6.4.4 Water Supply System in Large Urban Areas

The water supply systems that should be promoted in large urban areas are as shown in Table-6.9.

Table-6.9 Recommended Water Supply Systems

City	Water Supply System	Construction	Catchment Area or Well Number	Development Volume (m^3/s)	Cost (10^6US$)
Ponta Grossa	direct intake from Tibagi river	pumps, pipeline (Ø 400 x 6,000 m x 2)	1520km²	0.433	13.5
Londrina	direct intake from Tibagi river	pumps, pipeline (Ø 500 x 13,400 m x 3)	21955km²	1.223	46.5
and	(Alternative) wells (Serra Geral F.aquifer)	wells pipeline (Ø 400 x 5,000 m, Ø 400 x 7,500 m)	30 boreholes	(0.494*)	(47.1)
Cambe	and (Botucatu aquifer)		4 boreholes	(0.496*)	
Apucarana	wells(Serra Geral F. aquifer)	wells, pipeline (Ø 300 x 9,000 m, Ø 300 x 8,000 m)	8 boreholes	0.260	14.9

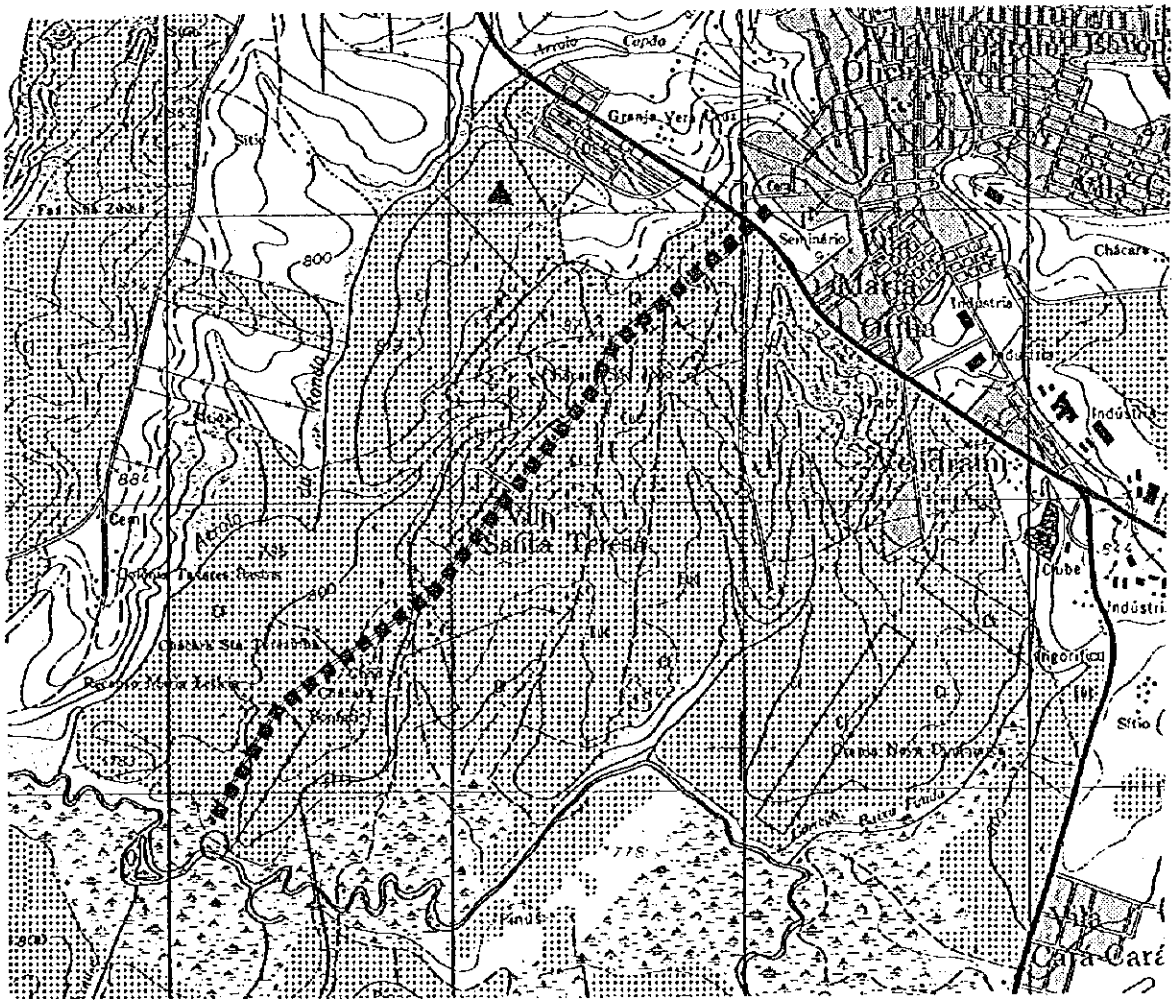
Note: * is development volume for only Londrina

The intake points and pipe lines for each city are as illustrated in Figure-6.2 - 6.4.

6.4.5 Implementation Schedule of Water Development

The implementation schedules for each city are as shown in Figure-6.5.

No.			Scale : 1 / 50,000
(Location)	X =580	Y =7216	
Basin Iguacu	River Rio Tibagi	Municipality Ponta Grossa	Others



Legend (Scale : 1/50,000)	
●	Existing Surface Intake
▩	Existing Well Intake
○	Planned Surface Intake Point
▲	Existing Sewage Plant
△	Planned/constructed Sewage Plant

Figure-6.2 Water Supply System in Ponta Grossa

No.			Scale : 1 / 100,000
(Location)	X =510	Y =7416	
Basin Tibagi	River Rio Tibagi	Municipality Londrina and Cambe	Others

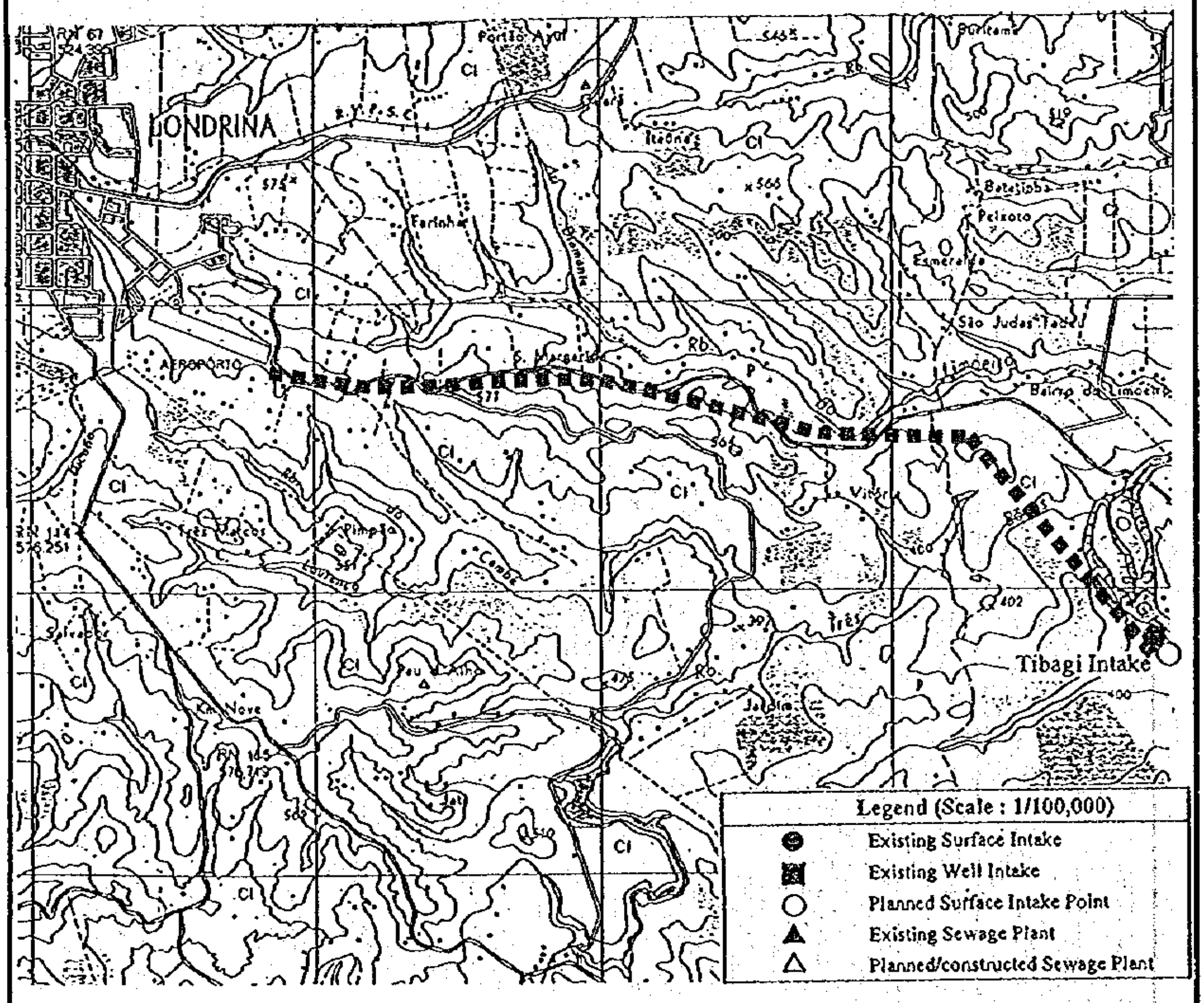


Figure-6.3 Water Supply System in Londrina and Cambe

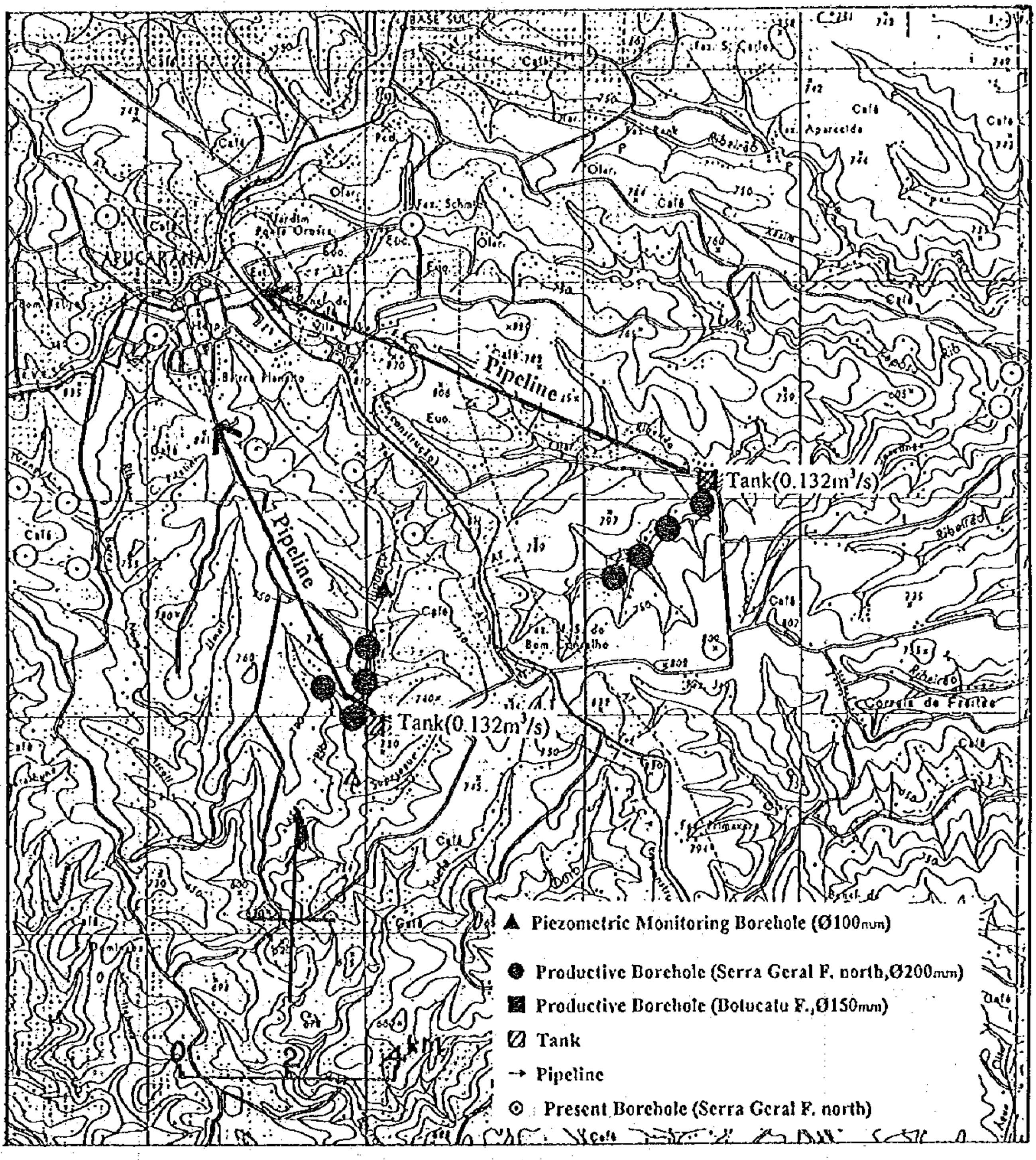


Figure-6.4 Water Supply System in Apucarana

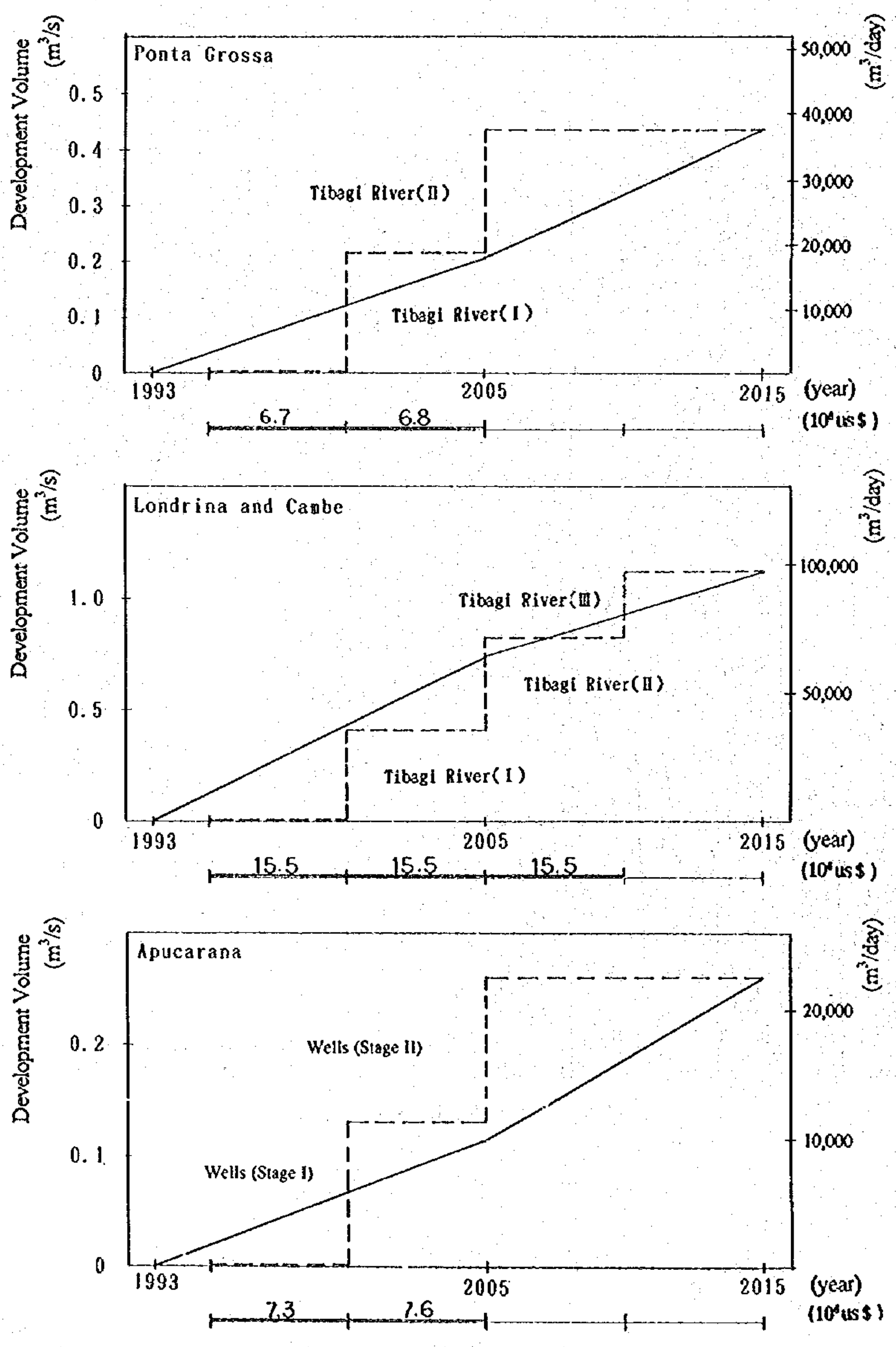


Figure-6.5 Implementation Schedule of Large Urban Area

6.5 Water Development in Medium Urban Areas (Type-B)

The urban areas were defined that their population will be more than approximately 50,000 in 2015. The following urban areas belong to Type-B as medium urban areas in Tibagi river basin.

- Castro
- Telemaco Borba
- Cornelio Procopio
- Arapongas
- Cambe (be mentioned with Londrina in sector 6.4)
- Ibipora
- Irati

6.5.1 Water Requirement

Required water supply in medium urban areas is shown in Table-6.10.

Table6-.10 Required Water Supply in Medium Urban Areas [m^3/s]

Municipality	Year	
	2005	2015
Castro	0.124	0.250
Telemaco Borba	0.112	0.215
Cornelio Procopio	0.027	0.069
Arapongas	0.061	0.142
Ibipora	0.044	0.105
Irati	0.033	0.075

[Note] Water requirement for urban area is mainly composed of urban domestic water and industrial water.

6.5.2 Process of Water Resources Development Study

The process of water resources development in medium urban areas is as shown below.

(1) In cities where main rivers are nearby and direct intake is simple, water supply shall be secured through surface water development.

(2) In cases where development by means of direct intake is difficult, careful consideration shall be given to the ease of development, the development capacity and the development cost, etc. for both surface water and groundwater.

(3) Regarding the development of surface water, examination shall be made based on the topographical conditions and water resource data.

(4) Examination shall be given to the case where the whole water supply is provided by groundwater development.

(5) Based upon the examination results of (3) and (4), the optimal development plan shall be formulated upon first giving careful consideration to the conditions stated in (2).

6.5.3 Water Resources Development Policies

Based upon consideration of the topographical conditions in Type-B cities and the surface water and groundwater conditions in the target area, the water resources development policies as shown in Table-6.11 were decided upon.

Table-6.11 Water Resources Development Policies for Medium Urban Areas

City	Topographical Condition	State of Water Resources		Water Resources Development Policies
		Surface Water	Groundwater	
Castro	Castro is situated in the midstream of a tributary of the Tibagi river.	A river with a catchment area of 1,000 km² runs nearby the city and direct intake development is possible.	The Lower Paleozoic aquifer is located around the town, however, the productivity of existing wells is low and the permissive yield is small.	As the direct intake development of surface water is easy and no suitable aquifers are located nearby, development of surface water will be carried out.
Telemaco Borba	This city is situated in the midstream area of the mainstream Tibagi river.	The direct intake of water from Tibagi river is possible.	The Middle-Upper Paleozoic aquifer is located around the town, however, the productivity of existing wells is low and the permissive yield is small.	Same as above
Cornelio Procopio	This city is situated in the upper reaches (near the mountain tops) of a tributary of Tibagi river.	The water intake from the nearby small rivers is not enough to satisfy the total water demand. If water was taken from Congonhas river, it would be possible to meet the supply, however, the pipe line would stretch for more than 128 km.	The Serra Geral Formation north aquifer and below that the Botucatu Formation aquifer are located around the city, and the productivity levels of existing wells are relatively high.	As both surface water and groundwater development are possible, the development plan will be formed upon examining both cases.
Arapongas	Arapongas is situated on the ridge of the border between the Tibagi river and Pirapo river basins.	The amount of water that can be taken from the nearby small rivers is not enough to satisfy demand and, even if water is taken from the Pirapo river (200 km²) more than 10 km away, the amount will still not be enough.	The Serra Geral Formation north aquifer is located around the town, and the productivity of existing wells is high.	As surface water development is difficult, either a combination of surface water development with groundwater development or groundwater development alone will be implemented.
Ibipora	Ibipora is situated in the downstream area of a tributary that runs into the lower reaches of the Tibagi river.	The amount of water that can be taken from the nearby small rivers is not enough to satisfy demand. If water is taken from Tibagi river, the required supply will be secured, however, the pipe lines will extend for approximately 10 km.	Same as above	As both surface water and groundwater development are possible, the development plan will be formed upon examining both cases.
Irati	Irati is situated in the upper reaches (near the mountain tops) of a tributary running into the upper reaches of the Tibagi river.	The amount of water that can be taken from the nearby small rivers is not enough to satisfy demand. If water is taken from Invitavinha river, the required supply will be secured, however, the pipe lines will extend for in excess of 10 km.	The Upper Paleozoic aquifer is located around the town, however, the productivity levels of existing wells is low and the permissive yield is small.	As the nearby aquifer is not suited to groundwater development, surface water shall be developed to provide the water supply.

6.5.4 Water Supply System in Medium Urban Areas

The water supply system recommended for medium urban areas are shown in Table-6.12.

