JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTERIO DEL AMBIENTE Y DE LOS RECURSOS NATURALES RENOVABLES
THE REPUBLIC OF VENEZUELA

THE STUDY ON THE ENVIRONMENTAL IMPROVEMENT PROGRAM OF THE UPPER AND MIDDLE STREAM OF THE TUY RIVER BASIN

FINAL REPORT

VOLUME 2

MAIN REPORT (MASTER PLAN STUDY)

AUGUST 1997

CTI ENGINEERING CO., LTD.
KOKUSAI KOGYO CO., LTD.

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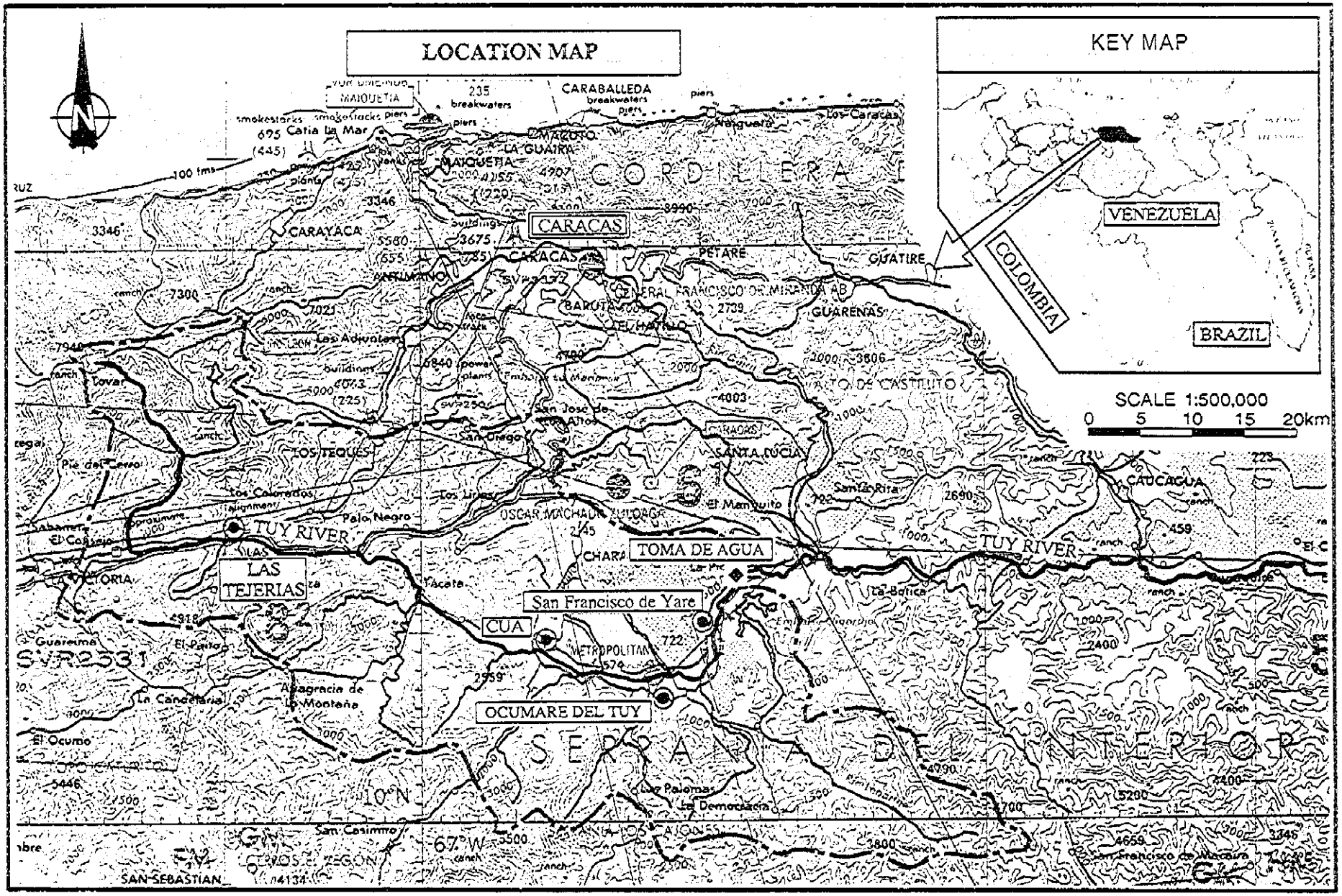
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LOS TEQUES
SANTA LUCIA
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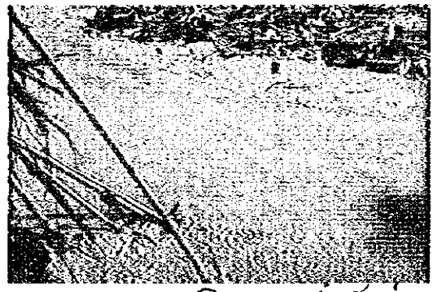

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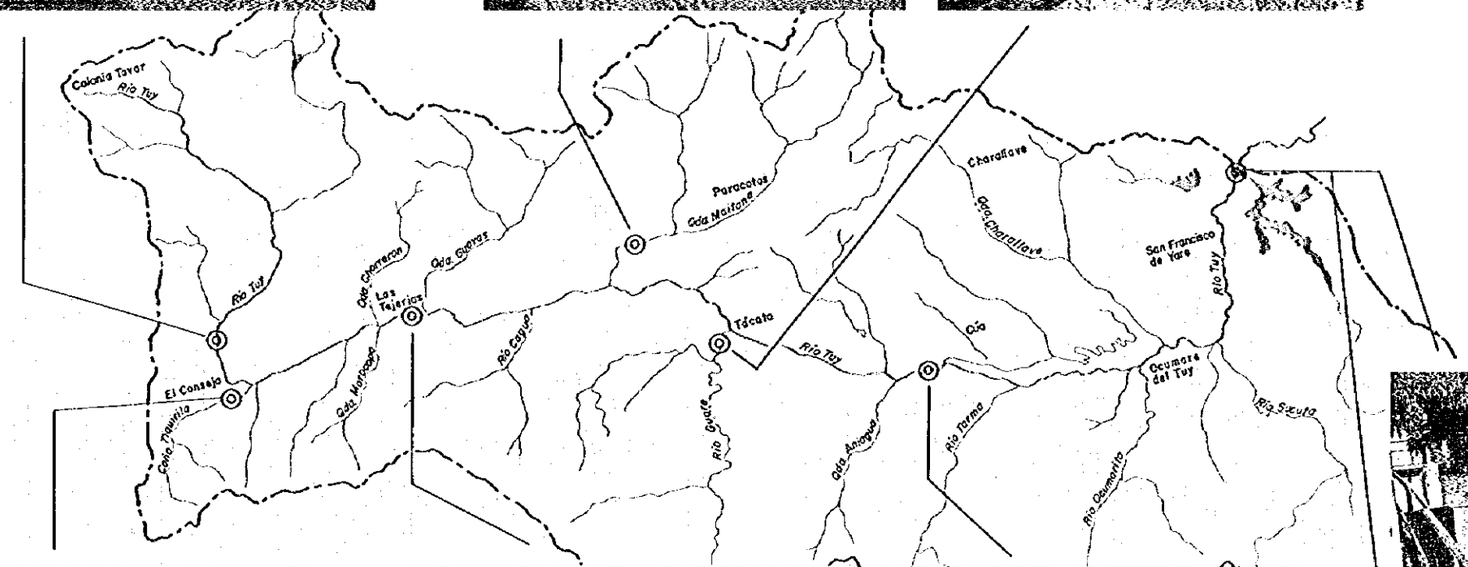

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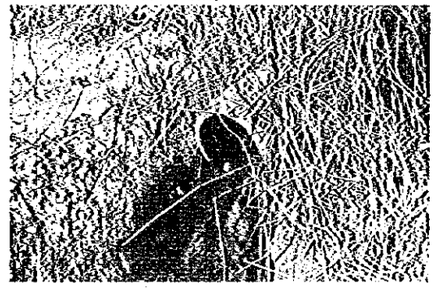

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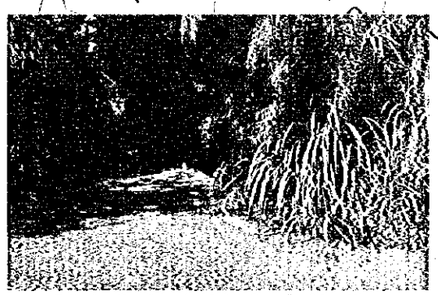

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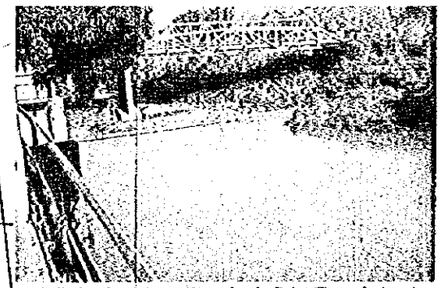

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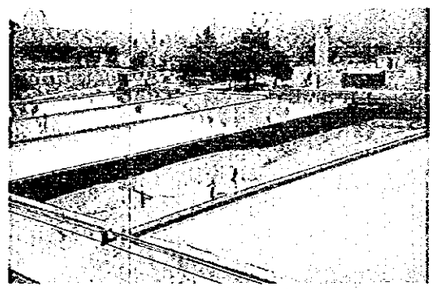

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THE STUDY ON THE ENVIRONMENTAL IMPROVEMENT PROGRAM OF THE UPPER AND MIDDLE STREAM OF THE TUY RIVER BASIN IN THE REPUBLIC OF VENEZUELA JAPAN INTERNATIONAL COOPERATION AGENCY	**POLLUTION CONDITION OF TUY RIVER**

PREFACE

In response to a request from the Government of the Republic of Venezuela, the Government of Japan decided to conduct the Study on the Environmental Improvement Program of the Upper and Middle Stream of the Tuy River Basin and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Venezuela a study team headed by Mr. Yoshiharu Matsumoto, CTI Engineering Co., Ltd., and composed of members from CTI Engineering Co., Ltd. and Kokusai Kogyo Co., Ltd., four times between January, 1996 and June, 1997.

The team held discussion with the officials concerned of the Government of the Republic of Venezuela, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Venezuela for the close cooperation extended to the team.

August 1997

KIMIO FUJITA
President
Japan International Cooperation Agency

August 1997

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Sir:

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report on the Study on the Environmental Improvement Program of the Upper and Middle Stream of the Tuy River Basin, Venezuela. The report contains the advice and suggestions of authorities concerned of the Government of Japan and the Japan International Cooperation Agency (JICA), as well as the formulation of the environmental improvement program for the study area. Also included are the comments made by the authorities concerned of the Government of the Republic of Venezuela during the technical discussions on the Draft Final Report.

The Final Report presents the Master Plan of the Environmental Improvement Program of the Upper and Middle Stream of the Tuy River Basin to secure a potable water supply with acceptable water quality and to establish a sustainable pollution control system. In view of the urgency and necessity to improve the environmental condition in the study area, the priority projects were selected and technical viability and financial feasibility were identified. It is recommended that the Government of the Republic of Venezuela should promote all priority projects to the next stage of project implementation at the earliest possible time.

Finally, we wish to take this opportunity to express our sincere gratitude to the Government of Japan, particularly, JICA, the Ministry of Foreign Affairs, the Ministry of Construction and other offices concerned. We also wish to express our deep appreciation to Ministerio del Ambiente y de los Recursos Naturales Renovables (MARNR), Tuy River Basin Agency, Oficina Central de Coordinacion y Planificacion de la Presidencia de la Republica (CORDIPLAN), HIDROCAPITAL and other authorities concerned of the Government of the Republic of Venezuela for the close cooperation and assistance extended to the JICA Study Team during the Study.

Very truly yours,

YOSHIHARU MATSUMOTO
Team Leader
JICA Study Team

Encl. : a/s

COMPOSITION OF FINAL REPORT

Volume 1:	Executive Summary
Volume 2:	Main Report (Master Plan Study)
Volume 3:	Main Report (Feasibility and Pre-Feasibility Study)
Volume 4:	Supporting Report (I) (Sector A to E)
Sector A:	Water Quality Condition and Monitoring
Sector B:	Existing Water Supply System
Sector C:	Industrial and Piggery Wastewater Treatment
Sector D:	Sewage Treatment
Sector E:	Turbid Water Treatment
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Sector F:	Securement of Water Quantity
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Sector H:	Construction Plan and Cost Estimate
Sector I:	Socioeconomic Condition and Project Evaluation
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Volume 6:	Data Book
Volume 7:	Resumen (Summary in Spanish)
Volume 8:	Informe Principal: Estudio del Plan Maestro (Main Report for Master Plan Study in Spanish)
Volume 9:	Informe Principal: Estudio de Factibilidad y de Pre-Factibilidad (Main Report for Feasibility and Pre-Feasibility Study in Spanish)

THE STUDY ON THE ENVIRONMENTAL IMPROVEMENT PROGRAM OF THE UPPER AND MIDDLE STREAM OF THE TUY RIVER BASIN

MAIN REPORT

MASTER PLAN STUDY

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ABBREVIATIONS

1. VENEZUELAN GOVERNMENT AGENCIES

MARNR	:	Ministerio del Ambiente y de los Recursos Naturales Renovables (Ministry of Environment and Natural Renewable Resources)
ODEPLI	:	Oficina de Desarrollo Profesional y Relaciones Internacionales
CORDIPLAN	:	Oficina Central de Coordination y Planificacion de la Presidencia de la Republica
SINAIHME	:	Database of the Office of Hydrology and Meteorology, MARNR
ACRT	:	Agencia de la Cuenca del Rio Tuy (Tuy River Basin Agency)

2. JAPANESE GOVERNMENT AND INTERNATIONAL ORGANIZATIONS

JICA	:	Japan International Cooperation Agency
IBRD	:	International Bank for Reconstruction and Development (World Bank)
UNDP	:	United Nations Development Programme
GTZ	:	Deutsche Gesellschaft für Technische Zusammenarbeit

3. UNITS OF MEASUREMENT

(Length)

mm	:	millimeter(s)
cm	:	centimeter(s)
m	:	meter(s)
km	:	kilometer(s)

(Area)

mm^2	:	square millimeter(s)
cm^2	:	square centimeter(s)
m^2	:	square meter(s)
km^2	:	square kilometer(s)
ha	:	hectare(s)

(Volume)

cm^3	:	cubic centimeter(s)
m^3	:	cubic meter(s)
ℓ	:	liter(s)

(Weight)

mg	:	milligram(s)
g, gr	:	gram(s)
kg	:	kilogram(s)
ton	:	tonne(s)

