CHAPTER 6 SUPPLEMENTAL CONDITIONS OF SELECTED PILOT RIVER BASINS

6.1 Introduction

In the present study phase, significant environmental issues related to the aquatic ecology of the selected pilot basins are assessed. The purpose of the study is to propose model environmental rehabilitation, preservation and/or protection programs that would be useful as models for the implementation of comparable programs in the other basins of the state.

By no means, all the environmental concerns regarding the aquatic ecology of the basin are assessed here, and the more specific and punctual issues should be assessed in future and more detailed studies.

6.2 Iguaçu River Basin

6.2.1 Aquatic Flora

Significative environmental conditions being generated by microalgae and macroalgae in this basin are mainly related to off flavor, oxygen depletion, and filter clogging in the water intakes. Table-2.7 summarizes the common aquatic plants found in the state, Table-2.36 shows common plants of lowland inundated areas, Table-2.38 shows typical vegetation of marshes, and Table-6.1 summarizes the problems associated with microalgae in water supply reservoirs.

Table-6.1 Microalgae Occurrence and Problems Associated in the Water Supply Reservoirs of the Iguaçu River Basin

Microalgae Genera	Occurrence in Reservoirs				Problems associated with Water Quality
	(1)	(2)	(3)	(4)	
Asterionella sp	X	X	X		Clog filters, hamper flocculation & decantation by pH
Dinibryon sp	X				Clog filters
Microcystis sp	X				Concrete corrosion can produce toxins, bad odor, and can produce thick layer on water surface limiting oxygenation
Achnanthes sp	X				Bioindicators of Phenols and polluted water
Melosira sp		X	X		Interfere with decantation, mud flavor, indicator of organic matter pollution
Euglena sp				X	Fishy odors, pollution indicator
Staurodesmus sp				X	Bad flavor, pollution indicators.

Source: Vitola, M., SANEPAR/Hydrobiology, 1995

(1) Passauna Reservoir, (2)Alagados, (3)Cedrix/Insam, (4) Stingler/Peripau

Microalgae population explosions are mainly attributed to excessive organic matter (nitrates and phosphates) originating from domestic sewerage and organic pollution of the water sources.

6.2.2 Aquatic Fauna

Aquatic fauna is referred in this section as fish, benthos, and aquatic birds. Reported fish and aquatic bird species for the basin can be found in Table-2.43 and Table-2.44, Fig-2.15 shows the reported fish fauna for Iguaçu river basin.

(1) Fish

Given the environmental deterioration of the Iguaçu river, the following fish species have not been collected since 1908, and they are considered endangered (36)

Table-6.2 Fish Species Considered Endangeredin the Iguaçu River Ichthyofauna

Scientific Name	Group
Hasemania melanura	Characiforme
Hasemania maxillaris	Characiforme
Hyphessobrycon taurocephalus	Characiforme
Glandulocauda melanopleura	Characiforme

Source: SUREHMA (36)

The main issues contributing to the degradation of the aquatic habitat in the basin are the following according to SUREHMA (36):

1) Water pollution by domestic sewerage and industrial effluents.

2) Water pollution by pesticide residues.

3) Increased turbidity by soil erosion.

4) Deforestation increasing erosion

5) Reduction of river margin vegetation coverage, increasing water temperature by shade reduction.

6) Destruction of lowlands adjacent to river margins, eliminating nursing areas where different aquatic species nurse and feed in primal stages of life.

7) Modification of the water environment with man made structures such as dams and hydroelectric projects.

Comprehensive studies on the impact caused by hydroelectric projects upon the fish fauna have been carried out by COPEL and the University of Maringa's Research Nucleus for Limnology, Ichthyology and Aquaculture (NUPELIA).

Studies performed include the limnological, fish inventory, and fish population

dynamics of the Salto Segredo reservoir. Results of a three year study will be available by September 1995. These studies will help evaluate the existing fish fauna conditions and potential for eventual aquaculture development with endemic or introduced species from other basins. Further studies suggested in this direction are discussed under section 7.2.

(2) Benthos

A summary of the benthos community reported for the rivers of the Curitiba metropolitan area can be found in Table-4.2

Other macroinvertebrates reported where sampled at the Passauna river sub-basin, where 12 stations where sampled by SUREHMA. Downstream from the sanitary landfill site the least biodiversity was found, and the occurrence of macroinvertebrates highly resistant to polluted waters such as Oligochaeta (Annelida) was significant, implying deteriorated environmental conditions in this area.

Similar samplings done by IAP (37) showed the least biodiversity downstream from the inactivated landfill Lamenha Pequena, where the occurrence of benthonic organisms resistant to pollution was significant.

The use of benthonic macroinvertebrates, as well as phytoplankton and zooplankton for the regular biomonitoring of the aquatic environment is recommended to establish environmental degradation indicators. These indicators, associated with the physical and chemical parameters will provide the baseline criteria for the implementation of corrective and mitigating measures in environmentally degraded areas. Monitoring programs with the use of bioindicators is further suggested under section 7.3 and 7.5.

(3) Aquatic Birds

Aquatic bird populations are indicative of the extent of the anthropic activities on the aquatic environment, Table 2.44 gives a summary of the reported aquatic bird population, and Appendix-4 in this report gives a detailed list of aquatic birds in the basin.

For the Iguaçu Environmental Protection Area (APA-Iguaçu) located adjacently to the Curitiba metropolitan area, the studies by Andre R. de Meijer and the Museum of Natural History reveal an important community of aquatic birds, including temporary resting populations migrating south and coming from the northern part of the American continent. The following table summarizes the reported bird species in this area:

Table-6.3 Reported Bird Species for the Iguaçu River Conservation Area (APA-Iguaçu)

Category	Number Reported	Percentage (%)
Birds species	117	100
Bird families	36	
Aquatic species	37	31.6
Migratory species	10	8.5
Rare species	6	5.1
Endangered species	2	1.7

Source: SMMA, 1993 (14), and Museum of Natural History

Among the migratory species, the Museum of Natural History has reported species with populations up to 600 individuals. Five species are known to depend on the wetland vegetation for shelter, nesting and food supply.

Other endangered bird species nesting in the vicinity of the proposed Irai reservoir and proposed conservation area for Serra da Baitaca will be discussed under section 6.2.4, and the location of these areas can be seen under Fig.6.1

6.2.3 Lowlands Along Watercourses

Lowlands along watercourses (Varzeas) are located in alluvial floodplains, subject to inundation by river peak flows. Its appearance can go between swampy to low bush areas, and the natural vegetation is directly related to the soil type. The importance of this habitat in relation to the fish and bird population can be summarized as follows:

1) Provides shelter and food to larval and juvenile fish, invertebrate fish species, and migratory and endemic birds.

2) Generates a flourishing food chain in a semi-closed system with the river allowing resting and feeding places for local and migrant bird species.

3) Acts as an interface between the land and the river, capturing nutrients, pollutants and soil erosion, behaving as a settling basin for the land runoff.

