Chapter 5 Proposed Master Plan

CHAPTER 5 PROPOSED MASTER PLAN

5.1 INTRODUCTION

As mentioned in the previous chapter, 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 among the three, 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. Water supply capacity build-up to mitigate current water shortage and to meet the future demand increase is to be accomplished by these two (2) projects.

Leakage Control Project is proposed to implement a system to acquire quantitative data necessary for a leakage reduction program. The leakage reduction program that shall be formulated and implemented as a result of the proposed Leakage Control Program may mitigate the increase of the required water quantity by reducing leakage loss.

In this chapter, firstly the proposed physical components of each project are presented together with their planning processes, then other plans such as operation and maintenance plan, cost estimate, organization plan, and financial plan, which secure the implementation of the Master Plan are presented.

5.2 FACILITY PLANNING OF LOS LAURELES II PROJECT

5.2.1 GENERAL

Los Laureles II Project can be considered that it creates one water source together with the present Los Laureles reservoir and new Los Laureles II dam constructed 3 km upstream. The design water yield of the present Los Laureles reservoir is 750 l/s, while an actual yield is 540 l/s 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.

As discussed later, transmission and distribution systems will be rearranged to optimize the system efficiency at the time when Quiebra Montes Project, which satisfies the ultimate required amount of water, is implemented. Therefore, the modification of distribution areas of Los Laureles WTP and the expansion of Los Laureles WTP will be discussed as a part of Quiebra Montes Project.

5.2.2 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.

(1) Dam Site Condition

Los Laureles II dam is proposed at the upper end of the reservoir of Los Laureles dam. The dam site is near settlements of Las Tapias and Campo de Balampie.

The Guacerique River in the vicinity of the proposed dam has a channel on a roughly straight line in the W-E direction for a stretch of approximately 600 m. Around the dam axis, a narrow gorge is composed of rhyolitic lava. The river bed elevation at the dam axis is 1,033 m with the width of about 10 m. The gradient of the abutment is approximately 45 degree from the riverbed to 1,060m in the left bank and 40 degree in the right bank.

The basement rock in and around the dam site is composed of rhyolitic ignimbrite, tuff, and lake deposits of sandstone and siltstone. There are two type of ignimbrite, namely strongly welded one and medium to low welded one. Alluvial deposit composed of sand and gravel covers the basement rock with the thickness of about 5 meters at the river bed. Topsoil is distributed on the bank with the thickness of about 0.5 to 2 m.

Accurate shear strength of the fresh Volcanic Breccia is unknown since foundation rock tests have not been carried out, but based on the results of field reconnaissance, it is considered to have sufficient soundness for the construction of a concrete gravity dam with a height of 40 m. As fractures are observed in the base rock, grouting operation will be necessary in order to improve water tightness.

(2) Dam and Reservoir Features

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 5.1 and 5.2* show the typical section and profile of Los Laureles II dam, respectively.

Figure 5.3 shows the water level-volume relationship of the reservoir. The reservoir volume for future sedimentation was designed as 2 million m^3 taking 50 years of life span and the expecting Quiebra Montes Project in future.

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

(3) Excavation of Sediment

Figure 5.4 shows the plan of the existing Los Laureles reservoir. The existing Los Laureles reservoir was constructed in 1974. It had the total reservoir capacity of 12 million m^3 at the initial stage. However, during these 26 years, approximately 3 million m^3 of sediment accumulated in the reservoir and hindering the function of the reservoir.

After the completion of Los Laurels II dam construction upstream, no more sediment will be brought in the reservoir and excavated volume becomes the effective volume. Therefore, this excavation is a joint project with Los Laurels II dam construction.

According to a survey of Los Laureles reservoir, the sediment is located mainly at low elevation of the reservoir. Therefore the sediment not only from the existing reservoir but also from the future Los Laureles reservoir was planned to be excavated. *Figure 5.5* shows the proposed location of the sediment excavation. The total amount of excavation is 600,000 m^3.