(Time)

s, sec	:	second(s)
min	:	minute(s)
h(hrs)	:	hour(s)
d(dys)	:	day(s)
y, yr(yrs)	:	year(s)

(Concentration)

mg/ℓ	:	milligram per litter
mcm	:	million cubic meter

(Speed/Velocity)

cm/sec, cm/s	:	centimeter per second
m/sec, m/s	:	meter per second
km/hr, km/h	:	kilometer per hour

(Stress)

kg/cm^2	:	kilogram per square centimeter
ton/m^2	:	ton per square meter

(Discharge)

ℓ/sec, ℓ/s	:	liter per second
m^3/sec, m^3/s	:	cubic meter per second
m^3/yr, m^3/y	:	cubic meter per year

(Electrical Units)

W	:	watt(s)
kW	:	kilowatt(s)
MW	:	megawatt(s)
kWh	:	kilowatt-hour
MWh	:	megawatt-hour
GWh	:	gigawatt-hour
V	:	volt(s)
kV	:	kilovolt(s)

(Water Quality related terms)

BOD ($BOD_{5,20}$)	:	5-day biochemical oxygen demand at 20°C
COD	:	Chemical oxygen demand
DO	:	Dissolved oxygen
EC	:	Electric conductivity
TOC	:	Total organic carbon
SS	:	Suspended solids
TN	:	Total nitrogen
TP	:	Total phosphorus
Pb	:	Plumbum (lead)
Cr	:	Chromium
Cu	:	Cuprum (copper)
Zn	:	Zinc
Pollution flowrate	:	

(Note: Other combined units may be constructed similarly as above)

4. MONETARY TERMS

¥	:	Japanese Yen
US$	:	United States Dollar
Bs.	:	Venezuelan Bolivare

5. SPANISH TERMS

Municipio	:	Municipality
Parroquia	:	Parish
Qda. (Quebrada)	:	Intermittent stream

6. Others

Art.	:	Article

CHAPTER 1. INTRODUCTION

1.1 Background

The Tuy River, with an aggregate catchment area of 8,619 km2 which encompasses Caracas and the area immediately south of Caracas in north central Venezuela, generally flows from west to east. Metropolitan Caracas is located along the upper reaches of a tributary, and the upper and middle streams of the Tuy River are the major sources of municipal water supply to the Caracas metropolitan area.

The upper and middle basins administratively belong to the states of Aragua and Miranda. On the upper basin, there are urban centers such as El Consejo and Las Tejerías in Aragua State. On the middle basin, in Miranda State, some of them are Ocumare del Tuy, Cúa and Charallave.

The right bank, or the southern side of the middle stream of the river marks the boundary of a national park and the area has less human habitation. Human activities causing pollution are, accordingly, less, and reservoirs for water supply to the Caracas metropolitan area have been constructed.

The condition is different in the upper stream and along the left bank, or the northern side of the middle stream where developed areas with medium and small scale factories such as wine distilleries, food factories, metal factories and piggeries exist. Human settlements in this area have the population ranging from 5,000 to 60,000.

Due to the wastewater from factories, piggeries and the urban areas, the water quality of the Tuy River has deteriorated. In addition, environmental conditions have become worse due to sediment production by human activities such as land development, riparian sand quarrying and deforestation of the mountains. The polluted water of the Tuy River has seriously affected the water supply to Metropolitan Caracas. Furthermore, the water supply system which started operation in the 1950's has become antiquated and inefficient.

To cope with the situation, and keen on improving the water supply system, the Government of Venezuela had considered two options for the improvement of the water supply condition to Metropolitan Caracas. These options are: (1) rehabilitation of the present water supply system, and (2) improvement of the water quality of Tuy River which should result in the securement of water quantity, and the first option is now ongoing

To pursue its goal of improving the water supply condition, the Government of Venezuela had requested technical assistance from the Government of Japan for the second option, namely the improvement of water quality of the Tuy River. In response, the Government of Japan had decided to conduct the subject study, the Study on the Environmental Improvement Program of the Upper and Middle Stream of the Tuy River Basin (hereafter called "the Study").

The Study has been entrusted to the Japan International Cooperation Agency (JICA), the official agency responsible for implementing technical cooperation programs of the Government of Japan. JICA had dispatched a study team in the beginning of February, 1996 and the Study has been substantially completed.

The study team had conducted four field studies in Venezuela and five in the home office in Japan. This Final Report presents all the results of the studies conducted, including the Master Plan, the Feasibility Study for selected priority projects for the improvement of water quality, and the Pre-Feasibility Study for the securement of water quantity.

1.2 Objectives of the Study

The objectives of the Study are:

(1) To formulate a master plan consisting of two stages, a short-term program and a mid-term program targeting the year 2010, on the environmental improvement program of the upper and middle Tuy River basin in order to secure a potable water supply with acceptable water quality and to establish a sustainable pollution control system;

(2) To conduct a feasibility study for the priority project(s) identified in the master plan; and

(3) To transfer technology on planning methods and skills to counterpart personnel.

1.3 Study Area

The Study Area covers the upper and middle stream basins of the Tuy River; namely, the watershed between El Consejo and the water intake site, La Toma de Agua, nearby San Antonio. The area of the basin up to the water intake is approximately 1,900 km^2.

1.4 Study and Staffing Schedule

The Study has been conducted through field studies in Venezuela and home office studies in Japan in accordance with the schedule shown in Fig. 1.4-1. Reports had been presented at times shown in this figure and meetings with the Steering Committee were held when these reports were presented. Workshops were held twice: the first one in the middle and the second at the end of the study period. A technology-transfer seminar was held at the end of the Study.

The members of the JICA Advisory Panel and the Study Team are listed in Table 1.4-1. The mobilization of members of the Study Team is shown in the staffing schedule in Fig. 1.4-2.

CHAPTER 2. PRESENT CONDITION AND STUDY RESULTS

2.1 Pollution Source Inventory

2.1.1 Factories

List of Factories

In the Study, the following factories have been selected for the inventory survey:

- Large scale factories with more than ten employees based on the 1990 OCEI (Central Office of Statistical Information) census.
- Large scale factories listed in the file of ACRT.
- Factories not included in the census and file, but considered to be significant polluters based on the other information such as branch office of ACRT and local governments.

Table 2.1-1 shows the factory categories or type of industry as well as the number of employees by administrative unit of city and town in the study area. The total number of factories and employees in the study area are 103 and 13,028, respectively.

Location of Factories

Factories are concentrated in the major cities of the basin such as Las Tejerías, Cúa, Charallave and San Francisco de Yare. Particularly in Las Tejerías and Charallave there are many factories with a high number of employees (see Fig. 2.1-1).

Pollution Source

(1) Food Related Industries

Food related industries which discharge organic substances causing organic pollution are dominant both in the number of factories and the number of employees. The industry has 23% of the total number of factories and 31% of employees. Wine manufacturers of chiefly rum have the largest number of employees among them. One factory in El Consejo employs 573 and another in Ocumare del Tuy has 440. In Charallave, one food and snack manufacturer has 691 employees.

(2) Non-Food Related Industries

The textile, tannery, and car parts industries, which possibly discharge heavy metals, come second to the food related industries in the number of factories and employees. One manufacturer of ceramic floor tiles in San Francisco de Yare has an exceptionally large number of employees, 1,039.

Other possible polluters include Tanneries which discharge large quantities of organic substances and probably also cyanide, chromium and lead; Paint factories; Plastics and synthetic fiber manufactures; Soap and cleaning

chemical factories; Other chemical manufactures; and Glass and fiberglass factories. These, however, are small in number compared with the other industries mentioned above.

The following table lists down the industries whose factories probably discharge inorganic chemicals, mainly heavy metals in their wastewater.

Factories probably discharging inorganic chemicals

CIIU	Industrial Category	Inorganic Chemicals	No. of factories (employees)
32311	Tannery and finishing of leather	CN, Pb, Cr^{6+}	1(14)
32321	Industry to prepare tanning leather	CN, Pb, Cr^{6+}	1(59)
35211	Manufacture of paint and varnishes	Cd, CN, Cr^{6+}, Hg	6(914)
35231	Manufacture of soaps and cleaning products	CN, Pb, Cr^{6+}	7(821)
36201	Production of fiberglass	CN, Pb, Cr^{6+}, As	2(87)
37201	Production of non-ferrous metals and alloys	CN, Pb, Cr^{6+}	6(524)
38191	Manufacture of metallic products, excl. machinery	CN, Pb, Cr^{6+}	3(183)
38193	Metal plating	Cd, CN, Pb, Cr^{6+}, As, Hg	7(833)
38431	Car parts factory	Cd, CN, Pb, Cr^{6+}, As, Hg	1(296)
38433	Automobile spare parts factory	CN, Pb, Cr^{6+}, As,	5(722)

Treatment Condition

During the master plan study period 40 factories were interviewed to collect information on their wastewater treatment conditions (see Table 2.1-2). It was found out that a significant number of them are without a wastewater treatment system (refer to Table 2.1-2).

Four (4) of the twelve food related factories surveyed have no treatment facilities. In the other 28 factories, 13 which may be discharging inorganic chemicals do not give any treatment at all. The 40 factories include one plant at a sand quarry in Paracotos which is a possible polluter causing the high turbidity in the Tuy River.

2.1.2 Piggeries

List of Piggeries

In the study area, the piggeries are also the main polluters in the upper and middle basin. The list of piggeries is shown in Table 2.1-3.

Location of Piggeries

Piggeries are mostly found in a few areas (see Fig. 2.1-2): Qda. Morocopo and Qda. Guayas in the upper basin, where 20 piggeries with a total 48,413 pigs exist, and Ocumare del Tuy and Charallave in the middle basin, where there are 13 piggeries with 23,068 pigs as of 1996 (see Table 2.1-4).

Compared to the condition in 1988, the number of piggeries decreased from 46 to 33, while the number of pigs did not change so much from 70,000 to 71,000 over the whole Study Area (see Table 2.1-5).

Treatment Condition

Most treatment systems are lagoons, and the removal efficiency is about 60% as a whole. According to the information, several piggeries do not discharge waste directly into a water course, but use it for irrigation or discharge it on to an open field. Thirty percent (30%) of the piggeries in the upper basin do not discharge waste, while the figure is 23% in the middle basin (refer to Table 2.1-3).

2.1.3 Population and Households

Spacial Distribution of Population

According to the population census data by OCEI, the population in the study area concentrate in the large cities of Las Tejerías (23,819), Charallave (59,939), Cúa and Las Mercedes (62,836) and Ocumare del Tuy and Colonia Mendoza (76,880). (See Table 2.1-6).

The population and area by sub-basin in 1995 were estimated based on the population data by OCEI-1990 considering the standard population growth rate obtained in this study. (Table 2.1-7 and Fig. 2.1-3). The sub-basins of Charallave (143,185), Ocumare del Tuy (95,399), and Las Tejerías (41,887) have a large number of population causing water pollution mainly from domestic waste.

Treatment Condition

In general, the following conditions regarding the treatment of wastewater from households in the basin were observed:

- Individual treatment by septic tank and flush toilet, but direct discharge of other wastewater.
- Sewage system without treatment plant which is connected to tributaries or to the Tuy River.
- Others

The percentage of households connected to a sewage system is 78% in Miranda State and 75% in Aragua State. The major cities in the basin where a sewage system is provided are La Mora, El Consejo, Las Tejerías in the upper basin, and Cúa, Charallave, Ocumare del Tuy, and San Francisco de Yare in the middle reaches (refer to Tables 2.1-8 and 2.1-9).

Besides, there exist seven sewage systems with treatment plants for the local communities as shown in the table below:

Treatment System for Domestic Wastewater

No.	Location	Type of Treatment	Treatment Ability (m^3/day)	Water body (receiving)	Status
1	La Mora	Oxidation pond	800	C. Tiquirito	Not connected to sewer
2	El Consejo	Oxidation pond	600	C. Tiquirito	Not connected to sewer
3	Las Tejerías	Oxidation pond	800	Tuy River	Not connected to sewer
4	La Estrella (Charallave)	Biological Treatment	2,100	Qda.Charallave	Operating
5	Vallecito (Charallave)	Biological Treatment	500	Qda.Charallave	Operating
6	Ave Maria (S.F de Yare)	Biological Treatment	1,500	Tuy River	Stopped
7	Terraza de Cúa	Biological Treatment	800	Qda. Cúa	Operating

Of the seven treatment facilities, three are located in the upper basin and four in the middle basin. The upper basin systems consist of oxidation ponds to treat wastewater from neighboring residential areas. However, wastewater is not collected from every area by the existing sewerage network due to damaged pipes and the ponds are not functioning at present. The latter for the collective housing are biological treatment plants and are functioning except one system.

2.2 Water Quality Analysis

2.2.1 Water Quality Standard

As stipulated in the "Standard for Classification and Quality Control of Water Bodies and Liquid Residues or Effluents" in Decree No. 883 (December 18, 1995), the general classification of water is summarized in the table below:

Type	Description
Type 1	Water for domestic and industrial use which requires potable quality, whatever part of a product or sub-product for humans or in contact with.
Sub-Type 1A	Water that can be adapted for use with only the addition of disinfectants in terms of sanitation.
Sub-Type 1B	Water that can be adapted by means of conventional treatment such as coagulation, flocculation, filtration and chlorinating.
Sub-Type 1C	Water that can be adapted by non-conventional potabilization processes.
Type 2	Water for agricultural and livestock use.
Type 3	Saline water or of marine related, destined to the growing and exploitation of mollusks to be consumed crude.
Type 4	Water for bathing resorts; aquatic sports; sport, commercial or subsistence fishing.
Sub-Type 4A	Water for total human contact
Sub-Type 4B	Water for partial human contact
Type 5	Water for industrial use which do not require drinking water.
Type 6	Water for navigation and power generation.
Type 7	Water for transportation, dilution and dispersion of contaminants without producing interference with the adjacent environment.

The water type currently applied to the Tuy River is Sub-type 1B of Type 1, whose precise qualities are listed in Table 2.2-1, compared with those of Type 2 and the standard limitations for discharged water. Later in this section, "the standard" particularly means the water quality standard for the Sub-type 1B.

2.2.2 Results of Water Quality Analyses in This Study Period

Condition of Water Quality Analysis

To identify the pollution condition of the Tuy River, a series of water quality analysis was conducted in the following manner:

(1) Parameter Analysis

The specific parameters were selected for this study from those commonly applied in examining pollution condition (see Table 2.2-2).

