease to 4 ton/ha·year and 2.4 ton/ha·year, respectively.

Costs estimated by proposed measure are shown in Table-8.9. Sufficient benefits, such as cost saving of fertilizer application, can be expected for the total cost of US$ 197 million.

Table-8.9 Soil Conservation Measures

Soil Conservation Measures	Iguaçu River Basin		Tibagi River Basin	
	Amount Covered	Cost (US$million)	Amount Covered	Cost (US$ million)
Terrace for Crop Land	10,781 Km^2	43.1	3,344 Km^2	13.4
Improvement of Farm Road	21,560 Km	32.3	6,690 Km	10.0
Maintenance of Terrace and Farm Road	-	33.0	-	10.7
Non Tillage	7,520 Km^2	35.5	2,530 Km^2	18.7
Agronomic Measures	30,700 Km^2	-	14,300 Km^2	-
Soil Management	30,700 Km^2	-	14,300 Km^2	-
Total		143.9		52.8

8.6 Ecological Conservation

Ecology conservation measures, their objectives and the costs, for the Iguaçu and the Tibagi River Basins are summarized in Table-8.10

Table-8.10 Ecology Conservation Measures

Conservation Measures	Objectives				Cost (U$thousand)	
	Conser -vation	Eco- nomic	Sani- tation	Moni- toring	Iguaçu River Basin	Tibagi River Basin
<Preservation Programs>						
fish population inventory survey	*			*	881	664
fish population dynamics survey	*	*			487	487
endemic fish reproduction survey	*	*			493	493
reservoir fish assessment	*	*		*	2,620	-
conservation unit management program	*	*			31	51
Serra Baitaca preservation	*	*	*		585	-
Eng. Bley preservation	*	*			241	-
Bitumuri River lowland program	*				-	245
Biodiversity Institute	*	*		*	not determined	-
<Environmental Education Program>						
water environment education	*		*		860	-
<Monitoring Programs>						
bioindicator monitoring			*	*	1,286	1,096
river margin vegetation monitoring	*		*	*	670	670
sandfly monitoring			*	*	414	
Total					8,568	3,706

8.7 Forest Preservation and Afforestation

The natural forest and reforestation in the Iguaçu River Basin cover 14.3 % (7,900 km^2) and 1.7 % (900 km^2) of its area, respectively. The total area of natural forest in the State is approximately 17,800 km^2 and its 44.4 % is in the Iguaçu River Basin. The natural forest in the Iguaçu River Basin is well preserved compared to other river basins. In the Tibagi River Basin, the natural forest and reforestation cover 3.8 % (900 km^2) and 9.4 % (2,300 km^2) of its area, respectively. The reforestation of the Tibagi River Basin accounts 36.5 % of the State total.

The measures to be taken initially are preservation in the area designated by the existing laws. Further, expansion of preservation area should be encouraged not only for ecosystem and environment conservation but also for scenic and recreational purposes. In Iguaçu River Basin, there are several plans for the establishment of new preservation areas, such as Irai reservoir area and Palmital River Basin. These plans should be implemented, with government assistance by means of finance, law enforcement and technical support.

Besides, afforestation should be promoted positively by means of commercial purposes. The land suitable for afforestation is; 1) the areas not suitable for agriculture and pasture and 2) the area of river margins in agricultural fields and so on. Afforestation plan in the Iguaçu and the Tibagi River Basins are given in Table-8.11.

Table-8.11 Afforestation Plan

River Basin	Purpose	Type	Area (Km^2)	Annual Area (ha/year)	Cost (US$ million)
Iguaçu River	Commercial	land not suitable for agriculture	1,900	9,500	135
	Water Environment Conservation	river margin in agricultural land	900	4,500	33
		sub-total	2,800	-	168
Tibagi River	Commercial	land not suitable for agriculture	2,000	10,000	142
	Water Environment Conservation	river margin in agricultural land	400	2,000	15
		sub-total	2,400	-	157
Total			5,200		325

8.8 Water Environment Management

The Master Plan for the improvement of monitoring system has been studied, since monitoring is a fundamental and most important component in water environment management. Measures to be taken for the improvement of the monitoring systems in the Iguaçu and the Tibagi River Basins, with their facility components and the costs are listed in Table-8.12.