Table-6.12 The Water Supply System Recommended for Medium Urban Areas

City	Water Supply System	Constructions	Catchment Area or Well Number	Development Volume (m^3/s)	Cost (10^6US$)
Castro	direct intake from Iapo river	pumps, pipeline (Ø 300 x 1,200 m x 2)	1,183 km²	0.250	5.5
Telemaco Borba	direct intake from Tibagi river	pumps, pipeline (Ø 300 x 2,700 m x 2)	13,743 km²	0.215	6.8
Cornelio	direct intake from Congonhas river	pump, pipeline (Ø 300 x 8,500 m)	413.3 km²	0.069	7.4
Procopio	(Alternative) wells (Botucatu aquifer)	well, pipe line (Ø 300 x 14,000 m)	1 boreholl	(0.129)	(9.7)
Arapongas	wells (Botucatu aquifer)	well, pipeline (Ø 400 x 9,000 m)	1 boreholl	0.124	7.2
	direct intake from Pirapo river	pump, pipeline (Ø 300 x 11,000 m)	200.0km²	0.101	8.7
Ibipora	direct intake from Tibagi river	pump, pipelin (Ø 300 x 6,900 m)	21,955 km²	0.105	7.4
	(Alternative) wells (Sella Geral F. aquifer)	wells, pipeline (Ø 200 x 3,500 m, Ø 200 x 6,000 m)	6 boreholls	(0.100)	(8.7)
Irati	direct intake from Imbituvinha river	pump, pipeline (Ø 300 x 13,200 m)	220.0 km²	0.075	9.0

6.5.5 Implementation Schedule of Water Development

Implementation schedule of water development is shown in Figure-6.6. (1) ~ (2).

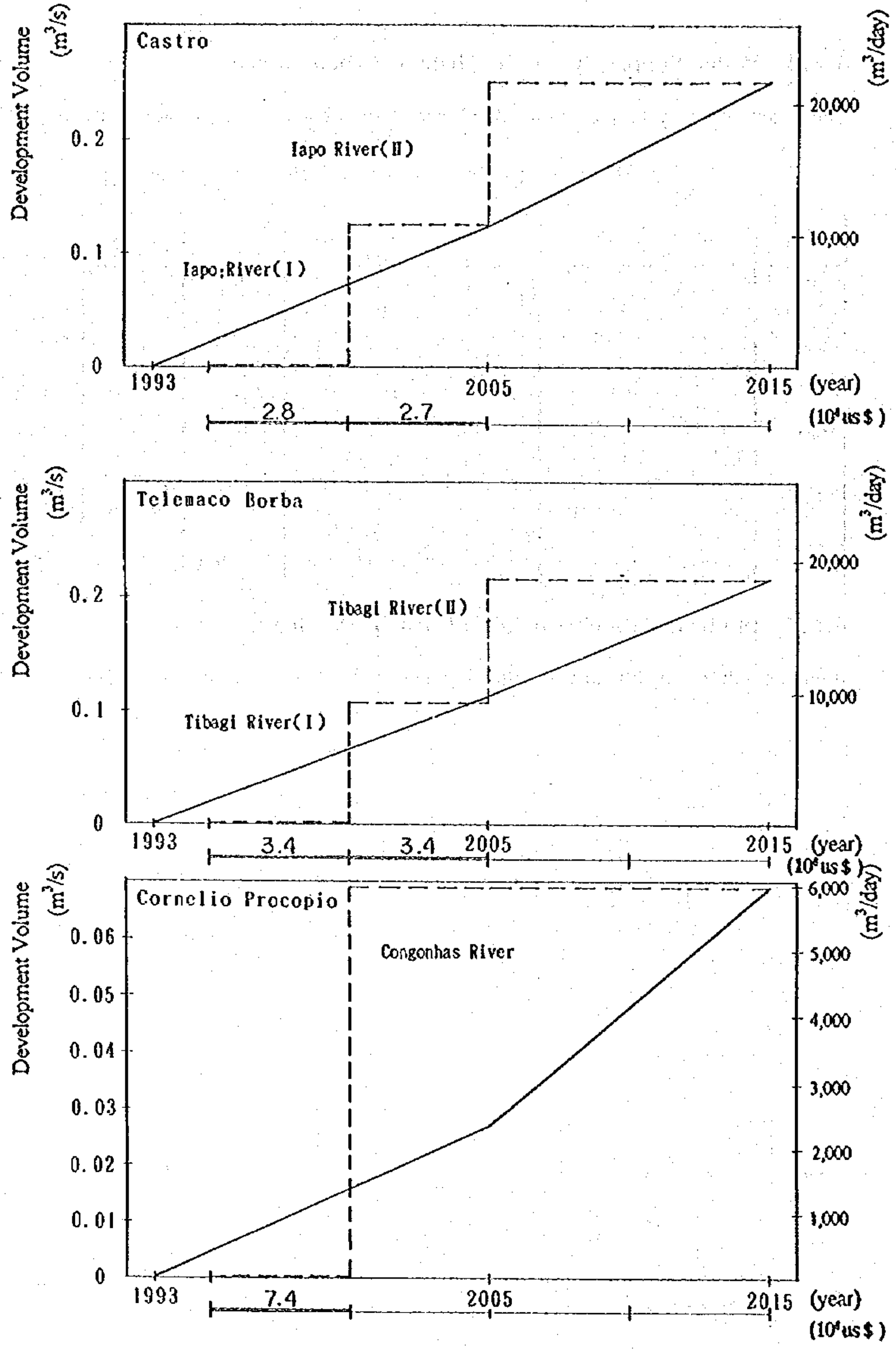


Figure-6.6 (1) Implementation Schedule of Medium Urban Area

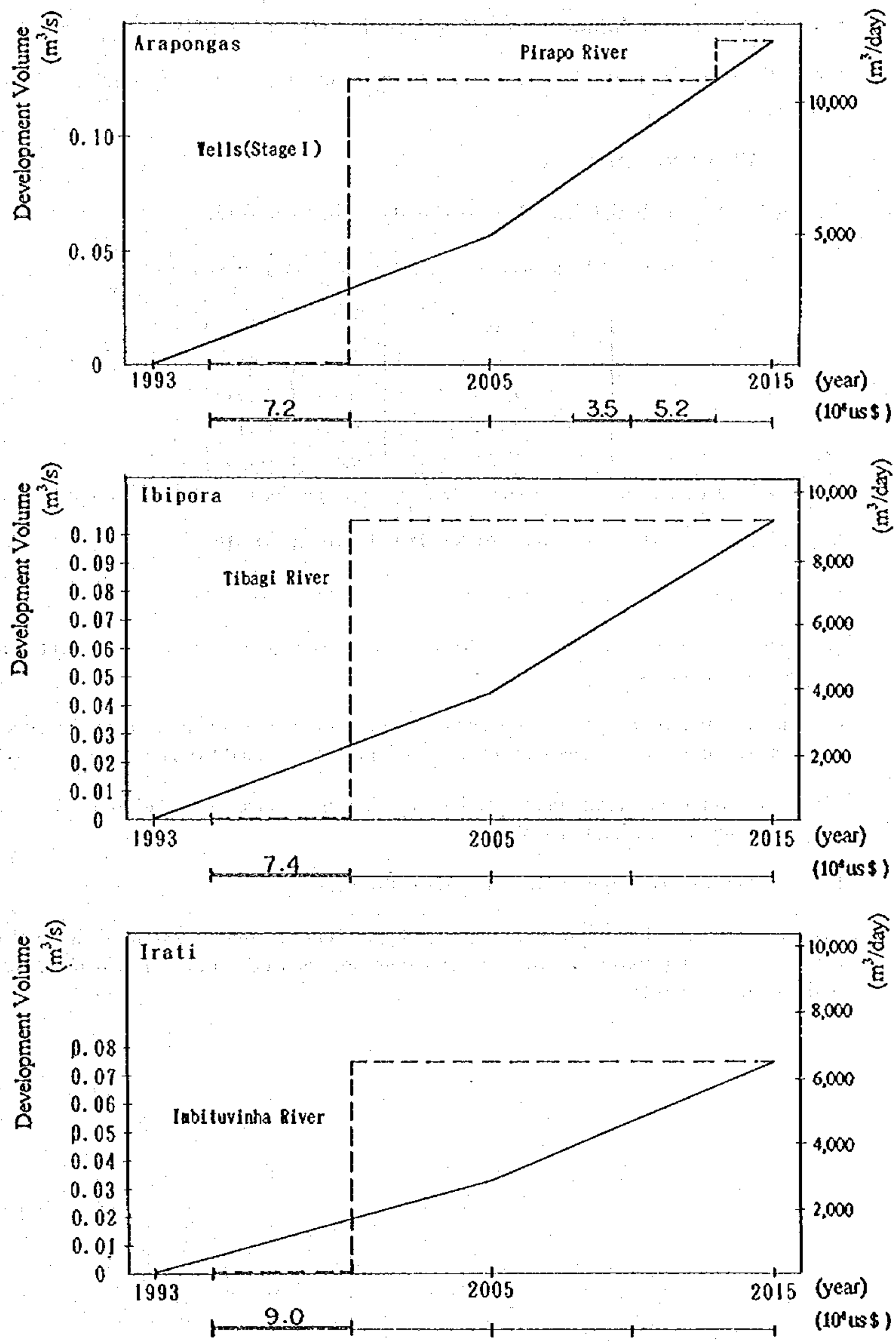


Figure-6.6 (2) Implementation Schedule of Medium Urban Area

6.6 Water Development in Other Urban Areas (Type-C)

Water development study of other urban areas was done for each zone as Zone-a, Zone-b and Zone-c.

6.6.1 Water Requirement

Required water supply in other urban areas is shown in Table-6.13.

Table-6.13 Required Water Supply in Other Urban Areas [m^3/s]

Zone	Year	
	2005	2015
Zone-a	0.055	0.123
Zone-b	0.056	0.119
Zone-c	0.045	0.105

[Note] Water requirement for urban area is mainly composed of urban domestic water and industrial water.

6.6.2 Process of Water Resources Development Study

Process of water resources development in other urban areas is as shown below:

(1) Determination of water resources for each zone evaluating surface water potential and groundwater potential.

(2) Identification of the relationship between the water requirement and its development cost based on the cost estimation of several municipalities selected from each zone.

(3) Cost estimation of all municipalities applying the above relationship to the water requirement of each municipality.

6.6.3 Water Resources Development Policies

The water resources development policies for Type-C cities, based upon consideration of the topographical conditions and surface water and groundwater conditions in each zone, are as indicated in Table 6.14.

Table-6.14 Water Resources Development Policies for Other Urban Areas

City	Topographical Condition	State of Water Resources		Water Resources Development Policies
		Surface Water	Groundwater	
Zone-a	These areas are situated nearby mainstream or downstream of tributaries.	As these areas are located nearby rivers with ample catchment areas, direct intake development is easy to achieve.	Of the aquifers located within the Tibagi river basin, those suited to groundwater development are the Farnas Formation,Botucatu Formation and the Serra Geral Formation north	As the direct intake development of surface water is easy, the nearby rivers will be developed as water supply sources.
Zone-b	These areas are situated upstream of second or third tributaries	The catchment areas of the nearby rivers are too small for performing the direct intake of water. The development of surface water would be possible if the intake points are placed further downstream, although the pipe line lengths would become long.	aquifers. Of these, the Farnas Formation aquifer is located in a narrow zone in the upper reaches of Tibagi river and does not lie close to Type-C cities. Regarding the supply of groundwater to Type-C cities, the Botucatu Formation and Serra Geral Formation aquifers, which are limited to the lower reaches of Tibagi river, can be utilized. The former of	For those cities, which are located on the Serra Geral Formation north aquifer and where the required water supply can be met by three wells (0.033 m^3/s or less), groundwater will be developed in order to provide the water supply. For those cities requiring a bigger water supply or which are not located on the said aquifer, direct intake development of surface water will be implemented.
Zone-c	These areas are situated on top of ridges of mountains.	Surface water resources are not sufficient to provide the required water in those cities with a large water demand.	these possesses greater productivity potential, however, deep drilling would be necessary. As the Type-C cities do not have such a high water requirement, development of the latter (Serra Geral Formation) aquifer is more appropriate	For those cities, which are located on the Serra Geral Formation north aquifer will be developed in order to provide the water supply. For those cities requiring a bigger water supply, the remaining water will be obtained from surface water development. In those cities not located on the Serra Geral Formation south aquifer, direct intake development of surface water will be implemented to meet the supply requirement.

6.6.4 Water Supply System in Other Urban Areas

Water supply system in other urban areas are shown in Table-6.15 by each zone.

Table-6.15 Water Supply System in Other Urban Areas

Zone	Number of Municipalities	Water Supply System	Development Volume		Cost
			Surface Water (m^3/s)	Groundwater (m^3/s)	(10^6US$)
C-a	9	direct intake from river	0.123	-	4.0
C-b	2	direct intake from river	0.057	-	5.1
	6	wells	-	0.062	7.8
C-c	3	direct intake from river	0.034	-	8.5
	6	wells	-	0.071	7.5
Total			0.214	0.133	32.9

6.6.5 Implementation Schedule of Water Development

Implementation schedule of water development is shown in Figure-6.7.

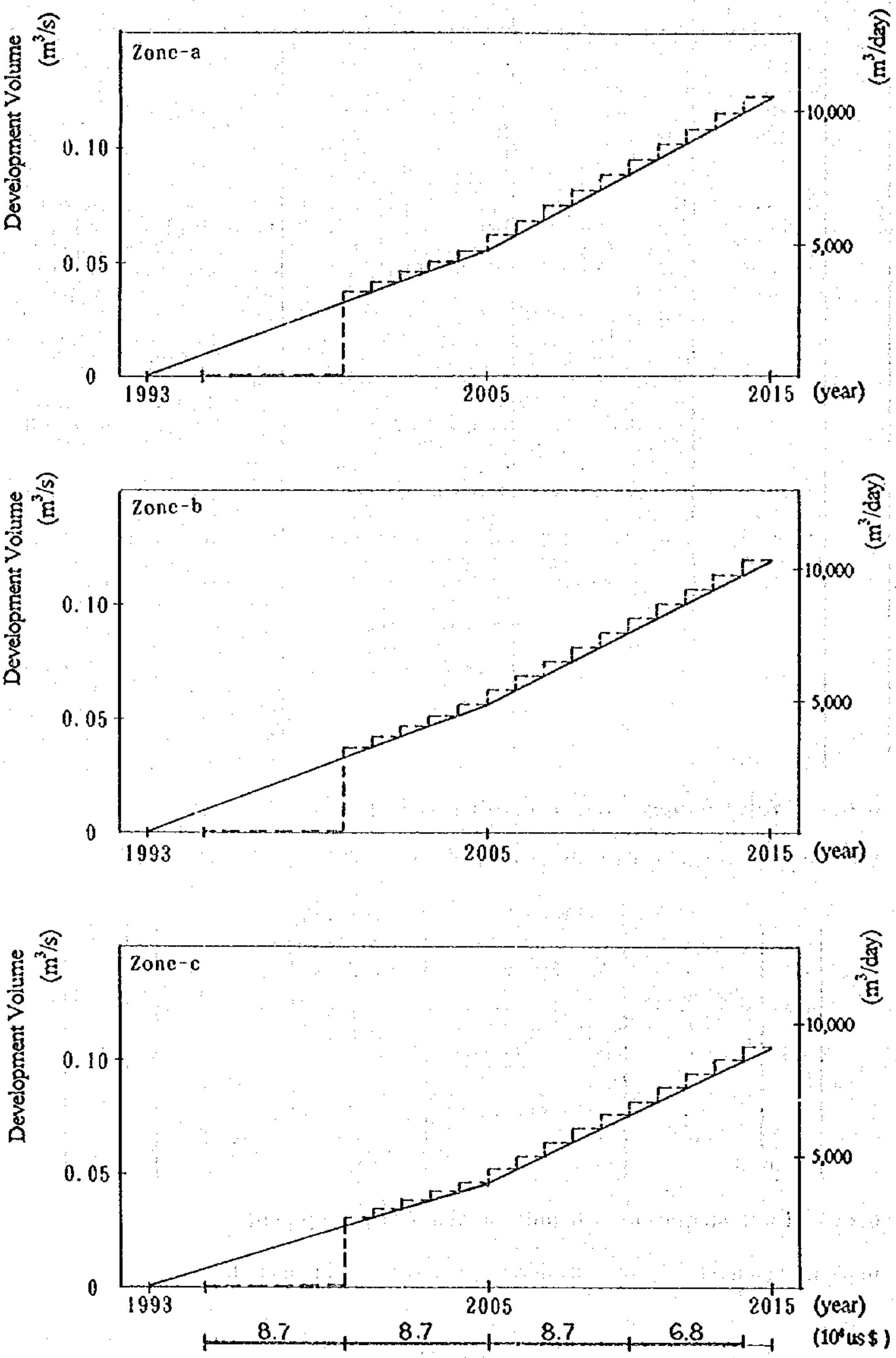


Figure-6.7 Implementation Schedule

6.7 Water Development for Rural Domestic Water

In rural areas, it is difficult to supply the water requirement by surface water systematically, because demand of domestic water is scattered due to topographic condition. Therefore, supply for domestic water will be done by groundwater development.

The demand of domestic water in rural areas tends to decrease from the point of view of the whole Tibagi river basin. Although there is an increase in some municipalities if the demand is examined with municipality wise, the volume of demand is very little. The maximum volume to be newly development is about 0.002 m^3/s.

As a result, the development of rural domestic water will not be necessary and only improvement or maintenance of existing wells is enough to satisfy the future water demand.

6.8 Water Development for Agricultural Water

Supply method of agricultural water at rural areas is generally a pipeline method with a direct intake using a pipeline and headworks.

According to hearing and field reconnaissance, an average of intake volume was less than 0.001 m^3/s, and average length of pipeline was 3 km.

The total water requirement for agricultural sector is 0.083m^3/s. The total cost of its development was estimated applying the cost of unit water development determined during the cost estimation for large and medium urban areas and thus the total cost is US$ 1.0 million.

6.9 Total Cost for Water Development

The total cost for water development covering from intake to water service installation was summarized in the Table-6.16.

Table-6.16 Total Cost for Water Development

Development Volume (m^3/s)		Cost (10^6us$)
(1) Domestic and Industrial Water Development (Urban Area)		
1) Large Urban Areas	1.629 (0.324)	74.9
2) Medium Urban Areas	1.115 (0.441)	52.0
3) Other Urban Areas	0.347 (0.102)	32.9
Sub-total	3.091 (0.867)	159.8
(2) Agricultural Water Development (Rural Area)		
	0.088	1.0
Total	3.179 (0.867)	160.8

Note: ( )shows industrial water.

The implementation schedule of water supply project is shown in Table-6.17.

Table-6.17 Implementation Schedule of Water Supply Project for Tibagi River Basin

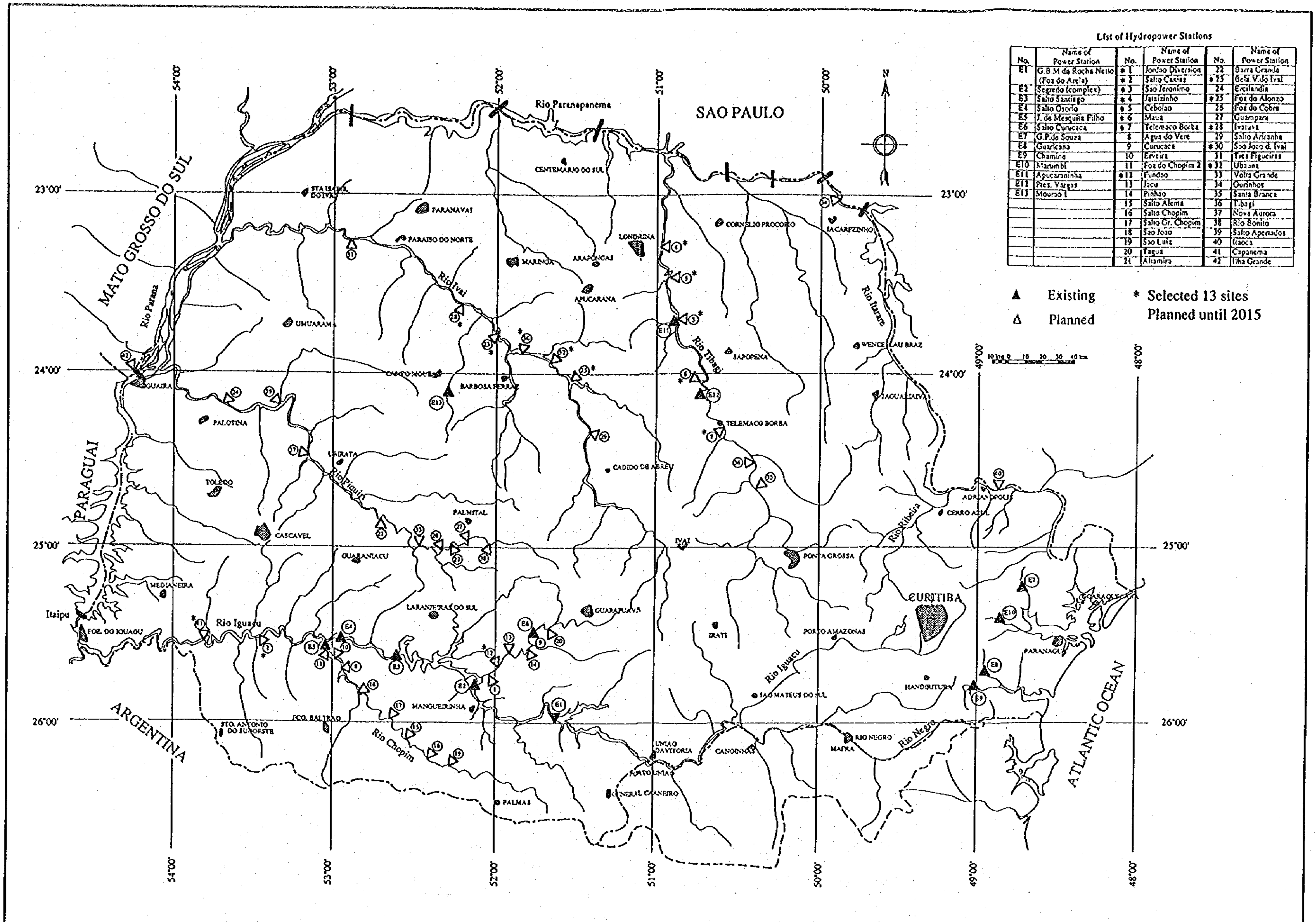
Area	Project	Water Resource	Development Volume (m3/s)	Project Cost (million us$)	Construction Schedule 96 97 98 99 00	01 02 03 04 05	06 07 08 09 10	11 12 13 14 15
<Large Urban Area>								
	Ponta Grossa	Tibagi River (I)	18,000	6.7				
		Tibagi River (II)	19,000	6.8				
	Londrina & Cambe	Tibagi River (I)	35,000	15.5				
		Tibagi River (II)	35,000	15.5				
		Tibagi River (III)	36,000	15.5				
	Apucarana	Wells (Stage II)	22,000	7.3				
		Wells (Stage I)	23,000	7.6				
(5 year Progress Rate)			188,000	74.9	29.5 [39%]	29.9 [40%]	15.5 [21%]	0 [0%]
<Medium Urban Area>								
	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	Wells (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				
(5 year Progress Rate)			81,000	52.0	37.2 [71%]	6.1 [12%]	3.5 [7%]	5.2 [10%]
<Other Urban Area>		Surfacewater & Wells						
(5 year Progress Rate)			30,000	32.9	8.7 [26%]	8.7 [26%]	8.7 [26%]	6.8 [22%]
<Agricultural Water>		Surfacewater						
(5 year Progress Rate)			8,000	1.0	0.2 [20%]	0.3 [30%]	0.2 [20%]	0.3 [30%]
Total			307,000	160.8	75.6 [47%]	45.0 [28%]	27.9 [17%]	12.3 [8%]

6.10 Hydropower Development

The hydropower development in the Tibagi river basin is planned as shown in Table-6.18 and in Figure-6.8.