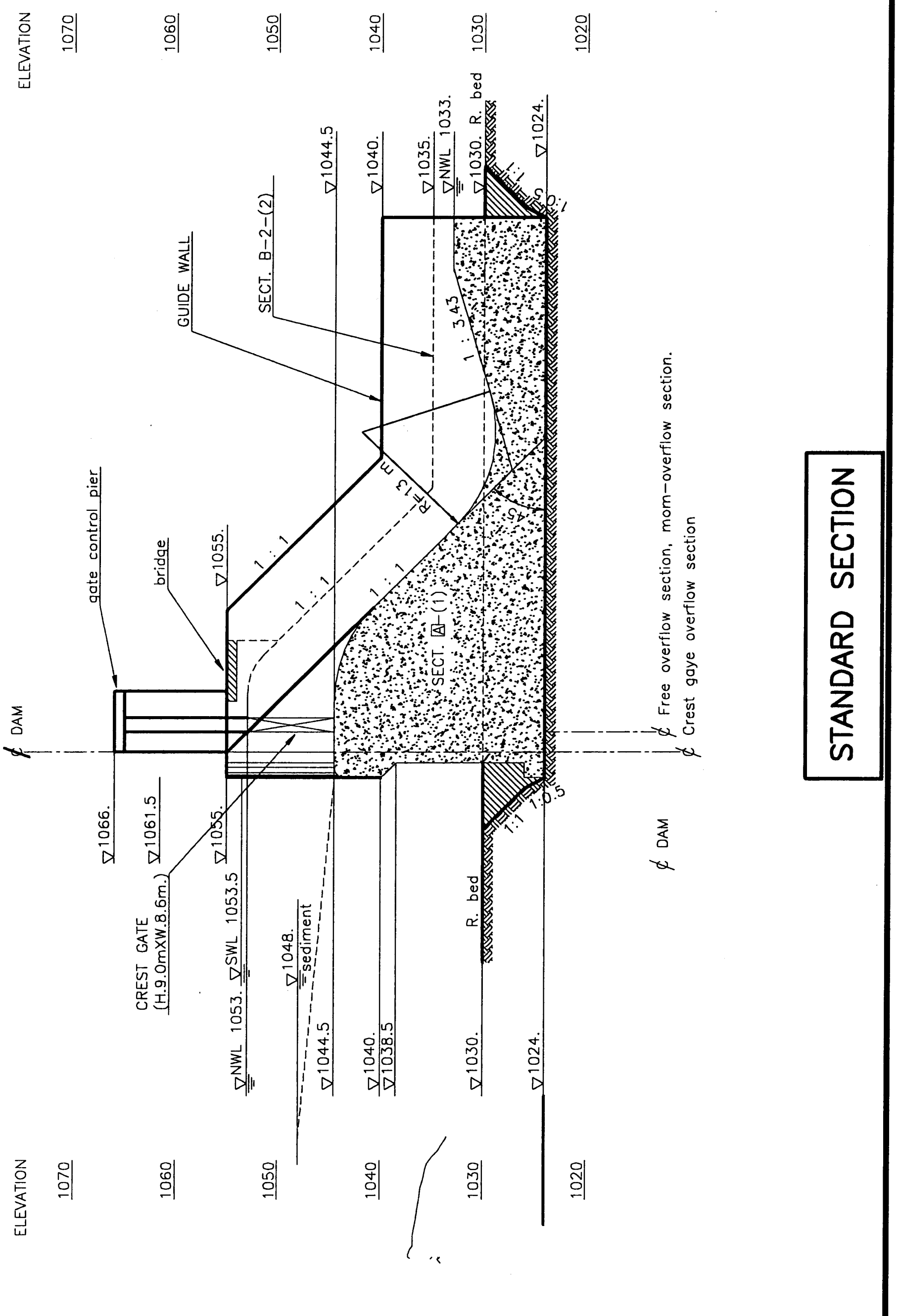

Figure 5.1	**Typical Section of Los Laureles II Dam**

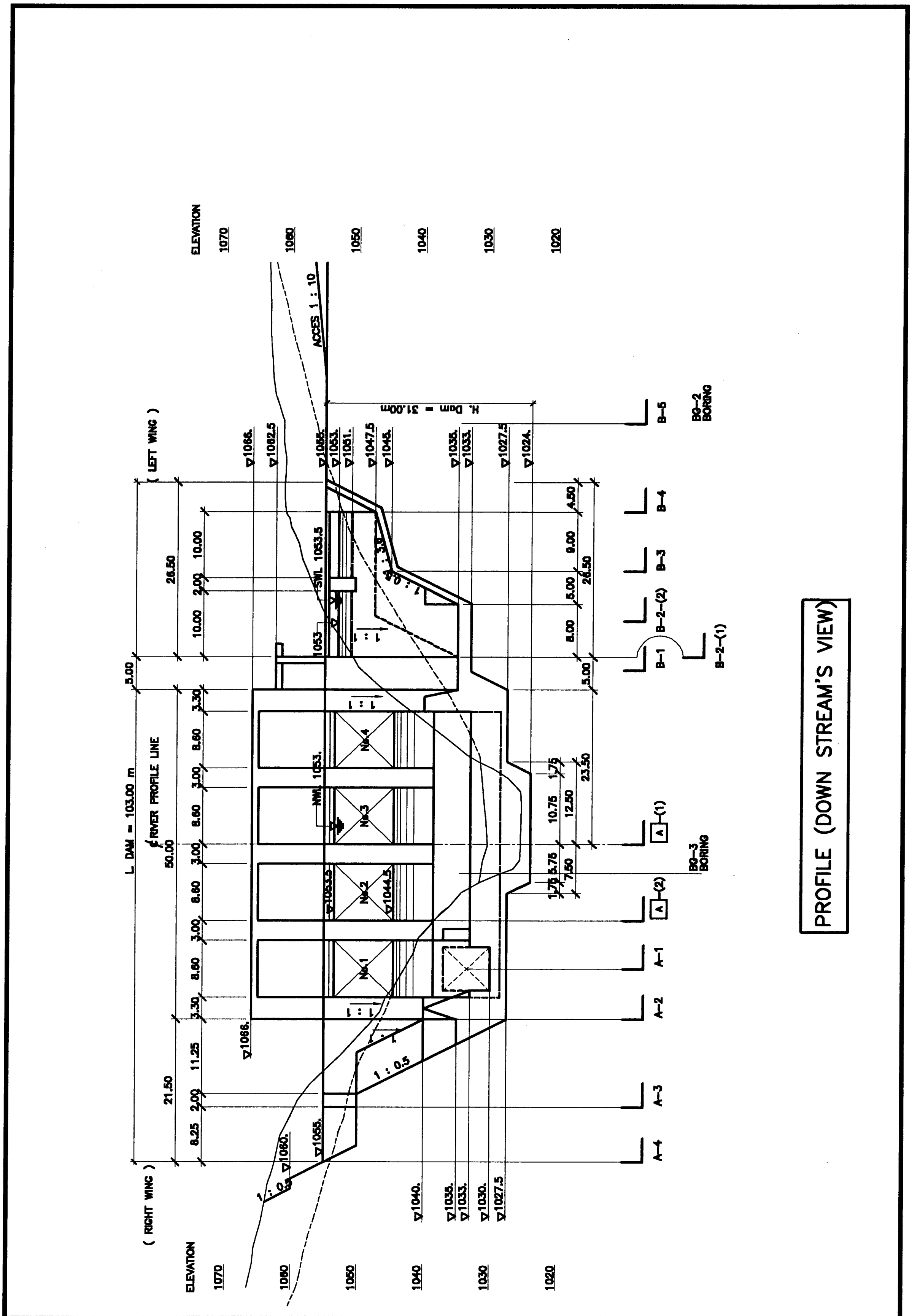

Figure 5.2	Profile of Los Laureles II Dam

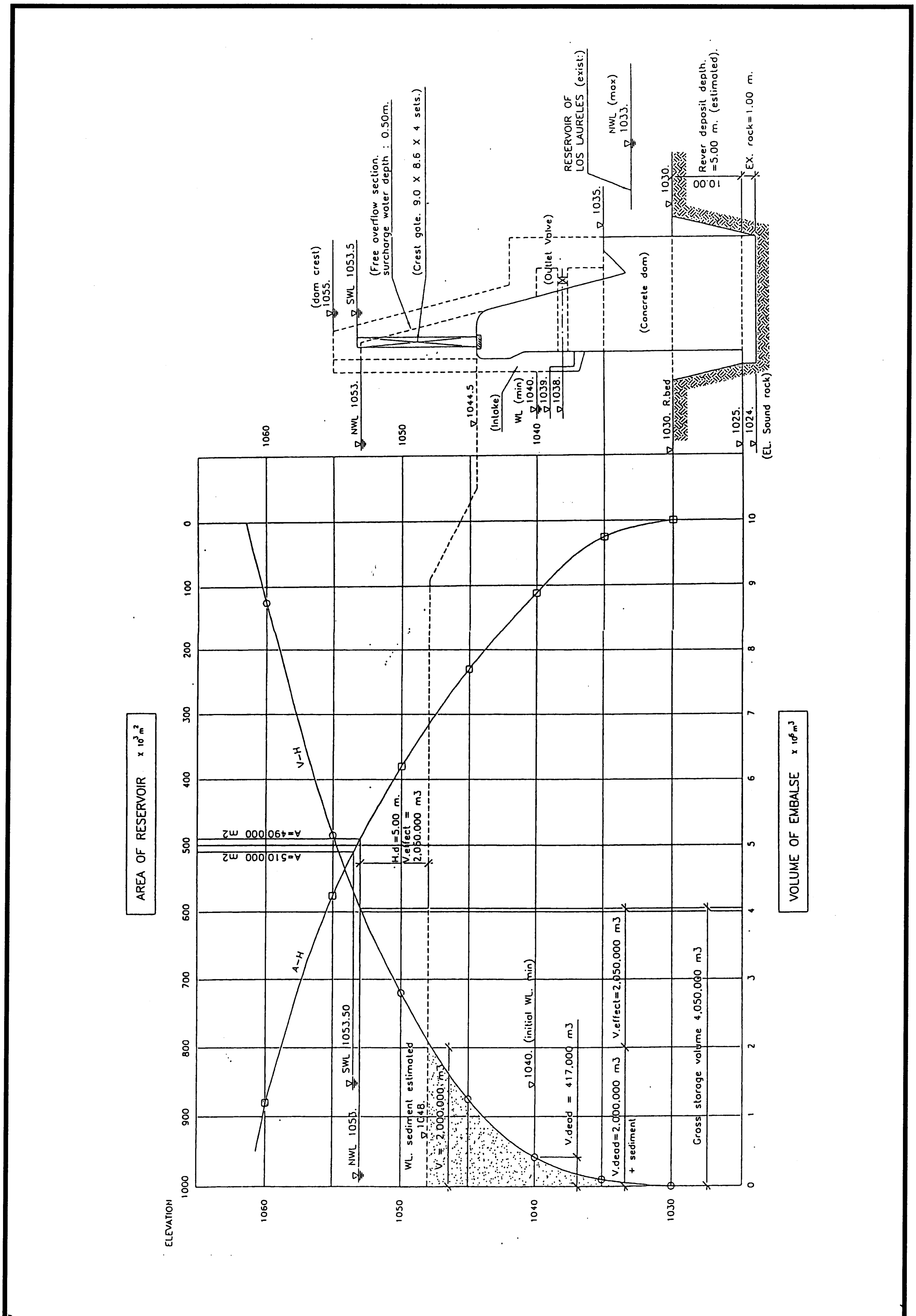

Figure 5.3	**Water Level – Volume Relationship of Los Laureles II Reservoir**

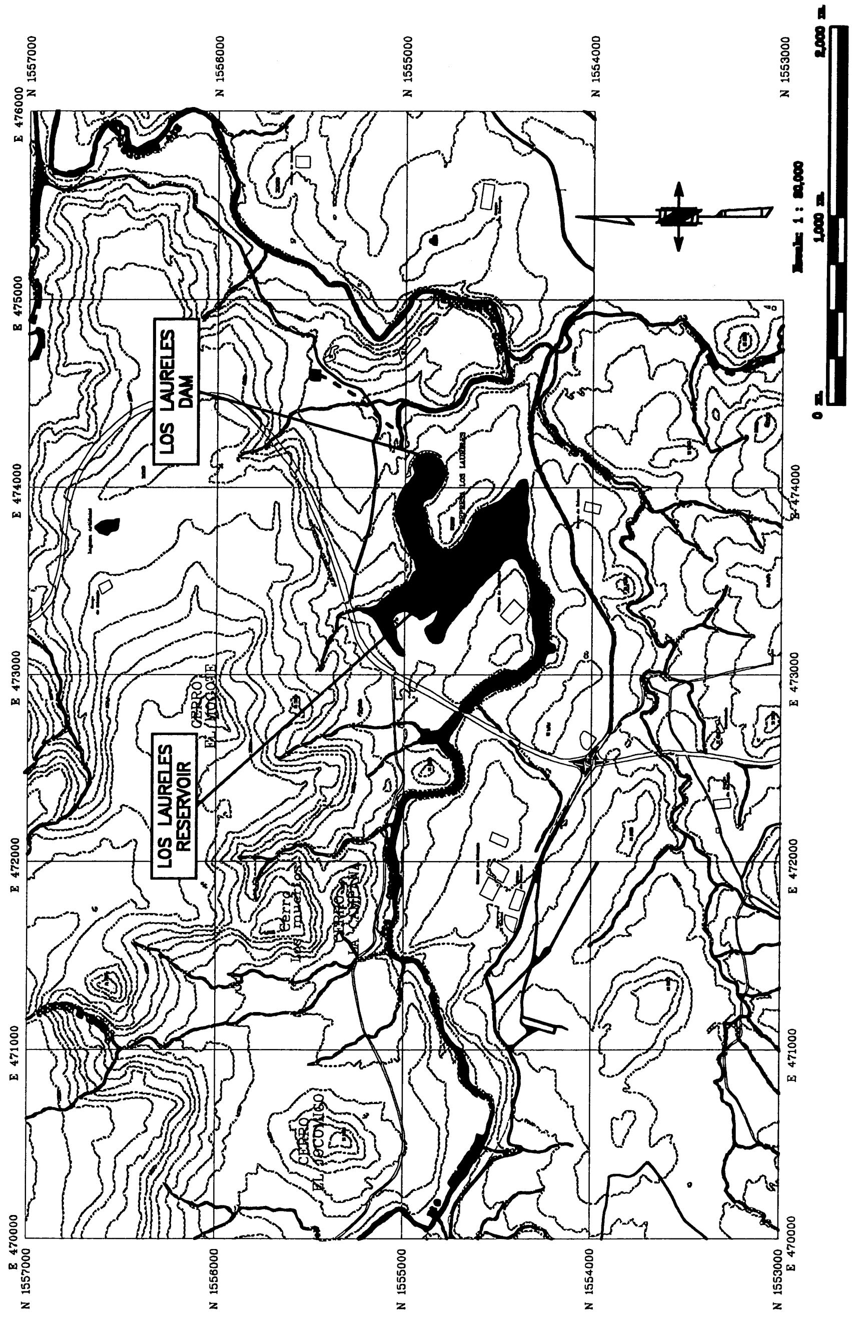

Figure 5.4	Plan of Existing Los Laureles Reservoir

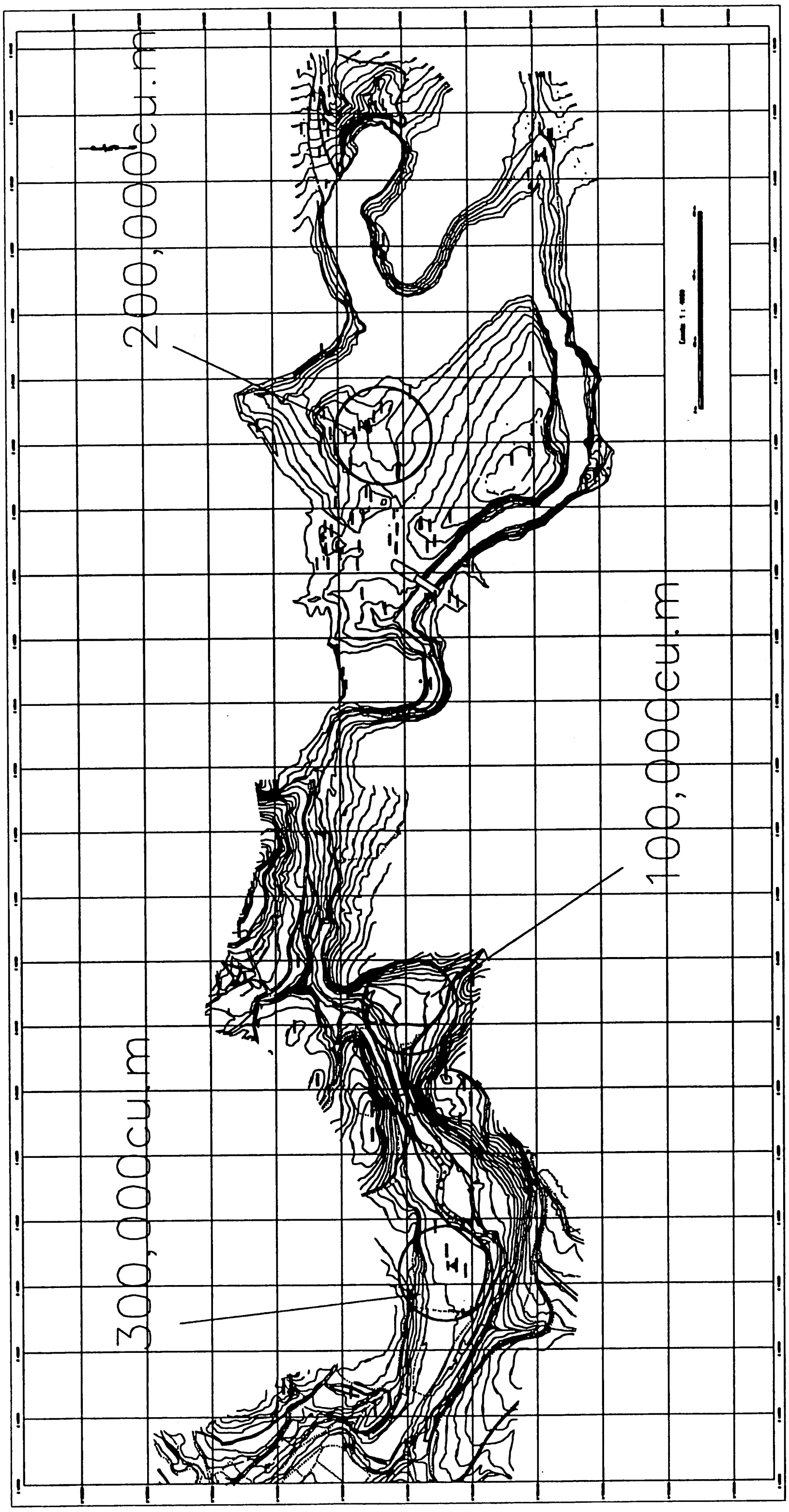

Figure 5.5	Proposed Location of Sediment Excavation

A part of the sediment excavated will be utilized as construction materials but most of it has to be hauled and disposed into a spoil bank near by. Spoil bank area is available near the site.

(4) Water Yield

1) Los Laureles II Dam

Water yield was calculated by using the abovementioned water level-volume relationship and the run-off records at Guacerique II stations. The observation records are between 1982 and 1996 and all data were used. The water balance analysis was made to preserve the water yield by the existing Los Laureles reservoir as it is. The result shows that the safe yield with 99 % reliability is 130 l/s.

2) Sediment Excavation

The water yield by this project is calculated assuming that the reservoir capacity is increased by 600,000 m^3. The developed water yield is 30 l/s.

5.2.3 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 as follows.

(1) Confirmation of Capacity of Existing Facilities

Actual capacities of the existing facilities were confirmed by following manners:

- Conduction line from Los Laureles reservoir to Los Laureles water treatment plant: The design capacity of the conduction line is 800 l/s. The capacity was calculated by applying the pump capacity and the pipe size and it was confirmed that it has the design capacity.
- The design capacity is 670 l/s and the plant is operated at the design rate for several days a year. Currently it has a problem in sedimentation process, causing failure to remove turbidity satisfactory during rainy season when raw water turbidity becomes higher. However, it was confirmed that the rehabilitation works was going to be taken place shortly. Therefore, it was concluded that the plant would have a production capacity same as the design capacity.
- Transmission and Distribution system: By network analysis using EPANET, it was confirmed that transmission lines, pumping stations, distribution reservoirs and primary distribution pipes have enough capacities to distribute water to the existing distribution network of Los Laureles WTP. EPANET is a simulation tool of hydraulic and water quality behavior within pressurized pipe networks, developed by U.S. Agency of Environmental Protection (EPA).

(2) Balance between Water Production Rate and Demand in the Distribution Areas

The present water distribution reservoirs supplied from Los Laureles WTP are shown in *Table 5.1*. There are 15 distribution reservoirs. Nine (9) reservoirs receive water exclusively from Los Laureles WTP while others receive water from both Los Laureles WTP and Concepcion WTP. A total of the estimated required water production rate of the distribution reservoirs is 552 l/s to 1,236 l/s depending to the supply from Concepcion WTP, as shown in *Table 5.1*. As a surplus water against a minimum required production rate (552 l/s) could be distributed other reservoirs, Los Laureles WTP is to be operated at the maximum production rate (670 l/s) if the water source can yield 670 l/s. Therefore, Los Laureles WTP is expected to be operated continuously at the maximum production rate after the water yield increase to 670 l/s by Los Laureles II Project.

Table 5.1 Required Water Production for Los Laureles Subsystem

Distribution Tanks	Estimated Required Production Rate (l/s)	Alternative Supply
Centro America Oeste	32.47	
Cerro grande	41.69	
Mogote	56.63	
Filtros 1/2	169.04	
La Fuente	6.58	
Los Laureles	45.04	
Olimpo 1	116.14	
Olimpo 2	70.42	
Residencia Centro America Este	14.24	
Sub-total	552.26	
Canal 11	126.40	Concepcion WTP
Estiquirin	320.99	Concepcion WTP
Juan A. Lainez	71.67	Concepcion WTP
Kennedy 3	134.09	Concepcion WTP
Las Hadas	4.75	Concepcion WTP
San Francisco	25.99	Concepcion WTP
Total	1236.16	

5.3 FACILITY PLANNING OF QUIEBRA MONTES PROJECT

5.3.1 GENERAL

Quiebra Montes Project consists of 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
- Reorganization of transmission system
- Reorganization of distribution system

The Master Plan is planned to meet the production capacity of the system to the required water production rate in 2015 by developing water sources and water supply facilities. The development of the water supply facilities in the Master Plan covers reorganization of the present system so as to optimize the system, as well as to propose water supply facilities for the newly developed water sources.

Optimization of the water supply system includes the optimization of the water treatment facilities to fully utilize the existing water treatment capacity and minimize the additional water treatment capacity increase, and reorganization of the distribution and transmission systems. In this section, optimization of the water treatment capacity is firstly discussed to determine the requirements for Quiebra Montes WTP and reorganization of the distribution and transmission systems will be discussed in their facility planning.

5.3.2 OPTIMIZATION OF WATER TREATMENT OF THE WHOLE SYSTEM

Each of the existing subsystem has its own conduction and treatment systems. Also, the proposed Quiebra Montes subsystem should have its own conduction and treatment systems because available water yield of Quiebra Montes reservoir is so huge that it is not realistic to absorb this increment only by expansion of the existing treatment plants. Therefore, the optimal system plan can be established basically by harmonizing the yield capacity of the water source and the capacity of conduction and treatment systems of each subsystem.

Table 5.2 shows the yield capacity of the water source and the capacity of the existing conduction and treatment facilities of each subsystem.

Table 5.2 Existing Yield Capacity and Conduction and Treatment Capacities

Subsystem	Yield capacity	Capacity of conduction line	Capacity of WTP	Dificit of WTP capacity
Picacho	304 l/s	782 l/s	782 l/s	-478 l/s (surplus)
Concepcion	1,310 l/s	1,303 l/s	1,303 l/s	7 l/s
Miraflores	43 l/s	43 l/s	43 l/s	0 l/s
Los Laureles	670 l/s	800 l/s	582 l/s	88 l/s

Note: All values are on average daily base.

The table shows that Picacho and Los Laureles subsystems need further optimization study while Concepcion and Moraflores subsystems have already been optimized.

There is a possibility to utilize the water of Quiebra Montes reservoir for the optimization of Picacho and Los Laureles subsystems. This possibility should be studied first. According to the result of this study, the optimal system plan can be established.

(1) Determination of Site of Quiebra Montes WTP

Prior to the studies below mentioned, it is necessary to determine Quiebra Montes WTP site.

Low water level of Quiebra Montes reservoir is planned at 1,113 m. This elevation has a potential to transmit water to a level of approx. 1,100 m by gravity flow. Therefore, treatment plant site at higher elevation is advantageous.

Candidate sites suggested by SANAA are shown in *Figure 5.6.* Both sites are located at slope of hills and at almost same level (approx. 1,100m). Accessibility from the existing main road is also similar. Required length of conduction and transmission in total is the same while No.2 site needs longer conduction line as the No.2 site locates farther from the reservoir than the No.1 site. From the viewpoint of construction work, No.2 site requires much more land preparation works than No.1 site due to a steeper slope. As a conclusion, No.1 site was selected as a site for Quiebra Montes WTP.

For the conduction line, no options were considered because there is an existing road passing near by the proposed dam site and below No.1 site and no difficulty is foreseen in the implementation works along the road.

(2) Alternative Study for the Optimization of Picacho Subsystem

Picacho WTP has excess capacity to the 99 % reliable yield capacity, as shown in *Table 5.2*. Since Picacho WTP locates at the highest elevation in the whole water supply system, exploitation of this excess capacity is advantageous to optimize distribution system.

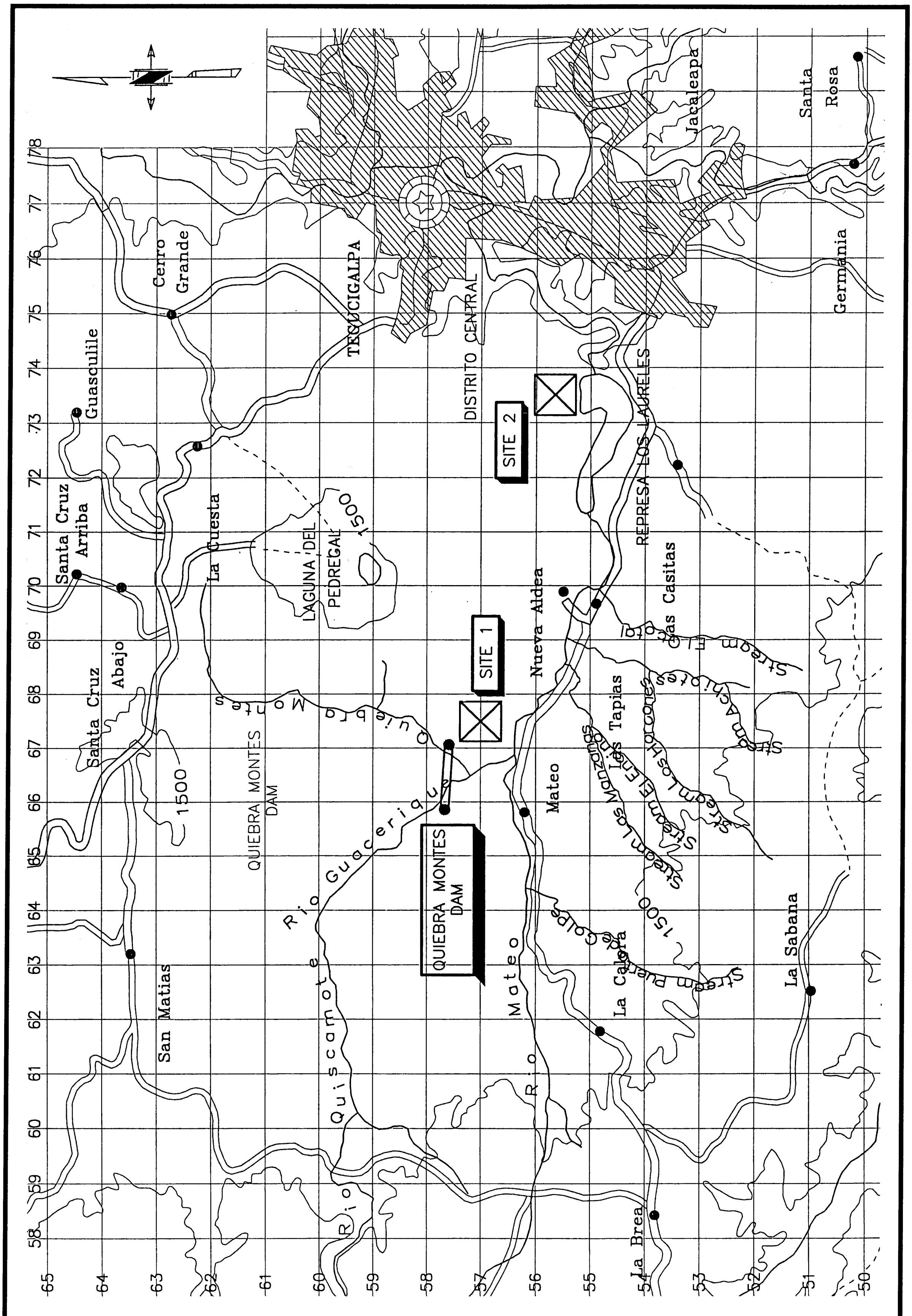

Figure 5.6	Candidate Sites for Quiebra Montes WTP

Therefore the possibility to increase inflow volume of Picacho WTP by sending water from Quiebra Montes reservoir was studied by comparing required cost of the following two (2) alternatives.

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

The deficit of yield capacity to the conduction and treatment capacity in Picacho subsystem is 550 l/s on maximum daily base, then the following planning bases for each alternative are adopted.

- Alternative 1:
  Capacity of Quiebra Montes WTP: 1,240 l/s
- Alternative 2:
  Conduction capacity from Quiebra Montes reservoir to Picacho WTP: 550 l/s
  Capacity of Quiebra Montes WTP: 690 l/s (= 1,240 l/s - 550 l/s)

The required construction costs for each alternative are summarized in *Table 5.3*.

Table 5.3 Required Construction Cost for Each Alternative

Facility	Specification	Quantity	Unit Price (USD)	Price (USD)
Alternative 1				
- Quiebra Montes WTP	107,136 m^3/day (1,240 l/s)	1 set		42,175,000
Total constructioin cost of Alternative 1				**42,175,000**
Alternative 2				
- Conduction pipeline	Diameter 700 mm DCIP	1,000 m	745	745,000
- Conduction pipeline	Diameter 900 mm DCIP	16,500 m	1,050	17,325,000
- River crossing	Siphon (diameter 900 mm DCIP)	360 m	3,600	1,296,000
- Booster pumping station	550 l/s (33 m^3/min) $\times$ 225 m	1 set	0	0
- Quiebra Montes WTP	59,616 m^3/day (690 l/s)	1 set		28,000,000
Total constructioin cost of Alternative 2				**47,366,000**

As a result of the alternative study, it was abandoned to exploit excess capacity of Picacho WTP by sending water from Quiebra Montes reservoir to Picacho WTP. Then, the production rate of Picacho subsystem is determined at 24,692 m^3/day (286 l/s) on average daily base.

(3) Alternative Study for the Optimization of Los Laureles Subsystem

The design capacity of Los Laureles WTP is 57,888 m^3/day (670 l/s) and the required production rate of the existing Los Laureles subsystem is estimated more than 800 l/s in the year 2006. As a result, the minimum daily required production rate of the subsystem becomes more than 679 l/s (800 l/s $\times$ 0.8488) which exceeds the design capacity of Los Laureles WTP.

Under this condition, Los Laureles WTP will be always operated at full capacity of 57,888 m^3/day (670 l/s) with the yield capacity of 670 l/s after the completion of Los Laureles II Project.

However, when Quiebra Montes Project will be completed, the whole water supply system will be optimized. The transmission and distribution systems will be reorganized so as to satisfy the estimated water demand. Under this condition the water supply system should have capacity to produce the maximum daily required production rate. As shown in *Table 5.2,* the capacity of Los Laureles WTP is not sufficient to the available yield capacity of Los Laureles reservoir under this condition.

To optimize Los Laureles subsystem the following two (2) alternatives were studied.

- 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.

In Alternative B, it is planned to connect both treatment plants by constructing bypass line from the transmission line of Quiebra Montes subsystem to the clear water reservoir of Los Laureles WTP, since the transmission line of Quiebra Montes subsystem runs near Los Laureles WTP. The clear water reservoir should be corresponding to the maximum daily production rate of 855 l/s because its minimum daily value is 630 l/s. Then, the capacity of bypass line should be 225 l/s (= 855 l/s - 630 l/s).

Then, planning bases for each alternative are as follows.

- Alternative A:
  Expansion of Los Laureles WTP: 101 l/s
  Capacity of Quiebra Montes WTP: 1,139 l/s (= 1,240 l/s - 101 l/s)
- Alternative B:
  Capacity of Quiebra Montes WTP: 1,240 l/s
  Capacity of connection line from Quiebra Montes WTP to Los Laureles WTP: 225 l/s
  Expansion of clear water reservoir of Los Laureles WTP: 900 m^3 (= 1 hour retention for 225 l/s)

The required construction costs for each alternative are summarized in *Tables 5.4*.

Table 5.4 Required Construction Cost for Each Alternative

Facility	Specification	Quantity	Unit Price (USD)	Price (USD)
Alternative A				
- Expansion of Los Luareles WTP	8,800 m^3/day (101.8 l/s)	1 set		9,717,000
- Quiebra Montes WTP	98,500 m^3/day (1,140 l/s)	1 set		40,080,000
Total construction cost of Alternative A				**49,797,000**
Alternative B				
- Quiebra Montes WTP	107,136 m^3/day (1,240 l/s)	1 set		42,175,000
- Expansion of clear water reservoir	900 m^3	1 set		470,000
- Bypass line to Los Laureles WTP	Diameter 500 mm (DCIP)	300 m	460	138,000
Total construction cost of Alternative B				**42,783,000**

There is no difference between operation and maintenance costs of conduction and transmission systems of both alternatives because the total of treated water volume is same. However, Alternative B has disadvantage of losing water head by sending 112 l/s of treated water from

Quiebra Montes WTP at 1,095 m to Los Laureles WTP at 1,015 m. To compensate this disadvantage, it is assumed that Alternative B requires pumping of 112 l/s water to 1,095 m elevation. The required operation cost is calculated as follows.

- Required energy : (0.112 m^3/s × 60 sec × 80 m) / (6.12 × 0.75) = 125.5 kW/h
- Annual operation cost : 125.5 kW/h×0.8×24 hr×0.1233 USD/kW×365days = USD 108,430

The cost comparison of alternatives is shown in *Table 5.5.*

Table 5.5 Cost Comparison of Alternatives

	Price (USD)
Alternative A	
- Construction cost	49,797,000
Total cost of Alternative A for 30 years	**49,797,000**
Alternative B	
- Construction cost	42,783,000
- Annual operation cost of pumping	108,430
Total cost of Alternative B for 30 years	**46,035,900**

Based on the result of the cost comparison, Alternative B, joint operation of Quiebra Montes and Los Laureles WTPs, was selected.

