JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF TECHNIQUE AND INTERNATIONAL COOPERATION (SETCO)
NATIONAL SERVICE AUTHORITY FOR WATER SUPPLY AND SEWERAGE (SANAA)

THE STUDY

ON WATER SUPPLY SYSTEM FOR TEGUCIGALPA URBAN AREA IN THE REPUBLIC OF HONDURAS

FINAL REPORT

SUMMARY

JANUARY 2001

PACIFIC CONSULTANTS INTERNATIONAL

Foreign Currency Exchange Rates Applied in the Study

Currency	Exchange Rate/USD
Honduran Lempiras (Lps)	14.87
Japanese Yen (JPY)	107.9

(Rate as of the end of June 2000)

PREFACE

In response to a request from the Government of the Republic of Honduras, the Government of Japan decided to conduct the Study on Water Supply System for Tegucigalpa Urban Area in the Republic of Honduras and entrusted the study to the Japan International Cooperation Agency (JICA).

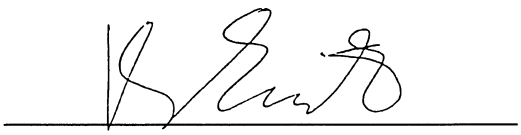
JICA selected and dispatched a study team headed by Mr. Akira Takechi of Pacific Consultants International (PCI) and composed of staff members of PCI to Honduras, two times between February 2000 and November 2000. In addition, JICA set up an advisory committee headed by Mr. Yoshiki Omura, Senior Advisor, Institute for International Cooperation, JICA, which examined the Study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the Republic of Honduras, and conducted field surveys in the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Honduras for their close cooperation extended to the team.

January, 2001



Kunihiko Saito
President
Japan International Cooperation Agency

THE STUDY ON WATER SUPPLY SYSTEM FOR TEGUCIGALPA URBAN AREA IN THE REPUBLIC OF HONDURAS

January, 2001

Mr. Kunihiko Saito
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

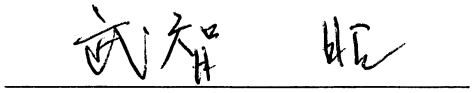
We are pleased to submit to you the final report entitled "The Study on Water Supply System for Tegucigalpa Urban Area in the Republic of Honduras". This report has been prepared by the Study Team in accordance with the contract signed on 18 January 2000 and amended on 10 August 2000 between the Japan International Cooperation Agency and Pacific Consultants International.

The report examines the existing conditions of the water supply system in the study area, proposes a master plan for the development of the water supply system and presents results of a feasibility study on the construction of a water source dam, which was identified as a priority project in the master plan.

The report consists of the Summary, Main Report, Supporting Report and Data Book. The Summary summarizes the results of all studies. The Main Report contains the existing conditions, the proposed master plan, the results of the feasibility study, and conclusions and recommendations. The Supporting Report includes technical details of contents of the Main Report. Data Book contains basic data used in the study.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Health and Welfare, and Embassy of Japan in the Republic of Honduras, and also to Honduran officials and individuals for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the improvement of the water supply conditions of Tegucigalpa, and that friendly relations of both countries will be promoted further by this occasion.

Yours faithfully,



Akira Takechi
Team Leader

EXECUTIVE SUMMARY

WATER SUPPLY MASTER PLAN

1. EXISTING PROBLEMS AND TARGETS OF THE MASTER PLAN

The study revealed a current water shortage due to a lack of water source capacity and water loss by leakage, causing constant water rationing, and a further water shortage in the future due to expected population growth. To address these problems, the Master Plan set up targets to supply water 24 hour continuously with 99% reliability for the water supply population of 1,376,822 and water demand of 267,494m^3/day in 2015.

2. MASTER PLAN PROJECTS

The Master Plan has been planned to achieve the targets by the following three projects:

Los Laureles II Project: The project develops 160 l/s water by constructing Los Laureles II dam and excavating the existing Los Laureles Reservoir. The developed water is supplied by using surplus capacity of the existing Los Laureles water supply sub-system.

Quiebra Montes Project: The project develops 1,040 l/s water by constructing Quiebra Montes Dam on the Guacerique River and constructs Quiebra Montes Water Treatment Plant. The project reorganizes the transmission and distribution systems to optimize the whole water supply system.

Leakage Control Project: The project installs water meters to major water supply facilities and water users to collect quantitative water flow data that are to be used for planning water leakage reduction programs.

3. FACILITY PLANNING

Major facility planning for the master plan projects is as shown in Table 1.

Table 1 Summary of Facility Planning for Mater Plan Projects

Projects	Components	Descriptions	
Los Laureles II	Los Laureles II Dam	Dam Type:	Concrete Gravity
		Dam Height:	31.0 m
		Dam Width:	103.0 m
		Reservoir Volume:	4,050,000 m^3
		Yield Capacity:	130 l/s (99% reliability)
	Excavation of Los Laureles Reservooir	Volume:	600,000m^3
		Yield Capacity:	30 l/s (99% reliability)
Quiebra Montes	Quiebra Montes Dam	Dam Type:	Rockfill
		Dam Height:	66.0 m
		Dam Width:	958.7 m
		Reservoir Volume:	53,000,000 m^3
		Yield Capacity:	1040 l/s (99% reliability)
	Conduction Facilities	1,200mm x 1 km	
	Quiebra Montes WTP	Type:	Rapid Sand Filtration
		Production Capacity:	108,000 m^3/day
	Reorganization of Transmission System	Installation of 5 pumping stations, expansion of 2 existing pumping stations and installation of new and additional transmission pipe (23.3km)	
	Reorganization of Distribution System	Installation of 12 reservoir tanks, installation of new and additional distribution pipe line (300km), installation of 4 water filling stations and purchasing of 204 tank lorries	
	Joint operation of QM WTP and LL WTP	Clear Water Reservoir in LL WTP: 900 m^3	

Continue

Continued

Projects	Components	Descriptions
Leakage Control	Water Quantity Measurement	Installation of watermeters to major water supply facilities and users.
	Strengthening Leakage Repair Capacity	Purchasing of repairing tools, detection devices and vehicles

Note: QM; Quiebra Montes, LL; Los Laureles

4. PROJECT COSTS

The construction costs for the proposed master plan and its operation and maintenance costs for 15 years from 2001 to 2015 are as shown in Table 2

Table-2 Project Costs of Proposed Master Plan (1,000USD)

Name of Projects	Construction Costs	Operation and Maintenance Costs (2001 to 2015)
Los Laureles II	25,722	2,970
Quiebra Montes	353,625	45,793
Leakage Control	16,550	1,201
Total	395,897	49,964

5. FINANCIAL PLAN

Financial plan was proposed based on the following principals:

- Transparency
- Financial autonomy
- Sustainability

The determined tariff levels were 102.0 Lps/household/month for the domestic users and 21.4 Lps/m^3 for the non-domestic users, respectively. The determined tariff levels are 3.62 times higher than the existing ones. This tariff level is much lower than those based on the affordability and the willingness to pay of the users. FIRR with the determined tariff levels becomes 6.0 %.

6 ORGANIZATION PLAN

Organization structure was proposed intending the following actions:

- Reorganization of Operation and Maintenance Department
- Strengthening of Information Function
- Strengthening of Planning Function
- Strengthening of Commercial Function

7 SELECTION OF PRIORITY PROJECT

By comparing the master plan projects in terms of urgency, significance, schedule, technical, economical, environmental aspects, Los Laureles II Project was selected as the priority project.

8 EVALUATION OF MASTER PLAN AND RECOMMENDATION

The proposed Master Plan was judged to be feasible from the viewpoints of economic, financial, managerial, technical, environmental and social aspects.

Although the project costs are considerably higher because of the water development by dam construction, which is not avoidable due to natural conditions in the study area, the economic benefits based on 24-hour continuous water supply exceed the economic costs, resulting in the project being feasible (FIRR=8.0%). Also, the project is judged to be financially feasible within people's willingness to pay by subsiding parts of the construction costs of the water source development as a social cost.

Apart from results of the economic and financial evaluation, it is foreseen that there would be a difficulty in procuring a large scale construction cost. Therefore, financial and institutional supports by the government and structural reform, setting up of proper tariff system and strengthening of tariff collection by SANAA were recommended as requirements for the realization of the Master Plan.

FEASIBILITY STUDY ON THE PRIORITY PROJECT

As a feasibility study project, Los Laureles II Project was selected. Los Laureles II Project comprises the following two components:

- Construction of Los Laureles II Dam
- Sediment Excavation

1 LOS LAURELES II DAM CONSTRUCTION

Features of the dam and the reservoir are as shown below and the safe yield with 99 % reliability is 130 l/s.

Features of the reservoir

Surcharge water level (SWL)	:	1053.5	m
Normal maximum water level (NWL)	:	1053.0	m
Minimum water level (LWL)	:	1048.0	m
Reservoir surface area at SWL	:	510,000	m^2
Reservoir surface area at NWL	:	490,000	m^2
Reservoir surface area at LWL	:	315,000	m^2
Gross storage capacity	:	4,000,000	m^3
Effective storage capacity	:	2,000,000	m^3
Sediment storage volume	:	2,000,000	m^3/50 years
Annual inflow volume of sediment	:	40,000	m^3/year

Features of the dam

Dam type : Concrete gravity dam with a spillway of crest gates for flood discharge

Dam crest elevation	:	1055.0	m
River bed elevation	:	1032.0	m
Dam foundation rock elevation	:	1024.0	m
Dam height	:	31.0	m
Dam total crest length	:	103.0	m
Width of dam crest	:	5.0	m
Width of river bed in spillway apron	:	30.0	m

2 SEDIMENT EXCAVATION

Excavation of sediment in the reservoir area in order to increase the effective storage volume of the reservoir was planned. It was concluded that dredging of sediment under water from the existing Los Laureles reservoir is costly and not feasible while excavation of river bed material and sediment above water is feasible as a technique to increase the storage volume of reservoir.

reservoir.

In this plan the amount of sediment excavation is 600,000 m^3 including sediment material in the existing Los Laureles reservoir and river bed material in the future Los Laureles II reservoir. The water yield by the project is 30 l/s compensating the ongoing sedimentation in the existing Los Laureles reservoir.

3 Project Costs and Financial Plan

The total project cost is estimated at USD 25,722,000. The breakdown is shown in Table3.

Table 3 Project Costs

Item	Amount (USD)
Direct Construction Cost	18,621,950
Engineering Service Cost	1,862,195
Physical Contingency	1,862,195
Compensation Cost	2,444,570
Administration Cost	931,097
Grand Total	25,722,007

From the table above, compensation cost and administration cost are not covered by foreign loan or grant. Therefor, the total project cost subject to loan or grant is USD 22,346,000. Remaining USD 3,376,000 should be prepared by SANAA or Honduran government.

4 Project Evaluation and Recommendation

The project was judged to be economically and financially feasible (EIRR=14.7%, FIRR=10.7%).

From the technical view point, it was considered that there would be no particular problems in the dam construction because SANAA has a similar experience in the construction of Concepcion Dam.

The dam construction requires relocation of 22 houses. Since new houses and cropland can be provided in the nearby areas of the current location, impacts of the relocation would be minimized.

Dam height was determined not only based on hydrological, topographical and geological conditions but also aiming to reduce showing up of a reservoir, which is an alteration of nature, as much as possible. Environment Impact Assessment (EIA) was made based on the "National System of Environment Impact Assessment" to obtain the Environmental License for the project. As a result, several factors that would be affected by the project were identified and mitigation methods for the factors were proposed

The Study identified unauthorized water uses in the basin and recommended to protect the water right because further unauthorized water uses may unset the water balance for the water development proposed in the Master Plan. Also it was recommended that the suspended Ciudad Mateo Project should be ceased because it was found that resume of the project could cause water pollution of the existing and future reservoirs.

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1 INTRODUCTION

Tegucigalpa (its administrative name is the Central District), the capital of the Republic of Honduras, is a center of governmental legislative and administrative, and education. Water supply service for Tegucigalpa is managed by the Metropolitan Division of the National Service Authority for Water Supply and Sewerage (SANAA) that is a responsible organization for the administration of nation-wide water supply and sewerage services.

Present water supply service coverage in Tegucigalpa counts about 90% in terms of population, approximately 900,000 residents. However, service condition of the water supply is such far from satisfactory level as water rationing has become common practice in most service areas throughout the year.

Moreover, Hurricane Mitch hit Tegucigalpa in October 1998, causing enormous damages on its infrastructures, as well as human damages. Since the disaster, restoration works under international cooperation by numbers of foreign countries have been concentrated in various damaged facilities and the water supply capacity is going to be recovered to some extent. However, those restoration works are not well organized due to their urgent nature and will not improve the conditions systematically. The capacity would remain much worse than the one before the disaster, which was already far less than the demand.

This study (hereinafter “the Study”) aims to prepare a master plan for the middle term development of water supply capacity and to conduct a feasibility study for a priority project in the master plan to improve the current water shortage.

The objectives of the Study are as follows.

- To formulate a water supply master plan for the target year of 2015,
- To conduct a feasibility study (F/S) on priority project(s), which should include the water source development in the Guacerique River and/or the Sabacuante River basins, identified in the master plan, and
- To pursue technology transfer to the counterpart personnel in the course of the study.

The Study covers the urban area of Tegucigalpa as water supply service areas, and areas related to the potential water sources. The development of water source in the master plan is limited in sites within the urban area of Tegucigalpa and its upper-stream basins, in principle. *Figure 1* shows the study area for the water source development. The study area for the water supply service adopted the urban area proposed by SANAA as the study area for water supply service in the master plan. The area is shown in *Figure 1*.