Table-6.18 Planned Hydropower Stations in Tibagi River Basin

No.	Name of Power Station	Basin	River System	Intalled Capacity MW	Firm Energy Gwh	Planned Start-up Year
4	Jataizinho	Tibagi	Tibagi	156	758	2003
5	Cebolao	Tibagi	Tibagi	156	757	2003
	Total (up to 2005)			312	1,515	
3	Sao Jeronimo	Tibagi	Tibagi	284	1,386	2006
6	Maua	Tibagi	Tibagi	388	1,617	2007
7	Telemaco Borba	Tibagi	Tibagi	112	541	2008
	Total (2005 to 2015)			784	3,544	
Grand Total				1,096	5,059	



List of Hydropower Stations

No.	Name of Power Station	No.	Name of Power Station	No.	Name of Power Station
E1	G.B.M da Rocha Netto	* 1	Jordao Diversion	22	Barra Grande
	(Foz do Areia)	* 2	Salto Caxias	* 23	Bcla. V.do Ivai
E2	Segredo (complex)	* 3	Sao Jeronimo	24	Ercilandia
E3	Salto Santiago	* 4	Jataizinho	* 25	Foz do Alonzo
E4	Salto Osorio	* 5	Cebolao	26	Foz do Cobre
E5	J. de Mesquita Filho	* 6	Maua	27	Guampara
E6	Salto Curucaca	* 7	Telemaco Borba	* 28	Ivatuva
E7	G.P.de Souza	8	Agua do Vere	29	Salto Ariranha
E8	Guaricana	9	Curucaca	* 30	Sao Joao d. Ivai
E9	Chamine	10	Erveira	31	Tres Figueiras
E10	Marumbi	11	Foz do Chopim 2	* 32	Ubauna
E11	Apucaraninha	* 12	Fundao	33	Volta Grande
E12	Pres. Vargas	13	Jacu	34	Ourinhos
E13	Mourao I	14	Pinhao	35	Santa Branca
		15	Salto Alema	36	Tibagi
		16	Salto Chopim	37	Nova Aurora
		17	Salto Gr. Chopim	38	Rio Bonito
		18	Sao Joao	39	Salto Apenados
		19	Sao Luiz	40	Itaoca
		20	Tagua	41	Capanema
		21	Altamira	42	Ilha Grande

Figure-6.8 Existing and Inventoried Hydropower Stations in Paraná State

Source : COPEL

CHAPTER 7 ENVIRONMENTAL CONSERVATION AND IMPROVEMENT

7.1 Flood

7.1.1 Planning Criteria

Within the context of the goal and principle of water excess management of the Strategy the flood control model areas and design standard for the Master Plan are established as set out below.

(1) Model areas

Model areas are designated in the Iguaçu river basin as shown below, but no model area is designated in the Tibagi river basin, because the flood damage in these areas is minor though some flood inundation is reported in the municipalities of Irati, Ivai and Ipiranga.

<u>Iguaçu River Basin</u>
Region-1: Curitiba Metropolitan area
Region-2: Porto Amazonas, São Mateus do Sul
Region-4: União da Vitoria
Region-5: Rio Negro
Region-6: Foz do Iguaçu

(2) Flood Plain Management and Urban Storm Water Management

Non-structural measures are to be primarily employed for the flood prone areas in the municipalities in the Tibagi river. Integrated view of urban sewage, flood protection, storm drainage and environmental protection may be necessary for the urban area in the future after the year 2006. Environmental protection includes waste disposal control, water quality control, protection of aqua-ecosystem, and protection of riverine landscape.

(3) Design Standard

The flood control (or protection) level for zoning must be determined appropriately taking into consideration of social significance of damage level and efficiency of benefit and cost with the principle of risk and benefit for the municiparities in the Tibagi river basin.

7.1.2 Master Plan for Tibagi River Basin

(1) General

Zoning for land use control is the most effective measures for all the flood prone areas in and around the urban areas in Paraná State (Region-1 to 8). Zoning for land use control includes restricted area, river regime, natural preservation and recreational park, and retarding basin area. Zoning and resettlement are a tandem for implementation and have been widely applied in the Curitiba metropolitan area (CMA), São Mateus do Sul, Porto Amazonas, Reboucas, Guarapuava, União da Vitoria, Rio Negro, etc. in the Iguaçu river basin, and Irati and Ipiranga in the Tibagi river basin. Resettlement includes relocation of illegal residents occupying the river regime and legal residents in the flood prone areas.

The existing flood forecasting and warning system (FFWS) is planned to be upgraded by the provision of the new lightening sensoring and rainfall monitoring system under SIMEPAR. This upgraded system will provide basic warning information required for rescue activities for the time being. This system will be necessary to be upgraded for a basinwide real time flood management and operation to avoid artificial flood disaster in the future when number of water rescues and flood control facilities is increased significantly.

Flood proofing such as elevating ground level and structures is effective for some locally inundated areas in CMA and other flood prone areas.

Review of the operation rule of the existing and planned dams and reservoirs will be necessary taking flood control function into consideration for the integrated and effective operation.

(2) Master Plan

There was a report of flood inundation in 1983 in the municipalities of Irati, Ipiranga and Ivai in the Tibagi river basin. However the damage of these municipalities was assessed to be rather light in accordance with the reconnaissance done by the Study Team in 1994 and 1995. Therefore, the Master Plan for the Tibagi river basin is limited to non-structural measures by zoning for land use control with resettlement and parks only as shown in Table-7.1.

Table-7.1 Proposed Nonstructural Flood Countermeasures and Implementation Schedule for Tibagi River Basin

Municipality	Non-Structural Measures	1st Stage Present - 2005	2nd Stage 2006 - 2015 onward
Irati	Zoning	Improvement of Present method	Improvement of Present method
	Evacuation	Extension of Present method	Improvement of Present method
Ipiranga	Zoning	Improvement of Present method	Improvement of Present method
	Evacuation	Extension of Present method	Improvement of Present method

7.2 Water Quality and Sewerage

7.2.1 Present Condition and Future Prediction of Pollutant Load of the Tibagi River Basin

(1) Present Condition of Pollution Load and the River Water Quality

Figure-7,1 illustrates the average BOD values for Tibagi river basin, based on the water quality data measured by SUREHMA and IAP in the past 12 years from 1982 to 1993.

The BOD values in Figure-7.1 are the annual average values of all the water quality monitoring points in this basin. Generally speaking, water quality of Tibagi river is good and can meet Class 1 (BOD less than 3 mg/L) according to IAP's classification for river water quality.

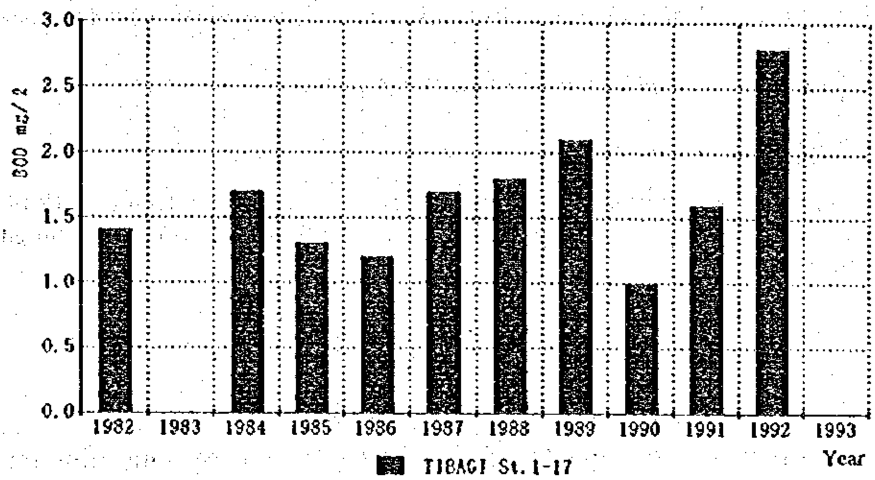


Figure-7.1 BOD Average of Tibagi River Basin (1982 ~ 1993)

(2) Pollutant Load Prediction

Table-7.2 shows the predicted discharge BOD loads of domestic sewage and industrial wastewater by the years of 2005 and 2015 with a comparison with those in 1993.

It is understood from this table that the domestic BOD load from urban area will increase greatly due to the high rate increase in urban population. Therefore, pollutant load reduction should mainly be carried out in the urban area, especially in the large municipalities.

Table-7.2 Pollutant Load Prediction of TIBAGI River Basin

Unit: KgBOD/day

Item	1993	2005	2015
Domestic (Urban Area)			
Population	1,175,818	1,430,343	1,738,970
BOD Load	63,494	77,238	93,904
Domestic (Rural Area)			
Population	381,686	328,830	295,220
BOD Load	20,611	17,757	15,942
Industrial BOD Load	12,335	19,624	29,035
Total BOD Load	96,440	114,619	138,881

(3) Target Cities for Pollutant Load Reduction

Table-7.3 shows the domestic BOD loads from several large cities in Tibagi basin area and their populations. The largest BOD load is from Londrina followed by Ponta Grossa. These two cities are selected as the target cities in Tibagi basin for pollutant load reduction.

Table-7.3 Pollutant Load from Large Cities

City	1993		2005		2015	
	Population	BOD (kg/day)	Population	BOD (kg/day)	Population	BOD (kg/day)
LONDRINA	380979	20573	488396	26373	579760	31307
PONTA GROSSA	226776	12246	269880	14574	306720	16562
APUCARANA	88221	4764	110160	5949	129880	7014
ARAPONGAS	61063	3297	70520	3808	78620	4245
TELEMACO BORBA	57538	3107	80350	4339	99820	5390

7.2.2 Pollutant Load Reduction Plan for Londrina and Ponta Grossa

(1) Target Water Quality and the Quantity of Diluting Water

1) Target Water Quality

The target water quality for pollutant load reduction for Londrina and Ponta Grossa is set as follows considering present water quality and reasonably attainable water quality in future:

Londrina $BOD \leq 10$ mg/L (Class 3)

Ponta Grossa $BOD \leq 10$ mg/L (Class 3)

2) River Water Flow

The river flow (draught flow $Q_{10.7}$) is calculated from the specific flow rate and the city areas as follows:

Londrina $Q_{10.7} = 0.091(m^3/s/100km^2) \times 1{,}500\ (km^2)$

$= 1{,}365\ m^3/sec = 117{,}936\ m^3/day$

Ponta Grossa $Q_{10.7} = 0.214\ m^3/s/100km^2 \times 650\ km^2$

$= 1{,}391 m^3/sec = 120{,}182\ m^3/day$

3) Quantity of Diluting Water

The quantity of water which dilutes the run-off BOD consists of the base flow in the river ($Q_{10.7}$) and the quantity of domestic sewage and industrial wastewater flowing into the river. Table-7.4 shows the calculated quantity of diluting water for the two cities.

Table-7.4 Quantity of Diluting Water

Unit: m^3/day

City	Year	$Q_{10.7}$	Domestic Sewage Discharge(1)	Industrial Wastewater Discharge(2)	Total
LONDRINA	2005	117,936	68,375	26,716	213,027
	2015	117,936	97,400	39,487	254,823
PONTA	2005	120,182	28,068	2,569	150,819
GROSSA	2015	120,182	39,260	3,798	163,240

Note: (1) = population x unit water consumption rate x 80%
(2) = actual discharge in 1993 x (1 + industrial sector growth rate)

(2) Pollution Analysis for 2005 and 2015

1) Analysis methods

a) The domestic and industrial discharge BOD loads were calculated as follows:

- Domestic load : From the population predicted for the future.
- Industrial load : Directly proportional to GRDP growth.

b) Target water qualities for the two cities were set as follows:

Londrina : BOD < 10 mg/l

Ponta Grossa: BOD < 10 mg/l

c) The permissible BOD load was calculated according to the target water quality.

d) The purification-residual ratio was assumed to be 0.3 referring to the result of pollution analysis for Curitiba M.A. (see 7.2, Master Plan for Iguaçu river basin).

e) The quantity of pollution reduction was evaluated from the difference between the predicted run-off BOD load and the permissible run-off BOD load.

2) Calculation results

The calculation results are shown in Table-7.5.

Table-7.5 Pollution Analysis and Pollutant Reduction Plan for 2005 and 2015

Item		LONDRINA		PONTA GROSSA	
		2005	2015	2005	2015
Urban Population	1)	488,390	579,760	269,880	306,720
Discharge BOD Load					
From domestic sewage (kg/day)	2)	26,373	31,307	14,573	16,563
From industrial wastewater (kg/day)	3)	5,012	11,778	1,964	2,902
Permissible Flow-out Load					
Target Water Quality (BOD mg/L)	4)	10	10	10	10
Diluting Water (m^3/day)	5)	213,027	254,823	150,819	163,240
BOD Load (kg/day)	6)	2,130	2,548	1,508	1,632
Permissible Run-off Load (kg/day)	7)	8,520	12,740	5,027	5,440
Run-off Load of the Permissible Domestic Wastewater (kg/day)	8)	551	1,000	3,063	2,538
BOD Load Reduction for Domestic Wastewater Load					
Total BOD Load (kg/day)	9)	26,373	31,307	14,573	16,563
Treated Load by existing system (kg/day)	10)	10,458	10,458	4,492	4,493
Reduction Load (kg/day)	11)	15,226	20,849	6,252	8,897
Quantity of Sewage Treatment					
Method of Treatment		Standard Activated Sludge	Standard Activated Sludge	Anaerobic + Aerobic Treatment	Anaerobic + Aerobic Treatment
BOD Removal Efficiency (%)	12)	80	80	80	80
BOD Load Factor (g/person/day)	13)	54	54	54	54
Unit Discharge (lit./person/day)	14)	140	168	104	128
Treatment BOD Load (g/day)	15)	16,027	21,919	7,815	11,121
Population to Serve	16)	296,803	406,413	144,722	205,944
Quantity of Sewage Treatment (m^3/day)	17)	41,552	68,277	15,051	26,361

Note: 2) = 1) x 0.054, 3) = discharge in 1993 (1 + industrial sector growthrate), 5): refer to Table-7.4,
6) = 4) x 5) ÷ 1,000, 7) = 6) ÷ 0.30, 8) = 7) - 3), 9) = 2), 10) = Treated BOD in 1993 x 0.8
11) = 9) - 8) ÷ 0.8 - 10), 15) = 11) ÷ 12) ÷ 100, 16) = 15) ÷ 0.054, 17) = 16) x 14 ÷ 1,000

(3) Plans for the Reduction of Pollutant Load by 2005 and 2015

Based on the result of calculation shown in Table-7.5, the BOD load to be reduced for Londrina is 15,226 and 20,894 kg/day by the years of 2005 and 2015, respectively, and that for Ponta Grossa is 6,252 and 8,897 kg/day. This needs implementation of sewage treatment facilities of capacities to remove these amounts of pollutants.

Plans of sewage treatment are also shown in the table. For Londrina, the standard activated sludge process will be applied in consideration of its high treatment efficiency (95% BOD removal) for reduction of the great amount of pollutants. For Ponta Grossa, the method of anaerobic digestion followed by aerobic treatment (80% BOD removal) will be applied.

7.2.3 Pollution Analysis of the Whole Tibagi River Basin

(1) Objective and Methodology

1) Objective

The objective of pollution analysis is to investigate the water quality at each of the control points in the whole Tibagi river basin in 2005 and 2015 on condition that pollutant reduction plans are implemented in Londrina and Ponta Grossa. If the target water quality cannot be met at some of the control points, additional plans will have to be worked out for pollutant reduction in the related areas.

2) Methodology

For the pollution analysis of the whole river basin, a water quality simulation model is formulated on the basis of Streeter-Phelps formula. This model can mainly simulate the self-purification process in a river course where organic pollutants are removed by biological degradation, sedimentation and absorption.

(2) Pollution Analysis

1) Water Quality Control Points

In order to select water quality control points for pollution analysis, Tibagi river basin was divided into 20 sub-basins. Each sub-basin contains one or two water quality control points. The locations of the selected 22 water quality control points are shown in Figure-7.2.

2) Fundamental Parameters

(I) The parameters used for pollutant load calculation were assumed as shown in Table-7.6 referring to Japanese guideline.

Table-7.6 Parameters for Pollutant Load Calculation

Item	Pollutant Load Factor	Run-off Ratio
Domestic Sewage	54 gBOD/person/day	Urban area: 0.8 Rural area: 0.1
Industrial Wastewater		1.0
Livestock Wastewater	Cattle: 600 gBOD/head/day Pig: 200 gBOD/head/day	0.05 0.05

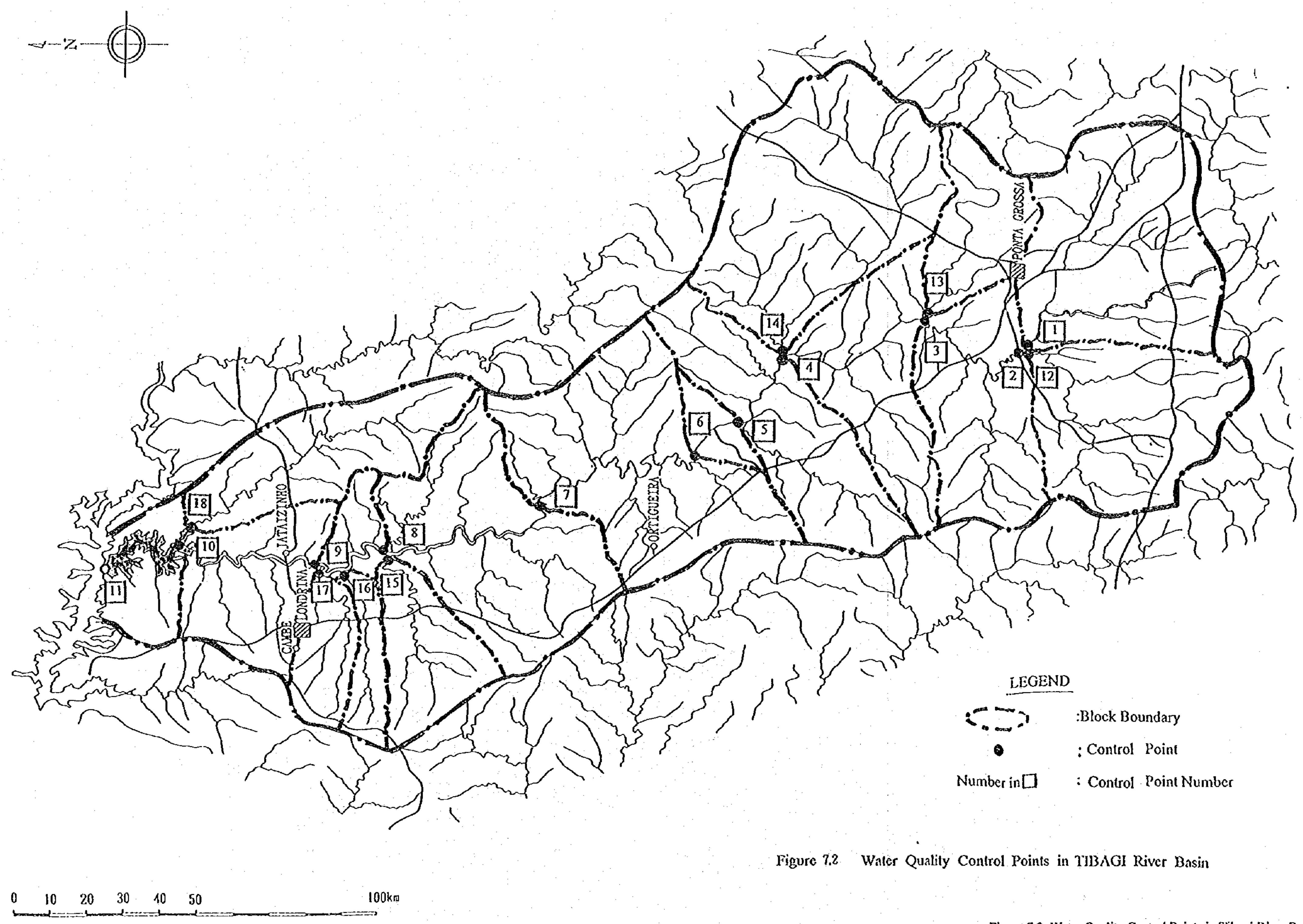


Figure 7.2 Water Quality Control Points in TIBAGI River Basin

Figure-7.2 Water Quality Control Points in Tibagi River Basin

(ii) Self-purification Coefficient

By an analysis of the current condition of pollutant load and water quality in the river basin, the self-purification coefficient was evaluated as 1.5 for the main stream and 0.8 for the tributaries of Tibagi river.

(iii) River Flow Velocity

Based on the collected information about the hydrological characteristics of Tibagi river, the average flow rate was assumed as 0.4 m/sec in the river course and 0.01 m/sec in the dam area.

3) Analysis Results

Table-7.7 shows the results of water quality prediction for the 11 control points along Tibagi river. The BOD concentrations at most of these points are lower than 2.0 mg/L by both the years of 2005 and 2015, except for No. 1 and No.2 near Ponta Grossa. The lowest BOD value appears at control points No. 7 and No. 8 as only 0.01 mg/L. This is because dams are built in these sub-basins where water flows very slowly and self-purification efficiency is very high. The results indicate that if pollutant load from Londrina and Ponta Grossa can be reduced as has been planned in the former section, the water quality in the whole river basin can be soundly improved. Therefore, sewage treatment implementation should mainly be planned for the two large municipalities.