Table-8.12 Master Plan for the Improvement of the Monitoring System

Description	Facility	Amount		Cost (US$ thousand)	
		Iguaçu	Tibagi	Iguaçu	Tibagi
1) Completion of SIMEPAR's System	- weather radar	3			
	- satellite image reception	1			
	- weather stations (telemetric)	116		(35,000)*	
	- hydrological stations (telemetric)	44			
	- environmental stations	3			
	- others				
2) Strengthening of Meteorological Observation	- meteorological observatory	4	-	30	-
	- rainfall gauge	103	19	155	29
3) Provision of Stream Gauges	- stream gauge	11	7	110	70
4) Establishment of Sediment Observatory	- sediment observatory	-	3	-	30
5) Groundwater Monitoring	- monitoring well	-	16	-	231
6) Establishment of Integrated Monitoring System in Curitiba Metropolitan and surrounding areas	- stream gauge	5	-	50	
	- monitoring well	81	-	1,381	-
7) Aquatic Ecology Monitoring		1	1	332	292
8) Establishment of Integrated Database System	- computer system and telephone line network	7	7	70	70
Total		-	-	2,120	722

(Note) * Since the installation of the SIMEPAR's system has already been included in funding by the Government and relevant entities, covering the whole State, the cost is not included in the above total.

8.9 Institutional Improvement

In addition to the programs 1-6 described in the Section 7.6 on the Strategy for institutional improvement, the implementation of following programs from 7) to 12), by 2015 is recommended as the institutional Master Plan.

(7) Introduction of River Basin Management and Establishment of Competent Entities

Option A) establishment of a river basin committee with functions to coordinate basin planning, operation and regulatory activities of the political jurisdictions, or to issue guidelines or recommendations; or

Option B) establishment of a river basin committee for regulatory functions and a river basin agency with operational functions for integrated water allocation and development, as well as the conservation of resources.

For the Iguaçu River Basin management, where main stream of the river is the domain of the Federal Republic, Option A is recommendable under the current legal frame. In the long term, however, the target should be set towards Option B, especially in the Upper Iguaçu River Basin. For the Tibagi River Basin management, Option B can be recommendable, emphasizing preventive natural resources conservation.

(8) Promotion of Coordination for Comprehensive Management

1) Establishment of an "Inter-sectoral Committee"

2) Further Close Coordination with Land Use Management

(9) Establishment of Public Hearing System into the Water Right Granting Procedure

(10) Comprehensive Water Quality Management by River Basin

1) Effluent Standards by River Basin

2) Introduction of Sewerage Scheme and Management by River Basin

(11) Enhanced Administration of Water Resources Development

1) Strengthened Management of Water Resources Development

2) Cost Allocation for Construction, Operation and Maintenance

(12) Water Pricing and Charging for Optimal Water Allocation and Demand Control

8.10 Costs and Implementation Schedule of the Master Plan

Cost estimated roughly and implementation schedule of the projects proposed in the Master Plan for the Iguaçu and the Tibagi River Basins are shown in Table-8.13 and 8.14, respectively. The total cost excluding hydropower projects for the Iguaçu and the Tibagi River Basins amount to US$ 1,726 million and US$ 464 million, respectively.

Table-8.13 Cost and Implementation Schedule of the Master Plan for the Iguaçu River Basin (1)