The planning bases of Quiebra Montes and Los Laureles subsystems are determined as shown in *Table 5.6*.

Table 5.6 Planning Bases of Quiebra Montes and Los Laureles Subsystems

Subsystem	Design capacity of WTP (m^3/day)	Production rate for distribution reservoirs (m^3/day)
Los Laureles	57,888 (670 l/s)	64,128 (742 l/s)
Quiebra Montes	108,000 (1,250 l/s)	69,273 (802 l/s)

(4) Result of System Planning of Conduction and Treatment Systems

Table 5.7 shows the production rate for distribution reservoirs for each subsystem. The total of production rate satisfies the total required production rate in 2015.

Table 5.7 Production Rate of Each Subsystem

Subsystem	Production rate for distribution reservoirs (m^3/day)
Picacho	24,692 (286 l/s)
Los Laureles	64,107 (742 l/s)
Concepcion	105,823 (1,225 l/s)
Miraflores	3,527 (41 l/s)
Quiebra Montes	69,345 (802 l/s)
Total	267,494 (3,096 l/s)

The proposed conduction and treatment facilities are as follows.

- Quiebra Montes WTP: 108,000 m^3/day
- Bypass line from Quiebra Montes WTP to Los Laureles WTP: 225 l/s
- Expansion of the clear water reservoir of Los Laureles WTP: 900 m^3

5.3.3 WATER SOURCE

(1) Dam Site Condition

The vicinity of the dam site is a large fluvial plain. The width of the gorge at the elevation 1,152 m is 1030m. The left abutment has milder slope than the right and the slope between the river bed (1,094m) and the abutment (1,152m) is around 1 to 18.

The base rock at the site is rhyolitic ignimbrite and the river bed deposit is 5 to 8 m thick. The left abutment is covered by 5 to 10 m thick of talus. The deposit on the right abutment is thin. There are a few fractures in the base rock but those fractures are loose and permeable. However, it is possible to improve the water tightness by grouting.

(2) Dam and Reservoir Features

The project was studied by BCEOM in 1990 and it was reviewed in the Study. The capacity of the spillway was revised based on the flood record of Hurricane Mitch. *Figures 5.7* and *5.8* show the plan and profile of Quiebra Montes dam, respectively.

Figure 5.9 shows the relationship between the reservoir water level and the reservoir volume. 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

(3) Water Yield

Water yield was calculated by using the above relationship between the reservoir water level and the reservoir volume and the run-off records at Quiebra Montes stations. The observation records are between 1982 and 1992 and all data were utilized. The water balance calculation was made to preserve the water yield by the existing Los Laureles reservoir and maximize the yield by Quiebra Montes reservoir. The result shows that the safe yield with 99 % reliability is 1,040 l/s.

5.3.4 CONDUCTION

(1) Planning Basis

An adopted design capacity is 108,000 m^3/day (1,250 l/s), which corresponds to the maximum production rate of Quiebra Montes WTP.

Adopted design criteria are as follows:

- Soil covering: 1.2 m or more
- Pipe Materials: Ductile cast iron (DCI) pipe with corrosion prevention

(2) Proposed Conduction Facility

Proposed conduction facility is as shown in *Table 5.8.*

Table 5.8 Proposed Conduction Facility

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

Note: DCI : Ductile cast iron

5.3.5 WATER TREATMENT

(1) Treatment Process

The treatment process of Quiebra Montes WTP employs a similar process as the one of the existing Los Laureles WTP because water sources of both treatment plants are the same river. Considering the site conditions that require a considerably large amount of land preparation works due to a steep slope, sedimentation with plate settler is adopted in order to reduce the site area as much as possible. Sludge from sedimentation process and filter backwashing process are planned to be thickened by thickeners and dried up by sludge drying beds for the final disposal. The adopted process flow is shown in *Figure 5.10.*

(2) Planning Basis

Adopted design capacity of Quiebra Montes WTP is 108,000 m^3/day (1,250 l/s), which includes a production loss.

The design criteria of major facilities and design water quality of Quiebra Montes WTP are as shown in *Tables 5.9* and *5.10*, respectively.

Table 5.9 Adopted Design Criteria for Major Facilities

Facilities	Description	Criteria
Aeration	Multi step cascade aeration	- Contact time: 4 - 5 seconds - Drop head: 3 - 4 m
Coagulation	Water flux rapid mixing and horizontal baffled channel flocculation	- Retention time: 20 - 40 min - Coagulants: Aluminum sulfate with polymer
Sedimentation	Rectangular sedimentation basin with plate settling	- Surface loading: 0.25 - 0.55 m^3/m^2/day - Average flow: 0.6 m/min or less
Filtration	Rapid sand filtration with air scoring backwash	- Filtration rate: 120 - 150 m/day - Media size: 0.6 - 0.7 mm - Media thickness: 0.6 - 0.7 m
pH Control	Lime water dosing with automatic control	
Disinfection	Liquid chlorine dosing	- Residual chlorine at the clearwater reservoir outlet: 0.2 - 0.3 mg/l (as Cl_2)
Clear Water Storing	Full or semi underground reservoirs	- Retension time: 1 hr or more

Table 5.10 Design Water Quality

Parameters	unit	Design treated water quality	Design raw water quality
Total Coliform	N/100mL	0	1,700
Fecal Coliform	N/100mL	0	1,700
True Color	Pt-Co unit	15	130
Turbidity	NTU	5	50
pH	-	6.5~8.5	6.8

(3) Proposed Facilities

The layout and the hydraulic profile of Quiebra Montes WTP are shown in *Figures 5.11* and *5.12*, respectively.