Table-7.7 Water Quality Prediction of Iguaçu River

Unit: mgBOD/L

Water Quality Control Point	2005	2015
No.1	2.83	3.35
No.2	2.55	2.95
No.3	0.55	0.63
No.4	0.94	1.08
No.5	0.51	0.59
No.6	1.89	2.64
No.7	0.01	0.01
No.8	0.01	0.01
No.9	0.76	0.91
No.10	0.33	0.39
No.11	0.18	0.21

7.2.4 Sewage Treatment Plan

(1) Quantity of Sewage to be Treated

As has been discussed in the former sections, the target cities for pollutant reduction are Londrina and Ponta Grossa. Therefore, sewage treatment facilities have to be implemented in these two municipalities. Table-7.8 shows the quantity of sewage to be treated by the years of 2005 and 2015, based on the results of pollution analysis in 7.2.2.

Table-7.8 Quantity of Sewage to be Treated

Unit: m^3/day

Year	LONDRINA	PONTA GROSSA
2005	42,000	15,000
2015	70,000	30,000

(2) Project Implementation Plan

Table-7.9 shows the implementation plan of sewage treatment project. For Londrina, two stages are considered by the years of 2005 and 2015, and for Ponta Grossa, the plan shall be implemented at one stage by the year of 2005 because of the smaller scale of the required facility.

Table-7.9 Project Implementation Plan

Unit: m^3/day

Implementation Period	LONDRINA		PONTA GROSSA	
	Treatment Capacity	Treatment Method	Treatment Capacity	Treatment Method
1996~2000	-	-	-	-
2001~2005	40,000	a	30,000	b
2006~2010	-	-	-	-
2011~2015	30,000	a	-	-
Total	70,000		30,000	

Note: The treatment methods and efficiencies corresponding to the symbols are as follows:

		BOD Removal (%)
a:	Standard Activated Sludge Process	95
b:	Anaerobic Digestion + Aerobic Treatment	80

(3) Project Cost Estimation

The project cost was estimated based on the SANEPAR's "Plano Director de Esgotamento Santario de Curitiba de Regao Metropolitana (Sept., 1993)" which provided the standard unit cost for sewerage system construction. Table-7.10 shows the costs for sewage treatment facility construction including the additional cost for the construction of sewer pipelines and other accessory facilities. For Londrina, the total cost will be about US $ 59.4 million, and for Ponta Grossa, it will be about US $ 29.2 million.

Table-7.10 Total Construction Cost

(Unit: US$ x 1,000, Year 1994)

Period	LONDRINA	PONTA GROSSA
1996~2000	---	29,200
2001~2005	32,800	---
2006~2010	---	---
2011~2015	26,600	---
Total	59,400	29,200

Note) The cost includes those for sewage treatment facilities sewer pipelines and other accessory facilities.

7.3 Soil Erosion

At the Strategy study, the current and future soil loss from Tibagi river basin was roughly estimated with USLE, Universal Soil Loss Equation. Since the main objectives of USLE application at Strategy is to grasp the magnitude of soil loss, the data with a large division wise was used and analyzed.

USLE was applied to Tibagi river basin again for the following objectives and Municipality wise data was used to determine each factor in USLE. The data regarding agriculture in 1994 was obtained from EMATER and GIS computation was conducted by SANEPAR based on the IAP satellite imagery analysis (1990 &1994).

1) To identify the location with high degree of soil erosion in order to formulate the soil conservation plan with location priority

2) To evaluate the effectiveness of the soil conservation plan proposed

7.3.1 Current Gross Soil Loss

(1) Determination of Factors in USLE

Compared to the simulation at the Strategy study, the simulation for Tibagi river basin was involved in much detail analysis of the data with Municipality wise and some factors of USLE were estimated applying RUSLE, Revised Universal Soil Loss Equation. In the following sections, the determination of USLE factors is briefly explained and the result is discussed.

USLE is expressed in equation-1.

$$A = R \cdot K \cdot LS \cdot C \cdot P \qquad \cdots\cdots\cdots (1)$$

where A: annual gross erosion (ton/ha), R: rainfall factor (MJ·mm/ha·hr), K: soil erodibility (ton·ha·hr/ha·MJ·mm), LS: slope length and steepness factor (dimensionless), C: cover and management factor (dimensionless), P: support practice factor (dimensionless)

Since the above factors in USLE are local dependent variables, the improvement of model requires careful examinations of local data. Therefore, the model was applied close cooperation with Roloff, Federal University of Paraná, especially the determination of K and C factors.

1) R factor

Rufino et al. (1993) derived the following correlation equation of rainfall factor, R, with average monthly and annual rainfall. Their equation was applied to compute rainfall factor of each Municipality.

$$R = a + b \cdot Rc$$

$$Rc = p^2 / P$$

where R; rainfall factor, a and b: coefficient, Rc: rainfall coefficient, p: average monthly rainfall (mm), P: average annual rainfall (mm)

2) K factor

Roloff and Denardin (1994) derived the regression equation to estimate K with silt fraction, fractions of iron and aluminium oxides, amount of fine sand and permeability. Assuming no seasonal variation of K, their equation was adopted to determine K factor of soils in Tibagi river basin.

3) LS factor

The following equations in RUSLE were applied.

$$L = (\lambda / 22.1)^m \qquad m = \beta / (1 + \beta)$$

$$S = 10.8 \sin(\theta) + 0.03 \qquad steepness < 9\%$$

$$S = 16.8 \sin(\theta) - 0.50 \qquad steepness \geq 9\%$$

where λ: slope length (m), β: a ratio of rill and interrill erosion, θ: slope angle

4) C factor

Compared to USLE, the major advantage of RUSLE is the determination of C for crop land as a function of the effect of prior land use, canopy cover, surface cover and surface roughness. Since C determination with RUSLE requires crop and tillage databases, agricultural data from EMATER and Roloff's database were used.

C factors for perennial crops, reforestation and fallow were estimated with the surface method developed by Dissmeyer and Foster (1981), while C factors for forest and permanent pasture were estimated with the original USLE, Agricultural handbook No. 537 (Wishmeier and Smith, 1978).

5) P factor

It was obtained from the original USLE, Agricultural handbook No. 537 (Wishmeier and Smith, 1978).

(2) Result of Simulation

Current gross soil loss estimated for each landuse classification is shown in Table-7.11 with Municipality wise. The soil loss from crop land ranges between 0.1 to 128.0 ton/ha·year depending on the spatial variation of cropping pattern, tillage, soil conservation and so on. The average soil loss from Tibagi river basin is 24 ton/ha·year at the Strategy study, while one at the Master Plan study is 10.9 ton/ha·year. This discrepancy is mainly due to:

1) difference in scale of data

The Strategy study adopted agricultural data with EMATER division wise, which splits Paraná in 20 regions, while the Master Plan study adopted agricultural data with Municipality wise in order to specify the crop land (the land use classification) with cropping pattern, tillage and cultivation methods, extension of soil conservation and so on.

2) difference in scale of analysis

The data analysis for the determination of USLE factors was conducted by EMATER division wise at the Strategy study, while USLE factors were determined for the specific land use in each Municipality at the Master Plan study.

The accuracy of the model should be examined through the comparison between the result computed and real data; however, in Paraná neither USLE nor RUSLE has been tested enough. Since the USLE model at the Master Plan study was involved in the detail analysis of data to compute factors of USLE, the result in Table-7.11 was adopted to propose the Master Plan. The result of USLE at the Strategy study is considered to have at least enough accuracy to compare the magnitude of soil loss from river basins.

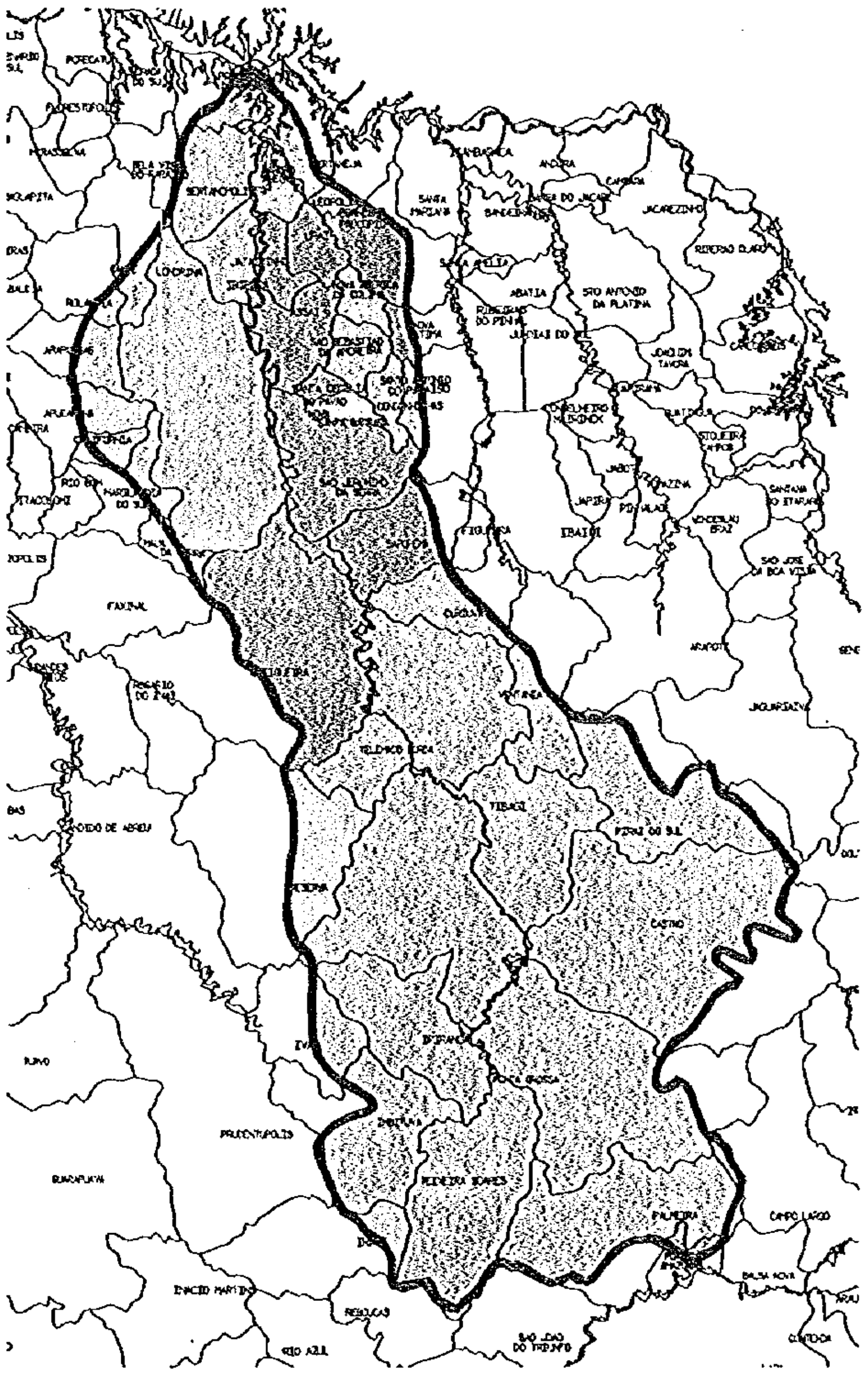
The average soil loss of Municipalities was classified from low to high. Low means soil loss less than 10 ton/ha·year, Medium is between 10 and 20 ton/ha·year and High is more than 20 ton/ha·year. As shown in Figure-7.3, the upstream of Tibagi river basin is classifed in low soil loss because of high rate of reforestation, while soil loss on the right side in the downstream of Tibagi is high due to the large expansion of crop land with the low coverage of soil conservation measures .

Table-7.11 Current Gross Soil Loss in Tibagi River Basin

Unit: ton/ha•year

No.	Municipality	Area (km2)	1994 Forest	2nd Veg.	Ref.	Pasture	Crop	Average
T-001	Porto Amazonas	53.8		3.1		11.4	45.9	23.4
T-002	Palmeira	1227.4	0.2	3.1	1.0	2.7	4.9	3.7
T-003	Teixeira Soares	1303.5	0.0	0.7	0.2	2.3	9.4	3.4
T-004	Irati	139.6	0.2	4.8	1.7		16.6	11.4
T-005	Imbituva	811.3	0.2	1.5	0.5	2.4	7.2	2.9
T-006	Ipiranga	932	0.1	1.1	1.5	2.3	11.3	4.6
T-007	Ponta Grossa	1870.8	0.2	1.5	1.1	2.1	4.2	2.9
T-008	Castro	2278.4	0.2	3.9	1.7	1.9	1.1	2.2
T-009	Ivai	212.2	0.2	3.2		2.4	18.7	8.6
T-010	Reserva	555.9	0.1	6.1	1.4	4.1	21.5	11.8
T-011	Tibagi	2926.6	0.2	3.1	2.0	4.3	2.1	2.9
T-012	Pirai do Sul	965.2	0.2	4.3	2.1	2.4	10.0	4.7
T-013	Ventania	380.1	0.2	4.5	2.0	4.5	3.1	3.4
T-014	Telemaco Borba	1625.3		3.1	0.5	10.3	13.9	1.8
T-015	Ortigueira	1588.5	0.2	5.3	1.8	16.3	46.9	24.1
T-016	Curiuva	361.8	0.1	0.8	0.3	3.6	26.4	10.1
T-017	Sapopema	531.9	0.2	5.3		17.5	113.1	51.7
T-018	Sao Jeronimo da Serra	851.3	0.2	5.5		7.9	128.0	92.8
T-019	Maua da Serra	48	0.2	6.9		15.9	0.1	6.6
T-020	Marilandia do Sul	152.2	0.3	4.0		9.4	4.5	4.2
T-021	California	97.2	0.3	2.5		6.1	27.3	8.3
T-022	Apucarana	182.2	0.2	4.1		7.8	33.6	15.5
T-023	Arapongas	191.9	0.1	2.3		7.8	9.5	5.7
T-024	Londrina	2095.6	0.2	4.1		5.8	5.7	4.7
T-025	Nova Santa Barbara	112.2		2.5		8.0	15.2	14.1
T-026	Santa Cecilia do Pavao	68.5					32.1	32.1
T-027	Santo Antonio do Paraiso	151.9	0.2	6.0		7.6	6.7	6.8
T-028	Congonhinhas	104.6		5.6		7.4	8.2	7.9
T-029	Nova Fatima	83.5		6.6		22.0	37.1	29.8
T-030	Sao Sebastiao da Amoreira	217.4	0.2	2.0		5.1	3.1	3.3
T-031	Assai	450.5	0.3	7.8		9.4	32.2	28.2
T-032	Nova America da Colina	133.3		7.0		21.6	14.1	15.4
T-033	Cornelio Procopio	336.7	0.2	6.6		17.8	37.3	25.8
T-034	Urai	209.6	0.3	7.8		26.0	25.2	25.0
T-035	Jataizinho	199.1	0.3	7.8		26.0	41.4	34.2
T-036	Ibipora	295.4		6.2		5.7	7.1	6.8
T-037	Rolandia	57.4		1.5			5.5	4.1
T-038	Cambe	143.5	0.0	1.8			7.1	5.3
T-039	Sertanopolis	478.9	0.3	5.8		5.5	5.7	5.7
T-040	Rancho Alegre	187.4		7.5			2.4	2.4
T-041	Leopolis	68.9	0.3	7.8		26.0	16.0	16.4
T-042	Sertaneja	226.7	0.1	1.7			1.9	1.9
T-043	Primeiro de Maio	142.8		4.7			2.2	2.7
	Total	25051					Average	10.9

Area: = Total Area of Municipality - Area of Others in Landuse Classification
2nd Veg.: Secondary Vegetation, Ref.: Reforestation



Legend

Boundary of River Basin

Boundary of Municipality

Soil Erosion Degree

- Low (< 10 ton/ha•year)
- Medium (10 - 20 ton/ha•year)
- High (> 20 ton/ha•year)

Scale 1:1,750,000

Figure-7.3 Local Variation of Soil Erosion in Tibagi River Basin

7.3.2 Master Plan

The soil conservation is to control the erosion below a threshold level depending on a specific object. The theoretical threshold is a state of equilibrium between the amounts of erosion and soil formation. On the other hand, the practical threshold generally applied is a less severe level to maintain soil fertility in the medium term (20 and 25 years) allowing soil amendment with fertilizer, green manure, lime etc.

To determine criteria and threshold, the specific object is required. Since no criteria are available in Paraná to establish a threshold of erosion control for the water environment, the widely acceptable figures in terms of area of river basin were adopted at the Strategy. These figures were applied to Tibagi river basin also as a goal of soil conservation. Therefore, the threshold of soil loss to propose a soil conservation plan (Master Plan) by the year of 2015, is 11 ton/ha·year. After the suppression of soil loss below the threshold, 2 ton/ha·year which is widely acceptable values for a large river basin will be achieved successively.

The soil conservation plan have to integrate the agronomic measures, soil management and mechanical measures because they have different effect on soil erosion and are the most effective when integrated rather than individual implementation.

Specific countermeasures depend on crop, size of farmers, farming system and so on. Considering the agricultural characteristics in Tibagi river basin, the soil conservation plan was formulated as a Master Plan and shown in Table-7.12. For the application of the soil conservation plan at field, the suitable measures should be selected from the table examining local variation of agriculture.

The main target of the Master Plan in Tibagi river basin is to suppress the soil loss from crop lands. Since terracing and non tillage are the most effective measures, their implementation is essential. Terracing with contouring should cover 100 % of the crop area and non tillage is expected to be practiced in 50 % of beans, maize and soybean fields by the year of 2015. Application of other measures depend on the local characteristics of agriculture.

The effectiveness of soil conservation plan was examined applying USLE. For the computation sake, the following assumptions were made.

1) 100 % implementation of terracing with contouring to crop land

2) 50 % implementation of non tillage to beans, maize and soybean field where the current application of non tillage is less than 50 %

3) no consideration of other measures , such as agronomic measures and soil management

As shown in Table-7.13, the average soil loss would be reduced to 2.4 ton/ha·year with the Master Plan. Since no other measures than terracing and non tillage are counted in estimation of future soil loss, the result is considered as underestimation. If the Master Plan was implemented fully, less soil loss would be expected.

Table-7.12 Soil Conservation Plan (Master Plan) in Tibagi River Basin

Crop	ML	Essential TY	Measures	Effect	Ideal TY	Measures	Effect
all crop field and Pasture	—	M	improvement of farm road	2	M	diversion ditches	2
		M	drainage along road side	2	M	terrace channels	2
		A	proper spacing of crops	1 &2	M	grass water ways	2
		A	proper crop calendar	1 &2	M	energy dissipater at outlet of drainage	2
		S	maintenance of soil fertility	1 &2			
		A	proper plant selection	1 &2			
Soybean Wheat Maize Beans	I	M	terracing with contour cropping	2	M	contour stripcropping	2
		M	buffer stripcropping	2	A	non tillage	1&2
		S	avoid excess operation of machinery	2			
		S	subsoiling to stir hard pan of soil	2			
		S	proper plowing or harrowing	2			
		A	mulching by crop residue	1 &2			
		A	seeding of winter green manure crops	1 &2			
Maize Beans	II	M	terracing with contour cropping	2	A	non tillage with animal	1&2
		M	buffer strips with stones	2			
		M	buffer stripcropping	2			
		A	mulching by crop residue	1 &2			
		A	seeding of winter green manure crops	1 &2			
		M	contour stripcropping	2			
		A	intercropping with green manure crops	1&2			
		M	stripcropping with spring & summer crop	1			
Potato	I	M	terracing with contour cropping	2			
		S	proper plowing or horrowing	1			
		S	avoid excess operation of machinery	2			
		S	seeding of winter green manure crops	1 &2			
Cotton Sugarcane Cassava	I	M	terracing with contour cropping	2	M	contour stripcropping	2
		M	buffer stripcropping	2			
		S	avoid excess operation of machinery	2			
		S	subsoiling to stir hard pan of soil	2			
		S	proper plowing or harrowing	2			
		S	seeding of winter green manure crops	1 &2			
Cotton Sugarcane Cassava	II	M	terracing with contour cropping	2	M	contour stripcropping	2
		M	buffer strips with stones	2			
		M	buffer stripcropping	2			
		A	seeding of winter green manure crops	1 &2			
Coffee	I	M	terracing with contour cropping	2	A	intensive planting	1&2
		M	contour bunds	2			
		A	intercropping with green manure crops	1&2			
Pasture	I & II	M	terracing	2	A	crop rotation	1
		M	water supply system for cattle	1&2	A	perennial forage	2

Abbreviation: ML: Management Level, I: Mechanized Farming System, II: Farming System with Man or Animal Power
TY: Type of Measures, M: Mechanical Measures, A: Agronomic Measures, S: Soil Management
1: Effect on Rainsplash, 2: Runoff

Table-7.13 Soil Loss with Master Plan in 2015

Unit: ton/ha•year

No.	Municipality	Area (km2)	2015 Forest	2nd Veg.	Ref.	Pasture	Crop	Average
T-001	Porto Amazonas	53.8		3.1		11.4	0.9	6.6
T-002	Palmeira	1227.4	0.2	3.1	1.0	2.7	0.6	1.8
T-003	Teixeira Soares	1303.5	0.0	0.7	0.2	2.3	0.7	0.6
T-004	Irati	139.6	0.2	4.8	1.7		0.3	2.1
T-005	Imbituva	811.3	0.2	1.5	0.5	2.4	0.3	0.9
T-006	Ipiranga	932	0.1	1.1	1.5	2.3	0.5	1.0
T-007	Ponta Grossa	1870.8	0.2	1.5	1.1	2.1	0.4	1.2
T-008	Castro	2278.4	0.2	3.9	1.7	1.9	0.3	2.0
T-009	Ivai	212.2	0.2	3.2		2.4	0.3	2.0
T-010	Reserva	555.9	0.1	6.1	1.4	4.1	0.4	2.5
T-011	Tibagi	2926.6	0.2	3.1	2.0	4.3	0.2	2.3
T-012	Pirai do Sul	965.2	0.2	4.3	2.1	2.4	0.7	2.5
T-013	Ventania	380.1	0.2	4.5	2.0	4.5	0.2	2.3
T-014	Telemaco Borba	1625.3		3.1	0.5	10.3	0.3	0.9
T-015	Ortigueira	1588.5	0.2	5.3	1.8	16.3	0.7	5.0
T-016	Curiuva	361.8	0.1	0.8	0.3	3.6	0.9	1.2
T-017	Sapopema	531.9	0.2	5.3		17.5	1.8	5.7
T-018	Sao Jeronimo da Serra	851.3	0.2	5.5		7.9	3.4	4.4
T-019	Maua da Serra	48	0.2	6.9		15.9	0.1	6.6
T-020	Marilandia do Sul	152.2	0.3	4.0		9.4	0.3	2.3
T-021	California	97.2	0.3	2.5		6.1	0.4	1.5
T-022	Apucarana	182.2	0.2	4.1		7.8	1.0	2.2
T-023	Arapongas	191.9	0.1	2.3		7.8	0.9	1.5
T-024	Londrina	2095.6	0.2	4.1		5.8	0.7	2.8
T-025	Nova Santa Barbara	112.2		2.5		8.0	1.2	1.6
T-026	Santa Cecilia do Pavao	68.5					2.0	2.0
T-027	Santo Antonio do Paraiso	151.9	0.2	6.0		7.6	0.9	2.7
T-028	Congonhinhas	104.6		5.6		7.4	0.8	2.3
T-029	Nova Fatima	83.5		6.6		22.0	2.4	8.9
T-030	Sao Sebastiao da Amoreira	217.4	0.2	2.0		5.1	0.7	1.5
T-031	Assai	450.5	0.3	7.8		9.4	0.9	2.2
T-032	Nova America da Colina	133.3		7.0		21.6	0.7	6.5
T-033	Cornelio Procopio	336.7	0.2	6.6		17.8	0.8	7.4
T-034	Urai	209.6	0.3	7.8		26.0	2.3	5.2
T-035	Jataizinho	199.1	0.3	7.8		26.0	1.6	11.2
T-036	Ibipora	295.4		6.2		5.7	1.1	2.8
T-037	Rolandia	57.4		1.5			0.9	1.1
T-038	Cambe	143.5	0.0	1.8			0.7	1.1
T-039	Sertanopolis	478.9	0.3	5.8		5.5	1.0	2.6
T-040	Rancho Alegre	187.4		7.5			1.3	1.3
T-041	Leopolis	68.9	0.3	7.8		26.0	4.7	7.3
T-042	Sertaneja	226.7	0.1	1.7			0.9	0.9
T-043	Primeiro de Maio	142.8		4.7			1.0	1.7
	Total	25051					Average	2.4

Area: = Total Area of Municipality - Area of Others in Landuse Classification
2nd Veg.: Secondary Vegetation, Ref.: Reforestation

7.3.3 Implementation Schedule, Cost and Benefit

(1) Implementation Schedule

Crop land where the current soil loss exceeds the permissible level, 11 ton/ha·year, requires the urgent implementation of soil conservation. Thus, 100 % implementation of terracing inclusive of the improvement of farm roads should be achieved by the year of 2005. Since the total crop area which is not conserved currently is estimated 330 thousand ha, the implementation rate would be 40 thousand ha per year to achieve 100 % coverage of terracing.

