CHAPTER 3. PROJECTION OF WATER QUALITY

3.1 General

Water quality is subject to the conditional changes in pollution sources. Based on the present conditions discussed in Chapter 2, the baseline is estimated for the future conditional changes of water quality due to pollution without undertaking countermeasures. As identified in Chapter 2, the main pollution sources are the factories, piggeries, and households, as well as erosion and sediment transport within the Tuy River basin, and the magnitude of pollution is closely related to the size of these pollution sources. The basic mechanism of pollution is shown in Fig. 2.5-3.

As discussed later in Chapter 4, there are three main pollutants of water quality in the Tuy River, namely, organic substances, heavy metals, and turbidity, which are dealt within the baseline projection and referred to as BOD for organic pollutants and SS for turbidity as a reference of the quantity of substances in a river. For toxicants (heavy metals), a qualitative study was conducted due to insufficient data for quantitative analysis.

The BOD and SS calculation process is summarized as follows:

Item	Source	Parameter of pollution flow rate	Related economic indicator
BOD	factory	number of employees	industrial growth
	piggery	heads of pig	considered to be constant*
	residence	population	population growth
SS	factory	number of employees	industrial growth
	piggery	heads of pig	considered to be constant*
	residence	population	population growth
	sand quarry	number of employees	industrial growth
	basin erosion	land use	population growth

*: Refer to Section 3.2.4

In order to estimate and forecast the condition of BOD and SS in the future, two economic indicators are selected, namely, industrial growth and population growth.

Firstly, three basic patterns were considered for projection. In this study, it is assumed that the trend of indicators is independent in each pattern. The future trend is estimated according to three socioeconomic scenarios which are underlain by the national target, past performance, and the relation of the two. These are combined into the patterns below:

(1) Pattern 1, Standard : Combination of median estimation
(2) Pattern 2, High : Combination of highest estimation
(3) Pattern 3, Low : Combination of lowest estimation

3.2 Projection of Socioeconomic Conditions

3.2.1 Basic Pattern for Projection of Industry and Population

The three patterns are discussed in more detail regarding future changes in industrial and population growth.

Pattern 1 (Standard)

Pattern 1 is the combination of the median estimation. The following scenarios of industrial and population growth were considered for this pattern.

(1) Industrial Growth

Industrial growth is readily derived from the estimation of economic (GDP) growth. It is assumed that the rate of growth of industries in the Study Area corresponds with the national economic condition because the economy of Caracas, at the pace with the national economy, has a direct impact on industrial development in the Study Area.

(2) Population Growth

The existing study on population growth in the Tuy River basin, the "Scenarios of Land Occupation in the Tuy River Basin" ("Scenarios") prepared by the Ministry of Environment and Natural Renewable Resources in January, 1990 was used to make population projections.

The Pattern 1 (Standard) projection is a trend forecast, where the OCEI Population Census data in 1961, 1971, 1981 and 1990 for the municipalities concerned were used for the time series regression analysis. The resultant regression equation has the form of either natural or exponential. The dependency of each equation is expressed and confirmed by the correlation coefficient and T value. As regards populations of individual towns within "parroquias" (parishes), they were projected to increase at the same rate as the parroquia.

Pattern 2 (High)

Pattern 2 is the combination of the highest estimation. The following scenarios of industrial and population growth were considered for this pattern.

(1) Industrial Growth

In the Pattern 1 projection, the relationship between the economy and the economic activity of industry follow what they used be. In the Pattern 2 (high) projection, their relationships follow what the Plan envisages.

Under the Plan the industrial sector of the country is forecast to grow at the average annual rate of 8.0% and 9.5% during the periods 1999 to 2004 and 2005 to 2010, respectively. Here new relationships between the economy and industry are aimed for. It is clear that the government wants to put this sector

at the helm of economic progress. In this projection the growth of industry as a whole in the Study Area will follow the above rates with the relative position of each industry remaining as it is in the preceding projection.

(2) Population Growth

The Pattern 2 (High) projection follows the Middle Tuy Scenario in "Scenarios", as proposed by ORCOPLAN (*Plan Regional de Ordenacion del Territorio para la Region Capital*). The scenario considers the fact that the migration around the Caracas Metropolitan Area (CMA) is increasing, moving from the center to the outer suburbs as well as the Study Area due to growing constraints: space, infrastructure, economic opportunities and environment in the CMA. This trend results in the increase of the population concentration in the Middle Tuy River basin.

Pattern 3 (Low)

Pattern 3 is the combination of the lowest estimation. The following scenarios of industrial and population growth were considered for this pattern.

(1) Industrial Growth

In the Pattern 3 (Low) projection, the time series regression equation of the economy was obtained using GDP from 1986 to 1994 to estimate the future economic growth. The average annual growth rate was around 3% during this period. It is a unique condition that the past performances were considered with the exception of the national economic target in order to distinguish it from the Pattern-1 projection.

(2) Population Growth

The Pattern-3 (Low) projection follows the Intermediate Cities' Scenario in "Scenarios". It is an interpretation of PNOT (*Plan Nacional de Ordenacion de Territorio*). The scenario aims at the strengthening of remote, first and the second level regions, and cities (intermediate cities) to alleviate the population concentration of the central northern coastal region, by encouraging political and economic decentralization and environmental protection.

Comparison of Three Pattern

The comparison of the three pattern is summarized as follows:

(1) Industrial Growth

Projection Pattern	Description
Pattern-1 (Standard)	The regression relation between GDP (x) and industrial GDP (y) is established. Then, x is substituted by the future GDP projected by CORDIPLAN. As a result, the future industrial GDP is obtained. Finally, the future industrial GDP is compared with the industrial GDP in 1990.
Pattern-2 (High)	The future industrial GDP projected by CORDIPLAN is compared with the industrial GDP in 1990.
Pattern-3 (Low)	The regression relation between GDP (x) and industrial GDP (y) is established. Then, x is substituted by the future GDP projected by time-series regression equation. As a result, the future industrial GDP is obtained. Finally, the future industrial GDP is compared with the industrial GDP in 1990.

(2) Population Growth

Projection Pattern	Description
Pattern-1 (Standard)	The time series regression equation is prepared to project future population. Then, future population is compared with the population in 1990. This projection methodologically follows the trend analysis in "Scenarios of Land Occupation in the Tuy River Basin" (for short "Scenarios").
Pattern-2 (High)	An increasingly higher concentration of population in the Middle Tuy area is assumed due to spatial, infrastructural and other constraints in CMA. This projection is based on the Middle Tuy Scenario in "Scenarios".
Pattern-3 (Low)	An interspersing of the population in the central-northern-coastal region to the outlying first and second order regional cities is assumed for politico-economic decentralization and environmental protection. This projection is based on the Intermediate Cities Scenario in "Scenarios".

For the calculation of industrial growth, the following GDP growth is applied:

GDP Growth based on Past Performances and Future Projection by CORDIPLAN

GDP Growth	1990-1997	1997-1998	1999-2004	2005-2010
Annual	0.9%	6%	5.2%	6.2%
Periodic	6.5%	6%	35.5%	43.5%
Total (1990=1)	1.06.5	1.126	1.526	2.190
Ave. (1990-2010)	4.0%/year			

Summary of Results of Projection

As the results, the following projections are obtained:

(1) Projection of Industrial Growth

Projection Pattern	GDP Growth (1990 to 2010)	Industrial Growth (1990 to 2010)
Pattern-1 (Standard)	4.0%/year	4.3%/year
Pattern-2 (High)	-	5.8%/year
Pattern-3 (Low)	3.0%/year	2.5%/year

(2) Projection of Population Growth

Projection Pattern	Population Growth (1990 to 2010)
Pattern-1 (Standard)	4.7%/year
Pattern-2 (High)	5.3%/year
Pattern-3 (Low)	3.0%/year

3.2.2 Piggeries

At present the government policy is not to allow the establishment of new piggeries. Furthermore, the existing ones which do not follow the wastewater quality standard shall be closed and only those that follow the standard can continue operations. For this reason, it is assumed that the piggery business will not grow, but the status quo is maintained in the future. This assumption was applied to all three projections.

3.2.3 Land Use

One of the main pollutants in the Tuy River is turbidity, and in this study SS is selected as a parameter to express the degree of turbidity. Approximately 85% of the SS is from basin erosion and, accordingly, the volume of sediment production is closely related to the land use condition of the area. Future land use in the Study Area has been studied for the baseline projection.

Current Situation

The following table is the land use situation for the upper and middle basins in the study area in 1990.

Basin	Unit	Land use pattern						Total	Rate
		Forest	Bush	Savanna	Grass	Agri-culture	Urban		
Upper	km^2	201	404	110	136	110	35	996	53.7
	%	20.2	40.6	10.0	13.7	11.0	3.5	100	-
	%	71.8			28.2			100	-
Middle	km^2	85	338	43	51	294	49	860	46.3
	%	9.9	39.3	5.0	5.9	34.2	5.7	100	-
	%	54.2			45.8			100	-
Total	km^2	286	742	187	153	404	84	1,856	100
	%	15.4	40.0	10.1	8.2	21.8	4.5	100	-
	%	65.5			34.5			100	-

The Upper Tuy basin (or Upper Tuy) makes up 53.7% of the total area and the Middle Tuy basin (or Middle Tuy) the remaining 46.3%.

The combined area of natural lands (forest, bush and savanna) makes up 75.2% of the Upper Tuy basin and 54.2% of the Middle Tuy, while the total area of cultivated or land used for human activity (pasture, agriculture and urban areas) makes up 24.8% and 45.8%, respectively.

Observation of Changing Land Use

Lack of past data makes it difficult to do a more detailed analysis of changing land use in the Study Area. Comparing with the future trends, the observation is therefore limited to deal with the latest data at hand.

Based on sporadic data, in fact, the total agricultural area is estimated to be decreasing each year in Middle Tuy at around 3%. The area is either being turned into urban areas (including industrial areas) or it is being used for dam sites or roads.

The production of cereals, beans, sugarcane, coffee and horticulture sectors are sharing a tendency to decline while that of tuber vegetables and fruits is rising.

The livestock sector is not clearly defined but the numbers are tending to increase as a whole. The number of cows, pigs, and poultry are increasing. However, horses, mule, and donkey numbers are decreasing.

In contrast to the Upper Tuy, all agricultural sectors are increasing with the exception of pasture lands.

Future Trends in Land Use Conversion

Compared with the population, which is forecast to double in the Upper Tuy and triple in the Middle Tuy by 2010, the expansion of urban areas should coincide with this trend. Assuming the urban area increases at a rate two-thirds of the population growth, it will be 58 km^2 and 114 km^2 in the Upper Tuy and the Middle Tuy, respectively, or 172 km^2 in total. In other words the urban area will make up 5.8% of the Upper Tuy, 13.3% of the Middle Tuy, and 9.3% of the whole Study Area.

Industrial production in the Study Area is estimated to grow by two to three times by 2010. The industrial area now occupies 1.6 km^2 and 2.8 km^2 of the Upper Tuy and Middle Tuy, respectively, which is incorporated in the urban area and will expand to 3.2 km^2 and 5.6 km^2 in the two basins.

In conclusion, the agricultural area in the Middle Tuy is gradually decreasing while the urban area is increasing along with the growth of population and industry: Therefore, erosion will increase sediment production on watersheds. In the Upper Tuy, the pasture, agricultural and urban areas are forecast to expand thus reducing other areas, also leading to undesirable effect at least on sediment production. The condition of the land use change is summarized as follows:

Basin	Population growth rate	Land use conversion	
Upper Tuy	Based on basic projection patterns (Pattern 1 to 3)	Increase in agricultural land	2/3 of population growth rate
		Decrease in bush land	2/3 of population growth rate
Middle Tuy	Based on basic projection patterns (Pattern 1 to 3)	Increase in urban land	100% of population growth rate
		Decrease in agriculture land	100% of population growth rate

3.2.5 Projection Results

The results of the socioeconomic growth projections are summarized in the table below.

Projection Pattern	Industry			Population		
Year	1990	2000	2010	1990	2000	2010
Pattern-1 (Standard)	1.000	1.275	2.309	1.000	1.568	2.524
Pattern-2 (High)	1.000	1.311	3.075	1.000	1.634	2.819
Pattern-3 (Low)	1.000	1.193	1.634	1.000	1.381	1.815

Note: The growth of industry is finally indicated as the growth of the employment in factories (the Subsection 3.2.2).

This table is analyzed as follows:

As for the growth of industry, the number of employees rises 2.3 times in the target year of 2010 compared with 1990 at the average annual rate of 4.2% in Pattern 1. Similarly, in Patterns 2 and 3, the number rises 3.1 and 1.6 times at the annual rates of 5.8% and 2.5%, respectively. The number of employees in Pattern 1 is 35% larger than in Pattern 2 and 30% smaller than in Pattern 3 in 2010.

As for the population, it grows 2.5 times from 1990 to 2010 at the average annual rate of 4.7% in Pattern 2; in Patterns 2 and 3 it grows 2.8 and 1.8 times at the annual rates

of 5.3% and 3.0%, respectively. The population of Pattern 1 is 12% larger than in Pattern 2 and 28% smaller than in Pattern 3.

These industrial and population estimations are applied to water quality projection.

3.3 Baseline Pollution Projection

Baseline pollution projection has been conducted by indices, i.e., organic pollution (BOD) and turbidity (SS) as discussed below.

3.3.1 Organic Pollution

Calculation Method of Production and Effluent Load

BOD is selected as the indicator of organic pollution. Application of the pollution flow rate has been common for the calculation of BOD pollution. The pollution flow rates in the previous studies in Venezuela as discussed in Section 2.5 are deemed appropriate thus are used for the present study.

(1) Pollution Flow Rate at the Source

The pollution flow rate at the source is calculated as follows:

(a) Industrial Wastewater

The BOD pollution flow rate per number of employees determined by the category of industry (CIIU code) is applied. The applied value is as presented in Section 2.5.

(b) Wastewater from Piggeries

The BOD pollution flow rate of 162 g/pig/day is applied.

(c) Domestic Wastewater

The BOD pollution flow rate of 54 g/person/day is applied.

(2) Effluent Load

The effluent pollution load is calculated by multiplying the produced pollution load at each pollution source by the removal efficiency. The removal efficiency obtained through the water quality test before and after the treatment plant is applied. The values are as follows:

Sub-basin	Effluent ratio (%)
El Consejo	17.4
Las Tejerías	55.6
Qda. Guayas	46.8
Paracotos	94.7
Guare River and Tazón	98.7
Tama River	95.0
Charallave	83.7
Ocumare del Tuy	73.5

(3) Pollution Discharged into the River

The Streeter and Phelps's modified formula is applied. This formula is used in the RIOS model (see Section 3.5). Pollution reduction factor of "K" is considered for reduction in BOD.

Baseline Pollution Projection

Projected BOD production and effluent load by sub-basin in the years 2000, 2005 and 2010 are as presented in Table 3.3-1.