4) The river margin vegetation provides shade and nutrients to the river, regulating the water temperature, and providing fruits, nuts and organic matter for specific fish species and the general nutrient balance of the river.

Varzea ecosystem in the Iguaçu river running adjacently (south) to the Curitiba metropolitan area, and along both sides of the river, has suffered severe alterations by human activities such as sand extraction, and uncontrolled occupation and house construction. The area in question is under consideration by COMEC/PROSAM for the establishment of the Iguaçu Flood Control Park, which includes several land use categories which go from public recreation park to preservation and conservation areas.

Table-2.36 summarizes the typical vegetation found in this habitat, further discussion of these areas subject to sand mining can be found under section 6.2.4.

6.2.4 Conservation Units and Environmentally Sensitive Areas

A summary on the existing conservation areas in the Iguaçu river basin can be found in section 2.4.1, Table-2.8, and Table-6.4. Multipurpose conservation areas within the urban environment or closely accessible to it enhance the quality of life of the population while educational and genetic conservation purposes are met.

The proposed conservation units to be further discussed in this section are considered to meet the above purpose, including values such as recreational, historic, landscape, preservation of endangered species, and environmental quality improvement. See Fig.6.1

(1) Existing Conservation Units

1) Iguaçu Flood Control Park

a) Major Characters

A significant section of the proposed Iguaçu Flood Control Park is already under the Management concept of the "Iguaçu Environmental Protection Area" or APA established by decree No.472 in 1993. The area in question is defined between the Victor Ferreira do Amaral Avenue and the confluence of the Barigui river with the Iguaçu river. See Fig.6.8.

Wetland Varzea areas located in the right bank of the Iguaçu river, in the municipalities of Pinhais and Curitiba, occupying an area of 3,969 ha.

The area comprehended between the Irai and Barigui rivers also has extensive Varzeas and plenty meanders along the alluvial plane, configuring a dendritic drainage system. In general the area comprehended by the APA-Iguaçu presents isolated patches of river margin vegetation (Mata Ciliar), in some sectors of significant extension and fairly well preserved, followed by extensive sand extraction caving and/or dense human settlements allocated in flood prone areas.

In other cases the vegetation is highly altered, and no reminiscence of the original vegetation is left, specially between Belem river and Comendador Franco Avenue (14).

The high Iguaçu area has a significant potential for sand mining in its lowland Varzeas, see Fig.6.9. Sand deposits have between 1.0 and 2.5 m depth, with a clay layer of 2.0-2.5 m normally used in the ceramic industry. The abandoned mined areas in many cases are settled by low income people, and in other remain as pond like holes of varying depth (2-5 m) and areas (176 - 8,000 m^2). Main issues related to these holes are summarized as follows:

i) Abandoned holes are always with water given the ground water level in the area.

ii) A high total coliform count has been reported for the water stored in this holes.

iii) Fish species are trapped in the holes, favoring the fishing activity of the adjacent settlers.

iv) Swimming and recreation is common among the young with the consequent health hazards.

v) Cattle is taken to drink water.

vi) Many of the areas have been occupied by low income settlers with consequent solid waste and sewerage disposal problems, besides exposure to flood hazard.

The relevant problems associated with water quality are related to sewerage disposal, industrial effluent disposal, and organic pollution. Unplanned occupation of lowlands will be discussed under section 6.2.4 based upon the Palmital river condition as model area for this problem type. The location of the Palmital river as tributary to the Iguaçu river can be seen under Fig.6.1, and Fig.6.6

While the APA type of conservation strategy allows the multiple use of the conservation area, the COMEC/PROSAM planning strategy is allowed to coexist in this context, including the APA areas, and extending further west, along the Iguaçu river up to the confluence with the Papagaios river. The proposed conservation area of Corredeiras Eng. Bley has a geographical continuity to this area. See Fig.6.1

b) Discussion

The revegetation and rehabilitation of the degraded areas could contribute in the retention of sediments originating from runoff, improve water quality, and eventually act as a barrier for new settlements intending to establish themselves in flood prone areas.

The following outline summarizes the criteria to be considered for the rehabilitation of degraded lowlands along the river margin based on Ziller, S. (41):

i)Information attained upon the original botanical coverage and their succession process is important to finally select the species for revegetation.

ii) Soil characterization, to recompose as much as possible the physical and chemical characters of the original environment supporting the plants.

iii) Obtaining of seeds and seedlings can be done in non disturbed areas of the same habitat, after a socio-botanical survey is done.

iv) Proportion of species to be re-introduced are to resemble those identified in the species succession study.

v) Once the pioneering species are established, re-vegetation with species occurring in posterior stages of the natural regeneration process will accelerate the regeneration process.

Monitoring and rehabilitation of the river margin vegetation will be further discussed under section 7.2.

2) State Conservation Units in the Iguaçu River Basin

A summary of conservation units and their areas can be found under Table-2.8. the following table summarizes the problems associated to the existing conservation units, see Fig.6.10.

3) Iguacu National Park

The park includes 185,262 ha, 300 Km of border limits are represented by rivers. main problems reported in this area are the following:

1) Fires starting close to the BR-277, and the Cascavel-Foz road, these fires are originated by tourists and people in cars discarding cigarrete buts and glass.

2) Wild animal feeding by tourists provoques hair falling and other diseases.

3) The Hotel Cataratas releases the raw sewarage into the waterfalls, and no contribution to the park is generated by the hotel occupying a privileged location.

4) Extraction of heart of palm (Palmito) by poachers.

5) Car accidents in the BR-277 with animals along the park area

6) Recuperation of the river margin vegetation along the river boundries of the park is necessary, specially in the following rivers: Sao Joao, Represa Grande, Silva Jardim, Goncalvez Dias. Projeto Agua Limpia from IAP has estimated a US$ 2'766,000 budget required for the revegetation of river margin vegetation in these areas.

7) Existing infrastructure in the park requires maintenace, and it's considered in bad condition.

8) Insuficient number of park guards

9) Only an estimated 27.3% of the established management plan was implemented, the remaining research, monitoring, education, tourism and administration programs where not implemented yet.