(2) Sampling Sites and Sampling Times

Sampling sites were selected from the following view points:

- To examine pollution load balance (Tuy River and tributaries)
- To identify the pollution sources (Factories, piggeries and residences discharging wastes)

Herein, the pollution load balance is defined as the balance between inflow pollution load and outflow pollution load in a certain section. Each sampling

site was selected, corresponding to that of the previous studies in order to compare with past observation results and the key points to examine the pollution load balance of the Tuy River. The number of sampling sites are listed in Table 2.2-2 and each site location is shown in Fig. 2.2-1.

Results of Water Quality Analysis

(1) Water Quality of Tuy River

(a) Organic Pollution

Organic pollution is basically identified by the indices of the dissolved oxygen (DO), the biochemical oxygen demand (BOD) and the chemical oxygen demand (COD). Their values for the samples are shown in Fig. 2.2-2.

In Fig. 2.2-2, organic pollution at the BOD concentration of 720mg/ℓ is apparent in the upper reaches and gradually improves to a BOD of 32mg/ℓ towards the lower reaches. This condition is presumably owing to the wastewater from the factories on the upper reaches, especially in the Caño Tiquirito Basin and Qda. Guayas. On the other hand, the improvement in the lower reaches is attributable to clean water discharged from the Ocumarito Reservoir and the river's purification effect observed in the stretch between the point R5 of the Tuy River called "Boca de Cagua" and the point R6 called "Tazón". The BOD at the water intake point becomes as low as 7 mg/ℓ which is mostly attributable to the purification effect in this reaches.

(b) Heavy Metal Pollution

Heavy metal pollution can be identified by the metals T-Cr, T-Pb, T-Cu, T-Zn, etc. The results of analysis are shown in Fig. 2.2-3. Heavy metal pollution is critical as three samples at R4, R5 and R8 show higher values than the standard limit for T-Cr.

(c) Turbidity

The results of turbidity analysis are shown in Fig. 2.2-4. Turbidity and suspended solids (SS) in the Tuy River are not serious except at one point, R8, which is attributable to the wastewater discharged from factories of sand quarries along the river course.

The self-purification effect between R5 and R6, which is derived from the BOD analysis, is not apparent in the results of turbidity and SS. This is due to solid particles from the sand quarries in this stretch which overburden the purification effect.

(d) Others

Among other indices, the fecal cloakroom group was analyzed and its results are shown in Fig. 2.2-5. The value of total coliform is far higher than the standard limit of 10,000 MNP/100ml and thus, such pollution condition is considered to be serious.

(2) Water Quality of Tributaries

(a) Organic Pollution

The tributaries giving pollution load to the Tuy River were selected for sampling. A set of results is shown in Fig. 2.2-6.

Judging from the results, the tributaries in the upper reaches are severely polluted as the BOD values of 840 mg/ℓ in Caño Tiquirito (T1) and 1,740 mg/ℓ in Qda. Guayas (T12) reveal. On the other hand, those in the lower reaches with BOD in the range of 10 to 20 mg/ℓ are not regarded as severely polluted and some are clean enough as a water supply source.

(b) Heavy Metal Pollution

All observed values of metal pollution indices are within the allowable range of the standard. No severe heavy metal pollution condition in the tributaries was detected.

(c) Turbidity

Turbidity in the tributaries is not excessive by the standard (see Fig. 2.2-7) except in one tributary, Qda. Maitana, where a sand quarry exists releasing highly muddy water. The turbidity of Qda. Maitana is 15,000 NTU, though the limitation is not specified in the standard. However, the influence of a large amount of substances may be weakened by the purification effect in this stretch of the Tuy River. This is proven by the fact that the turbidity of the Tuy River after the confluence with Qda. Maitana does not significantly increase.

(d) Others

Among other indices, total coliform is high in most of the tributaries and all values exceed the limit of the standard (see Fig. 2.2-8).

(3) Water Quality from Factories

The factories in the basin are classified into two categories by their products: Non-food and food related factories. The wastewater released from these factories has the following qualities:

(a) Non-food Related Factories

Among the non-food related factories in the basin, the main pollution sources of the Tuy River are textiles, metal works, sand quarries, and tanneries. The quality of wastewater from these factories is shown in Fig. 2.2-9 and explained as follows:

Organic pollutants released from some factories are over the standard limit, which is 350 mg/ℓ for factories discharging into the sewer system and 60 mg/ℓ for the factories directly discharging into the river. Among the samples from 17 factories, those from 5 factories discharging directly into the river were higher than 60 mg/ℓ, and those from two factories discharging into sewers were higher than 350 mg/ℓ.

Levels of heavy metals in the effluent from factories discharging into the Tuy River are high according to the results. Three cases, two for T-Cr and one for T-Hg, were higher than the standard limit.

In general, the turbidity is not high except the samples nearby the sand quarries. In contrast, SS values from 11 factories among 17 factories are above the standard limit of 80 mg/ℓ for direct discharge to the river and samples from two other factories were above the standard of 400 mg/ℓ for the discharge to the sewer system.

(b) Food Related Factories

Among the food related factories, the main pollution source of the Tuy River are from an wine distillery, meat processing, and soft drink factories. The figures for the quality of wastewater from these factories are in Fig. 2.2-10. The following remarks are derived from the results:

Organic pollution is dominant in the wastewater. BOD ranges from 5 mg/ℓ to 7,000 mg/ℓ. Six in ten factories released more highly polluted wastewater than the standard (60 mg/ℓ) limit for the factories directly discharging into the river, and five factories also violated the standard limit (350 mg/ℓ) for those discharging into the sewage system.

The turbidity, in general, is not high, judging from the observed values, although SS values of the samples from eight of ten factories were above the standard limit (80 mg/ℓ) while the values of the other samples were higher than the standard limit (400 mg/ℓ).

(4) Water Quality from Piggeries

As in the case of the factories producing food related products, the quality of wastewater from piggeries is characterized by organic pollution as summarized below (also see Fig. 2.2-11):

Organic pollution is dominant in the wastewater from the fact that the samples from seven of eight piggeries releasing wastewater into the river were above the standard limit for BOD (60 mg/ℓ) and the samples from five piggeries releasing into sewers were above 350 mg/ℓ.

Turbidity and SS were also high in the analyzed data. The samples from seven of eight piggeries releasing waste into the river were above the standard limit (80 mg/ℓ), and the samples from five piggeries releasing into sewers were above the limit of 400 mg/ℓ.

(5) Water Quality of Domestic Wastewater

The domestic wastewater was observed at points where raw sewage discharges into the rivers. The water pollution by domestic wastewater is identified as follows (refer to Fig. 2.2-12):

Organic pollution was dominant in the wastewater from the results. The values of BOD at five out of eight points observed were above the standard limit of 350 mg/*l*, although those of COD at all points satisfy the standard.

Turbidity is also high from the observed values of SS; four out of nine points are above the standard limit of 80 mg/ℓ.

2.2.3 Water Quality Analysis Using the Previous Study Results

To identify some long term characteristics, past data were examined, focusing on the historical and seasonal changes of pollution conditions.

Historical and Seasonal Change at Toma de Agua

In the Tuy River, water quality was analyzed several times and the BOD data at Toma de Agua are available for 1968, 1985, 1990, 1992 and 1996. The data are shown in Fig. 2.2-13 and 2.2-14. From these figures, the following pollution conditions are recognized:

With reference to the annual change from 1968 to 1995, pollution became worse until 1985 due to the increased pollution load from the river basin. Then improvement between 1985 and 1995 was observed (see Fig. 2.2-14). Remarkable improvement had been observed since December, 1995, when inspection to control the illegal discharge of wastewater was strengthened (see Fig. 2.2-14). Thus, this improvement is presumably owing to the efforts for reduction of pollution load by the agencies concerned.

There is no remarkable difference in the average BOD value between the dry and rainy seasons partly because of the limited data, although high BOD values are observed in the rainy season. The maximum value reaches 50 mg/ℓ in the rainy season, while that in the dry season is 35 mg/ℓ (see Fig. 2.2-14).

The fluctuation of BOD values detected is relatively large even in the short period of the data. According to those in 1985, the values fluctuated between 15 mg/ℓ in

August 14 and 50 mg/ℓ in August 28. This may have been caused by a flood that occurred at that time.

Besides these comments, relatively stable pollution conditions were also observed in the rainy and dry seasons from the data of 1990 and 1995.

Longitudinal Pollution Condition of the Tuy River

Simultaneous water analyses at several sampling points in the upper and lower reaches were conducted five times: twice in April 1989 and one each in April 1991, December 1995, January 1996 and February 1996 (see Fig. 2.2-15).

Despite the limited data, it was noticed that the characteristics of the present pollution conditions have not particularly changed from the past. The general pattern is that BOD is very high in the upper reaches and tends to decrease towards the lower reaches due to the remarkable purification effect observed along the Tuy River.

Heavy Metals in the Tuy River

Heavy metals of Cadmium, Chromium, Lead, Zinc, Iron, Copper, Manganese and Nickel in the water of the Tuy River were measured several times in the last ten years. As shown in Table 2.2-3, the concentrations of Cadmium, Chromium and Lead exceed the limit given in the standard, Decree Type 1-B, for the last ten years.

2.3 Meteorology and Hydrology

2.3.1 Available Data

An inventory of the meteorological and hydrometric stations in and around the study area is given in Table 2.3-1. The location of these stations is indicated in Fig. 2.3-1. The number of stations where data was collected is tabulated as follows:

Station Type	Organization			Total
	SM	MA	AC	
Climatology	1	1	-	2
Pluviograph	-	10	-	10
Pluviometer	-	-	1	1
Hydrometric	-	15	-	15

Note: SM: Aeronautical Meteorological Station
MA: MARNR
AC: Tuy River Basin Agency

The Team installed three automatic water level gauges at the locations shown in Fig. 2.3-2.

The condition of observation, data filing, operation and maintenance at each station was investigated and compiled in "*Sistema de Control de los Recursos Hídricos en la Cuenca Alta y Media del Río Tuy, Septiembre 1995, GTZ*", which is summarized as follows:

2.3.2 General Climate

The climatic condition of the study area is shown in Fig. 2.3-3 and the characteristics of climate are mentioned below:

Temperature

The monthly mean temperature is almost constant throughout the year. The difference between months is small, even much smaller than the fluctuation of daily temperature. Variation in altitude is more pronounced than the horizontal variation which is constant. The temperature in the middle basin of the Study Area, Cúa-Tovar to Santa Teresa is approximately 26°C on the average, while it is 15-17°C in the mountainous area, Colonia Tovar and Agua Fría in the upper basin.

The variation in maximum and minimum temperatures is small at ±1°C to 2°C from the average temperature in both mountainous and plain areas. At either locations, the maximum temperature occurs in May and the minimum in January.

Relative Humidity

Monthly variation of relative humidity is illustrated in Fig. 2.3-3. At Colonia Tovar, at an elevation of 1,435 m, the relative humidity is slightly higher than those in the lowlands varying from about 80% to 90%. In the relatively lower lands at Cúa-Tovar and Santa Teresa, these vary in the range from 70% to 80%.

The relation between the patterns of relative humidity and rainfall is clear at all the stations. It rises in May, at the beginning of the rainy season, and is lowest in March.

Winds

Data of mean wind velocity in the study area is available only at Colonia Tovar. According to these, no distinct variations are obvious throughout the year. It is slightly higher from January to March at about 3.3 to 3.5 km/hour and the lowest in November at about 2.5 km/hour.

The prevailing wind direction in Colonia Tovar is NW to NNW from January to April and SSE to ESE from May to December. In Cúa-Tovar, winds from ENE-ESE prevail throughout the year.

Evaporation

Annual evaporation is high at approximately 1,700 to 2,100 mm in the lowlands. The monthly evaporation ranges between 180 and 250 mm in the dry season and between 110 and 150 mm in the rainy season. The monthly variation presents a peak in March, at the end of the dry season, with higher values until May. It decreases when the rainy season starts.

2.3.3 Rainfall

Annual Rainfall

Average annual and monthly distribution of rainfall in the Study Area are illustrated in Fig. 2.3-4. The average annual rainfall ranges from 800 to 1,000 mm. In the flat valley in the areas of Cúa-Tovar to Santa Teresa, it is relatively higher at about 1,100 mm. It is less on the mountain slopes to the north and the south. The annual rainfall in the valley, namely, at El Consejo, Las Tejerías, Paracotos and Charallave is the lowest at about 800 mm.

Effect of the altitude is not very clear except in the northern mountainous area, and it is not very distinguished even there. Geomorphological effect or difference by location on the basin is more pronounced to the amount of annual rainfall.

Monthly Rainfall

The monthly rainfall increases in May and continues until November or December at all the stations in the basin. Although some variations exist by location, the rainy season is from May to December and the dry season in the rest of the year.

The rainfall pattern of Venezuela can be broadly divided into two: (1) the Llanos pattern which has a single maximum occurring during the high-sun months and distinct low-sun dryness; and (2) the semi-annual pattern which during the course of the year completes two oscillations between wet and dry. The Llanos pattern is characteristic of the entire central area of Venezuela, while the semiannual pattern is most prevalent over the coastal areas.

When this is compared to the patterns in the study area, the distribution in the lower lands in the east of Cúa is similar to the complete Llanos pattern. Areas in the western part, El Consejo and to the north, presents some influence of semi-annual pattern with two peaks in the year.

Approximately 95% of an annual rainfall concentrates in May to December. The dry season is very distinct from January to March nearly without rainfall.

Daily Rainfall

Daily rainfall distributions of representative stations are presented in Fig. 2.3-5. Annual number of rainy days in 1983 is 132 (4.4 months) at Las Tejerías and approx. 170 (5.7 months) at Colonia Tovar, Cúa-Tovar, Rio Arriba and Santa Teresa. Rainfall in the rainy season is usually 5-10 mm per day.

Short-term Duration Probable Rainfall Intensity

Fig. 2.3-6 presents 2-year return period probable 1-hour and 24-hour rainfalls calculated at each station in the study area. The rainfall in the study area is characterized by concentration in a short period.

2.3.4 Runoff

River Features

The division of the catchment basin for major tributaries is presented in Fig. 2.3-7, and the longitudinal profile of the Tuy River and major tributaries is shown in Fig. 2.3-8. The river features, e.g., catchment area, river length, by tributary are summarized in Table 2.3-2. The catchment basin of the Tuy River at the water intake of San Antonio (Toma de Agua) is 2,162 km^2, while the total river length is 129 km.

Runoff Discharge

The river runoff data to be used in the study is as follows:

- Confirmation of available water at water intake of San Antonio
- Development of tributary water for securement of water supply source

The available discharge data with a sufficient observation period in the study area are limited as discussed in 2.3.1. The following study has been conducted.