3.3.2 Toxicant

There is no applicable method to conduct future projection for toxicants in a quantitative manner. Since toxicants will be discharged more into the river in proportion to the increase of industry, toxicants in the river water will naturally increase unless measures are taken.

3.3.3 Turbidity

Calculation Method

Suspended solids (SS) are regarded as the index for turbidity. Production of SS is broadly divided into three sources of sediment production: land erosion, riparian sand quarries, and organic substances from factories, farms and households in the river basin.

The production of SS by basin erosion is calculated by the USLE method as discussed in Section 2.4. In the method, land coverage is one of the factors that affect the volume of sediment production. For the baseline projection, the land coverage factor is selected as a parameter to express future conditions.

The projection of the future SS from sand quarries and of organic substances is conducted based on the industrial and population projections.

Baseline Pollution Projection

Projected SS values at major points along the Tuy River in the years 2000, 2005, and 2010 are as presented in Fig. 3.3-1.

CHAPTER 4. IDENTIFICATION OF KEY ISSUES AND PROBLEMS RELATED TO ENVIRONMENTAL MANAGEMENT

4.1 Water Quality

A summary of key issues and problems for water quality is presented in Table 4.1-1 based on the discussions presented in the following subsections.

4.1.1 Identification of Key Issues and Problems

Based on the present conditions discussed in Chapter 2, it is concluded that the issues of water quality in the Study Area can be represented by three factors: (1) Organic Pollution, (2) Toxicants and (3)Turbidity.

<u>Organic Pollution</u>

Organic pollution is very serious in the Tuy River at present. BOD, the indicator of organic pollution, has been observed at more than 800 mg/l in the upstream and over 10 mg/l at the water intake point in the middle stream.

From the environmental viewpoint this is an abnormal condition because the river water cannot support aquatic life under these water quality conditions. According to the baseline projection of water quality, the BOD of the Tuy River in the year 2010 is 2,440 mg/l in the upstream and 14 mg/l at the water intake point in the middle stream.

Organic pollution damages the river water as a domestic water supply source in the following manner:

- Suspension of water intake.
- Increased use of chlorine having potential creation of organic chloride and resultant adverse effects on human health.
- Increased operation costs for treatment.

Suspension of water intake at Toma de Agua occurred 36 times a year on the average for three years from 1993 to 1995. Of these, 18 stoppages were the result of organic pollution, namely, odor, color and high chlorine demand.

<u>Toxicants</u>

Toxicants exceeding the Type 1B standard have been observed at several points along the Tuy River. Since toxicants have the potential of causing serious damage to human health for generations to come, the present condition is very serious when it is considered that the Tuy River is the source of water supply for domestic use in Caracas. Furthermore, the potential of contamination by toxicants will increase in accordance with the future increase of factories, although a quantitative projection cannot be done as aforementioned.

Turbidity

Turbidity is also an important factor of water pollution in the Tuy River. Turbidity in the Tuy River creates aesthetically unfavorable environmental conditions. The high turbidity in the Tuy occurs mainly during the rainy season when the total load of suspended solids becomes high. The load of suspended solids at Toma de Agua in the year 2010 is projected from the baseline projection as follows:

Projected SS at Toma de Agua in 2010

Point	SS (mg/ℓ)
Toma de Agua (water intake site)	1,080

Note: SS is approximately three times Turbidity in NTU, according to test results of the study. SS is of the value for the 95-day river flow.

High turbidity causes problems at the intake. Suspension of water intake shared 11 (31%) of the total suspension of 36 on average from 1993-95, the highest antong the causes of turbidity. High turbidity also causes a higher annual operation cost for the pre-treatment facility.

4.1.2 Pollution Source and Spatial Distribution

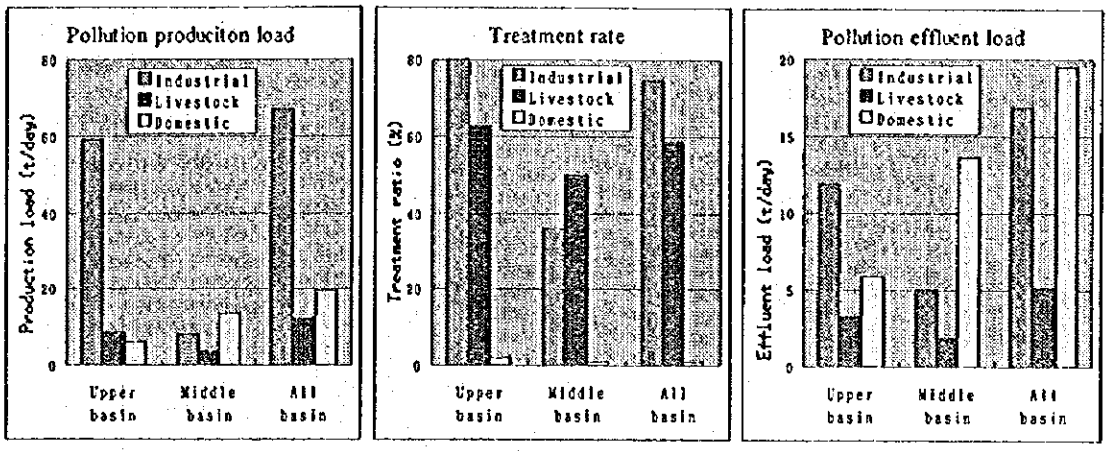
Pollution sources and their spatial distribution have been identified as follows:

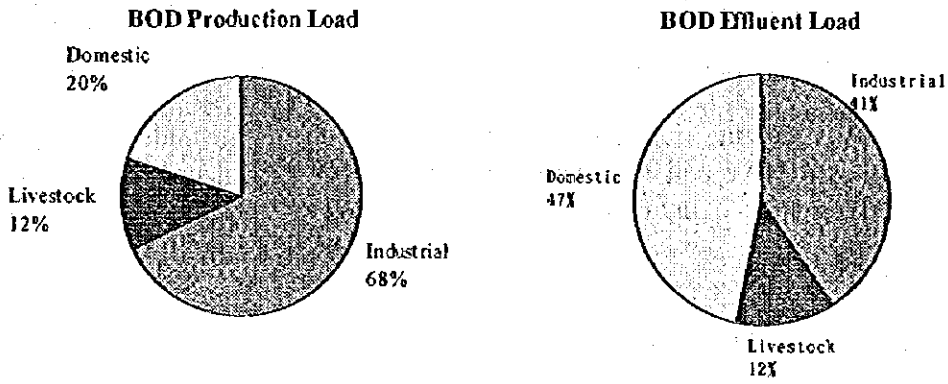
Organic Pollution

(1) Pollution Source

The sources of organic pollution in the study area are broadly divided into three; namely, industrial wastewater, wastewater from piggeries and domestic wastewater. The share of BOD production and effluent pollution loads from each source is summarized as follows (see Table 4.1-2):

Pollution production load, removal efficiency, and effluent pollution load are plotted for pollution from the upper, middle, and overall basin. It is apparent from the charts below that the removal efficiency of domestic wastewater is very low and thus there are high effluent pollution loads in spite of its moderate pollution production load. Resultantly, effluent loads due to industrial and domestic wastes are at similarly high levels. The domestic wastewater would warrant closer attention in addition to the industrial pollution.





For the entire study area, 68% of the total BOD production load originates from industry. That of domestic origin and from piggeries is comparatively less at 20% and 12%, respectively.

When the BOD effluent pollution loads are compared, the share of domestic wastewater becomes higher to 47% and that of industrial wastewater decreases to 41%. This is because the present removal efficiency of industrial wastewater is relatively high at 75% compared to the low removal efficiency of domestic wastewater of 1%.

(2) Spatial Distribution

Spatial distribution of the organic pollution sources in the Study Area is illustrated in Fig. 4.1-1 by the parameter of BOD effluent load by sub-basin and by pollution source (see Table 4.1-3).

The following can be deduced from Fig. 4.1-1:

- The BOD effluent load from factories and piggeries is relatively high in the upper basin, El Consejo and Las Tejerías;
- Domestic wastewater is a major source of pollution in the Qda. Maitana basin and the middle basin; and,
- The total BOD effluent load is high in the El Consejo, Las Tejerías, Charallave and Ocumare del Tuy areas.

Toxicants

(1) Pollution Source

Toxicants in the Study Area are heavy metals from factories especially those from non-food factories. These metals are found in the discharge of the following factories:

Heavy metal	Kind of factory
Pb	car parts
Cr	tannery, faucet factory, car parts
Cu	faucet factory, car parts
Zn	textiles

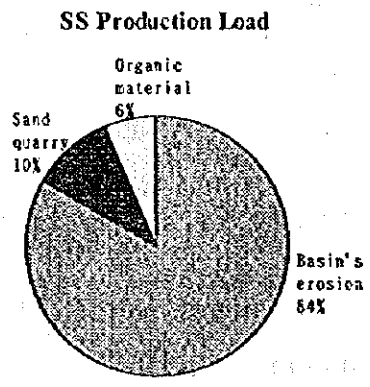
(2) Spatial Distribution

Most of the non-food factories are located in the middle basin, namely in Charallave and Ocumare del Tuy. A few are located in Las Tejerías and Paracotos in the upper basin (see Fig. 4.1-2).

Turbidity

(1) Pollution Source

Turbidity is discussed here using suspended solids (SS). The source of SS pollution is broadly divided into three: erosion, sand quarries, and organic pollution. Erosion includes sheet erosion in all the areas of the catchment basin, bank erosion of rivers, and from human related activities in the basin, e.g., land reclamation and road construction. The projected composition in the year 2000 is as follows:



Of the annual amount of total suspended solids, those from basin erosion make up 84%; sand quarries contribute 10%; and the share of organic material in the composition of SS is comparatively low at 6%.

(2) Spatial Distribution

As for the basin erosion, the sediment production volume is calculated by a 1×1-km grid as presented in Fig. 4.1-3. As seen in the illustration, the production is comparatively low in the moderately undulated areas of Charallave, Cúa, San Francisco de Yare and in the catchment of the Guare River basin. In other mountainous areas, no distinguishable differences were identified, i.e., sediment production occurs throughout the basin.

4.1.3 Technical Measures Adopted and Their Status

To the pollution sources identified above, some measures have already been applied. In this section, technical measures already adopted are identified and the status of these measures are confirmed for planning. Tables 4.1-4 and 4.1-5 summarize the results of the study.

Organic Pollution

(1) Factory

A wine distillery located in the upper basin is the factory having the greatest impact on the water of the Tuy River. A biological treatment plant has been introduced and the present BOD removal efficiency is around 95%. However, the concentration of BOD exceeds 2,000 mg/ℓ, even with the high removal efficiency. This level is still well above acceptable limits for effluent being discharged into the river.

In general, the removal efficiency of BOD by factories with biological treatment plants is above 95% for food factories, e.g., chicken meet processing, flour milling and dairy product processing. Furthermore, the removal efficiency of other parameters ranges widely, from 10 to 90% for SS. With regard to the installation of treatment plants, more than 50% of the total number of factories remain without any form of treatment. The low level of installation of treatment plants is due to financial difficulty, lack of knowledge of environmental issues, lack of technical knowledge for treatment plant, etc.

(2) Piggeries

The effect of piggeries on river water pollution is significantly different between piggeries with oxidation ponds and those without any treatment facilities. For example, in the case of a piggery located along Qda. Morocopo, pre-treatment is conducted to remove and compost solid wastes, and water is treated in three oxygenation ponds. Another example is the utilization of water from the oxygenation ponds for the irrigation of adjacent upland crop fields. In these cases, more than 90% of pollution can be removed. However, in the case of no treatment like the piggeries located along the Tuy River, 100% of wastes are discharged into the river. At present, 3 piggeries out of 33 have a treatment plant.

(3) Domestic Wastewater

The removal efficiency of domestic wastewater is presently very low in the Study Area. Although sewerage networks have been developed in many of the urban centers, treatment plants have not been installed. In the upper basin, oxygenation lagoons have been developed at three locations, but these are not utilized due to inappropriate maintenance of the related facilities.

Toxicants

Based on the interview survey results, 54% of non-food factories have treatment plants. Of the factories with treatment plants, 53% are equipped with physical-chemical treatment facilities, 13% are with separators (including those of removal of solid particles), 7% are with biological treatment, and the remaining 27% have other treatment facilities that include the storage tank.

With regard to Pb, one factory achieved a 53% removal efficiency. Other factories are below the measurable limit. The discharge from the factory with the removal efficiency of 53% still exceeds the standard to the river, and implies that there is a problem in the plant itself or in maintenance.

The removal efficiency of Cr vary widely between 20 and 72%. At two factories, the concentration after the treatment is higher than that before, indicating a possibility of inadequate operation and maintenance.

Also for Zn, the removal efficiency varies from 20 to 95%. At three factories, high concentrations were found in water after treatment. The removal efficiencies for Hg and Ni also have a wide range and high concentrations were found even from the sample after treatment.

Turbid Water

As discussed before, turbid water originates, chiefly, from erosion over the entire basin and sand quarries. Of these, sand quarries are considered as sources of industrial wastewater and the other is a natural condition although the destruction of the basin is due to human activities.

(1) Sand Quarries

Wastewater from sand quarries is from flushing water. In the case of sand quarries along the Qda. Maitana, 20 to 25 ℓ/sec of water is used. One site is equipped with two sand settling ponds and these are used alternately. Overflow water from the settling ponds flows into the river. Where there are no sand settling ponds high concentrations of suspended solids flow into the Tuy River.

(2) Erosion in the Basin

For the erosion in the basin, no measure has been implemented so far. Some riverbank protection works have been conducted along the Tuy River, but

these are mainly for the protection of bridges and not to protect the river from bank erosion.

(3) Measure at Utilization Site

As a measure at the water intake of Hidrocapital, a pre-treatment facility has been introduced and is presently operated.

4.2 Water Quantity

4.2.1 Identification of Key Issues and Problems

The Tuy I, II, and III water supply systems are literally the lifeline to the 3.6 million inhabitants of the metropolitan Caracas area. At present, Hidrocapital faces several problems in the operation of the current water supply system such as water sources and operation and maintenance of facilities including intake, pre-treatment, transmission, treatment facilities and distribution facilities, and institutional problems including the water tariff collection system. Thus, the problems spread in a wide range.

Among these problems, discussion in this section is made only for (1) shortage of water supply, (2) the water intake suspension from Tuy River, and (3) failures of the water supply system which are the concern of this study.

Shortage of Water Supply

As discussed in Subsection 2.8.1, the water supply capacity of the entire Metropolitan Caracas area was 19.5 m^3/sec for a population of 3.5 million in 1994, corresponding to 480 liters per capita per day which seems to be more than adequate. A daily amount of around 360 liters per capita is the water supply demand projected by MARNR, a reasonable figure for a city like Caracas.