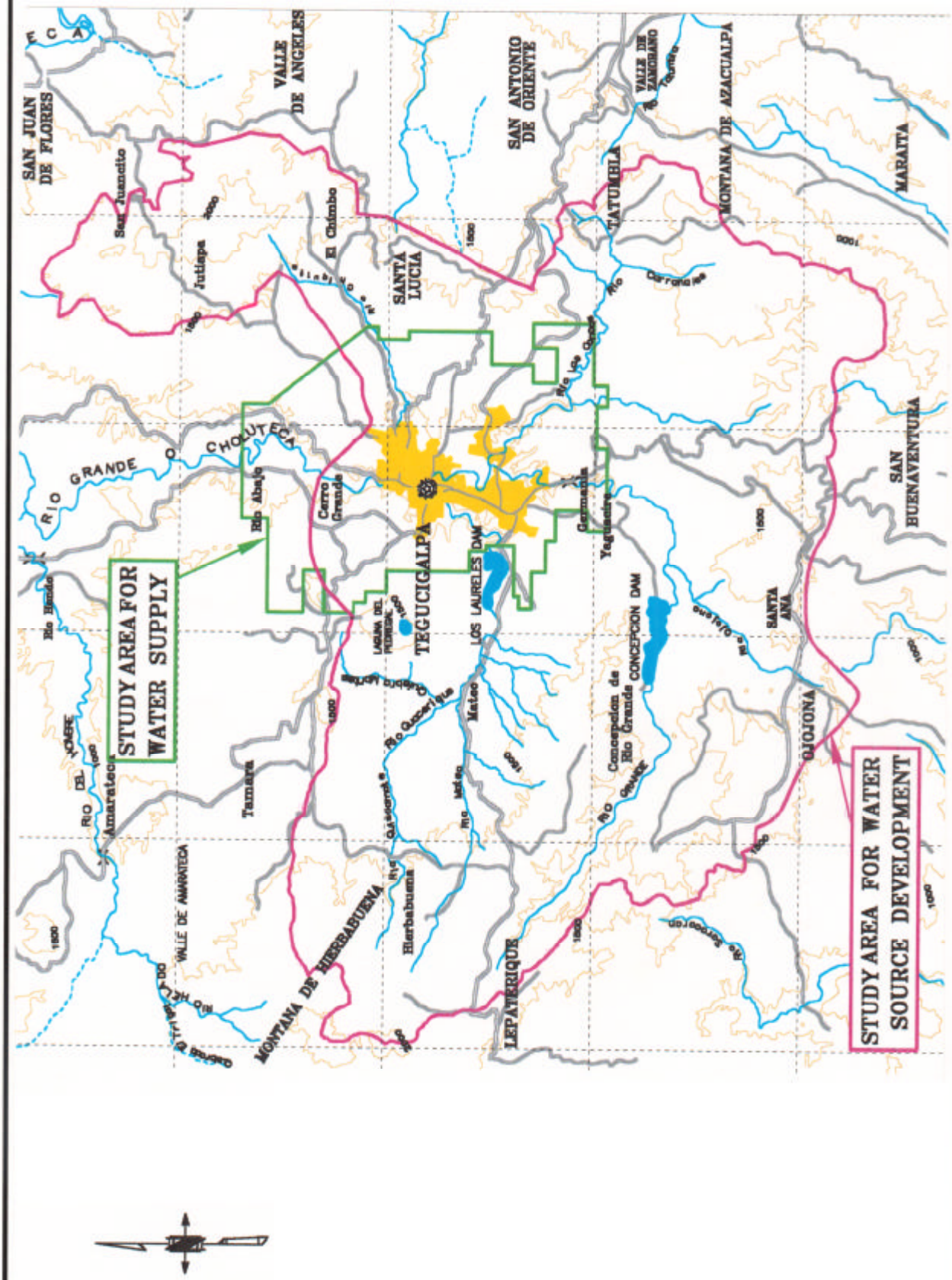


Figure 1	Study Area

The Study is conducted under the following organizational scheme:

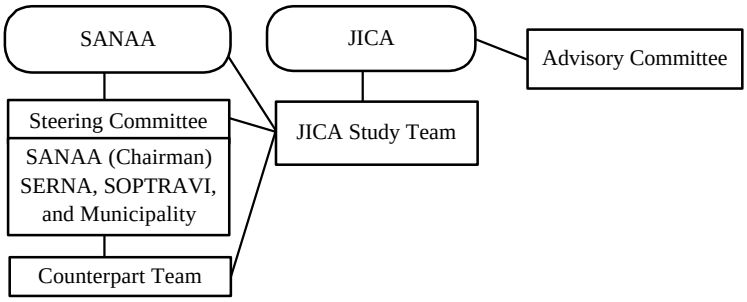


Figure 2 Study Organization

A time schedule of the Study is shown in *Figure 3* together with a staffing schedule.

Year	2000											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Study Schedule												
Work Items												
Preparatory work												
Water Supply Master Plan												
Urgent Water Source Development												
Feasibility Study for Priolity Project(s)												
Preparation of Draft Final Report												
Presentation of Draft Final Report												
Technology Transfer Seminar												
Preparation of Final Report												
Report		IC/R						I/R			DF/R	F/R
Staffing Schedule												

Position	Name
Team Leader / Water Supply Planning	Akira TAKECHI
Duputy Team Leader / Water Source Development	Mitsuo MIURA
Hydrology and Hydraulics	Chaisak SRIPADUNGTHAM
Geology	Teruo TAHARA
Transmission and Distribution Planning	Rebert PEZET
Network Analysis	Didier RENARD
Water Supply Facility Planning	Hiroaki MIYAKOSHI
Organization Management	Satoshi KOJIMA
Economic / Financial Analysis / Privatization	Akihiro NAKAGOME
Water Source Designing	Hirokichi YOSHIZAWA
Leakage Control	Masayuki KIKUCHI
Natural Environment / Water Quality / Social	Valerio GUTIERREZ
Construction Plan and Cost estimates	Kazutoshi KASHIMA
Study Administration	Kyoichi SUGIMOTO

Legend: Study in Hondura Study in Japan

IC/R: Inception Report, I/R: Interim Report
DF/R: Draft Final Report, F/R: Final Report

Figure 3 Study Schedule

This report contains all the results of the Study and comprises of Main Report, Supporting Report, Summary, and Data Book.

2 PLANNING BASIS

2.1 POPULATION PROJECTION

(1) Present Population

The present population was estimated based on number of household in each neighborhood, which was obtained from an interim result of the pre-census 2000 conducted by the General Directorate of Statistics and Census (DGEC) for the preparation of a new census to be submitted in 2001, and the average household size obtained from the Permanent Multiple Purpose Questionnaire Survey of Families conducted by DGEC.

The total urban population of Tegucigalpa in 2000 is estimated at 932,288.

(2) Population Projection

The total population was projected by applying a liner extrapolation to a regression line shown in *Figure 4*, which was obtained based on the census 1974, the census 1988, and the present population estimated in the Study. The total urban population in 2015 was estimated at 1,376,822 as shown in *Table 1*.

Table 1 Projection of Total Urban Population in Tegucigalpa

Year	2000	2005	2010	2015
Projected population	932,288	1,080,466	1,228,644	1,376,822

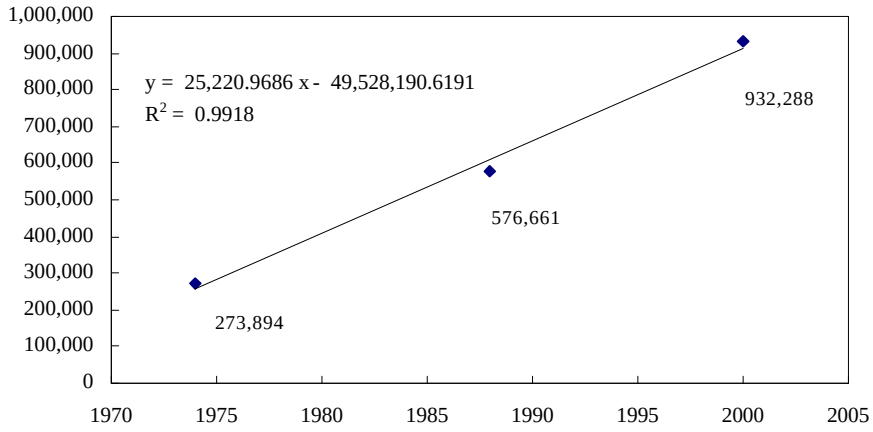


Figure 4 Trend of Total Urban Population in Tegucigalpa

(3) Population Projection by Each Neighborhood

The population projection was classified into following groups.

- Population in the existing inhabited neighborhoods
- Population in the planned neighborhoods/the existing neighborhoods with expansion plan
- Population in the neighborhoods to be settled in future

The population by above each group was estimated by applying the concept shown in *Table 2*.

Table 2 Concept of Annual Population Growth

Group	2000-2005	2006-2015
Existing neighborhoods without expansion plan	Constant (Total–16,886 = 12,750 persons/year)	Constant (Total – 16,886 = 12,750 persons/year)
Existing neighborhoods with extension plan/ Planned neighborhoods	Estimation based on planned lot number (*x* persons/year)	
Future neighborhoods	16,886 – *x* persons/year	Constant (16,886 persons/year)
Total	Constant (29,636 persons/year)	

2.2 URBAN AREA

The urban boundary is defined in the Study as follows.

- To apply the boundary of the existing neighborhood listed in the pre-census 2000 as the existing urban area.

- To apply the proposed urbanization limit by SANAA as the boundary of future urban development.

2.3 WATER DEMAND FORECAST

Water demand was forecasted by the following categories.

- Domestic use
- Commercial use
- Industrial use
- Public use

(1) Domestic Use

Water demand for domestic use was calculated with multiplying unit water demands by number of users. The Study applied the following water supply policies for the domestic use.

- Neighborhoods where water is supplied by well are left as it is for the effective utilization of limited water sources.
- In existing, planned and expanded neighborhoods, water is supplied by pipeline.
- In neighborhoods to be formed in future other than planned one, water is supplied by tank lorry.

The existing service population is estimated based on the existing population in each neighborhood and its social class. The future service population is estimated according to the above water supply policies. For the unit demand, the Study applied SANAA's design standards of unit water demand of each social class as shown in *Table 3.*

Table 3 Adopted Unit Water Demand

Social Class	Unit Demand (l/c/d)
S (Superior)	300
A (High)	230
M (Middle)	180
C (Central)	150
B (Low)	150
P (Programmed urbanization)	150
T (Developing community)	100
W (Well user)	100
L (Tank lorry user)	30

(2) Non-domestic Use

Based on the existing composition of water uses, the future water demand for non-domestic uses are estimated by the following equations. Here, D_p is demand for domestic use through pipe system.

$$\text{Commercial use} = 0.130 \times D_p,\ \text{Industrial use} = 0.039 \times D_p,\ \text{Public use} = 0.130 \times D_p$$

(3) Estimated Water Demand

Water demands in 2000 and 2015 are compared in *Table 4.*

Table 4 Comparison of Water Demands in 2000 and 2015

Category	Water Demand in 2000 (m^3/day)	Water Demand in 2015 (m^3/day)	Increase (%)
Domestic by pipe	112,195	150,832	34.4
Domestic by tank lorry	3,010	6,314	209.8
Domestic by well	1,331	1,601	20.3
Commercial	14,571	19,589	34.4
Industrial	4,371	5,877	34.4
Public use	14,571	19,589	34.4
Total demand	150,049	203,800	35.8

2.4 REQUIRED FLOW RATE

Design capacities for facility planning were determined based on the following flow rates.

- Required intake rate
- Required production rate

Both flow rates on average daily base were defined as follows.

- Required production rate = Water demand + Physical loss
- Required intake rate = Required production rate + Operation loss

The relation of both flow rates is schematically explained in *Figure 5.*

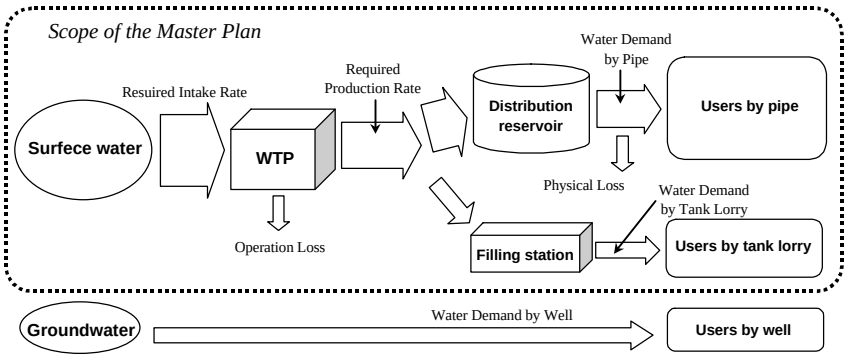


Figure 5 Definition of Various Planning Bases

The required production rate is estimated as shown in *Table 5.*

Table 5 Estimated Required Production Rate

Required production rate	2000	2005	2010	2015
Average daily rate	211,164	233,747	256,298	267,494
Maximum daily rate	240,908	267,544	294,090	307,934

(Unit: m^3/day)

The required intake rate is estimated as shown in *Table 6.*

Table 6 Estimated Required Intake Rate

Required intake rate	2000	2005	2010	2015
Average daily rate	224,643	248,668	272,657	284,568
Maximum daily rate	256,285	284,668	312,862	327,589

(Unit: m^3/day)

Figure 6 shows the estimated average daily and maximum daily required intake rates.

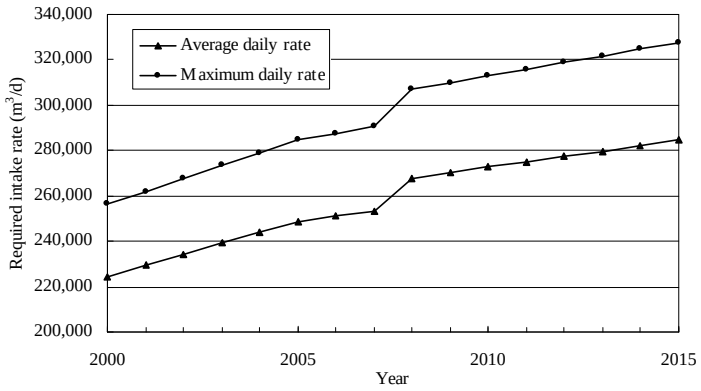


Figure 6 Required Intake Rate

3 SELECTION OF MASTER PLAN PROJECTS

3.1 GENERAL PRINCIPLES

Tegucigalpa is the capital of Honduras and the present water supply service coverage exceeds 90 %. Considering these facts, the following general goals were set for the master plan proposed in the Study.

- Stable water supply service with 99 % reliability against draught, which is equivalent to the driest month in 10 years.
- 24-hour continuous water supply service with adequate quantity and quality.

The Study analyzed available water supply capacity in the study area based on the 99% reliable yield capacity of each water source. Then, the master plan components, which will enable to achieve the above goals, were selected based on a cost benefit analysis. They should be able to satisfy the future required water production rate of 267,494 m^3/day (3,096 l/s) on average daily base.

3.2 EXISTING PRODUCTION RATE

The existing water production rate based on the 99% reliable yield capacity was estimated at 177,896 m^3/day (2,059 l/s) on daily average base, as shown in *Table 7*. This production rate will decrease 406 m^3/day (4.7 l/s) every year, due to sedimentation of Los Laureles reservoir.

Table 7 Existing Available Water Production Rate

Subsystem	Available water production rate with 99% reliability (m^3/day)	
Picacho	24,689	(286 l/s)
Los Laureles	*43,856	(*508 l/s)
Concepcion	105,824	(1,225 l/s)
Miraflores	3,527	(41 l/s)
Total	*177,896	(*2,059 l/s)

*: The production rate in 2000. It will decrease 406 m^3/day (4.7 l/s) a year.

The existing deficit of production rate to the required production rate in 2015, 267,494 m^3/day (3,096 l/s), is 89,598 m^3/day (1,037 l/s).

3.3 CANDIDATE PROJECTS

The following projects were studied as the candidate master plan projects.

- Los Laureles reservoir dredging project,
- Los Laureles II project, consisting of construction of Los Laureles II dam and necessary water supply facilities, and excavation of the existing Los Laureles reservoir,
- Quiebra Montes project, consisting of construction of Quiebra Montes dam and necessary water supply facilities,
- Sabacuante project, consisting of construction of Sabacuante dam and necessary water supply facilities,
- Tatumbra project, consisting of construction of Tatumbra dam and necessary water supply facilities, and
- Water leakage reduction project.

Table 8 shows the result of cost benefit analysis.

Table 8 Result of Cost Benefit Analysis

Project	Developed production rate (m^3/day)	Required investment cost (USD)	Specific cost (USD/m^3/day)
Los Laureles reservoir dredging project	4,057	48,800,000	12,029
Los Laureles II project	12,995	28,300,000	2,178
Quiebra Montes dam	84,464	212,000,000	2,510
Sabacuante dam	20,332	93,000,000	4,574
Tatumbra dam	17,882	115,000,000	6,431
Water leakage reduction (8-inch or less)	27,833	160,000,000	5,749
Water leakage reduction (3/4-inch or less)	2,227	22,800,000	10,238

3.4 SELECTION OF MATER PLAN PROJECTS

(1) Projects for Water Supply Capacity Build-up

The candidate projects were compared by cost benefits analysis as shown in *Table 8.* Based on the priority given by the cost benefit analysis, required water supply capacity build-up was studied. As shown in *Table 9*, two (2) projects with lower specific cost, *i.e*. Los Laureles II project and Quiebra Montes project satisfy the required production rate of 267,494 m^3/day. These two (2) projects were selected as the master plan projects.

Table 9 Water Supply Capacity Build-up

Project	Developed production rate (m^3/day)	Cumulative production rate (m^3/day)	Deficit to requirement (m^3/day)
(Existing condition)	-	*175,459	92,035
Los Laureles II project	12,995	188,454	79,040
Quiebra Montes project	84,464	272,918	(-5,424)

*: The production rate in the year 2006 when Los Laureles II project will be completed.