(1) Runoff Discharge in the Tuy River at Toma de Agua

(a) Available Data

As discussed in Section 2.3.1, the following data are available for the discharge of the main stream of the Tuy River.

Location	C.A. (km^2)	Observation Period
Hda. Barrios	248	1941-77
Hda. Tazón	1,180	1941-77
San Antonio	1,843	1989-92

(b) Historical Trend in Monthly and Annual Average Runoff Discharge

The runoff discharge at San Antonio includes supply from Camatagua Reservoir through Ocumarito Reservoir. Accordingly the discharge at Hda. Tazón is used for the discussion of the discharge of the Tuy River in the middle stream. Fig. 2.3-9 illustrates the monthly average, maximum and minimum discharges of the Tuy River at Hda. Barrios (248 km^2) and Hda. Tazón (1,180 km^2) for the 37-year period from 1941-1977. These values for 20-year period from 1958-1977 are presented in Table 2.3-3.

Both stations show a pronounced decreasing trend in the discharges. It is assumably due to human intervention of water balance. Historical change in the annual average discharges of the Tuy river at Toma de Agua is presented in Fig. 2.3-10. As seen in the figure, there is a

decreasing trend in the annual average discharge. The degree of decrease, however, seems less in the latter years compared to the 1940's and 1950's.

(c) Monthly Average Runoff Discharge

Monthly average specific runoff discharges at Hda. Barrios and Hda. Tazón are as follows: Specific runoff discharge per 100 km^2 at Hda. Barrios is small due to the use in the basin.

Monthly Average Specific Runoff Discharge of the Tuy River

$m^3/s/100km^2$

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Hda. Barrios	0.11	0.08	0.08	0.12	0.23	0.36	0.37	0.44	0.42	0.40	0.35	0.19	0.27
Hda. Tazón	0.23	0.16	0.12	0.12	0.21	0.51	0.61	0.83	0.68	0.70	0.51	0.34	0.39

The monthly runoff discharge at Toma de Agua calculated on the basis of the specific runoff discharge at Hda. Tazón is presented in Table 2.3-3. Monthly average values are as follows:

Monthly Average Runoff Discharge of the Tuy River

$m^3/s/100km^2$

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
San Antonio	4.34	2.91	2.14	2.22	3.89	9.49	11.27	15.31	12.60	12.93	9.39	6.29	7.19

Note: Data is calculated based on the specific discharge data at Hda. Tazón

(d) Flow Duration

Daily discharge data of the Tuy River is available at San Antonio. A flow duration curve has been accordingly prepared at San Antonio as presented in Fig. 2.3-11.

(2) Runoff Discharge in Tributaries

Runoff discharge data in tributaries of the Tuy River are available at the following stations:

(a) Available Data

River	Location	C.A. (km^2)	Observation Period
Guare	Rio Arriba	92.0	1978-93
Ocumarito	El Desecho	122.7	1960-67

(b) Monthly Average Discharge

At Rio Arriba on the Guare River, a right bank tributary that flows into the Tuy River at Tácata, relatively latest observed data from 1978 are available, but with a lot of missing data. Accordingly as runoff discharge data for tributaries, those at El Desecho in the Ocumarito River have been used.

The monthly average discharge is presented in Table 2.3-4, and the daily discharge plot and the duration curve are illustrated in Fig. 2.3-12. Monthly average discharges are summarized as follows:

Monthly Average Discharge of the Ocumarito River

$m^3/s/100km^2$

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
El Desecho	0.84	0.61	0.42	0.31	0.55	1.49	2.71	3.78	3.02	1.95	1.49	1.42	1.56

Catchment area: 122.7 km^2

2.4 Survey and Analysis on Turbid Water

2.4.1 Cause of Turbid Water

On the Tuy River basin, the obvious causes of turbid water are the wastewater due to human activities and sediment partly due to erosion, and these are individually examined as follows:

Wastewater of Human Activities

As identified in the water quality analyses in Section 2.2, some factories frequently discharge large quantities of organic pollutants including organic suspended solids (SS) and the plants at sand quarries discharge a large quantity of turbid water. The total volume is roughly estimated at 159.1 ton/day.

The organic SS pollution load is mainly detected in the upper reaches, at Caño Tiquirito and Qda. Guayas, while solid particles from sand quarries are discharged into the middle reaches, at Qda. Maitana and the stretch along the Tuy River between El Conde and Colonia Mendoza.

Pollution loads causing turbidity are detected throughout the year. In the dry season, however, these pollution loads partially become less as flow in the Tuy River become less. Some are deposited on the riverbed due to the dissipated transporting forces of the river, which is regarded as a natural purification effect. As a result, the human activities related turbidity is not severe at the water intake point in the dry season (turbidity due to basin erosion is also less in this period).

In contrast, in the rainy season, the SS increase due to accumulated deposition on the riverbed with the pollutants produced by daily activities of factories, though natural runoff discharge also increases.

In this connection, it is assumed that the sediment load deposited throughout the dry season is transported in the rainy season when runoff discharge reaches a certain level. The typical runoff discharge of each season is low water discharge of 1.9 m^3/sec and ninety-five-day runoff discharge of 10.3 m^3/s, as follows:

Season	Pollution Load (SS) from factories	Deposited in Riverbed	Balance (Pollution Load at Water Intake)	Water Discharge	Water Quality
	(ton/day)	(ton/day)	(ton/day)	(m^3/sec)	(mg/ℓ)
Dry	159.1	130.6	28.5	1.9	174
Rainy	159.1	-130.6	289.7	10.3	326

Natural Sediment Production

Sediment from the basin generally consists of three types of loads depending on the grain size as shown in table below. The relation of their volume for the Tuy River is empirically put in Fig. 2.4-1, which shows the portion of each sediment load deposited in dam reservoirs.

Item	Suspended Solids		Bed load
	Wash load	Suspended load	
Diameter (mm)	d < 0.1	0.1 < d <1	1 < d
Volume (%)	85	12	3
Porosity	0.75	0.4	0.3

Suspended solids are composed of wash load and suspended load. It is difficult to separate clearly the cause of production of each load, but wash load as fine particles is attempted to be defined mainly as a product of natural surface erosion due to a storm. Suspended load as coarser particles is by bank erosion and collapse. In this study, wash load is calculated by the Universal Soil Loss Equation (USLE) and suspended load is calculated by the volume rate between wash load and suspended load.

Precise calculation of the amount of sediment depends on the complexity of the surface erosion mechanism and technically, in general for the estimation, two methods are adopted: (1) estimation based on the experimental equation applying USLE and (2) estimation based on the observed data at Had. Tazón and in Lagartijo reservoir.

As the result, the annual amount of total suspended solids from the basin is estimated as 221 (ton/km^2/year).

2.4.2 Turbidity in the Tuy River Basin

In the former sub-sections, SS volume which causes turbidity in Tuy River basin was examined as summarized below:

- SS load from factories : 159.1 (ton/day) × 300 (days) = 47,730 (ton/year)
- SS load from river basin : 221 (ton/km^2/year) × 2,162 km^2 = 478,000 (ton/year)

The differences between the pollution loads with their production and effluent are summarized in the table below. The total SS production volume from human activities is 1/8 of that from the river basin and thus the major origins of SS production is concluded to be from the river basin.

Source of SS load	Time of Production	Transport in dry season	Transport in rainy season
Human activity (47,730 ton/year)	throughout the year	most of the production is deposited on the river course	all production amount and deposited ones are transported
Basin (478,000 ton/year)	rainy season	-	all the production amount are transported

Besides this, Fig. 2.4-2 shows the SS duration curve at the water intake point. The total SS is the one from the river basin plus the other from human activities. This total SS has to be below the standard limit.

SS for 75% of the samples from the river basin is 900 mg/ℓ and that from factories is 330 mg/ℓ. Therefore, the actual SS of the Tuy River at the water intake point does not satisfy the standard limit. Judging from this, control of factory wastewater is needed for calming the problem of pollution load (SS).

2.5 Pollution Discharge and Flow Mechanism Study

2.5.1 Pollution Flowrate in Past Studies

Pollution flow rate, which is defined as production pollution load per capita, a worker or a pig per day in this study, is necessary to calculate the effluent pollution load discharged into the Tuy River. The following pollution flow rate is obtained based on the previous study results and the other reference materials.

Pollution Source	BOD Pollution Flow Rate	Reference Materials
Industry	Shown in Table 2.5-1	CIIU
Piggery	162 (g/pig/day)	PETA
Domestic	54 (g/person/day)	SARETUY Report

2.5.2 Pollution Load Balance

In this study, water quality and runoff discharge were observed at several points. Based on the observed data, pollution loads of BOD and SS at these points can be calculated multiplying the water quality value (mg/l) by runoff discharge (m^3/s) in a manner of ton per day (ton/day). The pollution load balance was examined at each main point in the Tuy River and its tributaries based on the observed value as discussed below (refer to Figs. 2.5-1 and 2.5-2).

BOD Pollution Load

BOD pollution load balance in the Tuy River is featured as follows:

- At the uppermost point R1, the pollution load is as small as 0.1 g/s (0.0 ton/day) and water is less polluted.
- After receiving the pollution load at Caño Tiquirito, the pollution load of the Tuy River sharply increases to 113 g/s (9.8 ton/day) at point R1.
- Pollution load at point R2 in the Tuy River increases towards the lower reaches, up to 277.7 g/s (24.0 ton/day) at the confluence point with the Cagua River, then suddenly reduces to 29 g/s (2.5 ton/day) at the R6 point in the Tuy River. The river's self purification effect may contribute to this improvement of water quality.
- Lower than R6 point, the pollution load does not significantly change, fluctuating between 29 g/s and 40 g/s (3.5 ton/day), finally marked at 30.9 g/s (2.7 ton/day). This is because the pollution load released and the self-purification effect in this stretch are balanced.
- Major pollution loads come from the two tributaries: Caño Tiquirito and Qda. Guayas with the values of 90.7 g/s (7.8 ton/day) and 43.5 g/s (3.8 ton/day) flowing into the Tuy River near Las Tejerías, while pollution loads from other tributaries are less than 5 g/s (0.4 ton/day).

SS Pollution Load

SS pollution load balance is slightly different from that of BOD pollution load as described below:

- At the uppermost point R1, the pollution load of 2.2 g/s (0.0 ton/day) is quite small and water is less polluted.
- After receiving the pollution load from Caño Tiquirito, the pollution load of the Tuy River sharply increases to 125.6 g/s (10.9 ton/day) at point R1.
- Pollution load at point R2 in the Tuy River increases towards the lower reaches, up to 326.0 g/s (28.2 ton/day) at the confluence point with the Cagua

River, though the maximum value emerges at R4 point of 380.3 g/s (32.9 ton/day).

- Pollution load at point R6 in the Tuy River does not increase in spite of the high pollution load of 1,728.3 g/l (149.3 ton/day) from Qda. Maitana. This reduction is attributable to the self-purification effect in this stretch of the Tuy River.
- The pollution load in the lower reaches does not change in the stretch from R6 up to R7 point with the pollution load of 277.1 g/s (23.9 ton/day).
- After R7 point, the pollution load increases up to 660.3 g/s (57 ton/day) because of the sand mining operations along the river course in this stretch.
- Finally, the pollution load at the water intake point R10 is 494.1 g/s (42.7 ton/day).
- Major pollution loads come from four tributaries: Caño Tiquirito, Qda. Guayas, Qda Maitana and Ocumarito. Although the pollution load of Ocumarito River has a high value of 70.4 g/s due to the large amount of discharge, SS is not high. Besides this, other polluters are the sand quarries along the stretch between points R7 and R8.

2.5.3 Pollution Analysis by Simulation Model

It is necessary to identify the pollution mechanism to prospect the pollution condition by changes of pollution loads from basin and to examine the effect of measures to control the pollution loads. For that purpose, pollution analysis was conducted using a simulation model in accordance with the procedure in Fig. 2.5-3.

The pollution analysis was conducted in the following conditions:

- The RIOS model is chosen as a simulation model.
- For verifying this model, observation data were used as the present pollution condition in this study period.
- As the water quality index for simulation of organic pollution, BOD is used.
- For the estimation of BOD production pollution load, flow.rate discussed in the section 2.5.1 is used.

As the results, the following pollution conditions were identified (see table below and Fig. 2.5-4, 2.5-5 and 2.5-6):

Pollution Load	Pollution source	Upper Basin		Middle Basin		Total	
		(kg/day)	(%)	(kg/day)	(%)	(kg/day)	(%)
Production Load	Factory	58,243	81.9	8,429	30.5	66,672	67.5
	Piggery	8,554	12.0	3,759	13.6	12,313	12.5
	Domestic	4,290	6.1	15,466	55.9	19,756	20.0
	Total	71,087	100.0	27,654	100.0	98,741	100.0
Effluent Load	Factory	11,362	56.6	5,503	24.2	16,864	40.7
	Piggery	3,222	15.4	1,878	8.3	5,100	12.3
	Domestic	4,173	28.0	15,337	67.5	19,510	47.0
	Total	18,757	100.0	22,718	100.0	41,474	100.0

Relation between Production and Effluent Pollution Load

- The BOD production pollution load at the source in the upper and middle basin of the Tuy River is 73 ton/day and 25 ton /day, respectively.
- The effluent pollution load from the basin is 20.9 ton/day in the upper basin and 20.6 ton/day in the middle basin. This is because the production pollution load at the source of a wine distillery in the upper basin shares a large amount and the treatment at the same factory greatly reduces the effluent pollution load.
- Effluent pollution load in the middle basin is relatively high because of the high share and low treatment rate of the domestic wastewater.
- On the whole basin, the total production pollution load is 99 ton/day, and effluent pollution load is 41 ton/day.

Share of Pollution Load among Factory, Piggery and Domestic

- In the upper basin, the share of the production pollution load from the factories is 80% at the source and 56% in effluent pollution load to river.
- Production pollution load from piggeries is 12% at the source and 15% in effluent pollution load.
- Production pollution load from domestic wastewater is only 8% at the source but it increases up to 28% in effluent pollution load because the treatment rate is low.
- In the middle basin, factories share 31% of production pollution load at the source and 25% of effluent pollution load.
- Piggeries share only 9% of effluent pollution load in the middle basin.
- The share of the production pollution load from domestic wastewater is as high as 54% at the source and 66% in effluent pollution load.
- As a whole in the upper and middle basins, the production pollution load from factories is as high as 68% at the source. It decreases to 41% in effluent pollution load and lower than that of domestic wastewater of 47%.