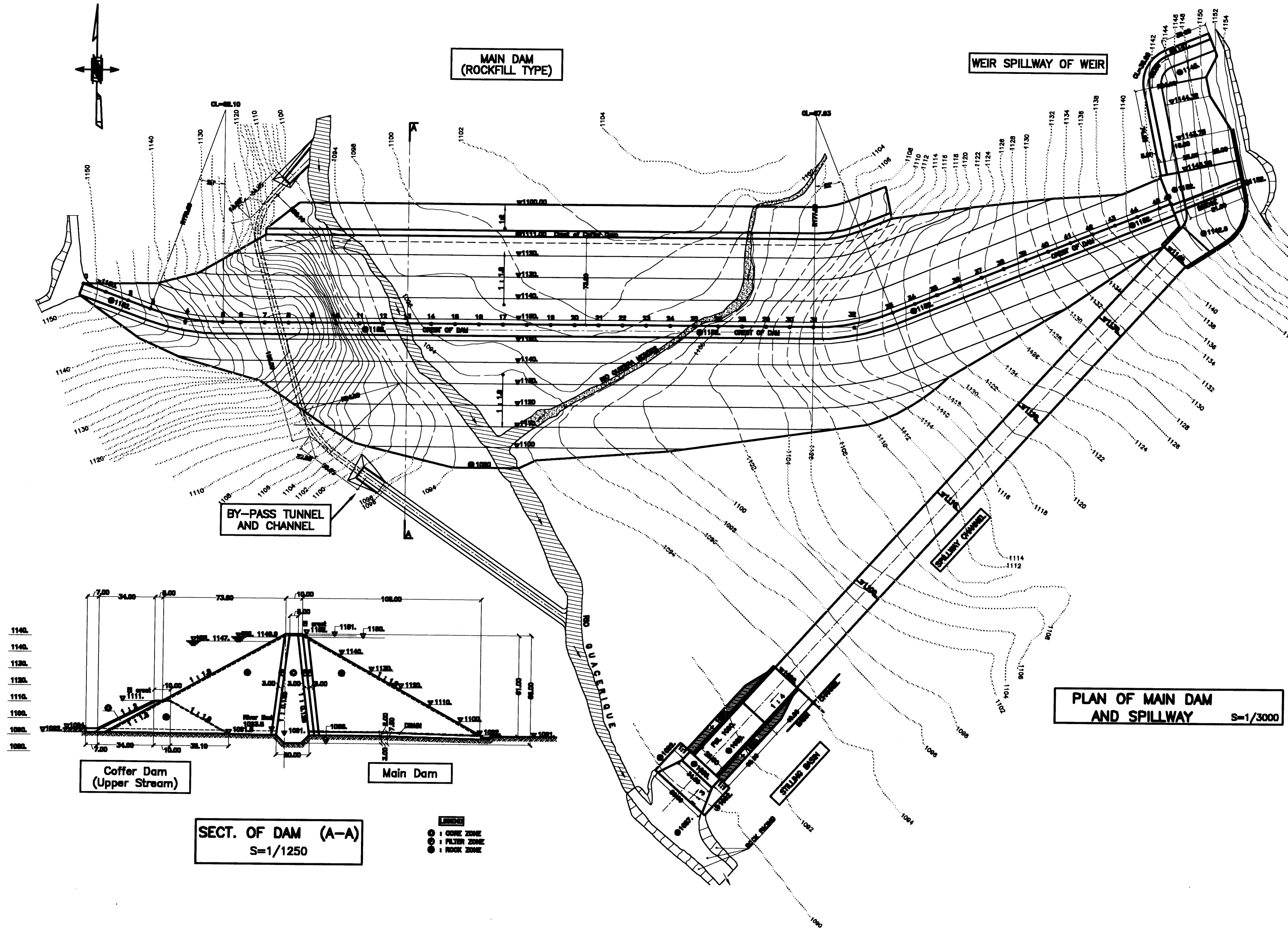

Figure 5.7	Plan of Quiebra Montes Dam

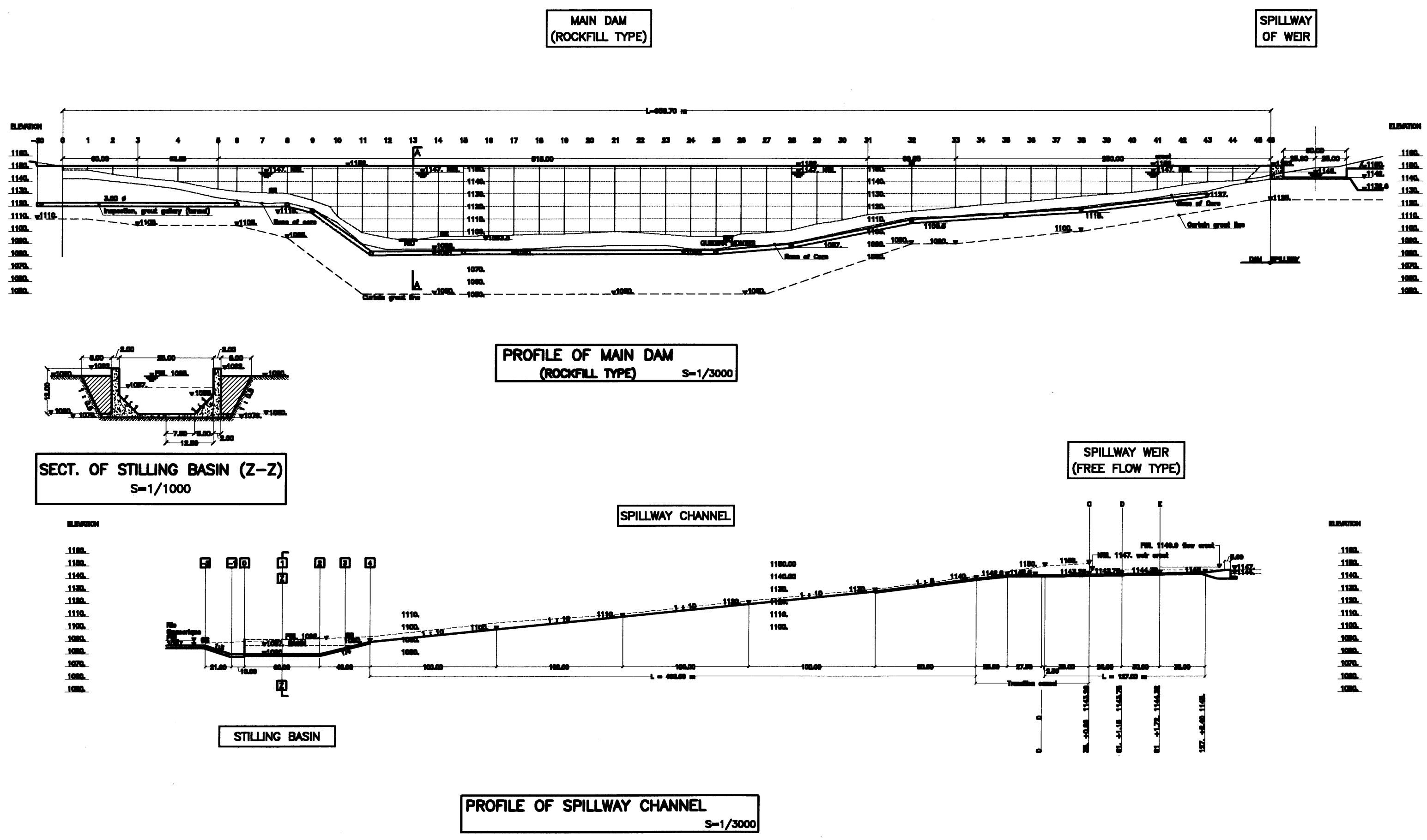

Figure 5.8 Profile of Quiebra Montes Dam

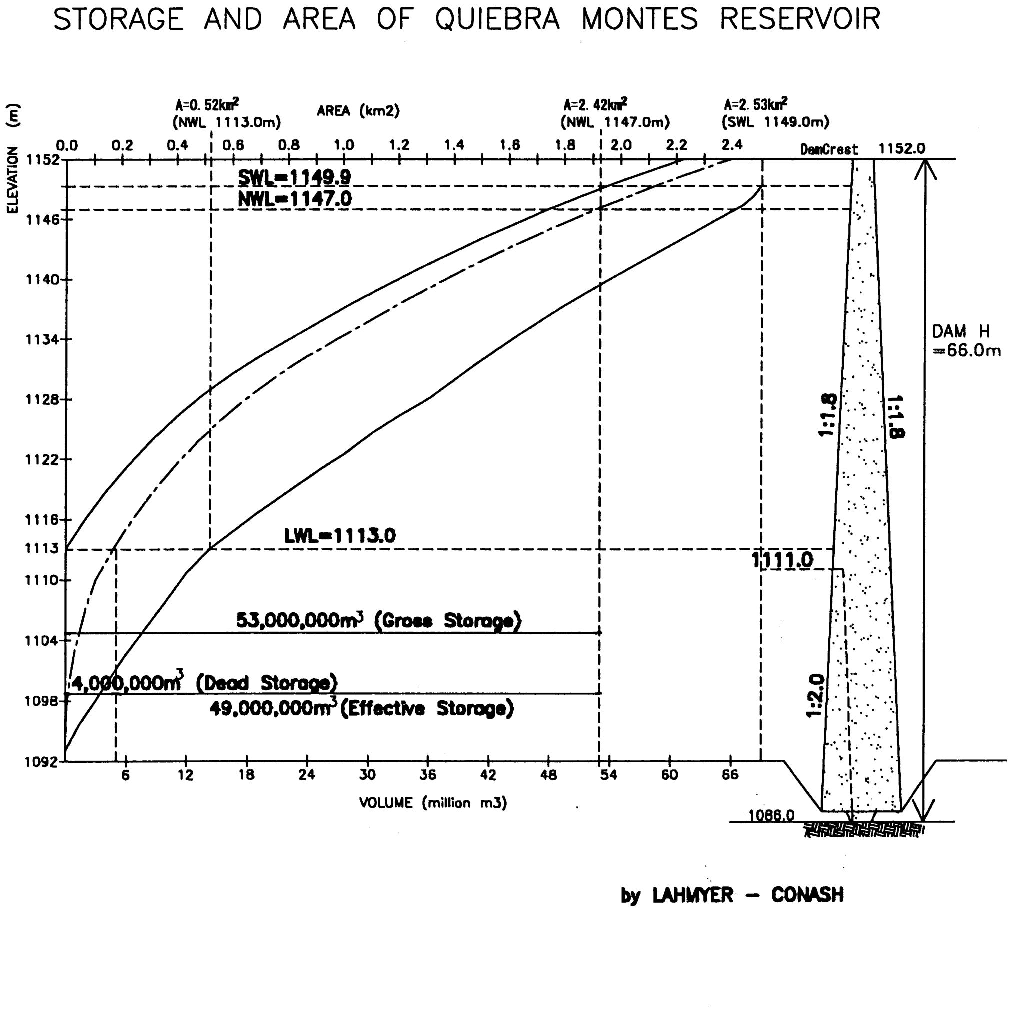

Figure 5.9	Water Level – Volume Relationship of Quiebra Montes Reservoir

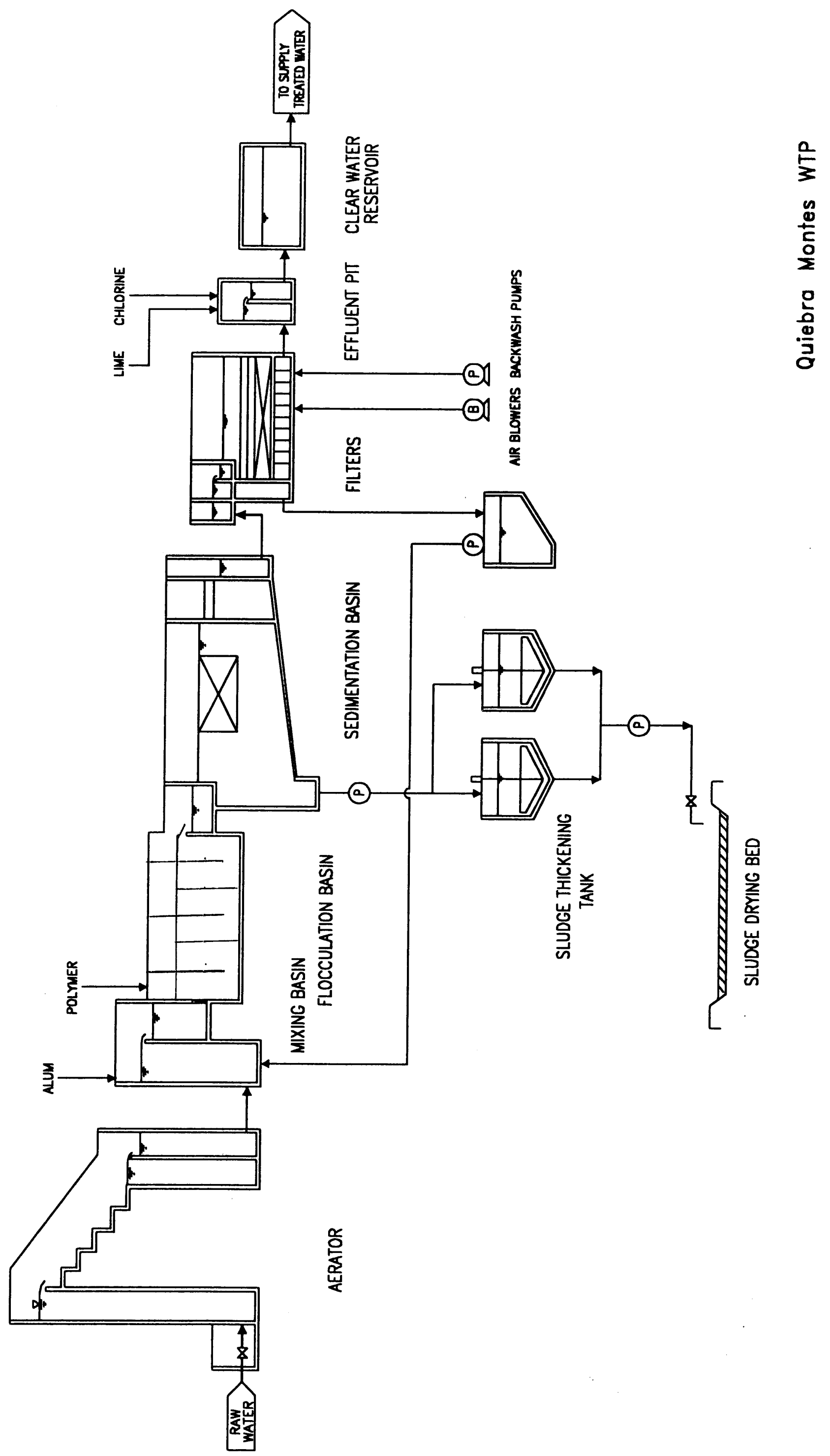

Figure 5.10	Process Flow Sheet of Quiebra Montes WTP

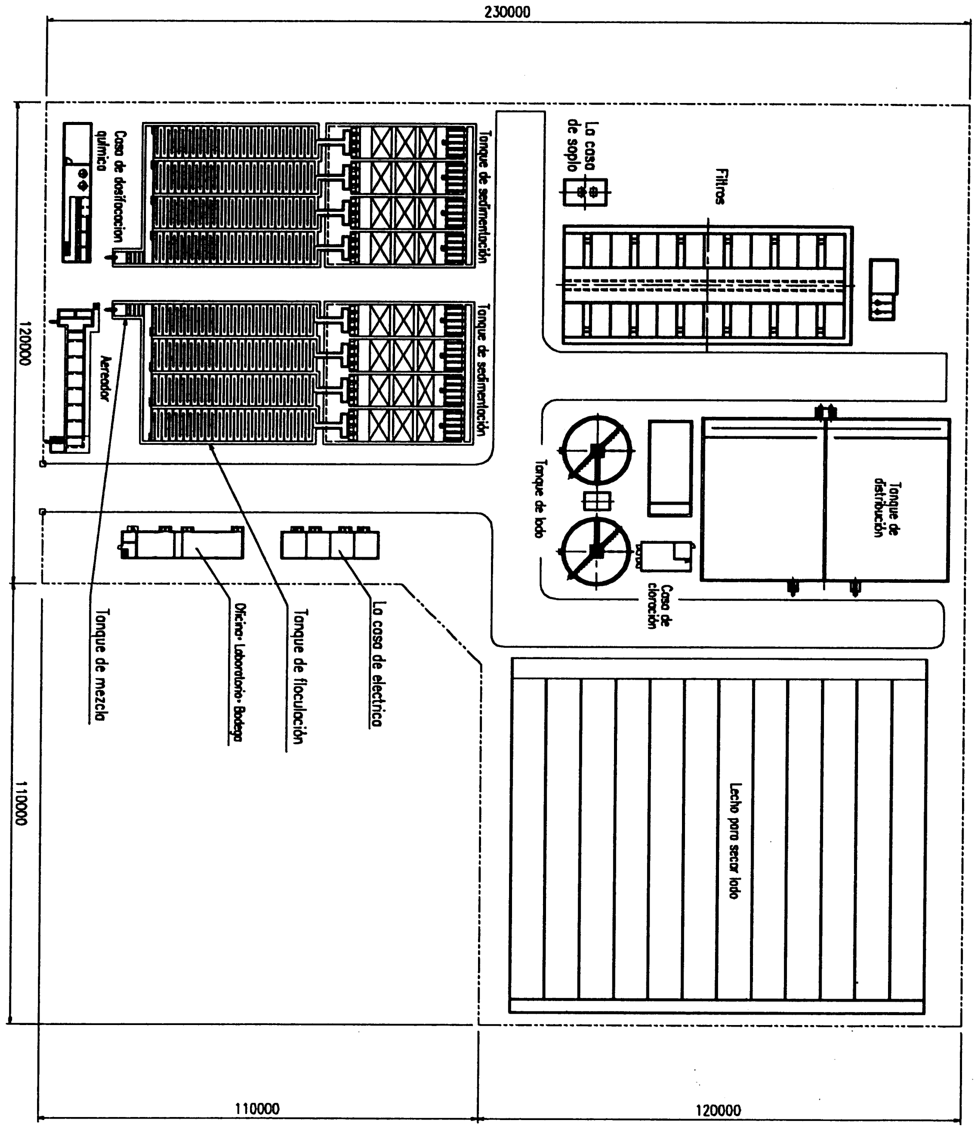

Figure 5.11	Layout of Quiebra Montes WTP

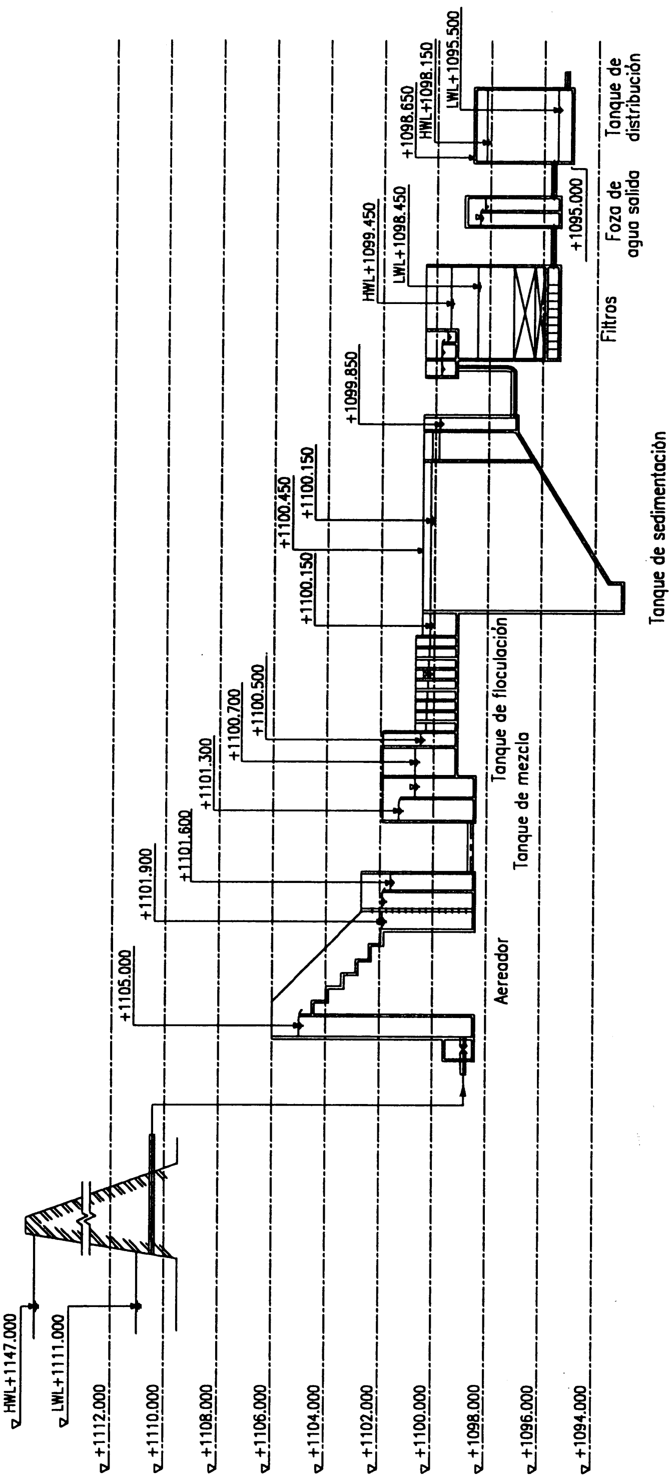

Figure 5.12	Hydraulic Profile of Quiebra Montes WTP

Table 5.11 shows major specifications of the proposed facilities.

Table 5.11 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 ,pump
Polymer dosing	4 - 20 lit/min x 1	solution ,pump
Lime dosing	0.6 m^3/min x 1	solution ,pump
Disinfection	40 kg/hr x 1	Liquid chlorine

5.3.6 FACILITIES FOR JOINT OPERATION WITH LOS LAURELES WTP

(1) Design Criteria

Planning bases are as follows.

- Bypass line from Quiebra Montes WTP to Los Laureles WTP: 225 l/s
- Expansion of the clear water reservoir of Los Laureles WTP: 900 m^3

Adopted planning criteria are as follows.

- Pipe material of bypass line: Ductile cast iron with corrosion prevention
- Soil cover of pipe: More than 1.2 m
- Retention time of clear water reservoir: 1 hour

(2) Facility Plan of Bypass Line

Quiebra Montes WTP and Los Laureles clear water reservoir are connected by the inter-connection transmission line between Concepcion and Quiebra Montes subsystems explained in the transmission facility plan and the existing inter-connection line between Concepcion and Los Laureles subsystems. It is confirmed that both inter-connection lines satisfy the design criteria for the bypass line.

(3) Facility Plan of Additional Clear Water Reservoir of Los Laureles WTP

To increase the capacity of clear water reservoir of Los Laureles WTP, an additional reservoir with 900 m^3 will be constructed. The newly constructed clear water reservoir will be connected to the existing one by connection pipe equipped with valve. The specifications of the additional clear water reservoir of Los Laureles WTP are as follows.

- Dimension: 16m width × 16m length × 4m height
- Material: Reinforced concrete

5.3.7 TRANSMISSION

(1) Reorganization of the Transmission System

Transmission system allocates water from five (5) water treatment plants to distribution reservoirs which acts as a distribution center of a distribution area, consisting of transmission pipes and pumping station.

As explained later, the distribution areas were reorganized to make a distribution plan to accommodate the demand in 2015. 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.

Considering these factors, new transmission system was planned to replace the existing water sources of some distribution reservoirs with water from Quiebra Montes WTP.

Table 5.12 shows the result of reorganization of the transmission system together with the existing system. The general layout of the transmission system is shown in *Figure 5.13.*

Table 5.12 Result of Reorganization of Transmission System

Distribution Reservoirs	ELEVA-TION	Water Sources (Name of Water Treatment Plant): Present			Water Sources (Name of Water Treatment Plant): 2015				Elevation of WTP
		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

Figure 5.13 General Map of Proposed Transmission System in 2015

In addition to the reorganization of the distribution assignment above, Concepcion and Quiebra Montes subsystems are connected by an inter-connection line in order to increase system security.

(2) Network Analysis

Facility planning employed a network analysis by EPANET to determine pipe sizes and pumping station capacities. The analysis was carried out by transmission system, namely, Los Laureles, Concepcion, Picacho, and Quiebra Montes transmission systems. The distribution reservoirs assigned to each subsystem, their flow rates, supply modes, and pumping flow rates are shown in *Tables 5.13 to 5.16*.

Table 5.13 Operation Conditions for Network Analysis (Quiebra Montes Subsystem)

Distribution Reservoir	Maximum daily demand	Distributed flow	Supply mode	Pumping flow	Supply options
Mogote	56.22	56.22	Pump.	67	
New San Francisco	109.86	109.86	Pump.	131	
Estiquirin	364.18	127.18	Grav.		LL, C
La Fuente	8.62	8.62	Grav.		
Centro A. Este	15.44	15.44	Pump.	47	LL, C
Centro A. Oeste	43.09	43.09	Pump.	47	LL, C
Independencia	190.45	190.45	Grav.		
Ulloa	99.33	99.33	Pump.	119	
Villafranca	28.81	28.81	Pump.	35	
Olimpo I	87.16	87.16	Pump.	305	P, C, LL
Olimpo II	67.82	67.82	Pump.	100	P, C, LL
Cerro Grande	88.47	88.47	Pump.	106	P, C, LL
Total	1,159.45	922.45			

LL: Los Laureles WTP, P: Picacho WTP, C: Concepcion WTP (Unit: l/s)

Table 5.14 Operation Conditions for Network Analysis (Los Laureles Subsystem)

Distribution Reservoir	Maximum daily demand	Distributed flow	Supply mode	Pumping flow	Complementary supply
Filtros	282.22	282.22	Gravity		
Filtros Cisternas	30.00	30.00	Gravity		
Juan A Lainez Quesada	32.24	32.24	Gravity		
Estiquirin	364.18	237.00	Pumping	258	Quiebra Montes
Los Laureles	4.81	4.81	Gravity		
Juan A Lainez	174.14	94.00	Pumping	94	Concepcion
Centro Loma	72.05	72.05	Pumping	86	
Canal 11	111.00	84.68	Pumping	88	Concepcion
Los Laureles Cisternas	30.00	30.00	Gravity		
Total	1,100.64	853.92			

(Unit : l/s)

Table 5.15 Operation Conditions for Network Analysis (Concepcion Subsystem)

Distribution Reservoir	Maximum daily demand	Distributed flow	Supply mode	Pumping flow	Complementary supply
Kennedy	187.24	187.24	Gravity		
Hato 1	27.39	27.39	Gravity		
Hato 2	23.89	23.89	Pumping		
Honduras	25.80	25.80	Gravity		
Monterey	12.28	12.28	Gravity		
Loarque	66.83	66.83	Gravity		
Robles	15.77	15.77	Gravity		
14 de Marzo	79.74	79.74	Gravity		
Covespul	2.19	2.19	Gravity		
Los Pinos	21.96	21.96	Pumping	26	
Suyapita	64.38	64.38	Pumping	112	
Nueva Suyapa	60.94	60.94	Pumping	66	
Lomas del Toncontin	28.62	28.62	Gravity		
La Cascada	8.55	8.55	Gravity		
Las Uvas	21.25	21.25	Pumping	27.5	
Las Hadas	15.39	15.39	Pumping	19	
La Cañada	47.51	47.51	Gravity		
Miraflores	92.73	42.73	Gravity		Miraflores WTP
Lomas 2da etapa	21.88	21.88	Pumping	47	
Universidad Norte	7.89	7.89	Pumping	47	
Nueva Ciudad	3.46	3.46	Pumping	4	
Villa Nueva	100.45	100.45	Pumping	110	
La Leona	219.18	219.18	Gravity		
Suyapita Cisternas	20	20	Gravity		
Villa Nueva Cisternas	24.91	24.91	Gravity		
Canal 11	111.00	111.00	Gravity		Los Laureles WTP
Juan A. Lainez	174.14	148.77	Gravity		Los Laureles WTP
Total	1485.37	1410.00			

(Unit : l/s)

Table 5.16 Operation Conditions for Network Analysis (Picacho Subsystem)

Distribution Reservoir	Average daily in 2015		Maximum daily in 2015	
	By reservoir	Accumulated	By reservoir	Accumulated
Picacho	202.96	202.96	233.42	233.42
Travesia	38.50	241.46	44.27	277.69
Sosa	73.35	314.81	84.35	362.04
Lindero	54.56	369.37	62.74	424.78
Cerro Grande 1	48.67	418.04	55.97	480.75
Cerro Grande 2	28.26	446.30	32.50	513.25
Olympo 2	58.97	505.27	67.82	581.07
Olympo 1	75.79	581.06	87.16	668.23

(Unit: l/s)

The flow diagrams of each transmission system are shown in *Figures 5.14 to 5.17*.

A total of supplied flow to the distribution reservoirs assigned to Picacho WTP exceeds the production capacity. This is because the constraint of the production capacity of Picacho WTP is a yield of the water sources and the treatment plant can produce more water if the yield is sufficient, which could happen in not draught years. Therefore, conditions that Picacho WTP produces water as much as possible to reduce the operation costs are applied in the analysis.