(2) Project for Water Leakage Control

Though the water leakage reduction projects were given lower priority as a result of cost benefit analysis, necessity of leakage control is still high from the viewpoint of saving not only precious water resource but also resource input on production processes. It is essential for implementation of leakage reduction program to understand actual situation of leakage by monitoring both outflow of distribution reservoirs and water consumption of each user. Therefore, as a measure of leakage control installation of micrometers to all users and flow

meters to all distribution reservoirs is proposed as one of master plan projects.

4 PROPOSED MASTER PLAN

4.1 INTRODUCTION

Three (3) projects, namely Los Laureles II Project, Quiebra Montes Project, and Leakage Control Project, were selected as the projects to achieve the targets of the Master Plan.

Two (2) projects, Los Laureles II Project and Quiebra Montes Project, develop additional water sources by constructing new dams and supply developed water to the existing and future distribution areas by implementing new or additional water supply facilities.

Leakage Control Project is proposed to implement a system to acquire quantitative data necessary for a leakage reduction program.

4.2 FACILITY PLANNING OF LOS LAURELES II PROJECT

(1) General

The design water yield of the present Los Laureles reservoir is 750 l/s, while an actual yield is 540 l/s in 2000 and further decreasing 5 l/s a year because of decrease of the reservoir volume by sedimentation. Los Laureles II Project increases it to 670 l/s.

The design capacity of the water supply facilities, such as a water treatment plant, transmission facilities and distribution networks, are 670 l/s. Therefore, it is planned that the water of Los Laureles II reservoir is discharged to the present Los Laureles reservoir downstream, taken at Los Laureles reservoir, treated at the existing Los Laureles WTP, and transmitted to distribution reservoirs currently supplied from Los Laureles WTP.

(2) Water Source Development

Water source development of Los Laureles II Project consists of the construction of Los Laureles II dam and the excavation of sediments in the existing Los Laureles reservoir.

Los Laureles II dam

The elevation of top of the dam was designed taking into account the elevation of Mateo Bridge and houses to be relocated by the project. The maximum normal water elevation of the reservoir is 1,053 m. *Figures 7* and *8* show the typical section and profile of Los Laureles II dam, respectively.

The amount of construction work for the dam is as follows;

- Excavation: 65,000 m^3
- Concrete: 42,000 m^3
- Gate: 9m × 8.6 m × 4 sets

Excavation of Sediment

Figure 9 shows the proposed location of the sediment excavation. The total amount of excavation is 600,000 m^3.

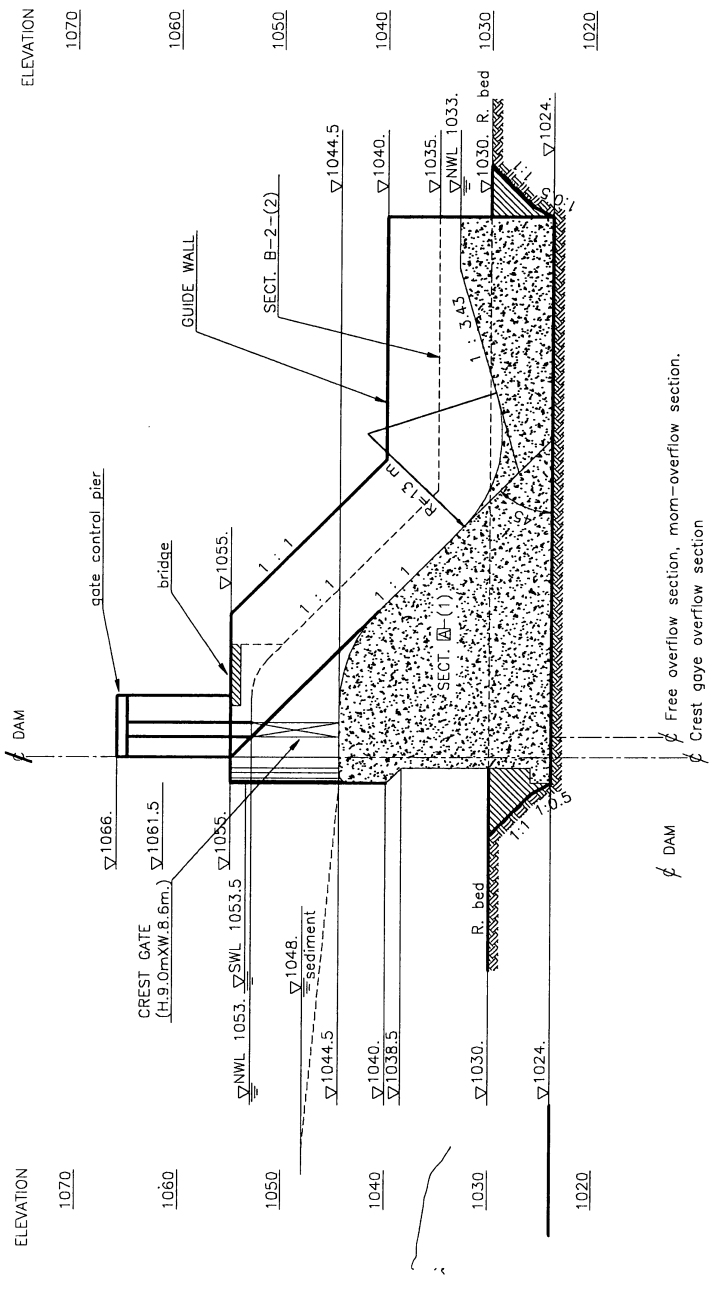


Figure 7	Typical Section of Los Laureles II Dam

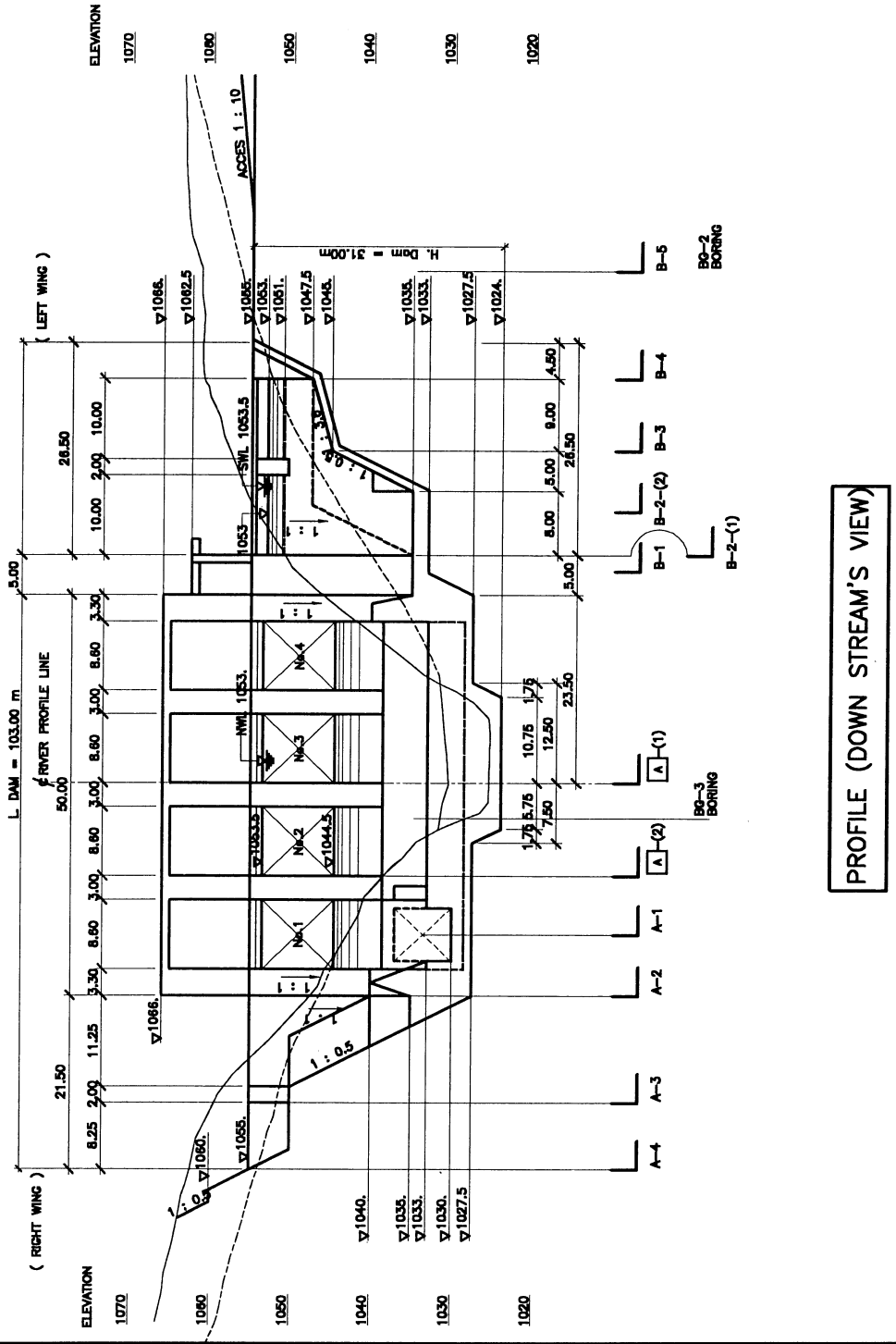


Figure 8	Profile of Los Laureles II Dam

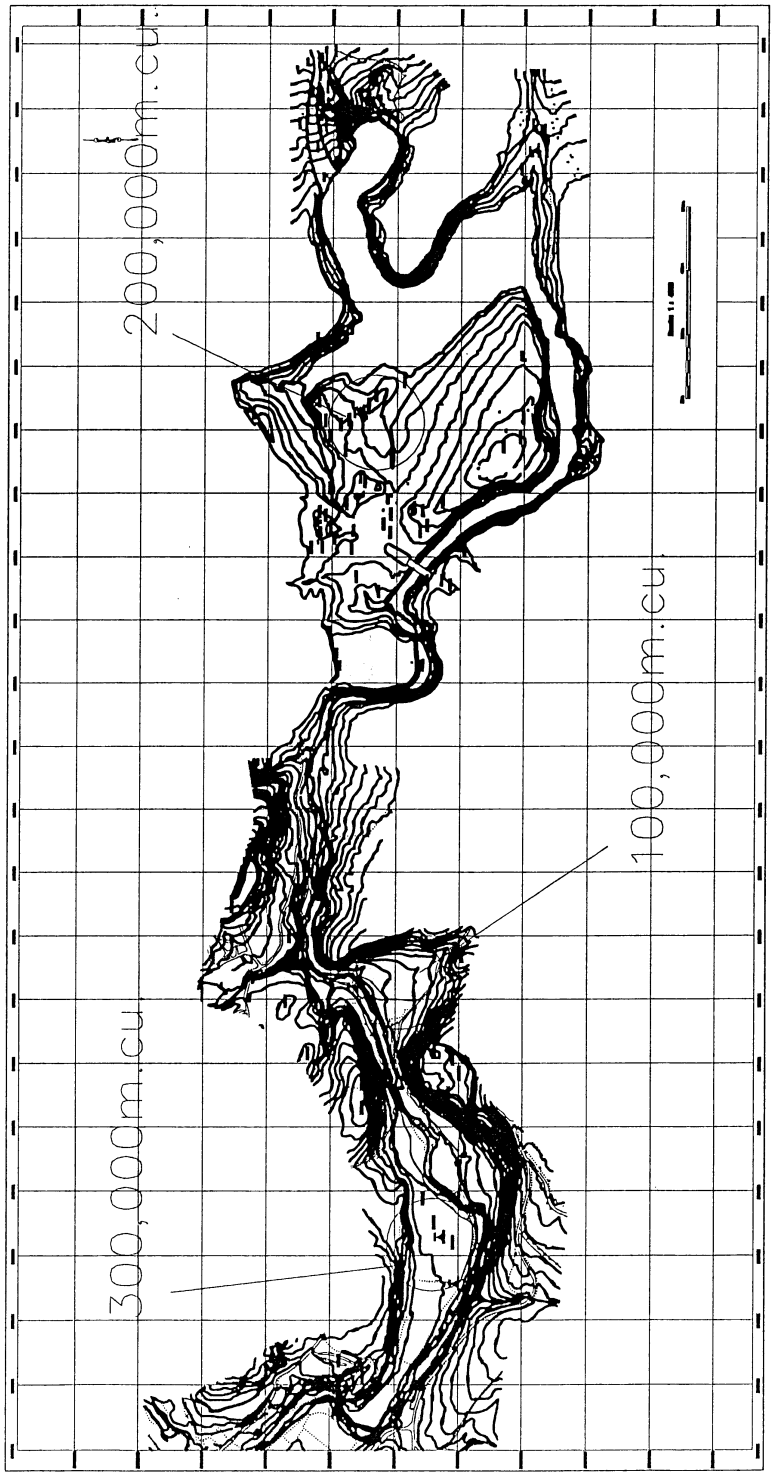


Figure 9	Location of Sediment Excavation

Water Yield

Water yield of Los Laureles II dam was 130 l/s with 99 % reliability. The water yield by the sedimentation excavation of the existing Los Laureles reservoir and future Los Laureles II reservoir is 30 l/s assuming that the reservoir capacity is increased by 600,000 m^3

(3) Water Supply Facilities

As the developed water is supplied through the present water supply facilities, no additional water supply facilities should be required in Los Laureles II Project. This was confirmed by the actual capacity of the existing water supply facilities and water supply and demand balance in the distribution areas.

4.3 FACILITY PLANNING OF QUIEBRA MONTES PROJECT

(1) General

Quiebra Montes Project consists of the following components:

- Construction of Quiebra Montes dam
- Installation of conduction line from Quiebra Montes dam to a new water treatment plant
- Construction of a new water treatment plant
- Expansion of the clear water reservoir of the existing Los Laureles WTP
- Construction of a bypass line for introducing the water of Quiebra Montes reservoir to the clear water reservoir of the existing Los Laureles WTP
- Reorganization of transmission system
- Reorganization of distribution system

(2) Water Source

Figures 10 and *11* show the plan and profile of Quiebra Montes dam, respectively. The amount of construction work for the dam is as follows;

- Excavation: 753,000 m^3
- Concrete: 64,000 m^3
- Fill: 3,500,000 m^3

Water yield was 1,040 l/s with 99 % reliability.

(3) Optimization of the Water Supply System

Each of the existing subsystem has its own conduction and treatment systems. The optimal system plan was established by harmonizing the yield capacity of the water source and the capacity of conduction and treatment systems of each subsystem and by reorganizing transmission and distribution system.

Alternative Study for the Optimization of Water Treatment

To optimize the water treatment of the system, the following two (2) alternative studies were conducted.

<u>Alternative Study 1: Optimization of Picacho WTP</u>

- Alternative 1:
  To utilize the water of Quiebra Montes reservoir exclusively in Quiebra Montes WTP. Picacho subsystem will remain in the existing conditions.