A detailed emergency plan has been elaborated by IAP/GTZ in April 1994, where the following areas have specific programs suggeted for implementation and improvement:

1) Human resources

2) Administration

3) Protection

4) Infra-structure

5) Research

6) Tourism orientation and environmental education

7) Definition of property ownership

8) Monitoring

Total estimated cost for the implementation of the emergency plan is US$ 1'689,202

Table-6.4 Summary of Problems Detected in the Existing State Conservation Units of the Iguaçu River Basin

Name	M. Plan	Infra-structure	Eco-tourism	Problems
Metropolitan S.F.	yes	no	yes	- No guard house
				- Housing invasion
				- No fence
				- No maintenance
Santana S. F.	no	no	yes	- Pinheiro seed poaching
				- No fence
				- No trails
				- No M. Plan
S. P. do Monge	no	no	yes	- Private lands inside park
				- TELEPAR infrastructure inside park
				- Private access roads inside
				- Exotic trees
				- No maintenance
Buriti	yes	yes	yes	- No fences
				- No maintenance
Pinhão F. R.	no	no	no	- No management plan
Palmas	yes	no	yes	- Forest fires
				- No fences
				- No official decree
Passa Dois F. R.	no	yes	yes	- No maintenance
				- Bad infrastructure
				- No electricity
Serra do Tigre	no	no	yes	- Illegal fishing
				- Illegal hunting
				- No fence
				- No maintenance
Mananciais da Serra	no	yes	yes	- Illegal hunting
				- Illegal fishing
				- No M. Plan
Passaúna APA	-	yes	yes	- Agriculture and grazing activities
				- No soil use criteria
				- No definition of limits
Serra da Esperança	-	no	yes	- Agricultural, grazing and reforestation land use
				- No soil use zoning
Escarpa Devoniana	-	no	yes	- Fire risk
				- Agricultural, grazing and reforestation land use
				- No soil use zoning
Rio dos Touros E. S.	yes	yes	yes	- No maintenance
				- No personnel
				- Administrative indefinition
João Paulo II S. P.	no	yes	yes	- Urban pressure

Source: Da Silva Pinheiro Evandro (IAP), 1995

Notes:

M.Plan: Existing Management Plan, Eco-Tourism: Potential, SF: State Forest, APA: Environmental Protection Area, FR: Forest Reserve, EE: Ecological Station, SP: State Park, BG: Botanical Garden

(2) Proposed Conservation Units

1) Serra da Baitaca - Irai Reservoir

a) Serra da Baitaca

The Serra da Baitaca is a small mountainous complex located 30 Km east of the Curitiba metropolitan area preceding the major mountain complex known as Serra do Mar, and between the Serra do Mar, and the proposed Irai water supply reservoir. See Fig.6.1

The highest peak in the complex has 1,420 m elevation, allowing panoramic views, as well as a stratified vegetation community according to the different elevations. See Fig.6.2.

Main components associated to this area are summarized as follows according to Roderjan et al, 1990 (38), and the Museum of Natural History of Parana:

i) Existence of water intake location for the public water supply of the municipality of Quatro Barras, and the springs which originate the Capitanduva, Cercado, do Sapo and Ipiranga rivers, which contribute westerly to the Iguaçu river basin, and easterly to the Coastal basin, integrating the water intake sources for the Curitiba metropolitan area and of reservoirs located in the Serra do Mar.

ii) Botanical formations include Pinheiro (Araucaria angustifolia) coppices, open natural grass fields, exuberant vegetation in the slopes of the Serra do Mar. Representative areas of the original vegetation cover are still present, specially above 1,200 m elevation, and the vegetation cover is that of transition between the Atlantic influenced vegetation and that of savannas with Araucarias. See Fig.6.3.

iii) Above the 1,100 m elevation, soils have no aptitude for agriculture, and the trees are only economically viable for charcoal. In general, the vegetation cover is still in its primitive stage. Areas under the 1,100 m elevation have been altered by granite extraction, subsistence agriculture, grazing and exotic species reforestation efforts.

Other areas are under natural regeneration process and have secondary vegetation mainly compromising bushes, grasses and fast growing trees. See Fig.6.3

iv) Studies performed by Dr. P. Scherer, ornithologist from the Museum of Natural History of Parana have identified more than 130 bird species in the area. 3,665 individuals where marked and released for recapture, in an effort to identify territory and habitats.

Among the species identified, 3 species are endangered, and have their nesting grounds in the future reservoir area. The endangered species are:

- Eleotherpfus animalus (Curiango do Brejo)
- Macropsalis creagra (Curiango Tesoura)

- Culictivora caudacuta (Mosqueteiro do Brejo)

v) Popular recreational area for the population of Curitiba, including activities such as hiking, delta-wing flying sightseeing, mountain climbing, landscape appreciation, visiting the Capindatuva river waterfalls and leisure.

vi) Historical component including a Jesuit settlement area from the XVIII century, adjacent to the Caminho da Graciosa (Jesuits Road), an Italian chapel built in 1950

The main problems associated to and affecting this area are summarized hereunder:

i) Pollution of water springs by municipal solid waste disposal.

ii) Uncontrolled and extensive tourism and solid waste disposal.

iii) Eroded trails from tourism transit.

iv) Mining of exposed and underground granite sources degrading landscape and promoting erosion and landslides.

v) Forest fires to clean the land for mining, and incidental fire startups.

vi) Increased turbidity in rivers originating in this area

vii) Significant denuding of the forest cover up to 1,100 m altitude was done between 1953-1980 by granite mining and forest fires.

b) Proposed Irai Reservoir Area

The adjacent Irai reservoir project in Piraquara-Quatro Barras for the supply of potable water for Curitiba up until 2020 is also thought of as a valuable conservation area.

The proposed reservoir area is 19.8 Km^2, with an inundated area of 14.6 Km^2. See Fig.6.1, the direct area of influence is composed of 4 botanical formations according to SANEPAR, 1992 (39) and Ziller (40):

i) Inundated open fields, unique and typical of the area, comprising important genetic and endemic material of botanical origin.

ii) Natural open fields with grasses

iii) Coppices of natural vegetation remains with an average of 1,371 trees/ha, with a mean height of 9 m, the most important species being the Pinheiro Bravo (Podocarpus lambertii), followed by Pinheiros (Araucaria angusifolia) and species of the Lauracea family. 25% of the species are considered rare.

iv) Vegetation along river margins, where 28% of the species are considered rare. The most important and preserved areas occur along the Irai river, where dense river margin vegetation prevails.

The main environmental impacts foreseen are summarized as follows:

i) The highest percentage area to be inundated is dominated by fields subject to inundation, typical of the eastern region of Curitiba, and only

occurring in this area. Many endemic species will be destroyed.

ii) The river margin vegetation destruction will reduce the habitat for birds and small mammals. This destruction will occur in the Irai, Timbu, Curralinho, and Cercado rivers, also allowing the runoff of sediment and agrochemicals from adjacent agricultural fields, within this habitat. Four species of orchids are endangered:

- Cleisthes sp,
- Habenaria sp,
- Cyrtopodium sp,
- Pelexia sp.