However, when losses by treatment and distribution are included in the equation (according to data from Hidrocapital the efficiency of the system is around 80%), the actual supply falls to 384 ℓ/capita/day and the following problems arise from this amount:

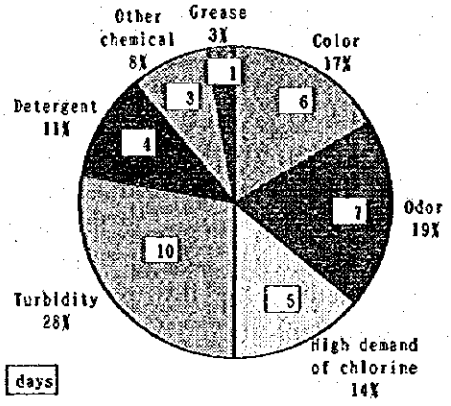
- In the dry season the amount of water actually supplied falls. In 1992, when Caracas suffered a particularly severe water crisis, the amount of water per capita dropped to 274 ℓ/capita/day (11.1 m3/sec). This occurred due to the shortage of storage capacity of the reservoirs in the whole system.
- During the rainy season, there are periods when water cannot be taken from the Tuy River due to deterioration of water quality including high turbidity. At such times water must be taken from other sources.

The situation is expected to be more serious in the near future considering the increase of future population at the growth rate of 2% corresponding to an increase of water demand of 0.4 m^3/sec a year.

Suspension of Water Intake

(1) Cause and Frequency

The average annual number of suspensions for 1993-95 was 36 times, with an average daily suspension duration of 8 hours. The breakdown of suspension by cause is as follows:



Organic pollution, namely, odor, color and high chlorine demand is the major cause of water intake suspension with the rate of 50% of the total suspensions. Turbidity caused 28% of the total.

(2) Effect of Suspension on the System

According to the operation records of the pre-treatment plant in 1995, the suspension condition is as shown in the table below:

Item	Record
Suspension Times	25 times
Total Suspension Hours	191 hours.
Average Suspension Hours per One Time	8 hours/times
Water volume not transmitted	2,725,000 m^3
Average Volume not Transmitted per One Time	109,000 m^3/times (= 3.8 m^3/s)

As shown in this table, Metropolitan Caracas is affected due to the suspension of intake which amounts to 109,000 m^3 per suspension (=3.8 m^3/s) and this amount corresponds to about 20% of the total supply volume of 19 m^3/s. As mentioned before, suspension occurs 36 times a year, corresponding to one in every 10 days. Along with the frequency and suspension volume, the suspension of intake causes problems from the aspect of securement of water quantity.

Failures in the Operation of the System

As mentioned earlier, Hidrocapital operates the complicated water supply system to assure the water supply. However, it is sometimes confronted with failures due to electrical and mechanical problems and others.

The following table shows the failures in the transmission operation of the Tuy systems in 1995.

Item	Tuy I	Tuy II	Tuy III
Frequency of failure	22	26	30
Failure duration (total)	166 hrs.	155 hrs.	202 hrs.
Average failure period	452 min.	404 min.	404 min.
Volume not transmitted per failure	73,365 m³	138,040 m³	174,138 m³
Total volume not transmitted	1.6 mcm	3.6 mcm	5.2 mcm

Failures in transmission attributed to certain factors are as follows:

Factor	Tuy I	Tuy II	Tuy III
Electrical Failure	14	14	13
Mechanical Failure	5	9	10
Others	3	3	7
Total	22	26	30

Among the three systems, there is not much difference in frequency, duration and period of failures. However, the water volume not transported is quite large in case of failure of the Tuy-III system. Thus, the influence of failure of the Tuy III system on water supply is large.

As for the factors causing failures, the electrical failure is dominant in all systems. The number of mechanical failures is also large for the Tuy-III system and this is mainly attributed to the maintenance problem of pumps and valves.

4.2.2 Measures Adopted

To cope with the problems on securement of water quantity, Hidrocapital has been taking the following measures:

Shortage of Water Supply

To counter present and future water supply shortages, Hidrocapital formulated a large scale and expensive plan, the Tuy IV system, but work on the system has slowed down due to financial difficulty. To ensure that the Tuy systems obtain the required water demand, Taguaza-Taguacita inter-connection is ongoing in order to transmit water stored in the Taguaza reservoir to the Tuy-II system through the Taguacita reservoir.

Suspension of Water Intake

In principle, to solve the problems on suspension of water intake, Hidrocapital expects the Tuy River Basin Agency to take measures to improve the water quality of the Tuy River, since the major cause of water suspension is the deterioration of river water quality.

Hidrocapital is considering several programs to improve the intake facilities and the pre-treatment system with the utilization of the existing Qda. Seca reservoir as the sand settling and oxygenation pond. The idea is to transmit the raw water taken from the Tuy River to the Qda. Seca reservoir to settle the suspended solids and to oxygenate the organic substances before transmission to the pre-treatment plant. The project is under study and is expected to proceed to the detail design in 1997.

Mitigation of Failures

To reduce the failure, Hidrocapital has taken several system improvement programs, which include the repair of the pumping station of the Tuy-I system in December, 1996. With the completion of the repair, the failure frequency of the Tuy-I system is expected to decrease. The rehabilitation of the Tuy System II in 1997 is also planned and improvement of Tuy-III will follow.

4.3 Institutional Measures Already Adopted and Their Status

4.3.1 Laws and Regulations

Legal Framework

The present condition of laws and regulations is discussed in Section 2.11. The legal framework, consisting of about 35 laws and regulations related to environmental problems, seems to cover the current environmental problems.

The water quality standard to conserve the environment is provided for the Tuy River. Under the water quality standard, activities of pollution sources are strictly regulated, namely, the operation of factories, sand quarries and piggeries as well as land development.

To strengthen the enforcement of the legal framework, a penal law regarding the environment is in force against offenders of laws and regulations. A tax reduction law was also enacted to encourage the preservation of a better environment.

In this connection, the present legal framework should be reinforced to give a more complete coverage with complementary laws and regulations in the following issues:

- To update the necessary items of the water quality standards.
- To update the current tax law to facilitate its application to beneficiaries.

- To introduce a new law to create a fund for the implementation of fiscal incentive schemes and to strengthen enforcement through the introduction of pollution charges.

Enforcement of Laws

The status of law enforcement is discussed as to monitoring system and punishment below.

(1) Monitoring System

The monitoring of water quality in the upper and middle streams of the Tuy River basin was proposed by GTZ and implemented by the Tuy River Basin Agency, but the number of monitoring stations, frequency and monitoring items are not sufficient in quality and quantity. Consequently, it is necessary to consider the possibility of reinforcing the present monitoring system in both quality and quantity.

(2) Punishment in Case of Violation

Considering that many laws and regulations (about 35) have been established regarding all the known environmental aspects and specifically concerning the Tuy River basin, it is certain that the legal framework has been almost settled. What is important is the enforcement of the laws.

For example, the Penal Law of Environment stipulates some action to persons who start forest fires. The punishment corresponds to one to five years in prison and fines of 1,000 to 5,000 DSM (Minimum Salary per Day). According to the collected information, punishments have not been handed out because it is so difficult to apprehend the perpetrators.

In the Forest Law of Soils and Water it is stated that, in case permission is granted to burn residues of tree felling around parcels having a width of about 5 meters, open fire shall be carried out by burning in small portions on the days without strong winds, etc. Since these conditions are difficult to check, the regulation is not obeyed.

4.3.2 Organization and Operational Management

Organization

The Tuy River Basin Agency was created by Decree No. 2,307 in 1992, but the setting up of the main structures of the institution is pending. According to the Decree, the Superior Council should be comprised of 4 members, the Advising Council of 97 members and the Executive Directorate of 9 members. Up to the present, however, only the General Manager in the last group has been designated by the Minister of MARNR; the other members have not been named yet after 3 years since the creation of the Agency.

In a sense the completion of the organization may produce a more strong institution capable of generating enough economic resources to comply with the purpose to which it was created.

Personnel Aspects

Basically the staff is sufficient in number and well trained, however, it is advisable to complete the training in environmental aspects such as monitoring, environmental inspections, procedures, etc. Also related to the legal regulations, constant training is necessary, especially for the personnel concerned with the activities of inspection.

Financial Aspects

As observed from the budgetary allocation for the Agency, personnel expenses (salaries) consist of more than two-thirds of the total budget, 483,351 out of 702,624 US dollars, reducing the budget for operations to a minimum portion.

Considering the magnitude of the work assigned to the Agency, the budget seems to be inadequate. Knowing that the total budget of the MARNR is 97,873,000,000 Bolivares (approx. 211 million US dollars) and the Agency's budget only represents about 0.3% of the MARNR budget, and considering that the beneficiary population in the Tuy River Basin approaches 5 million (almost 25% of total population), and also the area covers one of the most important industrial zones of the entire country (about 50% of the total), the Agency should be correspondingly strengthened financially.

Facilities and Equipment of the Tuy River Agency

At present the Agency is lacking in equipment and materials, for example, copying machine, printer, audio-visual equipment, vehicles, etc. Similarly, small purchases of paper, and several office supplies cannot be readily obtained because of the lack of a quick purchase system. Also the scarcity of funds is so extreme that the funds run out before the scheduled period.

In the field, the operative units have resource limitations (vehicles, daily allowances) for performing specific inspections and to follow up the activities of vigilance in the assigned areas related to allowed (authorized activities) or those prohibited in the area of the basin.

4.3.3 Public Awareness to Environment

Environmental education has been performed by the Programmatic Management of the Tuy River Basin Agency, having periodic meetings with the resident associations of the municipalities, with the mayors and others representatives of the civil society. Also, some seminars promoted by GTZ have been organized focusing on the manufacturers. Other activities are the publication of environmental issues in local newspapers, as well as participation in national or international events.

One of the aspects which is apparently lacking in public awareness in relation to the environment is the disposal of domestic garbage, which people usually throw over

nearby riverbanks with the intention of flowing them downstream. However, the garbage accumulates contaminating the waters.

Another factor to be taken into account is the large number of forest fires produced in the dry season. Even when there are sufficient legal regulations regarding the prevention of forest fires it seems that compulsory measures are inadequate. Also, countermeasures should be strengthened in order to quickly extinguish fires.

CHAPTER 5. POLICY FOR FORMULATION OF THE MASTER PLAN

5.1 Selection of Targets

Based on the objectives of the Study presented in Chapter 1 and taking into account the identified issues and problems presented in the previous chapter, targets for the Short Term and Mid Term programs have been selected as discussed below.

5.1.1 Short Term Program

Target Year

The target year for the Short Term Program is set at 2003.

Target Water Quality

Target water quality in the Short Term Program is set as the improvement of water quality at Toma de Agua (see table below). These are interim targets which are selected for the purpose of achieving the objectives of the Mid-Term Program.

Item	Description
Reference point	San Antonio (Toma de Agua)
Organic pollution	BOD of 3.5 mg/ℓ (proposed in the Study)
Toxicant	Type 1B in Decree No. 883
Turbidity	SS of 925 mg/ℓ (proposed in the Study)

Target Water Quantity

The target for the securement of water quantity has been defined as follows:

- Stable water supply to the Caracas Metropolitan Area.
- Securement of water for the demand increase in the Caracas Metropolitan Area.

To achieve the stable water supply to Caracas Metropolitan Area, it is important to maximize the use of water in the upper and middle streams of the Tuy River. Maximization of the use of water would be attained by utilizing water that would otherwise be wasted at Toma de Agua. It would resultantly reduce the dependency on the Tuy III system that has higher potential of water supply failures due to the long pipelines with many pumps.

For the securement of water for the demand increase in the Caracas Metropolitan Area, the concrete target has been obtained as follows: Hidrocapital is presently implementing Taguaza-Taguacita Interconnection Project. This project will increase the present amount of 19 m^3/s for water supply to the Caracas metropolitan area by approximately 1.5 m^3/s (8%). The increase of 8% will cover the population increase for approximately 4 years since the population increase rate in the area is about 2.2%. Consequently, a water shortage is foreseen after then unless new water sources are secured, because it will take a longer time to complete the Tuy IV system.

Accordingly, the concrete target for the securement of water quantity is: to develop by the year 2003 approximately 2.0 m^3/s of water that would otherwise be wasted in

the upper and middle streams of the Tuy River basin. The adequacy of this quantity, however, should be confirmed through a study on the availability of water resources in the study area.

With the addition of the newly developed water, suspension of the intake due to color and odor should be eliminated.

Item	Value
Monthly average secured water from the upper and middle streams of the Tuy River basin	4.0 m^3/s
Intake at Toma de Agua	2.0 m^3/s
Newly developed water	approx. 2.0 m^3/s
Reduction in suspension of intake at Toma de Agua	
Elimination of water intake suspension due to color and odor	13 days/yr
Reduction in water intake suspension due to high turbidity	5 days/yr

5.1.2 Mid-Term Program

Target Year

The target year for the Mid Term Program is set at 2010.

Target Water Quality

Target water quality in the Mid-Term Program is set respectively for the upper and middle basins to achieve a favorable river environment as follows:

Environmental improvement of the Tuy River in the upper basin targets dissolution of the present sewage-like condition. In the middle basin, improvement of water in the Tuy River focuses on securement of water with acceptable quality at Toma de Agua.

The target water quality to be achieved by the year 2010 is set for the upper and middle basins, respectively, as follows:

Basin	Upper basin	Middle basin
Reference point	Boca de Cagua	San Antonio (Toma de Agua)
Organic pollution	BOD of 60 mg/ℓ (Wastewater discharge criteria to the river in Decree No. 883)	BOD of 3 mg/ℓ *1 (proposed in the Study)
Toxicant	Type 1B in Decree No. 883	Type 1B in Decree No. 883
Turbidity	SS of 750 mg/ℓ Turbidity of 250 NTU (Type 1B in Decree No. 883)	SS of 750 mg/ℓ Turbidity of 250 NTU (Type 1B in Decree No. 883)

*1: BOD of 3 mg/ℓ is the limit for the conventional treatment.

Target Water Quantity

The target of water quantity for the Mid-Term Program is the securement of stable water supply for the Tuy I and II systems, amounting to approximately 4 m^3/s consisting of 2 m^3/s of average intake at Toma de Agua and approximately 2 m^3/s of newly developed water. This target is set because the intake of 2 m^3/s at Toma de

Agua would not be maintained if no measures for the improvement of water quality were undertaken.

5.2 Strategies for Application of Countermeasures

Countermeasures are to be studied and proposed to achieve the objective of the program on the basis of the identified key issues and problems as discussed in the previous chapter. Strategies for application of countermeasures are established in the following manner (see Fig. 5.2-1).

(1) Promotion of a higher removal efficiency for industries with enforcement of supporting system.

(2) Improvement in household wastewater removal efficiency.

(3) Introduction of measures in the River to improve water quality.

(4) Reduction in turbidity.

(5) Assurance of water supply source.

(6) Strengthening of institutional measures.

