Chapter 6
Evaluation of the Proposed Master Plan

CHAPTER 6
EVALUATION OF THE PROPOSED MASTER PLAN

6.1 GENERAL

The Study revealed the following facts in relation with the water supply of Tegucigalpa.

- There exists a water supply deficit between the present water supply capacity and the estimated required water production.
- Major constraint of the water production capacity is a water source capacity.
- The current water deficit will aggravate further due to the expected population growth.
- Leakage loss aggravates the water shortage by wasting treated water.
- Even if it is possible to reduce the leakage loss to the utmost limit, the estimated required water production rates at present and in future exceed the existing water source capacity and water production capacity.

Based on these findings, the Master Plan proposes following three (3) projects to dissolve the current deficit, to address the expected future demand increase and to improve the leakage problems for the conservation of precious water resource and for the prevention of wasting operation costs:

- Los Laureles II Project, which develops 160 l/s of water by constructing Los Laureles II dam with excavation of the existing Los Laureles reservoir and supplies the water by fully utilizing the existing water supply facilities.
- Quiebra Montes Project, which develops 1,040 l/s of water by constructing Quiebra Montes dam and increases and optimizes the water supply capacity by constructing a new water supply facilities and by reorganizing distribution and transmission systems.
- Leakage Control Project, which provides water measuring system through the whole system to obtain basis necessary for establishing the future cost effective leakage control measures.

Los Laureles II Project and Quiebra Montes Project physically secure the water production capacity built-up to address the water shortage at present and in future. Both projects involve dam constructions. Quiebra Montes Project, in particular, involves a considerably large scale dam construction, resulting in a huge project cost. Such a large scale project may cause a severe difficulty in the implementation of the Master Plan from the viewpoints of financial sources and environmental and social aspects. However, in the area where the rainy and dry seasons are distinctly separated and catchment areas of rivers are relatively small although there is a considerable rain fall, and moreover, availability of the groundwater is very limited, storing water in the wet season and using water in the dry season is the only one method to utilize surface water. Therefore, the dam construction is considered to be an imperative way of the water source development.

While the Study recognized importance of the leakage control, the Master Plan does not propose a countermeasure to reduce leakage loss actually. This is because available information about the actual conditions of leakage is very limited and they are not enough to estimate the effects and to assess the cost effectiveness with solid background. Therefore, the Master Plan proposes Leakage Control Project to install flow measuring devices throughout the system in order to obtain basic data required for leakage analysis, expecting that the cost effective countermeasures will be formulated based on the analysis in near future. This would be more realistic than to propose the countermeasures without solid background.

6.2 ECONOMIC ASPECT

6.2.1 ECONOMIC BENEFIT

In general, the expected economic benefits of water supply improvement projects are additional water uses which bring better economic activities, hygienic improvement such as decrease of infant mortality or morbidity of waterborne diseases, and so on. However, these kinds of economic benefits can not be expected as a result of the proposed Master Plan, because the review of the existing conditions reveals that the existing water supply service coverage exceeds 80 % and generally water quality is acceptable.

What can be expected as economic benefits of the proposed Master Plan is improvement of the water supply service level in Tegucigalpa. It is easy to describe this service level improvement in qualitative manner, that is, to increase service population and to realize 24-hour water supply with enough water pressure. On the other hand, to evaluate economic benefits of this improvement is far from easy. For example, when the water supply service duration will increase from 8 hours to 24 hours per day, apparently it is more convenient for the user. However, it is very difficult to evaluate economic benefit of this convenience, because a value of convenience is determined rather subjectively than objectively. To evaluate this type of subjective benefit, it is common to measure users' willingness to pay. Though this willingness to pay approach has a weakness in its accuracy, it is a useful method to evaluate this type of economic benefits.

In the Study, users' willingness to pay was estimated as one of the objectives of the water utilization survey. To estimate the additional economic benefits born by the Master Plan, willingness to pays for the existing service and the better service with 24-hour water supply were asked in the questionnaires. The estimated willingness to pays of the domestic users are shown in *Tables 6.1*.

Table 6.1 Estimated Willingness to Pay of the Domestic Users

Social class	For the Better Service (Lps/HH/month)	For the Exisitng Service (Lps/HH/month)	Additional willingness to pay (Lps/HH/month)
S and A	217.6	17.3	200.3
M, B, and C	98.4	4.9	93.5
P	86.8	5.6	81.2
T	116.6	2.2	114.4

The estimated willingness to pays of the non-domestic users for the better service and existing service are 3.87 times and 0.26 times of the existing tariff level, respectively. Thus, the additional willingness to pay become 3.61 times of the existing tariff level.

The estimated willingness to pay of the nonusers for the better service is 255.0 Lps/household/month. It is assumed that the nonusers do not have any willingness to pay for the existing service.