These species take many years to flower, and thus are difficult to find.

iii) Aquatic macrophite plants common in the area could invade the reservoir and cause problems in water quality. Given the low depth (5 m) of the reservoir, rooted aquatic plants could invade vast areas of the reservoir.

iv) The aquatic mammal Lutra longicaudis (Otter), considered endangered will probably be displaced by the environmental alterations.

v) Diminution of the bird population by disappearance of their habitat, and possible increment in the aquatic bird population. According to Bornschein and Rivero, ornithologists of the Museum of Natural History of Parana, 18 species of birds with habitats in the area between the Serra do Mar slopes and the Irai river basin are endangered. The endangered species reported in the Brazilian list are the following:

- Curiango-do-Banhado (Eleotherptus anomalus)
- Mosqueteiro-do-Brejo (Culicivora caudacuta)
- Curiango tesoura (Macropsalis creagra)
- Pavo (Pyroderus scutatus)
- Cisqueiro (Clibanornis dendrocolaptoides)
- Negrinho-do-Mato (Amaurospiza moesta)

The conclusion and recommendation of Dr. Gerdt Hatschbach curator of the Hartsbach herbarium and director of the Curitiba Botanical Museum is that:

"All the area should be transformed into a conservation unit subject to intense control to avoid invasions"(40)

c) Discussion

The creation of a wide scope conservation unit between the proposed Irai reservoir area, and Serra da Baitaca, will provide continuity between these environments allowing a multipurpose conservation area to be characterized among the following components:

i) Preservation of water supply sources.

ii) Preservation of natural flora, botanical genetic bank of endemic origin and landscape values.

iii) Protection of endangered and rare botanical species.

iv) Preservation of endangered bird species and their habitats.

v) Rehabilitation of degraded ecosystems.

vi) Continuity of the Serra do Mar mountain components towards the Curitiba urban area through the Baitaca complex and the Irai river basin allowing physical continuity to migratory species.

vi) Possible fauna corridors between Serra do Mar, the Baitaca complex, and the Piraquara-Quatro Barras area. See Fig.6.1.

vii) Recreational, sport, cultural, religious, scientific and scenic values preservation.

Rehabilitation and conservation efforts should be understood attending the following main strategies:

i) Natural regeneration process for those areas affected by forest fires, allowing the pioneer species to settle, and the natural succession to occur.

ii) Restablishment of degraded areas by selective use of organic soil layers, and allowing natural regeneration or planting of endemic seedlings in the area.

iii) Avoidance of exotic species for reforestation.

iv) Prevention of forest fires , specially during windy and dry periods.

v) Above the 1,100 m elevation, the preservation of the existing flora and habitat should prevail. Below this altitude, where degradation is more evident, a multipurpose protection area could be viable, allowing some of the above mentioned activities combined with tourism, climbing, and leisure.

2) Corredeiras Engenheiro Bley

a) Preservation Values

The area along both margins of the Iguaçu river, between Serrinha and some 12 Km upstream of Porto Amazonas as referred to in Fig.6.1, and known as Corredeiras Eng. Bley has important scenic, touristic, and recreational values being left without any conservation criteria in the planning process. This river sector maybe the last one resembling the original Iguaçu river condition of rapids.

The river margin vegetation is fairly well preserved, allocating fauna and flora resources, among which we can find endangered species of orchids only found in this sector such as:

i) Sophronitella violacea .

ii) Cyrtopodium dugenii

iii) Pleurothallis bleyenne

Other endangered botanical species include Mondovilla coccinez, Hezperozigis spathulata, and Parodia ottonis among others.

Open natural fields with Araucaria angustifolia coppices are also present along the river, intermixed with exposed rock and sandstone walls bordering the river margin, and allocating important botanical species.

b) Discussion

The creation of hydroelectric projects along the Iguaçu river has transformed the aquatic environment from that of rapids into a slow moving and enclosed one. The mentioned sector is the last area resembling the landscape and hydrographic regime of the river, and this could still be preserved. Section 7.2 further discusses this possibility.

The unusually high fish endemism present in the river, as discussed under section 2.7.1, and the preservation of a sector resembling their original habitat is another reason to consider the preservation of this area.

3) Palmital River

The Palmital river runs North to South, and joins the Irai river approximately 3 km upstream from the confluence between the Irai and the Iguaçu river. See Fig.6.1.

For the study purpose, the Palmital river can be divided into 3 sectors as follows. See Fig.6.6.

a) Upper Palmital

Located north of the "Anel do Contorno Norte", and coinciding with the northern urban limit of the Curitiba Metropolitan Area, this area is considered of very low urban and industrial impact, with extensive cleared areas in the right margin, and estates of 1,000m - 50,000 m area/each on the left margin. The uppermost northern sector of this area is dominated by fairly well preserved forest and river margin vegetation. Soil use category is defined as rural area for agricultural use.

The area is considered rich in groundwater resources, and the river margin vegetation is still in a well preserved condition.

b) Middle Palmital

Located between the Anel do Contorno Norte, and the BR-116 access. This area is highly encroached by low income housing from rural immigrant population on both river margins. The populated areas are some 30 Km from Curitiba center, where most of the people work. Main settlements in this area are the following:

i) Maracana and Guarituba, with approximately 90,000 people.

ii) Zumbi dos Palmares, located on both sides of the main BR-116, with approximately 20,000 people.

Main problems associated with these settlements are the following:

i) Raw sewerage is disposed of in the Palmital river, no sewerage treatment is operating.

ii) Municipal solid waste is also disposed of in the river and adjacent open fields.

iii) At least 10% of the population is living in flood prone areas and lowlands, exposed to floods.

iv) High criminal and low educational status, along with low income per family.

v) No recreational, educational or municipal facilities

vi) Low land elevation and high groundwater level makes difficult sewerage drainage and traditional sewerage treatment systems.

vii) Settlements are isolated from the potable water network system. Implementation of such system would be more expensive than average cost.

viii) Raw sewerage disposal, and open solid waste disposal are polluting the Palmital river, and affecting water quality of SANEPAR water intake located at the BR-277 intersection with the Palmital river, and eventually deteriorating the water quality of the Iguaçu river.

c) Lower Palmital

Located between the BR-116, and the intersection between the Palmital and Irai rivers, this area is less encroached than the middle Palmital sector. Major urbanization development occurs between the intersection with the Irai river and some 2 km upstream, up to the intersection of the Palmital with the PR-415, on the right margin, known as Joaquina II settlement.

Between the PR-415 and the BR-116, extensive and open grass fields can be seen, mainly along the left river margin, intermixed with a thin river margin vegetation residuals, lowlands subject to inundation, and some urban development in patches, located in the higher land elevations.

Main urban developments are located on the right margin, north of the PR-415, these are Alto Taruma and Jardim Fenix.

Problems in this area are not so critical, sewerage treatment is planned to be done at the Atuba river sewerage treatment plant, and the area is closer to the Curitiba Metropolitan area for solid waste collection and disposal. Population density is considered low. Left river margin settlement located north and adjacent to the PR-415 is to be serviced by PROSAM's sewerage treatment system.

d) Discussion

i) Upper Palmital

For the preservation of the groundwater resources existing in the upper Palmital, the following guidelines are suggested:

- Disencouragement of further housing/urban development.
- Total disencouragement of industrial development
- Protection and conservation of the existing river margin vegetation, and forest coverage.

ii) Middle Palmital

The actual urban encroachment condition existing in the middle Palmital, caused by rural immigration, and promoting a variety of environmental, social, and pollution problems is a typical human settlement "solution" to the socio-economic and centralized development policy based on economicist short term planning instead of on an environmentally conscious and human oriented economy.