5.2.1 Promotion of a Higher Removal Efficiency for Industries with Strengthening of Supporting System

In order to improve the water quality of the Tuy River and accordingly reduce suspension of water intake at Toma de Agua, reduction of pollution effluent at each pollution source is very important and this is a basis of the plan. Pollution effluent from each pollution production source, e.g., factories, piggeries and sand quarry sites, should be below the criteria established in the law. Polluter Pay Principal (PPP) should be applied to industrial wastewater. Toxicants, organic pollution and turbidity from factories shall be controlled through this measure.

However, from the realistic point of view, the introduction of appropriate measures is sometimes not very easy for the factories especially those of small to medium scale. This is due to lack of funds, lack of technical knowledge, lack of incentive, etc.

Accordingly, in order to promote improvement of treatment at each factory, the provision and enforcement of a supporting system is deemed necessary. The concept of an environmental fund is proposed to this end, to the provision of a loan for the introduction and improvement of treatment plants.

For the actual introduction of treatment facility improvement, priority should be accorded to those related to the deterioration of water quality in color and odor.

5.2.2 Improvement in Household Wastewater Removal Efficiency

Identified as one of the key issues in the previous chapter is the necessity of development of sewage systems in order to raise the removal efficiency of domestic wastewater and hence to reduce total pollution effluent in the objective area. The present removal efficiency of domestic wastewater is very low at 1%. Even though sewage pipeline systems are developed, treatment plants are not constructed or not operating.

Treatment for domestic wastewater is divided into three: individual or combined septic tanks, middle scale public sewerage systems and large scale public sewerage systems. The optimum sewerage system is examined through the several cases of alternatives.

The effect of the treatment on the river will be confirmed through the application of pollution effluent model, e.g., RIOS Model.

An appropriate annual investment until the year 2010 shall be taken into consideration to decide the number of objective areas for treatment to be included in the Mid-Term Program.

5.2.3 Introduction of Measures in the River to Improve Water Quality

All other measures are to reduce pollution effluent load that flows into the river. Treatment measures in the river, on the other hand, are those to improve water in the river. A possible measure for water pollution reduction in the river is the retarding basin.

The measure will be studied in combination with the countermeasures for the reduction of pollution effluent to the river to achieve the target and to cope urgently with the condition before attaining the target.

5.2.4 Reduction in Turbidity

Turbidity is one of the most important factors regarding water pollution in the Tuy River. The major sources are erosion in the basin including those related to human activities and industrial activity (sand quarries).

Among the measures to reduce the erosion, the following should be considered in this study:

- Reforestation
- Sand settling ponds for tributaries
- A sand settling pond before pre-treatment at Toma de Agua

5.2.5 Securement of Water Quantity

Amount of water with sufficient quality will be increased when the water quality target is realized at the water intake of Toma de Agua. Direct measures for the securement of water quantity shall include the following:

- Utilization of spilling water at Toma de Agua through development of tributary water by torrent diversion.
- Utilization of spilling water at Toma de Agua through utilization of presently spilling water at reservoirs.
- Development of new dams.

5.2.6 Strengthening of Institutional Measures

Strengthening of institutional measures will include those identified in the previous chapter. Although further study is needed, the following will be taken into consideration.

Laws and Regulations

Laws and regulations are sufficient to a large extent. The following will be necessary to promote the implementation of the program.

- Introduction of BOD and SS as pollution indicators to the Tuy River.
- Necessary arrangement of laws for the establishment of the Environmental Fund and collection of pollution charge.
- Consideration of incentives like income tax reduction for investments in treatment plants.

Enforcement of Laws

Many of the present problems related to the environmental improvement of the objective area have causes in application of laws and regulations. The following action will be needed for the implementation of the program.

(1) Monitoring System

The proposed activities are the following:

- Installation of new stations or rehabilitation of the existing monitoring stations in order to make more accurate and sustainable measurements of water quality and quantity.
- Arrangement of the necessary equipment and facilities.
- Strengthening of the existing organization for monitoring.
- Reinforcement of the present laboratory or installation of another one exclusively for the Tuy River Agency.

(2) Punishment and Collection of Pollution Charge

Application of punishment and collection of pollution charge are deemed necessary along with the support system. Application of punishment and collection of pollution charge shall be promoted with enhancement of monitoring system and measures to level up public awareness of the environment.

Organization and Operational Management

Organizational, personnel and financial measures will be proposed on the basis of the present key issues and problems as presented in the previous chapter.

Public Awareness of the Environment

As discussed in the previous chapter, some activities have been conducted under the assistance of GTZ. In the present program, necessary items for public awareness will be identified and selected considering no parallel work under GTZ.

5.3 Sensitivity Analysis

As discussed in Chapter 3, three patterns, standard, high and low, are examined regarding the projection of future pollution production load. The measures to cope with the future increase of the pollution production load, in principle, are studied for the standard pattern. For the other patterns, sensitivity analysis will be made to achieve the target.

CHAPTER 6. FORMULATION OF THE MASTER PLAN

6.1 Study and Selection of Applicable and Optimum Measures

6.1.1 Structural Measures for Water Quality Improvement

For the formulation of the master plan, the applicable and optimum measures are examined, aiming at the reduction of pollution caused by organic substances, toxicants and turbidity.

Applicable Structural Measures

In accordance with the strategy for applicable measures as shown in Fig. 5.2-1, the following structural measures for pollution reduction are examined.

Kind of Pollution	Pollution Source	Measures at Pollution Source (Private Sector)	Measures at Pollution Source (Public Sector)	Measures at River (Public Sector)
Organic	Factory	Treatment Plant	Public Sewerage System*	Retarding Basin
	Piggery	Treatment Plant		
	Domestic Wastewater	Septic Tank	Public Sewerage System	
Toxicant	Factory	Treatment Plant	Public Sewerage System*	
Turbidity	Factory	Treatment Plant	Public Sewerage System*	Sand Settling Pond
	Basin Erosion		Watershed Management	

* For factories whose effluents are received by the public sewerage system.

Measures to Reduce Pollution from Factories and Piggeries

(1) Study Procedure for Factories and Piggeries

To cope with the organic pollution problem from factories and piggeries, the applicable structural measure is the installation of treatment plants in factories and piggeries. In principle, the selection of a suitable treatment plant and its installation to fulfill the water quality standard are the responsibilities of the factory and piggery owners. In this Master Plan study, the suitable treatment plant and the necessary cost to install the treatment plant are examined in the following procedure:

- Preparation of an inventory of factories and piggeries.
- Identification of installation and treatment conditions of the plant.
- Study on unit cost to treat wastewater from the factories and piggeries.

- Blocking the study area to estimate the treatment cost for factories and piggeries.
- Cost estimation of wastewater treatment plants for existing factories and piggeries.
- Cost estimation of treatment plants for newly built factories.

(2) Investigation of the Installation and Treatment Conditions of Plants

Tables 2.1-2 and 2.1-3 give an inventory of existing factories and piggeries. The number of factories in the list is 103 and piggeries, 33.

From the inventory, 40 factories and 10 piggeries were selected to investigate the installation and treatment conditions and to examine the unit cost to treat wastewater from the factories and piggeries so as to fulfill the water quality standard. Among those surveyed, 18 factories and 2 piggeries fulfill the water quality standard as shown below:

Group	Number of Factories	Number of Piggeries
(1) Factories and piggeries that fulfill the water quality standard	18	2
(2) Factories and piggeries with treatment plant but do not fulfill the water quality standard	9	5
(3) Factories and piggeries without treatment plant	13	3
Total	40	10

The suitable treatment plant for Group (1) above has been identified. The cost of the suitable treatment plant has been examined, as shown in Fig. 6.1-1.

(3) Unit Cost to Treat Wastewater from Factories and Piggeries

For the group of factories and piggeries which fulfill the standard, the unit cost to remove the effluent pollution load up to the level fulfilling the standard was examined. The unit costs obtained are as shown below.

Category (Factory/Piggery)	Average Discharge Wastewater Volume (ton/day)	Average Construction Cost of Treatment Plant (US$)	Unit Cost (US$/ton/day)
Food Related	317.0	404,924	1,277
Non-Food Related	106.0	208,724	1,963
Piggery	11.5	20,000	1,739

(4) Blocking of Study Area to Estimate Treatment Cost for Factories and Piggeries

In connection with the study on the sewage treatment plant, the study area is divided into several blocks and the treatment cost for factories and piggeries is

calculated for each blocked area. The treatment cost for existing factories and piggeries is US$ 14,055,000 in total, as shown in Table 6.1-1.

(5) Cost to Install Treatment Plants in Factories Built by 2003

In the future, it is expected that factories will be newly built as discussed in the baseline projection. The number of factories newly built by 2003 is 45. The cost to install treatment plants in these factories will be US$ 10,791,000, as shown in Table 6.1-2.

(6) Cost to Install Treatment Plants in Factories Built by 2010

Furthermore, the necessary cost for factories newly constructed by 2010 after 2003 is estimated. The number of factories newly built after 2003 up to 2010 is 75. The cost to install treatment plants in these factories will be US$18,606,000, as shown in Table 6.1-3.

(7) Cost to Install Treatment Plants to Reduce Odor and Color

As discussed in the key issues, 13 water intake suspensions at the water intake point occur in a year due to odor and color. Since it may be possible to reduce the water intake suspension with the installation of treatment plants for factories discharging the elements of odor and color at the earliest opportunity, the cost to install treatment plants at such factories is calculated.

The factories which discharge the elements of odor and color seem to be the industrial category of drinks and plastic products according to the interview survey results. The number of these factories are 6 at present and the cost of a treatment plant is US$1,692,000 as shown in Table 6.1-4.

Measures for Pollution from Domestic Wastewater

Water pollution problems due to domestic wastewater is focused on the improvement of sewage removal efficiency. To treat domestic wastewater, the following two systems are, in principle, applicable: (1) the public sewerage system for urban centers, and (2) the private sewerage system for individual houses by septic tank. Among these two systems, the public sewerage system which will be able to cover 76% of the total domestic pollution production load at present is examined. A study on the private sewerage is not made, because it is difficult to quantify the introduction of the private sewerage system by individuals and to practically evaluate the effect of the sewerage system. Besides, the pollution production load covered by the private sewerage system is not large compared with the public sewearge system.

In this study, the formulation of the public sewerage system is mainly examined in the following procedure:

- Study on areas covered by public sewerage systems.
- Selection of optimum treatment method for the public sewerage system.
- Study on independent vs. integrated sewerage system for several urban centers.

- Selection of priority areas for the public sewerage system.

Study has been made for each item as follows:

(1) Areas Covered by Public Sewerage System

In the Tuy River basin, a plan to provide a public sewerage system for major urban areas was studied by INOS in the 1970's, where the sewerage system is to be provided for areas with a population density of more than 40 persons/ha. In this present study, the same areas are proposed to be covered by sewerage system, as follows (refer to Fig. 6.1-2):

Urban Center	Area (ha)	Population (2010)	Density (person/ha)
El Consejo	710	39,000	54.8
Las Tejerías	619	31,000	49.8
Cúa	3,978	159,000	40.0
Charallave	4,736	199,000	42.1
Ocumare del Tuy	3,738	152,000	40.7
S. F. de Yare	680	30,000	44.4

(2) Selection of Optimum Treatment Plant

Four of the most common types of treatment plants in Venezuela are (1) Stabilization Pond System Process, (2) Simplified Activated Sludge Process (Aerated System), (3) Trickling Filter Process, and (4) Conventional Activated Sludge Process. The comparison of several factors to decide the type to be introduced are shown in the following table.

Factors	Stabilization Pond System	Aerated System	Trickling Filter	Activated Sludge
BOD Removal	*	**	**	**
System Stability	-	**	**	**
Simple Operation	**	-	**	-
Land Acquisition	-	**	**	**
Sludge Removal	**	**	**	-
Cost	**	*	*	-

** Good * Fair - Poor

Judging from the table above, the trickling filter process (third type) is preliminary selected as the optimum sewerage treatment plant in this study, though further study is required in the Feasibility Study stage. The flow sheet of these sewerage treatment plants are shown in Fig. 6.1-3.

(3) Independent vs. Integrated Sewerage System for Several Urban Centers

Although there are varying distances among the urban centers for the application of a public sewerage system, it is necessary to examine the advantages and disadvantages of the following combinations of integrated sewerage system for urban centers.

Case 1	One integrated sewerage system (Combination of all urban centers in the study area).
Case 2	Two integrated sewerage systems (One combination for all urban centers in the upper stream and another for all urban centers in the middle stream).
Case 3	Several integrated sewerage system (Combination of several urban centers in the upper stream and the middle stream).
Case 4	Independent sewerage system for each urban center.

For economic comparison, the costs of land acquisition, sewage treatment plant and transmission pipe between urban centers are considered. The cost for the installation of sewerage pipe inside urban centers which is necessary in all cases is not included.

The comparison results are shown in Table 6.1-5. The cost comparison shows that Case 4 has an economic advantage; hence, it is applied to formulate the sewage system plan.

(4) Selection of Priority Area for Public Sewerage Systems

The priority area to install a sewerage treatment plant is selected from the viewpoint of effectiveness to reduce pollution to the target point:

- RIOS model is used to identify effectiveness.
- For production pollution load, that of the year 2010 is adopted.
- The BOD effluent pollution load from factories is assumed to be 350 mg/ℓ after treatment in accordance with the water quality standard.
- As the design wastewater, the following values are adopted: design maximum daily wastewater of 388 liters and design average daily wastewater of 272 liters (70% of design maximum daily wastewater) which are based on the report "Saneamiento del Rio Tuy Venezuela PN 90.2241.9-01.100".
- The area for the construction of sewerage treatment plant is calculated assuming that the necessary area is 4 ha for 10,000 m^3/day of design wastewater volume.
- The construction cost is calculated applying the unit cost of US\$98/m^3 for wastewater based on the interview survey results.
- O&M cost is calculated applying the cost of US\$8/m^3 for wastewater.

Based on the above conditions, the effectiveness of the sewage treatment plant has been evaluated by the reduction effect of pollution.

The study results are shown in Table 6.1-6 and Fig. 6.1-4. Judging from the table, the effectiveness of a treatment plant is the highest at Ocumare del Tuy, followed by S. F. de Yare. Although the effectiveness at El Consejo and Las

Tejerías is not so high, these areas are effective to improve the water quality at Boca de Cagua which is also a reference point to achieve the target.

The relation between effectiveness and cost is shown in Fig. 6.1-5.

Measures to Reduce Organic Pollution in River (by Storage Pond)

Besides the sewage treatment plant for factories and piggeries and the sewerage system for urban centers, organic pollutants in a river can be reduced by providing a storage pond as oxygenation pond.