Annual economic benefits born by the proposed Master Plan were estimated by the following calculations.

- Domestic users: Annual economic benefit = $\Sigma (N_{Di} \times WTP_{Di})$
- Non-domestic users: Annual economic benefit = $T_{ND0} \times C_{ND} \times WTP_{ND}$
- New domestic users: Annual economic benefit = $N_N \times WTP_N$

Where,

N_{Di} : number of domestic users of social class i,
WTP_{Di}: additional willingness to pay of domestic users of social class i,
T_{ND0}: the existing tariff level for non-domestic users,
C_{ND}: annual water consumption of non-domestic users,
WTP_{ND} : additional willingness to pay of non-domestic users,
N_N : number of new domestic users in the extended pipe water service area, and
WTP_N: additional willingness to pay of the nonusers.

6.2.2 ECONOMIC COSTS

The economic costs of the proposed Master Plan were estimated based on the aforementioned cost estimates with the following preconditions and assumptions.

- Standard conversion factor was calculated at 0.9634 based on the import and export statistics and the existing tax and subsidy on import and export. The standard conversion factor was applied to all the costs except imported goods.
- Import tax for chemicals (16%) and fuels (5%) were deducted from chemical and fuel costs.
- Income tax of 10 % was deducted from personal costs.
- Adjustment factor for personal costs of unskilled laborers was not applied.
- The real exchange rate is assumed to be fixed because so far the government has not introduced any special protective measure for trade and its currency.

6.2.3 RESULTS OF ECONOMIC EVALUATION

Based on the economic benefits and economic costs of the Master Plan, the economic internal rate of return (EIRR) was calculated 8.0 %. A calculation sheet of EIRR is shown in *Table 6.2*. Since the opportunity cost of capital (OCC) is assumed 4 % based on a real yield of the Honduran state bond, the calculated EIRR of 8.0 % indicates that the proposed Master Plan is viable from the economic viewpoint.

A sensitivity analysis on EIRR of the proposed Master Plan was conducted with 10 % variation of the economic costs and benefits. The results are shown in *Table 6.3*.

Table 6.3 Results of Sensitivity Analysis of EIRR

Economic cost variation	Economic benefit variation		
	+10 %	0 %	-10 %
-10 %	10.2 %	9.1 %	8.0 %
0 %	9.0 %	8.0 %	6.9 %
+10 %	8.0 %	7.0 %	6.0 %

It is confirmed that the proposed Master Plan is economic viable even under the severest condition with 10 % increased economic costs and 10 % decreased economic benefits.

Table 6.2 EIRR of Master Plan

(Unit: USD)