The priority of location where terracing will be implemented depends on the magnitude of the current soil loss. The larger the soil loss is, the higher the priority is. In Table-7.14, the priority of Municipality is shown with the area to be terraced.

50 % implementation of non tillage is expected to be achieved by the year of 2015. Non tillage is currently practiced in 280 thousand ha of beans, maize and soybean field. With the Master Plan, it would increase evenly in the next twenty years to 530 thousand ha.

Other measures, such as agronomic measures and soil management would be practiced continuously in the next twenty years.

(2) Cost

Main measures which should be considered for the cost estimation are terracing, improvement of farm roads and non tillage. The costs of other measures are considered as small compared to ones of main measures. For the computation sake, the assumptions made are: 1) Cost of terracing is 40 US$/ha., 2) Cost of improvement of farm roads is 1,500 US$/km and average length of farm roads per ha is 0.02 km., 3) Maintenance costs of terraces and farm roads are 3 % of their construction costs., 4) The difference between machinery costs for non tillage and for traditional tillage is 4,000 US$. Thus, 4,000 US$ is the cost for application of non tillage and its maintenance cost is negligible., 5) Machinery for non-tillage lasts ten years., 6) One machinery for non tillage covers 200 ha., 7) The cost for herbicide for non tillage is not considered.

The result of cost estimation is shown in Table-7.15. The total cost would be 53 million US$.

(3) Benefit

Paraná Rural Program (SEAB, 1989) has estimated nutrient loss compensated by fertilizers assuming the average soil loss of 20 ton/ha·year and enrichment ratio of 1.0. Consequently, the fertilizer applications of nitrogen and potassium are 20 kg/ha and 2.3 kg/ha, respectively. The cost of fertilizer is approximately 200 US$/ton for calcium nitrate and 220 US$/ton for potassium chloride.

The reduction of fertilizer application with the Master Plan is considered as one of benefits. Assuming that terraces and farm roads last 30 years with the proper maintenance, above rate of nutrient loss and cost of fertilizer were applied to estimate the benefit by the year of 2025. The total cost would be 70 million US$, while the benefit would be 77 million US$.

Table-7.14 Priority of Municipality for Master Plan

No	Municipality	Soil Loss from Municipality (ton/ha year)	Terrace (1,000 ha): Area to be Terraced	1996	1997	1998	1999	2000	2001	2002	2003	2004
T-18	Sao Jeronimo da Serra	92.8	41.4	40.00	1.40							
T-17	Sapopema	51.7	17.3		17.30							
T-35	Jataizinho	34.2	3.8		3.80							
T-26	Santa Cecilia do Pavao	32.1	1.6		1.60							
T-29	Nova Fatima	29.8	1.4		1.40							
T-31	Assai	28.2	15.6		14.50	1.10						
T-33	Cornelio Procopio	25.8	9.4			9.40						
T-34	Urai	25.0	3.1			3.10						
T-15	Ortigueira	24.1	49.5			26.40	23.10					
T-1	Porto Amazonas	23.4	1.9				1.90					
T-41	Leopolis	16.4	0.2				0.20					
T-22	Apucarana	15.5	4.0				4.00					
T-32	Nova America da Colina	15.4	2.8				2.80					
T-25	Nova Santa Barbara	14.1	2.4				2.40					
T-10	Reserva	11.8	17.9				5.60	12.30				
T-4	Irati	11.4	5.0					5.00				
T-16	Curiuva	10.1	4.7					4.70				
T-9	Ivai	8.6	5.6					5.60				
T-21	California	8.3	1.9					1.90				
T-28	Congonhinhas	7.9	1.3					1.30				
T-36	Ibipora	6.8	1.7					1.70				
T-27	Santo Antonio do Paraiso	6.8	1.1					1.10				
T-19	Maua da Serra	6.6										
T-23	Arapongas	5.7	1.7					1.70				
T-39	Sertanopolis	5.7	2.2					2.2				
T-38	Cambe	5.3	1.6					1.6				
T-24	Londrina	4.7	10.9					0.9	10.00			
T-12	Pirai do Sul	4.7	6.9						6.90			
T-6	Ipiranga	4.6	14.8						14.80			
T-20	Marilandia do Sul	4.2	2.3						2.30			
T-37	Rolandia	4.1	0.5						0.50			
T-2	Palmeira	3.7	13.2						5.50	7.70		
T-3	Teixeira Soares	3.4	13.8							13.80		
T-13	Ventania	3.4	4.7							4.70		
T-30	Sao Sebastiao da Amoreira	3.3	1.2							1.20		
T-5	Imbituva	2.9	10.2							10.20		
T-7	Ponta Grossa	2.9	21.8							2.40	19.40	
T-11	Tibagi	2.9	22.0								20.60	1.40
T-43	Primeiro de Maio	2.7	0.1									0.10
T-40	Rancho Alegre	2.4										
T-8	Castro	2.2	7.4									7.40
T-42	Sertaneja	1.9	0.2									0.20
T-14	Telemaco Borba	1.8	5.3									5.30
		Total=	334.4	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	14.40

Table-7.15 Cost and Implementation Schedule of Soil Conservation

Soil Conservation Measures	Amount to be covered	Cost (million US$)	1990s 2000s 96 97 98 99 00	01 02 03 04 05	06 07 08 09 10	11 12 13 14 15
Terrace for crop Land	3,344 km²	13.4				
Improvement of Farm Road	6,690 km	10.0				
Maintenance of Terrace and Farm Road	—	10.7				
Non Tillage	2,530 km²	18.7				
Agronomic Measures	14,300 km²	not estimated				
Soil Management	14,300 km²	not estimated				
5 Year Progress Rate		52.8	30 %	36 %	12 %	22 %

Since the determination of agronomic measures and soil management involves the detail study, it was not estimated.

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7.4 Ecology

7.4.1 Biological Environment

(1) Flora

1) Terrestrial Flora

The total forest cover area as percentage of the basin area is estimated in 41.18%, most of this area (27.84%) is considered under brush coverage (Capoeira), followed by 9.54% of reforestation area, and 3.8% of native forest coverage. The total conservation area is estimated in 16.76% of the basin area.

Main problems associated with the existing conservation areas are related to illegal fishing and hunting, forest fires, lack of maintenance or management plan implementation and uncontrolled tourist pressure.

Areas which are not yet under a specific conservation program have been detected by COPATI as areas related to surface water supply sources which are experiencing the urban growth pressure from the municipality of Arapongas.

2) River Margin Vegetation

According to EMATER, 1980, some 249,000 ha of river margin vegetation where detected in the upper and middle Tibagi. No reliable monitoring has been carried out until now, and the reduction of this area has been related to the expansion of agricultural areas, sand and wood extraction, and urban growth.

(2) Aquatic Fauna

Preliminary fish inventories carried out by the State University of Londrina in 5 locations of the upper, middle, and lower Tibagi river showed the existence of the most common species.

Further collections and study of the existing ichthyofauna is required to attain knowledge of the existing fish species and their population dynamics. This knowledge will allow to propose and implement mitigating and recuperation measures to the existing and future impacts on the aquatic habitat.

A total of 26 fish species of commercial interest are reported by UEL, IBAMA, artisanal fishermen and COPATI. From the reported fish species 50% are migratory, 27% are considered endangered, and only 15% are abundant.

Table-7.16 Commercial Fish Species Reported in the Tibagi River

SCIENTIFIC NAME	COMMON NAME	ENDANGERED AND/OR MIGRATORY	
Salminus hilarii	Tabarana	(*)	(M)
Salminus maxilosus	Dourado	(*)	(M)
Prochilodus lineatus	Curimba	(*)	(M)
Leporinus elongatus	Piapara	(*)	
Leporinus obtusidens	Piapara		(M)
Leporinus friederici	Piava	(*)	(M)
Schizodon nasutus	Piau		(M)
Pseudoplatistoma corruscans	Pintado	(*)	(M)
Schizodon intermedius	Piava		(*)
Plagioscion squamosissimus	Corvina		(M)
Rhinelepis aspera	Cascudo preto		(M)
Astyanax bimaculatus	Lambari	(A)	(M)
Astyanax eigenmenniorum	Lambari	(A)	(M)
Astyanax sp	Lambari		
Moenkhausia intermedia	Lambari		
Iheringichthys labrosus	Mandi		(M)
Pimelodus maculatus	Mandi	(A)	(M)
Triphorteus angulatus	Sardinha		
Hoplias malabaricus	Traira		
Gymnotus carapo	Tuvira		
Eigenmannia virescens	Tuvira		
Apteronotus brasiliensis	Tuvira cavalo		
Pinirampus pirinampu	Barbado		
Hypostomus tietensis	Cascudo	(A)	
Hypostomus sp	Cascudo		
Synbranchus marmoratus	Mucum		

Source : COPATI/UEL (35)
(*) Endangered, (M) Migratory, (A) Abundant.

(3) Benthos

The University of Londrina has been working with benthos, in an effort to characterize the local species, and the typical bioindicators for polluted and clean waters.

The locality of Telemaco Borba seems to be the most polluted, since 93.4 of the samples were Oligochaeta, exemplifying a low biodiversity of the sample, with many individuals per group.

Periodical monitoring of the benthic community, correlated with physical and chemical monitoring of the water is desirable to evaluate the environmental condition of the aquatic environment.

(4) Aquatic Birds

The bird populations are a significant indicator of environmental deterioration. Deforestation, pesticides and habitat reduction take away fruits, insects, seeds and shelter used by them, and thus inflicts severe impacts on their populations. Out of the reported bird species, 5.2% (13 species) are considered endangered.

Table-7.17 Summary of Reported Bird Populations in the Tibagi River Basin

HABITAT	NUMBER OF SPECIES	%
Aquatic	56	22.4
Forest	142	56.8
Open Pasture land	61	24.4
Secondary Forest	62	24.8
Migratory	77	19.5

Source: COPATI (35)

7.4.2 Socioeconomic Environment

(1) Hydroelectric Projects

The existing hydroelectric projects in the Tibagi river basin are lacking on environmental impact studies, and according to COPATI little or no study was carried out before the construction of the existing hydroelectric projects, with a loss of important data concerning the ichthyofauna of the basin.

The most significant impact attributed to the existing projects was the inadequate resettlement of affected families, although the lands and properties where paid, no sociological program was implemented to reconstruct social and community values.

In respect to the planned hydroelectric projects, most of the projects are of small to medium scale, taking advantage of the river course morphology, and thus inundating a rather reduced area along the river course.

Table-7.18 Summary of Environmental Impact Context of the Proposed Hydroelectric Projects in the Tibagi River

PROJECT	INUNDATED AREA			
	% FIELDS	% CROPS	% FOREST	% REFORESTATION
Santa Branca	80	24	-	1
Tibagi	ND	ND	ND	ND
Tel. Borba	-	5	88	7
Maua	23	6	57	14
San Jeronimo	57	2	41	-
Cebolao	73	27	-	-
Jataizinho	50	50	SCARCE	-

Source ; COPEL

(2) Landfills

Major municipal solid waste producer is Londrina, with 250 MT/day (40% of the basin volume) disposed of in the open. Hospital disposals are estimated in 1.38 MT/day, disposed of in incinerators and septic holes, except for Curiuva and Sao Jeronimo da Serra which dispose hospital solid waste in open air.

No environmental impact studies are reported for landfill operations in the Tibagi river basin.

(3) Water Intake Locations

Main problems associated to the water intake locations in the Tibagi river basin are domestic, industrial and agricultural pollution, as well as high turbidity originated from sediment runoff.

Other problems associated to these locations are the urban and industrial expansion of the municipality of Arapongas and Rolandia towards the Apucarana spring and the Bandeirantes do Norte river.

7.4.3 Master Plan for Tibagi River Basin

The Master Plan is conceived as a series of specific programs to be implemented in the conservation, rehabilitation, and monitoring context. Figure-7.4 shows the relationship between monitoring and preservation programs.

(1) Program for the Inventory of Fish Populations

Seven hydroelectric projects are being sought for the Tibagi river between 2003 and 2010, fish population inventories are the first step to assess possible impacts on the resource. See Figure-7.5.

(2) Program for the Assessment of the Fish Population Dynamics.

The study of the fish population dynamics becomes highly desirable at the time when no dams, and no reservoirs have occurred yet in the river, this studies will give the baseline for future impact mitigation on the resource. See Figure-7.6.

(3) Program for the Artificial Reproduction of Native Fish with Ecological and/or Economic Interest.

The artificial reproduction of fish is a viable means of producing vast amounts of offspring for repopulation of endangered species, and/or economic fisheries purposes.

(4) Program for the Upgrading of Management Plans for Existing Conservation Units.

The present program is oriented towards the assessment of problems such as forest fires, excessive tourism, and solid waste disposal, which are reported to be common and require adequate solutions.

(5) Program for the Assessment of the Aquatic Environment through the use of Bio-Indicators.

The use of bio-indicators represents a fast and comprehensive method for the assessment of the aquatic ecosystem through monitoring of indicative river sectors subject to agricultural, municipal, and industrial pollution, and water intake locations. See Figure-7.7.

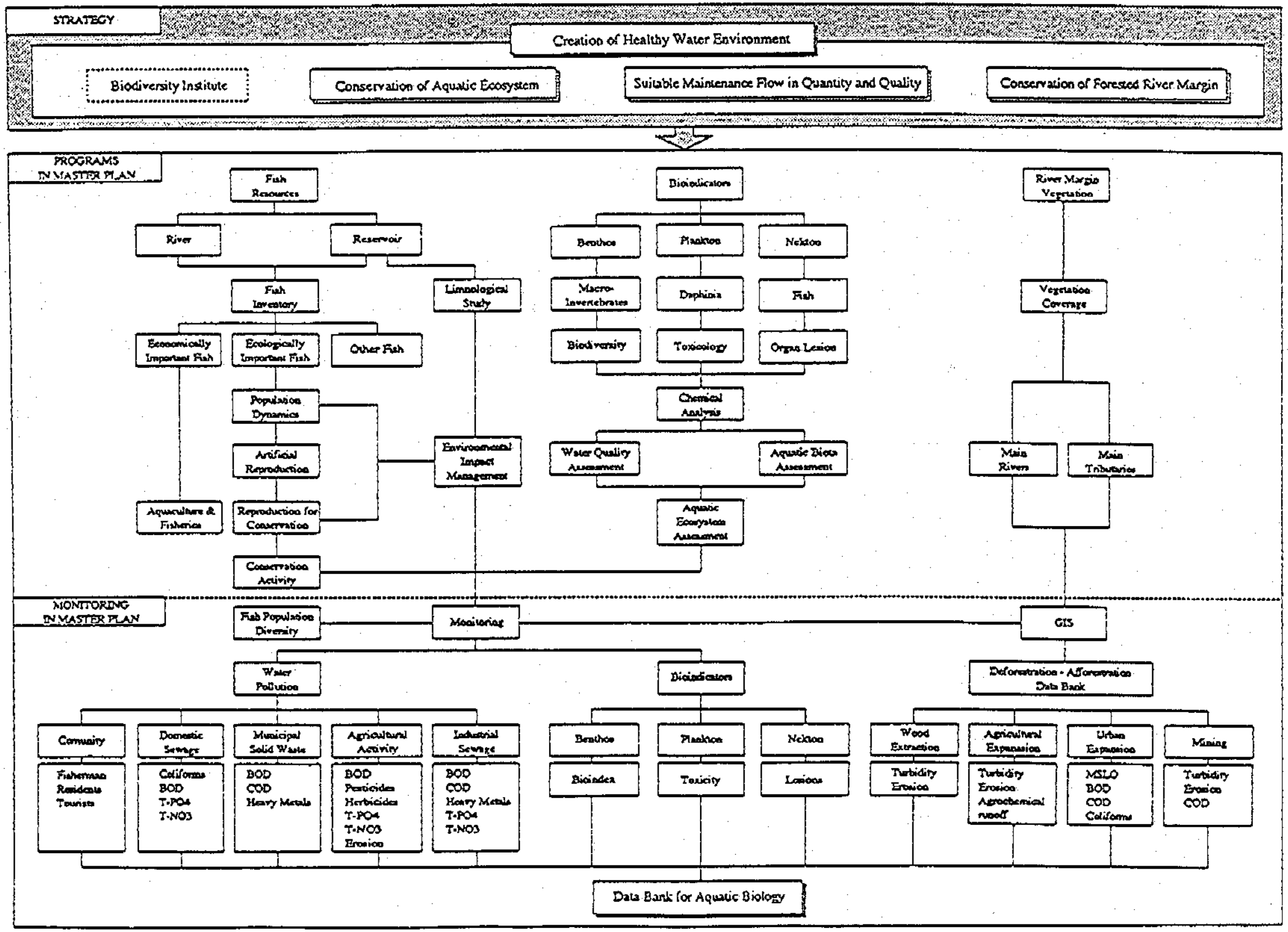

Figure-7.4 Interrelationship Between Monitoring and Preservation Programs

Area	Monitoring Stations	IAP Station #
A =	16 Benthos Stations to be allocated	
	2 Daphnia Monitors	
	. Arapongas Water Intake	Ribeirão dos Apertados
	. Cafezal Water Intake	Cafezal River
B =	2 Benthos Stations	Tibagi River
	1 Daphnia Monitor	
	. Londrina Water Intake	Tibagi River
C =	Benthos Station	Telêmaco Borba
	1 Daphnia Monitor	Telêmaco Borba
	. At Water Intake	
D =	4 Benthos Stations to be defined	Ponta Grossa
LAB. 3	Integrated Regional Laboratory	Londrina

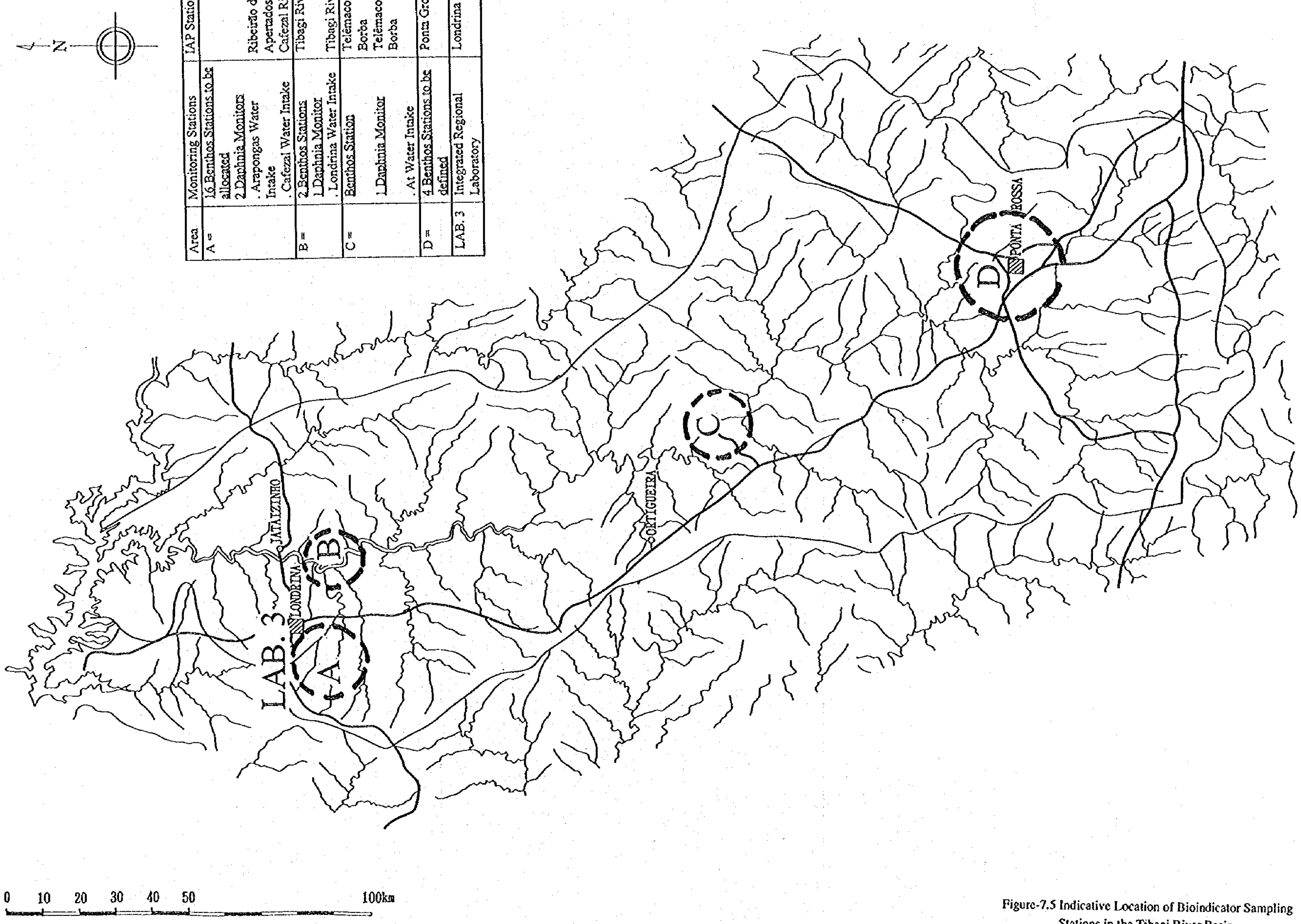

Figure-7.5 Indicative Location of Bioindicator Sampling Stations in the Tibagi River Basin