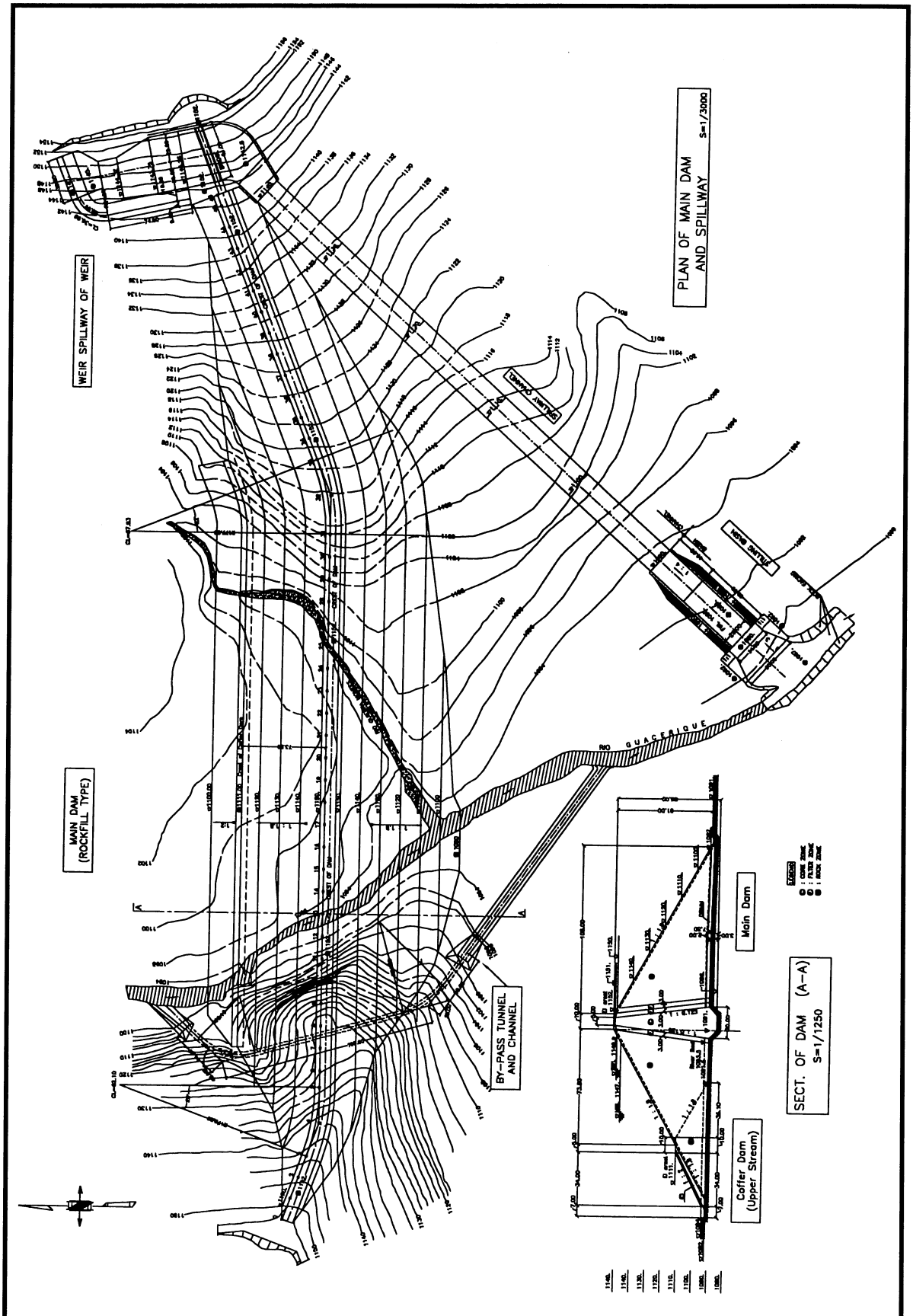


Figure 10 | **Plan of Quiebra Montes Dam**

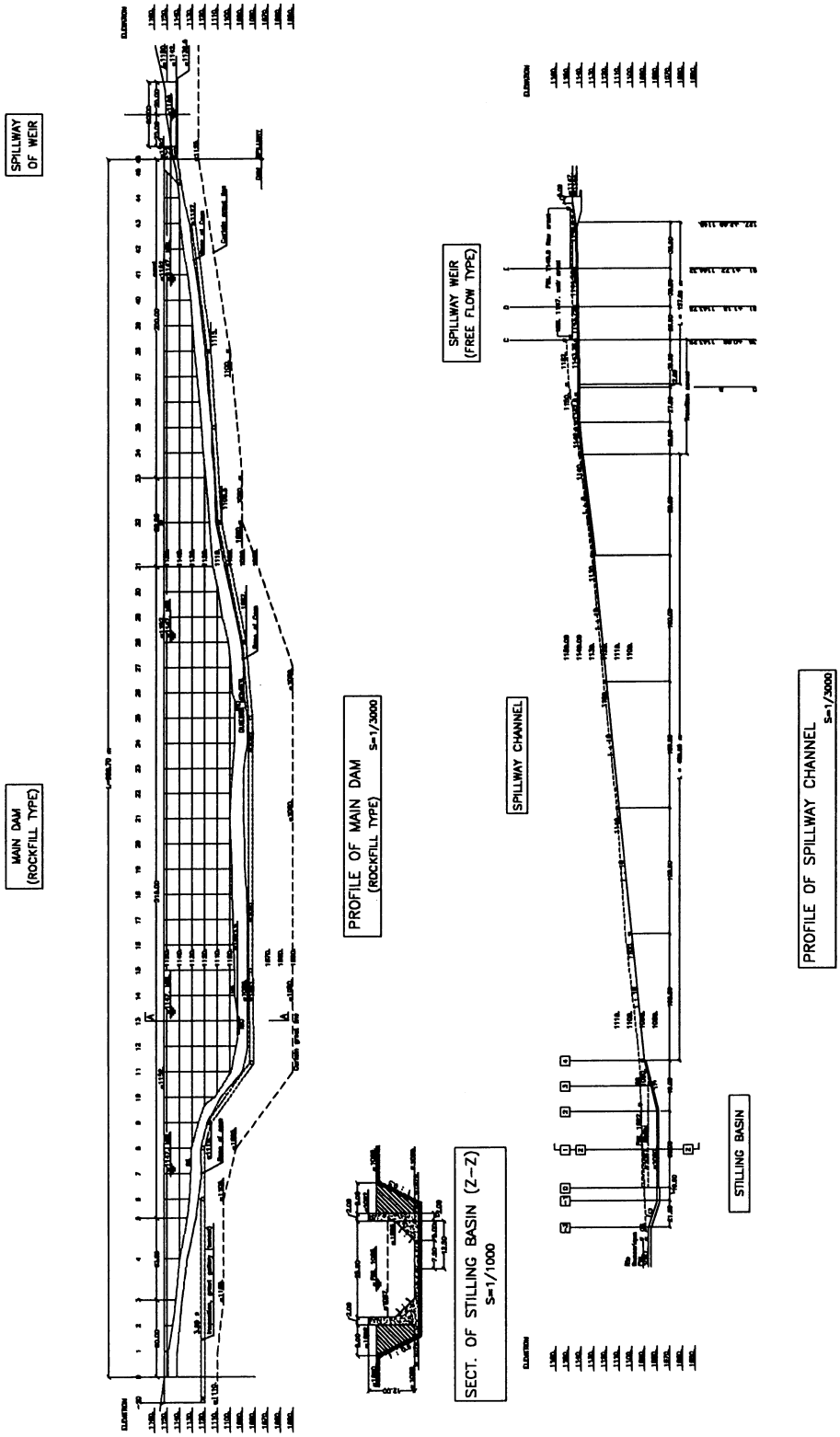


Figure 11	Profile of Quiebra Montes Dam

- Alternative 2:
  To cover the deficit of yield capacity of Picacho WTP by receiving water from Quiebra Montes reservoir. This alternative requires transmission system from Quiebra Montes reservoir to Picacho WTP, on the other hand, the required capacity of Quiebra Montes WTP can be reduced.

Alternative Study 2: Optimization of Los Laureles WTP

- Alternative A:
  Optimize the capacity of Los Laureles and Quiebra Montes WTP independently. It requires expansion of Los Laureles WTP so as to absorb the peak of demand fluctuation.
- Alternative B:
  Joint operation of Los Laureles WTP and Quiebra Montes WTP so as to operate Los Laureles WTP always at the existing design capacity. All the demand fluctuation will be absorbed by Quiebra Montes WTP.

As a result of the alternative studies, Altenative-1 and Alternative-B were selected based on a cost comparison and the following facilities are proposed:

- Quiebra Montes WTP: 108,000 m^3/day
- Bypass line from Quiebra Montes WTP to Los Laureles WTP: 239 l/s
- Expansion of the clear water reservoir of Los Laureles WTP: 900 m^3

Reorganization of Transmission

The reorganization of the transmission system was carried out by allocating the newly planned distribution reservoirs to the planned or existing water treatment plans. Important factors for planning of the transmission system were the existing transmission system and the relation between elevations of the treatment plant and the distribution reservoirs.

Table 10 shows the new distribution reservoirs assignments by water treatment plants in the reorganized transmission system together with the one of the existing system.

Facility planning employed a network analysis by EPANET to determine pipe sizes and pumping station capacities.

Reorganization of Distribution

Based on the required water amount of each neighborhood in 2015, reorganization of the existing distribution areas were conducted by the following manners.

- To assess the capacity of distribution reservoirs against the estimated required water amount in 2015.
- To expand or reduce the estimated required water amount by adding or subtracting neighborhoods between bordering distribution areas so as to adjust the estimated required water amount to the capacity of the existing distribution reservoirs as much as possible.
- To adjust a distribution area to reduce elevation difference within distribution areas.
- To construct additional distribution reservoir to satisfy the required capacity, unless otherwise there is no constraint in the site.
- To construct new distribution reservoirs in case the existing site does not have a space for additional ones and there are particular reasons, such as typographic conditions, to divide the existing distribution areas.

Results of the reorganization are shown in *Table 11*.

Table 10 Reorganization of Transmission System

Distribution Reservoirs	ELEVA-TION	Water Sources (Name of Water Treatment Plant)							Elevation of WTP
		Present			2015				
		PICACHO	LOS LAURELES	CONCEP-CION	PICACHO	LOS LAURELES	CONCEP-CION	QUIEBRA MONTES	
PICACHO	1296.70	●			●				Picacho WTP
MOGOTE	1254.25		●			○		●	
ULLOA	1240.00							●	
CERRO GRANDE 2	1240.00				○			●	
VILLAFRANCA	1220.00							●	
CERRO GRANDE 1	1215.40		●	◎	○			●	
LA TRAVESIA	1198.06	●		○	●		○		
SAN FRANCISCO	1147.00							●	
LAS UVAS	1130.00						●		
C.A. OESTE	1126.50		●			○	○	●	
OLIMPO 2	1121.00	○	●	◎	○		○	●	
COVESPUL	1117.85			●			●		
HATO 2	1110.00			●			●		
LA SOSA	1110.00	●		○	●		○		
SUYAPITA	1110.00			●			●		
C.A. ESTE	1105.30		●	○		○	○	●	
OLIMPO 1	1103.00	○	●	◎	○		○	●	
CONCEPCION	1099.00	○		●			●		Concepcion/
UNIVERSIDAD NORTE	1093.00			●			●		Quiebra Montes WTPs
NUEVA CIUDAD	1087.00						●		
LAS HADAS	1085.00		●	●			●		
LOMAS 2 ETAPA	1084.00			●			●		
LOMAS DEL TONCONTIN	1078.37			●			●		
CANAL 11	1070.20		●	●			●		
CASCADA	1070.00						●		
HONDURAS	1069.43			●			●		
LINDERO	1068.75	●		○	●		○		
KENNEDY 3	1068.00			●			●		
LOS PINOS P.S.	1065.00			●			●		
LA INDEPENDENCIA	1065.00							●	
LA Canada	1060.00						●		
LOS ROBLES	1055.55			●			●		
LOARQUE	1053.45			●			●		
HATO 1	1050.70			●			●		
LA FUENTE	1049.45		●			○		●	
VILLA NUEVA	1045.00			●			●		
JUAN A. LAINEZ	1044.90		◎	●		●	○		
ESTIQUIRIN	1043.85		●	●		○	○	●	
CALPULES	1042.25			●	Abolished				
14 DE MARZO	1042.00			●			●		
NUEVA SUYAPA P.S.	1039.50			●			●		
CENTRO LOMAS 1	1033.70		○	●		●	○		
MIRAFLORES	1024.50			●			●		Miraflores WTP
MONTERREY	1024.10			●			●		
LOS LAURELES	1015.20		●			●			Los Laureles WTP
LA LEONA	1006.65	○		●	○	○	●		
LA LEONA	1006.05	○		●	○	○	●		
LOS FILTROS	1003.45		●	○		●	○		
SAN FRANCISCO P.S	990.00		●		Abolished				
JUAN A LAINEZ QUESADA	885.00					●			

● Main supply ◎ Complementary supply ○ Supply option

Table 11 Reorganization of Distribution Reservoirs

Name of distribution reservoir	2000			2015		
	No.of Neighborhood	Population	Water demand (m^3/day)	No.of Neighborhood	Population	Water demand (m^3/day)
14 de Marzo	4	19,038	3,362	11	33,362	5,991
Calpules	3	4,356	970	-	-	-
Canal 11	23	15,701	10,921	23	18,708	8,340
Centro Lomas	11	10,756	4,276	13	13,812	5,413
Centro America Oeste	1	12,291	2,805	2	15,026	3,237
Cerro Grande 1	4	15,177	3,602	4	18,687	4,205
Concepcion	16	38,569	6,773	-	-	-
Covespul	1	530	145	1	635	165
Hato 1	3	2,209	1,437	1	8,987	2,058
Hato 2	2	3,318	1,124	1	8,475	1,795
Mogote	12	25,911	4,893	10	22,082	4,224
Estiquirin	104	120,557	27,733	94	139,200	27,361
Filtros 1/2	34	41,686	14,605	34	59,074	21,204
Honduras	1	3,980	891	5	9,711	1,938
Juan A. Lainez	24	13,488	6,193	17	21,761	13,083
Kennedy 3	25	22,366	11,585	17	58,815	14,067
La Fuente	2	2,371	569	2	2,845	647
La Leona	47	33,489	18,450	34	32,342	16,467
Las Hadas	2	1,193	411	5	3,906	1,156
Los Laureles	5	18,491	3,892	4	2,340	361
Lindero	22	20,864	5,143	13	21,106	4,714
Loarque	16	14,424	3,748	15	19,439	5,021
Lomas 2da etapa	7	4,955	1,239	6	7,620	1,644
Lomas Toncontin	5	5,084	1,205	6	9,903	2,150
Los Robles	2	4,316	1,157	1	4,680	1,185
Miraflores	17	34,794	9,377	10	26,067	6,967
Monterrey	1	5,301	809	1	6,361	923
Olimpo 1	23	55,807	10,035	13	34,925	6,548
Olimpo 2	19	36,574	6,084	20	33,918	5,095
Picacho	59	74,658	14,648	50	90,273	17,537
Res. Centro A. Este	8	5,546	1,230	7	4,953	1,160
San Francisco	5	14,224	2,246	-	-	-
Sosa	16	39,805	7,432	10	35,429	6,337
Suyapita	6	7,529	1,788	17	19,410	4,837
Travesia	5	14,328	2,222	6	22,658	3,326
Universidad Norte	9	6,937	1,727	7	2,548	593
Villa nueva	3	30,200	4,602	4	47,350	7,547
Nueva Suyapa	12	25,458	3,907	12	31,187	4,579
Cascada	-			2	2,505	643
Las Uvas	-			2	6,436	1,597
La Cañada	-			7	15,344	3,570
Est. Bombeo Los Pinos	1	9,494	1,446	1	11,391	1,650
La Independencia	-			26	85,022	14,308
New San Francisco	-			19	51,478	8,254
Ulloa	-			15	41,764	7,463
Villa Franca	-			10	13,966	2,165
Cerro Grande 2	-			3	13,553	2,442
Juan A. Lainez Quesada	-			5	3,584	2,422
Nueva ciudad	-			1	814	260

Tank Lorries Water Supply System

The construction of three (3) water filling stations were proposed considering accessibly and effects to traffic and increase of numbers of tank lorries were proposed based on required water amount and handling capacity of each tank lorries.

(4) Proposed Facilities

Water Treatment WTP

The layout of Quiebra Montes WTP is shown in *Figure 12.* *Table 12* shows major specifications of the proposed facilities.