2.6 Study on Securement of Water Supply Source

2.6.1 Existing Dam/Reservoirs and Regulation Ponds

Major Features

Major features of reservoirs in and around the Tuy River basin are presented in Table 2.6-1. The summary of those features is represented by effective storage capacity in the table below:

Reservoir and Regulation Pond	Effective Storage Capacity (million m^3)	Major Function
Ocumarito	8.4	To supply water to the cities of middle basin area of the Tuy River. To release supplemental water to Tuy I and Tuy II system receiving that from Camatagua
Lagartijo	70.0	To supply water to Tuy I and Tuy II system
Taguacita	2.0	To supply water to Tuy II system
Camatagua	1,532.1	To supply water to Tuy III system, Irrigation (6,000 ha) and Recreation
Qda. Seca	6.5	To regulate pre-treated water of a pre-treatment facility at San Antonio To receive water from Tuy III system
La Mariposa	7.0	Regulation before Mariposa treatment plant.
La Pereza	8.0	Regulation before La Guairita treatment plant.

Operation Condition of the Reservoirs

The reservoirs' daily stored water volume for the 10-year period between 1986-1995 are plotted in Fig. 2.6-1 and discussed as follows:

(1) Ocumarito Reservoir

It takes 4.3 months of the year on average to fill the reservoir to its full capacity. This means that water flowing into the reservoir in this period is left to be spilled over and flown downstream. If the total water volume including this spilled water from Ocumarito Reservoir at the intake of San Antonio exceeds the intake capacity, water flows down without use.

(2) Lagartijo Reservoir

A discharge of 3.5 m^3/s on an average is transmitted for the intake from Lagartijo Reservoir. Spill rarely occurs and water stored in the reservoir is effectively used.

(3) Camatagua Reservoir

It has a large capacity of 1,530 million m^3 and seldom spills water. The water for Tuy-III system is taken from Camatagua Reservoir. It is also used to supply the Tuy-I and Tuy-II systems.

(4) Qda. Seca Reservoir

The reservoir had been used until 1993 mainly in the dry season of December to April. Based on the reservoir operation results, it has not been used effectively since 1994.

(5) La Mariposa Reservoir and La Pereza Reservoir

From the reservoir curve, they are used for short time (daily or weekly) regulation.

2.6.2 Status of Presently Proposed Water Resources Development Project

Tuy-IV and Taguaza-Ciudad Fajardo System is presently under construction. The outline and progress of the work is as follows:

The purpose is to complement the water supply systems of the Metropolitan Area of Caracas and Ciudad Fajardo (Guarenas, Guatire and Caucagua). Sources of water are the Taguaza and Cuira reservoirs to be constructed on the right bank tributaries of the Tuy River. Water to the Metropolitan Caracas area is delivered by the Tuy-IV system to the Caujarito treatment plant. The capacity of Tuy IV system is 5.0 m^3/s with Taguaza Reservoir and 24 m^3/s with Cuira Reservoir.

The pipe for water transmission from Taguaza Reservoir to the Caujarito treatment plant is 51.75 km-long and 3,000 mm-diameter. During this study period, the Taguaza Dam and a water transmission system were under construction. Taguaza Dam was 50% in progress and was scheduled to be completed by January, 1996. Of the 52 km transmission pipeline, 25 km was completed. The dam was scheduled to start operations in January, 1996.

2.6.3 Possible Water Supply Source in the Study Area

As discussed in the previous sections, the present river water use in the upper and middle streams of the Tuy River basin are the following:

- Intake at Toma de Agua by Hidrocapital
- Intake at Ocumarito Reservoir

The potential sites for supplemental water supply sources in the study area are studied from the view of water quality and quantity and identified as listed below (see Table 2.6-2):

River	Location	Catchment Area (km^2)
Cagua River	Upstream of confluence of the Tuy River	49.9
Guare River	Tácata	186.0
Aniagua River	Upstream of confluence of the Tuy River	53.3
Tarma River	ditto	78.0
Súcuta River	ditto	65.0

2.7 Monitoring System

2.7.1 Present Situation of Monitoring System in the Tuy River Basin

The present monitoring system in the Tuy River Basin was basically established through the project which started in 1992 in cooperation with GTZ. The present monitoring system in the Tuy River Basin is outlined below:

Monitoring Site, Parameters for Water Quality Measurement and Frequency

Although nine points used to be counted at the beginning of the project, the monitoring of the Tuy River is periodically operated from November 1995 at two points, Puente Ocumare and Qda. Charallave, and at factories. The sampling and observations are conducted once a week. The parameters of water quality analyses of the Tuy River are in the table below.

Place of Test	Water Quality Parameter
Field Measurement (Ocumare del Tuy and Qda. Charallave)	Temperature
	pH
	Dissolved Oxygen (DO)
	Conductivity
Laboratory Analysis	Solid (Several Types)
	COD
	BOD
	Heavy Metals*

Note: * limited cases only

Besides, the monitoring of wastewater from factories is conducted as well in the following manner:

Item	Description
Number of Factories	Two or Three
Time	Weekly
Place	
- Middle Tuy Basin	Ocumare del Tuy, Cúa and San Francisco de Yare
- Upper Tuy Basin	Las Tejerías industrial area, Paracotos
Water Quality Analysis	Same as River

The water quality of samples are analyzed in the laboratory of MARNR.

Organization and Personnel

The Unidad Operativa Tuy Medio (Ocumare del Tuy) and Unidad Operativa Tuy Alto (Los Teques) of the Agencia de la Cuenca del Rio Tuy handles the monitoring works. The number of staff members engaged in the works is 6 in total: 1 engineer, 1 coordinator, 1 biologist and 3 technicians.

Budget for Monitoring Works

Although there is no specific amount of annual budget for the monitoring works, the spending for personnel and transportation in this work costs roughly 1,000,000 Bolivares annually. This amount corresponded to 0.3% of the budget of the agency in 1996 which was 326,720,000 Bolivares

2.7.2 Present Situation of the Laboratory

All the samples are basically analyzed in the laboratory. The laboratory belongs to the Division of Investigation and Determination, MARNR, "Environmental Laboratory Dr. Leopold Blumenkranz", founded in 1977, which is located outside of central Caracas, in El Hatillo.

Laboratory Structure and Function

The laboratory is composed of (1) a water quality section, (2) an air quality section, (3) a biological section, and (4) a waste treatment section. Among them, the water quality section covers physical and chemical analyses of water and soil, support for water quality control program, and direction of analytical technique for other laboratories.

Staff

Laboratory staff consists of six chemists, three biologists, one pharmacist, three technicians, five assistants or trainees and a librarian and a few office workers at the time of this study.

2.7.3 Problems on the Current Monitoring System

The problems involved in the current monitoring system are emphasized by the following points:

(1) No program for emergency cases

There is no program to avoid supplying unsafe water. The water quality of Tuy River should be monitored continuously to fulfill its function as a domestic water source.

(2) Insufficient number of points and frequency of monitoring

The current monitoring points are not enough in number to conduct effective monitoring of the pollution condition of the Tuy River. It is necessary to have monitoring points for the whole area of the upper and middle basins and its tributaries which receive a large amount of pollution loads.

Besides, the wastewater from factories, piggeries, and outlet of sewer of domestic waste should be collected to identify the pollution source.

The measurement and collecting samples for monitoring is currently conducted once a week on the Tuy River and a tributary. This frequency may

be sufficient for some water quality parameters; however, in order to collect more information on the pollution condition from factory discharge, more frequent sampling is necessary.

(3) Shortage of qualified staff

Qualified staff is short in number. This may be due to the insufficient budget allocated. Personnel who are frustrated with inadequate salary tend to choose quitting their job and moving to private companies.

(4) Insufficient data filing system

Functional data filing system is necessary in order to analyze the present pollution condition and formulate proper countermeasure for the pollution. This problem is also due to the insufficient budget.

2.8 Present Condition of the Water Supply System of Metropolitan Caracas

2.8.1 Outline of the Water Supply System

Figures 2.8-1 and 2.8-2 are the Metropolitan Caracas Water Supply Map and Water Supply System Diagram. The present condition for the water supply system are discussed below.

Development of Water Supply System

The Metropolitan Caracas water supply system was established in 1950 using groundwater resources in the surrounding area. The increase in the population and the demand for water supply led to the gradual development of other water resources, namely the Tuy River and reservoirs in the surrounding area. Table 2.8-1 shows the progress in the development of the water supply system of Metropolitan Caracas.

Agency Responsible for Water Supply

"Hidrocapital", a public organization, is responsible for the construction, operation and maintenance of water supply systems in Metropolitan Caracas. The Tuy River Basin Agency supervises the use of the Tuy River as a water source. Both organizations are under the jurisdiction of MARNR.

Deficiency of Metropolitan Caracas Water Supply System

The Metropolitan Caracas water supply system has a deficiency in the following points:

- Water resources in the Caracas valley are limited and are found outside of the metropolitan area. Production costs are high due to the disparity between the elevation of the water source (100 to 200 meters) and the service area (900 m) as well as the long distance of from 35 to 40 km between these areas.
- Production costs considerably exceed the amount of money collected from the water consumers because of the low water fee structure set by the government.

The collected water fees cover only 44% of the production costs. The operation of the water supply is therefore precarious.

Composition of the System

Water supply system to the Caracas Metropolitan area is composed of the Tuy-I, Tuy-II and Tuy-III systems. The composition of the system is outlined in Fig.2.8-2 and Table 2.8-2.

(1) Tuy-I System

Tuy-I system, which is the oldest system among the three systems, relies on the water of the Tuy River and Lagartijo and Taguacita reservoirs as the major sources. Occasionally, it receives supplemental water from the Camatagua reservoir through Ocumarito reservoir. The water of the Tuy River taken at the Toma de Agua is transported to the pretreatment plant and after pretreatment, the water is mixed with the water from the Lagartijo and Taguacita reservoirs. The water is further transported to the treatment plant at La Mariposa and distributed to the water supply area in Metropolitan Caracas.

The installed facilities at Toma de Agua are pumps with the capacity of 7.7 m^3/s. In the case of Lagartijo Dam, the intake facility is installed in the reservoir and has the maximum capacity of 7.0 m^3/s. The capacity of pipeline to transport water to the treatment plant at La Mariposa is 4.0 m^3/s. This is because part of the intake water is also distributed to the Tuy-II system.

The features of Tuy-I are summarized as follows:

- Since the system relies on the Tuy river water as part of its water source, the intake water volume fluctuates depending on the season, rainy or dry.
- To supplement the shortage of river water in the dry season, Tuy-I system receives water from the other water source, Camatagua reservoir.
- The intake water volume is also affected by the water quality of the Tuy River; turbidity, odor, color and so on.
- To treat the polluted river water, a pretreatment plant has been provided.
- In general, compared with the Tuy-III system, the Tuy-I system is not so fragile for water supply failures due to natural disasters and mechanical and electrical problems, since it has a geographic advantage such as shorter distance between water source and water supply area.(refer to Table 2.8-2.).

(2) Tuy-II System

Tuy-II system has the same water source as the Tuy-I system. Besides, it also uses the water from the Taguacita reservoir. The water is transported to La Gairita treatment plant to be finally distributed to the water supply area.

The facilities to take the water at Taguacita reservoir is a pump with the capacity of 4.1 m^3/s. The other intake facilities are as mentioned in the Tuy-I system, while the transportation capacity to water treatment plant is 6.0 m^3/s.

The features of the Tuy-II system are the same as that of the Tuy-I system except Taguacita reservoir.

(3) Tuy-III System

Tuy-III system relies on the water of Camatagua reservoirs as the source. The water taken from the reservoir is transported to Caujarito treatment plant and distributed to the water supply area. Tuy-III system also distributes the water to the consumption areas of the Tuy middle basin and supplements the Tuy river water in the dry season.

The intake capacity of the Tuy-III system is based on the capacity of the pump installed at Mamonal point which is 11.7 m^3/s. The capacity of the pipeline to Caujarito treatment plant is 15 m^3/s. At the Caicita point on the way to Caujarito, it has a distribution system with a control gate to the Tuy middle basin and Tuy-I and Tuy-II, which can distribute a maximum of 2.1 m^3/s.

The features of the Tuy-III system are summarized as follows:

- Since the capacity of the Camatagua reservoir is quite large, it can cover a major part of the total supply water volume and play an important role in the water supply to Caracas metropolitan area.
- Since the system has no alternative route to supply water to Caracas but only one major route and minor supplemental water supply route, it has a great influence in case of supply failures.
- Since the Camatagua reservoir is located at a far distance compared with the Tuy-I and Tuy-II systems, it is highly potential to failures due to mechanical and electrical problems and natural disasters. Thus, it has risks as a stable water source.

Water Supply Facilities

Fig. 2.8-2 is the layout of the Metropolitan Caracas water supply facilities. Of the various facilities, the outline of the intake of the Tuy River, intake pump and pretreatment facilities at Toma de Agua are described as follows:

(1) Intake Pumps

The specification of the intake pumps is in the table below:

Specification of Intake Pumps

Station	No. of Pumps	Capacity (ℓ/s)	Head (m)	Power (kW)
Toma II	7	600	25	350
Toma III	2	1750	25 (assumed)	950
Total	9	max.: 7,700 normal: 4,500		4320

(2) Pretreatment Plant

Water is currently pumped from the intake to a pre-mixing facility where aluminum sulfate, organic polymers, and activated carbon are added. After such treatment the water flows into sedimentation ponds. At the discharge point chlorine is added. The system is outlined in Fig. 2.8-3.

The pre-treatment plants are currently installed with settling tanks, six in total, rectangular in shape, 24.0 meters wide, 82.0 meters long, and 3.25 meters deep. Each of these settling tanks is equipped with a carriage type sludge collector. These sludge collectors are, in fact, broken down at present.

2.8.2 Operation of Water Supply System

Basic Principle for Operation

As for the water intake from the sources, Hidrocapital operates the above water supply systems according to the following principle:

- In general, Hidrocapital faces water shortage for water supply in the dry season, during which it relies on the water stored in the reservoirs such as Camatagua, Lagartijo and Taguacita.. Consequently, the major concern for operation is to secure water in dry season, so that it is necessary to save water in the reservoirs as much as possible.
- To save the reservoir's water, Hidrocapital maximizes the use of water of the Tuy River in rainy season, since it cannot regulate and save the river water which flows down wastefully. Even in the dry season, Hidrocapital tries to maximize the use of the Tuy river water. (However, the river water has two deficiencies: water shortage and unsuitable water quality for water supply.)
- When the reservoirs have water spill in rainy season, the water saved in the reservoirs is used for the water supply prior to the Tuy river water because of the advantage of water quality.
- As the operation results, the monthly average intake volume of the overall Tuy-I, II and III systems is about 19 m^3/sec. The breakdown, namely the average water volume by source is given by Hidrocapital as follows:

Water Source	Intake Volume (m^3/s)
Tuy River	2.0
Lagartijo	3.5
Taguacita	1.5
Camatagua	12.0
Total	19.0

Operation in 1995

The water supply condition in 1995 based on the above policy is shown in Fig. 2.8-4 and 2.8-5. From these illustrations, the following statements could be made.