The effectiveness of the storage pond is examined under the following conditions:

- Proposed site of storage pond: Las Tejerías and Cúa considering the geographical and pollution conditions.
- Area and size of storage pond (assuming one day of retention time and BOD load rate of 80 kg/ha):

Site	Area of Pond (ha)	Capacity (m^3)	Depth (m)	BOD Load per ha. (kg/ha/m)
Las Tejerías	70.0	1,050,000	1.5	5,600
Cúa	9.5	142,500	1.5	760

The construction cost of the storage pond is estimated as follows:

(Unit: Bs. Million)

Item	Las Tejerías	Cúa
Excavation	1,050	142.5
Land Acquisition	700	95
Intake Facilities	40	20
Total	1,790	252.5

The effectiveness of the storage pond is as shown below:

(BOD mg/ℓ: Year 2010)

Target Point	Without Storage Pond	With Storage Pond	
		Las Tejerías	Cúa
Boca de Cagua	205	152	-
Toma de Agua	9.5	9.5	9.4

Judging from the table, the effectiveness of a storage pond to reduce pollution load at Toma de Agua is not expected and thus, construction of a storage pond is not recommended.

Study on Reduction of Toxicants

The study on the reduction of toxicants is conducted as discussed below.

(1) Applicable Measures

As shown in the present condition, Section 2.1, the source of toxicants seems to be the effluent from non-food factories, and the applicable measure to control the toxicants is the installation of factory treatment plants.

The treatment plant to control the toxicants has been examined by factory owners to comply with the requirement of the agency concerned. According to the results of the interview survey to factory owners, there are two applicable treatment methods for toxicants: (1) chemical sedimentation method and (2) dissolved oxygen method.

(2) Proposed Measures

As to the control of toxicants from factories, it may be possible to pinpoint factories that discharge toxicants, because their number is limited. Therefore, it is proposed that all factories which are found to be discharging toxicants in the Study Area shall be required to install a treatment plant irrespective of the area at the same time.

(3) Cost for Installation of Treatment Plant

The number of factories discharging toxicants at present is 12. Since these factories do not have treatment plants to fulfill the standard, it is necessary for them to install a suitable treatment plant. The cost of a treatment plant is US$365,000, which can be obtained by multiplying the unit cost of a treatment plant of US$1,963/ton/day with the number of factories.

As for the factories to be built in the future, it is assumed that they will install a treatment plant when they start their operations.

Study on Reduction of Turbidity

As discussed in setting the target, the necessity to reduce turbidity that is mainly caused by suspended solids (SS) is from the following two reasons: (1) to secure water supply quantity, and (2) to improve water quality from the environmental viewpoint.

In this context, the optimum measure is examined in two cases: Case 1, to secure water quantity, and Case 2, to improve water quality. In the former case, the target is to decrease the frequency of suspension of intake at the water intake point through the reduction of high turbidity which mainly emerges in flood time. In the latter case, the target is to reduce turbidity under normal flow conditions over the entire basin.

(1) Case 1: To Secure Water Quantity

(a) Applicable Measures

Judging from the river conditions, the following measures against high turbidity are proposed to be taken to secure water quantity:

For SS from basin erosion:

- Reforestation to reduce soil erosion from exposed areas.
- Sand settling pond to reduce suspended solids in turbid water of tributaries.
- Sand settling pond to reduce suspended solids at the water intake point.

For SS from factories:

- Factory treatment plant.

Among these applicable measures, the study on optimum measures puts emphasis on soil erosion because the turbidity problem is mainly caused by soil erosion. It also examines the factory treatment plant to control other effluents together with turbidity.

(b) Outline of Measures and Effectiveness

(i) Reforestation

It has been identified that soil erosion in the basin is abundant from the denuded area due to logging operations and land development, and one of the effective measures to control soil erosion is reforestation.

To examine this measure's effectiveness, the production of suspended solids is calculated for each tributary area to be reforested excluding the present forested, bush and urban areas. Calculation is performed using the experimental "Universal Soil Loss Equation" discussed in Subsection 2.4.3, and the results are shown in Table 6.1-7.

In the results, the three most efficient tributaries are selected. SS reduction volume per unit area of reforestation at each tributary and the removal efficiency of actual total SS volume at the water intake point are as shown in the following table (refer to Fig. 6.1-6):

Tributary	Reforestation Area (km^2)	SS Removal Volume (m^3/year/km^2)	Removal efficiency (%)
Qda. Maitana	40	642	4.6
Qda. Guayas	16	616	1.8
Cagua River	46	579	4.7

The effectiveness of reforestation is considered in three cases, cumulatively combining the areas of the above tributaries for higher efficiency.

(ii) Sand Settling Pond on Tributaries

The function of the sand settling pond is to settle and thus reduce suspended solids in diverted water and to return less turbid water to the river. Such ponds are proposed to be provided on four tributaries which are heavy contributors of sediments upstream, namely, upper Tuy River, Qda. Guayas, Qda. Maitana and Guare River. (Refer to Fig. 6.1-7.)

To evaluate the effectiveness, the discharge is prepared by the annual duration curve explained in Subsection 2.4.3, and the pond size is examined in the following three cases (refer to Fig. 6.1-8):

Case 1	70% of discharge volume is diverted from tributaries to the pond.
Case 2	60% of discharge volume is diverted from tributaries to the pond.
Case 3	50% of discharge volume is diverted from tributaries to the pond.

The effectiveness of the sand settling pond is as shown in Table 6.1-8.

(iii) Sediment Settling Pond at Water Intake Point and Qda. Seca

To reduce turbidity at the water intake point, the following two measures are considered: (1) construction of the sand settling pond near the water intake point, and (2) utilization of existing Qda. Seca reservoir. The former measure is designed to flush out the sediment from the pond utilizing the flushing force of the flow by operating the gate at the pond (refer to Fig. 6.1-8). The latter which utilizes the part of the existing reservoir of Qda. Seca providing a small dike is necessary to remove the deposited sediment and keep a space for sediment deposition.

To evaluate the effectiveness, the following cases of pond size are taken into consideration:

Construction of Sand Settling Pond

Case	Settling Pond Size (m)			SS Removal Efficiency (%)
	Length	Width	Depth	
1	130	40	3.1	47.4
2	100	40	3.3	45.5
3	70	40	3.6	42.9

In these cases, 40 m of width and 1 m of effective depth are fixed to keep the flow velocity lower than 0.2 m/s. Depth in the above table includes the sediment deposited depth and the effective depth.

On the other hand, for the above measure, Hidrocapital is planning to use a part of the Qda. Seca reservoir as a sedimentation and oxygenation pond by providing a dike inside the reservoir to cope with the high turbid and polluted water of the Tuy River as shown in Fig. 6.1-9.

In this connection, it is necessary to confirm the advantage of the sand settling pond proposed before the intake.

Case	Settling Pond Size (m^2)	SS Reduction Rate (%)
1	3,000	48
2	5,000	71
3	7,000	79

Considering the maximum water level and the cleaning of the sand settling pond, the depth is set at 6.5~7.0 m with inclining bottom.

The sediment volume to be dredged is calculated by applying the monthly discharge data from 1993 to 1978 and assuming different reservoir sizes; 3,000 m^2, 5,000 m^2 or 7,000 m^2.

Table 6.1-9 shows SS and sediment volumes settled in the three cases of pond size. Their annual sediment flowing into the pond is estimated at 235,140 m^3, while the settled sediment volumes for the three sizes of ponds are estimated at 113,420 m^3, 166,060 m^3 and 185,930 m^3.

(c) Comparison of Alternatives

Table 6.1-10 shows the economic comparison of alternatives in a manner of Cost-Benefit ratio (B/C) and net present value (B-C). In this table, the benefit and cost are considered, as follows:

(i) Benefit

- Reduction of necessary maintenance cost to reduce the turbidity for water supply at the existing pre-treatment facility.
- Increase of water supply volume resulting from the decrease of frequency of water intake suspension due to high turbidity.

(ii) Cost

- The cost required includes the initial cost and the operation and maintenance cost for each case.

Based on the table, the optimum measure is the construction of a sand settling pond at the water intake point.

(2) Case 2: To Improve Water Quality from the Environmental Viewpoint

(a) Applicable Measures

The measures to reduce turbidity from the environmental viewpoint are the following two cases which were narrowed down from the measures considered in Case 1. The sand settling pond at the water intake point and utilization of Qda. Seca reservoir are eliminated, because those are only effective to assure water quantity but not the environmental impacts.

- Reforestation to reduce soil erosion in the waste area.
- Sand settling pond to reduce suspended solids in turbid water in tributaries.

(b) Optimum Measure

The outline of the two measures and their costs are the same as in Case 1 above, but the benefits are evaluated from the environmental viewpoint.

However, from the environmental aspect it is difficult to calculate the benefit to improve turbidity in monetary terms. Therefore, the optimum measure is selected by the comparison of costs to reduce the volume of turbidity.

Fig. 6.1-10 shows the relation between the unit cost and the reduction volume of the two measures. According to the figure, there is a turning point in the advantage and disadvantage of unit cost between the two measures. Reforestation is economically advantageous when the SS reduction volume is below 60,000 m^3, while the sand settling pond is advantageous when the reduction volume is 60,000 m^3 and above.

At present, turbidity is estimated at less than 900 mg/ℓ for a 25% daily discharge in annual duration curve and this value will increase to

1,080 mg/ℓ at the year of 2010 due to future land development. However, the target for the year of 2010 is set at 750 mg/ℓ.

Under these circumstances, it is necessary to introduce the measures of reforestation and sand settling pond to reduce turbidity from 1,080 mg/ℓ to 750 mg/ℓ. The reduction volume of 330 mg/ℓ is shared between reforestation and sand settling pond, i.e., 110 mg/ℓ by reforestation and 220 mg/ℓ by the sand settling ponds in four tributaries.

6.1.2 Securement of Water Quantity

A master plan study and pre-feasibility studies have been conducted for the securement of water quantity. This section summarizes the results of these studies (for details, see Sector F and the main report for the feasibility and pre feasibility study).

Applicable Measures

Applicable measures for the securement of water quantity in the upper and middle streams of the Tuy River basin are as follows:

(1) Torrent Diversion

Water of tributaries are taken and diverted to the existing reservoirs or to regulation ponds to minimize spill at Toma de Agua in the rainy season.

(2) Effective Utilization of Existing Reservoirs

Ocumarito Reservoir is full to capacity for 4.3 months of the year on the average. During this period, water is spilled from Ocumarito Reservoir and finally flows down at Toma de Agua. Accordingly, the utilization plan for the Ocumarito River is studied to minimize spill at Toma de Agua in the rainy season.

(3) Development of New Dams

Construction of dams on tributaries to minimize spill at Toma de Agua in the rainy season is considered. Guare Dam and El Peñón Dam are the possible ones.

The optimum plan for each alternative measure is studied and determined. A master plan study has been conducted for the torrent diversion plan. For the utilization plan of the Ocumarito River, Guare Dam Plan and El Peñón Dam Plan, pre-feasibility studies have been conducted.

Summary of the Study Results

The following table compares the efficiency of the optimum case of each plan, Annual Net Present Value (B-C), Benefit-Cost Ratio (B/C), and unit cost per cubic meter of water.

Plan	Capacity	Ave. annual diverted water		Const. Cost *3	B-C *4	B/C	Unit Cost
		$10^6m^3/yr$	m^3/s	$mil	$mil/yr		$/m^3$
Torrent div. of Súcuta	Q=1.34	5.84	0.19	16.4	-0.06	0.97	0.337
O-L div. *1	Q=2.0 m^3/s	10.2	0.32	19.4	1.01	1.43	0.228
O-L div with El Peñón Dam	Q=2.0 m^3/s	13.9	0.44	41.0	-0.61	0.88	0.371
O-Tuy III pumping	Q=5.0 m^3/s	20.3	0.64	9.88	4.00	2.52	0.130
Guare Dam	Eff.40×10^6m^3 *2 Dam height: 61m	55.4	1.76	76.1	8.19	1.82	0.179

Note: *1: O-L div:: Ocumarito-Lagartijo diversion
*2: Effective storage capacity
*3: Construction cost
*4: Unit benefit is $0.327

(1) Torrent Diversion

Torrent diversion is not selected for implementation because B/C is less than 1.0.

(2) Utilization Plan for Ocumarito River

In case of the Ocumarito-Lagartijo diversion plan without El Peñón Dam, the optimum development scale is a capacity of 2 m^3/s. In this case, an amount of 10.20×10^6m^3 of water (an annual average of 0.32 m^3/s) will be developed at the unit construction cost of US$0.228/$m^3$.

If the construction of El Peñón Dam is considered, an additional 3.66×10^6 m^3 (an average of 0.12 m^3/s) is obtained, at the annual construction cost of US$2.81 million. This means that the construction of El Peñón Dam costs US$0.768/$m^3$.

On the other hand, the unit construction cost of the Ocumarito-Tuy III pumping plan pipeline is relatively low at US$0.130/$m^3$. In this case, the annually developed water is 20.3×10^6m^3 (an annual average of 0.64 m^3/s).

In conclusion, for the use of the Ocumarito River, the pumping plan with a capacity of 5 m^3/s is recommended.

However, it should be noted that in the case of Ocumarito-Lagartijo diversion, it could be used as an emergency route, i.e., water from Camatagua could be sent through this diversion if the Tuy III pipeline had a problem,. In the case of pumping plan to Tuy III pipeline, this emergency function could not be obtained.

It is recommended that the following hydrological observation is conducted for the detailed study in the future:

- Daily record of inflow and release at Ocumarito Dam.
- Daily record of water released at Caicita.

(3) Guare Dam Plan

The optimum scale of the proposed Guare Dam has been determined at $40\times10^6m^3$ of gross storage capacity with a dam height of 67 m. The annually developed water is $55.4\times10^6m^3$ (equivalent to an average flow of 1.76 m^3/s).

The unit construction cost is estimated at US\$0.179/m^3. This is competitive to the US\$0.262/m^3 of the presently ongoing Taguaza-Taguacita interconnection.

It is recommended that a study be conducted to examine the feasibility in more detail. The study should include the possible option of water diversion from the proposed dam. The following hydrological observations should be initiated.

- Daily record of water level at the proposed Guare damsite.
- Periodical discharge measurement to develop a H-Q curve.

6.1.3 Study on Institutional Measures

Improvement Plan for Laws and Regulations

As mentioned in Section 2.10, Institutional Arrangement, there are about 35 laws and regulations concerning the environmental aspects which comprise matters like mining, forestry, erosion and sedimentation, water quality, discharge of liquid effluents, territory ordination, urban ordination, piggery activities, environmental safeguards, management of solid residues, etc.

It seems that the current environmental problems are already covered by this legal framework. In this connection, the issues of the current legal framework will be to give a more complete coverage of current legal frame work with complementary laws and regulations in the following points.

- To complement the current tax law to facilitate its application for beneficiaries.
- To introduce a new law to create a fund for implementation of a fiscal incentive scheme.
- To complement the necessary items of water quality to the current water quality standard.
- To introduce a new system to impose a kind of penalty.

The following is the summary of the improvement plan for each item:

(1) Tax Reduction

Decree No. 1,302 of October 8, 1986 published on October 10, 1986 had the objective of establishing incentives to persons who make investments in equipment, civil works or facilities for the conservation, safeguard and improvement of the environment. In Art. 3 of such decree is defined a limit of 10% income tax reduction for non-local equipment and 15% reduction in the case of local equipment.