Table 12 Specifications of Major Facilities of Quiebra Montes WTP

Facilities	Size/Capacity	Remarks
Cascade aeration	4.0mW x 16.0mL x 1	Multi-step
Coagulation channels	8.0mW x 43.0mL x 1.5mH x 8	Baffled channels
Sedimentation basins	8.0mW x 36.0mL x 4.0mH x 8	Plate settler
Filtration basins	10.7mW x 8.2mL x 3.8mH x 12	Rapid sand filter
Clear water reservoirs	30.0mW x 40.0mL x 3.6mH x 2	Rectanguler
Sludge thicknner	8mW x 43mL x 1.5mH x 2	Circular thickner
Sludge drying	16.2 mϕx 5.5mH x 12	Natural dring bed
Alum dosing	0.6 m^3/min x 1	Solution injection
Polymer dosing	4 - 20 lit/min x 1	Solution injection
Lime dosing	0.6 m^3/min x 1	Solution injection
Disinfection	40 kg/hr x 1	Liquid chlorine

Conduction Facility

Proposed conduction facility is as shown in *Table 13.*

Table 13 Proposed Conduction Facility

Flow Type	Design Flow Rate (l/s)	Conduction Pipeline			
		Diameter (mm)	Length (km)	Material	Flow Velocity (m/s)
Gravity flow	1,250	1,200	1.0	DCIP	1.1

Note: DCIP : Ductile Cast Iron Pipe

Transmission Facility

Table 14 summarizes pipeline facility plan required for the reorganization of the transmission system based on the result of the network analysis. *Table 15* shows new and additional pumping stations required for the reorganization.

Table 14 Required Pipe Installation Work for Transmission Reorganization

Diameter (mm)	Length (m)
1200	7,500
1000	1,500
800	4,290
700	2,160
500	500
450	30
400	1,800
300	1,750
250	1,820
200	350
150	50
100	1,550
Total	23,300

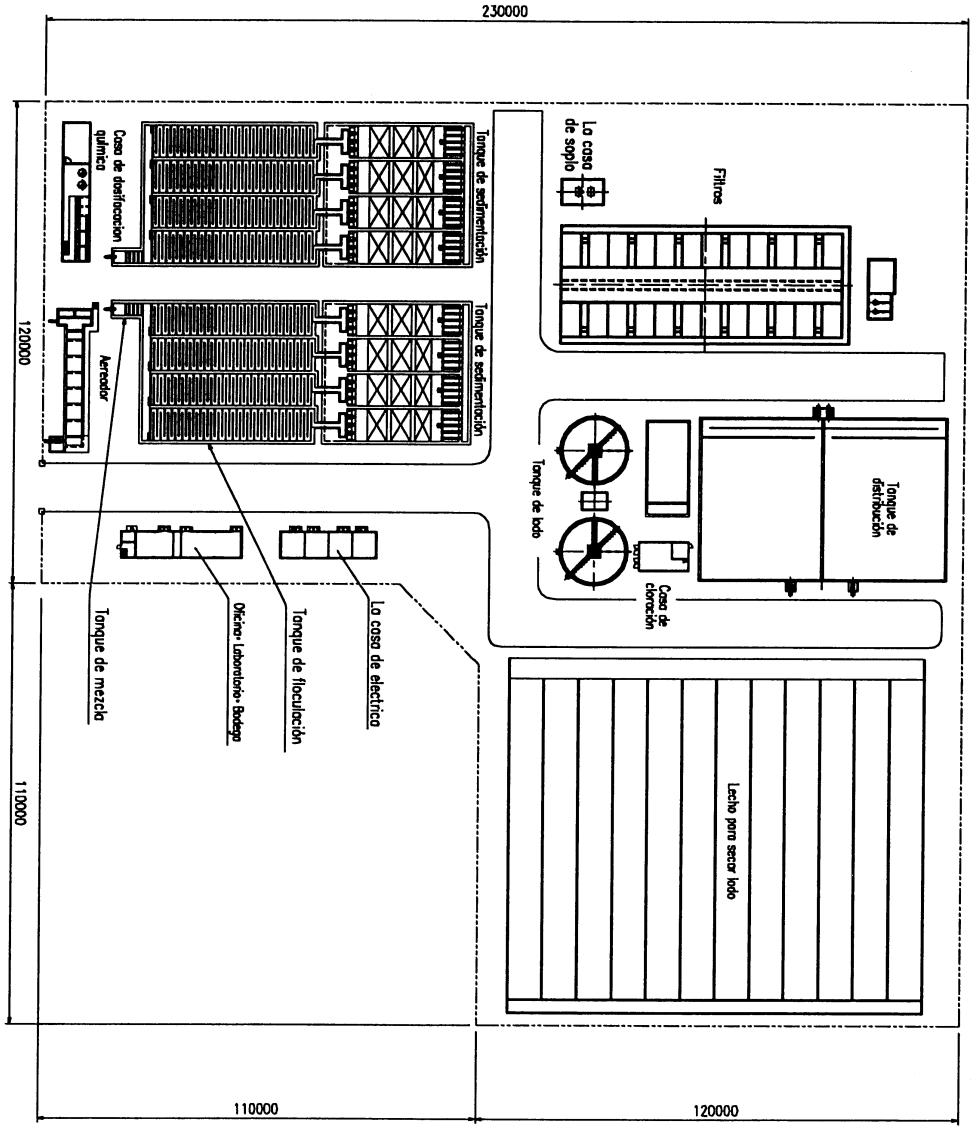


Figure 12	Layout of Quiebra Montes WTP

Table 15 Facility Plan for Transmission Pump Stations

Name of Pumping Station		No. of Pumps		Discharge (l/s)	Total Head (m)	Remarks
		Operation	Stand-by			
Mogote	- to Mogote Res.	2	1	67	170	Expansion
	- to S. Franscisco	2	1	131	70	
Booster Soledad		1	1	119	15	Expansion
Independencia	- to Olimpo I	2	1	305	50	Expansion
	- to Villafranca	1	1	35	165	
Booster Las Hadas		1	1	19	25	Expansion
Booster Nueva Ciudad		1	1	4	20	Expansion
Estiquirin		1	1	258	57	New
Loma Linda	- to Centro Loma	1	1	86	51	New

Distribution Facility

Tables 16 and *17* summarize facilities required for the reorganization of the distribution system.

Table 16 Proposed Distribution Tanks Installation

Name of Distribution Reservoir	Types	Required Volume (m^3)
Canal 11	Additional	1,330
Juan A. Lainez	Additional	3,200
La Leona	Additional	1,477
Olimpo 1	Additional	600
La Sosa	Additional	2,300
La Canada	Additional	800
La Independencia	New	5,200
New San Francisco	New	3,000
Ullua	Additional	800
New Juan A. Lainez Quezada	New	650
Nueva Ciudad	New	100

Table 17 Summary of Expansion and Reinforcement of Distribution Network

Diameter of Pipe (mm)	Reinforcement in existing areas (km)	Needs of distribution network expansion		Total (km)
		New urbanizations in areas currently cover by pipes (km)	Areas currently covered by tank lorries (km)	
50 – 80		65.0	58.0	123.0
100	13.0	30.0	22.0	65.0
150	12.0	12.0	14.0	38.0
200	10.0	4.0	12.0	26.0
250	8.0	1.0	9.0	18.0
300	7.0		6.0	13.0
350	5.0		4.0	9.0
400	3.5		2.0	5.5
500	1.0		1.0	2.0
600	0.5			0.5
Total	60.0	112.0	128.0	300.0

Facilities for Tank Lorry Water Supply

Required facilities for the tank lorry water supply are as shown in *Table 18*

Table 18 Facility and Equipment required for Tank Lorry Water Supply

Facility/ Equipment		2000	2001	2002	2003	2004	2005	2010	2012	2015
Tank Lorries (10ton)	Required No	93	106	120	133	146	160	177	204	195
	No of procured/year		13	13	13	13	13	17	27	-
Water Filling Stations	Required total volume (m^3)	3,100	4,400	4,400	4,400	5,200	5,800	6,600	6,600	6,600
	Volume to be installed (m^3)		1,300			800		600	800	

4.4 FACILITY PLANNING OF LEAKAGE CONTROL PROJECT

Ultimate goal of Leakage Control Project is to reduce the physical loss to a certain acceptable level. The leakage control program consists of following strategies:

- To acquire information necessary for implementing leakage reducing program, such as water quantity data through out the system, as-built drawings of distribution pipe laying and pipe registers
- To set up task force for leakage repairing
- To establish a leakage reducing program
- To implement the leakage reduction program

The leakage study conducted in the Study revealed that there is not enough basic information necessary for establishing effective measures. Therefore, the Master Plan proposed to implement water quantity measuring system as a first step of the leakage control. Actual reducing program should be established after accumulating water quantity data throughout the system for several years. The Master Plan also proposed a task force that increases a capacity of the leakage repairing section.

Required manpower and equipment necessary for strengthening leakage repair capacity are shown in *Table 19*. Required meter installation is shown in *Table 20*.

Table 19 Proposed Leakage Repair Capacity Strengthening

Works	Description	Remarks
Leakage Patrol	- Leakage Detector (Hearing rod, Drill, Flowmeter) x 2 sets - Patrol Vehicle x 2 - Inspector x 4	Frequency of patrol: 4 times/year
Repair Works	- Repairing tools 5sets - Vehicle x 5 - Worker x 15	Repair: 10 leakage/day

Table 20 Required Meter Installation for Water Quantity Measurement

Facilities	Measuring Point	Number of Facilities	Required Quantity
Water Treatment Plant	Inlet	3	3
Pumping Stations	Outlet	24	24
Distribution Reservoirs	Outlet	44	101
Water Meters	Service Pipe	48,500	48,500

Note: Only for the existing facilities. For the new facilities, it is supposed that necessary flow measurement devices are installed in all the facilities.

4.5 SUMMARY OF FACILITY PLANNING

Proposed facilities in the Master Plan Projects are summarized in *Table 21.* and their locations are shown in *Figure 13.*

Table 21 Summary of Facilities Planning for Mater Plan Projects

Projects	Components	Descriptions	
Los Laureles II	Los Laureles II Dam	Dam Type:	Concrete Gravity
		Dam Height:	31.0 m
		Dam Width:	103.0 m
		Gates:	9m x 8.6m x 4 sets
		Reservior Volume:	4,050,000 m^3
		Yield Capacity:	130 l/s (99% reliability)
	Excavation of Los Laureles Dam	Volume:	600,000m^3
		Yield Capacity:	30 l/s (99% reliability)
Quiebra Montes	Quiebra Montes Dam	Dam Type:	Rockfill
		Dam Height:	66.0 m
		Dam Width:	958.7 m
		Reservior Volume:	53,000,000 m^3
		Yield Capacity:	1040 l/s (99% reliability)
	Conduction Facilities	Conduction Pipe:	1,200mm x 1 km
	Quiebra Montes WTP	Type:	Rapid Sand Filtration
		Production Capacity:	108,000 m^3/day
	Reorganization of Transmission System	Pumpimg Stations:	5 new pumping stations and 2 expansion of existing pumping stations
		Transmission Pipe:	100-1,200mm x 23.3 km
	Reorganization of Distribution System	Reservoir Tanks:	100 - 5,200 m^3 x 12 tanks
		Distribution Pipe:	50 - 600 mm x 300 km
		Filling Stations:	600 - 1,300 m^3 x 4 stations
		Tanlk Lorries:	204 vehicles
	Joint operation of QM WTP and LL WTP	Clear Water Reservoir in LL WTP: 900 m^3	
Leakage Control	Water Quantity Measurement	Flowmeter:	3 existing WTP, 24 existing Pumping Stations and 44 existing Reservoirs
		Watermeter:	48,500 users
	Strengthening Leakage Repair Capacity	Leakege repair tools, leakage detection tools and vehicles	

Note: QM; Quiebra Montes, LL; Los Laureles

4.6 OPERATION AND MAINTENANCE PLAN

(1) Dam

Operation and maintenance plan for dams were proposed from the view points of joint operation of three (3) dams in the Guacerique River basin and flood forecast and warning.

(2) Water Supply Facilities

Operation and maintenance plan for the water supply facilities were from following view points:

- Water quantity control through the whole system
- Water quality control
- Daily operation and maintenance for facilities

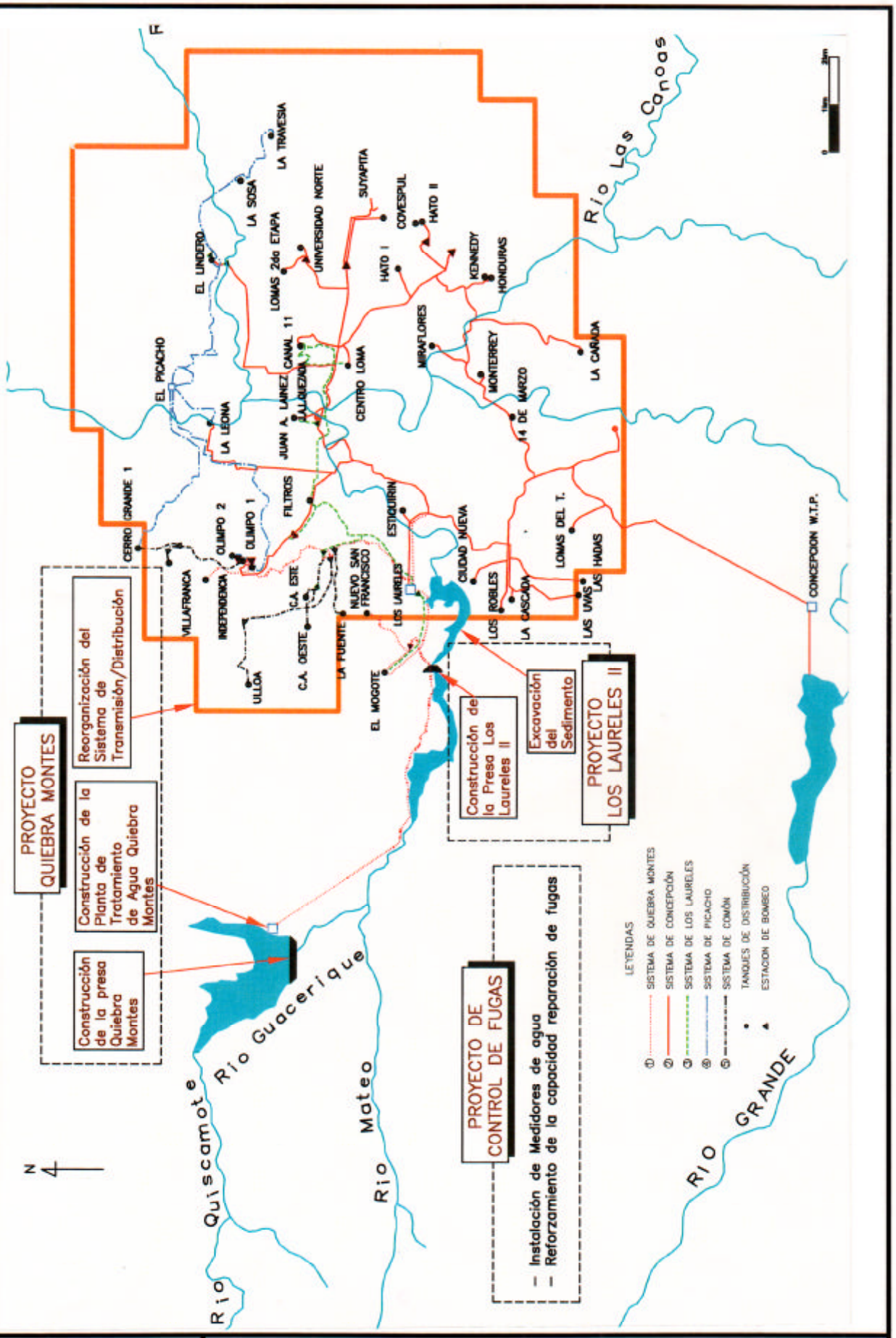


Figure 13	Locations of Master Plan Projects

4.7 ORGANIZATION PLAN

The basic approaches for the organization plan were as follows and the proposed organization structure is shown in *Figure 14*.

- Transfer planning, financial, and commercial functions from the headquarters to the Metropolitan Division
- Clear separation of financial and commercial functions
- Strengthen information, planning and commercial functions
- Achieve high efficiency by activity oriented segmentation

In accordance with the above approaches, the following actions were proposed.