Year	Economic benefits	Economic costs	Cost benefit stream	Present value		
				Benefits	Costs	NPV
2001	0	2,435,236	-2,435,236	0	2,341,573	-2,341,573
2002	0	6,038,827	-6,038,827	0	5,583,235	-5,583,235
2003	0	27,052,399	-27,052,399	0	24,049,484	-24,049,484
2004	0	48,636,128	-48,636,128	0	41,574,366	-41,574,366
2005	0	54,767,379	-54,767,379	0	45,014,794	-45,014,794
2006	0	98,905,709	-98,905,709	0	78,166,618	-78,166,618
2007	0	95,622,174	-95,622,174	0	72,664,994	-72,664,994
2008	40,807,229	57,883,809	-17,076,580	29,817,442	42,295,132	-12,477,690
2009	41,331,515	5,988,547	35,342,969	29,038,974	4,207,473	24,831,501
2010	41,856,194	6,926,760	34,929,433	28,276,545	4,679,471	23,597,074
2011	42,381,264	6,814,614	35,566,650	27,530,061	4,426,644	23,103,418
2012	42,906,727	7,571,355	35,335,373	26,799,415	4,729,046	22,070,370
2013	43,432,583	5,437,838	37,994,745	26,084,484	3,265,825	22,818,659
2014	43,958,831	5,424,811	38,534,019	25,385,129	3,132,693	22,252,436
2015	44,485,471	5,458,993	39,026,477	24,701,203	3,031,185	21,670,018
2016	44,485,471	7,018,993	37,466,477	23,751,156	3,747,498	20,003,659
2017	44,485,471	7,138,993	37,346,477	22,837,650	3,664,968	19,172,682
2018	44,485,471	9,087,333	35,398,138	21,959,279	4,485,763	17,473,516
2019	44,485,471	9,087,333	35,398,138	21,114,692	4,313,234	16,801,458
2020	44,485,471	10,223,866	34,261,604	20,302,588	4,666,039	15,636,549
2021	44,485,471	8,409,478	36,075,993	19,521,719	3,690,361	15,831,358
2022	44,485,471	8,409,478	36,075,993	18,770,884	3,548,425	15,222,459
2023	44,485,471	5,458,993	39,026,477	18,048,927	2,214,857	15,834,070
2024	44,485,471	6,811,493	37,673,977	17,354,737	2,657,310	14,697,428
2025	44,485,471	7,716,493	36,768,977	16,687,247	2,894,586	13,792,661
2026	44,485,471	17,979,803	26,505,668	16,045,430	6,485,121	9,560,309
2027	44,485,471	28,528,276	15,957,195	15,428,298	9,894,079	5,534,220
2028	44,485,471	5,458,993	39,026,477	14,834,902	1,820,451	13,014,451
2029	44,485,471	5,699,843	38,785,627	14,264,329	1,827,663	12,436,666
2030	44,485,471	5,458,993	39,026,477	13,715,701	1,683,110	12,032,592
2031	44,485,471	7,018,993	37,466,477	13,188,174	2,080,853	11,107,322
2032	44,485,471	7,138,993	37,346,477	12,680,937	2,035,027	10,645,910
2033	44,485,471	9,087,333	35,398,138	12,193,208	2,490,785	9,702,423
2034	44,485,471	9,087,333	35,398,138	11,724,239	2,394,986	9,329,253
2035	44,485,471	10,464,716	34,020,754	11,273,306	2,651,921	8,621,385
2036	44,485,471	8,409,478	36,075,993	10,839,718	2,049,127	8,790,591
2037	44,485,471	8,409,478	36,075,993	10,422,806	1,970,314	8,452,491
2038	44,485,471	5,458,993	39,026,477	10,021,928	1,229,832	8,792,097
2039	44,485,471	9,236,756	35,248,715	9,636,470	2,000,872	7,635,598
2040	44,485,471	15,952,281	28,533,190	9,265,836	3,322,685	5,943,151
2041	44,485,471	28,163,759	16,321,711	8,909,458	5,640,579	3,268,879
2042	44,485,471	27,147,105	17,338,365	8,566,786	5,227,852	3,338,935
2043	44,485,471	5,458,993	39,026,477	8,237,295	1,010,832	7,226,463
2044	44,485,471	8,630,534	35,854,937	7,920,476	1,536,635	6,383,841
2045	44,485,471	8,853,163	35,632,307	7,615,842	1,515,647	6,100,194
2046	44,485,471	38,281,881	6,203,590	7,322,925	6,301,728	1,021,197
2047	44,485,471	40,773,681	3,711,790	7,041,274	6,453,762	587,512
2048	44,485,471	9,806,235	34,679,236	6,770,456	1,492,458	5,277,998
2049	44,485,471	9,806,235	34,679,236	6,510,054	1,435,055	5,074,998
2050	44,485,471	10,223,866	34,261,604	6,259,667	1,438,627	4,821,040
Total	1,898,151,283	854,862,748	1,043,288,535	678,671,648	451,035,574	227,636,074

EIRR= 8.0%

OCC= 4%

6.3 FINANCIAL ASPECT

The following basic principles applied in the proposed financial plan are also criteria to evaluate the Master Plan from the financial aspect.

- Transparency
- Financial autonomy
- Sustainability

Transparency is evaluated by whether it is possible to assess the financial conditions of the Metropolitan Division based on the financial statements. We conclude that the proposed financial plan, which requires to introduce inflation accounting and to book government subsidy and retirement allowance reserves in the financial statements, will enable third party to assess the abovementioned conditions.

Financial autonomy largely depends on the decision of state government. It is concluded that the proposed Master Plan can achieve the financial autonomy of SANAA on condition that the state government will approve the tariff regime proposed in the Master Plan.

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

6.4 MANAGERIAL ASPECT

Although there are big discussions concerning future organization form of SANAA, a direction of decentralization seems to be agreed by all the relevant parties. Decentralization is one of the evaluation criteria.

The discussions concerning future organization form of SANAA in fact get caught in a vicious circle. To solve the existing managerial problems municipalization or privatization is called for, however the same problems obstruct to implement these structural reforms. Therefore, we select another criterion of managerial evaluation as flexibility of organization structure.

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

The proposed organization plan and financial plan are prepared with taking into consideration of future municipalization and privatization. The proposed Master Plan will prepare the foundation of future privatization, and when it will be implemented a privatization will be not a solution of managerial problems but an option to pursue better service efficiency.

For the evaluation of service efficiency, a number of users per one staff is widely adopted as an evaluation criterion. *Table 6.4* shows the result of service efficiency evaluation by this criterion.

Table 6.4 Number of Service Users per One Staff

Item	Year 2000			Year 2015			Improvement (%)		
	Pipe	Tank lorry**	Total	Pipe	Tank lorry**	Total	Pipe	Tank lorry	Total
Staff number*	962	36	998	824	470	1,294	51.1	-1,206	-23.3
User number	854,271	66,706	920,977	1,150,348	210,459	1,360,807	34.7	215.5	47.8
Number of users per staff	**888**	**1,853**	**923**	**1,396**	**448**	**1,052**	**57.2**	**-75.8**	**14.0**

*: Staff number of SANAA Metropolitan Division excluding the sewerage department. In case of year 2000, it includes the number of staff in headquarters who exclusively works for metropolitan division.