The problem is not mainly spatial or environmental, the problem is originated in the development policies, and what we are confronted with now, is a consequence of the policy.

To ameliorate the impacts originated from this condition, the following guidelines are suggested:

- Relocation of the necessary number of families actually settled in flood prone areas in the middle Palmital river.
- Installation of educational centers for the young, including comprehensive approach towards environmental and sanitation education, in a long term perspective to avoid the reproduction of poverty.
- Educational programs for adults oriented towards the development of small business in accord with the environment around them, such as honey production, medicinal plant gardens, organic vegetable gardens, mushroom, frog and snail production in accord with state programs for the development of small industry.
- Educational programs and incentives to recycle waste, and to generate organic compost from organic waste for the above mentioned activities.
- Design and implementation of non traditional sewerage treatment system(s) for low elevation areas with drainage problems.
- Allocation of pertinent landfill or municipal collection system for the disposal of solid waste.
- Allocation of groundwater resources available in the vicinity, for the potable water supply.

- Development of sociological program for the integration of the community in the solution of the various problems.
- Disencouragement of further housing development.

iii) Lower Palmital

At the lower Palmital sector, the following guidelines are suggested:

- Zonation of the open fields and lowlands located in the lower Palmital area, allocating recreational parks, rehabilitation and preservation areas for lowland vegetation and river margin vegetation, as well as endemic vegetation coppices within the open fields.
- Modification of the existing land use criteria allowing small construction lots, to a rural type criteria, where more than 1,000 m^2 lots are required for construction, and in this way reducing the occupation density.
- Protection of river margin vegetation and buffer zone disincentivating constructions bordering the river margin.
- To take advantage of the open space still available to plan for an environmnetally friendly urban development that could be used as a model for future urban pressure conditions upon other microbasins.

iv) Water Intake Condition

- Described environmental conditions have deteriorated the water quality of the Palmital river as contributor to the SANEPAR water intake located downstream of this river.
- The Palmital river sub-basin has 95 Km^2, and the exclusion of this river as contributor to the SANEPAR intake would cause a flow loss of 1,000-1,500 l/sec
- The pollution load of the Palmital has in several occasions surpassed the treatment capacity of SANEPAR's system, specially during the rainy season, and the water intake have been stoped during such periods.
- Main problems related to water quality deterioration are municipal solid waste, sewarage and ceramic industry effluents in the river.

The recuperation of the Palmital river would contribute to the environmental awarness of the population related, and avoid possibly more expensive alternatives such as construction of a reservoir to supply the flow required.

It is considered that only an integrated approach such as the suggested above would improve the water quality and it's environment in a sustainable condition.

6.2.5Initial Environmental Examination of Major Projects in the Iguaçu River Basin

(1) Major Reservoirs and Water Intake Locations

The reservoirs and water intake locations monitored and presenting detrimental environmental conditions according to SANEPAR limnological laboratory, are summarized hereunder. Main pollution problems are attributed to organic pollution generating excessive microalgae growth and eventual oxygen depletion cycles.

Pollution attributed to heavy metals and industrial effluents has little support based on available data, future efforts should consider the monitoring of pollutants other than those of organic origin to assess this condition.

1) Miringuava Intake Location

Located in the Miringuava river, at the Iguaçu Aquatic Park, Curitiba metropolitan area downstream from the Zoo.

The disposal of raw sewerage effluent from the zoo contributes to the increased organic load of this river sector, promoting eutrophication and massive microalgae growth between the zoo and the water intake. Concentrations up to 1,200 ppm nitrates have been observed at the intake (7).

Microalgae cell counts have exceeded up to 4 times the limit (7) of 500,000 UPA (Unidade de Padrao de Area por Litro), a unit of measure adopted by SANEPAR to evaluate cell counts by the Whipple grid method. Most abundant microalgae identified are Trachelomonas sp, Microsystis sp, and Anabaena sp; these algae have the potential to clog sand filters, give bad taste to the water, and are indicators of polluted water.

2) Rio das Pedras Intake

Located in the Guarapuava region, in the middle Iguaçu basin, and downstream from the privately owned Cedix and Insam reservoirs.

The Ceix and Insam reservoirs are recipients of dissolved organics, produced by fish culture operations in the area. This water is discharged in the Rio das Pedras, with high concentrations of microalgae such as: Anabaena sp, Synedra sp, and Asterionella sp. Algae concentrations at the discharge point have reached 100 million UPA/l, doubling the acceptable level for algae concentration established by SANEPAR.

3) Passauna Reservoir

The Passauna river basin is a water supply area for 1/3 of the population of Curitiba. Located west of the Curitiba metropolitan area, occupies an area of 18,489 ha, with a population of 35,000 people concentrated in urbanized areas without basic sanitation, and deficient municipal solid waste collection (37)

The Passauna reservoir area is 8.4-12.3 Km^2, depending on its water level, and the frequency of occurrence of microalgae blooms indicates that the reservoir is under the process of eutrophication.

The microflora existing belongs to the following groups:

Table-6.5 Reported Microflora of the Passauna Reservoir

Taxa	Number of Species
Nostocophyta	9
Chlorophyta	65
Crysophyta	26
Pirrophyta	03
Euglenophyta	05

Source: SANEPAR/SUREHMA/GTZ (8)

Macrophytes have flourished and are colonizing the margins of the reservoir, and in conditions where the reservoir level is low, and the macrophytes are exposed, they die, originating the decomposition of organic matter, and subsequent oxygen depletion in the water body, 15 genera of macrophytes where identified, infestation mainly by Salvinia auriculata, Elodea densa, Eichhornia crassipes and Nymphea sp.

Total Phosphate concentration has a tendency to increase given the organic load entering the reservoir through fertilizers and domestic raw sewerage disposal (8). This tendency is favorable to the promotion of the eutrophic condition.

Five species of vector insects where identified, the most siginficative are:

a) Aedes fluviatilis, vector for yellow fever.

b) Aedes aegypti, vector for yellow fever and dengue

c) Simulium pertinax, most frequent species, vector for filariosis

In the adjacent terrestrial environment, 70% of the existing forest coverage is concentrated in the left margin of the river. The areas have been gradually deforested, and wood extraction for fuel is a common practice.

The main causes of detrimental environmental effects on the Passauna river basin, and directly related to the Passauna reservoir are summarized as follows:

a) Agrochemical runoff from agricultural fields located north of the reservoir.

b) Leaching effluents from the abandoned Lamenha Pequena landfill affecting water quality is proven by the low benthos diversity and Daphnia toxicity tests.

c) Domestic sewerage disposal without previous treatment, enhancing phosphorus concentrations and promoting a tendency towards eutrophication in the reservoir.

d) Industrial effluent runoff from paper industry and swine slaughter house.

e) Inadequate municipal solid waste disposal from the existing population.

f) Erosion and water turbidity enhancement from deforested areas on the south-west bank of the reservoir.

g) Urban expansion pressure on the area.

h) Integrated physical-chemical, limnological and biological monitoring of the reservoir is non-existing and necessary to evaluate the habitat condition and to implement the necessary corrective measures.