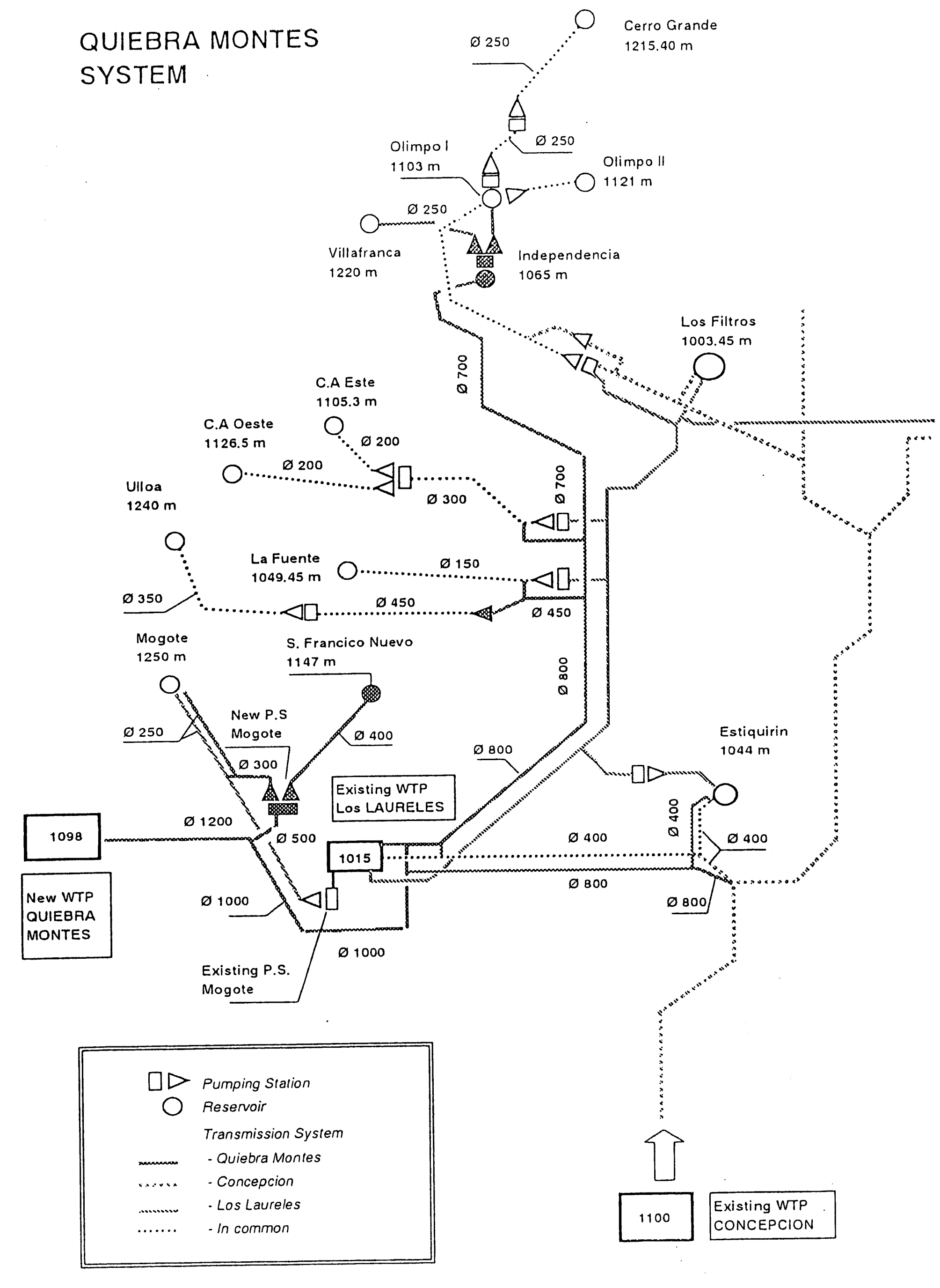

Figure 5.14 | **Flow Diagram of Quiebra Montes Transmission System in 2015**

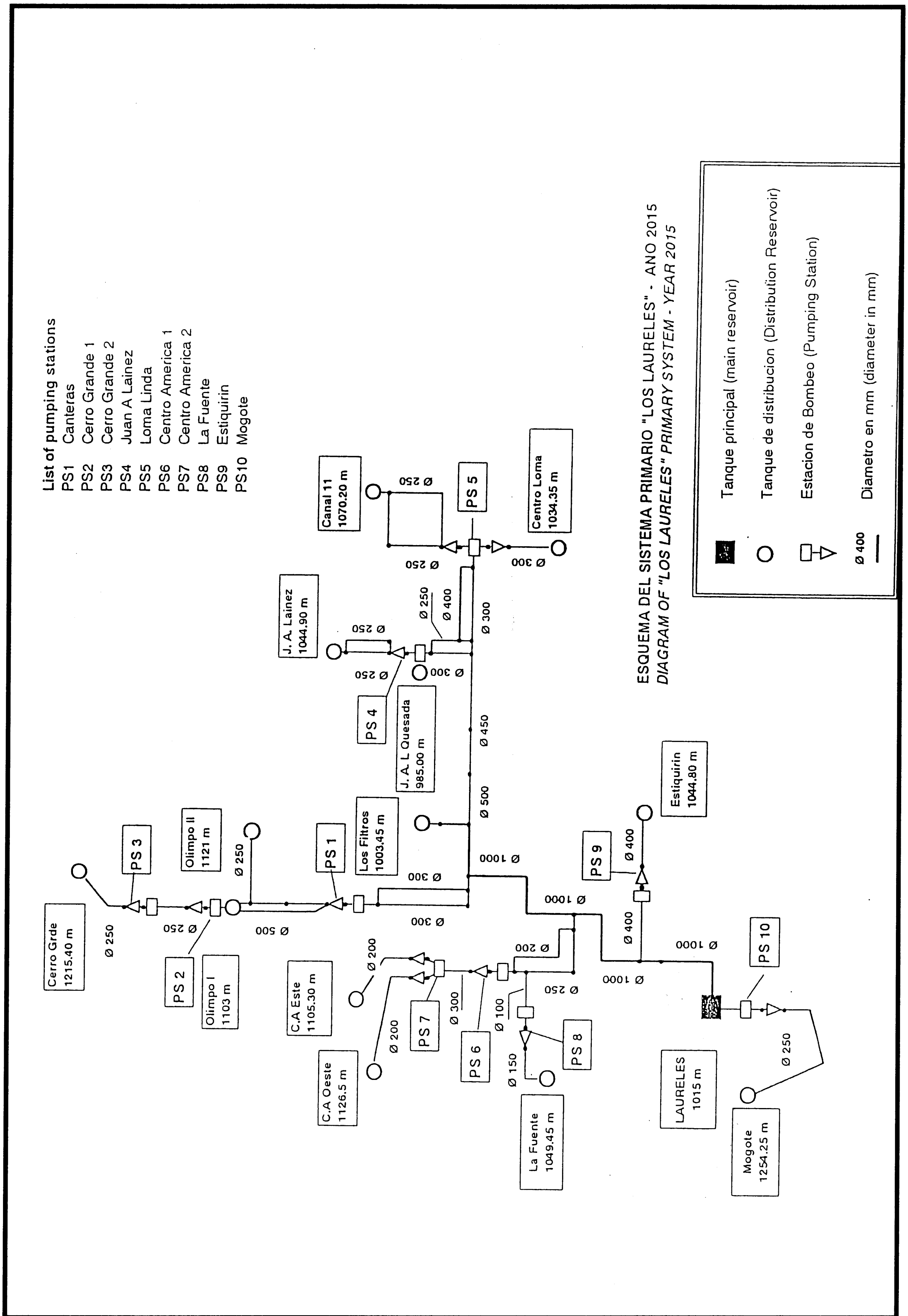

Figure 5.15	Flow Diagram of Los Laureles Transmission System in 2015

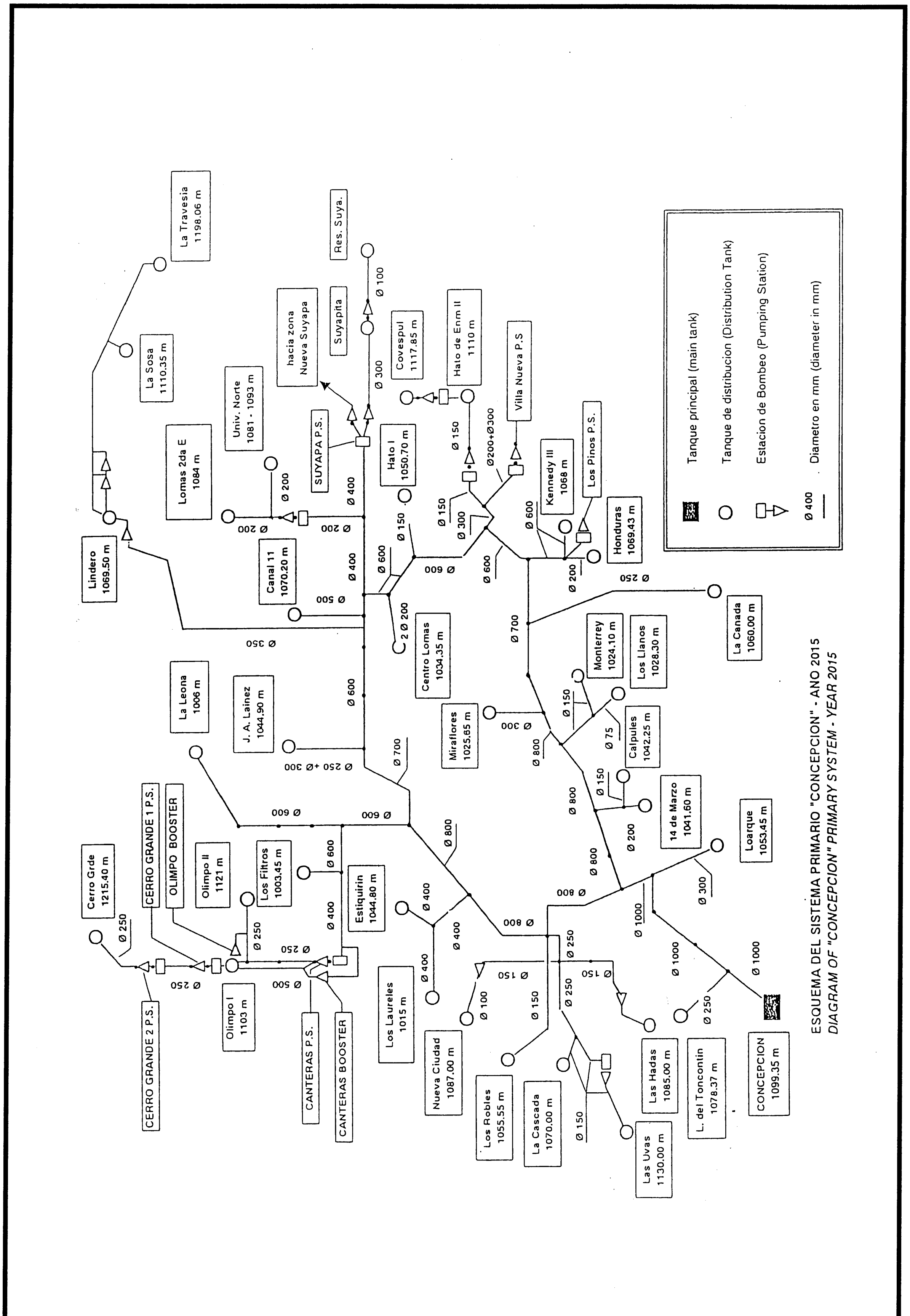

Figure 5.16	**Flow Diagram of Concepcion Transmission System in 2015**

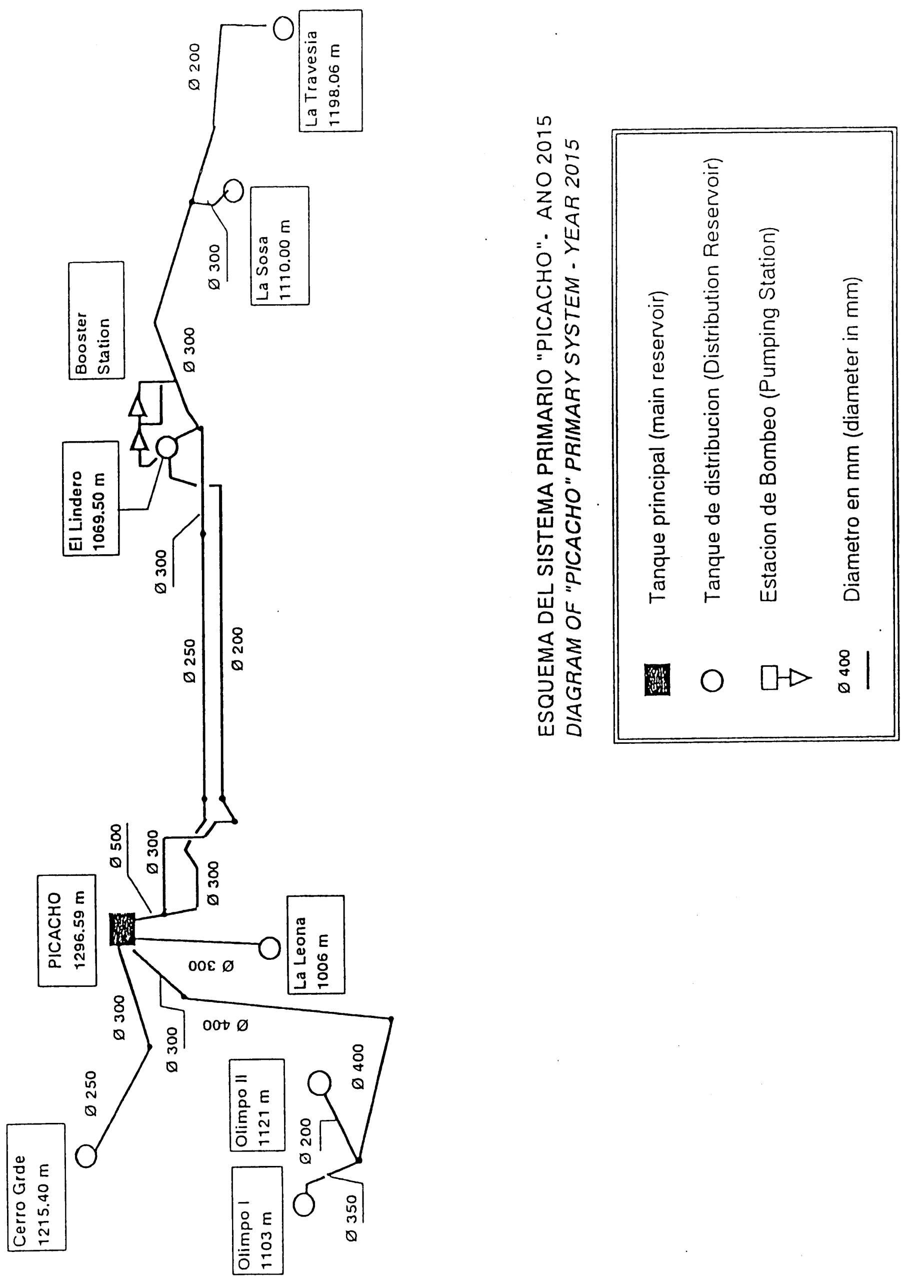

Figure 5.17	Flow Diagram of Picacho Transmission System in 2015

(3) Facility Plan

Applying the operation conditions mentioned above and the design criteria shown in *Table 5.17*, the network analysis was carried out to determine required facilities.

Table 5.17 Design Criteria for Transmission Network Analysis

1. Transmission Pipe	
Water velocity	3 m/sec or less
Depth of soil cover of pipe	1.2 m or more
Materials of pipe (from WTP to network)	Ductil cast iron pipe with corrosion prevention
Materials of pipe (network)	Ductil cast iron pipe with corrosion prevention
Roughness coeffcient	120 for Los Laureles and Picacho subsystems 110 for Quiebra Montes and Concepcion subsystems
2. Pumping Station	
Type of pumps	Centrifugal of horizontal or vertical type
Stand-by of pumps	1set
Retention time of suction pit	20 minutes
Accessories	Generator

Table 5.18 summarizes pipeline facility plan required for the reorganization of the transmission system based on the result of the network analysis. *Table 5.19* shows new and additional pumping stations required for the reorganization.

Table 5.19 Facility Plan for Reorganization of Transmission Pumping Stations

Name of Pumping Station	Elevation	No. of pumps		Total discharge (l/s)	Total Head (m)	Power (HP)	Suction pit (m^3)	Supply	Remarks
		Opera-tion	Stand-by						
Mogote	1,091						320		New
- to Mogote Res.		2	1	67	170	120		Q.M	
- to S. Franscisco		2	1	131	70	100		Q.M	
Booster Soledad		1	1	119	15	40	0	Q.M	New
Independencia							2,750		New
- to Olimpo I	1,065	2	1	305	50	145		Q.M	
- to Villafranca	1,065	1	1	35	165	100		Q.M	
Booster Las Hadas	1,065	1	1	19	25	15	0	C	New
Booster Nueva Ciudad	1,065	1	1	4	20	3	0	C	New
Estiquirin	1,000	2	1	258	57	145	310	LL	New pumps installed in existing P/S
Loma Linda - to Centro Loma	988	1	1	86	51	100	90	LL	New pumps installed in existing P/S

Table 5.18 Facility Plan for Reorganization of Transmission Lines

Systems	Diameter	Length	Remark
Quiebra Montes System			
Main transmission Lines			
From Quiebra Montes clear water reservoir to diversion towards new Mogote pumping station.	1,200 mm	7,500 m	
From diversion towards Mogote Pumping Station to Los Laureles existing reservoir	1,000 mm	1,500 m	
From Los Laureles existing reservoir up to diversion towards Centro America 1 Pumping station	800 mm	2,550 m	Including the bypass transmission line from Quiebra Montes WTP to Los Laureles clear water reservoir
From diversion towards Centro America 1 P.S to Independencia Reservoir	700 mm	2,160 m	
Diversions			
Conduction line to new Mogote P.S	500 mm	360 m	
Pumping Line from New Mogote P.S to Mogote reservoirs	300 mm 250 mm	130 m 530 m	
Impulsion Line from New Mogote P.S to San Francisco reservoir	400 mm	1,450 m	
Conection line to La SOLEDAD Booster	450 mm	30 m	
Conection to La Fuente impulsion line	150 mm	50 m	
Pumping line to Villafranca reservoir	250 mm	1,290 m	
Pumping line to Olimpo 1 reservoir	500 mm	140 m	
Interconnection Between Concepcion And Quiebra Montes Systems			
Main Line	800 mm	1,740 m	
Diversion to Estiquirin Reservoirs	400 mm	300 m	To reinforce the existing 400 mm Line
Concepcion System			
Reinforcement of the diversion to Centro Loma reservoir	200 mm	350 m	To reinforce the existing 200 mm Line
Reinforcement of the diversion to Juan A Lainez reservoir	300 mm	620 m	To reinforce the existing 250 mm Line
New diversion to Nueva Ciudad reservoir	100 mm	1,550 m	
Reinforcement of the diversion to Villa Nueva Pumping Station	300 mm	600 m	To reinforce the existing 200 mm Line
Los Laureles System			
Reinforcement of the impulsion line to Centro Loma reservoir	300 mm	350 m	To substitute the existing 200 mm line
Remodeling entrance and exit pipes of Juan A Lainez PS to conect it to the new Juan A Lainez Quesada reservoir	400 mm 300 mm	50 m 50 m	
	Total	23,300 m	

5.3.8 DISTRIBUTION

(1) Reorganization of Distribution Areas

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

- To calculate the required water amount in 2015 in the present distribution areas of each distribution reservoir.
- 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.
- In addition, to adjust a distribution area to reduce elevation difference within distribution areas.
- To calculate required capacity to increase the existing distribution reservoirs.
- In principal, 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.
- To construct new distribution reservoirs for the neighborhood to be constructed by 2015.

Results of the reorganization are shown in *Table 5.20* and the proposed distribution areas are shown *Figure 5.18.*

(2) Facility Plan for Distribution Reservoirs

Necessary volume of distribution reservoir(s) for each distribution area were calculated based on the estimated required distribution amount (a total of estimated demand and leakage loss) and the following criteria:

- Volume : 35% of the estimated daily required water amount + Fire security,
- Fire security: 72 m^3 for the reservoir covering 2,000 population. No water for the distribution reservoir covering less than 2,000 population.

For the distribution reservoirs that are newly installed, the calculated volume is adopted as a volume for the reservoir to be constructed. For the existing distribution reservoirs, the calculated volume is compared to the actual volume of the existing reservoirs and the installation of additional reservoirs are proposed for cases where there is a shortage in a reservoir volume.

Table 5.20 Result of Reorganization of Distribution Areas

Name of distribution reservoir	2000			2015			Proposed action		Remarks
	No.of Neighborhood	Population	Water demand (m^3/day)	No.of Neighborhood	Population	Water demand (m^3/day)	Required reservoir	Volume (m^3)	
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	Additional	1330	Embodied to other distribution area
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	-	-	-			Embodied to other distribution area
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	Additional	3200	
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	Additional	1477	
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	Additional	200	
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	Additional	600	
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	-	-	-			Embodied to other distribution area
Sosa	16	39,805	7,432	10	35,429	6,337	Additional	2300	
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			New reservoir is under construction by on-going projects
Las Uvas	-			2	6,436	1,597			New reservoir is under construction by on-going projects
La Cañada	-			7	15,344	3,570	Additional	800	New reservoir is under construction by on-going projects
Est. Bombeo Los Pinos	1	9,494	1,446	1	11,391	1,650			
La Independencia	-			26	85,022	14,308	New	5200	
New San Francisco	-			19	51,478	8,254	New	3000	
Ulloa	-			15	41,764	7,463	Additional	800	New reservoir is under construction by on-going projects
Villa Franca	-			10	13,966	2,165			New reservoir is under construction by on-going projects
Cerro Grande 2	-			3	13,553	2,442			New reservoir is under construction by on-going projects
Juan A. Lainez Quesada	-			5	3,584	2,422	New	950	
Nueva ciudad	-			1	814	260	New	100	

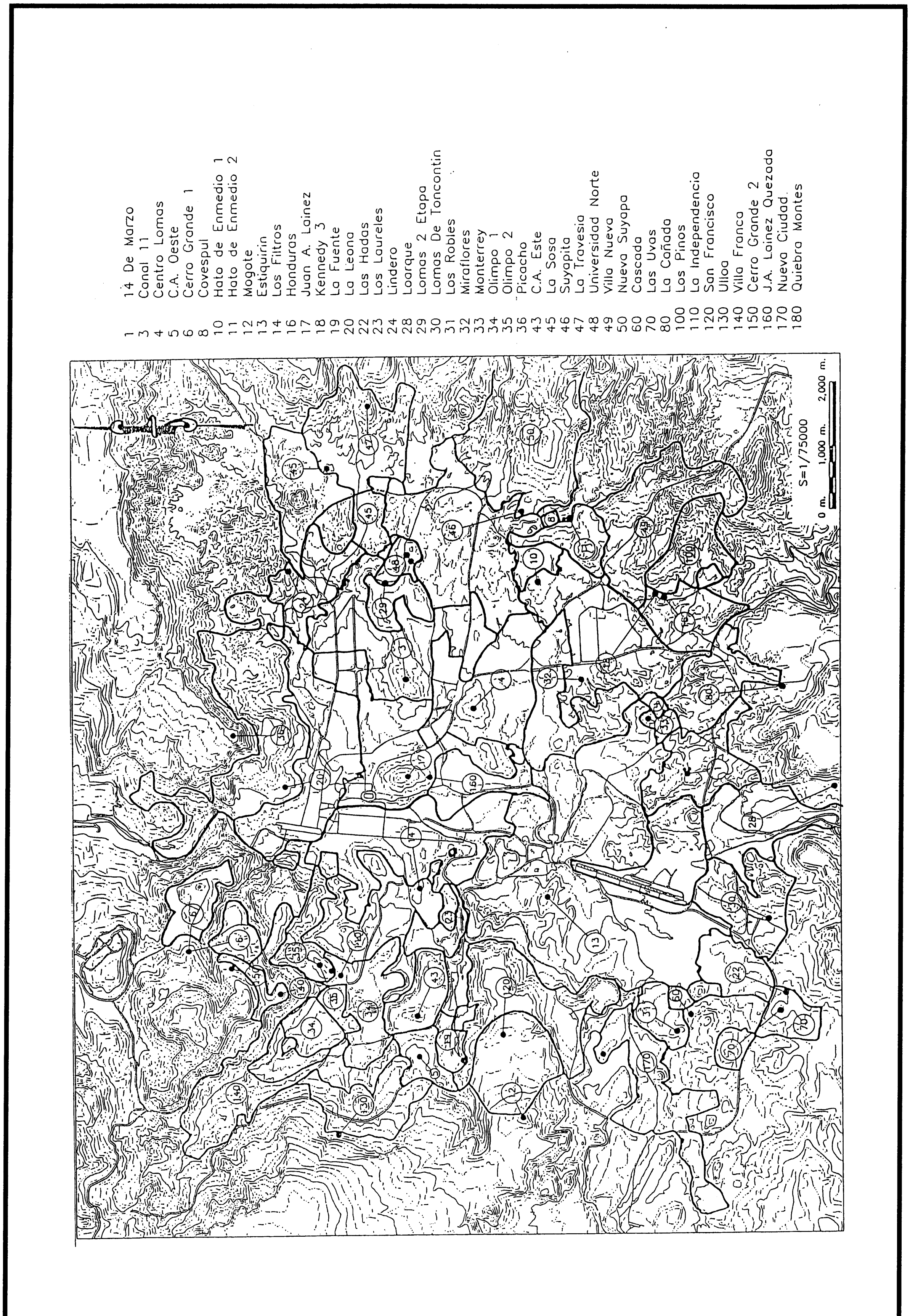

Figure 5.18 **Proposed Distribution Areas in 2015**

As a conclusion, it is proposed to install a total of 12 distribution tanks as shown in *Table 5.21*. Four (4) tanks among them are for the newly proposed distribution reservoirs, while eight (8) tanks are additional installation to the existing distribution reservoirs.