**: Staff number for tank lorry means the staff number of developing community unit. It should be noted that there are a lot of private tank lorry operators which are not counted here.

Table 6.4 shows that the service efficiency of the metropolitan division increases 14%. According to the proposed organization plan, number of users per staff for pipe water supply reaches 1,396 persons/staff, which is 57 % increase from the present 888 persons/staff.

The Study also analyzed staff requirement for new staff. *Table 6.5* summarizes the comparison of staff requirement of the existing organization and planned organization.

Table 6.5 Comparison of Staff Requirement

Level of staff	Current organization*	Proposed organization	Increment
Executive and chief level	62 (29**)	79	17
Administrtor and technician level	167 (129**)	289	122
Un-skilled labor level	849 (674**)	1,006	157
Total	1,078 (832**)	1,374	296

* : Applied information from SANAA Human Resource Department, April 2000. This figure includes a part of headquarters staff who exclusively works for the metropolitan division.

**: Number of staff who currently belongs to the metropolitan division.

The proposed organization plan requires new staffs of all levels. Therefore, the optimization of the organization will not need personnel downsizing.

Based on the above discussions, it is concluded that the proposed Master Plan is viable from the viewpoint of managerial aspect.

6.5 TECHNICAL ASPECT

SANAA has a plenty of experience in construction of water supply facilities including dams, conduction lines, treatment plants, transmission lines, and distribution pipes. On the other hand, the structural scale of the dams and water supply facilities in the Mater Plan is not so large and SANAA has construction experiences both in a concrete gravity dam and a rockfill dam with significant scales. Therefore, the Master Plan is viable in construction techniques.

SANAA has also abundant operation and maintenance experiences in water supply facilities. Operation technique of dam gates is also familiar with SANAA. The existing Los Laureles dam is equipped with a rubber gate for eight (8) years and there is a plan of gate installation at Concepcion dam. When Los Laureles II dam and Quiebra Montes dam are completed SANAA has to operate four (4) dams, among which three (3) dams are equipped with gates. This complexity of operation is inevitable considering the scarceness of water sources compared to the increasing demand. SANAA has to accumulate the experience of operation of four (4) dams during both dry and rainy season.

In the Master Plan, the evaluation of water sources was made in consideration of the driest month of the driest year once in 10 years. Thus, for example, the water source capacity of Picacho subsystem is evaluated as 350 l/s while the production capacity of Picacho WTP is 900 l/s. Therefore, by optimizing the operation of the integrated system including four (4) dams (Quiebra Montes, Los Laureles II, Los Laureles, and Concepcion) and four (4) treatment plants (Quiebra Montes, Los Laureles, Concepcion, and Picacho), it may be possible to increase the supply capacity of the system. This point should be studied further in future.

6.6 ENVIRONMENTAL AND SOCIAL ASPECT

6.6.1 ENVIRONMENTAL ASPECT

From the view point of water resources potential, the Guacerique River basin is the most reliable and essential source of water. Both two (2) projects proposed in the Master Plan are in the basin of the Guacerique River.

However, because of comparatively flat topography and convenient transportation condition, housing development and private irrigation are proceeding with uncontrolled manner and there is a danger of deterioration of water sources in terms of both quality and quantity.

In the proposed Master Plan, importance of preservation of water source in the basin was highlighted as follows.

(1) Ciudad Mateo Project

The difficulty of securing scarce water resources was recognized in the Study and the suspension of the Ciudad Mateo project was evaluated as a very wise decision considering the tremendous impact of the project to the water source policy of Tegucigalpa. As this Master Plan is based on the assumption that the Ciudad Mateo project is suspended as it is now, a regional development program should be formulated to integrate both this water supply master plan and housing development master plan of Tegucigalpa.

(2) Non Authorized Water Intake

In the Study, non-authorized water intake by the military base and private irrigation were identified in the Guacerique River basin. According to “Law of National Waters Exploitation”, it is possible for SANAA to claim the illegality of the deed and force them to stop the intake in order to preserve quantity of water.

(3) Water Quality

The present values of water quality in the tributaries of the basin mostly satisfies the water quality standard by Ministry of Health except some locations, where particular entities discharge waste water. By enforcing the Law of National Water Exploitation, this problem could be solved and water quality in the future will be maintained.