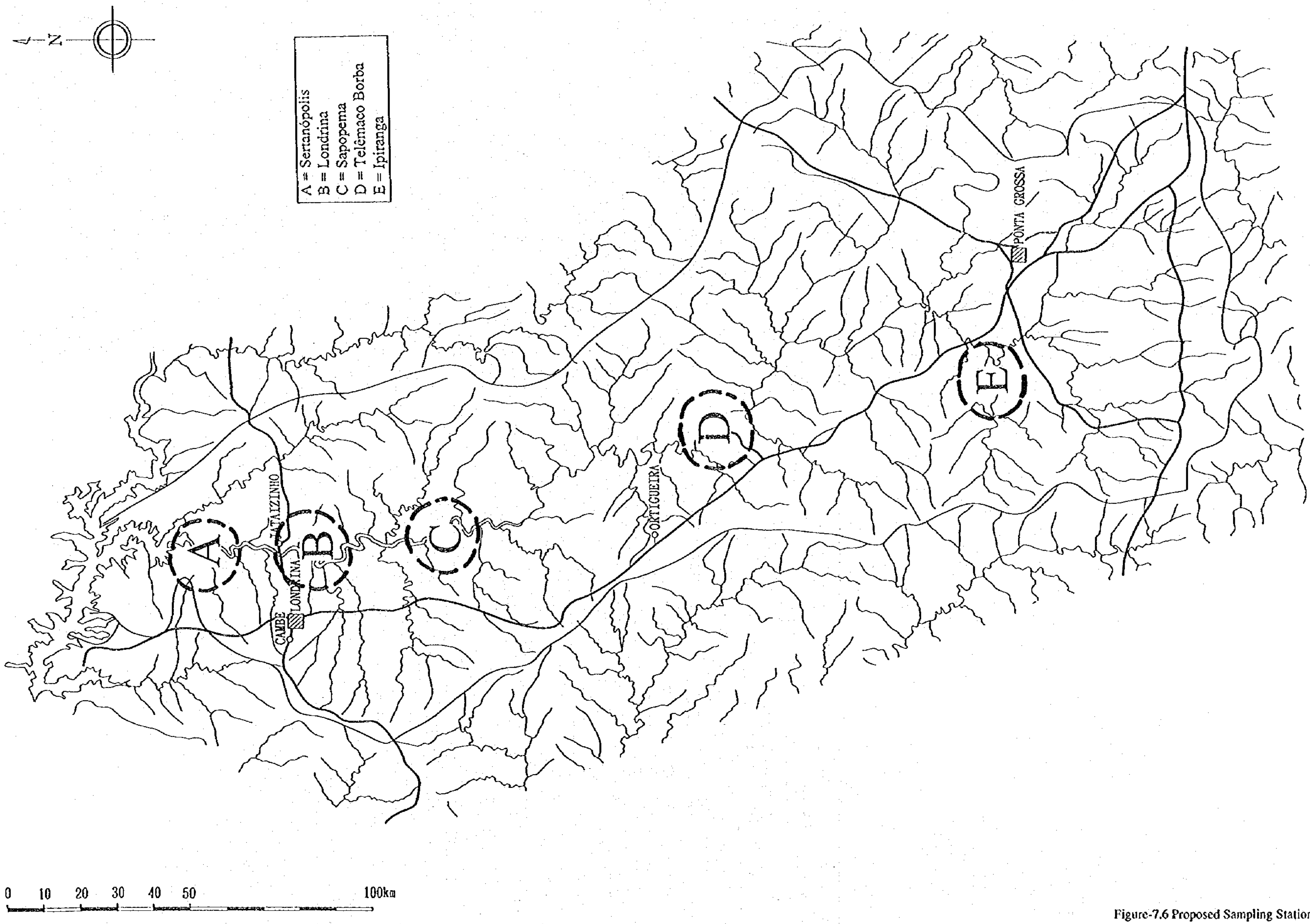

Figure-7.6 Proposed Sampling Stations for Fish Biodiversity in the Tibagi River Basin
Source: COPATI/UEL, 1995

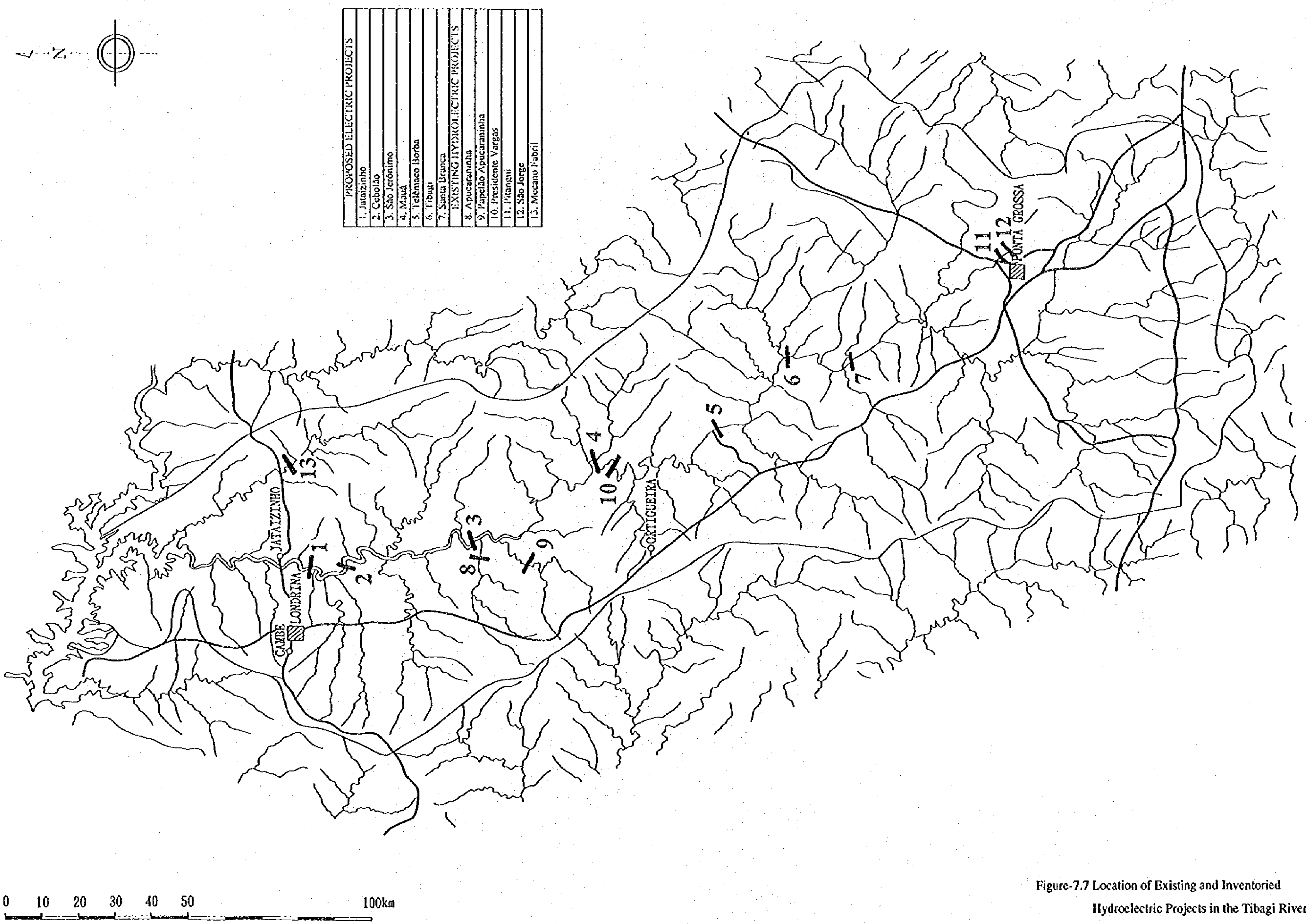

Figure-7.7 Location of Existing and Inventoried Hydroelectric Projects in the Tibagi River Basin

Source: COPEL, 1995

(6) Program for the Identification and Monitoring of the River Margin Vegetation and Lowlands Along Water Courses.

Inventorying these environments before major hydroelectric project are installed will give the data base to identify extent and magnitude of environmental impacts upon these resource.

(7) Program for the Identification of the Periodically Inundated Lawlands along the Bitumiri River

To identify the habitat and biota relationship in the remaining lowland ecosystem is considered urgent, before the existing change in the use of the soil totally eliminates this environment.

7.4.4 Summary of Program Objectives and Indicative Costs

The following table summarizes the area of influence of each one of the proposed projects:

Table-7.19 Summary of Program Objectives for Tibagi River Basin

PROGRAM NAME	COST US$ X 1000	OBJECTIVES (1)	(2)	(3)	(4)
Preservation Programs					
1) Fish Population Inventory	664	X			X
2) Fish Population Dynamics	487	X	X		
3) Native Fish Reproduction	493	X	X		
4) Management Plans for Conservation Units	51	X	X		
7) Inundated Lowlands Study	245	X			
Monitoring Programs					
5) Bioindicator Monitoring	1,096	X		X	X
6) River Margin Vegetation	670	X		X	X

NOTE: (1) CONSERVATION, (2) ECONOMIC, (3) SANITATION, (4) MONITORING

7.5 Forest

7.5.1 Existing Forest

As shown in Table-7.20, the natural forest and reforestation in Tibagi river basin cover 3.8 % (900 km^2) and 9.4 % (2,300 km^2) of its area, respectively. The total area of reforestation in the sate is approximately 6,300 km^2 and 36.5 % of them belongs to Tibagi river basin. Reforestation is well practiced in Tibagi river basin compared to other river basins and it is mainly achieved by means of commercial afforestation, especially paper industry, as shown in Figure-7.8. In contrast to reforestation, the area of natural forest is limited.

Table-7.20 Forest and Reforestation Coverage in Paraná

		River Basin Area (km^2)	Landuse (%)	
			Forest	Reforestation
State		197882.0	9.0	3.2
River Basin	Cinzas	9290.7	2.9	6.2
	Iguacu	55318.0	14.3	1.7
	Itarare	5197.7	1.3	21.7
	Ivai	35878.9	5.0	1.8
	Litoranea	5766.0	68.9	3.9
	Parana	13156.3	7.5	0.0
	Paranapanema	9797.0	4.9	0.0
	Piquiri	24707.9	2.1	0.3
	Pirapo	5005.9	2.5	0.0
	Ribeira	9129.3	5.7	5.3
	Tibagi	24634.7	3.8	9.4

Source: SANEPAR GIS Computation
IAP Satellite Imagery Analysis

7.5.2 Master Plan

Proper management of forest contributes to sustainable level of production of timber, preservation of environment, erosion control, flood control, maintenance of soil fertility and so on. Considering the development of society, it is not possible and not necessary to go back 19 century, when forest covered most of the land; however, afforestation is essential to improve the water environment and is a part of the river basin management.

Benefits of afforestation consist of direct and indirect ones. The former is an income from timber production, wood as fuel and perennial crops, such as fruit trees. The latter is the conservation of the water environment, such as erosion control, flood control, improvement of water quality in a river basin and so on.

The main concern to formulate the Master Plan is the proper landuse. In other words, the land not suitable to agriculture and pasture should be converted to forest for direct and indirect benefits. For the conservation and preservation purposes only, direct benefit is not expected; however, indirect benefit is much greater than income born from forest if the effect on the environment, such as suppression of soil erosion and flood, is counted.

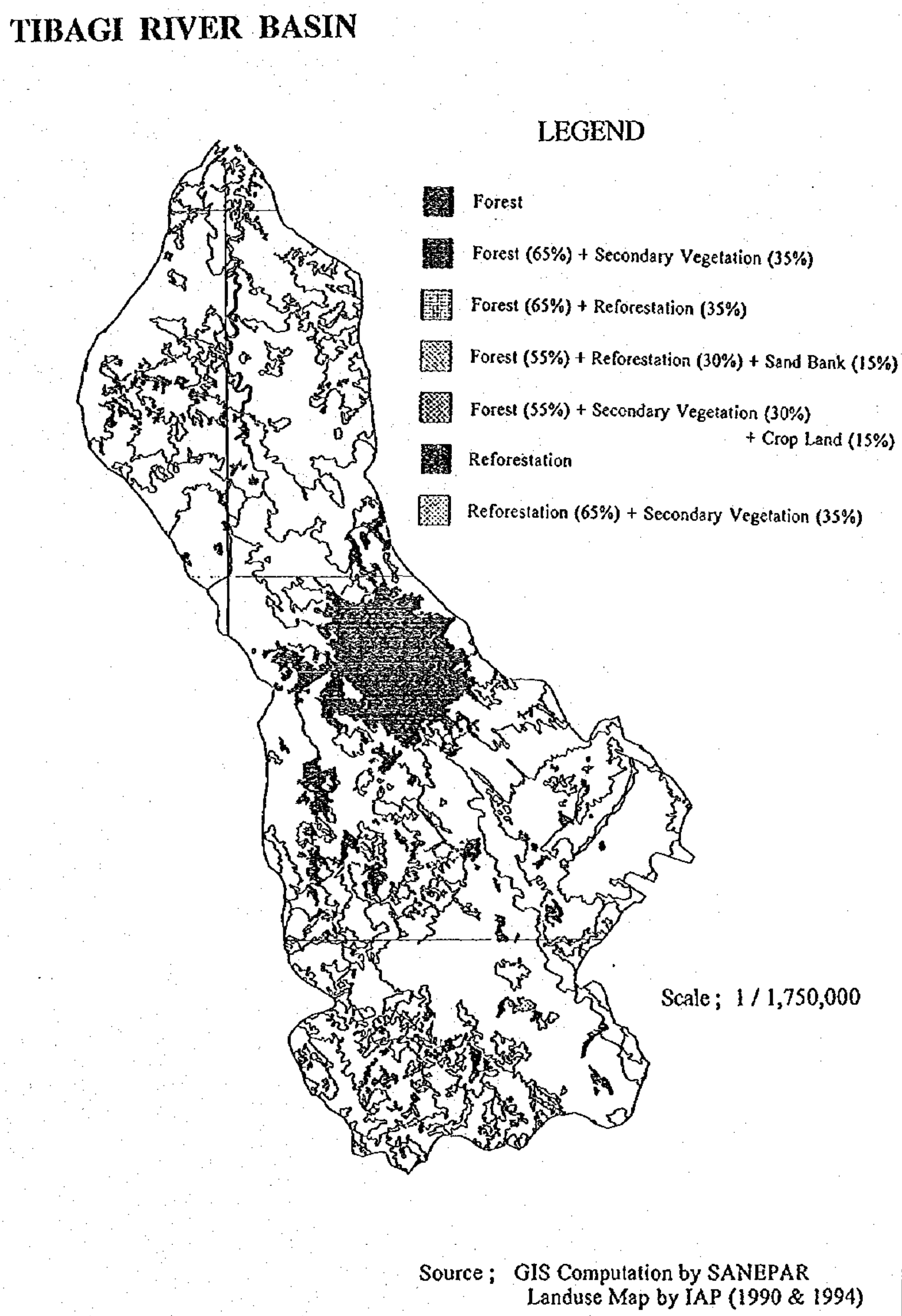

Figure-7.8 Location of Forest and Reforestation in Tibagi River Basin

The Master Plan for forest consists of three purposes, preservation of natural forest, conservation of water environment and commercial afforestation. Recommended species and sites for each purpose are summarized in Table-7.21. The implementation of Master Plan will involve the detail study site by site, such as identification of soil and climate, selection of forest species, plan of thinning etc. For the selection of specific species, recommendations of native and exotic species dividing the sate in 7 bio-climatic regions are available from EMBRAPA (1985).

Table-7.21 Recommended Species and Sites

Purpose	Direct Benefit	Indirect Benefit	Site Recommended	Recommended Species
Preservation of natural forest	No	Yes	1) Current preservation area 2) Promotion of preservation area to protect ecosystem, landscape and so on	Native forest, Wild Fruits
Conservation of water environment	No	Yes	The area stipulated by law, such as along rivers or any water courses, steep land, etc.	Native Forest, Wild Fruits, Araucaria, Bracatinga
Agroforestry	Yes	Yes	Farm land	Bracatinga, Mate
Energy	Yes	Yes	The land whose slope steepness is less than 25 degree.	Bracatinga, Eucalyptus
Commercial use for timber &	Yes	Yes	1) Brush fields 2) The land not suitable for both crop and pasture cultivation	Eucalyptus, Araucaria, Pine

Direct Benefit: to generate income
Indirect Benefit: to conserve the water environment

Considering the current conditions, the area expansion of forest for preservation and conservation of the water environment purposes is expected to be gradual. Therefore, afforestation should be promoted by means of commercial afforestation. Each purpose of the Master Plan is described in the followings.

(1) Preservation of Natural Forest

Currently preserved areas must not be exploited as laws control (Forest Code, Law 4771/65). Besides, the promotion of preservation area should be continued not only to preserve the ecosystem and environment but also scenic and recreational purposes. For the implementation, the government assistance by means of finance, law enforcement and technical support is essential.

(2) Afforestation for Conservation of Water Environment

Currently degraded areas despite the fact that Forest Code defines the preservation areas have to be afforested for preservation of native flora and fauna, erosion control, stabilization of hydrologic cycle and so on. The recommended forest species for this purpose are native ones because exotic species often alter the endemic ecosystem.

(3) Afforestation for Direct Benefits

Land with no aptness for agriculture and pasture should be converted to forest to generate more income instead of bearing the low productivity. Besides, this afforestation contributes to conserve the water environment because the applicable land is steep and has a great potential of soil erosion and flood.

For the sustainable production of wood and conservation of the water environment, it requires the proper management system, such as space of seedlings, thinning plan and so on. The relative institutions, for example IAP and EMATER, should support the formulation of forest management system.

Since Tibagi river basin belongs to 1, 2, 4 and 6 bio-climatic regions (EMBRAPA, 1985), main species recommended for commercial afforestation are Araucaria, Mate, Bracatinga, Eucalyptus and Pinus. The use of recommended species is shown in Table-7.22.

Table-7.22 Use of Recommended Species for Commercial Afforestation

Species	Bio-climatic Region				Use					
	1	2	4	6	paper & cellulose	construction	timber	plywood	firewood & charcoal	nourishment
Araucaria angustifolia (Araucaria)	X	X	X		X	X	X			
Ilex paraguariensis (Mate)	X	X								X
Mimosa scabrella (Bracatinga)	X					X	X	X	X	
Eucalyptus	X	X	X	X	X	X			X	
Pinus (Pine)	X	X	X	X		X	X			

Souce: EMBRAPA (1985)

7.5.3 Implementation Schedule and Cost

The average cost and gross income from afforestation of main species suitable for Tibagi river basin were estimated by Ferreira (1995) as shown in Table-7.23. Cost and income depend on the use of wood products. For example, the price of Eucalyptus for fuel is approximately 3.3 US\$/m^3, while one for sawmill is 10 US\$/m^3. Assuming the specific use of wood, cost and gross income were estimated.

Based on the agriculture aptness map (Ministry of Agriculture, 1981) and Landuse map (IAP, 1990 &1994), the area of existing secondary vegetation spreading over the land suitable for forest was estimated at approximately 2,000 km^2. This land should be afforested for commercial use to generate income. If Pinus was adopted, the total cost and net income would be US$ 142 million and US$ 1,218 million, respectively. The implementation depends on ability of annual afforestation. Considering its annual average of the state, 10,000 ha/year of implantation is feasible. Therefore, 2,000 km^2 of the land should be afforested evenly in next twenty years.

Net income of Mate is much greater than other species and the recent market seems to be favor to Mate. However, its internal and external market is still limited compared to one of Pinus or other species for timber. Since one of advantages of Mate is the harvest during the winter, when the source of farmers' income is limited. Therefore, Mate is recommended for agroforestry, intercropping with maize and beans. Its area expansion depends on the future market and to avoid the risk of market crush, agroforestry is practical for Mate.

Table-7.23 Cost and Gross Income of Afforestation

Species	Spacing (m x m)	Cost (US$/ha)			Yield		Rotation Year	Gross Income (US$/ha)	Net Income (US$/ha·year)
		Planting	Maintenance	Pruning	Product	Production			
General native species	4x4	270	100	-	-	-	-	non	non
angustifolia (Araucaria)	3x3	270	100	-	cellulose	400 m^3/ha	45	4,000	301
					saw-mill	30 m^3/ha		900	
					lamination	180 m^3/ha		9,000	
Ilex paraguariensis (Mate)	3x3	430	360	-	Mate Tea	17 ton/ha·harvest	30	34,500	1124
Mimosa scabrella (Bracatinga)	1 kg seed/ha	260	370	-	fuel wood	270 m^3/ha	6	900	267
					maize, beans			700	
Eucalyptus	2x2	470	100	-	fuel wood	670 m3/ha	21	2,240	80
Pinus (Pine)	2x2	460	150	100	cellulose	160 m^3/ha	25	800	244
					saw-mill	150 m^3/ha		1,500	
					lamination	150 m^3/ha		4,500	

Note 1) Harvest of Mate starts after 5 years of implantation and harvest rotation is every 20 months. Therefore, in 30 years, harvest is possible 15 times.