- In the dry season, the supply from the Lagartijo and Taguacita reservoirs is increased as much as possible resulting in the full use of these reservoirs. As shown in the illustration, from January to April the total supply of the Tuy-I and II systems, namely from the Tuy River, Lagartijo Reservoir and Taguacita Reservoir gradually decreases. The supply from Camatagua Reservoir consequently increases in this period.
- In May, even Camatagua Reservoir nearly empties, and the total water supply decreases to approximately 13 m^3/s.
- In the rainy season, from August to December, water is taken from the Tuy River as much as possible to preserve the water in Camatagua Reservoir.
- During the dry season when the river flow decreases, the intake volume from the Tuy River only amounts to 10% of the total intake volume. In the rainy season, however, it makes up approximately 30%. Camatagua, on the other hand, makes up approximately 60%, at times 70% of the total intake volume in the dry season, and 50% in the rainy season.
- Accordingly, the Tuy River is a valuable resource in the dry season. In the rainy season, it is a very important resource as it aggressively accumulates the water of other watercourses.

2.8.3 Problems on Current Water Supply System

At present, Hidrocapital faces several problems to operate the current water supply system such as problems on water sources and operation and maintenance of facilities including intake, pre-treatment, transmission, treatment facilities and distribution facilities, and institutional problems including water tariff collection system. Among these problems, discussion in this section is made only for (1) balance between supply and demand, (2) the water intake suspension from the Tuy River, and (3) failures of the water supply system which are the concern of this study.

Balance between Supply and Demand

As discussed in Subsection 2.8.1, the water supply capacity of the entire Metropolitan Caracas area in 1994 was 19.5 m^3/sec for a population of 3.5 million; 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. 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.

To counter future water supply shortages, Hidrocapital formulated a large scale and expensive plan, the Tuy IV system. Currently, work on the Tuy IV system has slowed down due to financial difficulty. To ensure that the Tuy systems obtain the required water demand, it is necessary to take other measures.

<u>Water Intake Suspension from Tuy River</u>

(1) Water Quality Limit to decide Intake Suspension

As one of the major sources for water supply, Hidrocapital has been taking water from the Tuy River since 1965. However, due to the deterioration of water quality of the Tuy River, the intake water causes a problem on the operation of intake facilities and the quantity is over the capacity of pre-treatment facilities. Furthermore, river water is sometimes not suitable for domestic water use. Thus, Hidrocapital is obliged to suspend the water intake at Toma de Agua.

To decide on the water intake suspension, Hidrocapital applies the following water quality limit for the Tuy river water.

Water Quality Limit to Decide Intake Suspension

Item	Point A*	Point B*
Turbidity	< 2000 NTU	< 600 NTU
Color		< 1200
T_{12} (Chlorine Demand)		< 12 mg/l
Alkalinity		> 18 mg/l
Oil	not included	

Note: Point A is at the intake and Point B is at the outlet of the pre-treatment. (Refer to Fig.2.8-3.)

Besides, Hidrocapital suspends water intake in case the water has an obnoxious odor. Every two hours, samples are taken at the intake point and

tested for turbidity, color, odor, alkalinity, hardness, pH, and T_{12} (Chlorine Demand).

In practical use, the above limits are not always strictly followed and sometimes Hidrocapital compromises on applying the limit due to shortage of supply water.

(2) Cause of Water Intake Suspension

According to the data from 1993 to 1995, Hidrocapital has been obliged to suspend water intake 36 times a year on an average for these three years. The duration of suspension for one time was about 8 hours and the intake suspended volume for one time was about 58,000 m^3. The main causes of water suspension were high turbidity, odor, color, chlorine demand, detergent, etc.

Fig. 2.8-5 illustrates daily intake volume at Toma de Agua in 1995. Fig. 2.8-6 presents the percentages by cause of intake suspension, while Fig. 2.8-7 depicts the percentages by cause for the case of intake suspension due to water quality. The following discussion is made based on these figures.

As seen in Fig. 2.8-5, the condition of intake suspension in the dry season and the wet season seems similar. The cause of suspension is, however, different:

(a) Suspension Caused by All Reasons

In accordance with the actual record of intake suspension in 1995, total suspension in the dry season and rainy season is similar at 25 times and 28 times, respectively (see Fig. 2.8-7). The causes are, however, different; water quality and low water level make up 40% and 36% (total 76%) in the dry season, respectively, but 46% and 4% (total 50%) in the rainy season.

(b) Suspension Caused by Water Quality

On the basis of the data for three years from 1993-95, suspension of water intake at Toma de Agua occurred 14 times (39%) in the dry season and 22 times (61%) in the rainy season, totaling 36 times (see Fig. 2.8-7).

Suspension of water intake due to organic pollution, namely, color, odor, and chlorine demand totals 18 times (50%) a year. Suspension caused by turbidity is 10 times (28%).

The average duration of suspension is 8 hours based on the records of 1995. Although suspension happens more often in the rainy season, water shortage is more critical in the dry season due to lack of abundant water resources. Suspension of water intake operations in the rainy season is offset by the availability of other water resources.

Failures in the Operation of the System

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

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

System / Items	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

Failure in transmission is attributed to the following factors:

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

Judging from the above table, the following conditions are considered:

- 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 failures of the Tuy-III system. Thus, the influence of the failure of Tuy III system for water supply is large.
- As for the causes of failure, electrical failure is dominant for all systems, while the number of mechanical failure is also large for the Tuy-III system. This is mainly attributed to the maintenance problem with pumps and valves.

To reduce the failures, Hidrocapital has taken several system improvement programs, which include the repair of pumping stations of Tuy-I system in December, 1996. With the completion of the repairs, the failure frequency of the Tuy-I system is projected to decrease. The rehabilitation of the Tuy II system is also planned within 1997.

2.8.4 Future System Improvement Plan

To cope with the present water supply problem, Hidrocapital has a future plan until the year 2000 for systems development as presented in Table 2.8-1. The Tuy-IV

system was firstly proposed by INOS (Hidrocapital at present) over 15 years ago. Its original purpose was to complement the water supply system in the metropolitan Caracas area and Ciudad Fajardo (consisting of Guarenas, Guatire and Caucagua), and to meet future demands.

The Tuy IV system was planned to utilize the proposed reservoir water on the Taguaza and Cuira rivers, right bank tributaries of the Tuy River, in the lower Tuy basin. Water from the Cuira Reservoir is to be pumped from a station (capacity 16 m^3/s) located near the Cuira Reservoir to another station near Taguaza. Water from the Taguaza and Cuira reservoirs will be pumped (capacity 24 m^3/s) into the Tuy I and II systems, and to Ciudad Fajardo. The total capacity of the Taguaza pumping station is higher than the flow that can be regulated in order to provide water when water shortage due to weather conditions affects the supply from other sources.

From the Taguaza pumping station, water will be pumped in two directions: west to the existing Caujarito treatment plant, and north to Ciudad Fajardo:

- The west branch is planned to have a total length of 43.7 kilometers and will be constructed in two stages. The first, a 23.3 km section of ϕ3000 mm steel pipe connected to a 20.5 km section of ϕ1700 mm steel pipe, will deliver 4.2 m^3/s to the Caujarito treatment plant. The second stage involves laying a ϕ2300 mm steel pipe parallel to the ϕ1700 mm pipe. The average discharge of the completed system will be 7.38 m^3/s.
- The north branch has a total length of 30 km. At first, water will be pumped to the Taguaza-Cuira treatment plant and then on to reservoirs in Ciudad Fajardo.

Fifteen years ago many of the materials for the works were acquired, and construction began. However, insufficient budget and other reasons forced construction to be halted. Today, many works are left incomplete. This condition has allowed some of raw materials to be used elsewhere while others have deteriorated. In order to resume the construction, another large scale capital investment will be needed.

As a matter of fact, the construction was recently resumed on the Taguaza reservoir, pumping station, and pipeline to Caujarito and the first stage is scheduled to be completed in 1999. The second stage is planned to be completed by the year 2023.

2.9 Socioeconomic Condition

The analysis and observation in this section was mainly based on the Population Census and the Statistical Yearbook of Venezuela published by OCEI (Oficina Central de Estadistica e Informatica). First of all, useful data in the census were chosen to characterize the country's condition (Tables 2.9-1 to 2.9-3).

2.9.1 Population

Table 2.9-1 shows the population in the Study Area in 1981 and 1990. In 1990, the population of Venezuela was 19,501,849 and that of the Study Area was 309,463 or

1.6% of the national population. The population of Caracas Metropolitan Area (CMA) was 3,124,171 in 1990, comprising 16.0% of the population of the country.

The population of the upper basin was 113,393 in 1990 accounting for 36.6% of total, while the population of the middle basin was 196,070 accounting for 63.4%. The population of the upper basin grew at the average annual rate of 3.2% in the nine years, 1981 to 1990, while the population of the middle basin grew at the average annual rate of 6.4% in the same period.

The Study Area consists of 44 towns; the boundary of the area divides several towns such as Carrizal and San Diego. For convenience, the population of these towns were entirely incorporated in that of the Study Area. Five of the towns have more than twenty thousand population as of 1990, namely Ocumare del Tuy with 61,043, Carallave with 51,807, Cúa with 50,520, Carrizal with 30,423 and Las Tejerías with 20,246.

2.9.2 Economy

Income Level

Table 2.9-2 contains the information on income level of the people in the Study Area, based on the 1981 Population Census data by OCEI. The amount of income in an income group was updated taking inflation into consideration in order to be applied in 1996. It is assumed that Table 2.9-3 reflects the existing status of the income level. The table shows the number of inhabitants interviewed. The assumption is that they represent an income earner in a household and that the average monthly income of the less than Bs.200,000 income group, the Bs.200,000 to Bs.1,000,000 group and the more than Bs.1,000,000 group is Bs.100,000, Bs.500,000 and Bs.1,500,000 respectively. Then, the average monthly household income is calculated as Bs.235,911 in the Study Area. Such income becomes Bs.232,247 and Bs.238,348 in the upper and middle basins, respectively. In the same way the average monthly household income in CMA is calculated at Bs.233,161. It is to be noted that so far as the average household income is concerned, there is little difference between the two basins and also between the Study Area and CMA.

Employment Structure

Table 2.9-3 shows the employment structure in 1981.

The assumption is that the characteristics of the employment structure remain unchanged today. In terms of the number of employees the primary (agricultural and fishery), secondary (industrial) and tertiary (services) sectors were 6%, 46% and 48% respectively in the Study Area. In the upper basin of the area they were 9%, 45% and 46%, and in the middle basin they were 4%, 47% and 49%.

In CMA the employment structure was 1% for agriculture, 28% for industry and 71% for services. A higher share of the industrial sector and the agricultural sector as well is seen in the Study Area in comparison with CMA.

2.9.3 Public Budget

National Budget

Ministries with major budget allocations in 1996 are in the table below:

No.	Name of Ministry	Amount (Million Bs.)
1.	Ministry of Finance	1,730,380
2.	Ministry of Internal Affairs	671,807
3.	Ministry of Education	631,813
4.	Ministry of Defense	240,576
5.	Ministry of Sanitation and Welfare	193,982
6.	Ministry of Urban Development	156,798
7.	Ministry of Environment and Renewable Natural Resources	97,873
8.	Ministry of Transport and Communications	97,574

The national budget of Venezuela in 1996 is Bs.4,104,890 million. It can be converted to US$8,828 million by the exchange rate of Bs.465 to a US dollar. The GDP of the country is estimated to reach US$59,024 million in the same year. It means that the national budget as the percentage of GDP is 15.0%.

The budget is allocated for 24 public organizations including 17 ministries, the average amount per organization being calculated at Bs.171,037 million or US$368 million, sharing 4.2% each.

The allocations for Ministry of Environment and Natural Resources (MARNR) are Bs.97,873 million or US$210 million, accounting for 2.4%. The ministry is in the seventh position.

Budget for Tuy River Basin Agency

The budget for Tuy River Basin Agency amounts to Bs.326,720,000 or US$703,000 in 1996 and MARNR divides Bs.311,720,000 or 95.4% from its allocation to the agency. In the balance of Bs.15,000,000, the amount Bs.10,000,000 derives from its own resources and Bs.5,000,000 is a transfer from the Federal District Government.

The transfer to Tuy River Basin Agency accounts for 0.3% of the MARNR budget. In the total budget of Bs.326,720,000, Bs.224,758,253 or 68.8% is earmarked for personnel expenses.

Budget of Miranda and Aragua States

The table below shows the sectors with major budget allocations in 1994 (Aragua State)

No.	Sector	Amount (Bs.)
1.	Urban Development, Households and Related Services	5,147,700,000
2.	Education	2,647,900,000
3.	Security and Defense	2,292,400,000
4.	Superior Directorate of the State	1,935,700,000
5.	Social Security	1,295,400,000
6.	Health	1,212,600,000
7.	Social Development and Participation	726,000,000
10.	Agriculture	15,000,000

The budget of the Aragua State was Bs.19,765,100,000 or US$133,300,000 in 1994 at the exchange rate of Bs.148.3 to a US dollar.

The table below shows the sectors with major budget allocations in 1994 (Miranda State).

No.	Sector	Amount (Bs.)
1.	Education	4,503,900,000
2.	Urban Development, Households and Related Services	3,049,400,000
3.	Security and Defense	2,958,400,000
4.	Health	1,923,500,000
5.	Superior Directorate of the State	1,854,200,000
6.	Social Security	1,453,100,000
7.	Social Development and Participation	1,304,300,000
8.	Agriculture	431,800,000

The budget of the Miranda State was Bs.21,287,900,000 or US$143,500,000 in 1994 by the exchange rate of Bs.148.3 to a US dollar.

2.9.4 Existing Financial Status of Factories and Piggeries in the Study Area

Financial Status of Factories

The following table is a result of the questionnaire survey conducted by JICA in May, 1996 with the OCEI information.

Financial Status of Factories

Item	Food	Non-Food	Total
Number of Factories	22	72	94
Number of Employees	4,114	9,081	13,195
Shipment (Bs. million/annum)	86,602	168,038	254,640
Profit Rate (%)	12.62	16.40	15.11
Number of Employees / Factory	187	126	140
Shipment/Factory (Bs. Million/annum)	3,936	2,334	2,709
Profit/Factory (Bs. million/annum)	497	383	409

Sources: JICA and OCEI

The total produce of the 94 factories in the Study Area is forecast to reach Bs. 254,640 million or US$ 548 million in 1996 at the exchange rate of Bs. 465 to the US dollar. Food factories account for 34.0%, or about one third and non-food factories account for the balance of 66.0%, or about two thirds.