(4) Precious Flora and Fauna

In a literature review of this Study, existence of eight (8) flora and 10 fauna threatened or endangered species in the Guacerique River basin, was identified. This fact helps to proceed the projects in feasibility study stage, detail design stage and implementation stage. For the priority project of Los Laureles II Project, none of these precious species will be directly affected. When Quiebra Montes Project is studied further for feasibility, this information should be appreciated and detail field survey should be conducted.

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

6.6.2 SOCIAL ASPECT

The implementation of Los Laureles II Project requires relocation of 20 houses and compensation for private land such as agricultural land. SANAA has experience of relocating 34 houses for Concepcion dam project in 1992. Since the scale of necessary house relocation for Los Laureles II Project is smaller than that in the previous Concepcion dam project, it is concluded that the proposed Master Plan will not create a serious social problem. In addition, the experience of Concepcion dam will help SANAA to make a better relocation plan to mitigate the difficulty of the people who are obliged to move.

Therefore, it is concluded that the proposed Master Plan is viable from the social point of view.

6.7 REQUIREMENTS FOR THE REALIZATION OF THE MASTER PLAN

As described above, the proposed Master Plan will dissolve the current water shortage and address the expected water shortage in the future and, moreover, the Master Plan has been judged to be viable from viewpoints of economic, financial, managerial, technical environmental and social aspects.

Nevertheless, it is foreseen there would be a severe difficulty in the realization of the Master Plan. A concern over the possibility of the realization mainly comes from a size of the project costs for Quiebra Montes Project. Judging from a scale of the Honduran economy, possible financial sources for the Project could be loans from foreign financing organizations, such as World Bank and IDB. However, they do not have a financial instrument that can cover such a large scale of project costs in general. Therefore, SANAA and the state government have to accomplish special financing instruments or joint financing with other donors through enduring negotiations.

Although the Master Plan could give theoretical basis to persuade the financing organizations, they could require the practical basis, such as financial capability that are proven by policies of tariff setting, efficiency of tariff collection, and effective organization and managerial functions. Therefore, the implementation of the organization plan and financial plan proposed in the Master Plan, and establishment of the policy for the subsidy covering parts of the construction costs by the state government or the Municipality are considered to be the minimum requirements for the realization of the Master Plan. In particular, the implementation of the proposed financial plan, which increases the tariff level by 3.62 times ultimately, is the essential requirement that not only enables the plan feasible but also shows SANAA’s executive abilities.

Chapter 7
Feasibility Study for the Priority Projects

CHAPTER 7
FEASIBILITY STUDY FOR THE PRIORITY PROJECTS

7.1 FACILITY PLANNING

7.1.1 GENERAL

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

- Construction of Los Laureles II dam.
- Excavation of the existing Los Laureles Reservoir.

After the selection of the project, reservoir survey of the existing Los Laureles reservoir and environmental investigation were conducted by local consultants.

By using the result of the survey and the investigation, Los Laureles II dam construction and Los Laureles reservoir excavation were studied further to assess the feasibility of the project.

Main points of the facility planning are as follows:

- Detail layout of the dam body,
- Stability of the dam body,
- Hydraulic feature of the spillway,
- Sedimentation plan,
- Hydraulic effect of the dam,
- Compensation works,
- Related facilities, and
- Sediment excavation plan based on the reservoir survey result.