2) For Bracatinga, the intercropping with maize and beans is considered. Therefore, the income is a result of annual crop yields and Bracatinga felling which is once in 6 years.

3) For Eucalyptus, the natural regeneration method, which the stand regenerates by budding of the stumps, is considered. Three successive rotation is possible for one Eucalyptus.

4) Since the cost of felling and transportation depends on use of wood and location, their estimation requires the detail plan. Therefore, they are not included in the table.

5) Net Income = (Gross Income-Cost) / Rotation Year

Source: Ferreira (1995)

In general, the lateral of each plot of agricultural land inclusive of pasture faces to the water course and is deforested for the maximum cultivation despite the fact that Forest Code defines the preserved area. Exact figures of these area is not countable at this study level; however, the approximate figures were estimated with the following assumptions.

1) The river margin protected by Forest Code occupies 3 % of each plot of agricultural land.

2) All river margins belonged to agricultural land are currently deforested.

Since the total area of agricultural land in Tibagi river basin is approximately 14,000 km^2, the river margins deforested is 400 km^2. This land should be afforested with native forest species for conservation of the water environment. The total cost would be US$ 15 million. The implementation would be evenly in the next twenty years. Therefore, annual area of afforestation would be 2,000 ha.

Table-7.24 Implementation Schedule

	Area to be Afforested	Cost (million US$)	Year 1996	2005		2015
Afforestation for conservation of the Water Environment	400 km^2	15				
Commercial Afforestation	2,000 km^2	142				
5 Year Progress Rate		157	25 %	25 %	25 %	25 %

Literature Cited

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2) Ministry of Agriculture. (1981). Aptidão agricola das terras do Paraná. (Agricultural land aptitude of Paraná). Brazil.

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CHAPTER 8 OPERATION AND MONITORING SYSTEM

8.1 Existing Monitoring and Operation System in the Tibagi River Basin

Table-8.2 indicates the existing operation and monitoring system for water environmental management and its present situation is described in the following sub-sections:

8.1.1 Operation System

The existing domestic water supply systems using surface and subsurface water sources have been operated by the SANEPAR and OUTONOMO, and its system management has been done well on measuring intake discharge, counting distributed water amount, and so on. While, industrial water users are mainly taking water in from the both water sources individually. These industrial water users are divided into two (2) parts; authorized and unauthorized water users. The former users apply for their water uses with their intake discharges and industrial waste water amount to the IAP, and the IAP permits/registers them taking into account the water availability. But, operational records are not submitted to the IAP. As for the later users, there is no management work done by the IAP and SANEPAR. Especially, there is a report that a number of the bore holes managed with permission by the IAP are 3,400 while unmanaged ones are more than 10,000 in the whole Paraná State.

No dam and reservoir have been provided in the Tibagi river basin. However, there are needs for such multifarious use of the planned reservoirs as hydropower generation, water supply, flood control, inland navigation and fish culture in order to effectively use the available water resources. Especially, there is a plan for inland navigation development connecting Paraná river and the Paranapanema with the Tibagi river through the existing and planned reservoirs in these federal rivers.

Two (2) hydropower stations in the Tibagi river basin are operated and managed by the COPEL.

8.1.2 Monitoring System

Monitoring of meteorological and hydrological data in the Tibagi river basin has been made by the DNAEE, IAP, COPEL and IAPAR. A number of the observation stations in the Tibagi river basin is summarized as follows:

Table-8-1 Number of Observation Station in the Tibagi River Basin

Observation Items		Tibagi River
Catchment area (km²)		24,635
Meteorological stations		7 (3,519)
Rainfall observation stations		126 (196)
Rate of automatic and telemetering gauges (%)		13
Flow observation stations	a) Main stream	21
	b) Tributaries	25
Water quality observation		38
Sediment observation stations	a) Main stream	10
	b) Tributaries	21

Note: Figures in parenthesis indicate density of observation station (1 no. / km²).

Table-8.2 Existing Monitoring and Operation Systems in the Tibagi River Basin

Monitoring and Operation Systems	Tibagi River Basin	Related Institutions
I. OPERATION SYSTEM		
(1) Ground water supply	Insufficient data	SUCEAM,IAP, SANEPAR
(2) Surface water supply		
a) Water amount taken from the river based on data base system established by JICA Study Team	7.2	SANEPAR, OUTNOMO
(3) River-reservoir Operation for Multifarious Water Use	None	COPEL, SUCEAM
(4) River-reservoir Operation for Flood Control	None	COPEL, SUCEAM
(5) Power Load Operation		COPEL
a) Nos. of hydropower stations	2	
b) Total installed capacity (MW)	32	
II. MONITORING SYSTEM		
(1) Meteological data observation (nos. of stations)	7 with an automatic gauge	DNAEE, IAP, COPEL, IAPAR
(2) Precipitation observation		
a) Nos. of stations with manual reading gauge	111	DNAEE, IAP,
b) Nos. of stations with automatic recording gauge	10	COPEL, IAPAR
c) Nos. of stations with telemetering system	5	
(3) FLow observation system		
a) Nos. of stations with manual reading gauge		
• Main stream	15	
• Tributary	22	DNAEE, IAP,
b) Nos. of stations with automatic reading gauge		COPEL, IAPAR
• Main stream	4	
• Tributary	3	
c) Nos. of stations with telemetering system		
• Main stream	2	
• Tributary	-	
(4) Flood forecasting and warning system	none	DNAEE, COPEL, SUCEAM, IAPAR
(5) River water quality		
a) Nos. of observation stations		
• Main stream	13	DNAEE, IAP
• Tributary	15	
(6) Aqua ecology monitoring	Reseach of fauna and flora by COPATI in specific area	IAP
(7) Fish resources monitoring	An inventory survey at the downstream of Tibagi river by Londrina University	EMATER, COPEL, COPATI
(8) Waste discharge monitoring	not available	IAP, SANEPAR
(9) Watershed and sediment monitoring		
a) Nos. of sediment flow observation stations		EMATER, COPEL,
• Main stream	10	DNAEE, IAP
• Tributary	21	
(10) Surface and sub-surface water supply monitoring	done by individual users	SUCEAM, SANEPAR

The SIMEPAR is implementing the weather observation system described in the Main Report I for the Strategy and will improve the meteorological and hydrological observation network by introduction of rainfall radar and telemetering system covering the whole Paraná state.

River water quality monitoring has been carried out at the main stream and tributaries of the aforesaid rivers with a frequency of four (4) times or more a year by the IAP and DNAEE. However, it is identified that there are interrupted periods in the large part of observation records at many stations and that it is impossible to evaluate its change on river water quality there. Test items are 1) water temperature, 2) pH, 3) dissolved oxygen, 4) coliform fecal, 5) BOD, 6) total nitrogen, 7) total phosphate, 8) turbidity, and 9) total solid in general. Water quality analysis for heavy metal have been undertaken in accordance with the requirement.

As for monitoring on aquatic ecological system, there have been no integrated and/or periodical investigation but it is initiated by the IAP and COPATI in these years.

Sediment sampling and its analysis have been made at 31 sites in the Tibagi river by the IAPAR, COPEL, DNAEE and IAP. However, the frequency of observation is quite insufficient for evaluating soil erosion rate with high accuracy. While, the gross soil erosion rate has been examined by the pilot projects by the IAPAR under the EMATER.

8.2 Master Plan for Operation and Monitoring System

8.2.1 General Conditions

Currently, the Tibagi river basin faces the problems in water environment as described in the previous chapters and summarized in Figures-8.1. In order to manage the water environment in Paraná state, the Master Plan was studied by applying the methodology for planning and the Strategy for the operation and monitoring system. Figure-8.2 indicates issues to be monitored in the Tibagi river basin.

The Study employed an integrated management framework composed of; 1) integrated institutional framework; 2) water uses and waste water forecasting for planning in socio-economy-hydrology-aquaecology system; 3) project management for multifarious water use and water environmental improvement; 4) monitoring and operation of surface and subsurface water system; and 5) global hydrological cycle model.

The current study has established the following implementation targets for monitoring and operation system as illustrated in Figures-8.3 and 8.4:

Target-A: High density and multi-dimensional monitoring

Target-B: Unified monitoring

Target-C: Integrated operation and monitoring for effective operation for water use facilities, river structures, water treatment facilities and water quality facilities

The Master Plan aims to enhance the existing monitoring and operation systems to the target levels during 20 years till 2015.

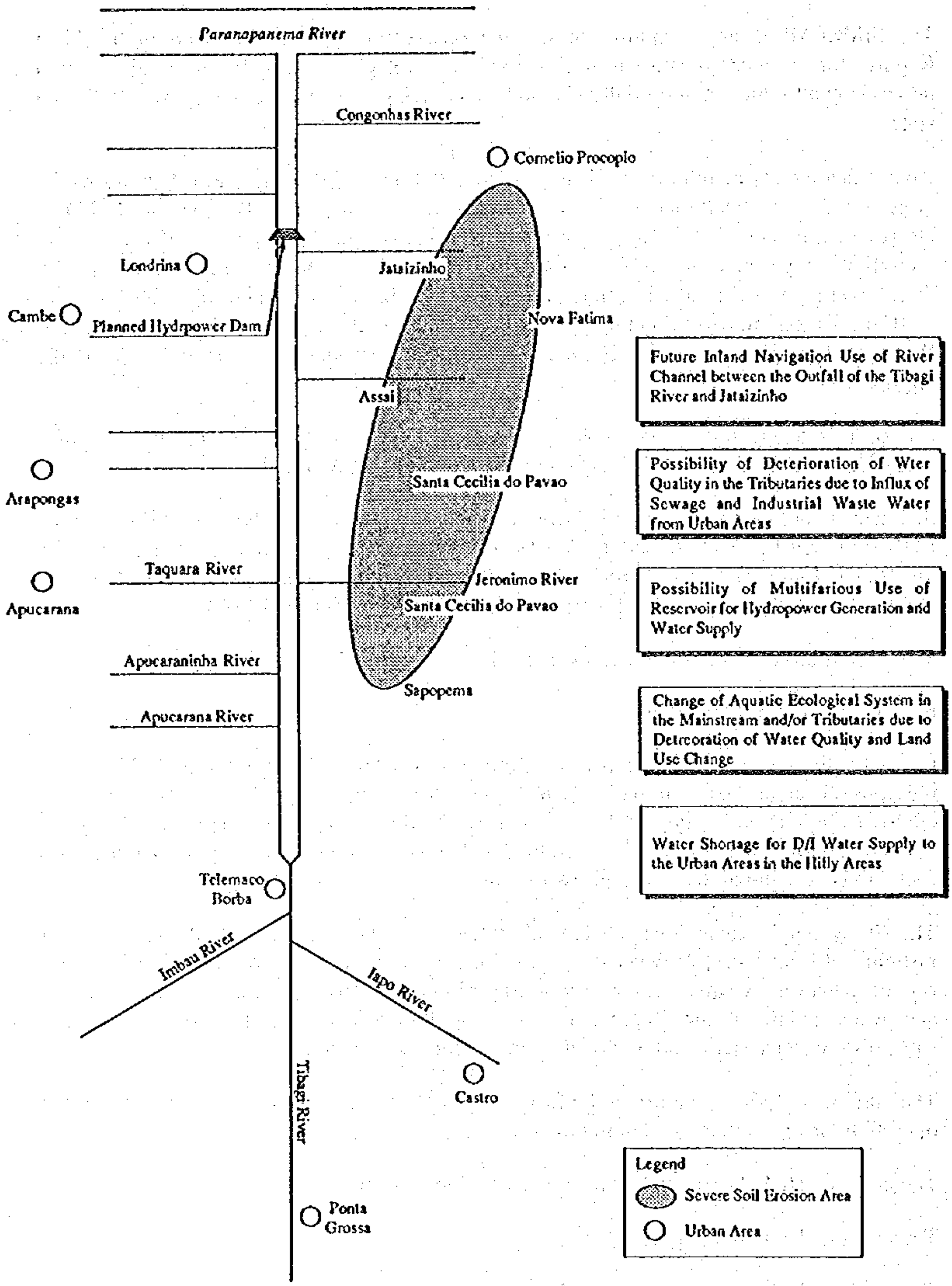

Figure-8.1 Problems and Needs Identified in the Tibagi River Basin

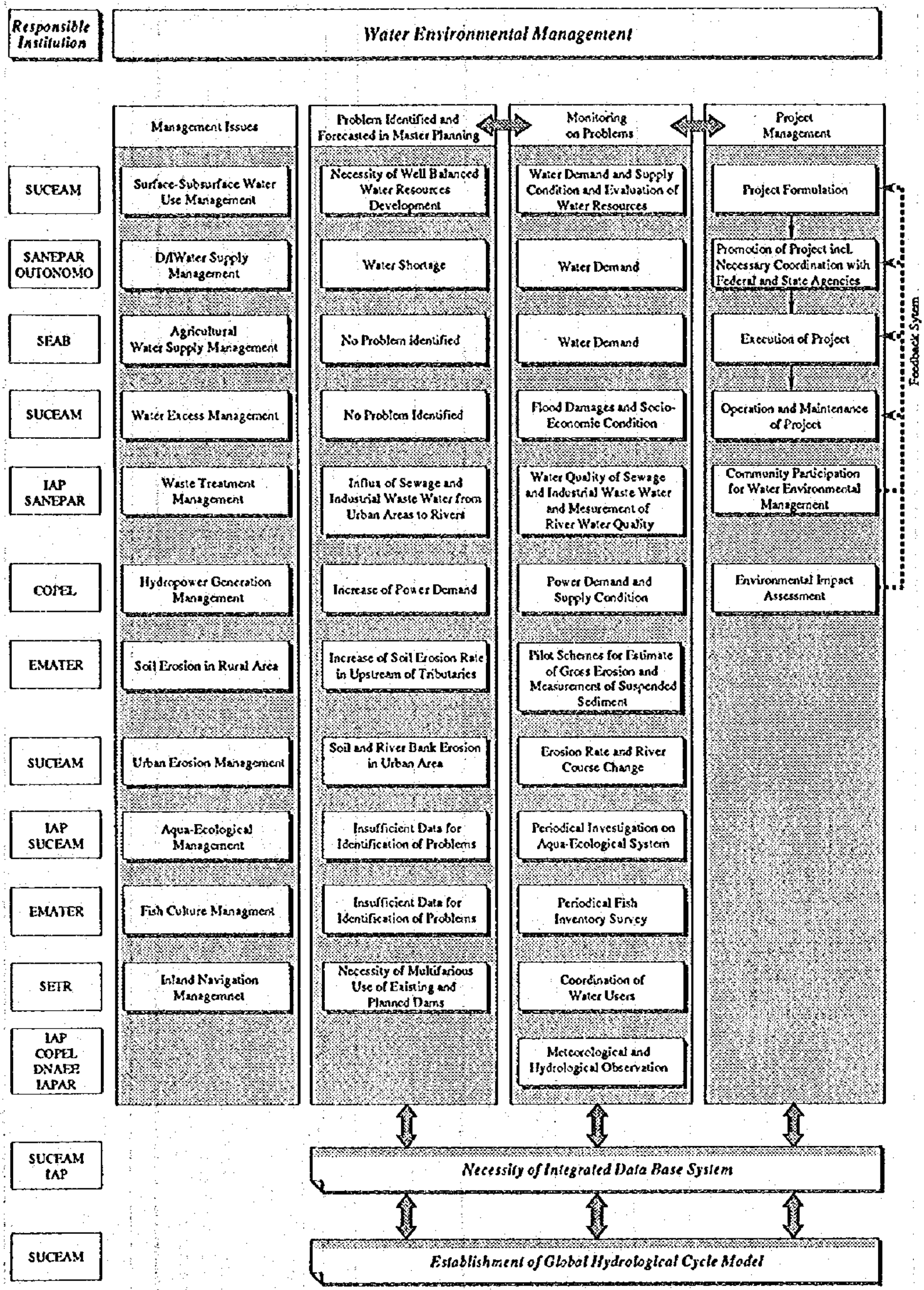

Figure-8.2 Water Environmental Management

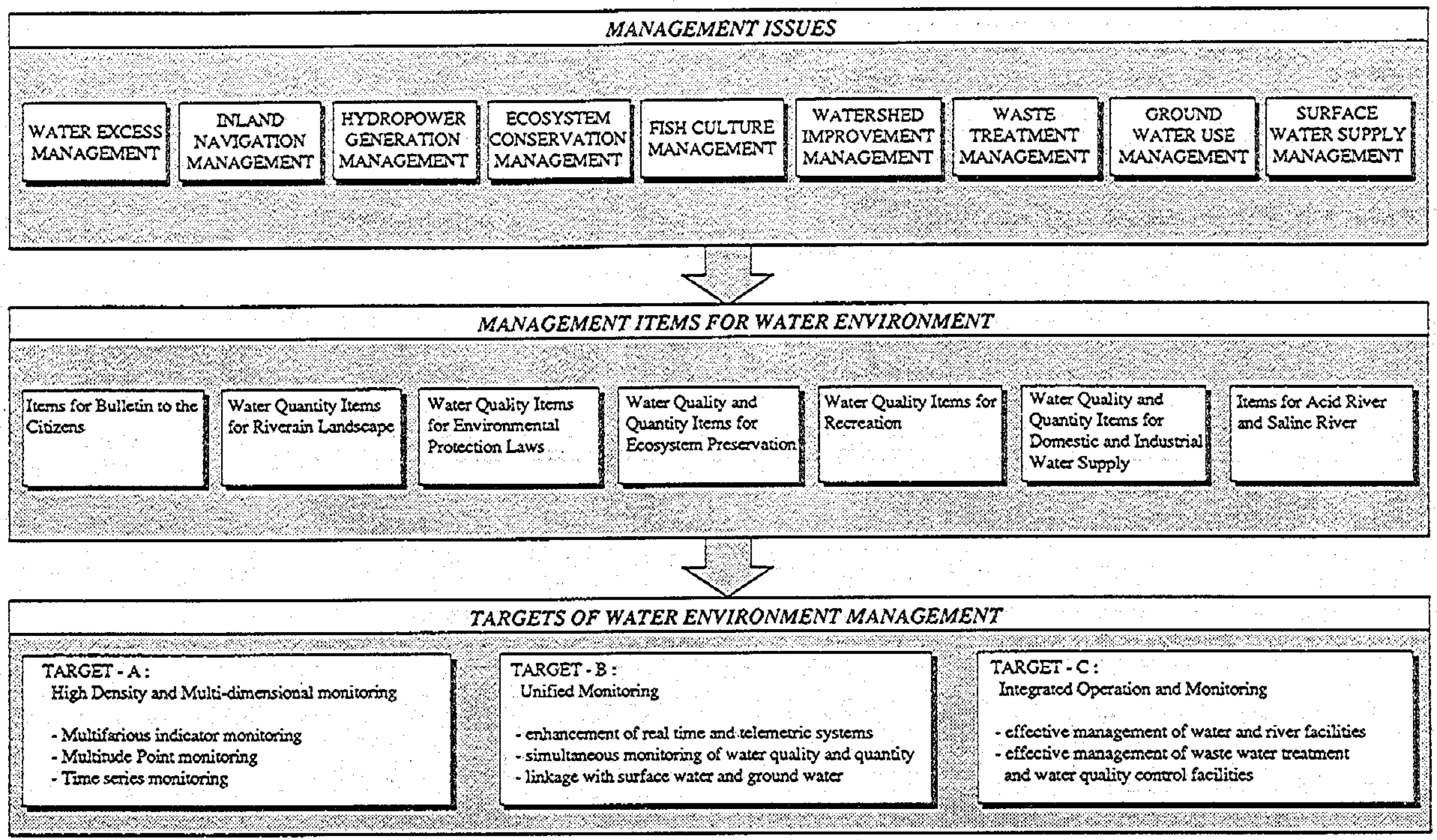

Figure-8.3 Targets and Management Items of water Environment

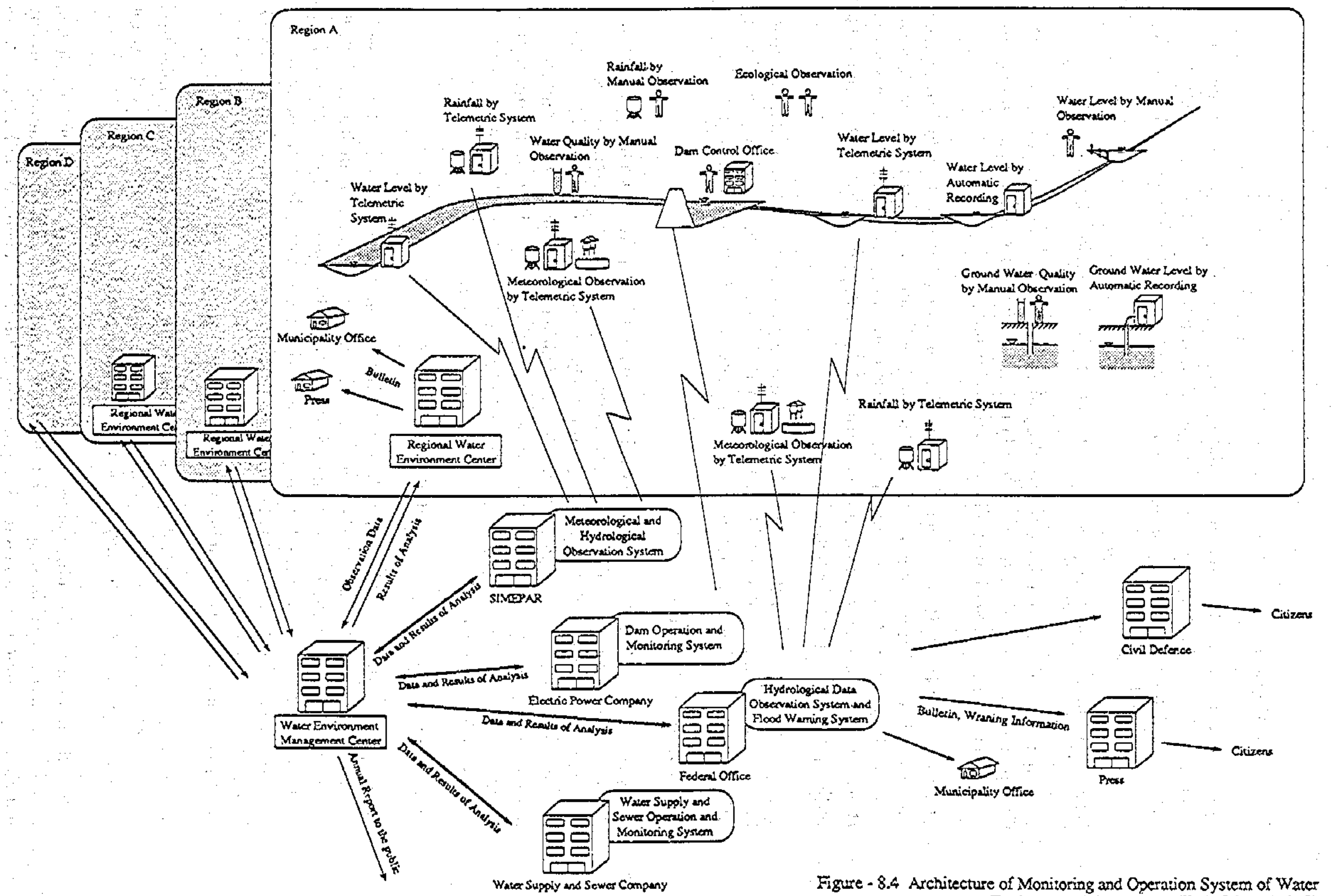

Figure - 8.4 Architecture of Monitoring and Operation System of Water Environment Management (TARGET - B & C)

8.2.2 Master Plan

The current level of the existing monitoring and operation system was evaluated by comparing the targets of A to C and the required activities for reaching these target levels were studied together with their urgencies and implementation schedule. The result is described as follows:

(1) Strengthening of monitoring system for meteorological and rainfall observation

The required number of additional meteorological and rainfall gauging stations are estimated by applying the required density of 1,200 km^2 per a station for meteorological observatory and 170 km^2 per a station for rainfall observation network.