Contents of Master Plan	Development Water (m³/day)	Development Method	Cost 10⁶ US$	Implementation Schedule: Present - 2000	2001 - 2005	2006 - 2010	2011 - 2015
1.Water Supply			962.40				
(1) Domestic and Industrial Water			957.80				
1) Large Urban Areas: Population more than 100,000 in 2015			819.10				
(a) Curitiba Metropolitan Area	625,000		760.00				
Well Stage I	111,000	29 wells	110.60				
Well Stage II	103,000	27 wells	157.90				
Iraí Dam	121,000	Dam	135.40				
Piraquara II Dam	65,000	Dam	60.40				
Pequeno Dam	69,000	Dam	78.50				
Alto Miringuava Dam	52,000	Dam	96.90				
Cotia Despique Dam	104,000	Dam	120.30				
(b) Cascavel			38.90				
San Jose River I	13,000	Direct Intake	7.10				
San Jose River II	13,000	Direct Intake	7.10				
Well Stage I	16,000	9 wells	17.70				
Well Stage II	10,000	1 well	7.00				
(c) Foz do Iguacu			11.10				
Parana River I	30,000	Direct Intake	3.70				
Parana River II	30,000	Direct Intake	3.70				
Parana River III	30,000	Direct Intake	3.70				
(d) Guarapuava			9.10				
Bananas River I	13,000	Direct Intake	4.60				
Bananas River II	12,000	Direct Intake	4.50				
2) Medium Urban Areas: Population more than 50,000 in 2015			35.80				
(a) Francisco Beltrao			4.70				
Marrecas River I	10,000	Direct Intake	2.40				
Marrecas River II	10,000	Direct Intake	2.30				
(b) Pato Branco							
Chopim River	10,000	Direct Intake	9.10				
(c) Medianeira							
Well	11,000	1 well	4.30				
(d) Dois Vizinhos							
Chopim River	12,000	Direct Intake	9.10				
(e) Palmas							
Caldeiras River	6,000	Direct Intake	4.90				
(f) Uniao da Vitoria							
Iguacu River	3,000	Direct Intake	3.70				
3) Other 76 Urban Areas	72,000	Direct Intake & Wells	102.90				
(2) Agricultural Water Supply							
Whole River Basin	33,000	Direct Intake	4.60				

Table-8.13 Cost and Implementation Schedule of the Master Plan for the Iguaçu River Basin (2)

Contents of Master Plan	Cost 10⁶ US$	Implementation Schedule: Present - 2000	2001 - 2005	2006 - 2010	2011 - 2015
2. Flood Control	97.00				
(1) Non-structural Measures (Zoning, FFWS[1], Evacuation, Proofing ,Operation Rule) for Curitiba Metropolitan Area, Sao Mateus do Sul, Porto Amazonas, Reboucas, Guarapuava, Uniao da Vitoria, Rio Negro, Foz do Iguacu, Capanema	N.A				
(2) Structural Measures	97.00				
1) Curitiba Metropolitan Area					
(a) Continuation of PROSAM (Channel, Landscape Restoration, Park, Resettlement etc.)	(34.30)				
(b) Extension of PROSAM	N.A				
Channel Excavation					
Dams with Flood Control Function					
2) Sao Mateus do Sul					
Dike System with a Sluice	11.10				
3) Uniao da Vitoria					
Dike System (L=17 km, H=5m) with Sluices	85.90				
3. Sewerage Treatment	344.00				
(1) Development of Sewerage System					
Area — Sewerage Treatment Volume (m³/day)					
(a) Curitiba Metropolitan Area 420,000	294.00				
(b)Cascavel 45,000	50.00				
4. Soil Erosion Control	143.90				
(1) Terrace for Crop Land 10,781 km²	43.10				
(2) Non Tillage 7,520 km²	35.50				
(3) Improvement of Farm Road 21,560 km	32.30				
(4) Maintenance of Farm Road	33.00				
(5) Agronomic Measures and Soil Management	N.A				
5. Ecosystem Conservation	8.63				
(1) Preservation Program	5.33				
1) Fish Population Inventory	0.90				
2) Fish Population Dynamics	0.50				
3) Endemic Fish Population	0.50				
4) Reservoir Fish Assessment	2.60				
5) Management Plan for Conservation	0.03				
6) Serra Baitaca Preservation	0.60				
7) Eng. Bley Preservation	0.20				
8) Biodiversity Institute	N.A.				
(2) Environmental Education Program	0.90				
1) Water Environment Education	0.90				
(3) Monitoring Program	2.40				
1) Bioindicator Monitoring	1.30				
2) River Margin Vegetation	0.70				
3) Sand Fly Monitoring	0.40				
6. Afforestation	168.00				
(1) Afforestation for Conservation of the Water Environment: 900 km²	33.00				
(2) Commercial Afforestation: 1,900 km²	135.00				
7. Establishment of Monitoring System	2.13				
(1) Completion of SIMEPAR's System	(35.00)				
(2) Strengthening of Monitoring System	0.19				
1) 4 Meteorological Observations	0.03				
2) 103 rainfall gauges	0.16				
(3) Provision of 11 Stream Gauges	0.11				
(4) Integrated Monitoring System for Surface and Subsurface Water Resources in Curitiba Area	1.43				
1) 5 Stream Gauges	0.05				
2) 17 Boreholes in the Karst	0.41				
3) 20 Boreholes in the Guabiroutuba	0.34				
4) 44 Boreholes in the Other Urban Areas	0.63				
(5) Aquatic Ecological Monitoring	0.33				
(6) Integrated Data System with 7 sets of Computer Systems and Telephone Line Network	0.07				