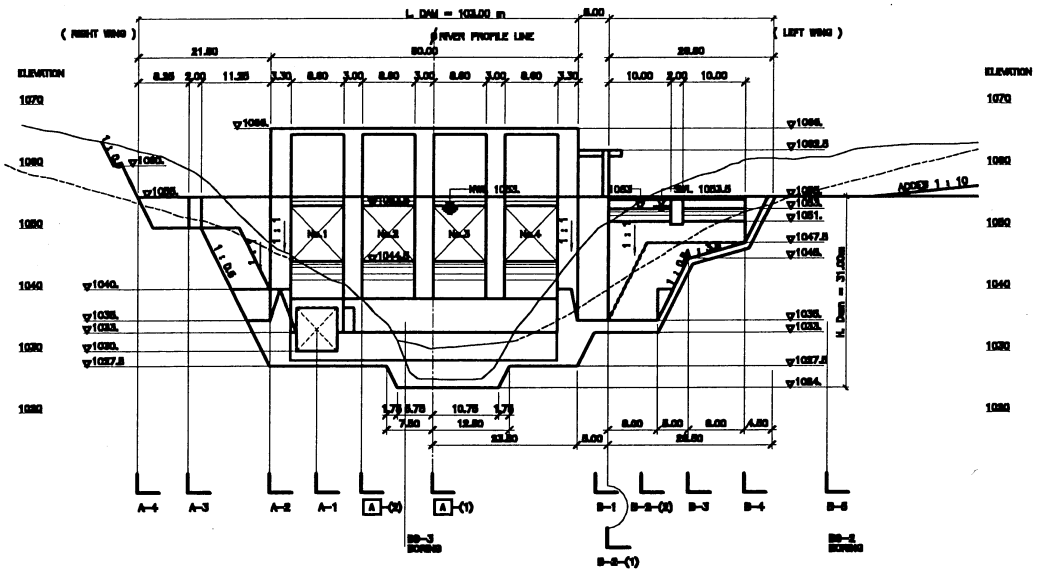
7.1.2 LOS LAURELES II DAM CONSTRUCTION

(1) General Plan

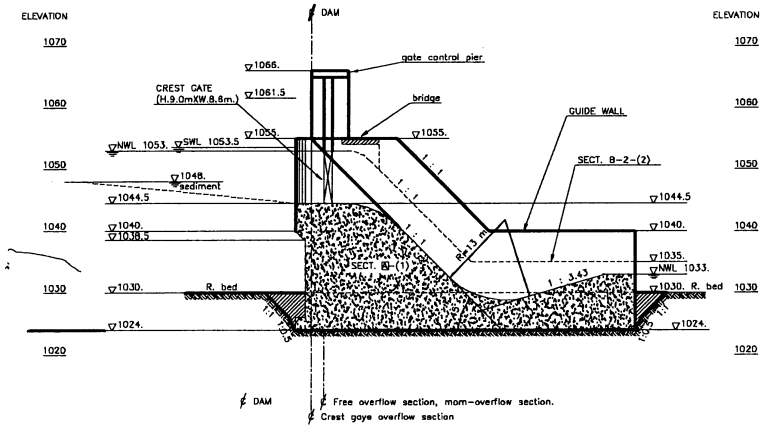
Detail study was made on the layout of the dam body. *Figure 7.1* shows the profile and standard section of the dam, and *Figure 7.2* shows the plan of the dam. *Figure 7.3* shows the water level and storage volume relationship (H-V curve) of the reservoir. Features of the dam and the reservoir are as follows:

Features of the reservoir

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



PROFILE (DOWN STREAM'S VIEW)