The on-going SIMEPAR's project are scheduled to provide the meteorological gauging stations with telemetering equipment in the Tibagi river basin. The SIMEPAR's system will give more detailed data and information related to water environment management. However, taking into account the current density of the observation network, it is required to further provide 19 rainfall gauges.

The spatial distribution of the proposed new gauges are recommended to be decided taking into account the meteorological characteristics based on the data to be provided by the SIMEPAR's system and the existing observation network after its completion of the project.

(2) Provision of new stream flow gauges

The water resources development by providing dam/reservoir or weir structures will require the stream flow data for evaluating the available water resources with high accuracy at the structure sites for managing the project from planning to operation and maintenance. Since the currently proposed development schemes for Londrina, Apucarana and other urban areas ranked at the type of B are located in the upstream river basin and there are no stream flow gauges at the site, seven (7) stream gauges are required to be installed in accordance with project implementation.

(3) Strengthening of river water quality observation

Water quality stations have been installed at the major points along the main stream, at the main tributaries and at locations where quality problems are identified or predicted. But, its observation work after 1990 has been interrupted at several stations. Also, water quality in the rivers adjacent to the major cities are predicted to be worsened by the increase of sewage loads discharged by the expanding urban areas. Therefore, the current observation network is required to be strengthened by restarting the observation work at the mentioned stations and by providing new stations in the rivers in the urban areas.

The aforesaid urban areas with the types of A and B located at the upstream of tributaries have no observation station. The water quality observation at the proposed 7 stations for water use management is also required to be undertaken additionally.

While, the pesticide and fertilizer utilized in agricultural sector are one of the water pollution source. It is necessary to investigate and identify the kind of pesticide and fertilizer currently utilized in agricultural sector and its chemical composition, and degree of influence of those to water environment and human beings firstly, since there are no sufficient data to specify test items for detecting pesticide and fertilizer in the Study. The standards and guidelines for water quality monitoring for pesticide and fertilizer are required to be established on the basis of the investigation result.

(4) Strengthening of sediment observation

Research and investigation work have been made by the IAPAR under the EMATER, and sediment observation has been made mainly by the DNAEE, COPEL, IAP and IAPAR. In order to identify problems and monitor effects due to reforestation and terracing works proposed in the current study, it is necessary to undertake more frequent observation of sediment loads at the existing stations or stations to be newly established in the severe erosion areas. In observation, sediment flow samples at flood time, which occupies the major part of the annual sediment discharge, is necessary to be taken intensively.

Identified severe erosion areas are the tributaries; 1) Congonhas, 2) tributary in Assai, 3) J. Jeronimo, and 4) tributary near Saponema. In these river basins, the intensive measurement is required to be carried out at the existing gauge in the Congonhas river and at new stream flow gauges to be provided in the aforesaid tributaries excluding the Congonhas river.

(5) Initiation of aquatic ecology monitoring

There has been no integrated aquatic ecology monitoring. It, therefore, is required to initiate the monitoring work so as to provide basic data for establishing the conservation plan of aquatic ecosystem along the rivers.

Aquatic ecology monitoring is required to include bioindicator sampling such as benthos, plankton and nekton and chemical analysis for aquatic biota and water quality as proposed in the ecological improvement study. Also, investigation on vegetation along the river side area using the available Geographic Information System (GIS) and fish inventory survey are recommended to be carried out as proposed by the ecological study.

(6) Groundwater monitoring in urban Areas

There are many bore holes provided by the SANEPAR and private industrial factories. The surface water resources development is going on in the urban areas in the Tibagi river basin where both water resources is mutually affected in quality and quantity. In order to undertake well balanced development for these water resources, the following monitoring work is required:

a) prediction of domestic and industrial water demands based on population, land use, economic data, and so on,

b) installation of flow meter to the authorized and unauthorized bore holes as well as identification of location of the unauthorized bore holes, and

c) establishment of global hydrological cycle model which enables to estimate potential water resources and to evaluate water demand/supply balance incorporating both water resources and other hydrological components.

The establishment of monitoring system including the model mentioned above is recommended to be made in the 2nd stage by using the established hydrological cycle model in Curitiba metropolitan area. However, groundwater monitoring is recommended to be undertaken in the urban areas where the boreholes are deveolped for domestioc and industrial water supply in order to accumulate the necessary data for establishing the hydrological cycle model. The required inspection bore holes for the urban areas are as shown in Table-8.3.

Table-8.3 Required Number of Inspection Boreholes

Municipalities	Required Number of Boreholds	Total Length of Boreholds (m)
1) Londrina	4	320
2) Apucarana	2	160
3) Other large urban areas (7 municipalities)	10	800

(7) Establishment of integrated data base system under SEMA

There are no integrated data base system for water environmental management in the SEMA. While, the SUCEAM and IAP will require the data base system for planning water resources development and conservation of water environment. The proposed data base system will contain; a) socio-economic data such as economic indices, land use and population, b) meteorological and hydrological data, c) data on groundwater, d) water quality records, e) sediment observation data, and f) aquatic ecological data. The data accumulated in the data base system will be used for prediction of water demand, water demand/supply balance analysis incorporating surface and subsurface water resources, simulation of river water quality, and so on.

(8) Data and information network

The proposed state center is able to collect data and information from the SIMEPAR and DNAEE between their computer systems through the existing telephone cable line. This data transmission system is applied for communication system between the state and regional centers and other related institutions.

8.2.3 Required Cost

(1) Provision of additional meteorological and hydrological observation stations

The required cost for establishing the proposed monitoring system was estimated on the basis of the cost data and information provided by the counterpart personnel. The result is shown in Table-8.4.

Table-8.4 Cost for Monitoring System

Description	Work Items	Required Cost (US$ thousand)
1) SIMEPAR's system	-	35,000
2) Strengthening of monitoring system for meteorological and rainfall observation	• 19 rainfall gauges	29
3) Provision of new stream gauges for water use management and water quality observation	• 7 stream gauges	70
4) Provision of new stream gauges for sediment observation	• 3 gauges	30
5) Groundwater monitoring	• 4 boreholes in Londrina • 2 boreholes in Apucarana • 10 boreholes in other urban areas	58 29 144
6) Aquatic ecology monitoring		292
7) Establishment of integrated data base system under SEMA, including data and information network	• 7 sets of computer system and telephone line network	70
Total	-	35,652

The SIMEPAR's project is going on as described in the Main Report I and the total cost of US$ 35 million is scheduled to be disbursed during coming 5 years from 1996. Since this system covers the whole Paraná state including the Tibagi river basin, the mentioned cost is incorporated into the Master Plan.

(2) Annual observation cost for water quality and sediment loads

The annual cost for water quality analysis is estimated by assuming test items of water and air temperature, dissolved oxygen, coliform fecal, pH, BOD, COD, total nitrogen, total phosphate, turbidity, total solid, heavy metals such as mercury and chrome, and pesticide and fertilizer for identifying the basic condition of river water quality. Assuming that observation frequency is four (4) times a year, and that two (2) samples are taken at one location and analyzed, the required cost for sampling and laboratory test for samples to be taken at the existing and newly provided 41 stations are estimated at US$ 246 thousands.

Sediment sampling and analysis for identification of sediment loads require the annual cost of US$ 102 thousand assuming the frequency of 10 times a year and three (3) samples/location per sampling, and undertaking of observation at the existing and proposed 34 stations.

8.2.4 Implementation Schedule

The implementation schedule for the required activities is given as shown in Figure-8.5. The required activities to cope with the problems and needs related to urbanization and industrialization, and the on-going projects and strengthening of the existing monitoring systems are scheduled to be undertaken in the 1st stage during 10 years to 2005. The activities in the 2nd stage are mainly for the expansion or upgrading of monitoring system established in the 1st stage.

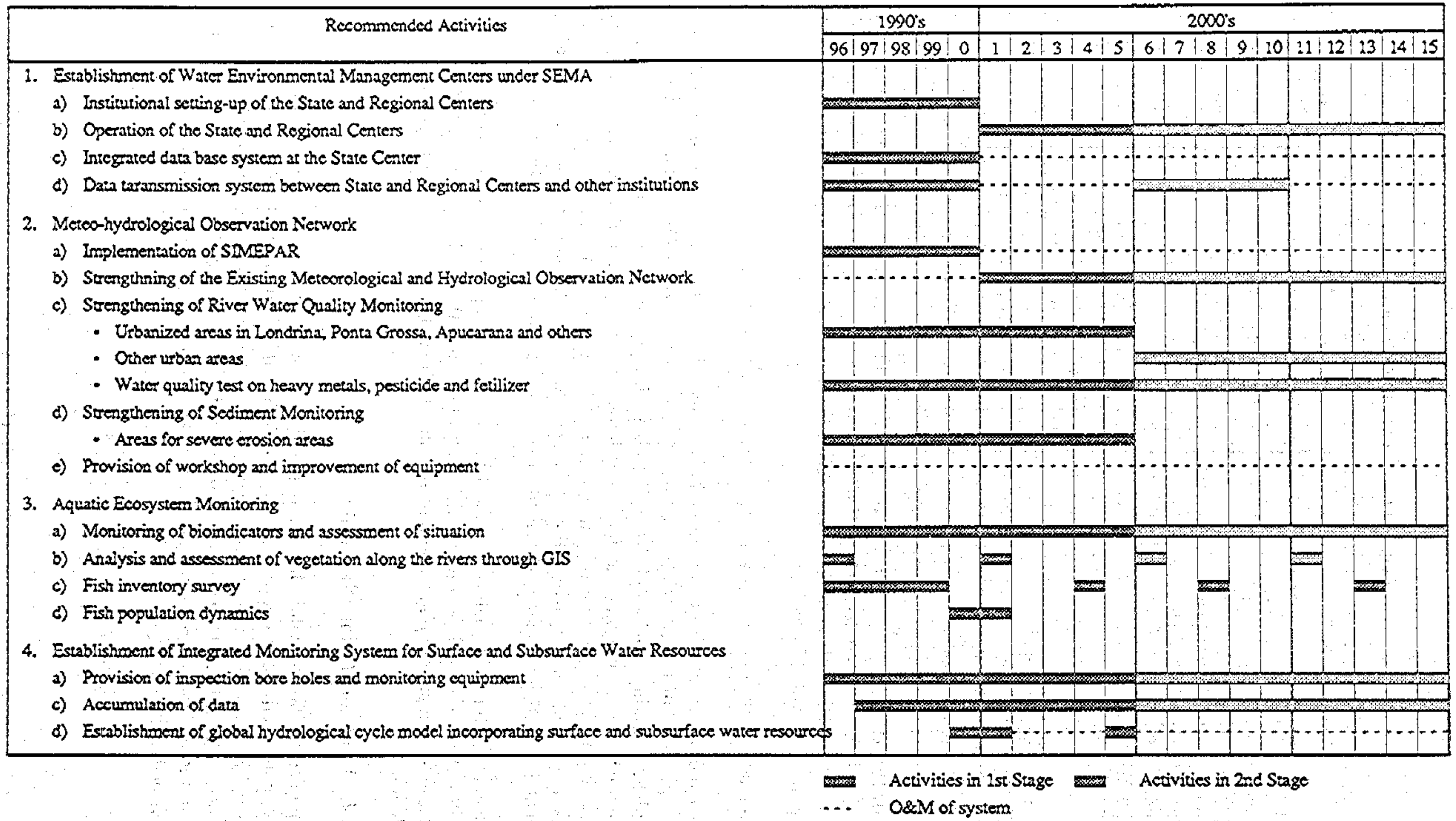

Figure-8.5 Implementation Schedule of Operation and Monitoring System

CHAPTER 9 INSTITUTION

9.1 Current Institutional Framework in the Tibagi River Basin

9.1.1 Legislation in Force on Water Environment

(1) Ownership and Administration of Water

According to the Constitution, the ownership of main stream water in the Tibagi River except hydraulic energy potential is the property of the State of Paraná.

(2) Use of Water and Water Right

Derivation of water in State domain requires concession, authorization or permission, provided that water use for the first necessity of life is free in case that the access to the water is lawful. The State Regulation No. 004/89, 1989, by the SUREHMA (Superintendency of Water Resources and Environment, currently being changed to the SUCEAM-Superintendency of Erosion Control and Environmental Sanitation), gives provisions for the use of water of the State domain, based on the stipulation of the Water Code.

(3) Water Resources Development

The works necessary to derive or store water shall be planned and constructed under the responsibility of a certified professional registered in CREA (Regional Council of Engineers and Architects). Any alternation or any part of alternation and any change in intakes or dikes are subject to the approval of the SUCEAM.

(4) Water Resources Conservation

The Water Codes prohibit degrading or contaminating waters by discharging waste water. The Code orders the entity who causes the nuisance to take remedial actions at the polluter's expense and to compensate for the loss or damage caused by the effluent discharge. In the State domain, the SUCEAM or the IAP (Environmental Institute of Paraná) can demand of the water user to prevent waste of water, to control, or to protect against pollution.

The Federal Law 6766, 1979 prohibits the land allotments for urban purposes in swampy or flood prone areas before taking precautions against water flow, and in land belt along water courses, as well as in areas for ecological preservation, and polluted areas before the recovery. The law requires some portion of land allotment for community facilities, including those for water supply, sewerage, electric power supply and storm water collection. The State Decree No. 2963, 1980 designates areas of the special interest and protection, such as areas contained in the water divisions of surface run-off which contribute as sources of public potable water supply.

The State Law No. 8935, 1989, and an additional stipulation by the State Law No. 11055, 1995, prohibits installation, operation, or implementation of highly polluting industries, hospital establishments, waste disposal sites and parcels of land for high population density, in catchment areas of sources for the public water supply.

9.1.2 Current Organizational Framework

(1) Federal Level

(a) Water Resources Administration

Water resources administration at the Federal level is discharged by the National Department of Water and Electric Energy (DNAEE) of the Ministry of Mines and Energy (MME). Although the Constitution provided that the permanent defense against floods is the federal matter, the National Department of Sanitation Works (DNOS), which was the competent organization under the Ministry of Agriculture, was abolished in 1990.

(b) Environmental Entities

The National Council of Environment (CONAMA) and the Brazilian Institute of Environment (IBAMA) administer environmental conservation, preservation of eco-system and pollution control, including water quality management, under the Ministry of Environment and Legal Amazon.

(2) State Level

The prime institute of water environment administration at the State level is the State Secretariat of Environment (SEMA), subordinating the SUCEAM and the IAP. These organs have been in the course of re-organization and strengthening since January, 1995.

(3) Municipal Level

Participation in water environment administration by the Municipalities varies according to the level of their establishment and capabilities. Some Municipalities discharge major responsibilities in water environment management, while many of Municipalities are raised very recently and are still in the process of their consolidation.

Inter-municipal Consortium for Environmental Protection of the Tibagi River Basin (COPATI) was established in 1989, composed of around 40 municipalities represented by the mayors. It represents, nationally and internationally, in common interests of the member municipalities, with regard to the following objectives:

- to elaborate and execute together plans, programs and projects, aiming at improvement of environmental conditions and the eco-system conservation in the Tibagi River Basin, reinforcing development programs in the region, when necessary
- to promote afforestation, reforestation and other programs and measures for preservation of fauna and flora in the region included in the territories of the member municipalities
- to develop services and activities of the interest of the member municipalities in accordance with the working programs approved by the Deliberative Council

9.2 Institutional Issues of Water Environment

9.2.1 Concepts and Approaches for Institutional Improvement

The following two concepts are employed to formulate institutional improvement programs:

Concept I: *Promotion of Appropriateness, Effectiveness and Efficiency through Remedial Measures against Current Problems*

Concept II: *Responding to Future Needs for Integrated Water Environment Management*

The first concept should be applied everywhere in the world for the improvement every sector of management and government administration. Considering the Concept I, current institutional problems are identified and analyzed for compiling remedial measures to solve the problems.

Since water resources development incurs huge costs and long period for project implementation and the resources conservation will affect future generations, water environment management should cover long term perspectives. Future needs and corresponding institutional responsibilities of government administration are discussed under the Concept II.

Introduction of successful models practiced in other countries, including those in Japan, which might be suitable to Paraná State, is applied as a basic approach in programming institutional improvement measures under both of the two concepts, especially those under the Concept II.

9.2.2 Identified Institutional Problems and Principles to be Followed

The problems to be discussed in the institutional study are selected as follows:

- inappropriate responsibility assignment
- insufficient instructions and training
- insufficient assessment of water resources potential and the existing use
- insufficient detecting capability of polluting sources
- insufficient data and information publication
- unrecovered cost

In order to solve the above problems, the following principles are set to be obeyed under the Concept I.

1) Definite Assignment of Operational and Regulatory Responsibilities and Configuration of Line Responsibilities
2) Enhanced Enforcement of Legislation on Water Environment Management and Administration
3) Establishment of Proper Cost Recovery System
4) Encouragement of Public Participation

9.2.3 Future Needs

Population growth, accompanied by agricultural and industrial development, boosts water demands. Agricultural and industrial expansion will lead to increase in polluting loads as well, reducing quality water available. Raised living standards increase recreational and environmental demands. In order to meet increasing demands with limited budget, water environment management requires much more efficiency. The management at this stage should be integrated in order to achieve optimal use of limited water resources and efficient resources conservation. Responsibilities for water environment administration will largely grow corresponding to socio-economic development.

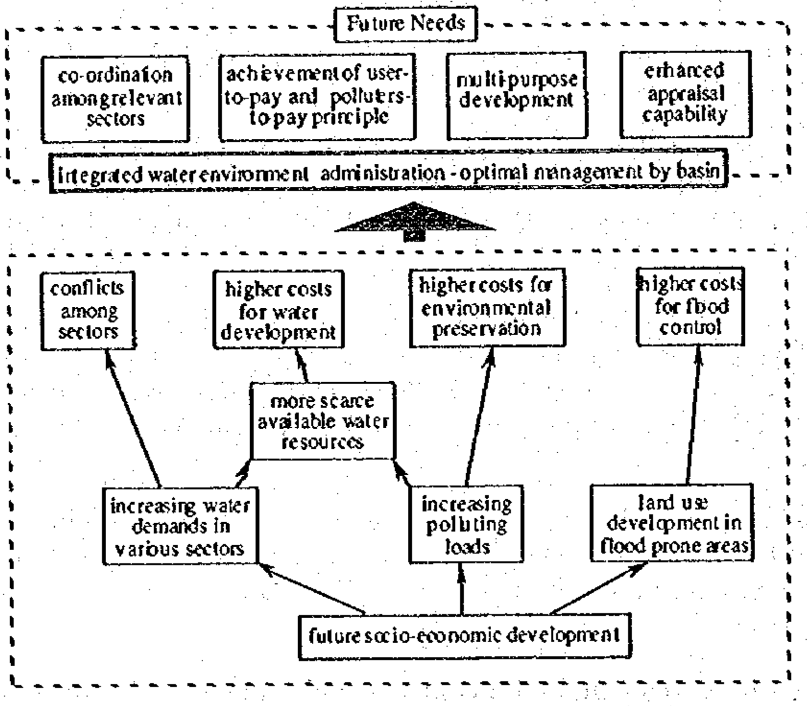

Figure-9.1 Future Needs for Integrated Water Environment Management

Principles to be observed in formulation of institutional improvement programs to meet the future needs in water environment management are set as follows:

5) Introduction of Basin Management and Establishment of the Competent Entity
   - Equitable and Definite Policy Formulation on Water Allocation and Water Quality Control
   - Comprehensive Planning, Evaluation and Regulation
6) Coordinated Administration and Management among Relevant Administrative Sectors
   - Linkage of Water- and Land-use Management
   - Linkage of Quantity and Quality Management
   - Linkage of Surface Water Management and Groundwater Management
7) Equitable Water Pricing

9.3 Master Plan for the Tibagi River Basin

9.3.1 Phased Development of Institutional Improvement

The programs under the Concept I are recommended for immediate implementation, while the programs under the Concept II are generally proposed for longer term implementation after the programs under the Concept I. Generally, the completion of the programs under the Concept I would be a prerequisite for the implementation of the programs under the Concept II. Continuous upgrade of water environment management could be achieved