Note 1) FFWS: Flood Forecasting and Warning Systems

Table-8.13 Cost and Implementation Schedule of the Master Plan for the Iguaçu River Basin (3)

Contents of Master Plan	Cost 10⁶ US$	Implementation Schedule Present - 2000	2001 - 2005	2006 - 2010	2011 - 2015
8. Institutional Improvement Program (1) Organizational Strengthening through Implementation of the Current Re-Organization (2) Strengthening Groundwater Management (3) Enhancement in the Enforcement of Environmental Regulations (4) Legal Arrangement for the Control of Soil, Sand and Stone Taking in river areas (5) Cost Recovery of Water Environment Management (6) Promotion of Residents Participation through Information Publication	N.A.		to be continued		
(7) Introduction of River Basin Management and Establishment of Competent Entities (8) Promotion of Coordination for Comprehensive Management (9) Establishment of Public Hearing System into the Water Granting Procedure (10) Comprehensive Water Quality Management by River Basin (11) Enhanced Administration of Water Resources Development (12) Water Pricing and Charging for Optimal Water Allocation and Demand Control	N.A.				
Sub Total	1,726				
9. Hydropower 3-stations, Total Installation Capacity: 1,400 MW	1,194				
Grand Total	2,920				

Note (1) Price level in August 1994 is applied with the exchange rate 1 US$ = 0.89 R$.
(2) Costs for continuation of PROSAM and SIMEPAR's System are not included in the total.

Table-8.14 Cost and Implementation Schedule of the Master Plan for the Tibagi River Basin (1)

Contents of Master Plan	Development Water (m³/day)	Development Method	Cost 10⁶ US$	Implementation Schedule: Present - 2000	2001 - 2005	2006 - 2010	2011 - 2015
1.Water Supply			160.80				
(1) Domestic and Industrial Water			159.80				
Area of Project							
1) Large Urban Areas: Population more than 100,000 in 2015			74.90				
(a) Ponta Grossa			13.50				
Tibagi River I	18,000	Direct Intake	6.70				
Tibagi River II	19,000	Direct Intake	6.80				
(b) Londrina & Cambe			46.50				
Tibagi River I	35,000	Direct Intake	15.50				
Tibagi River II	35,000	Direct Intake	15.50				
Tibagi River III	36,000	Direct Intake	15.50				
(c) Apucarana			14.90				
Well Stage I	22,000	4 Wells	7.30				
Well Stage II	23,000	4 Wells	7.60				
2) Medium Urban Areas: Population more than 50,000 in 2015			52.00				
(a) Castro			5.50				
Iapo River I	11,000	Direct Intake	2.80				
Iapo River II	11,000	Direct Intake	2.70				
(b) Telemaco Borba			6.80				
Tibagi River I	9,000	Direct Intake	3.40				
Tibagi River II	9,000	Direct Intake	3.40				
(c) Cornelio Procopio							
Congonhas River	6,000	Direct Intake	7.40				
(d) Arapongas			15.90				
Wells Stage I	11,000	1 Well	7.20				
Pirapo River	9,000	Direct Intake	8.70				
(e) Ibipora							
Tibagi River	9,000	Direct Intake	7.40				
(f) Irati							
Imbituvinha River	6,000	Direct Intake	9.00				
3) Other 26-Urban Areas	30,000	Direct Intake & Wells	32.90				
(2) Agricultural Water Supply							
Whole River Basin	8,000	Direct Intake	1.00				
2. Flood Control							
(1) Non-structural Measures (Zoning and Evacuation for Irati & Ipiranga)			N.A.				
3. Sewerage Treatment			88.60				
(1) Development of Sewerage Treatment							
Area	Sewerage Treatment Volume (m³/day)						
(a) Ponta Grossa	30,000		29.20				
(b) Londrina	70,000		59.40				
4. Soil Erosion Control			52.80				
(1) Terrace for Crop Land	3,344 km²		13.40				
(2) Non Tillage	2,530 km²		18.70				
(3) Improvement of Farm Road	6,690 km		10.00				
(4) Maintenance of Farm Road & Terrace			10.70				
(5) Agronomic Measures and Soil Management			N.A				