STANDARD SECTION

Figure 7.1	Profile and Standard Section of Los Laureles II Dam

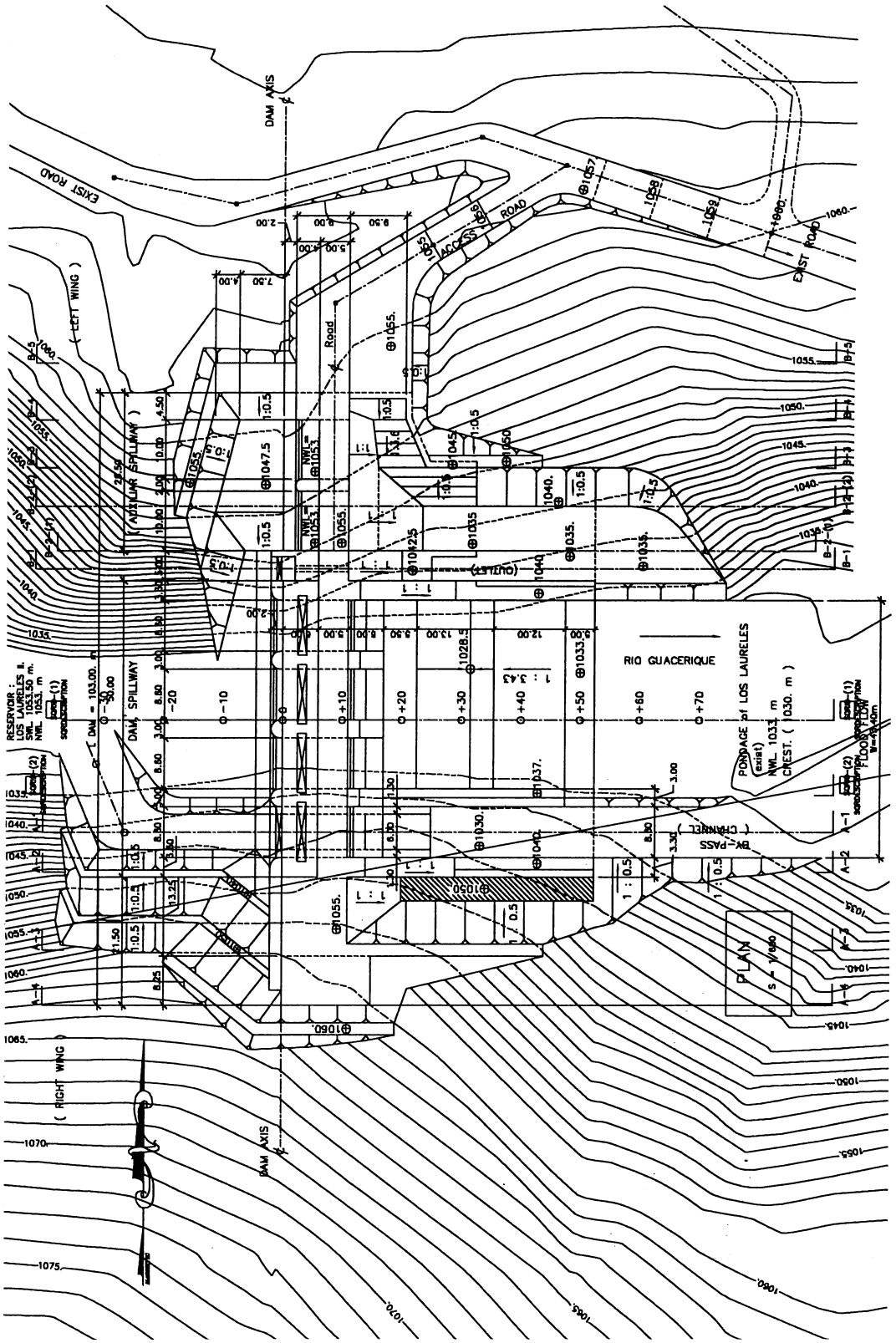


Figure 7.2	Plan of Los Laureles II Dam

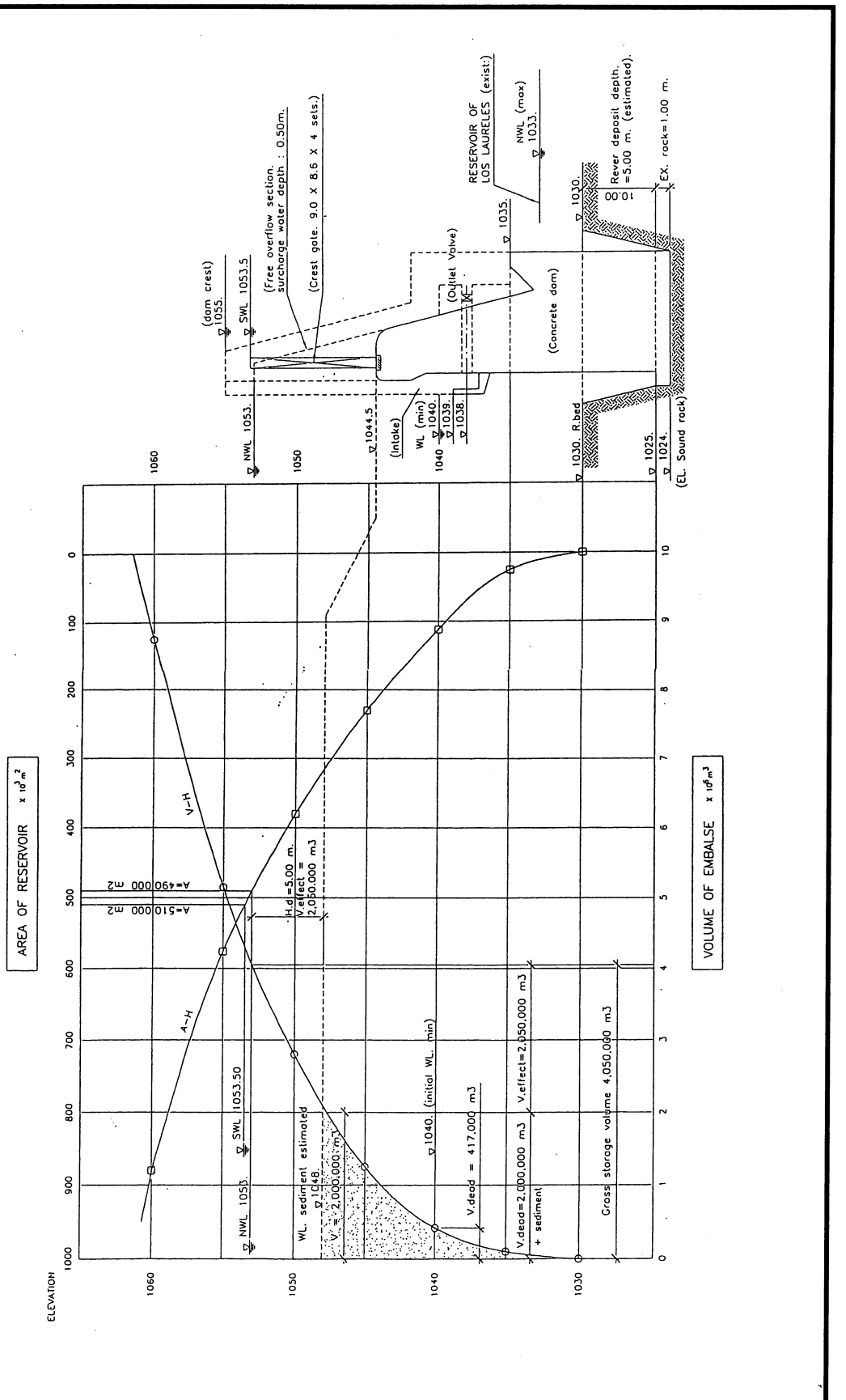


Figure 7.3 | **H-V Relationship of Los Laureles II Reservoir**

Features of the dam

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

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

(2) Stability Analysis

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

Strength of the foundation rock

According to the field reconnaissance and the unconfined compression test of the boring sample of the foundation rock, it is estimated that the shearing strength of the foundation rock is in the range of 80 t/m^2 and 120 t/m^2. Taking a conservative side, the design strength of the foundation rock is determined as shearing strength τ_0 = 80 t/m^2 and angle of internal friction f = 40°.

Design seismic acceleration

There is a study of expected accelerations at various cities in Honduras. For the design seismic acceleration, the value with 100 year-expectation is adapted as seismic coefficient k_h = 0.077 G.

Safety factor of stability

The safety factor against sliding is designed 3 for usual conditions and 1 for an extreme condition, according to the “Design Criteria for Concrete Arch and Gravity Dams”, United States Department of the Interior Bureau of Reclamation.

The result of stability calculation shows that the design satisfies the required safety factor.

(3) Hydraulic Analysis of Stilling Basin

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

(4) Sedimentation Plan

According to the latest survey of the existing Los Laureles reservoir, the total sedimentation between 1974 and 2000 is 3,000,000 m^3. As the catchment area of the reservoir is 194 km^2, the specific sediment run-off of the basin is calculated as 600 m^3/ km^2/year.

According to the Master Plan, Quiebra Montes dam will be constructed one year after Los Laureles II dam. Therefore, the catchment area of Los Laureles II reservoir will be reduced that much to 190 km^2 after one (1) year and it makes the burden of sedimentation less.

Thus, the design sedimentation into Los Laureles II dam is calculated as follows:

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

Among the total estimated sediment, a part of it is to be taken out from the reservoir periodically in order to prolong the life span of the reservoir. For that purpose, a sediment control structure is proposed in the middle of the reservoir so that periodical hauling of sediment becomes easier. The sediment trap structure was planned 3.8 km upstream from the Los Laureles II dam site. The features of the structure are described as follows:

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

(5) Hydraulic Effect of Dam

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