(1) Reorganizing of Operation and Maintenance Department

The required activities for operation and maintenance were analyzed and it was proposed to reorganize the current Operation Department and Maintenance Department into the Water Supply Department to achieve better coordination between operation and maintenance functions.

(2) Strengthening of Information Function

An establishment of Information Department with the following functions was proposed.

- Operation and maintenance of the whole information network system in the division.
- Operation and maintenance of technical information database for the purpose of planning and public information.
- Operation and maintenance of the archive of the division.

(3) Strengthening of Planning Function

It was proposed to establish Planning Department which has capability to analyze existing conditions and work out necessary actions towards service improvement, and prepare investment plans. The Planning Department should be a window to foreign assistant agencies.

(4) Strengthening of Commercial Function

It was proposed to strengthen commercial function by the following steps.

- Design of a commercial system composed by a customer database with geographic information, and an invoice preparation function
- Collection of necessary data for the commercial system by field surveys
- Installation of the commercial system
- Installation of micrometers to all the users

Currently SANAA attempts to introduce new commercial database, but due to budget limitation the work delays. Taking the importance of powerful commercial system for the SANAA management into account, we recommend reviewing the SANAA's on-going commercial database project from the viewpoint of powerful commercial system.

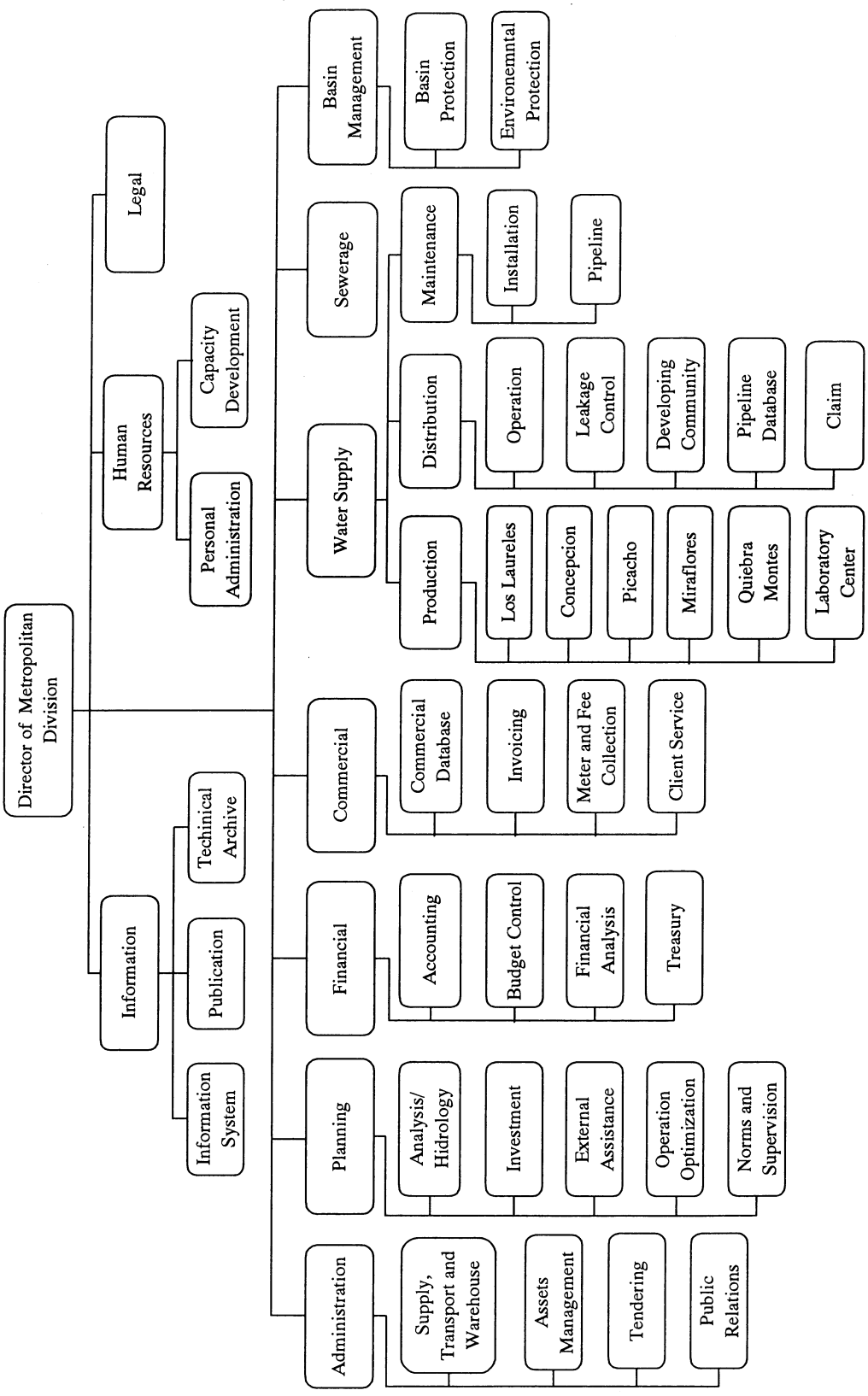


Figure 14 | **Proposed Organization Chart of SANAA Metropolitan Division**

4.8 COST ESTIMATE

(1) Construction Costs

A total projects cost were calculated by following breakdown and the direct cost and land acquisition cost are calculated by the unit prices and the quantities while other breakdowns are calculated by ratios to the direct cost and/or land acquisition cost:

- Direct construction cost
- Engineering cost : 10 % of a direct construction cost of dams, 8% of direct construction cost of water supply facilities and 3% of water tank lorries.
- Land acquisition cost
- Administration cost: 5% of a direct construction cost
- Physical contingency: 10% of a total of direct construction cost, land acquisition cost and administration cost.

The estimated construction costs of the Master Plan is shown in *Table 22*.

Table 22 Estimated Construction Costs of the Master Plan

Item	Direct Construction Costs	Engineering Cost	Land Acquisition Cost	Administration Cost	Physical Contingency	Total
1. Los Laureles Project	**18,621,950**	**1,862,195**	**2,444,570**	**931,097**	**1,862,195**	**25,722,007**
2. Quiebra Montes Project	**284,701,470**	**17,756,607**	**8,462,000**	**14,235,074**	**28,470,147**	**353,625,298**
(1) Quiebra Montes Dam	143,867,020	7,193,351	7,500,000	7,193,351	14,386,702	180,140,424
(2) Water Supply Facilities	140,834,450	10,563,256	962,000	7,041,723	14,083,445	173,484,874
3. Leakage Control Project	**13,455,120**	**1,076,390**	**0**	**672,740**	**1,345,440**	**16,549,690**
Total	**316,778,540**	**20,695,192**	**10,906,570**	**15,838,911**	**31,677,782**	**395,896,995**

Unit: USD

(2) Operation and Maintenance Costs

The calculated costs covers manpower costs, material costs and power costs required for the operation and maintenance of the facilities proposed in the Master Plan.

The costs were calculated for the period of year 2001 to 2015. Operation and maintenance costs presented in *Table 23* are a summation of the whole period.

Table 23 Estimated Operation and Maintenance Costs

	Los Laureles Project	Quiebra Montes Project	Leakage Control Project	Total
O&M Costs	2,970,000	45,793,145	1,201,335	49,964,480

Unit: USD

4.9 IMPLEMENTATION PROGRAM

It is necessary to implement Quiebra Montes Project at the earliest occasion to dissolve the current deficit earlier. However, Quiebra Montes Project will take a longer implementation period because of the construction of a rather large scale dam that is an essential part of the projects. The implementation of Los Laureles II Project, which does not take as long period as Quiebra Montes Project because of its smaller scale, can mitigate the deficit until the completion of Quiebra Montes Project.

It is concluded that the preparation works for the both projects start immediately, and Los Laureles II Project will complete one (1) year before the completion of Quiebra Montes Project, and will mitigate the deficit until the completion of Quiebra Montes Project.

On the other hand, the leakage control is an urgent matter not only from the viewpoint of recovery of the production loss but also from the viewpoint of the conservation of precious water resources. The Master Plan proposes Leakage Control Project that provides the water quantity monitoring system so that an actual leakage water reduction program can be formulate based on a solid technical background. Therefore, it is also required to implement Leakage Control Project at the earliest timing to start the leakage water reduction program earlier.

Proposed implementation schedule is shown in *Table 24* and the balance between the required water production rate and water production capacity by the proposed implementation schedule is shown in *Figure 15*

Table 24 Implementation Schedule

No	Scheme	Description	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Los Laureles II																	
-1	Dam	new																
2	Quiebra Montes																	
-1	Dam	new																
-2	Conduction Facility	new																
-3	Quiebra Montes WTP	new																
-4	Transmission Facilitiy																	
	1) pipeline	new																
	2) pumping stations	new																
	3) expansion of reservoir of Los Laureles WTP	new																
	4) connection with Los Laureles WTP	new																
-5	Distribution Facility																	
	1) distribution reservoirs	new																
	2) distribution pipeline	new																
	3) water filling stations	new																
	4) water tank lorries	new																
3	Leakage Control																	
	1) Installation of Water Meters	expansion																
	2) Flow Meter for Existing Distribution Reservoirs	new																

[Note] : Preparation Works
: Design Works
: Construction Works

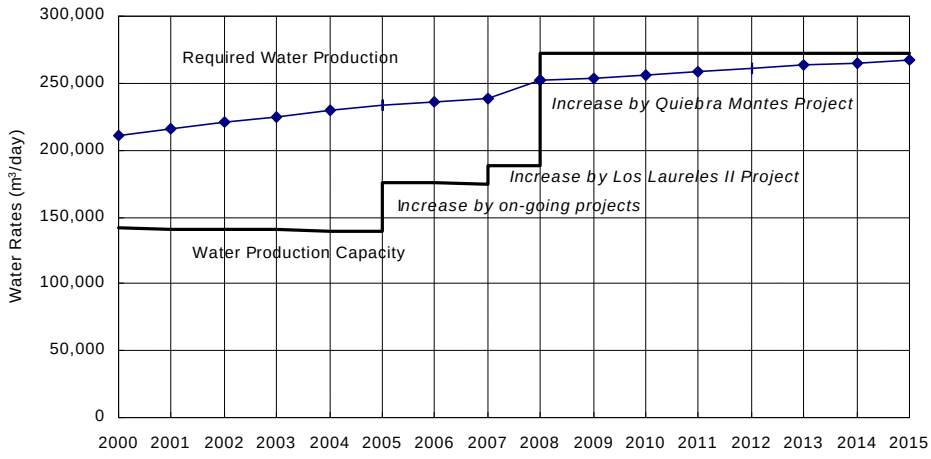


Figure 15 Required Production Rate and Water Supply Balance

4.10 FINANCIAL PLAN

The following basic principles are applied in the proposed financial plan.

- Transparency

- Financial autonomy
- Sustainability

The following procedures were applied to make the proposed financial plan.

- To estimate investment costs of the proposed projects in the Master Plan and the on-going projects in each year. The investment costs of the on-going projects were roughly estimated based on the available information/data.
- To estimate operation and maintenance costs for the all the facilities including the existing facilities. The operation and maintenance costs of the existing facilities were roughly estimated base on the past financial statements.
- To study tariff level required for sustainable water supply service.
- To determine the optimal tariff with satisfying the sustainability criteria.
- To conduct sensitivity study of sustainable criteria against variation of costs and revenues.

As a result, the determined tariff levels were 102.0 Lps/household/month for the domestic users and 21.4 Lps/m^3 for the non-domestic users, respectively. The determined tariff levels are 3.62 times higher than the existing ones. This tariff level is much lower than those based on the affordability and the willingness to pay of the users. FIRR with the determined tariff levels becomes 6.0 %.

4.11 SELECTION OF PRIORITY PROJECT

In order to select the priority projects, those projects included in the Master Plan were compared in terms of urgency, significance, schedule, technical, economical, environmental aspects.

The comparison result is shown in *Table 25*. Based on the above comparison, discussion was made between the Study Team and SANAA on the selection of F/S projects. It was concluded that Los Laureles II Project was selected as a project for the feasibility study.

Table 25 Selection of Priority Projects

Name of Project	Urgency	Significance	Schedule	Technical	Economical	Environmental	F/S Projects
Los Laureles II Project	A	B	A	A	A	B	X
Quiebra Montes Project	A	A	B	A	B	B	
Leakage Control Project	A	B	A	A	B	A	

4.12 PROJECT EVALUATION

(1) Economic Aspect

Economic evaluation was conducted by quantifying increase of the service level of the water supply as an economic benefit.

Based on the economic benefits and economic costs of the Master Plan, the economic internal rate of return (EIRR) was calculated 8.0 %. Since the opportunity cost of capital (OCC) is assumed 4 % based on a real yield of the Honduran state bond, the calculated EIRR of 8.0 % indicates that the proposed Master Plan is viable from the economic viewpoint.

(2) Financial Aspect

An increase of the tariff level by 3.62 times is proposed to achieve financial sustainability. Since the proposed tariff level is lower than both affordability and willingness to pay of users, it is concluded that the proposed Master Plan is financially viable.

(3) Managerial Aspect

The proposed organization plan will strengthen the self-sustainability of SANAA Metropolitan Division by establishing several important sections like planning, financial, and information departments. It is concluded that the proposed Master Plan will contribute to realize decentralization of SANAA in proper way.

Moreover, the proposed organization plan was evaluated from the viewpoints of service efficiency and staff requirement. Service efficiency was evaluated by a number of users per staff and confirmed that it would increase by 14 % from the present level. Staff requirements were also confirmed that it will not need the personnel downsizing. Therefore, it is concluded that the Master Plan is viable from the managerial viewpoint.

(4) Technical Aspect

SANAA has a plenty experience in the construction and operation of proposed facilities in general. However, when Los Laureles II dam and Quiebra Montes dam are completed SANAA has to operate four (4) dams, among which three (3) dams are equipped with gates. This complexity of operation is inevitable considering the scarceness of water sources compared to the increasing demand. SANAA has to accumulate the experience of operation of four (4) dams during both dry and rainy season.

(5) Environmental Aspect

The Master Plan is completely in line with the authorized institutional framework on environment conservation and only enforcement of the relevant laws could conserve the water resources in the basin and insure the sound development and utilization of scarce water resources.

(6) Social Aspect

The implementation of Los Laureles II Project requires relocation of 22 houses. SANAA has experience of relocating 34 houses for Concepcion dam project in 1992. The experience of Concepcion dam will help SANAA to make a better relocation plan to mitigate the difficulty of the people who are obliged to move.

(7) Requirements FOR THE Realization of the Master Plan

Judging from a scale of the Honduran economy, possible financial sources for the Project could be loans from foreign financing organizations, such as World Bank and BID. SANAA and the state government have to accomplish special financing instruments or joint financing with other donors through enduring negotiations. The implementation of the organization plan and financial plan proposed in the master plan, and establishment of the policy for the subsidy covering parts of the construction costs by the stage government or the Municipality are the minimum requirements to persuade the foreign financing organizations.

5. FEASIBILITY STUDY FOR THE PRIORITY PROJECTS

5.1 FACILITY PLANNING

(1) General

For Feasibility Study, Los Laureles II Project was selected. Components of Los Laureles II Project are as follows:

- Construction of Los Laureles II dam

- Excavation of the existing Los Laureles reservoir

(2) Los Laureles II Dam Construction

General Plan

Detail study was made on the layout of the dam body. *Figure 16* shows the plan of the dam (refer to *Figures 7* and *8* for typical cross section and profile). *Figure 17* shows the water level and storage volume relationship (H-V curve) of the reservoir. Features of the dam and the reservoir are as follows.