4) Piraquara Reservoir

Located east of the Curitiba metropolitan area, in the municipality of Piraquara, also has spring water as its main water supply. No significant water quality or microflora problems are reported by SANEPAR in this area.

Problems associated with this reservoir are related to ilegal fishermen using bombs to fish, urban pressure for house construction, and lack of control for visitors.

5) Peripau Reservoir

Located in the Municipality of Lapa, on the Piripau river also has spring water as its main water supply. No significant water quality or microflora problems are reported by SANEPAR in this area.

6) Stingler Reservoir

Located in the Municipality of Lapa, on the Peripau river also has spring water as its main water supply. No significant water quality or microflora problems are reported by SANEPAR in this area.

7) Discussion

Although no EIA study has been performed for the SANEPAR reservoirs, it is advisable that an environmental examination in detail be carried out to identify and categorize existing environmental problems to propose and implement solutions and mitigating meassures aiming at the environment preservation and the sustainability of the water quality for human consumption.

The improvement of comunnication between IAP and SANEPAR is important for the assessment of river and reservoir conditions related to the water environment, as well as for the implementation of monitoring and mitigating meassures in these areas.

(2) Hydroelectric Projects

Five hydroelectric projects operating and one under construction are the existing projects in the Iguaçu river. All of the projects are located in the main course of the Iguaçu river, damming approximately 50% of its extensions. See Fig.6.7.

Main environmental impacts are associated with the transformation from a rapid water flow to a slow water environment, interfering with the natural habitat of the fish populations, where by a high degree of speciation and endemism is attributed to the multiple naturally occurring barriers along the river stretch.

Other impacts are associated to the migration interference created by the dams, limiting the access of fish populations of migratory habitats to the adjacent 103 tributaries, where fish could obtain shelter and food (1). For this reason, the study of the population dynamics of fish populations becomes of utmost importance as a basis to implement mitigation measures for the present and future impacts on the ichthyofauna. Studies in this direction are suggested to be done in the basin under section 7.2.

Extensive fish population inventories have been carried out in the main course of the Iguaçu river, except in the river stretch adjacent to the Iguaçu National Park and Iguaçu river tributaries.

Future efforts should contemplate inventories along these areas, to contribute in the design of mitigating measures for present and future environmental impacts on the resource. Section 7.2 suggests the continuation of these efforts, and Fig.6.3 shows the indicative location of the sampling areas suggested.

The following table summarizes the existing hydroelectric projects:

Table-6.6 Inventory of Major Hydroelectric Projects in the Iguaçu River

Project	Operating Since	Inundated Area	EIA-Study Performed
Foz do Areia	1980	148.2	No
Salto Segredo	1991	83.0	Yes
Salto Santiago	1981	230.0	No
Salto Osorio	1970	62.9	No
Salto Caxias	UC	124.0	Yes

Source: COPEL

UC: Under Construction.

The main environmental issues related to the above mentioned projects, besides their impact on the fish populations are summarized as follows:

1) Foz do Areia

The population of Uniao da Vitoria believes that the hydroelectric project is responsible for the flood damages in Uniao da Vitoria.

2) Salto Segredo

The environmental impact study for this project was the first one developed in Brazil for a hydroelectric project, and thus it is full of repetitions and not well summarized.

The inundated area was one of the last canyon type stretches of the Iguaçu river. The area in general was highly altered by human action and deforestation, being estimated only 5% of the study area as covered by natural forest.

The reservoir area was densely occupied by small properties, 68-76% of the properties had resident families according to COPEL, 88% of the properties had 125 ha or less in extension, with an estimated population of 2,752 persons, 300 families where affected one way or another, and 160 families were resettled.

3) Salto Santiago

Salto Santiago does not have a EIA study, the main issue regarding this endeavor is related with the existence of an indigenous reserve associated with the project.

Areas in the river considered important as fisheries locations for the indigenous population have been affected, and the marginal land of these areas has been inundated.

ELETROSUL is the government agency responsible for the integration of the reserve and the hydroelectric project.

4) Salto Osorio

Salto Osorio has the smallest influence area, located in a canyon like area of the river. No major environmental impact except from impacts related on the fish population is reported. No environmental impact assessment study was done for this project.

5) Salto Caxias

After the EIA Study performed in Salto Segredo, major improvements were attained with the Salto Caxias EIA Study, reflecting a well organized and structured study, with a comprehensive environmental management and monitoring plan including various programs to be implemented for the mitigation and/or prevention for foreseeable impacts reflected in the study.

Eighty five percent (85%) of the area of influence is dedicated to agriculture or pastureland, 1,500 families were affected one way or another, out of which, 800 families were resettled.

A summary of the management and monitoring plan is summarized in the following programs, exemplifying a comprehensive approach to the mitigation of the project impacts. The implementation cost for the environmental programs is estimated in US$150'000,000, or 15% of the total value of the project according to COPEL.

a) Program for Public Health

COPEL furnishes the funds, and the administration is done by the Prefecture, who pays the services. The program includes training courses for nurses of the area to treat the workers of three municipalities, and epidemiology

campaigns.

b) Program for the Salvaging of the Archaeological Patrimony

This program is done in cooperation with the Parana Archaeological Museum.

c) Program for Disappropriation

A multidisciplinary study group was created among Prefectures, land owners, and the church, to discuss the most appropriate method of Disappropriation and the value of the land.

d) Program for Resettlement

The resettlement method is discussed and agreed upon owners, Prefecture and the church. Individual families depending on number of people receives a given amount of land, house, barn, water well, and electric energy.

In the case of resettling a whole community, the communal values are provided, such as church, school, cemetery, and social centre.

e) Program for the Rural Support of the Affected Communities

Local schools teaching skills directly applicable in the community economic activities are developed. The student alternates theory in school, and practice in the fields, with his father and family, then workshops are held at school where confrontations between theory and practice in the field are resolved while the student develops lecturing capabilities by communicating to his fellow students on his experience. The teacher acts like a monitor and intermediary between student and family.

Children to attend these schools are required to be sons of families directly affected by the project.

f) Program for the Multiple Use of the Reservoir

Multiple use of the reservoir includes recreation, fish culture, camping, boating, and water quality monitoring.

g) Program for the Establishment of Ecological Station

Includes the disappropriation of 2,000 ha of secondary forest, and the establishment of agreements with IAP, IBAMA, and specialized universities to undertake studies in flora, fauna, degraded areas and the like.

h) Program for the Recuperation of Degraded Areas

Includes the recuperation of areas such as workers camp, spoil banks, quarries and other areas affected by the project.

i) Program for Environmental Monitoring

The program includes the monitoring of activities causing alterations though construction and operation of the project. The objective is to implement corrective or emergency measures in case of detection of negative impacts.