The profit rate for this year will be on average 12.62% for the food industry, 16.40% for the non-food industry and 15.11% for the whole manufacturing industry.

In terms of factory performance, the annual produce will be on average Bs. 3,936 million for the food industry, Bs. 2,334 million for the non-food industry and Bs. 2,709 million for the whole manufacturing industry. Also, the annual profit will be on average Bs. 497 million, Bs. 383 million and Bs. 409 million for the food, non-food and entire manufacturing industry, respectively.

Financial Status of Piggeries

Financial status of piggeries according to interview results is as follows:

Item	Values
Number of Piggeries	33
Number of Employees	118
Sales (Bs. Million/annum)	3,629
Profit Rate (%)	2.5
Number of Employees / Piggery	3.58
Sales/Piggery (Bs. million/annum)	110
Profit/Piggery (Bs. million/annum)	2.7

Sources: JICA and OCEI

The total sales for the 33 piggeries in the Study Area is forecast to be Bs. 3,629 million or US$ 7.8 million in 1996 at the exchange rate of Bs. 465 to a US dollar. The profit rate will be on average 2.5%. The annual sales and profit will be on average Bs 110 million and Bs. 2.7 million, respectively. Relatively speaking, piggeries are small-scale industries.

2.9.5 Financial Status of Water Organizations

Major Characteristics of Water Tariffs of Hidroven

Hidroven is the national organization for water supply and sewerage, consisting of 10 regional water supply organizations.

The same tariff rules are applied nationwide. Some of the salient features of the rules are listed below.

- The tariff structure is that water price per unit consumption volume varies in accordance with the monthly volume of water consumption per client and at the same time in accordance with the types of clients such as social residential, residential, commercial and industrial customers.

- The periodic tariff will be adjusted considering the changes that have been apparent in personnel, electricity, chemical and maintenance cost since the preceding period.
- The tariffs are determined to balance income with cost.
- The cost consists of the running cost and the installation cost of the water supply and sewerage systems.

Financial Performances of Hidrocapital and Hidrocentro

Hidrocapital covers the Federal District and Miranda State, while Hidrocentro covers the Aragua State.

Financial performances in 1995 of the two water supply organizations are tabulated below.

Item		Hidrocapital	Hidrocentro
Income (Thousand Bs.)	(1)	12,685,352	3,500,000
Cost (Thousand Bs.)	(2)	28,612,099	3,545,062
Water Produced (thousand m^3)	(3)	824,468	447,988
Water Sold (thousand m^3)	(4)	318,810	133,793
Income Cost Ratio (%)	(1)/(2)	44.3	98.7
Unit Cost of Water Produced (Bs./m^3)	(2)/(3)	34.7	7.9
Unit Price of Water Produced (Bs./m^3)	(1)/(3)	15.4	7.8
Unit Price of Water Sold (Bs./m^3)	(1)/(4)	39.8	26.2
Ratio of Water Sold (%)	(4)/(3)	38.7	29.9

Source: *Memoria y Cuenta Ano 1995*, MARNR

Hidrocapital received as income from the sale of water Bs. 12,685 million or US$ 71.8 million in 1995 with the exchange rate of Bs. 176.6 to a US dollar. It incurred the total cost of Bs. 28,612 million or US$ 162.0 million in the same year. The income cost ratio is, thus, 44.3%.

The annual production of water was 824,468 thousand m^3, out of which 318,810 thousand m^3 (38.7%) was sold. The unit cost was calculated at Bs.34.7 per m^3, while the unit price of water produced was Bs. 15.4 per m^3. The unit price of water sold was Bs. 39.8 per m^3.

2.10 Institutional Arrangement

2.10.1 Institutional Organization

MARNR

The Ministry of Environment and Renewable Natural Resources (*Ministerio del Ambiente y los Recursos Naturales Renovables, MARNR*) was founded in accordance with Art. 2 of the Law of Administration of 26-12-1976 (see Fig. 2.10-1) This ministry is primarily responsible for actions such as planning and execution of the activities of the National Executive for the promotion of the quality of life, environment and the renewable natural resources and elaboration and execution of

the programs of conservation, preservation, improvement, regulation, exploitation and use of waters, forests, lands and soils and so on (Art. 36 Law of Administration).

Outline of the organization under MARNR is discussed hereunder for (1) Tuy River Basin Agency, (2) HIDROCAPITAL.

Tuy River Basin Agency

The Tuy River Basin Agency is described in the order of Functions, Organization, Personnel, Financial Aspects and Offices.

(1) Functions

The implementing agency of this study is the Unique Authority of Area of the Tuy River Basin and the North Slope of the Litoral Mountainous Region of Federal District and Miranda State.The Agency was established by Decree No. 2,307 of June 5, 1992 and published in the *Gaceta Oficial* (Official Gazette) on April 12, 1993.

The agency's roles are the following:

- To establish the standards and guidelines of environmental character, of exploitation, and affectation of the natural renewable resources and the ordering of the territory.
- To elaborate, coordinate and execute the plans, programs, and projects of investigation, information, administration, management, vigilance, control, education and environment norms, in the territorial scope of the Unique Authority of Area, as well as to foresee, process, and generate the financial resources necessary for its execution.
- To identify and evaluate the projects directed to the solution of the environmental problems, ordering of territory, and development of the natural renewable resources, within its spacial scope and to promote the execution of them.
- To perform the services and execution of works which are directed to the recuperation and environmental sanitation and the improvement of the renewable natural resources, within the territorial scope of the Unique Authority of Area.
- To promote and coordinate through the MARNR the necessary financing for the execution of the works for environmental maintenance, territorial ordering and development of renewable natural resources, either for the public or the private sectors.

(2) Organization

The organization of this Agency is shown in the chart of Fig. 2.10-2. Thus, the structure of the Tuy River Basin Agency may be divided into the following components:

- Superior Council (*Consejo Superior*) is the highest entity of coordination and support for making decisions in the Agency. According to the law it should consist of 4 members who are the minister of MARNR and the 3 related governors (Federal District, Miranda and Aragua states).

- Advising Council (*Consejo Consultivo*) is the advising entity of the Agency, and has a wide representation and participation of the social and government agents. According to the law it should be integrated by 97 members of the national and regional public institutes, the states and municipalities and legislative agencies, the association of companies, the associations of citizens and environmentalists, who decide their activities on the basin and relevant area.

- Executive Directorate is the directive entity of the Agency and is in charge of formulating the policies and strategies for the environment. According to the law it should consists of 9 members as the representatives of the MARNR, National Institute of Parks, State Governors, Mayorships, Municipal Councilors and non-governmental organizations. It is presided by the General Manager of the Agency.

- Programmatic Management (*Gerencias Programaticas*) is in charge of the coordination, formulation, and supervision of the programs and projects related to environment. It depends directly on the General Management.

- Territorial Management (*Gerencias Territoriales*) is in charge of the execution of programs and projects, through the coordination and direction of the operative units.

- Operative Units (*Unidades Operativas*) have specific programs and projects in assigned areas or activities of work within each of the Territorial Management.

- The specific activities are processing permissions of construction of roads, earth works, exploitation of sand, logging for agricultural activities, terracing, establishment of industries.

(3) Personnel

The number of the agency staff totals 161 members and a classification is shown in Table 2.10-1. The Miranda Management (office) which directly controls the upper and middle Tuy basin has its own personnel (Table 2.10-2).

The staff by title of profession are listed in Table 2.10-3, covering the entire agency.

(4) Financial Aspects

(a) Budget of Tuy River Basin Agency

The budget of the Tuy River Basin Agency for 1996 is allocated as shown in Table 2.10-4.

It can be observed that personnel expenses occupy more than two-thirds of the total budget, reducing the operations work to a minimum portion.

(b) Financing through the "Umbrella Law"

Regarding the execution of specific projects the Tuy River Basin Agency has been promoting the Project of Integral Sanitation of Tuy River Basin. For that purpose, it requests financial assistance from international institutions and promotes the counterpart budget for it in the Umbrella Law ("*LEY PARAGUAS*"), according to news reports of July, 1996, which is under discussion in the National Congress.

The Umbrella Law authorizes the national executive to undertake and execute public credit operations during the fiscal year of 1996, for an amount of about US$ 1,600 million. The Tuy River Basin Agency would have availability for the execution of sanitation projects through financing from international agencies.

According to the Umbrella Law the financing of projects is through multilateral and bilateral agreements. The bilateral finance will be a more viable one. The amounts of US$ 4.45 and 5.00 million were initially proposed in the Umbrella Law as counterpart budget for financing the Environmental Improvement of the Tuy River Basin, for the period of 1995 and 1996, for a total amount of US$ 20 million. However, in 1995 no disbursement was made because the law was not approved and total investment is expected to be made after approval of the law.

During the period 1997-1999 an investment of US$ 100 million was requested to make a total of US$ 120 million for a whole project (Table 2.10-5).

HIDROCAPITAL

(1) Functions

The functions of HIDROCAPITAL are:

- To improve the quality of services to satisfy the public water demand.
- To expand the coverage of services to improve the public's accessibility to water.
- To improve the level of efficiency in systems operation and provision of its service.
- To guarantee the potability of water.
- To obtain external financing sources.
- To bill the prices of the services provided such as water supply, as well as sewer and wastewater treatments where available.

(2) Organization

The general organizational structure of Hidrocapital is shown in Fig. 2.10-3. The System Management Section is divided by region, corresponding to the Losada-Ocumare System for the section of the upper and middle Tuy River basin. Its organizational structure is shown in Fig. 2.10-4.

(3) Personnel

The staff of Hidrocapital is classified (Table 2.10-6) with a total 716.

(4) Financial Aspects

The situation of the last 3 years budget is in Table 2.10-7:

It can be observed that the deficit has been increasing constantly since 1993. For the 1995 budget estimation, the cost of production-distribution of water made an 84% of the expenses of HIDROCAPITAL which reached the amount of about US$ 52 million while the revenues through the selling of water was only about US$ 27 million becoming about half of the total production. This situation makes a considerable deficit which have to be filled up by the central government.

(a) Budget

The estimated budget (balance sheet) of HIDROCAPITAL is summarized in Table 2.10-8.

The estimated deficit in 1995 is around US$ 34.25 million, basically due to the difference in the costs of production-distribution of water and the applied charges for its service.

(b) Charges for Water Supply, Sewer, and Wastewater Treatment

A resolution of the Ministries of Promotion and Environment and Renewable Natural Resources published in the Official Gazette No. 283,726 of March 1, 1993 dictates the charges for providing services for supplying water and collection, treatment and disposal of residual waters and it is effective in all the national territories except those districts where such services are not provided.

There are four categories of water uses:

- Residential use: To be applied to every household, exclusively used for living.
- Social use: For households exclusively for living which are located in geographical area classified as low income level.
- Commercial use: The activities are related to commerce, including those of offices.

- Industrial use: i) The industries which use water as the main raw material.

  ii) The industries where water is not the main raw material.

For billing purposes a monthly minimum consumption amount of 15 m^3/household was established. Then considering the extreme values of minimum and high consumption for each category the corresponding charges are in Table 2.10-9.

The costs of water supply are subsidized almost completely for the categories of residential and social uses and in the lower levels of the commercial and industrial uses.

Furthermore, according to the law, the established charges should serve as a basis for collection and disposal of wastewater. This charge should be 10% higher than the water consumption charge.

According to the same resolution, in the places where the service of wastewater treatment is possible to be provided, it will be charged 10% higher corresponding to water supply and collection and disposal of wastewater (Art. 24).

Although these charges have not been applied yet they have been proposed for future application when such treatment plants are in operation by the government institutions in charge.

According to the law, the regional water supply and sanitation companies (in the case of the Study Area it is HIDROCAPITAL) will decide the charges on their clients. However, the municipalities can also establish other price structures whenever operation costs need to be covered.

It seems reasonable that the same institution collects the payments for all these services, charging directly based on the water supply. Nevertheless an agreement between the Tuy River Basin Agency and Hidrocapital should define the terms of such payment collection.

2.10.2 National Environmental Policies

Legal Framework

The general legal framework of the environment policies in Venezuela which can be applied to the Tuy River Basin composes of 35 laws and regulations and their features are broadly divided into three: environment, water, and human activities (Table 2.10-10).

(1) Water Quality Standards

The regulation presently active and to be applied to the upper and middle stream of the Tuy River basin is Decree No. 883 "Standards for the Classification and Control of Water Quality of the Water Bodies and Discharges of Liquid Effluents" published on December 18, 1995.

The major items of the regulations comprising the several stages of water from the sewer discharge to the drinking stage are compared in Table 2.2-1.

(2) Factory Activities

The activities of the industrial factories are regulated by the following:

- Law of Environment, Art. 20, Item No. 1 and No. 6.
- Decree No. 883 concerning the discharges to sewer networks and water bodies.

(3) Sand Quarrying Activities

There are specific regulations about sand quarrying which are contained in the following:

(a) Law of Environment, Art. 20, Items No. 1, 2, 3, 4 and 5.

(b) Law of Mines and its By-laws:

(c) Plan of Regulating Use of the Critical Area with Priority of Treatment of the Tuy River Basin.

(d) Decree No. 2,219: Standards to Regulate the Affect on the Renewable Natural Resources Regarding to the Exploration and Exploitation of Minerals.

(e) Decree No. 2,220: Standards for Regulation of the Activities which can Produce Changes of Flows, Obstruction of Riverbeds and Problems of Sedimentation.

(4) Piggery Activities

The activities related with the piggeries are regulated as follows:

(a) Law of Environment, Art. 20, Item No. 1.

(b) Decree No. 883 concerning the discharges to sewer and water bodies.

(c) Decree No. 635: Regulation of Piggery Activities.

In this decree for the regulation of the piggery activities the following were obtained:

- All piggery facilities must have mechanisms to control the pollution generated by such activity, complying with the legal norms which regulate this matter.
- In the protected zones established in Art. 17, Numbers 1, 2, 3 and 4 of the Law of Forestry and Waters, piggery activities are prohibited.
- In the capital region, comprised by the Federal District and the Miranda State, enlargements, nor new installations of piggeries are not allowed.
- Those owners of piggeries located in the areas mentioned in the previous article, who do not have mechanisms for the treatment of wastes, will be forced to suffer the corresponding administrative procedures, and will be sanctioned according to the Art. 25 and 26 of the Environment Law. Further action will be the closure of the piggeries, in order to avoid the continuation of the activities harmful to the environment. The closure of installations mentioned above will be ordered to be undertaken within the maximum term of two years from the date of publication of the present Decree.