Table-8.14 Cost and Implementation Schedule of the Master Plan for the Tibagi River Basin (2)

Contents of Master Plan	Cost 10⁶ US$	Implementation Schedule: Present - 2000	2001 - 2005	2006 - 2010	2011 - 2015
5. Ecosystem Conservation	3.71				
(1) Preservation Program	1.94				
1) Fish Population Inventory	0.66				
2) Fish Population Dynamics	0.49				
3) Endemic Fish Reproduction	0.49				
4) Management Plans for Conservation Units	0.05				
5) Inundated Lowlands Study	0.25				
(2) Monitoring Programs	1.77				
1) Bioindicator Monitoring	1.10				
2) River Margin Vegetation	0.67				
6. Afforestation	157.00				
(1) Afforestation for Conservation of the Water Environment: 400 km²	15.00				
(2) Commercial Afforestation: 2,000 km²	142.00				
7. Establishment of Monitoring System	0.70				
(1) Completion of SIMEPAR's System	(35.00)				
(2) Strengthening Monitoring System ; 19 rain gauges	0.03				
(3) Provision of 7 Stream Gauges	0.07				
(4) Provision of 3 Stream Gauges for Sediment Observation	0.03				
(5) Groundwater Monitoring	0.23				
1) 4 Boreholes in Londrina	0.06				
2) 2 Boreholes in Apucarana	0.03				
3) 10 Boreholes in Other Urban Area	0.14				
(6) Aquatic Ecology Monitoring	0.29				
(7) Integrated Data Base System with 7 Sets of Computer System and Telephone Line Network	0.07				
8. Institutional Improvement Program					
(1) Organizational Strengthening through Implementation of the Current Re-organization					
(2) Strengthened Groundwater Management					
(3) Enhancement in the Enforcement of Environmental Regulations	N.A.				
(4) Legal Arrangement for the Control of Soil, Sand and Stone Taking in River Areas			to be continued		
(5) Cost Recovery of Water Environment Management					
(6) Promotion of Residents Participation through Information Publication					
(7) Introduction of River Basin Management and Establishment of Competent Entities					
(8) Promotion of Coordination for Comprehensive Management					
(9) Establishment of Public Hearing System into the Water Granting Procedure	N.A.				
(10) Comprehensive Water Quality Management by River Basin					
(11) Enhanced Administration of Water Resources Development					
(12) Water Pricing and Charging for Optimal Water Allocation and Demand Control					
Sub Total	463.60				
9. Hydropower					
5-stations: Total Installation Capacity; 1,096 MW	1,147.30				
Grand Total	1,610.90				

Note (1) Price level in August 1994 is applied with the exchange rate of 1 US$ = 0.89 R$.
(2) Cost for SIMEPAR's System is not included in the total.

8.11 Evaluation of the Master Plan

(1) Economic Evaluation

The followings are assumed in the economic analysis:

1) Construction costs shown in Table-8.13 and 8.14 are applied.
2) Assumption for the operation and maintenance (O&M) costs, construction periods, and evaluation periods are shown in Table-8.15.

3) A conversion factor of 0.85 is applied to adjust the investment and O&M costs to correct price distortion. The cost shown in Table-8.13 and 8.14 and O&M cost estimated above (financial costs) are multiplied by this factor for the economic evaluation (into economic cost).

4) A discount rate of 10 % is applied to calculate present value of costs and benefits.