The program includes the monitoring of:

i) Terrestrial Fauna
ii) Aquatic Fauna
iii) River Margin Vegetation and Islands
iv) Physical, Chemical and Biological parameters in the water
v) Sediment Deposition
vi) Climate
vi) Seismology
vii) Affected Families
j) Program for Reservoir Cleanup

Includes the retrieval of existing vegetation to avoid eutrophic conditions in the reservoir once filled with water.

(3) Solid Waste Disposal

1) Major Issues

The total volume of solid waste per day generated in the Iguaçu river estimated by IAP is approximately 2,200 MT/day. The major urban centers, their estimated volume and disposal system is summarized in the following table:

Table-6.7 Major Urban Centers and Municipal Solid Waste Disposal System in the Iguaçu River Basin

Municipality Name	Total Volume MT/day	MSW Disposal System (% of Total)		
		O. A	Recycling	Landfill
Curitiba	1000	nd	20	80
União da Vitória	20			100
F. Beltrão	30	10	P	P
Irati	20			100
P. Branco	40		5	95
Cascavel	100			100
Foz do Iguaçu	120*	100		

Source: L. Dudas, IAP, 1995

NOTES: MSW= Municipal Solid Waste, O.A.= Open Air, MT= Metric Tons, nd= No Data, P= Project Underway.

* Floating Tourist Population

These urban centers generate 56% of the municipal solid waste of the basin, the other municipalities are estimated to generate some 970 MT (44%) of the total for the basin, the system used for disposal goes from open air disposal to municipal landfill.

Data concerning disposal system being used in each municipality is being gathered until now by IAP. It is estimated that 56% of the total volume consists in organic matter, and that most of the municipalities have open air dumps.

Major problems associated with the municipal solid waste disposal are summarized hereunder:

a) Lack of proper equipment, or equipment capacity surpassing the real needs of the municipality

b) Most of the municipalities are disposing the solid waste in the open, without any sanitary measure. Only the municipality of Curitiba had so far an adequate landfill disposal system.

c) 95 % of the municipalities are considered to have horizontal urban growth tendencies, increasing more and more the distance between landfills and urban settlements.

d) Environmental education for recycling and adequate solid waste disposal is incipient in many municipalities.

e) Lack of planning in the allocation of the waste, and inefficient landfill Management are reducing the expected life of the landfills.

f) Reduced retention capacity in the existing MSW effluent treatment ponds of the Caximba landfill (Almirante Tamandare) is generating high BOD in the pond effluent.

2) Discussion

The present strategy being planned by IAP, for the centralizing of strategic landfills to attend several municipalities within a 20 Km range, instead of having one landfill per municipality is considered to have the following advantages:

a) Reduction of equipment needed.

b) Improved monitoring capability when less sites are available for control.

c) Centralizing solid waste could stimulate the private industry to manage the landfill as a business.

d) Pollution control of MSW effluent would be reduced to several sites, instead of one or several sites per municipality as it is today.

Environmental education and the stimulation of microindustry for the recycling of plastic, paper, glass, tin and organic compost is considered crucial for the reduction of MSW volume, increasing the life span of landfills, and for the raw material supply of goods that today have to be imported such as tin.

The elaboration of and environmental impact study before a given area and waste disposal system is implemented is recommended to help the implementation and Management of the area, and to reduce or ameliorate the foreseen impacts on the environment.

6.3 Tibagi River Basin

6.3.1 River Margin Vegetation

COPATI (35) has estimated 249,000 ha of river margin vegetation in the Tibagi river basin according to IMATER, 1980. The majority of these areas are located in the upper and middle Tibagi, and the most important causes for the depletion of these habitats are summarized as follows:

1) Expansion of the agricultural areas

2) Sand extraction

3) Wood extraction

4) Urban growth

According to IAP, no reliable data or monitoring system is available for the assessment and further rehabilitation of this vegetation type Section 7.3 deals with a proposed program for the monitoring and assessment of this resource. The historical base for the destruction of this resource in the Tibagi river basin is summarized under section 3.1.1.

6.3.2 Aquatic Fauna

(1) Fish

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 summarized below. Detailed list of species and research done on the ichthyofauna of the Tibagi river can be found in section 2.7.3 and Appendix -1 of this report.

Table-6.8 Most Abundant Fish Species Collected in the Tibagi River

Scientific Name	Common Name	% of Total
Astyanax bimaculatus	Lambari	12.6
Steindachnerina insculpata	Saguiru	9.7
Astyanax sp	Lambari	7.9
Hypostomus tietensis	Cascudo	6.3
Acestrorhynchus lacustris	Cachorro	5.8
Pimelodus maculatus	Mandiuva	5.6
Schizodon intermedius	Piava	--

Source: COPATI UEL (35)

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. Impacts on the environment are resembled by the following list of endangered fish:

Table-6.9 Endangered Fish Species Reported for the Tibagi River

Scientific Name	Common Name
Salminus hilarii	Tabarana
Salminus maxilosus	Dourado
Brycon sp	Piracanjuba
Prochilodus lineatus	Curimba
Leporinus elongatus	Piapara
Leporinus friderici	Piava
Schizodon intermedius	Piava
Pseudoplatistoma corruscans	Pintado
Steidachneridion sp	Surubim

Source: COPATUEL (35)

Other species subject to direct effect of proposed hydroelectric projects are the migratory species of fish. These species should be specially considered when dams are to constructed blocking access to other river sectors. The following table summarizes the 22 reported migratory species of fish in the Tibagi River.

Table-6.10 Migratory Species of Fish in the Tibagi River

Scientific Name	Common Name
Salminus hilarii (*)	Tabarana
Salminus maxilosus (*)	Dourado
Prochilodus lineatus (*)	Curimba
Leporinus elongatus (*)	Piapara
Leporinus obtusidens (*)	Piapara
Leporinus friderici (*)	Piava
Leporinus octofasciatus	Ferreirinha
Schizodon nasutus	Piava
Pseudoplatistoma corruscans (*)	Pintado
Steidachneridion intermedia	Bagre
Leporellus vitatus	Peba
Rhinelepis aspera	Cascudo preto
Pinirampu pirinampus	Barbado
Acestorhynchus lacustris	Peixe Cachorro
Astyanax bimaculatus	Lambari
Astyanax eigenmenniorum	Lambari
Moenkhausia intermedia	Lambari
Parodon tortuosos	Canivete
Apareiodon affinis	Canivete
Iheringichthys labrosus	Mandi
Pimelodus maculatus	Mandi
Plagioscion squamosissimus	Corvina

Source: COPATUEL (35)

(*) Also considered endangered.

The environmental impact on the fish resource and on the artisanal fisheries through pollution and dam construction is multiplied when the migratory species affected by the above impacts are also endangered and considered of commercial interest.

A total of 26 fish species of commercial interest are reported by UEL, IBAMA, artisanal fishermen and COPATI (35). From the reported fish species 50% are migratory, 27% are considered endangered, and only 15% are abundant. The following table summarizes this issue.

Table-6.11 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

Table-2.25 summarizes the most abundant fish species reported for the Tibagi river basin, and Table-2.26 shows the location of the most abundant fish species reported for the Tibagi river basin.