Table 5.21 Proposed Distribution Reservoirs 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
Lomas del Toncontin	Additional	200
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

(3) Facility Plan for Distribution Networks

The following two (2) types of distribution network development are planned for the reorganization of distribution system.

- Network reinforcement for the existing distribution areas to satisfy increased demand.
- Network expansion for newly proposed distribution areas.

Required work amount for the reinforcement was calculated based on analysis of Estiquirin distribution area, which covers 14% of total distribution areas and is the only one distribution area that has available pipeline information. Network analysis for the Estiquirin distribution area using EPANET was conducted under the demand conditions in 2015 and the required reinforcement was estimated by adjusting pipe sizes so as to satisfy the demand conditions in 2015. Results are shown in *Table 5.22*.

Table 5.22 Results of Distribution Network Analysis (Estiquirin)

	Diameter of Pipe (mm)							
	100	150	200	250	300	400	600	Total
Existing Network (m)	4,700	13,300	13,400	4,800	5,600	100		41,900
Required Reinforcement (m)	670	2270	380	1430	2250	950	50	8,000

As Estiquirin distribution area represents approximately 14% of the total existing distribution area covered by pipes, the total required reinforcement work was estimated at 60 km. Taking into account the different extensions and features of the distribution reservoirs, the following distribution by diameter has been established. Required reinforcement work for the entire system was estimated as shown in *Table 5.23*.

Table 5.23 Required Reinforcement Work for Entire Distribution System

	Diameter of Pipe (mm)								
	100	150	200	250	300	350	400	600	Total
Required Reinforcement (km)	13	12	10	8	7	5	3.5	1	0.5

The expansion of the network was estimated for planned urbanization areas and areas currently covered by tank lorry based on the population of each area and average pipe length per one person, 1.5 m/person, according to SANAA data. Required expansion work was estimated as shown in *Table 5.24*.

Table 5.24 Required Work for Expansion of Distribution Area

	Required pipe length (km)										
Diameter of pipe (mm)	50-80	100	150	200	250	300	350	400	500	600	Total
Planned urbanization	65	30	12	4	1						112
Areas currently covered by tank lorry	58	22	14	12	9	6	4	2	1		128

Table 5.25 presents a summary of the required expansion and reinforcement of distribution network.

Table 5.25 Summary of Expansion and Reinforcement of Distribution Network

Diameter of Pipe (mm)	Reinforcement in existing areas (km)	Needs of distribution network expansion		Total (km)
		Planned urbanizations (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

5.3.9 TANK LORRIES

The Master Plan proposes to distribute water to neighborhoods to be formed by 2015 and with no information about their location at present by tank lorries. The estimated water amount distributed by tank lorries is 3,000 m^3/day at present and will be 6,600 m^3/day. As far as the water amount is concerned, it is negligible to the total water demand. However, operational consideration including facilities planning that supports the actual operation could be required judging from the existing problems in the tank lorries operation.

Currently the tank lorries operation has a water filling station at Los Filtros. It has a problem of accessibility due to poor road conditions and constant traffic jam near by. Also the current operation is suffering from a shortage of numbers of tank lorries.

Therefore, construction of three 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.

Locations of the proposed new water filling stations are shown in *Figure 5.19*. Required numbers of tank lorries are calculated to be 204 vehicles as shown in *Table 5.26*.

Table 5.26 Expansion of Water Filling Stations and Tank Lorries

Item	Discription	Unit	2000	2001	2002	2003	2004	2005	2010	2012	2015
Required tank lorries	10 ton/tank	no's	93	106	120	133	146	160	177	204	195
Increase of tank lorries		no's		13	13	13	13	13	17	27	-
Water filling stations	supply rate	m^3/day	3,100	4,400	4,400	4,400	5,200	5,800	6,600	6,600	6,600
Expansion of filling station		m^3/day		1,300			800	600	800		

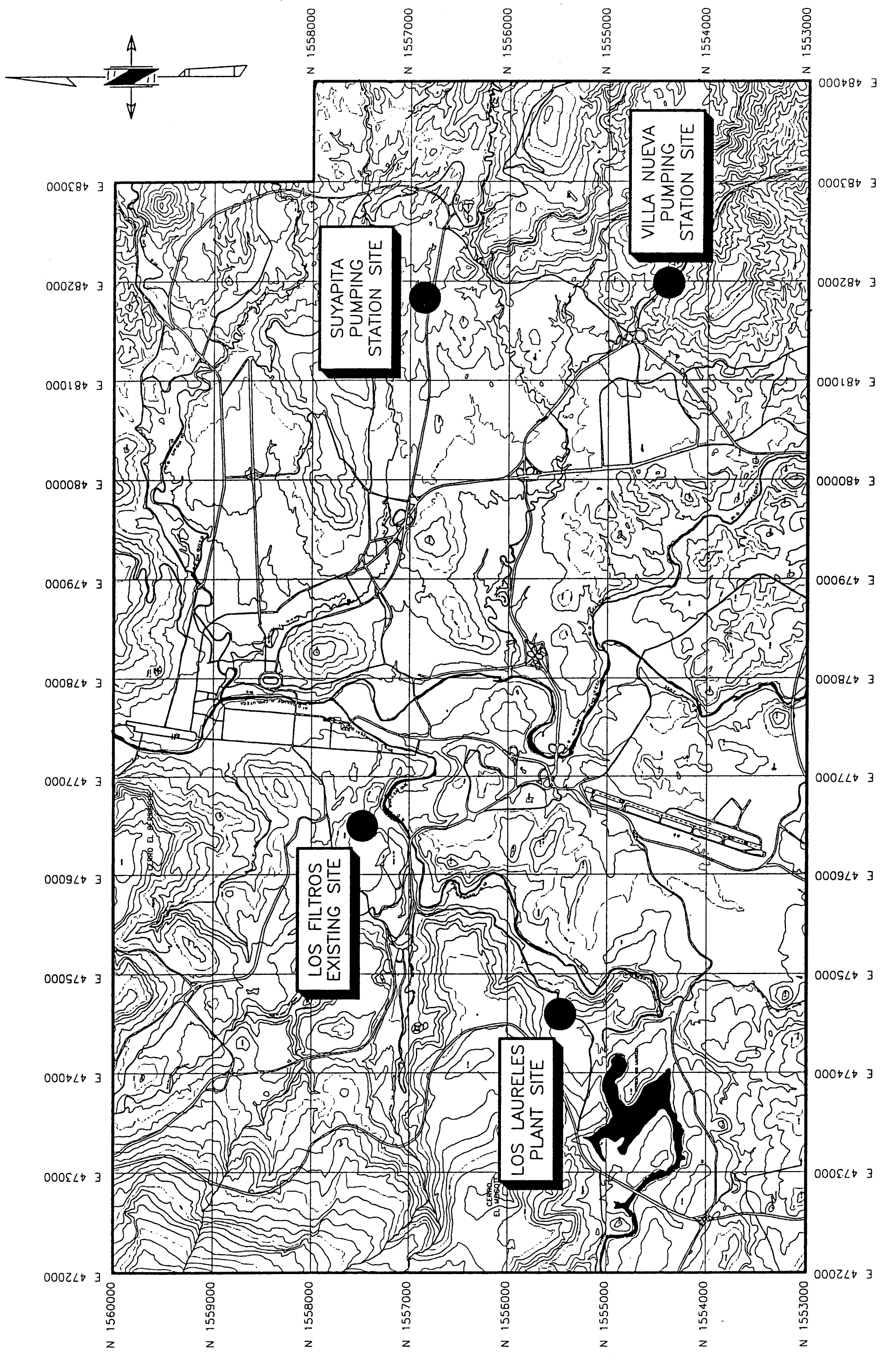

Figure 5.19	Location of Proposed Water Filling Stations in 2015

5.4 FACILITY PLANNING OF LEAKAGE CONTROL PROJECT

5.4.1 GENERAL

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 proposes 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 proposes a task force that increases a capacity of the leakage repairing section.

5.4.2 STRENGTHENING OF LEAKAGE REPAIRING CAPACITY

Required manpower and equipment necessary for strengthening leakage repair capacity are shown in *Table 5.27*.

Table 5.27 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

5.4.3 WATER QUANTITY MEASUREMENT

Water measurement devices for treated water of treatment plants are not working properly in the existing three (3) treatment plants and no water devices are equipped in the existing pumping stations nor distribution reservoirs. Although it would be not easy to install water meters to all the users, measurement of treated water and water inflow to each distribution reservoirs could improve understanding of the actual water balance. Therefore, the Master Plan proposes the installation of water meters at water treatment plants and distribution reservoirs. Required meter installation is shown in *Table 5.28*.

Table 5.28 Required Devices for Water Quantity Measurement

Facilities	Measuring Point	Type of Flowmeter	No. of Facilities	No. of meters	Remarks
Water Treatment Plant	Outlet	Flow rate and integrated value	3	3	
Pumping Stations	Outlet	Flow rate and integrated value	24	24	
Existing Distribution Reservoirs	Outlet	Flow rate and integrated value	44	101	Some tanks have several outlets.
Water Meters	Service Pipe	Integrated value	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.

5.5 SUMMARY OF FACILITY PLANNING

Proposed facilities in the Master Plan Projects are summarized in *Table 5.29* and their locations are shown in *Figure 5.20*.

Table 5.29 Summary of Facility Planning for Master Plan Projects

Projects	Components	Descriptions	
Los Laureles II	Los Laureles II Dam	Dam Type: Dam Height: Dam Width: Gates: Reservior Volume: Yield Capacity:	Concrete Gravity 31.0 m 103.0 m 9m x 8.6m x 4 sets 4,050,000 m^3 130 l/s (99% reliability)
	Excavation of Los Laureles Dam	Volume: Yield Capacity:	600,000m^3 30 l/s (99% reliability)
Quiebra Montes	Quiebra Montes Dam	Dam Type: Dam Height: Dam Width: Reservoir Volume: Yield Capacity:	Rockfill 66.0 m 958.7 m 53,000,000 m^3 1,040 l/s (99% reliability)
	Conduction Facilities	Conduction Pipe:	1,200mm x 1 km
	Quiebra Montes WTP	Type: Production Capacity:	Rapid Sand Filtration 108,000 m^3/day
	Reorganization of Transmission System	Pumpimg Stations: Transmission Pipe:	5 new pumping stations and 2 expansion of existing pumping stations 100-1,200mm x 23.3 km
	Reorganization of Distribution System	Reservoir Tanks: Distribution Pipe: Filling Stations: Tanlk Lorries:	100 - 5,200 m^3 x 12 tanks 50 - 600 mm x 300 km 600 - 1,300 m^3 x 4 stations 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: Watermeter:	3 existing WTP, 8 existing pumping stations and 44 existing reservoirs 48,500 users
	Strengthening Leakage Repair Capacity	Leakage repair tools, leakage detection tools and vehicles	

Note: QM; Quiebra Montes, LL; Los Laureles

5.6 OPERATION AND MAINTENANCE PLAN

5.6.1 DAM

(1) Operation Plan of 3 Dams in the Guacerique River during Drought

As three dams will be operated in the same river system, it is necessary to set up a synthetic operation rule to cover three dams. The principle idea of joint operation is as follows.

- Reservoir at lower reach is used first
- Reservoirs are operated as the specific vacancy (vacant storage volume/catchment area) becomes equal for all three reservoirs

Operation rule of Los Laureles II dam is described in the feasibility study.

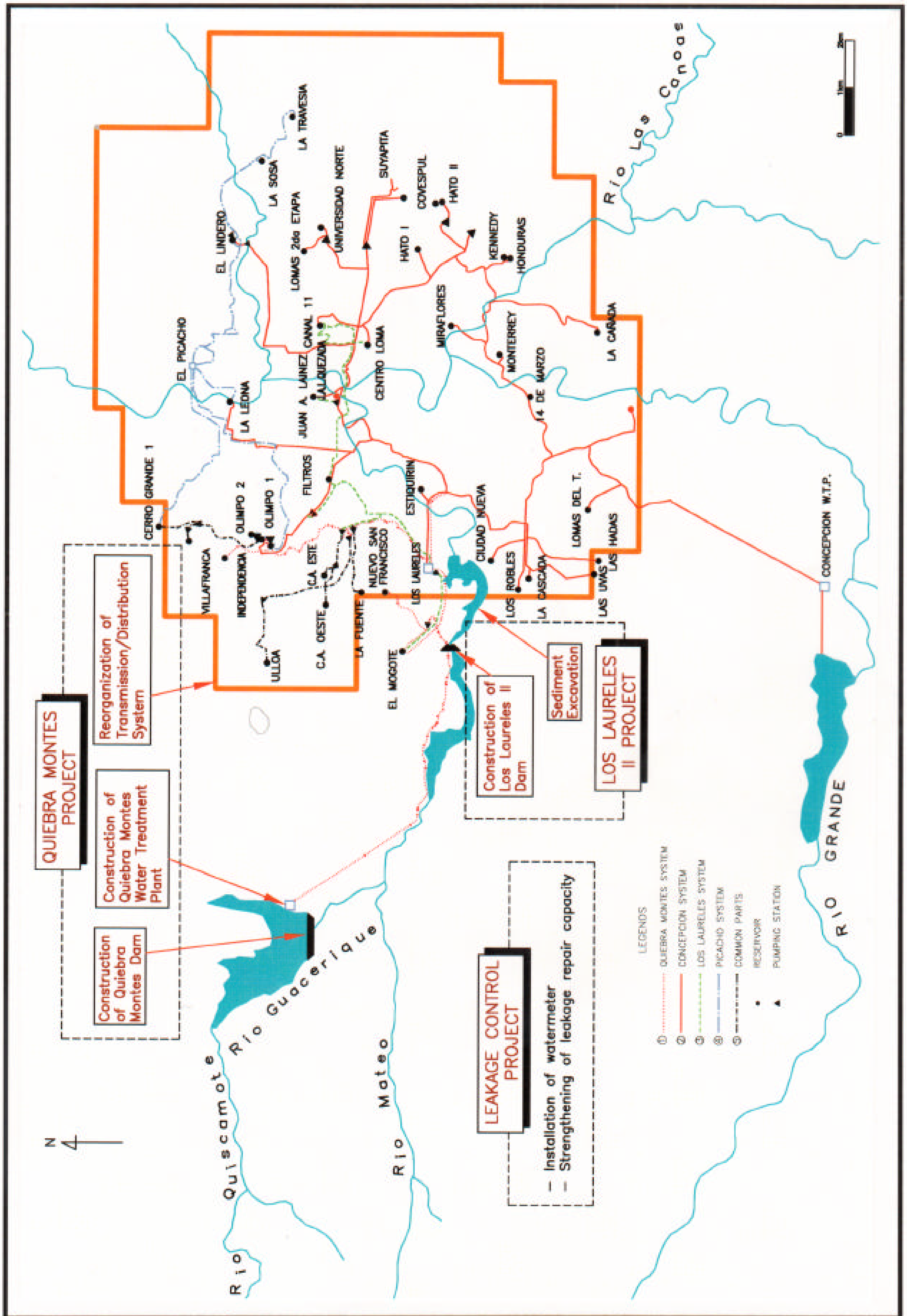

Figure 5.20 | Proposed Facilities in the Master Plan Projects

(2) Operation Plan of 3 Dams in the Guacerique River during Storms

Both Los Laureles dam and Los Laureles II dam will be equipped with gates, it is necessary to plan a gate operation rules during storms.

During a dry season, the gates are completely closed to store the inflow water, while during a wet season, the gates are fully open to release the flood water safely. The operation during the transition period between the wet and the dry season is difficult because the gate operation is required according to the amount of the inflow into the reservoir. Operation rule of Los Laureles II dam is described in the feasibility study.

(3) Flood Forecasting and Flood Warning

As gate operation required for Los Laureles II dam, flood forecasting and flood warning system is necessary. Flood forecasting system can be constructed by using the existing rainfall/gauging station at Mateo Bridge and a new rainfall/gauging station to be constructed at the confluence of the Guacerique River and the Mateo River.

When the gates are operated it is necessary to dispatch warning to the people who happen to be in the river course lower reach. The location of warning should be between Los Laureles II dam and the confluence of the Guacerique River and the Choluteca River.

(4) Maintenance Plan

The maintenance plan for the project is composed of the plan for the dam structure including the gates, and the plan for the reservoir.

The dam body itself is a massive concrete or a rockfill structure and there is little need of maintenance operation. However, steel structures such as gates and valves should be maintained periodically in order to keep the initial function.

In order to prolong the life span of reservoir, periodical excavation of sediment in the reservoirs are proposed. As Los Laureles dam and Los Laureles II dam are close to the urban area and there is a possibility to utilize the sediment as construction material such as sand or aggregate. Presently, sand is taken illegally upstream from Los Laureles dam in a small scale. However, it is preferable to make the operation authorized by SANAA and to make it more systematic. In order to facilitate the sand taking operation, a sediment control structure for Los Laureles II dam is proposed in the feasibility study.

(5) Water Quality

Maintenance of water quality is essential for reservoirs. As there is a possibility of housing development in the Guacerique River basin, it is necessary to study counter measures to cope with the situation.

According to the water quality survey in the Study, a housing area is discharging wastewater with unsatisfied quality. Pilot facilities for inflow water quality improvement are included in the Los Laureles II Project in the feasibility study.

At same time, it is strongly recommended to strictly imply controlling further development of catchment areas. Deterioration of water quality of artificial reservoirs by the eutrophication is a common problem among the world. It should be understood that experiences in many water reservoirs teach that it is practically impossible to recover once deteriorated water quality.