The current Income Tax Law published on May 25, 1994 and December 18, 1995 (revised) also includes the environmental aspect and it can be applied to the tax reduction, though the application has not been practiced. However, the contents of the regulations are unclear and ambiguous. Also lack of legal information to the beneficiaries results in loosing the chance to apply the tax reduction law.

In this sense, it is necessary to make the beneficiaries notice the application of the current law through an educational program.

(2) Environmental Fund

An Environmental Fund (EF) is proposed for the implementation of part of the program contained in this Master Plan.

The resources of the EF will be used to finance a soft loan for wastewater treatment facilities of factories, sand quarries and piggeries which do not have the financial capability to absorb the investment cost, or because of high priority given by the government due to their polluting effects.

The Tuy River Basin Agency shall establish the priorities for financing pre-investment studies and the realization of the works, depending on the location, used water volume, pollution loads, type of production process, economic activity, proposed treatment, etc.

At the pre-investment stages the EF will allow the elaboration of pre-feasibility, feasibility and design studies of treatment facilities. Projects of effluent treatment plants for a group of small or medium size factories or piggeries shall have high priority for inclusion in this program.

The financial aspects of the proposed Environmental Fund are considered in the corresponding section.

(3) Classification and Water Quality Standards

Decree 883, published in December 1995, in its Article 5 states that classification of each water body will be made by the national executive, and specific standards on effluents also will be classified.

Considering the fact that the water of Tuy River has not been specifically classified and Decree 883 does not consider the standards for BOD in the case

of water Sub-type 1B or the standards for SS, it is deemed necessary to elaborate the specific standards for Tuy River.

(4) Pollution Charge

It is proposed that pollution charges be introduced for factories and piggeries in the context of law enforcement. The main purpose is to charge polluters in accordance with their pollution effluent load. Increasing the charge periodically to take into account the delay in complying with the regulations and the relative damage to the environment is also considered.

Organization

For the implementation of the Master Plan, MARNR will act as the counterpart institution, and the offices of the Tuy River Basin Agency and Hidrocapital will directly coordinate the execution of the project.

Considering the specific purposes for which the Tuy River Basin Agency has been created, the Agency has the responsibility to execute plans, programs and projects of environmental management, and to execute works directed to environmental sanitation as well as promote and coordinate the necessary financing for the execution of the works of environmental conservation either for the public or private sector.

In the case of Hidrocapital, it has the duty to guarantee potable water, and should assume such responsibility. Therefore, at the stage of project execution, the Tuy River Basin Agency will participate through the Management of Studies, Planning and Projects Department for the physical execution and through the Office of Administration and Budget for the financial execution.

Considering that in the Tuy River Basin Agency there is no experience with projects of this magnitude, the creation of design and construction sections, as well as the recruitment of some technical staff such as engineers (sanitary, civil, electrical), and architects is considered. In view of the valuable experience of the staff working at present in the Valencia Lake Project which is in the final stage of execution, some of them may be transferred to the Tuy River Basin Agency, to work in the construction of wastewater treatment facilities.

In the case of Hidrocapital, an institution with long experience in the development of projects of different magnitude, the creation of new sections will be unnecessary, but recruiting of some staff and acquisition of equipment may be necessary.

Monitoring System

(1) Necessity of Monitoring

To cope with the environmental problem, it is necessary to collect basic information showing the environmental conditions that go with the provision of measures as well as identification of pollution sources.

To collect the basic information, it is essential to monitor the factors showing the conditions of (1) land development and land utilization, (2) industrial

activities, and (3) daily activities of inhabitants. Among these, the required monitoring system is discussed, putting emphasis on the monitoring of water pollution caused by (2) industrial activities and (3) daily activities of inhabitants.

(2) Objective of Monitoring

The main objective of monitoring is to collect basic information for the prevention of deterioration of water quality in the Tuy River from two aspects: (1) environmental aspect, for making the strategy to preserve the water of the Tuy River complying with the water quality standard, and (2) water supply source aspect, for water supply management, especially, to prevent water with unfavorable quality from being utilized as domestic water.

(3) Operation of Monitoring

The two types of monitoring are discussed below:

(a) Fixed Site Monitoring

(i) Monitoring Site

In the previous projects, nine monitoring stations (6 on the Tuy River and 3 on tributaries) have been selected to observe the environmental condition of water quality of the Tuy River. Since these monitoring stations cover the important points, they may be sufficient to establish the monitoring system in this present study from the environmental aspect.

Besides, it is desirable to designate at least two sites to monitor the water quality from the water supply source aspect, because there may be differences in monitoring items and frequencies depending on objectives.

Therefore, two cases of monitoring sites are proposed:

Case 1	Nine monitoring sites (from environmental aspect).
Case 2	Two monitoring sites designated among the above nine monitoring sites (from water supply source aspect).

The monitoring sites are shown in Fig. 6.1-11.

(ii) Monitoring Frequency

From the environmental viewpoint, the monitoring frequency of only once a month which is currently practiced is sufficient to grasp the water quality conditions.

From the water supply aspect, however, it is necessary to

continuously monitor the water quality conditions at several points to identify any sudden change of water quality, to prevent the transmission of unfavorable quality of water to the water supply system, and to detect polluters.

In this connection, two cases of monitoring frequency are proposed:

Case 1	Once a month (from environmental aspect)
Case 2	Continuous monitoring (from water supply source aspect)

(iii) Monitoring Items

Basically, monitoring items also depend on the objective and frequency. From the environmental viewpoint, it is necessary to cover all items stipulated in the water quality standard to confirm the environmental condition of the Tuy River, although monitoring all items every time and at every point may not be required.

In case of monitoring for the water supply aspect, it may be difficult to continuously monitor many items of water quality physically and economically, while it is desirable to cover the items showing a sudden change of water pollution condition by organic, toxicant and turbid substances. In practice, the items currently observed for continuous monitoring mainly include pH, EC, turbidity and DO which can be observed by automatic monitoring equipment and, generally, the sudden change of water pollution condition can be noticed through the monitoring of these items.

Under these conditions, the following items are proposed to be monitored:

Case 1	Monitoring of all items stipulated in the water quality standards for nine monitoring sites, though not every time and at every site (environmental aspect).
Case 2	Continuous monitoring of pH, EC, turbidity and DO plus water level and temperature at two monitoring sites (water supply source aspect).

(b) Non-Fixed Site Monitoring

(i) Monitoring Site

As the objective monitoring sites, the factories and piggeries, of which effluents have a large impact on water quality of the Tuy River are in principle nominated as non-fixed monitoring sites. In

addition, monitoring sites for effluent from urban centers are also nominated.

(ii) Monitoring Frequency

In the Tuy River basin, there are 103 factories and 33 piggeries which discharge a large amount of effluent, and it is desirable to monitor these polluters twice a year. For that purpose, 18 factories and 6 piggeries are required to be monitored once a month.

(iii) Monitoring Items

As the monitoring items, the major items stipulated in the water quality standard should be covered considering the extent of activities of factories, piggeries and urban centers.

(4) Organization

In principle, the monitoring work shall be undertaken by the Tuy River Basin Agency (Agencia de la Cuenca del Rio Tuy, ACRT) which has the full responsibility for monitoring the environmental condition of the Tuy river basin. Although the agency is currently operating the monitoring system, the number of staff, equipment and facilities will be insufficient considering the monitoring work volume to be covered. Therefore, it is necessary to strengthen the present organizational setup.

(5) Necessary Facilities and Equipment

To operate the monitoring system, the following facilities are necessary:

- Monitoring station to take water samples and to install the equipment.
- Office space for data filing staff and facilities.
- Laboratory facilities to conduct water quality analyses.
- Storage facilities for collected samples.
- Storage facilities for equipment.
- Transportation facilities to conduct the monitoring works.

The necessary equipment shall include those for laboratory tests, field investigations and continuous monitoring. The major equipment required is as given below.

Laboratory Equipment	Refrigerator, Incubator, Autoclave, DO meter, etc.
Equipment for Field Measurement	Current meter, EC meter, Turbidometer, etc.
Continuous Monitoring Equipment at Site	Sensor, Gauge, Recorder, Accessories, etc.

(6) Cost Required

The cost required to establish the monitoring system include those for facilities, equipment for monitoring station, continuous monitoring, laboratory equipment, and transportation equipment. The operation and maintenance costs required include operation of facilities and personnel expenses. The initial establishment cost amounts to US$1,651,000 and a further US$177,000 for operation and maintenance costs. (Refer to Table 6.1-13.)

Study on Education Program to Promote Public Awareness

(1) Necessary Program

For the effective implementation of the Master Plan, an education program to promote public awareness on environmental issues shall be undertaken to include all the sectors involved in the basin. Therefore, the program is focused on three education levels : (1) schools, (2) general public, and (3) factory and piggery owners.

(a) Schools

The Tuy River Basin Agency shall follow the current cooperation agreement between the Ministry of Education and MARNR signed in March, 1996.

Based on this agreement, the Agency shall promote all education-related institutions within the basin, from kindergarten to the highest level, and provide constant guidance on main environmental issues. This activity shall be coordinated with resident associations and the existing NGOs.

The main environmental issues include water pollution problems caused by effluent from factories and piggeries and wastewater from urban centers. Environmental issues also include the significance of improvement of water quality of the Tuy River.

(b) General Public

The following program should be included to educate the general public.

- Periodic publication of the "Informative Bulletin of the Agency" (Boletín Informativo de la Agencia) is highly recommended. This bulletin should be made available to the residents of the basin such as the municipal authorities and NGO related personnel. Contents shall always include the current main environmental issues, laws and regulations, etc.
- Publication of newspaper articles related to the environmental protection of the Tuy River Basin is recommended. The impact of newspapers on society is more direct and wide reaching compared with the bulletin. So partial reproduction of the contents of the bulletin can be included.

(c) Factory and Piggery Owners

- In the implementation of the project, periodic seminars addressed to factory and piggery owners shall be conducted by the Agency. This will promote the awareness of manufacturers about the significance of complying with the water quality standard and thus in turn promote the installation of treatment plants.
- The pamphlet "Standards of Environment Quality Control, a Guide for Manufacturers" is recommended to be published at least once a year.

It is estimated that the program will need an additional yearly budget of about US$40,000.

(2) Personnel

The personnel to perform these activities will be those currently employed in the Management of Participation, Education and Relations with the Users, a division of the Tuy River Basin Agency. Basically the staff is sufficient in number and well trained, however, some updating and/or training courses shall be considered for technicians. Recruitment of existing or new staff for the publication aspect is also recommended.

(3) Equipment and Materials

For performing the mentioned activities some basic initial equipment and materials will be necessary. This will be used to strengthen the office of the Programmatic Management of Participation, Education and Relations with the Users. The estimated costs of equipment are shown in the following table:

Equipment for Strengthening Environmental Education and Public Awareness

Equipment	Quantity	Cost (US$)
Vehicle	1	30,000
Computer/Printer Set	2	7,000
Portable Computer/Printer Set	1	4,000
Copy Machine	1	4,000
Overhead Projector	1	1,000
Slide Projector	1	800
VCR	1	700
Color TV	1	700
TV Camera	1	1,500
Photographic Camera	1	300
Total		50,000

6.2 Formulation of the Project

6.2.1 Prioritization

Considerations on Priority

For the formulation of the short term and mid-term programs, prioritization of project components has been examined.

Among the project components, the institutional measures are given the highest priority because they require a lesser financial burden and need to be implemented earlier to facilitate the implementation of structural measures. On the other hand, the prioritization of structure measures was made as follows:

Since the project components have different targets, the prioritization was made by first classifying them into two groups based on the two targets of improvement of water quality and securement of water quantity. Then the group for the improvement of water quality was further divided into two based on other two targets; improvement of pollution condition by organic substances and removal of turbidity. Finally, the project components in each group were given priority considering cost-effectiveness, total amount of investment cost, and the difference of investors in the public and private sectors.

Table 6.3-1 shows the grouping of the project components and their cost-effectiveness, as well as the results of prioritization. According to this table, priority is given as follows:

(1) Project Components for Improvement of Water Quality

(a) Removal of BOD Pollution Effluent Load

For the removal of BOD pollution effluent load, the installation of treatment plants for factories and piggeries is given high priority to achieve the target, because factory and piggery owners have the responsibility to fulfill the water quality standard immediately.

As to the installation of sewage treatment plant for the urban centers which is to be undertaken by the public sector, the priority is given based on cost-effectiveness.

(b) Removal of Turbidity

For the removal of turbidity, priority is given based on cost-effectiveness.

(2) Project Components for Securement of Water Quantity

Among the project components of the group for securement of water quantity, high priority is given to the sand settling pond at Toma de Agua and pump at the Ocumarito reservoir which can be executed under the public sector with less investment cost.

Although there is not much difference in cost-effectiveness compared with the construction of pump at Ocumarito reservoir, the construction of Guare Dam has a lower priority due to the high investment cost.

For improving color and odor, treatment plants for factories discharging wastewater causing the odor/color in river water are proposed to be installed. This can be done for the purpose of controlling the discharge of wastewater by factories, which is given high priority to achieve the target for water quality.

6.2.2 Short Term Program

Objective and Target

(1) Objectives

The short term program is formulated aiming to ensure potable water supply with acceptable water quality and to establish a sustainable pollution control system.

(2) Targets of Water Quality and Quantity

As discussed in Chapter 5, the following target is to be achieved for the improvement of water quality.

(a) Water Quality

Target water quality in the Short Term Program is set as the improvement of water quality at Toma de Agua (see table below). These are interim targets which are selected for the purpose of achieving the objectives of the Mid Term Program.

Reference point	San Antonio (Toma de Agua)
Organic pollution	BOD of 3.5 mg/ℓ (proposed in the Study)
Toxicant	Type 1B in Decree No. 883
Turbidity	SS of 925 mg/ℓ (proposed in the Study)

(b) Water Quantity

The target of securement of water quantity is as shown below:

Monthly average secured water from upper and middle streams of Tuy River basin	4.0 m^3/s
Intake at Toma de Agua	2.0 m^3/s
Newly developed water	approx. 2.0 m^3/s
Reduction in suspension of intake at Toma de Agua	
Elimination of water intake suspension due to color and odor (403,200 m^3/year (0.013m^3/s))	13 days/yr
Reduction in water intake suspension due to high turbidity (345,600 m^3/year (0.011m^3/s))	5 days/yr

Selection of Optimum Measure for the Short Term Program

The measures to achieve the target for the short term program are selected based on the prioritization discussed in Section 6.1.

(1) Structural Measures

(a) Water Quality Improvement

To achieve the target of water quality, the following measures are adopted:

(i) Organic Pollution

- Installation of treatment plants for existing factories which do not meet the water quality standards.
- Installation of treatment plants for newly built factories.
- Installation of sewage treatment plants for Las Tejerías and Ocumare del Tuy areas.