Features of the reservoir

Surcharge water level (SWL)	:	1053.5	m
Normal maximum water level (NWL)	:	1053.0	m
Minimum water level (LWL)	:	1048.0	m
Reservoir surface area at SWL	:	510,000	m^2
Reservoir surface area at NWL	:	490,000	m^2
Reservoir surface area at LWL	:	315,000	m^2
Gross storage capacity	:	4,000,000	m^3
Effective storage capacity	:	2,000,000	m^3
Sediment storage volume	:	2,000,000	m^3/50 years
Annual inflow volume of sediment	:	40,000	m^3/year

Features of the dam

Dam type : Concrete gravity dam with a spillway of crest gates for flood discharge

Dam crest elevation	:	1055.0	m
River bed elevation	:	1032.0	m
Dam foundation rock elevation	:	1024.0	m
Dam height	:	31.0	m
Dam total crest length	:	103.0	m
Width of dam crest	:	5.0	m
Width of river bed in spillway apron	:	30.0	m

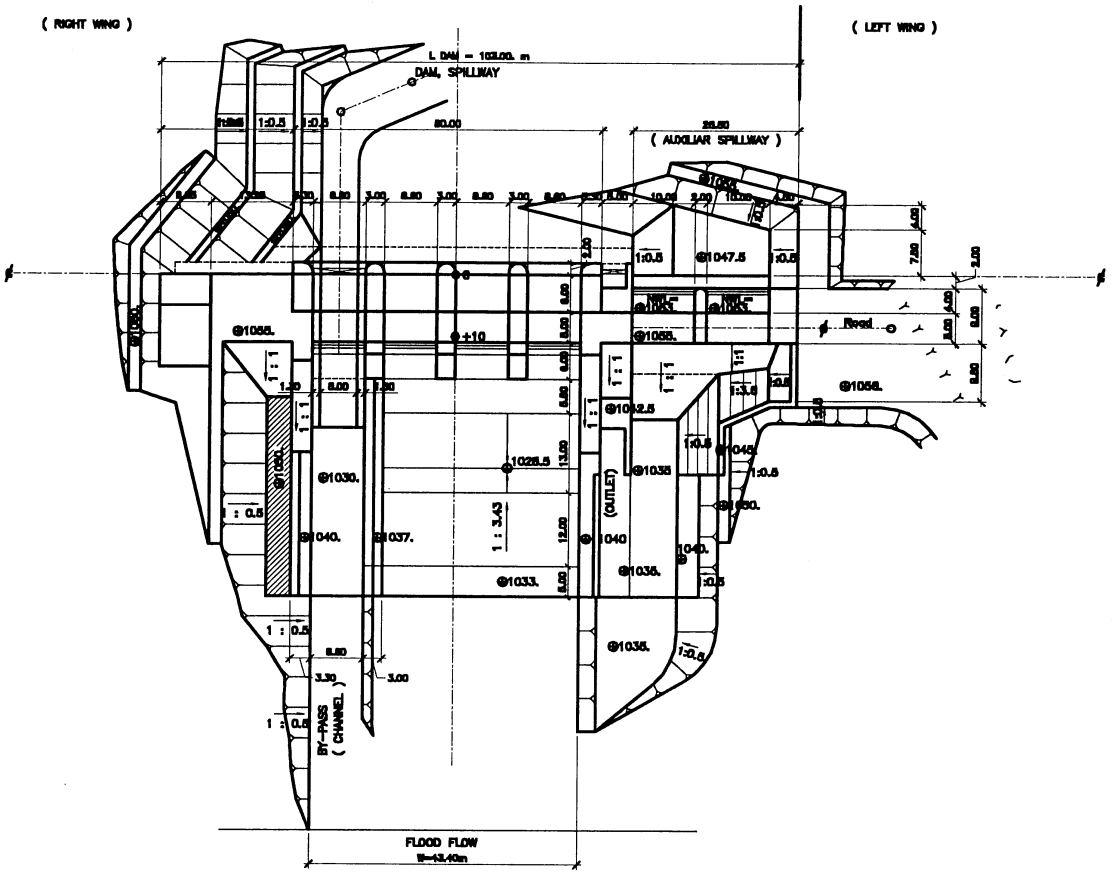
Stability Analysis

Based on the seismic study, a stability analysis of the dam body was made. The design criteria for the stability calculation are as follows;

- The design strength of the foundation rock is determined as shearing strength τ_0 = 80 t/m^2 and angle of internal friction f = 40°.
- For the design seismic acceleration, the value with 100 year-expectation is adapted as k_h=0.077 G.
- The safety factor against sliding is designed 3 for usual conditions and 1 for an extreme condition, according to the “Design Criteria for Concrete Arch and Gravity Dams”, United States Department of the Interior Bureau of Reclamation.

Hydraulic Analysis of Stilling Basin

A reverse slope stilling basin was proposed. The water level downstream of the basin was calculated as the flood water level when the dam design flood is discharged and the length of stilling basin was designed.



PLAN

Figure 16	Plan of Los Laureles II Dam

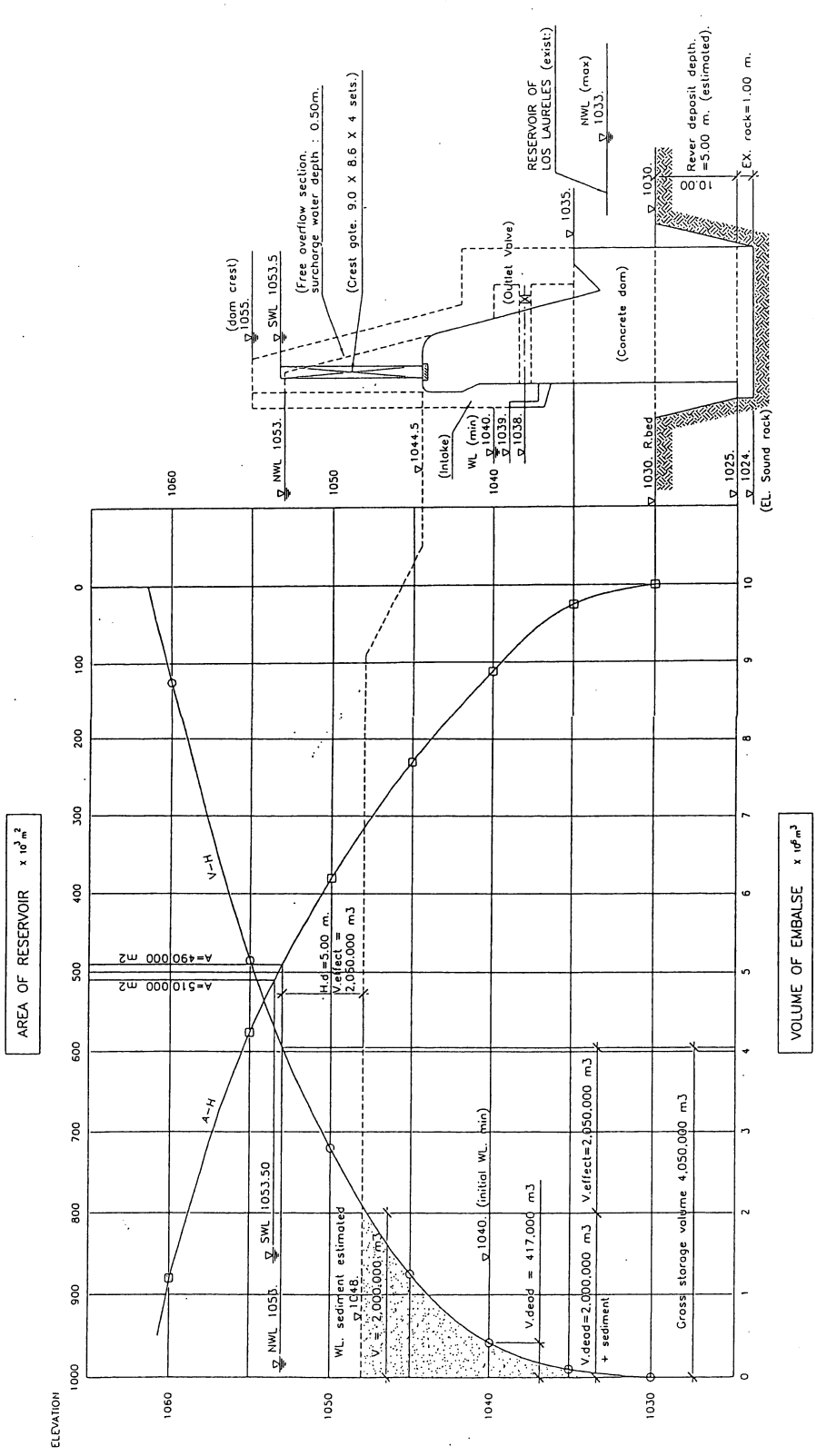


Figure 17	H-V Relationship of Los Laureles II Reservoir

Sedimentation Plan

Thus, the design sedimentation into Los Laureles II dam was calculated as follows;

- First year: $600 \times 190 \times 1 =$ 114,000 m^3
- Next 49 years: $600 \times 65 \times 49 =$ 1,911,000 m^3
- Total 50 years : 2,025,000 m^3 (40,500 m^3/year 40,000 m^3/year)

A sediment trap structure was planned 3.8 km upper from the Los Laureles II dam site. The features of the structure are described as follows.

- Structure type : Gabion with concrete base.
- Crest elevation level : 1050.0 m
- Base elevation level : 1044.5 m
- Height : 5.5 m
- Total crest length : 233.0 m
- Volume of gabion : 1,671 m^3
- volume of base concrete : 650 m^3

Hydraulic Effect of Dam

The effect of Los Laureles II dam was assessed through a hydraulic simulation by taking the flood pattern of Hurricane Mitch.

Water Yield

Water yield was calculated by using the H-V curve and the run-off record at Guacerique II stations. The result shows that the safe yield with 99 % reliability is 130 l/s.

Compensation Works

By the construction of the dam body and the reservoir, relocation works as compensation are needed. Another compensation work is relocation of a pumping station owned by military base.

Related Facilities

Simple water treatment facilities are proposed at one of the tributaries of the Guacerique River. The structure will improve the quality of the inflow water with a minimum cost.

(2) Sediment Excavation

Excavation of sediment in the reservoir area in order to increase the effective storage volume of the reservoir was planned. It was concluded that dredging of sediment under water from the existing Los Laureles reservoir is costly and not feasible while excavation of river bed material and sediment above water is feasible as a technique to increase the storage volume of reservoir.

In this plan the amount of sediment excavation is 600,000 m^3 including sediment material in the existing Los Laureles reservoir and river bed material in the future Los Laureles II reservoir. The proposed location of sediment excavation is shown in *Figure 18*. The water yield calculation shows that the water yield by the project is 30 l/s compensating the ongoing sedimentation in the existing Los Laureles reservoir.

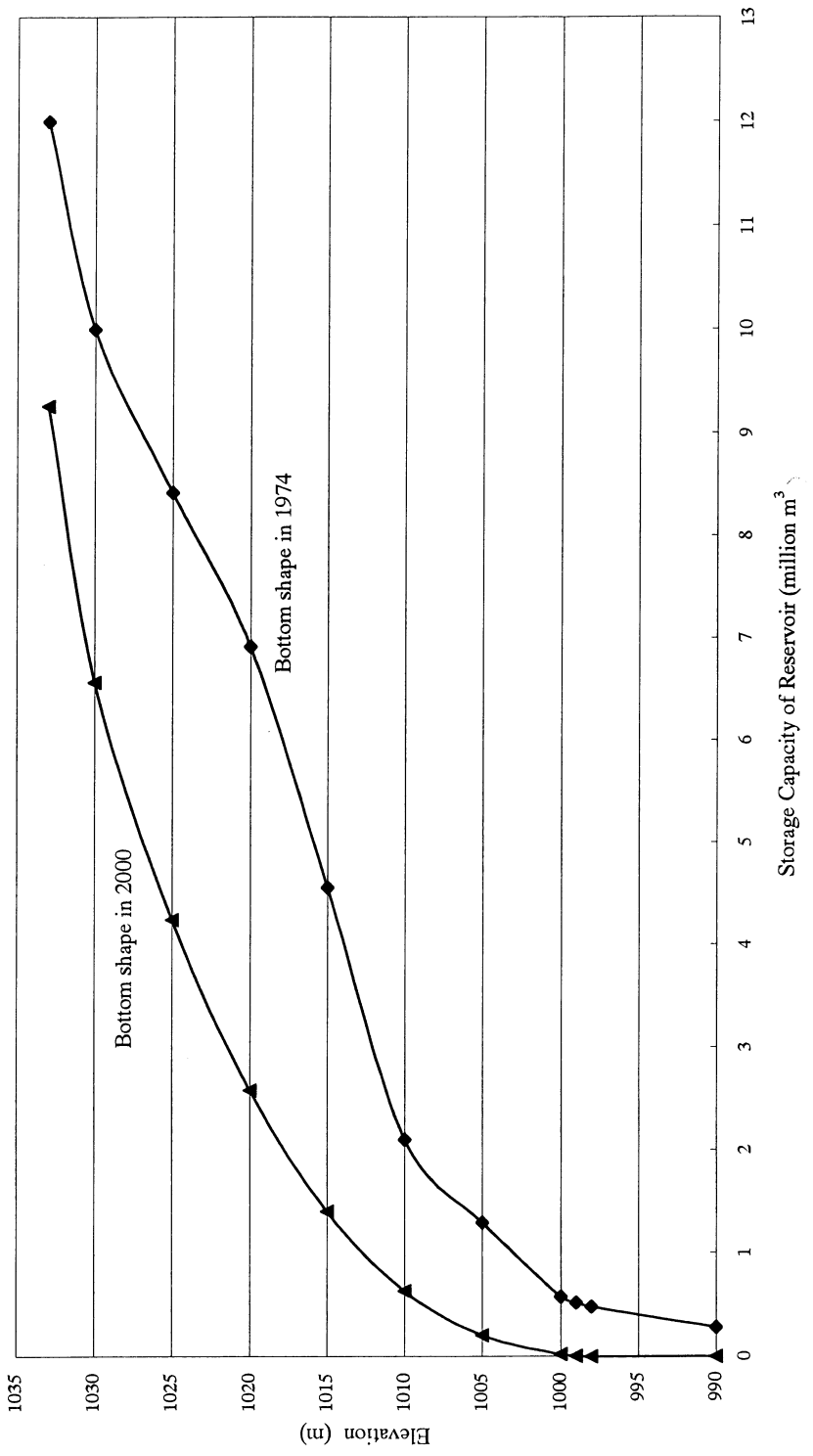


Figure 18	Sediment Distribution In Los Laureles Reservoir

5.2 OPERATION AND MAINTENANCE

(1) Operation Plan

The operation during dry season and the operation during wet season are different in basic idea. The operation during dry season mainly focuses on how to preserve water storage and supply water effectively. On the other hand, the operation during wet season has to include the emergency operation during flood and to show how to operate the gate effectively in order to secure the safety of the structure.

(2) Maintenance Plan

Sediment Excavation

In order to maintain the storage volume of the reservoir, it is desirable to excavate the sediment stored at the sediment control structure. The design amount of sediment to be removed is 10,000 m^3 as one fourth of the total sediment inflow into the reservoir

Painting

Periodical painting of gate leaves, valves are required every five (5) years.

Periodical Inspection and Maintenance

Periodical inspection and maintenance are required for the facilities, especially the gates and valves. When the reservoir water level of is lower than the crest level of overflow section, the gates should be inspected by test operation.

Water Quality Monitoring of Reservoir

As there is a possibility of water quality deterioration in the reservoir, it should be monitored periodically.

5.3 PROJECT COST ESTIMATE

Project cost is composed of following breakdowns:

Direct Construction Cost : Direct construction cost is composed of direct cost estimated based on the work quantities and indirect cost which is estimated in percentage.

Engineering Service Cost : Engineering service cost is mainly expended for the construction supervision services of consultants. It is estimated as 10 % of the direct construction cost.

Physical Contingency : 10 % of the sum of the direct construction cost is considered for contingent expenses for the incidental construction tasks.

Administration Cost : This cost is the project owner's expenditures for the proper project management to execute the project implementation smoothly. Five (5) % of the sum of the direct construction cost is adopted.