(6) Discharge Data on other River Systems

In future, if there is a need to make a new water supply master plan with a longer term beyond the year 2015, it is necessary to analyze streamflow discharge data on the other river systems like, Sabacuante River System or Hombre River System. Therefore, it is recommended to reinstall or newly install streamflow gauging stations on both river systems.

5.6.2 WATER SUPPLY FACILITIES

(1) Outline

Purposes of operation and maintenance plans for the water supply facilities are to achieve the optimum operation utilizing existing facilities and to prolong the life of the facilities. Major issues to be addressed in the operation and maintenance plans were identified as follows:

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

(2) Operation of Picacho Water Treatment Plant

The production rate of Picacho WTP varies from 250 l/s to 900 l/s depending on flow rates of water source streams where water is taken from small weirs that have no storage capacity. The proposed distribution plan is designed to limit the distribution areas of Picacho WTP so that the water demand in the areas is less than the minimum production rate. Therefore, basically it is no need to change the distribution areas between the dray and rainy seasons.

On the other hand, if the Picacho distribution areas expand during the rainy season, this results in reducing areas where water is supplied from Los Laureles WTP and Quiebra Montes WTP by pumping up, reducing electricity costs. The proposed transmission system is provided with dual supply lines to those distribution areas. Therefore, it is recommended to adjust the distribution areas of Picacho WTP time to time depending on its production rate.

(3) Water Quantity Control

Currently water quantity is measured at few points all over the system. Knowing actual water balance of the system is one of the essential factors for proper operation, appropriate water distribution and tariff collection.

Project to implement the water quantity monitoring system is proposed as Leakage Control Project in the Master Plan.

(4) Water Quality Control

A significant problem in the present operation is coloring of water by manganese which is supposed to be supplied from bottom sediment of water reservoirs during the dry season due to anaerobic condition. Existing treatment plants have a cascade oxidation process at the beginning of treatment process and occasionally apply oxidation by manganese dioxide. These treatments are somehow working and mitigating damages of coloring.

From viewpoint of water quality control of reservoirs, it is required to protect the water quality from the pollution and to take water from proper water layer. From a viewpoint of plant operation, this is a matter of a chemical cost. Monitoring of water quality and feedback of water quality to chemical dosing enable the optimum chemical dosing.

During the dry season, manganese concentration of raw water should be measured at least once a day and optimum dosing ratio should be established through pilot tests.

Another issue related to the water quality is a shortage of lime for pH adjustment. This happens depending on market conditions. Failing of pH adjustment causes less effective coagulation process, causing higher turbidity of treated water. Although this is rather matters related procurement, stable supply should be established by negotiating suppliers.

(5) Daily Operation and Maintenance Activities

List of daily operation and maintenance activities are provided in *Table 5.30.*

Table 5.30 Major Check Items for Operation and Maintenance Works

Facilities		Check Items	Frequency
Conduction		Pipe laying conditions	daily
Water Treatment Plant	Flow rate	Flow rate	hourly
	Water quality	Water quality	daily
	Chemical dosing rate	Chemical dosing rate	hourly, daily
	Equipment performance	Equipment performance	daily, weekly
		Test operation of emergency generators	weekly
Transmissiion	- Pipeline	Pipe laying conditions	daily
	- Pumping Stations	Flow rate	hourly
		Equipment performance	daily, weekly
		Test operation of emergency generators	weekly
Distribution	- Reservoirs	Water Level	hourly
		Flow rate	hourly
		Water quality	daily
		Equipment performance	daily, weekly
	- Pipeline	Pipe laying conditions	daily
	- Water Tank Lorries	Flow rate	daily
		Water quality	daily
		Equipment performance	daily, weekly

(6) Required Personnel

Required personnel for the operation of the proposed projects are shown in *Table 5.31*.

Table 5.31 Required Personnel for Operation of Proposed Projects

Facility	Director	Engineers	Operator	Others	Total
Quiebra Montes WTP	1	0	16	18	35
Pumping Stations	0	0	10	24	34
Leakage Conrol	1	0	14	1	16
Water filling station	3	2	10	24	39
Tank Lorry	0	0	222	8	230
Total	5	2	272	75	354

5.7 ORGANIZATION PLAN

5.7.1 PROPOSED ORGANIZATION STRUCTURE

Proposed organization structure is shown in *Figure 5.21*. The basic approaches are as follows.

- 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

5.7.2 STRENGTHENING OF KEY FUNCTIONS

(1) Reorganizing of Operation and Maintenance Department

It is necessary to achieve better coordination between operation and maintenance functions. Current organization structure for operation and maintenance is not strictly activity oriented. It is necessary to analyze required activities for operation and maintenance, and to reorganize organization based on the required activities.

The proposed Water Supply Department consists of the following sections.

- Production: Plant operation for each treatment plant and water quality analysis. For water quality analysis, a laboratory center will be established.
- Distribution: Operation of distribution facilities including leakage control and operation of pipeline database. Water distribution for developing communities by tank lorry is also operated by this section. The claim office will be established to cope with claims of leakage, water quality trouble, etc.
- Maintenance: Repair of pipelines and repair and overhaul of all types of installations. Preventive maintenance activities such as regular checks and lubrication of motors are duties of operators and out of scope of the maintenance section.

(2) Strengthening of Information Function

For the strengthening of the information function, the Information Department should be established in the Metropolitan Division with the following functions.

- 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.

Design of whole information network system and technical database requires clear concept and deep understanding of computer technology. The design stage may need intensive input of system specialists.

Internal monitoring for management is duty of the management of the division. A role of the Information Department in this issue is to design and maintain the information system.

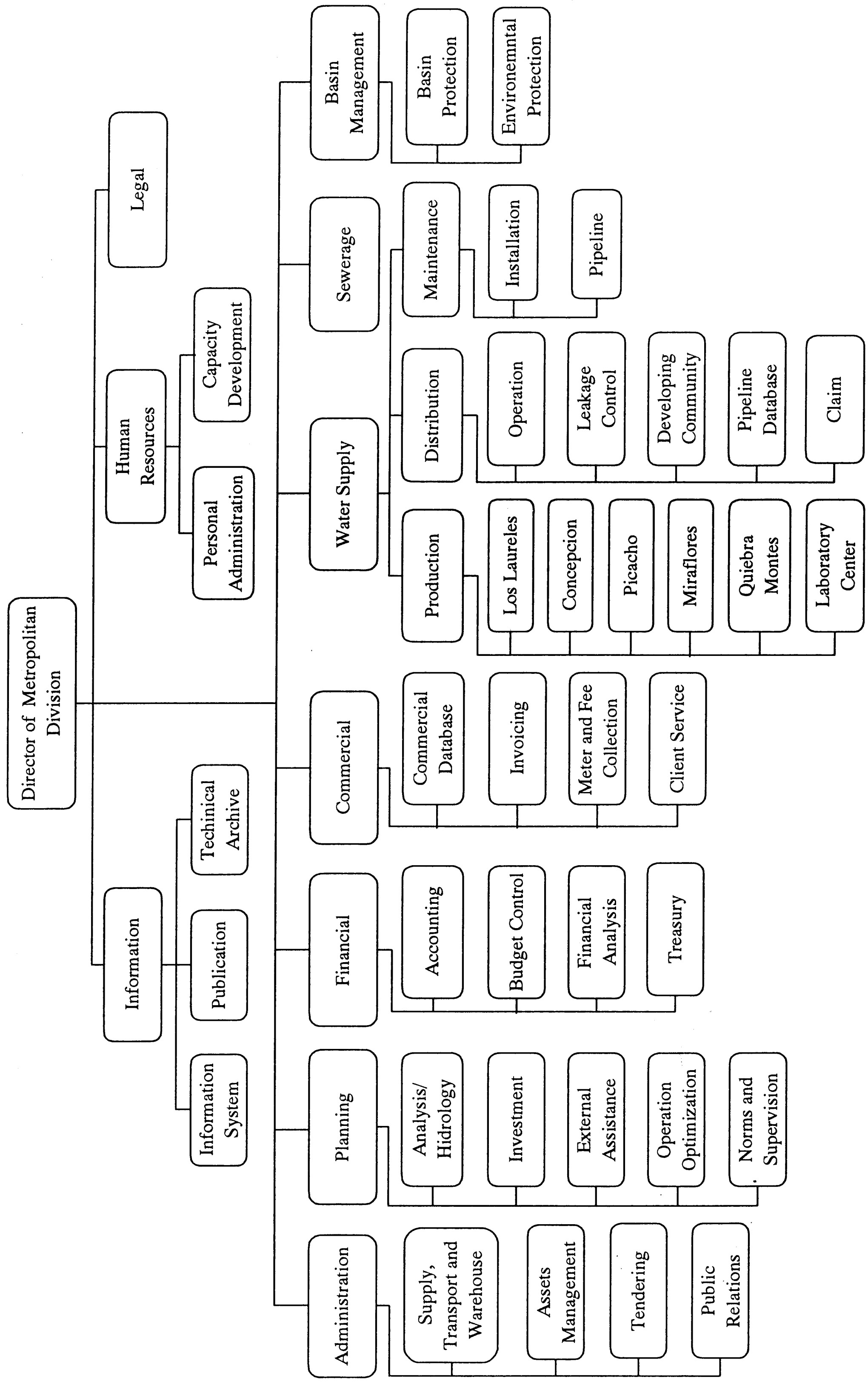

Figure 5.21	Proposed Organization Chart of SANAA Metropolitan Division

(3) Strengthening of Planning Function

The Planning Department shall have capability to analyze existing conditions and work out necessary actions towards service improvement, and prepare investment plans. Since a planning function of SANAA has been covered by external assistance, the Planning Department should be a window to foreign assistant agencies. Furthermore, the operation optimization of the whole water supply system will be done by the Planning Department.

(4) Strengthening of Commercial Function

Strengthening of commercial function should be achieved 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

Each step requires enormous amount of work and money. 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. Especially design of database and collection of necessary data need large input.

The preliminary implementation schedule is shown in *Table 5.32*.

Table 5.32 Preliminary Implementation Schedule for Commercial System

Work Items \ Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Analysis on existing conditions	*	*	*	*																				
Prepare Terms of Reference			*	*	*	*																		
Design of commercial system				*	*	*	*	*																
Design of commercial database						*	*	*	*	*														
Preparation of cartographic information						*	*	*	*	*	*	*	*											
Preparation of questionnaire survey											*	*	*											
Installation of commercial system											*	*	*	*	*	*	*							
Imprementation of the survey														*	*	*	*							
Data input, installation of commercial database																		*	*	*	*			
Training of operator																						*	*	*

According to the proposed Master Plan, the number of working micrometers will increase from current 40,000 to 120,000. It is also proposed to increase the number of meter reading staffs.

5.7.3 REQUIRED PERSONNEL

(1) Required Staff for Operation and Maintenance

The number of required staff for operation and maintenance is shown in *Table 5.33*. The required number of staff for the Water Supply Department is 961 persons including 470 persons for the developing community section which operates water filling stations and tank lorries. Exclusion of staff for developing communities shows that the required number of staff for water supply is 491 persons in the proposed Master Plan. This figure is almost 20% less than the existing level of 600 persons.

Table 5.33 Required Staff for Operation and Maintenance

Code	Department	Chief & deputy	Operator		Secretary	Unskilled Labor	Security guard		Cleaning	Driver	Total
9.0	**Management**	1			1				1	1	**4**
9.1	**Production**										**172**
9.1.0	Management	1			1						2
9.1.1	Los Laureles WTP	1	@4 x 4 shift x 1WTP	16	1	5	@2 x 4shift x 1WTP	8	2	2	35
9.1.2	Concepcion WTP	1	@4 x 4 shift x 1WTP	16	1	5	@2 x 4shift x 1WTP	8	2	2	35
9.1.3	Picacho WTP	1	@4 x 4 shift x 1WTP	16	1	5	@2 x 4shift x 1WTP	8	2	2	35
9.1.4	Miraflores WTP	1	@2 x 4 shift x 1WTP	8		2	@1 x 4shift x 1WTP	4	1	1	17
9.1.5	Quiebra Montes WTP	1	@4 x 4 shift x 1WTP	16	1	5	@2 x 4shift x 1WTP	8	2	2	35
9.1.6	Labolatory center	1		5	1	3			1	2	13
9.2	**Distribution**										**649**
9.2.0	Management	2			2				1	14	19
9.2.1	Operation	1			1						2
(1)	-Pumping stations		6 stations/team/day, 2 person/team	10			@1 x 4shift x 30stations	120			130
(2)	-Reservoirs		Existing 35, New 12	2							2
9.2.2	Leakage Control	1	@2 x 7 teams	14	1						16
9.2.3	Developing Community	1			1						2
(1)	-Water filling stations	4	@4 x 4 stations	16			@2 x 4shift x 4stations	32			52
(2)	-Water tank lorries		@2 x 204 lorries (->Driver)				@2 x 4shift x 1pool	8		408	416
9.2.4	Piipeline Data Base	1		3							4
9.2.5	Claim	1	8,000 clames/year	3	1					1	6
9.3	**Maintenance**										**136**
9.3.0	Management	2			2		@2 x 4 shift x 1site	8	3		15
9.3.1	Installation	1			1					8	10
(1)	-Machine			14		8					22
(2)	-Erectricity			6		8					14
(3)	-Instrument			5		3					8
(4)	-Civil & building			5		4					9
9.3.2	Pipeline	1			1					2	4
(1)	-Inspectioin		L=2,000km+300km 20km/day/team, 2 person/team	2		2					4
(2)	-Maintenance		5person/team x 5 teams	25		25					50
	Total										**961**

(2) Required Staff for the Metropolitan Division

The number of required staff for the Metropolitan Division is shown in *Table 5.34*. Required staff number for the departments other than water supply department is estimated based on the required function and the existing number of staffs.

Table 5.34 Required Number of Staff for Metropolitan Division

Name of department	Number of staff
Director and management of division	4
Informatioin	12
Human resources	10
Legal	6
Administratioin	49
Financial	16
Commercial	170
Planning	32
Water supply	961
Basin management	34
Sewerage	80
Total	1,374

5.8 COST ESTIMATE

5.8.1 CONSTRUCTION COSTS

Cost estimate of the construction costs were made by referring to the unit cost of similar projects such as Concepcion dam project, Conception water treatment plant project, Choloma Sabo project and SANAA's construction/installation works. Quantities of works for each project were estimated from the results of the aforementioned facility planning.

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 the 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 the direct construction cost
- Physical contingency: 10% of the total of direct construction cost, land acquisition cost and administration cost.

The estimated construction costs of the Master Plan is shown in *Table 5.35*.

Table 5.35 Estimated Construction Costs of the Master Plan

Item	Direct Construction Costs	Engineering Cost	Land Acquisition Cost	Administration Cost	Physical Contingency	Total
A. Los Laureles Project	**18,621,950**	**1,862,195**	**2,444,570**	**931,097**	**1,862,195**	**25,722,007**
1. Los Laureles II Dam	18,621,950	1,862,195	2,444,570	931,097	1,862,195	25,722,007
B. 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
(1) Conduction Facility	1,620,000	129,600	0	81,000	162,000	1,992,600
(2) Quiebra Montes WTP	42,175,000	3,374,000	187,500	2,108,750	4,217,500	52,062,750
(3) Transmission Facility	38,363,950	3,069,116	302,500	1,918,198	3,836,395	47,490,159
i) Pipeline	21,401,950	1,712,156	0	1,070,098	2,140,195	26,324,399
ii) Pumping Stations	16,492,000	1,319,360	302,500	824,600	1,649,200	20,587,660
iii) Expansion of LL reservoir	470,000	37,600	0	23,500	47,000	578,100
(4) Distribution Facility	58,675,500	3,990,540	472,000	2,933,775	5,867,550	71,939,365
i) Distribution reservoirs	12,105,500	968,440	422,000	605,275	1,210,550	15,311,765
ii) Distribution pipeline	32,500,000	2,600,000	0	1,625,000	3,250,000	39,975,000
iii) Water Tank Lorries	14,070,000	422,100	50,000	703,500	1,407,000	16,652,600
C. Leakage Control Project	**13,455,120**	**1,076,390**	**0**	**672,740**	**1,345,440**	**16,549,690**
1. Micrometer	10,670,000	853,600	0	533,500	1,067,000	13,124,100
2. Flow meter for WTP	129,850	10,390	0	6,490	12,970	159,700
3. Flow meter for P/S	490,270	39,200	0	24,500	48,970	602,940
4. Flow meter for Reservoirs	2,165,000	173,200	0	108,250	216,500	2,662,950
Total	**316,778,540**	**20,695,192**	**10,906,570**	**15,838,911**	**31,677,782**	**395,896,995**

(Unit: USD)

5.8.2 OPERATION AND MAINTENANCE COSTS

Operation and maintenance costs were calculated by each project. 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 5.36* are a summation of the whole period.

Table 5.36 Estimated Operation and Maintenance Costs

Los Laureles II Project	Quiebra Montes Project							Leakage Control Project	Total
	Dam	Los Laureles WTP	Conduction	Quiebra Montes WTP	Transmission	Distribution	Sub-total		
2,970,000	11,512,000	441,040	65,600	8,699,541	9,193,332	15,881,632	**45,793,145**	**1,201,335**	**49,964,480**

Note: Total operation and maintenance costs from 2001 to 2015 (Unit: USD)

5.9 IMPLEMENTATION PROGRAM

The Master Plan has three (3) objectives; to dissolve the present deficit of water supply, to provide for future demand increase and to improve leakage problems. The first objective is to address current problems people are suffering from, thus is of urgent nature.

Meanwhile, among the three, two projects are to increase the water supply capacity based on the specific development cost, Los Laureles II and Quiebra Montes Projects. The development capacities of each project are 160 l/s and 1,040 l/s, respectively, having a big difference in a scale of the development. The current deficit (after on-going projects) of the water supply is 675 l/s, the current deficit, therefore, can not be dissolved without Quiebra Montes Project.

Therefore, 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 5.37* and the balance between the required water production rate and water production capacity by the proposed implementation schedule is shown in *Figure 5.22.*

Item	Description	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Los Laureles II Project																	
- Dam	new																
Quiebra Montes Project																	
- Dam	new																
- Conduction facility	new																
- Quiebra Montes WTP	new																
- Transmission Facility																	
1) pipeline	new																
2) pumping stations	new																
3) expansion of Los Laureles clear water reservoir	new																
4) connection with Los Laureles WTP	new																
- Distribution Facility																	
1) distribution reservoirs	new																
2) distribution pipeline	new																
3) water filling stations	new																
4) tank lorries	new																
Leakage Control Project																	
- Installation of micrometers	expansion																
- Macrometer for existing WTP, P/S and distribution reservoirs	new																

[Note] : Preparation works
: Design works
: Construction works

Table 5.37 Implementation Schedule

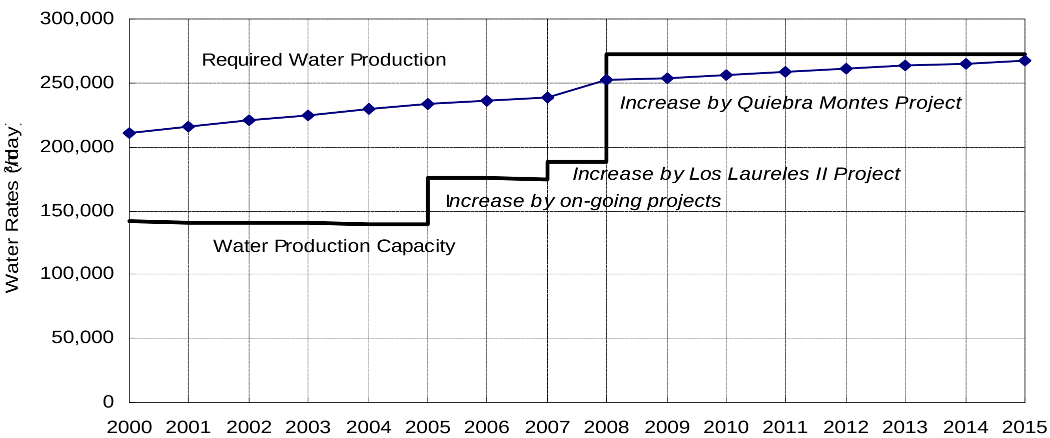

Figure 5.22 Required Production Rate and Water Supply Balance

5.10 FINANCIAL PLAN

5.10.1 BASIC POLICIES

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

- Transparency
- Financial autonomy
- Sustainability

Towards the above principles, the following policies were established.