The sewage treatment plant for Las Tejerías is necessary to improve the water quality at Boca de Cagua, while it is necessary for Ocumare del Tuy to achieve the target at Toma de Agua.

(ii) Toxicant

- Installation of treatment plants for the existing factories which do not meet the water quality standards.
- Installation of treatment plants for newly built factories.

(iii) Turbidity

- Installation of treatment plants for the existing factories which do not meet the water quality standards.
- Installation of treatment plants for newly built factories.
- Reforestation in an area of Qda. Maitana.

(b) Securement of Water Quantity

Judging from the function of measures, those to be applied for the Short Term Program to secure water quantity are as follows:

(i) To secure the water quantity of 2.0 m^3/s

To secure the water quantity of 2.0 m^3/s, it is necessary to apply two measures as examined in Subsection 6.1.2, as follows:

- Installation of pump at the Ocumarito reservoir to divert the storage water to the Tuy III system.
- Construction of Guare Dam.

(ii) To reduce frequency of water suspension due to odor, color and turbidity

- Installation of treatment plants for factories which discharge pollution effluents related to odor and color.
- Construction of sand settling pond at water intake point.

(2) Institutional Measures

In general, the following institutional measures are essential to achieve the objectives of the Short Term Program:

- Provision of laws and regulations.
- Strengthening of organizational functions.
- Establishment of monitoring system and enforcement of laws and regulations including penalty laws and pollution charge.
- Establishment of environmental fund and its use to assist factories and piggeries.

6.2.3 Mid Term Program

Objective and Target

(1) Objectives

As in the Short Term Program, the Mid Term Program is formulated with the objectives of securing a potable water supply with acceptable water quality and of establishing a sustainable pollution control system.

(2) Targets of Water Quality and Quantity

(a) Water Quality

The target water quality to be achieved by the year 2010 is set for the upper and middle basins, respectively as follows:

Item	Upper basin	Middle basin
Reference point	Boca de Cagua	San Antonio (Toma de Agua)
Organic pollution	BOD of 60 mg/ℓ (Wastewater discharge criteria to the river in Decree No. 883)	BOD of 3 mg/ℓ *1 (proposed in the Study)
Toxicant	Type 1B in Decree No. 883	Type 1B in Decree No. 883
Turbidity	SS of 750 mg/ℓ Turbidity of 250 NTU (Type 1B in Decree No. 883)	SS of 750 mg/ℓ Turbidity of 250 NTU (Type 1B in Decree No. 883)

*1: BOD of 3 mg/ℓ is the limit for the conventional treatment

(b) Target Water Quantity

The target of water quantity for the Mid Term Program is the securement of stable water supply for the Tuy I and II systems, amounting to approximately 4 m^3/s consisting of 2 m^3/s of average intake at Toma de Agua and approximately 2 m^3/s of newly developed water. This target is set because the intake of 2 m^3/s at Toma de Agua would not be maintained if no measures for the improvement of water quality were undertaken.

Selection of Optimum Measures

The optimum measures to achieve the objectives of the Mid Term Program are selected from among those which are confirmed to be applicable in Section 6.2.

(1) Structural Measures

Structural measures which should be provided to achieve the objectives of the Mid Term Program are mainly related to water quality improvement, and most of the measures for water quality improvement are employed for the Short Term Program. The difference between the Short Term and the Mid Term programs is only in the area to be provided with structural measures for domestic waste, but the application of pollution control measures to factory effluents, which are employed in the Short Term Program, are extended to the Mid Term Program.

(a) Organic Pollution

- Installation of treatment plants for newly built factories.
- Installation of sewage treatment plants for San Francisco de Yare and El Consejo areas.

(b) Toxicants

- Installation of treatment plants for newly built factories.

(c) Turbidity

- Installation of treatment plants for newly built factories.
- Reforestation in areas of Qda. Maitana, Qda. Guayas, and Cagua River.
- Sand settling ponds on the upper Tuy River, Qda. Guayas, Qda. Maitana, and Guare River.

(2) Institutional Measures

The institutional measures, most of which are employed for the Short Term Program, are extended to the Mid Term Program. The institutional measures applied to the Mid Term Program are as follows:

- Sustainable enforcement of laws and regulation.s

- Sustainable operation of monitoring system in the priority areas.
- Sustainable practice of educational program.
- Sustainable use of the environmental fund to assist factories in the priority areas.

6.2.4 Priority Projects

Priority projects are selected for the feasibility study. All measures employed for the Short Term Program are applied to the priority projects so as to promote the environmental improvement of the Tuy River basin under both the short term and mid term programs. To achieve the targets, all measures under the Short Term Program, as discussed in Subsection in 6.2.1, are necessary to be conducted as the first step, followed by the Mid Term Program.

6.3 Phased Implementation Plan and Cost Estimate

Phased Implementation Plan

Based on the prioritization in Subsection 6.2.1 and the discussion on the short-term and mid-term programs, a phased implementation plan is formulated as shown in the implementation schedule in Fig. 6.3-1. In this implementation plan, the construction period for each measure is assumed considering similar projects in Venezuela and other countries as well as the design scale of the proposed measures.

As for the Guare Dam, construction is scheduled in this implementation plan to commence from the beginning of the short-term program, though the priority is lower than the installation of pump at the Ocumarito reservoir. This is because the Guare Dam requires a 5-year construction period, and this measure is required to be completed by 2003 to achieve the target.

Preliminary Cost Estimate

In accordance with the implementation plan, project cost is preliminary estimated on the price level of July, 1996, at the exchange rate of US$1.00 = ¥110 = Bs 470. The cost estimation for each measure is summarized as follows:

(1) Sand Settling Pond at Toma de Agua

The cost of sand settling pond at Toma de Agua is estimated as follows:

(Unit: US$)

Work Item	Unit Cost	Quantity	Amount
Land Acquisition	12.8/m^2	4,000	51,200
Temporary Works	Lump Sum	-	233,409
Excavation Work	8.6/m^3	24,385	209,711
Concrete Works	428.6/m^3	3,702	1,586,677
Culvert	1,688.2/m	150	253,230
Piling	75.6/pole	1,200	90,720
Embankment	45.6/m^3	1,880	85,728
Gate	20,000/unit	5	100,000
Total Cost			2,610,700

(2) Treatment Plant for Factories and Piggeries

The cost of a treatment plant for each factory and piggery is estimated as shown below based on the unit cost per volume of effluent from each factory or piggery as obtained from the interview survey:

Category (Factory/ Piggery)	Average Discharge Wastewater Volume (ton/day)	Average Construction Cost of Treatment Plant (US$)	Unit Cost (US$/ton/day)	O&M Cost (US$/ton
Food Related	317.0	404,924	1,277	5.4
Non-Food Related	106.0	208,724	1,963	33.6
Piggery	11.5	20,000	1,739	1.0

The procedure of cost estimation is as follows:

- Total and average effluents of factories and piggeries in the blocked areas that do not meet the water quality standard are calculated based on the observed data of water effluent.
- The unit cost of treatment plant of the factories and piggeries in the blocked area is obtained based on the average effluent and unit cost shown in the above table.
- The total cost in the blocked areas is estimated multiplying the unit cost with the number of factories and piggeries.

(3) Sewage Treatment Plant

The cost of sewage treatment plant is mainly composed of (1) land acquisition, (2) construction of treatment facilities, and (3) installation of sewage pipes. The area of land acquisition is calculated by multiplying the unit area per design sewage volume of 4 ha/m^3, and the construction cost of treatment facilities is estimated by multiplying the unit construction cost per design sewage volume. Unit costs of these items are as follows:

Work Item	Unit Cost
Land Acquisition	US$2.2/$m^2$
Construction of Treatment Facilities	US$98/$m^3$
Installation of Sewage Pipe	US$260/m
O&M	US$8/$m^3$

(4) Sand Settling Pond in Tributaries

The cost of sand settling pond is composed of (1) land acquisition, (2) excavation of pond, (3) concrete lining of channel, and (4) intake works.

The work quantities and unit costs are as shown below:

(Unit: US$)

Works	Unit Cost	Hda. Barrios		Cagua		Maitana		Guare	
		Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Land Acquisition	12.8/m^3	40,000	512,000	28,000	358,400	40,000	512,000	40,000	512,000
Excavation & Hauling	8.6/m^3	114,000	980,400	77,700	668,220	114,000	980,400	95,400	820,440
Concrete	428.6/m^3	2,500	1,071,500	2,500	1,071,500	2,500	1,071,500	2,500	1,071,500
Intake Works	Unit	1	456,900	1	441,000	1	456,900	1	456,900
Total Cost			2,979,520		2,539,120		3,020,800		2,860,840

(5) Reforestation

The cost of reforestation is roughly estimated based on the construction cost of forest road and tree planting. The unit costs for these items are as follows:

(Unit: US$)

Work Item	Quantity	Unit Cost	Amount
Forest Road	10,200	240/ha	2,448,000
Tree Planting	10,200	510/ha	5,202,000
Total			7,650,000

Preliminary cost estimates for the proposed projects are as shown in the following table:

(Unit: US$ thousand)

Stage	Category	Target	Measures	Initial cost	O&M cost	Annual cost*
Short term	Structural measure	Water quality	Treatment for existing factories and piggeries***	**(11,998)	**(562)	(1,882)
			Treatment for newly constructed factories***	(10,791)	(470)	(1,657)
			Treatment of domestic wastewater (Ocumare del Tuy)	28,020	519	3,601
			Treatment of domestic wastewater (Las Tejerías)	12,700	319	1,716
			Reforestation	2,520	17	319
			(Sub-total)	43,240	855	5,636
		Water quantity	O-TuyIII pumping and Guare Dam	85,980	2,623	12,579
			Lessening color/odor	(2,057)	(90)	(316)
			Lessening turbidity	2,610	61	348
			(Sub-total)	88,590	2,684	12,927
	Institutional measure		Monitoring	1,652	177	359
			Public education	50	40	46
			Environmental fund	24,846	120	2,853
			(Sub-total)	26,548	337	3,258
	Total			158,378	3,876	21,821

* Annual Cost = Initial Cost × Annuity Factor + O&M Cost (Annuity factor is 0.11 for civil structures and 0.13 for electrical equipment)

** The cost excludes factories related to color/odor.

*** The cost is included in the Environmental Fund.

Stage	Category	Target	Measures	Initial cost	O&M cost	Annual cost*
Mid term	Structural measure	Water quality and quantity	Treatment of newly constructed factories	(18,606)	(810)	(2,856)
			Treatment of domestic wastewater (Ocumare del Tuy)	4,914	172	713
			Treatment of domestic wastewater (S. F. de Yare)	14,100	343	1,892
			Treatment of domestic wastewater (El Consejo)	13,100	300	1,741
			Lessening turbidity (reforestation)	5,130	33	597
			Lessening turbidity (sand settling pond)	11,391	627	1,880
			(Sub-total)	48,635	1,475	6,823
	Institutional measure		Monitoring	0	177	177
			Public education	0	40	40
			Environmental fund	18,606	120	2,167
			(Sub-total)	18,606	809	2,384
	Total			67,241	2,284	9,207

* Annual Cost = Initial Cost × Annuity Cost (0.11~0.13) + O&M Cost

Responsible Agency/Body and Sharing of Cost

Based on the phased implementation plan, it is necessary to confirm the responsible agency/body and the sharing of cost among the concerned agency and the beneficiaries.

(1) Structural Measures

(a) Water Quality Improvement for Pollution by Factory and Piggery Effluent

Reduction of effluent pollution including organic, toxicant and turbid substances from factories and piggeries is the responsibility of the factory or the piggery owner. The installation of a treatment plant therefore should be done by the factory or piggery owner.

For factory and piggery effluent, the cost includes the initial cost to install a treatment plant and the O&M cost. Since factory effluents flow through the public sewerage system when provided to meet the water quality standards, the O&M cost for the public sewerage system must be shared.

In principle, the initial cost and the O&M cost for the treatment plant are shouldered by the factory and piggery owners. The government agency will however assist financially in the initial cost through the Environmental Fund. Besides, tax reduction to encourage factory and piggery owners to install a treatment plant is considered.

As the related agency, ACRT has the responsibility to promote installation of treatment plants by factory and piggery owners by applying institutional measures such as technical assistance, provision of funds, inspection and monitoring.

(b) Water Quality Improvement for Pollution by Domestic Waste

The installation and O&M work of the public sewerage system, as well as the collection of wastewater charge, are assumed to be the responsibility of ACRT. Hence, the initial and O&M costs are to be shouldered by ACRT. (As for the collection of wastewater charge, it is assumed that the charge will be collected together with the domestic water charge, so that the collection work will be entrusted to Hidrocapital.)

As related agencies, the local governments concerned are to cooperate in promoting the sewerage system through the provision of local urban development plans and the promotion of public awareness.

(c) Water Quality Improvement for Turbidity by Soil Erosion

To improve water quality degraded by turbidity due to soil erosion, two measures are proposed: (1) reforestation and (2) sand settling ponds on

tributaries. Judging from the contents of the project, it is proposed that the initial and O&M costs should be shouldered by the MARNR.

(d) Securement of Water Quantity by Ocumarito-Lagartijo Diversion Structure

To secure the water quantity from the Tuy River, a pump to divert the water in the Ocumarito reservoir to the Tuy-III system and the construction of Guare Dam are proposed. Judging from the contents, Hidrocapital, which has the responsibility to secure the quantity for water supply, should be the agency responsible for implementing the projects and to shoulder both the initial and O&M costs.

(e) Securement of Water Quantity by Sand Settling Pond

To assure water quantity through the reduction of turbidity, the installation of a sand settling pond at the water intake point is proposed. Judging from the contents, Hidrocapital should be the agency responsible for implementing the project and to shoulder both the initial and O&M costs.

(2) Institutional Measures

As for the institutional measures, MANR should be the agency responsible for the arrangement of laws and regulations, while ACRT should be responsible for the institutional arrangement in terms of strengthening of function of the organization, the establishment of monitoring system, the Environmental Fund, the Pollution Charge and the educational system.

As the related agencies, CORDIPLAN and the State Governments should be concerned in arranging and enforcing the institutional measures.

As to the cost of implementation of institutional measures, ACRT which has the main responsibility for the works, should shoulder the cost under the budgetary allocation from the MARNR.

Category	Measures	Financial Responsibility		Remarks
		Initial Cost	O&M Cost	
Structural	Ocumarito-Lagartijo Diversion Structure	HIDROCAPITAL	HIDROCAPITAL	
	Sand Settling Pond at Water Intake	HIDROCAPITAL	HIDROCAPITAL	
	Treatment Plant for Factories and Piggeries	Factory and Piggery Owner	Factory and Piggery Owner	Assistance from Environmental Fund
	Sewerage System for Domestic Waste	ACRT	ACRT	
	Reforestation	MARNR	MARNR	
	Sand Settling Pond on Tributaries	ACRT	ACRT	
Institutional	Monitoring	ACRT	ACRT	
	Public Education	ACRT	ACRT	

6.4 Evaluation of Optimum Measures

6.4.1 Technical Soundness

The adequacy of the optimum measures selected in Section 6.1 is confirmed from the technical viewpoint considering the technology being employed in Venezuela at present. The optimum measures, which include such major structures as diversion structures, treatment plant in factories, sand settling pond and sewage treatment plant, seem to have no difficulty for realization from the technical viewpoint as discussed below.