Environmental impact assessment studies for future hydroelectric projects in the basin should carefully consider the above issues. See Fig.6.11. The proposed sampling areas for a comprehensive fish population study of the basin are shown under Fig.6.3.

(2) 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. Up to 21 orders of benthonic macroinvertebrates were determined for the Tibagi river. Among them, 5 families are relevant. The following table summarizes these families.

Table-6.12 Main Benthic Macroinvertebrate Families Reported for the Tibagi River

Order	Family
Diptera	Chironomidae
	Ceratopogonidae
Ephemeroptera	Polymirtacyidae
Odonata	Gomphidae
Oligochaeta	Naididae

Source: COPATI/UEL (35)

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. Section 7.5 discusses this issue.

(3) Aquatic Bird Population

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. Section 2.8.1 of this report deals with the aquatic bird population of the state, while the following table summarizes the condition of this resource in the Tibagi river basin.

Table-6.13 Summary of Reported Bird Populations in the Tibagi River Basin

Habitat	Number of Species	%
Aquatic	56	22.4
Forest	142	56.8
Open Pastureland	61	24.4
Secondary Forest	62	24.8
Migratory	77	19.5

Source: COPATI (35)

Environmental impact is ultimately expressed in the extinction of a given species, in the case of the bird population, the following table summarizes the endangered bird population reported:

Table-6.14 Endangered Bird Species Reported for the Tibagi River Basin

Scientific Name	Common Name	Endangered Category
Dyocopus galeatus	Pica-Pau-de Cara Amarela	Vulnerable
Sarkidiomis melanotos	Palo de Crista	Indetermined
Columba speciosa	Pomba Irocal	Extinguished
Amazona vinacea	Papagaio-de- Peito-Roxo	Vulnerable
Amazona brasiliensis	Papagaio-Cara- Roxa	Vulnerable
Piprites pileatus	Caneleirinho-de-Chapeu-Preto	Vulnerable
Anthus nattereri	Caminheiro-Grande	Indetermined
Pipile jacutinga	Jacutinga	Endangered
Morphnus gujanensis	Uiracu-Falso	Rare
Leucopternis polionola	Gavião	Rare
Leucopternis lacernulata	Gavião-Pombo	Rare
Spizaetus ornatus	Gavião-de-penacho	Rare
Harpia harpia	Gavião-Real	Rare

Source: COPATI/UEL (35)

Out of the reported bird species, 5.2% (13 species) are considered endangered. Fig.2.14 summarizes the endangered species list of the state, Table-2.31 summarizes the bird families with aquatic habitats in the Tibagi river basin, and Table-2.34 lists the reported quantity of bird species occurring in the different aquatic habitats of the Tibagi river basin.

6.3.3 Lowlands Along Water Courses

Lowlands along river margins are located on alluvial soils appearing along river banks, usually associated with organic soils in poorly drained areas. These areas are flooded periodically, favoring hydrophilic plant species to dominate. The following table shows the approximate extension of these areas in the Tibagi river basin:

Table-6.15 Approximate Extension of Lowlands in the Tibagi River Basin

Location	Extension in ha
Tibagi River and Tributaries	16,509
Iapo River and Tributaries	31,883
Total	48,392

Source: COPATI (35)

This extension represents approximately 12% of the area reported by EMATER (410,719 ha) in 1981. The remaining area 362,327 ha (88%) has been drained and cleared and reclaimed for agriculture. Impacts on the aquatic environment have been outlined under section 6.3.3 of this report. Section 2.9.1 and section 3.1.1 summarize the

importance and the historical reasons for the destruction of this habitat.

More than 65% of the lowlands are located in the municipalities of Castro, Ponta Grossa and Palmeiras, and most of this area has been drained for the agricultural expansion of rice, soy, beans and pasture, according to COPATI (35).

By 1981 approximately 16.62% of the state lowlands were found in Tibagi river basin.

6.3.4 Conservation Units and Environmentally Sensitive Areas

(1) Existing Conservation Units

The Tibagi river basin has 28 federal, state, and county conservation units reported. The total area of these units according to its administration is summarized under Table-2.11. Some areas have just been recently declared, although not yet implanted (35)

Fig.6.4 shows the approximate location of the existing conservation units. The following table summarizes the existing problems reported by IAP.

Table-6.16 Summary of Problems Detected in the Existing State Conservation Units of the Tibagi River Basin

Name	M. Plan	Infra-structure	Eco-tourism	Problems
Caxambu S. P.	yes	yes	yes	- Degraded areas - Illegal fishing - Illegal hunting - No maintenance - Pirai river is polluted - M. Plan is operating
Geraldo Russi	no	no	yes	- Forest fire risk - Tourist pressure - Needed M. Plan
Córrego Biquinha	no	no	yes	- Forest fire risk - Tourist pressure - Needed M. Plan
Vila Velha S. P.	yes	yes	yes	- Forest fire risk - No maintenance - Visitors pressure - Exotic species - Erosion - No maintenance
Ibiporã F. P.	yes	yes	yes	- M. Plan not implemented - Urban pressure - Polluted waters
Saltinho F. R.	no	no	yes	- Forest fires - Need infrastructure - No M. Plan
Penhasco Verde S.P.	no	no	yes	- No maintenance - Forest fire risk - Soil use pressure - Erosion
Guartela	no	no	yes	- Forest fire risk - Soil use pressure - Erosion - Tourist pressure
Mata dos Godoy S.P.	yes	no	yes	- Urban pressure - Pollution - Soil use pressure - No M. Plan implemented
Escarpa Devoniana APA	-	no	yes	- Fire risk - Agricultural soil use and grazing

Source: Da Silva Pinheiro Evandro (IAP), 1995

Notes:

M Plan: Existing Management Plan, Eco-Tourism: Potential, ST: State Forest, APA: Environmental Protection Area, FR: Forest Reserve, EE: Ecological Station, SP: State Park, BG: Botanical Garden

Overall, the lower Tibagi region is the most deforested area in the basin, with only an estimated 9% of the existing basin forest coverage area, while 41% and 50% of the existing forest are located in the higher and middle Tibagi according to COPATI (35), these areas correspond to approximately 38,376 ha and 46,800 ha of native forest cover for the higher and middle Tibagi areas.

The total estimated native forest coverage area for the basin is 3.8% of the area, which is considered critical. See Table-2.41.

(2) Proposed Conservation Units

Significant forest remains can still be found in the middle and higher Tibagi. In these areas, significant river margin vegetation can also be found, particularly in the Tibagi river margins and its main tributaries.

Some of these forest coppices and river margin vegetation coincide with the location of surface water supply sources, Urban growth and housing expansion could eliminate such areas and affect the water sources, further studies are recommended, to define critical areas subject to urban pressure, and establish conservation units to avoid forest destruction and pollution of water sources.

Urban growth tendency towards important water sources has been pointed out by COPATI in the following municipalities:

1) Arapongas

2) Rolandia

3) Cambe