(1) Policies for Transparency

The current financial statements are not enough transparent due to the following reasons.

- Retirement allowance reserves around USD 6 million have not been booked.
- The state government has totally absorbed SANAA's capital investments.
- Severe inflation has not been reflected.

In other words, it is impossible to evaluate actual financial conditions of SANAA based on the current financial statements. SANAA itself concerns these problems and just starts to reevaluation of fixed assets considering inflation. We recommend proceeding the efforts to make financial statements more transparent, with booking capital investments by the state government as a subsidy and severance allowance reserve. In this financial plan retirement allowance and capital investment is included in the financial analysis, and the input from the state government is booked as a subsidy.

(2) Policies for Financial Autonomy

Financial autonomy of SANAA requires the proper tariff which can cover the necessary cost for the service. Here, it should be noted that because the necessary cost depends on the water production, theoretically this 'proper' tariff regime should be based on the consumption. Thus, financial autonomy also requires installation of micrometers.

Generally speaking, this 'proper' tariff regime is actually not proper from the viewpoint of socio-economy. Water supply system is one of infrastructures and generally needs huge investment. Especially in Tegucigalpa, water source developments require enormous costs due to its topographic and meteorological conditions. A tariff covering all the cost including investment for water source development would levy an excessive heavy financial burden on users. Therefore, it is necessary to adjust the tariff level for users. The reduced amount can be regarded as a social cost. It is natural to assign this social cost to the state government.

In the Study it is assumed that 30% of the initial investment costs for the water source development, namely construction costs of Los Laureles II dam and Quiebra Montes dam, will be covered by subsidy from the state government as the social cost.

(3) Policies for Sustainability

Establishment of sustainability can be achieved by selecting adequate indicators of sustainability and monitoring them. Here monitoring means to simulate financial conditions with estimated parameters, to monitor indicators, and to feed back. Currently SANAA lacks concept of monitoring in these meanings. Thus it is necessary to introduce new financial planning method towards sustainability. The Study adopts a cash flow statement as a monitoring tool, and a net cash flow and a financial rate of return (FIRR) as indicators of sustainability. The criteria of sustainability are as follows.

- Accumulated amount of net cash flow is always positive during the evaluation period.
- FIRR exceeds 6.0 %, which is the real money rate of market in Honduras.

5.10.2 PLANNING PROCEDURES

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.

5.10.3 FINANCIAL COSTS

(1) Major Preconditions and Assumptions

Following preconditions and assumptions were applied in the financial plan.

- The financial plan deals with all the cost accrued by the Metropolitan Division.
- Currency unit is Lempiras and the value of Lempiras is expressed as the June 2000 prices.
- Evaluation period is 50 years since the start of project implementation.
- After the target year of 2015, the values of variables related to revenues and operation and maintenance costs are assumed to keep the 2015 level.
- Retirement allowance is estimated at 6 million USD. It is assumed that the amount would be paid over 20 years. In addition, annual increment of the retirement allowance is estimated as equivalent amount of personnel cost for one (1) month. As a result, the annual expenditure of the retirement allowance is estimated at USD 834,000.
- Initial investment costs will be covered by external loans.
- It is assumed that SANAA could issue bonds to cover financial deficit in short term. Interest rate of the bond is assumed at 5 %, and repayment period is assumed five (5) years from the next year of the issuance.

For the proposed projects in the Master Plan as well as IDB/1029 Project, the following loan conditions were assumed, based on the conditions of IDB loan.

- Repayment period : 40 years
- Grace period: 10 years (only for principal repayment)
- Interest rate : 1 % for the first 10 years and 2 % afterwards

For the remaining on-going projects, the following loan conditions were assumed.

- Repayment period : 40 years
- Grace period: 10 years (only for principal repayment)
- Interest rate : 1 %

Depreciation period is assumed as follows.

- Civil work : 40 years
- Pipe (DCI) : 35 years
- Machinery and electrical equipment : 20 years
- Tank lorry : 15 years

(2) Investment Costs

The investment costs for the proposed projects in the Master Plan were estimated in the previous section. The investment costs for the on-going projects were assumed as follows.

- IDB/1029 Project: USD 10 million, annually USD 2 million from 2001 to 2005
- World Bank Project: USD 5 million, annually USD 1 million from 2001 to 2005
- French Government Project: USD 8 million in 2001
- European Community Project: USD 2.43 million, annually USD 1,215,000 in 2001/2002

(3) Operation and Maintenance Costs

The operation and maintenance costs for the proposed facilities in the Master Plan were estimated in the previous section. The total operation and maintenance costs including the existing facilities were roughly estimated based on the past financial statements of SANAA and the expected water sales (production base) of each year, basically.

However, personnel cost is assumed based on the estimated staff number, which would increase from the existing number in 2000 to the proposed staff number of 1,374 in 2008, and fixed afterwards. Repair cost is assumed to increase 10 % annually.

5.10.4 STUDY ON TARIFF LEVEL

(1) General

The study on tariff level aims to estimate the tariff level enabling SANAA to operate the water supply service under sustainable condition. As a criterion of sustainability, an accumulated amount of net cash flow was applied. The said tariff level, with which the accumulated amount of net cash flow was always positive during evaluation period, was obtained by try and error. The said tariff level is expressed as how many times higher than the existing level.

In addition, the tariff levels based on the affordability and the willingness to pay of users were also studied.

(2) Existing Tariff Level

The existing tariff level was estimated based on the SANAA sales records, as shown in *Table 5.38*.

Table 5.38 Existing Tariff Level

User category	Revenue in 1999	Service quantity	Existing tariff level
Domestic	Lps. 58,201,330	852,271 persons	28.2 Lps/household/month
Non-domestic	Lps. 56,157,464	9,492,120 m^3/year	5.92 Lps/m^3

Source: SANAA sales records

In addition, the existing tariff level of tank lorry supply was estimated at 15 Lps/m^3, based on the result of field survey.

(3) Tariff Level based on the Affordability and Willingness to Pay of Users

The water utilization survey conducted in the Study provides the average monthly household income and the willingness to pay for the 24-hour water supply service with adequate quality and quantity of water. According to these results, the tariff level for domestic users based on the affordability and willingness to pay of domestic users are estimated as shown in *Table 5.39*.

Table 5.39 Domestic Tariff Level based on Affordability and Willingness to Pay

Social class	Affordability (Lps/HH/month)	Willingness to pay (Lps/HH/month)
S class	581.3	217.6
A class	345.5	217.6
M class	250.8	98.4
C class	117.3	98.4
B class	189.5	98.4
P class	149.1	86.8
T class	65.5	116.6
Domestic user*	129.5	110.7

Weighted average across the social classes

The applied affordable level of the domestic water and sewerage charge is 2.5 % of household income, according to the World Bank. The result shows that the estimated tariff levels based on the affordability and the willingness to pay are 4.60 times and 3.93 times higher than the existing tariff level for the domestic users, respectively.

The tariff level for non-domestic users based on the willingness to pay was estimated at 3.78 times higher than the existing tariff level. Since there is no data concerning affordability of non-domestic users, the same level as the willingness to pay of non-domestic users is applied as the affordable tariff level for non-domestic users.

(4) Study on Tariff Level based on Basic Policies

The proposed tariff level was determined by repeating calculation with changing tariff level until the following conditions were satisfied.

- The state subsidy covers 30 % of the initial investment costs of Los Laureles II dam and Quiebra Montes dam.
- Accumulated amount of net cash flow is always positive during the evaluation period.
- FIRR exceeds 6.0 %.

It is noted that the fee collection rate is assumed at 95 % in the cash flow statements. The existing collection rate against the invoicing amount is nearly 100 %, however, it is said that approximately 7,000 users were not invoiced. In addition, the tariff level is planned to be increased stepwise. In 2001, when the Master Plan starts, the tariff level rises 40 % according to the latest information from SANAA, and in 2004 the level rises up to 3.05 times higher than the current level according to the current SANAA's tariff proposal, then in 2008, when Quiebra Montes WTP is put in service, the tariff level rises to the level proposed by the Master Plan.

The determined tariff levels are 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.

5.10.5 PROPOSED FINANCIAL PLAN

FIRR with the determined tariff levels becomes 6.0 %. The cash flow statements of the proposed financial plan are shown in *Table 5.40*.

A sensitivity analysis on the proposed financial plan in terms of FIRR was conducted with 10 % variation of the costs and revenues. The results are shown in *Table 5.41*.

Table 5.40 Cash Flow Statements of Proposed Financial Plan

(Unit : USD)

Year	Revenue A	OM cost (incl. retirement benefit) B	Investment cost (incl. replace) C	Subsidy D	Cash flow before financing E=A-B-C+D	Loan F	Cash available before debt service G=E+F	Principal pay H	Interest pay I	Net cash flow J=G-H-I	Accumulated NCF K=Σ J	Bond issuance L	Principal pay M	Interest pay N	Accumulated NCF after bond issuance O=Σ(J+L-M-N)
2001	10,575,866	10,335,251	17,493,423	0	-17,252,808	14,581,520	-2,671,288	0	145,815	-2,817,103	-2,817,103	3,100,000		155,000	127,897
2002	13,335,083	10,373,408	13,035,411	1,192,574	-8,881,162	10,123,507	2,434,919	0	247,050	2,187,869	-629,234	0	620,000	155,000	1,540,766
2003	13,578,163	10,416,285	33,176,093	6,159,204	-23,855,011	30,264,190	12,568,382	0	549,692	12,018,690	11,389,456		620,000	124,000	12,815,456
2004	20,508,708	10,464,354	55,052,108	10,800,050	-34,207,704	52,140,205	28,732,551	0	1,071,094	27,661,456	39,050,912		620,000	93,000	39,763,912
2005	26,118,411	11,332,533	60,782,485	9,147,769	-36,848,838	57,870,582	30,169,514	0	1,649,800	28,519,714	67,570,626		620,000	62,000	67,601,626
2006	26,498,507	11,392,572	102,776,527	10,140,175	-77,530,417	99,864,624	32,474,382	0	2,648,446	29,825,936	97,396,562		620,000	31,000	96,776,562
2007	27,816,519	11,757,978	98,809,102	8,106,319	-74,644,242	95,897,199	29,359,276	0	3,607,418	25,751,858	123,148,420		0	0	122,528,420
2008	38,806,466	13,250,236	56,954,030	16,212,638	-15,185,162	54,042,127	55,069,603	0	4,147,840	50,921,764	174,070,184		0	0	173,450,184
2009	39,481,066	13,393,495	3,885,163	0	22,202,408	973,260	23,175,668	0	4,157,572	19,018,096	193,088,280		0	0	192,468,280
2010	40,156,053	13,545,587	4,735,163	0	21,875,303	1,823,260	23,698,563	0	4,175,805	19,522,759	212,611,038		0	0	211,991,038
2011	40,831,429	13,707,437	4,485,163	0	22,638,829	1,573,260	24,212,089	1,402,753	4,436,331	18,373,005	230,984,043		0	0	230,364,043
2012	41,507,193	13,880,062	5,085,163	0	22,541,967	2,173,260	24,715,227	8,264,834	6,515,509	9,934,884	240,918,927		0	0	240,298,927
2013	42,183,344	14,064,579	2,911,903	0	25,206,862	0	25,206,862	14,044,233	8,089,175	3,073,454	243,992,381		0	0	243,372,381
2014	42,859,884	14,262,218	2,911,903	0	25,685,763	0	25,685,763	14,044,233	7,813,433	3,828,096	247,820,477		0	0	247,200,477
2015	43,536,811	14,474,328	2,911,903	0	26,150,580	0	26,150,580	14,044,233	7,537,692	4,568,654	252,389,131		0	0	251,769,131
2016	43,536,811	14,474,328	4,471,903		24,590,580	0	24,590,580	14,044,233	7,261,951	3,284,396	255,673,527		0	0	255,053,527
2017	43,536,811	14,474,328	4,591,903		24,470,580		24,470,580	14,044,233	6,986,209	3,440,137	259,113,664		0	0	258,493,664
2018	43,536,811	14,474,328	7,625,023		21,437,460		21,437,460	14,044,233	6,710,468	682,758	259,796,423		0	0	259,176,423
2019	43,536,811	14,474,328	7,488,903		21,573,580		21,573,580	14,044,233	6,434,727	1,094,620	260,891,043		0	0	260,271,043
2020	43,536,811	14,474,328	7,608,903		21,453,580		21,453,580	14,044,233	6,158,985	1,250,361	262,141,404		0	0	261,521,404
2021	43,536,811	14,474,328	5,045,903		24,016,580		24,016,580	14,044,233	5,883,244	4,089,102	266,230,506		0	0	265,610,506
2022	43,536,811	14,474,328	5,045,903		24,016,580		24,016,580	14,044,233	5,607,503	4,364,844	270,595,350		0	0	269,975,350
2023	43,536,811	14,474,328	2,911,903		26,150,580		26,150,580	14,044,233	5,331,762	6,774,585	277,369,935		0	0	276,749,935
2024	43,536,811	14,474,328	4,101,903		24,960,580		24,960,580	14,044,233	5,056,020	5,860,326	283,230,261		0	0	282,610,261
2025	43,536,811	14,474,328	4,681,903		24,380,580		24,380,580	14,044,233	4,780,279	5,556,068	288,786,329		0	0	288,166,329
2026	43,536,811	14,474,328	15,008,903		14,053,580		14,053,580	14,044,233	4,504,538	-4,495,191	284,291,138		0	0	283,671,138
2027	43,536,811	14,474,328	25,602,903		3,459,580		3,459,580	14,044,233	4,228,796	-14,813,450	269,477,689		0	0	268,857,689
2028	43,536,811	14,474,328	2,911,903		26,150,580		26,150,580	14,044,233	3,953,055	8,153,292	277,630,980		0	0	277,010,980
2029	43,536,811	14,474,328	3,161,903		25,900,580		25,900,580	14,044,233	3,677,314	8,179,033	285,810,013		0	0	285,190,013
2030	43,536,811	14,474,328	2,911,903		26,150,580		26,150,580	14,044,233	3,401,572	8,704,774	294,514,788		0	0	293,894,788
2031	43,536,811	14,474,328	4,471,903		24,590,580		24,590,580	14,044,233	3,125,831	7,420,516	301,935,303		0	0	301,315,303
2032	43,536,811	14,474,328	4,591,903		24,470,580		24,470,580	14,044,233	2,850,090	7,576,257	309,511,561		0	0	308,891,561
2033	43,536,811	14,474,328	7,625,023		21,437,460		21,437,460	14,044,233	2,574,348	4,818,878	314,330,439		0	0	313,710,439
2034	43,536,811	14,474,328	7,488,903		21,573,580		21,573,580	14,044,233	2,298,607	5,230,740	319,561,179		0	0	318,941,179
2035	43,536,811	14,474,328	7,858,903		21,203,580		21,203,580	14,044,233	2,022,866	5,136,481	324,697,660		0	0	324,077,660
2036	43,536,811	14,474,328	5,045,903		24,016,580		24,016,580	14,044,233	1,747,124	8,225,222	332,922,882		0	0	332,302,882
2037	43,536,811	14,474,328	5,045,903		24,016,580		24,016,580	14,044,233	1,471,383	8,500,964	341,423,846		0	0	340,803,846
2038	43,536,811	14,474,328	2,911,903		26,150,580		26,150,580	14,044,233	1,195,642	10,910,705	352,334,551		0	0	351,714,551
2039	43,536,811	14,474,328	6,881,903		22,180,580		22,180,580	14,044,233	919,900	7,216,446	359,550,997		0	0	358,930,997
2040	43,536,811	14,474,328	13,981,903		15,080,580		15,080,580	14,044,233	644,159	392,188	359,943,185		0	0	359,323,185
2041	43,536,811	14,474,328	26,303,853		2,758,630		2,758,630	12,641,480	368,418	-10,251,268	349,691,917		0	0	349,071,917
2042	43,536,811	14,474,328	25,281,903		3,780,580		3,780,580	5,779,399	115,588	-2,114,407	347,577,510		0	0	346,957,510
2043	43,536,811	14,474,328	2,911,903		26,150,580		26,150,580	0	0	26,150,580	373,728,090		0	0	373,108,090
2044	43,536,811	14,474,328	6,017,403		23,045,080		23,045,080	0	0	23,045,080	396,773,170		0	0	396,153,170
2045	43,536,811	14,474,328	5,911,903		23,150,580		23,150,580	0	0	23,150,580	419,923,749		0	0	419,303,749
2046	43,536,811	14,474,328	35,952,903		-6,890,420		-6,890,420	0	0	-6,890,420	413,033,329		0	0	412,413,329
2047	43,536,811	14,474,328	38,247,903		-9,185,420		-9,185,420	0	0	-9,185,420	403,847,909		0	0	403,227,909
2048	43,536,811	14,474,328	7,625,023		21,437,460		21,437,460	0	0	21,437,460	425,285,369		0	0	424,665,369
2049	43,536,811	14,474,328	7,488,903		21,573,580		21,573,580	0	0	21,573,580	446,858,948		0	0	446,238,948
2050	43,536,811	14,474,328	7,608,903		21,453,580		21,453,580	0	0	21,453,580	468,312,528		0	0	467,692,528

Tariff level : 3.62 times higher than the exisitng level   Subsidy level : 30% of Dam Investment Costs   FIRR = 6.0%

Table 5.41 Results of Sensitivity Analysis of FIRR

Cost variation	Revenue variation		
	+10 %	0 %	-10 %
-10 %	9.9 %	8.0 %	6.1 %
0 %	7.7 %	6.0 %	4.2 %
+10 %	5.8 %	4.2 %	2.4 %

The results show that the sustainability of the proposed financial plan is solid with 10 % variation of the cost and revenue in terms of the accumulated amount of net cash flow.

5.11 SELECTION OF PRIORITY PROJECT

5.11.1 SELECTION CRITERIA

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

(1) Urgency

Taking into account the present water deficiency in the area, all three projects are urgent.

(2) Significance

Quiebra Montes Project occupies a large portion of the Master Plan and it is the most significant component of the Master Plan. Leakage Control Project, which provides only the monitoring system, has less significance in the recognition of project effects, while it would be essential for the leakage reduction program.

(3) Schedule

Los Laureles II Project has an advantage of schedule as there is no need of construction of conduction lines, treatment plants, transmission or distribution system. Leakage Control Project has also an advantage of schedule.

(4) Technical Aspect

No significant technical problems are anticipated for all three projects.

(5) Economic Aspect

When compared by specific cost, Los Laureles II dam has better position than Quiebra Montes Project and Leakage Control Project.

(6) Environmental Aspect

Los Laureles II dam has a disadvantage of 20 houses relocation. Regarding the natural environment, Quiebra Montes has the largest effect because of the large reservoir area.

Leakage Control Project will have no effect on the environmental conditions.

5.11.2 CONCLUSION

The comparison result is shown in *Table 5.42.* 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 5.42 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	Selected
Quiebra Montes Project	A	A	B	A	B	B	
Leakage Control Project	A	B	A	A	B	A	