Based on the above description of this decree, the piggeries in the study area of Tuy River Basin which do not comply with the norms should have been closed down by around January, 1992.

2.10.3 Legal and Institutional Aspects Regarding the Tuy River Basin

There are nine (9) laws and regulations specifically related to the Tuy River Basin, which are broadly classified into three: conservation, development and administration (Table 2.10-11).

Water Pollution

For applying the current legal norms for reduction of the present pollution there are 7 industries whose installation schedules have been approved by the MARNR. Company names and due dates are listed below:

Company name	Date of completion
Slaughterhouse VITO	May, 1996
Investments ALNACA	July, 1996
INPRODECA	January, 1997
La MONSERRATINA	December ,1996
Textiles ARAGUA	April, 1996
RON SANTA TERESA	July, 1998
FITSA	August, 1996

Source: Tuy River Agency, Miranda Office

An example of the installation schedule approved to RON SANTA TERESA is in Fig. 2.10-5.

Land Use

Land use is regulated in the Tuy River basin by Decree No. 2,308 (5-6-1992), Plan of Ordination and Use Regulation of the Critical Area with priority of Treatment Tuy River Basin.

The general objective is to establish the guidelines for the administration and orientation of the uses and activities allowed in the critical area with priority of treatment.

The allowed uses for the Tuy River Basin in the zones corresponding to this study are:

- Sub-Basin High Tuy: agriculture, urban, tourism, recreation, industry and mineral exploitation; and,
- Sub-Basin Middle Tuy: a griculture, urban, industry.

2.10.4 Enforcement of Laws

With regard to the enforcement of laws, punishment in case of violation is discussed hereunder.

The several laws have established penalties for different prohibited activities as shown in Table 2.10-12.

Also, the Law of Environment establishes that after application of the corresponding penalties other actions may be taken as follows:

- Temporary, total or partial occupation of the polluting sources, which cannot exceed 6 months.
- Temporary or permanent closure of the factories or institutions which are the causes of the environment contamination.
- Temporary or permanent closure of the activity source of the contamination.
- Modification or demolishing of buildings which violate the regulations on protection, conservation or preservation of the environment.
- Any other measures to correct and repair the damages produced and avoid the continuation of actions harmful to the environment.

The branch office of the Tuy River Basin Agency in the Miranda State reported the following activities for the study during the period 1994-1995:

1994

- 560 cases of control of permissions and/or control of activities of affectation of the natural renewable resources.
- 784 cases of administrative sanctioning procedures, among which 523 cases were subjected to penalties.

- 210 cases of inspection and control of industries which discharged liquid effluents (including the industries extracting non-metal minerals).
- 157 cases of analysis of records of industries which degrade the environment.
- 110 cases of control of afforestation performed by persons who have obtained permission of felling of trees.
- 137 cases of analysis, processing and authorizations of requests for earth movement, including sand and rock mining, road openings, urban developments, agriculture "galpon".
- 518 cases of analysis and processing of requests for deforestation for agricultural purposes.

1995

- 260 cases of administrative sanctioning procedures.
- 107 cases of control of industries which discharge liquid effluents (including industries, piggeries, hotels and others).
- 3 piggeries were closed by public force in the sector of Bautismo, Guatire.
- Analysis and processing of requests of: 100 cases of environmental variables; 3 cases of occupation of territory; 80 cases of earth movement; 260 cases of deforestation for agricultural purposes.

2.11 Education and Public Awareness

2.11.1 Within the Scope of the Tuy River Agency

Within the Tuy River Basin Agency this responsibility is handled by the Programmatic Management of Participation, Education and Relations with the Users (*Gerencia Programática de Participacion, Educación y Relaciones con los Usuarios*).

This management office is directly under the General Management of the Agency of Tuy River Basin Agency.

Its main activities are:

- Execution of workshops for elaboration of Local Plan of Ordering and Environment Management.
- Participation in meetings of resident associations of the municipalities.
- Execution of seminars for manufacturers.
- Elaboration of the training plan of the Agency for the training and development of the human resources.

- Publication of the Informative Bulletin of the Agency (*Boletín Informativo de la Agencia*).
- Publication of articles in local newspapers about management of the Tuy River Basin Agency.
- Publication of "Standards of Environmental Quality Control", a guide for manufacturers.
- Others.

2.11.2 Cooperation Between the Ministry of Education and MARNR

On March 26, 1996 an agreement was signed between the Ministry of Education and the Ministry of Environment and Renewable Natural Resources. Its main purpose is to unify, formulate, and coordinate programs and projects in order to encourage environmental education in the development process of Venezuela.

Later, the agreement will be adjusted to an operative basic plan in order to be approved by both sides which will have the following guidelines:

- Evaluation and reconsideration of the environmental education in the curriculum design of education at different levels: pre-school, primary, secondary, tertiary and post graduate education.
- Integration of methodological strategies of environmental education in the practical guides of activities of the teachers at the pre-school level.

Besides, further topics are considered such as the incorporation of new environmental contents in the primary education, introduction of environmental information and teaching technique in the secondary and higher education.

Apart from public education, staff training for environmental education is also considered to be upgraded.

The agreement contains the promotion of the environmental education with different categories: adults, military, indigenous and border area.

Information on short term actions is not available yet because only a few months have passed since the agreement.

2.11.3 Existing Non-Governmental Organizations (NGOs)

There are four non-governmental organizations recognized to be important in the study area:

Name of NGO	Location
Sociedad Conservacionista del Tuy	Ocumare del Tuy, Miranda State
Junta del Ambiente de los Teques	Los Teques, Miranda State
Comision de Ecologia, Asamblea Legislativa	Los Teques, Miranda State
Sociedad Conservacionista Sucre	Cagua, Aragua State

Besides them, other environmental NGOs total 199, which are located in some entities as follows:

FEDERAL ENTITY	NUMBER OF NGO
Federal District	167
Miranda	16
Aragua	16
TOTAL:	199

Source: *Balance Ambiental de Venezuela*, 1994-95, MARNR

At present the Agency of Tuy River Basin keeps contact with some NGOs in order to coordinate the environmental actions in the basin.

2.12 Environmental Aspect

2.12.1 Areas under the Special Administration Regime (ABRAE)

In the Tuy River basin, there exist 12 special administration zones, called Areas under the Special Administration Regime (Areas Bajo Régime de Administración Especial: ABRAE) such as 4 national parks, 2 national monuments, 9 protected areas, 1 potential agricultural development area, and 3 tourist/recreation zones. ABRAE was established in 1983 under the land management law in order to ensure conservation and protection of natural resources as well as environmental improvement.

It is confirmed that in the study area ABRAE consists of 2 national parks, 1 protected zone and 1 tourist/recreation zone. Its total covering area is 96,750 ha of land, of which 67,010 ha is in the upper basin and 29,740 ha in the middle basin of the Tuy River. Macarao National Park is located in the upper basin covering 2,530 ha which account for about 17% of its total park area, while Guatopo National Park located in the middle basin is 29,740 ha accounting for 24%. Protected zone is predominant in the study area. It is estimated at 59,010 ha of land which is covering about 70% of whole protected zone of Caracas Metropolitan Area. As for tourist/recreation zone, it can be identified in the uppermost area where Colonia Tovar is symbolically located as a tourist attraction place. The details are shown below.

(Unit: ha)

Sub-basin	National park	Protected zone	Tourist/ recreation zone	Total
Upper stream	2,530	59,010	5,470	67,010
Middle stream	29,740	-	-	29,740
Total	32,270	59,010	5,470	96,750

Source: MARNR, SARETUY Caracas 1989. See also Fig. 2.12-1.

2.12.2 General Environmental Conditions of the Study Area

Under the present environmental conditions in the Tuy River basin, animal's habitat or refuge are limited to only such areas as national parks or some protected zones where the ecosystem remains favorable for them, However, there are still a number of species of mammal, fowl and reptile in both upper stream and middle stream of the river basin. Those are listed below.

Mammal : Cunaguaro, tigrito, otter, deer, squirrel, mouse, rabit, lapa, sloth, monkey (araguato), etc.

Fowl : Heron, sparrowhawk, falcon, humming bird, macaw, parakeet, zamuro, turtle dove, etc.

Reptile : Serpents (coral, mapanare) iguana, lizard, etc.

Among them, some animals are recognized as endangered species and protected under the Washington Convention, 1973 such as cunaguaro, tigrito, otter, deer (venado caramerudo), lapa and falcon (halcón peregrino).

As for aquatic fauna, it is understood that water pollution causes difficult conditions for animals to survive. Consequently, only a few kinds of fishes can be observed in the uppermost stream and middle stream. They are identified as catfish (bagre) and corroncho, but species of these mammals are not known. No animals are observed between El Consejo and Boca de Cagua because water is extremely contaminated by the industrial waste and piggery.

Vegetation in the study area consists of mainly thicket of less than 5 m high. Predominant species is Guatacare growing as regenerated wood after the natural vegetation cover has been intensively eliminated by cutting trees or fires. Hills and mountain foot around cities or roads are represented by the herbaceous feature. The presence of this type of vegetation is closely related to the deforestation caused by human intervention, and it can be seen in the sector of low mountain area between El Consejo and Colonia Tovar or between Cagua and Las Tejerías.

2.12.3 Regulation and Procedure for Environmental Impact Study

In June 1983, the EIA guideline was prepared in collaboration with the Office of Technical Standards in Sectoral Directorate General of Environmental Administration which is presently split into two directions: the Directorate General of Environmental Quality (Dirección General de Calidad Ambiental) and the Directorate General of Surveillance and Control (Dirección General de Vigilancia y Control).

Regulation on EIA was established in July 1991 under Decree No. 1741 including revision of the above guideline. This regulation was amended in April 1992. Currently this regulation is no longer effective because it was later revised again and final approval was obtained in the cabinet on March 13, 1996 under Decree No. 1257. The new regulation appeared in the Official Gazette No. 31946 dated April 25, 1996.

According to the new regulation, there are two different approaches to the study depending on the type of development schemes or activities such as natural resources development and other sector's development scheme. In either case, the study should be concluded to identify significant impact and impact sources by the project including measures to be taken in order to mitigate environmental degradation.

With regard to natural resources development such as mining or oil exploitation project, EIA is required on both exploration stage and operation stage, and approval (Autorización de Afectación de Recursos: AAR) should be obtained from the EIA evaluation committee on each stage. It is understood that a long span of period needs to be considered for the development of natural resources. Therefore, environmental impact study should be in such a way as proposed in the new regulation to cope with environmental changes which may occur as time goes by. Nevertheless, the procedure seems to be more complicated and consume longer time as a result.

For any program and activity other than mining or oil development project, EIA shall be conducted in accordance with the procedure shown in Fig. 2.12-2.

For any project to be undertaken in the Tuy River basin, the EIA committee of Tuy River Basin Agency is in charge of evaluating the environmental impact study. On the other hand, if the project location is out of the basin, it should be evaluated under the auspices of the Directorate General of Environmental Quality of MARNR.

The EIA committee has nine members consisting of seven permanent and two non-permanent members. All members are experts of different specialty selected from seven different Directions. The Administration and Protection Management (Gerencia de Administración y Resguardo) sends three members to the committee, and one of them is designated as a coordinator.

2.13 Related Ongoing Projects

The outline of the related ongoing projects are described in this section.

MARNR Strengthening Component of Venezuelan Environmental Management Project by World Bank

Purpose	Strengthening of MARNR and decentralization of some of MARNR functions to state governments
History	1995 Requested from the Venezuelán government 1996 Started preparation study
Schedule	Aug., 1996 Finalization of preparation report Sep. 1996 Appraisal, 1997 Loan agreement
Status	Conducting preparation study
Component	Seven components: 1. Information system 2. Environmental quality monitoring 3. Strengthening laboratory 4. National environmental plan 5. Legal framework 6. Enforcement of regulation 7. Training and environmental education
Cost	(Estimate) Loan from the Bank: US$30 million Local government budget: US$30 million

Sanitation of the Tuy River (Project under the Assistance of GTZ)

Purpose	Water management in upper and middle stream of the Tuy River basin
History	May, 1989 Request from the Venezuelan government Dec., 1991 Agreement between MARNR and GTZ
Schedule	Phase I August, 1992 - July, 1995 Phase II August, 1995 - July, 1998
Status	Conducting Phase II study
Component	Two long term experts from Germany Training course for Venezuelan personnel Donation of laboratory equipment
Cost	Total 1,600,000 DM (German government grant) Local government budget: Discussion each year to provide counterpart funds for the project

Wastewater Treatment Project in Valencia Lake Basin

Purpose	Water quality improvement of Valencia Lake
History	April, 1985 Government gave high priority to the project Nov., 1988 IDB approved loan for the project (US$50,000,000) July, 1990 Venezuelan congress supported investment up to US$75,000,000 Sep., 1990 Venezuela and IDB agreed
Schedule	Originally: July 1990 - September 1994 Extension till 1997-1998 for sanitation program Water supply program begin operation in January 1996 (1st stage aqueduct)
Agency	1988-1992 INOS/Hidrocentro for potable water supply 1988 MARNR (Lake Valencia Basin Agency) for wastewater treatment plants and sewage system Technical assistance France: Organization and management of "Basin Agency" Germany: Study on sediments in Valencia Lake Japan: Installation and management of "Center for Water Quality Research (CICA)"
Status	Presently, La Mariposa (60% advanced), Taiguaiguay (90% advanced) and Los Guayos (50%) treatment plants are under construction. The works are behind the schedule due to lack of local funds
Major Features	Basin area: 1,800 km^2 Lake area: 356 km^2 Inhabitants: 2,500,000 Industry: 30% of the total country Pollutant: Industry (48%), domestic waste (36%), piggery (15%) Treatment: Industry: Presently 50% have water treatment system Domestic: Presently no treatment, but, sewage system is existing in Maracay, Guacara and Velencia Water standard: Class 4A of Decree No.883 Target year: 2015
Cost	(Estimate) Loan from BID: US$50 million Local government budget: US$75 million

Improvement of Water Supply Administration

Purpose	Improvement of water supply in overall Venezuela
History	Oct, 1995 Appraisal for Phase I
Agency	Hidroven - IDB - World Bank
Component	Phase I General Improvement of accountability of the water supply in Venezuela Improvement of reliability Detail Establishment of laws and regulations on water supply Establishment of tariff and collecting system Phase II Water supply aspect Water quality aspect
Cost	Phase I IDB: approx. US$150 million World Bank: not much