5) The foreign exchange rate applied is R$ 0.89 = US$ 1.0.

Table-8.15 Conditions Applied in Economic Evaluation by Each Sector

Sector	Annual O&M Costs*1	Benefit	Construction Period (years)	Evaluation Period (years)
Water Supply	9%	Domestic Water; US$ 0.93 m^3 Industrial Water; US$ 0.56 m^3	4	30
Flood Control	0.5%	US$ 9.8 million/year *2	5	50
Sewerage	estimated separately	US$ 0.58 m^3	4	30
Soil Erosion Control	3%	saving in fertilizing	1	30
Hydropower	0.5%	US$ 72/MWh	5	50

(Note) *1 percentage to construction costs
*2 The benefit is assumed to grow 5% annually.

Various information in Paraná and Brazil indicates the opportunity cost of capital (OCC), which is a criterion against which an economic internal rate of return (EIRR) can be compared, is around 10 %~12 %. EIRR's of the projects are given in Table-8.16.

EIRR's of the projects for most of the water supply in large and medium urban areas, flood control, sewerage development, and hydropower development surpass 10 %. Out of water supply projects in medium urban areas, EIRR's of such projects for Irati in the Tibagi River Basin and for other areas than large or medium urban areas in the Iguaçu River Basin are derived under 10%. The reason can be that unit prices of water supplied in these area are high due to small scale of the development. Water supply projects generate various types of benefits other than economic ones, such as better public health with raised sanitation level, stable livelihood of the people and enhanced welfare, which cannot be quantified and taken into account in the economic evaluation. The water supply projects should not be judged only from the economic evaluation.

The projects of soil erosion control have also lower EIRR than the OCC (10 %). Benefits of these projects include not only savings in fertilizing as accounted in the evaluation of the Master Plan, but also increased agricultural productivity, saving in water purification for the supply, or other benefits resulted from better water quality or less sediment, which cannot or are difficult to be quantified.

(2) Financial Evaluation

Out of the projects analyzed in the above economic evaluation, water supply and sewerage projects and hydropower projects will generate revenue to managing entity, such as the SANEPAR and the COPEL. A financial evaluation was carried out for water supply and sewerage sector, whose services are limited within the State.

Assumptions for the financial evaluation are same as those used for the economic evaluation in terms of estimates of construction, and O&M costs and the exchange rates. The following revenue rates were applied to the evaluation.

- domestic water: US$ 0.62/m^3
- industrial water: US$ 1.10/m^3
- sewage: US$ 0.58/m^3

Financial internal rates of return (FIRR) of each of the water supply projects are shown in Table-8.17. Since water supply projects include water supply for domestic uses and industrial ones, the figures for domestic water supply only are also indicated in the table. FIRR's of industrial water supply are considerably higher than those of domestic water supply because of the higher tariff imposed on industrial users. Even though the current portion of industrial water supply to the total SANEPAR's is low and industries develop their own supply, the portion of industrial water will increase in the future because the regulations of groundwater abstraction will become stricter and uses of surface water will grow and more industries will rely on SANEPAR for their water supply. Sewerage projects show higher FIRR's compared to those for water supply. The results of the evaluation can be used in 1) procurement of finances of the projects, 2) revision or correction of tariff by area, 3) determination of priorities.

(3) Social and Environmental Assessment

The projects included in the Master Plan are 1) surface water use for water supply and power generation by dam development, 2) water supply by direct intake of surface water, 3) groundwater development by borehole drilling, 4) flood control by dike construction or channel improvement, 5) sewerage development, 6) soil erosion control by terracing or non tillage cultivation, 7) eco-system conservation, and 8) afforestation, aiming at improvement of water environment. The positive impacts will be much larger than the negative impacts on the society and the environment.

Since this Study is at a Master Plan level, detailed examinations of the negative impacts would be difficult at the moment. According to a preview over the negative impacts, the following issues should be examined in detail in feasibility studies.