Compensation Cost : Compensation cost consists of the land acquisition and house evacuation costs.

Cost estimation was made based on the following conditions:

- The cost estimate is made on the price level as of the end of July 2000.

- The foreign exchange rate applied to the cost estimate is USD 1.0 = Lps 14.87 = JPY 107.9.
- The project cost is divided into the foreign currency components and local currency component.

The result of the cost estimate is shown in *Table 26.* The total project cost of the priority project is USD 25,722,007.

Table 26 Cost Estimate of Los Laureles II Project

Description	Unit	Quantity	Local Portion (USD)	Foreign Portion (USD)	Total (USD)
Mobilization and Demobilization	l.s.	1	532,945	685,314	1,218,258
Excavation	m^3	65,000	752,846	969,405	1,722,251
Concrete	m^3	42,100	3,224,516	2,502,389	5,726,905
Curtain Grout+ Consolidation Grout	m	5,000	472,066	747,558	1,219,624
Crest Gates	l.s.	1	300,000	2,700,000	3,000,000
Crest Bridges	l.s.	1	178,860	146,340	325,200
Outlet	l.s.	1	36,000	324,000	360,000
Upper-stream Cofferdam	l.s.	1	105,895	79,943	185,838
Down-stream Cofferdam	l.s.	1	30,820	25,782	56,601
Diversion Channel	l.s.	1	69,942	59,899	129,842
Sub-total of Construction Cost of Dam	(1)		5,703,890	8,240,630	13,944,520
Excavation of Existing Reservoir and Disposal	m^3	600,000	1,748,016	2,036,826	3,784,842
Administration Office Building	l.s.	1	18,000	0	18,000
Relocation of Road	l.s.	1	160,310	147,442	307,752
Sand Deposit Dam	l.s.	1	116,226	50,610	166,836
Riverwater Direct Purification Facility	l.s.	1	400,000		400,000
Sub-total of Dam-related Construction	(2)		2,442,552	2,234,878	4,677,430
Engineering Cost (10 % of Construction Cost (1) + (2))			814,644	1,047,551	1,862,195
Physical Contingency (10 % of Construction Cost (1) + (2))			814,644	1,047,551	1,862,195
Sub-total of Project Related Expenses	(3)				3,724,390
Total	(1) + (2) + (3)				22,346,340
Administration Cost (5 % of Construction Cost)	l.s.	1	931,097		
Relocation of Household	l.s.	1	944,570		
Compensation of Submerged Land	l.s.	1	1,500,000		
Cost for Administration and Compensation	(4)		3,375,667	0	3,375,667
Grand Total	(1) + (2) + (3) + (4)				25,722,007

5.4 PROJECT IMPLEMENTATION PROGRAM

The implementation schedule is prepared to achieve prompt construction of the project so as to ease the problem of water shortage in the city of Tegucigalpa. Necessary undertakings and activities are incorporated in the Implementation Schedule as shown in *Figure 19*.

5.5 PROPOSED FINANCIAL ARRANGEMENT

The total project cost is estimated at USD 25,722,000. The breakdown is shown in *Table 27*.

Table 27 Project Cost

Item	Amount (USD)
Direct Construction Cost	18,621,950
Engineering Service Cost	1,862,195
Physical Contingency	1,862,195
Compensation Cost	2,444,570
Administration Cost	931,097
Grand Total	25,722,007

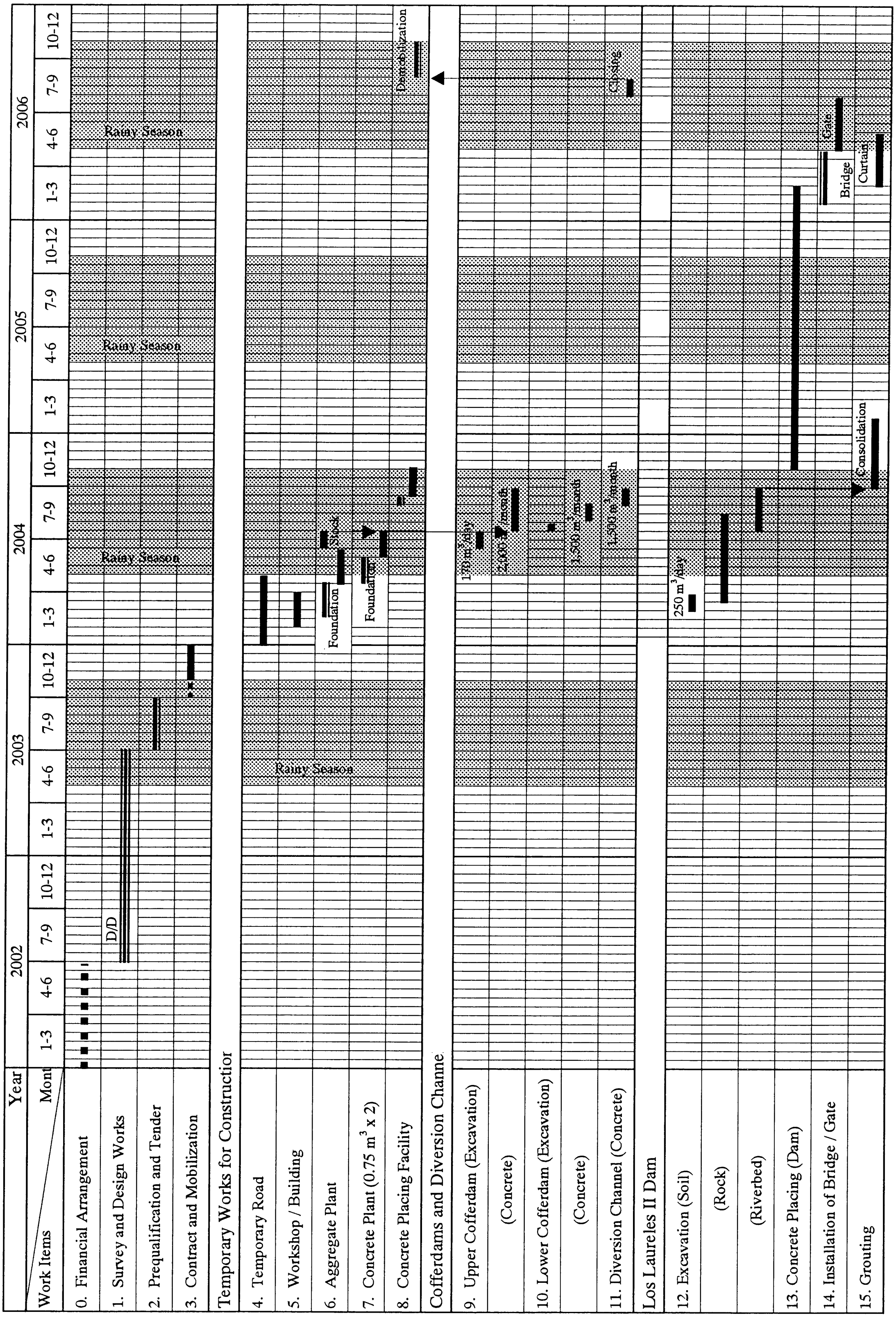


Figure 19	Construction Schedule of Los Laureles II Project

From the table above, compensation cost and administration cost are not covered by foreign loan or grant. Therefor, the total project cost subject to loan or grant is USD 22,346,000. Remaining USD 3,376,000 should be prepared by SANAA or Honduran government.

5.6 PROJECT EVALUATION

(1) Economic Feasibility

The economic internal rate of return (EIRR) of Los Laureles II Project was calculated 14.7 %, which is higher than the assumed opportunity cost of capital (OCC) of 4 %, thus Los Laureles II Project was justified to be economic feasible.

(2) Financial Feasibility

FIRR of Los Laureles II Project was calculated 10.7 %, and the accumulated amount of net cash flow of any year during the evaluation period is positive. Based on the financial criteria applied in the Master Plan, it is concluded that Los Laureles II Project is financially feasible, since its FIRR exceeds 6 % of the real money rate of market in Honduras and cash shortage will never happen.

(3) Technical Feasibility

Dam Construction

The structure of Los Laureles II dam is a 31 m high concrete gravity dam and it is much smaller than Concepcion dam. Four (4) leaves of steel gates are to be equipped at the crest of the dam. The size of the gate is 8.6 m (width) and 9.0 m (height) and there are enough techniques for qualified manufacturers to assemble and install such scale of gates. Therefore, Los Laureles II Project is feasible in terms of construction techniques.

Operation

SANAA has also abundant operation and maintenance experiences in dam and water supply facilities. In particular for the water supply facilities, there would be no change in operation because the Project just increase the supply capacity to the level of the original design capacity.

(4) Social Impact Assessment

Relocation of People

The most significant possible negative social impact of Los Laureles II dam project is the relocation of 22 houses in the proposed reservoir area. Candidate relocation sites are located in flat places near the proposed reservoir and not far from the present living place. A size of the candidate relocation sites is big enough to provide new houses and cropland for each house. Since major complaints to the relocation in the case of the Concepcion dam construction were that people were forced to give up farming because they did not receive enough substitute cropland, it is expected that the negative social impacts can be minimized.

Water Use Regulation

In the Study, non-authorized water intake by the military base and private irrigation were identified in the Guacerique River basin. It is necessary to regulate the water intake in the basin according to Law of National Water Exploitation.

Ciudad Mateo Project

The Ciudad Mateo project is located in the vicinity of Los Laureles II reservoir and restart of the project will give significant impact on water quality of the existing and future reservoir.

(5) Environment Impact Assessment

Dam height was determined not only based on hydrological, topographical and geological conditions but also aiming to reduce showing up of a reservoir, which is an alteration of nature, as much as possible.

Environment Impact Assessment (EIA) was made based on the "National System of Environment Impact Assessment" to obtain the Environmental License for the project. As a result, several factors that would be affected by the project were identified and mitigation methods for the factors were proposed as shown in a table below:

Environmental Impacts and Mitigation Measures

Environmental Impact	Mitigation Measures
Contamination by construction waste	Optimum construction planning in order to avoid excess use of concrete. Installation of collection system of concrete mix waste.
Temporary diversion of river	Diversion and protection works of river channel.
Noise, gas, dust, and vibration by machines	Control of vibrations and explosives. Use of silencers and catalysts for reducing noise and gas emissions. Regular watering of access roads.
River bed erosion and sedimentation	Drainage works, and covering of materials pile on site.
Loss of soccer field in case it is used for spoil bank	Create an alternative recreation area for the community.
Loss of vegetation cover	Estimation of vegetation mass usable within the inundation area. Propose method for exploitation, and propose alternative uses as compensation for the people to be resettled. Restore the vegetation cover in the area used for construction works.
Deterioration of water quality	Trap of sediment within the river bed during the construction to avoid discharge of turbid water to Laureles Reservoir. Installing of adequate system of water distribution, collection of waste water drainage of rain water, in temporary work area.
Development of economic activities	Preparation of area for temporary vendors. Agreement between vendors and the contractor.
Work accidents	Programs on work safety training and environmental education to workers. Safety equipment for workers should be supplied. Traffic control in the project area.
Resettlement of people and relocation of roads	Appropriate evaluation of houses to be relocated and land or cultivated area to be acquired by SANAA. Appropriate relocation plan taking into account the problems raised in Concepcion dam project. Alternative access road during the road relocation period.
Protected Fauna and Flora	No significant direct impacts by the dam and reservoir to protected species are expected. However, protection measures during the construction stage shall be required for Otter and Alligator, of which existence in the present Los Laureles Reservoir has been confirmed.

6 RECOMMENDATION

Recommendation presented the required actions of the state government and the Municipality, as responsible organizations for the provision of a platform of the project implementation, and of SANAA, as an responsible organization for the implementation and operation of the projects, to implement the priority project and to realize the Master Plan.

6.1 RECOMMENDATION TO THE STATE GOVERNMENT AND THE MUNICIPALITY

(1) Institutional Supports

Reform of SANAA

Even though it is a general tendency that water supply entities head for the privatization ultimately, it will never reach to the goal without stepping necessary process. It would be more

realistic to take time for the reform of SANAA and adjustment of surrounding conditions.

Guidelines for Tariff Setting

The state government is required to establish the guidelines for tariff setting. The Frame Law for Water Supply and Sewerage Sector currently under the deliberation intends to establish the guideline. The Government should take an action for its early enforcement or submit interim guidelines so as to make it possible to set out proper tariff.

Formulation of Development Plan

Currently there is no authorized development plan that covers Tegucigalpa. The Master Plan proposed the water source developments in the Guacerique River basin for the reasons of their cost effectiveness and its assignment as the protection area. However, still there is a possibility that other projects plan to develop the basin causing a severe conflict in the implementation stage. Therefore, it is strongly required to formulate comprehensive development plan covering Tegucigalpa and its surrounding areas.

Establishment of Water Right

Further unauthorized water intakes may unset the basis of the water balance for the water development plan in the Master Plan. Therefore, it is required to execute the protection of the water right.

Regulation of Developing Community

The Master Plan limits the water supply to unauthorized housing development (developing community) by not applying piping supply but applying tank lorry. This intends to indirectly regulate such illegal housing development by quality of public services. In this regard, the Municipality is required to implement an effective regulation for the uncontrolled expansion of the developing communities.

(2) Financial Support

Financial Arrangement

The Master Plan is proposed on condition that SANAA borrows loans from international financing institutions such as World Bank, IDB and other foreign financing agencies in the implementation of the projects because required investment costs far exceed the SANAA's self financing capability. The state government should provide the supports to obtain better financing conditions and the coordination to the financing institutions for easier access.

Governmental Subsidy

Development of the water supply facility generally needs huge investment and especially in Tegucigalpa due to its topographical and meteorological conditions water source development requires enormous costs. An increment of the cost by constructing dam to support the country's capital city's activities in such severe natural conditions should be considered to be a social cost. The state government or the Municipality should bear the social cost as a subsidy.

6.2 RECOMMENDATION TO SANAA

Early Implementation of the Projects

SANAA should concentrate their efforts to the implementation of Los Laureles II Project because this project not only increases water supply capacity but also utilizes the currently unused water supply capacity of Los Laureles WTP.

Necessity of Reviewing Master Plan

Quiebra Montes Project requires enormous costs. While it was judged to be financially feasible, there may be a difficulty in obtaining a proper financial instrument that can cover such a large scale construction costs. This may cause postponing or cancellation of the implementation of Quiebra Montes Project. In such case, the Master Plan should be reviewed by reconsidering the targeted service level. Also SANAA is required to implement Leakage Control Project and review the Master Plan depending on effects of the leakage control program.

Structural Reform

The Mater Plan proposed the organization plan of the Metropolitan Division of SANAA in line with the former structural reform conducted by SANAA. The proposed plan will contribute to further decentralization of SANAA by strengthening the self-sustainability of SANAA Metropolitan Division. This could benefit SANAA by improving their operation performance. SANAA is required to proceed to the realization of the proposed structural reform.

Leakage Control

Cost comparison preliminary conducted in the Study showed that the recovery of leakage water is less cost effective than the dam construction as a mean of water source development. However, because this is a preliminary result and from the viewpoints of conservation of precious water resources and wasting of the operation costs, SANAA should take necessary actions to address the leakage problems.

Tariff System

As mentioned in the section for the state government and the Municipality in this chapter, SANAA should have a competence of the tariff revision. In this regard, SANAA is required to continue their efforts to pursue the competence.

Meanwhile, the Master Plan requires SANAA to implement the installation of the water meter and to establish stronger tariff invoicing and collection system. The Master Plan has proposed the organization plan that covers the required departments and personnel.

Development of Sanitary System

The present sanitary system of Tegucigalpa has two major problems to be addressed urgently; a poor wastewater collection system damaged by Hurricane Mitch and a lack of wastewater treatment system. In addition, the development of the water supply system proposed in the master plan could cause increase of the wastewater generation. Therefore, SANAA is required to conduct a comprehensive study that covers the rehabilitation and strengthening of the wastewater collection system and the development of wastewater treatment system.