Improvement of Water Quality

Optimum measures selected for the improvement of water quality are the installation of treatment plants in factories and piggeries, sewage systems in urban centers and reforestation as practiced in Venezuela. Thus, the optimum measures have no difficulty for realization from the technical viewpoint.

Treatment plants are proposed to be provided in factories to secure water quantity through water quality improvement. Treatment plants to reduce organic pollution, toxicants and turbidity have been provided in several factories in Venezuela, and factory and piggery owners are planning to introduce new treatment plants based on their own study.

A sand settling pond to reduce turbidity is also a traditional method and the civil works including ground excavation and construction of the weir are based on commonly used methods.

Securement of Water Quantity

To assure water quality, the construction of a pumping station at Ocumarito reservoir and Guare dam is proposed as the optimum plan, and its advantage is confirmed through economic comparison. Pumping stations and dams are commonly adopted for water resource development and there are some examples of construction of these structures in the water supply system of Hidrocapital.

6.4.2 Financial Evaluation of the Master Plan

Sources of Cost Recovery

It is proposed that O&M cost, repayment cost and replacement cost of a particular project be met in accordance with the table below.

Sources of Cost Recovery	Projects
Income of Households in CMA	Securement of Water Quantity, Construction of Sand Settling Pond for Intake
Revenues of Factories and Piggeries	Environmental Fund
Income of Households in a Town	Construction of Sewage Treatment Plant in the Town
Budget of MARNR, Miranda State and Aragua State	Construction of Sand Settling Pond at Tributaries, Reforestation, Institutional Measures (Exc. Environmental Fund)

The financial sources of the initial cost will be entirely external except those for the construction of sewage treatment plants. Regarding the latter, they will be basically derived from the government budget (central and state) in consideration of repayment capability of the polluter, i.e.. households.

In this study, it is proposed that the following portion of the cost is covered by external loan, considering the repayment capability of the polluter, i.e., households, while the remaining portion by governmental budget.

Construction of sewage treatment plant in Ocumare del Tuy	35%
Construction of sewage treatment plant in Las Tejerías	20%
Construction of sewage treatment plant in San Francisco de Yare	25%
Construction of sewage treatment plant in El Consejo	7%

Financial Evaluation

In performing financial analysis, the following pre-conditions are established:

- Terms of external loan: Annual interest rate: 6%; grace period: 3 years; repayment period: 15 years
- Collection efficiency of sewerage charge from households and of repayments from factories and piggeries: 95%
- Durable life: electro-mechanical equipment: 15 years; civil engineering structures and other facilities: 40 years

- Implementation period:

Project	Short-Term Program	Medium-Term Program
Securement of Water Quantity - Ocumare-Tuy III Pumping Plan	1998-2000	-
Securement of Water Quantity - Guare Dam Plan	1998-2003	
Construction of Sand Settling Pond for Intake	2000-2003	-
Environmental Fund	2000-2003	2004-2010
Construction of Sewage Treatment Plant in Ocumare del Tuy	1998-2001	2004-2006
Construction of Sewage Treatment Plant in Las Tejerías	2000-2003	-
Construction of Sewage Treatment Plant in San Francisco de Yare	-	2004-2007
Construction of Sewage Treatment Plant in El Consejo	-	2007-2010
Construction of Sand Settling Pond at Tributaries	-	2004-2006
Reforestation	1998-2003	2004-2010
Institutional Measures (Exc. Environmental Fund)	1998-1999	-

- Period of financial analysis: 20 years from the start of project implementation

By financial analysis one means affordability analysis to see if the cost bearer is capable of shouldering the O&M, repayment and replacement costs.

(1) Cost Required

Eleven projects are proposed under the master plan. Initial costs are estimated as presented below:

(Unit: US$ thousand)

Project	Short-Term Program	Medium-Term Program	Total
Installation of Treatment Plant for Factories and piggeries (applying Environmental Fund)	24,846	18,606	43,452
Construction of Sewage Treatment Plant in Ocumare del Tuy	28,020	4,914	32,934
Construction of Sewage Treatment Plant in Las Tejerías	12,700	-	12,700
Construction of Sewage Treatment Plant in San Francisco de Yare	-	14,100	14,100
Construction of Sewage Treatment Plant in El Consejo	-	13,100	13,100
Construction of Sand Settling Pond at Tributaries	-	11,391	11,391
Reforestation	2,520	5,130	7,650
Institutional Measures (Exc. Environmental Fund)	1,702	-	1,702
Securement of Water Quantity - Ocumare-Tuy III Pumping Plan	9,880	-	9,880
Securement of Water Quantity - Guare Dam Plan	76,100		76,100
Construction of Sand Settling Pond for Intake	2,610	-	2,610
Total	158,378	67,241	225,619

As the table shows, the total cost is estimated to come to US$226 million. Out of it, US$159 million or 70% belongs to the short term program, and US$67 million or 30% to the mid term program.

In terms of financial sources, foreign resources will be US$173 million or 77%, while local resources will be US$53 million or 23% as the table below shows:

(Unit: US$ thousand)

Foreign Resources	Local Resources	Total
172,768	52,851	225,619

(2) Affordability of CMA Clients

The annual outlays of the three projects , "securement of water quantity - Ocumare-Tuy III pumping plan", "securement of water quantity - Guare dam plan" and "construction of sand settling pond for intake" and how they will be met for the period of 20 years are shown in Tables 2.2.1 to 2.2.3. The table below summarizes the sources of incomes.

Project	Income/Month/ Household (US$)	Payment in Percentage (%)	Payment/Month / Household (US$)
Securement of Water Quantity - Ocumare-Tuy III Pumping Plan	496	0.038	0.188
Securement of Water Quantity - Guare Dam Plan	496	0.131	0.650
Construction of Sand Settling Pond for Intake	496	0.005	0.025
Total	-	0.174	0.863

Clients in the CMA are represented by households. The monthly charge for a household will be 0.174% of its income, coming to US$0.863 or Bs.406 on average in 1997. This is not a heavy load.

(3) Affordability of Factories and Piggeries

The annual outlays of the Environmental Fund for the duration of 20 years and how they will be met for the short-term and mid-term programs are shown in Tables 2.2.4 and 2.2.5, respectively. The table below summarizes the sources of incomes.

Project	Revenues/Year/ Factory/Piggery (US$ thousand)	Payment in Percentage (%)	Payment/Year/ Factory/Piggery (US$)
Environmental Fund (Short-Term)	5,662 (Factory) 234 (Piggery)	0.53	30,009 (Factory) 1,240 (Piggery)
Environmental Fund (Mid-Term)	5,662 (Factory)	0.48	27,178 (Factory)

Each factory will annually pay 0.48% to 0.53% of its revenues, or US$27,178 to US$30,009 on average to the Environmental Fund. Each piggery will annually pay 0.53% of its revenues or US$1,240 on average. This does not appear to be an excessive amount.

(4) Affordability of Households

The annual outlays of each of the four sewage treatment plant construction projects for the duration of 20 years and how they will be met are shown in Tables 2.2.6 to 2.2.10. The table below summarizes the sources of incomes for those projects.

A household in the four towns will pay about 1% to 2% of its monthly income as the sewerage charge, amounting to US$5 to US$10 on average in 1997. This is considered a reasonable range. The World Bank recommends that the payment for sewerage service be within 2% of household income.

Project	Income/Month/ Household (US$)	Payment in Percentage (%)	Payment/Month /Household (US$)
Construction of Sewage Treatment Plant in Ocumare del Tuy (Short-Term + Mid-Term)	507	0.93+0.21	5.780
Construction of Sewage Treatment Plant in Las Tejerías	494	1.67	8.250
Construction of Sewage Treatment Plant in San Francisco de Yare	507	1.96	9.937
Construction of Sewage Treatment Plant in El Consejo	494	1.98	9.781

(5) Affordability of Government

The annual outlays of the three projects, "construction of sand settling pond at tributaries", "reforestation" and "institutional measures (exc. the Environmental Fund)" and how they will be met for the period of 20 years are shown in Tables 2.2.11, 2.2.13 and 2.2.14. The table below summarizes the sources of income.

Project	Annual Budget of MARNR, Miranda State and Aragua State (US$ thousand))	Payment in Percentage (%)	Payment/Year (US$ thousand)
Construction of Sand Settling Pond at Tributaries	486,800	0.219	1,066
Reforestation (Short-Term + Mid-Term)	486,800	0.041+0.060	492
Institutional measures (Exc. Environmental Fund)	210,000*	0.155	326
Total	-		1,884

* Annual budget of MARNR

The 1996 annual budgets of MARNR, Miranda State and Aragua State were US$210,000 thousand, US$133,300 thousand and US$143,500 thousand, respectively, totaling US$486,800 thousand.

Miranda State and Aragua State are annually going to set aside 0.320% of their budget, amounting to US$887 thousand in 1996 for repayment and other costs. Likewise, MARNR will set aside 0.475% of its budget amounting to US$997 thousand. This does not seem to be an extraordinary obligation.

Sensitivity Analysis

The above are the estimates on condition that population and industry in the study area follow the Pattern 1 (standard) projection. How will they change under the Pattern 2 (high) or Pattern 3 (low) projection?

In the Pattern 2 case the initial and O&M costs of a project will be greater than in the Pattern 1 case, while in the Pattern 3 case they will be less than in Pattern 1 case.

The table below shows the results of the estimation of initial cost in Pattern 2 and Pattern 3 cases.

(1) Pattern 2 Case

(Unit: US$ thousand)

Project	Short-Term Program	Medium-Term Program	Total
Total	165,491	88,917	254,408

As the above table shows, the total initial cost is estimated at US$254 million, which is US$29 million or 13% greater than the amount in the Pattern 1 case.

(2) Pattern 3 Case

(Unit: US$ thousand)

Project	Short-Term Program	Medium-Term Program	Total
Total	147,974	43,349	191,323

As the above table shows, the total initial cost is estimated at US$191 million, which is US$34 million or 15% less than the amount in the Pattern 1 case.

The results of the sensitivity analysis show that the estimated cost in the Pattern 1 case is possible to fluctuate between the +13% and -15% range.

Conclusions

(1) The total initial cost of master plan projects is estimated to come to US$226 million. Depending on the circumstances surrounding economic and population growths, this amount will change between the +13% and -15% range.

(2) Of US$226 million, US$173 million or 77% is proposed to be provided by external agencies such as the World Bank, the IDB (Inter-American Development Bank), and the OECF (Overseas Economic Cooperation Fund) of Japan, and the remaining US$53 million or 23% by the Venezuelan central government.

(3) It has been usually the case that the financial sources of externally assisted loan projects are 50% external and 50% domestic. As regards the master plan projects, however, affordability analysis shows that the cost-bearers (that is, beneficiaries and polluters) can afford to pay back up to 77% of the total initial cost. Therefore, it is recommended that the Venezuelan government and external financial agencies agree on the above-mentioned external versus domestic ratio.

(4) The repayments of the external loan are proposed to be entirely shouldered by beneficiaries or polluters themselves.

(5) Less than 0.2% of the income of the CMA households will be regularly collected as additional water charge by HIDROCAPITAL to meet the O&M, repayment and replacement cost of the securement of water quantity, i.e., Ocumare-Tuy III pumping plan, the securement of water quantity - Guare dam plan, and construction of sand settling pond for intake.

(6) Around 0.5% of the revenues of factories and piggeries will be annually collected by the Environmental Fund to meet the O&M, repayment and replacement cost of the Fund.

(7) Around 1% to 2% of the household income will be regularly collected as sewerage charge by the Tuy River Basin Agency to meet the O&M, repayment and replacement cost of the construction of sewage treatment plants in Ocumare del Tuy, Las Tejerías, San Francisco de Yare and El Consejo.

(8) Around 0.3% of the budgets of Miranda State and Aragua State will be annually set aside to meet the O&M, repayment and replacement cost of the construction of sand settling pond for tributaries and reforestation. Also, around 0.5% of the MARNR budget will be annually set aside to meet the O&M, repayment and replacement cost of the construction of sand settling pond foe intake, reforestation and institutional measures excluding the Environmental Fund.

(9) Items (4) to (7) attest to the adequate capability for the beneficiaries and polluters to shoulder the cost of all the master plan projects.

6.4.3 Institutional and Social Acceptability

Institutional Acceptability

The following institutions are mainly concerned with project realization: (1) Tuy River Basin Agency, (2) Hidrocapital, (3) MARNR, (4) Local Governments, (5) Chamber of Commerce, (6) educational institutions, and (7) other non-governmental organizations.

In principle, most of the institutions are keen to improve the water quality and assure the water quantity, and thus it is expected that full institutional acceptability can be assured, though they have to make every effort from their present situation.

Considering the great efforts of the Tuy River Basin Agency from the date of its creation, the institution is determined to implement the Master Plan.

Social Acceptability

In the course of the study, great cooperation has been received from the general public as well as many of those who are directly involved in activities contributing to the degradation of the environment within the basin, specially the factory and piggery owners.

The general populace wish to improve the water in quality and to assure the water in quantity along with the general conservation of the environment. Therefore, they want and accept the implementation of wastewater treatment works, even if it will mean a slight increase in water rates, as is established already by law.

Factory and piggery owners wish to improve the production process and/or perform wastewater treatment to avoid pollution of the river water. They are aware of their responsibility to the environment, and wish to abide by the existing laws because some penalties may be applied to them in cases of violation of the standards. However, they have to balance between the benefits of the improvement of facilities and the costs involved. This is true specially for the small and medium factory and piggery owners which cannot absorb costs of the wastewater treatment facilities. Nevertheless, when they heard that the Master Plan is considering incentives and soft financing conditions for some of the works they will have to undertake, their response has been very favorable.

Furthermore, the implementation of the organizational and institutional aspects of the Master Plan will greatly enhance the current situation in Venezuela. There are no significant adverse effects, only positive effects.

6.5 Summary of the Master Plan

In this Master Plan, the issues of present and future environmental conditions are identified based on the investigation of present condition and projection of future condition. To improve the present environmental condition and to cope with the deterioration of the future environmental condition, the target is set in two cases: short-term program and mid-term program.

To achieve the target, several measures consisting of structural measures and institutional measures are examined and optimum measures are selected. For the formulation of the Master Plan, the project components composing the optimum measures are arranged in the manner of short term program and mid-term program considering their priority. Thus the Master Plan is formulated to achieve the target.

Finally, evaluation of the master plan is made considering the technical soundness and financial affordability.

The outline of the Master Plan thus formulated is presented in Table 6.5-1 and location of measures is shown in Fig. 6.5-1.