1) lands acquisition, compensation or resettlement
2) water allocation between existing water right holders and prospective users
3) sedimentation in reservoirs and degradation of downstream river beds by dam construction
4) changes in reservoir water quality and effects on downstream river channel by dam construction
5) change in landscape and submergence of historical ruins, cultural heritage or conservation areas by reservoir development
6) groundwater level lowering or effects on water quality or discharge of surface water by groundwater development
7) affects on surrounding habitats of fauna or on aquatic or terrestrial flora by construction of dams or dikes, or channel excavation
8) effects on downstream river due to intake or outlet of water

Table-8.16 Result of Economic Evaluation

Sector	EIRR (%)	Net Present Value (US$ million)	Cost Benefit Ratio (B/C)
<Iguaçu River Basin>			
1. Water Supply			
• Large Urban Areas			
- Curitiba Metropolitan Region	10.3	14.9	1.02
- Cascavel	21.5	36.7	1.81
- Foz do Iguaçu	77.8	129.1	10.98
- Guarapuava	38.2	26.8	3.52
• Medium Urban Areas			
- Francisco Beltrão	51.2	24.0	5.38
- Pato Branco	17.0	4.9	1.46
- Medianeira	37.5	12.3	3.45
- Dois Vizinhos	18.4	6.0	1.56
- Palmas	18.8	3.4	1.59
- União da Vitoria	10.3	0.1	1.02
• Total of Other 76 Urban Areas	8.2	-11.7	0.90
2. Flood Control			
- União da Vitoria	14.7	52.2	1.91
3. Sewerage Development			
- Curitiba Metropolitan Region	24.3	359.2	2.65
- Cascavel	16.6	24.6	1.66
4. Soil Erosion Control	8.6	-7.7	0.93
5. Hydropower Development			
- Fundao Project	19.7	188.4	2.31
<Tibagi River Basin>			
1. Water Supply			
• Large Urban Areas			
- Ponta Grossa	37.6	38.6	3.45
- Londrina & Canbe	34.1	110.9	3.05
- Apucarana	40.9	49.9	3.87
• Medium Urban Areas			
- Castro	46.7	23.6	4.68
- Telemaco Borba	35.6	17.5	3.21
- Cornelio Procopio	10.8	0.4	1.05
- Arapongas	17.6	9.8	1.50
- Ibipora	19.1	5.3	1.61
- Irati	7.1	-1.6	0.85
• Total of Other 26 Urban Areas	12.9	6.7	1.18
2. Sewerage Development			
- Ponta Grossa	18.6	19.6	1.90
- Londrina	20.6	50.7	2.12
3. Soil Erosion Control	8.4	-2.0	0.92
4. Hydropower Development			
- 5-Stations	25.9	1,853.8	3.41

Note: Excluding two hydropower stations (Jordão Diversion and Salto Caxias) in the Iguaçu River Basin, of which construction already started.

Table-8.17 Result of Financial Evaluation

Sector	Construction Cost (US$ million)	Annual O&M Cost (US$ million)	Annual Revenue (US$ million)	FIRR (%)	Remark
<Iguaçu River Basin>					
1. Water Supply					
• Large Urban Areas					
- Curitiba Metropolitan Region	760.0	68.4	157.5	9.5 (4.0)	
- Cascavel	38.9	3.5	10.1	13.5 (11.6)	
- Foz do Iguaçu	11.1	1.0	17.4	62.2 (58.3)	
- Guarapuava	9.1	0.8	5.7	33.3 (27.2)	
• Medium Urban Areas					
- Francisco Beltrão	9.1	0.4	4.8	47.2 (39.0)	
- Pato Branco	9.1	0.8	2.1	11.2 (8.3)	
- Mediancira	4.3	0.4	2.2	27.6 (24.8)	
- Dois Vizinhos	9.1	0.8	3.3	20.4 (12.8)	
- Palmas	4.9	0.4	1.3	14.4 (10.5)	
- União da Vitoria	3.7	0.3	0.7	8.7 (3.6)	
• Total of Other 76 Urban Areas	102.9	9.3	16.2	4.8 (-)	
2. Sewerage Development					
- Curitiba Metropolitan Region	294.0	3.6	89.6	21.3	
- Cascavel	50.0	0.7	9.6	14.3	
<Tibagi River Basin>					
1. Water Supply					
• Large Urban Areas					
- Ponta Grossa	13.5	1.2	8.9	34.6 (27.4)	
- Londrina & Canbe	46.5	4.2	21.4	25.5 (22.3)	
- Apucarana	14.9	1.3	10.3	35.9 (29.6)	
• Medium Urban Areas					
- Castro	5.5	0.5	6.3	51.1 (38.5)	
- Telemaco Borba	6.8	0.6	4.7	36.1 (27.1)	
- Cornelio Procopio	7.4	0.7	1.4	7.3 (3.3)	
- Arapongas	15.9	1.4	4.8	16.5 (11.3)	
- Ibipora	7.4	0.7	1.6	13.0 (10.1)	
- Irati	9.0	0.8	1.4	4.7 (-)	
• Total of Other 26 Urban Areas	32.9	3.0	6.8	9.4 (5.4)	
2. Sewerage Development					
- Ponta Grossa	29.2	0.4	6.3	16.0	
- Londrina	59.4	1.0	14.8	17.7	

Note: ( ) shows domestic water supply.
(-) shows negative value.

CHAPTER 9 RECOMMENDATIONS

9.1 Studies to be Implemented Urgently

Such studies as described below are recommended to be urgently conducted, following this Study.

(1) Study of Comprehensive Regional Plan on Water Environment for the Curitiba Metropolitan Region

The following problematic issues regarding water environment were identified and clarified throughout the Study in Curitiba Metropolitan Region.

1) water supply by dam development
2) water supply by groundwater development
3) water quality control and sewerage development
4) flood control

A study of comprehensive regional plan on water environment should be conducted in more detail, containing the above issues. Feasibility studies should follow, after selection of programs or projects of priority regarding the above four issues.

(2) Feasibility Study on Flood Control in União da Vitoria

A feasibility study on flood control is recommendable for Uninão da Vitoria, where the largest damage by flood occurs.

(3) Feasibility Study on Water Supply and Sanitation in Londrina

Londrina has the second largest water demands, next to Curitiba. A feasibility study on water supply is necessary to be conducted, coupled with a study on sewerage development, taking into account of prospective water contamination in downstream rivers due to the location of the city on a mountain top.

(4) Feasibility Study on Water Supply and Sanitation in Cascavel

Water demand in Cascavel will grow rapidly corresponding to the urban development. Although the Study proposed the sources of water supply from surface and underground water, a feasibility study for more precise plans is required. A feasibility study on sewerage development to prevent water contamination in downstream rivers would be necessary because of the similar geographical conditions to Londrina.

(5) Feasibility Study on Water Supply and Sanitation in Ponta Grossa

Ponta Grossa has sufficient potential to develop as a satellite area of Curitiba. The population and industries will grow in the near future, causing problems in water supply and sanitation. Therefore, a feasibility study on these matters will be required.

9.2 Master Plan Study for Other River Basins than the Pilot River Basins of the Study

The Study formulated the Strategy to cover the whole state, and the Master Plan for Iguaçu and Tibagi River Basins, after the selection of these two basins as the Pilot River Basins. For other seven (7) river basins, Master Plan studies should be conducted as soon as possible by the Paraná State. The Steering and the Technical Committees established for the Study are expected to facilitate those Master Plan studies.

9.3 Review of Other Development Plans

The Strategy and the Master Plan proposed in the Study were formulated from the viewpoint of water environment applying various assumptions and estimates on socio-economic conditions. In other development plans, such as those for socio-economic development, regional development, industrial development of various sectors, and transportation and road network development, programs and projects should be planned or reviewed taking into account of the proposals made in the Study from the viewpoint of water environment. For example, in order to restrain the population concentration to the Curitiba Metropolitan Region and to distribute the population and industries to regional areas, definite schemes should be examined and programmed in regional development plans.

9.4 Implementation and Review of the Proposed Programs

In order to promote socio-economic development and to raise the living standards and to enjoy conserved or improved water environment, projects and programs proposed in the Study should be implemented steadily. Since the projects and programs were planned based on the estimated socio-economic framework in target years of 2005 and 2015, the plans should be reviewed every five years or when necessary, according to the changes in socio-economic conditions.

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