- The water level at Mateo Bridge will be higher by the effect of the dam in the case of a flood with a scale of Hurricane Mitch but the effect is very small.
- A land to be acquired was shown according to the hydraulic calculation in the case of a flood with a scale of Hurricane Mitch.

(6) Water Yield

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.

(7) Compensation Works

The construction of the dam body and the reservoir requires relocation works as compensation. One of the main compensation works is a road relocation 1.6 km upstream from the dam site. As the elevation of the existing road is lower than the normal maximum water level of 1053.0m, it is necessary to raise the elevation of the road.

Another compensation work is relocation of a pumping station owned by military base. As the pumping station is located 0.5 km upstream from the dam site, it should be moved to lower reach of the dam in order to maintain its function.

(8) Related Facilities

Simple water treatment facilities are proposed at one of the tributaries of the Guacerique River. The structure will improve the quality of the inflow water with a minimum cost and will become a pilot project to cope with future deterioration of the inflow water quality.

The features of the facilities are as follows:

- Location : On one of the tributaries of the Guacerique River
- Structure : Concrete box with water treatment devices

7.1.3 SEDIMENT EXCAVATION

(1) Sediment Distribution in the Reservoir and River

According to the reservoir survey of the existing Los Laureles reservoir and the planned Los Laureles II reservoir, the distribution of sediment is as shown in *Figure 7.4*. The figure shows almost no sediment above 1025.0 m. On the other hand there is around 3,000,000 m^3 of sediment below 1025.0m.

(2) Quality of Sediment

The quality of the sediment was analyzed in the Study. The results show that the sediment in the river course can be used as concrete aggregate or construction materials while the sediment in the existing Los Laureles reservoir is fine silt and difficult to use for concrete aggregate.

(3) Excavation Plan

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

In this plan the amount of sediment excavation is 600,000 m^3 including sediment material in the existing Los Laureles reservoir and river bed material in the planned Los Laureles II reservoir. The proposed location of sediment excavation is shown in *Figure 7.5*.

(4) Water Yield

The excavated volume becomes the effective storage volume as it is. The water yield calculation shows that the water yield by the project is 30 l/s compensating the ongoing sedimentation in the existing Los Laureles reservoir.

7.2 OPERATION AND MAINTENANCE

7.2.1 OPERATION PLAN

(1) General

After the completion of Los Laureles II dam, it is necessary to operate the existing Los Laureles dam and the new Los Laureles II dam simultaneously. The operations during dry season and rainy season are basically different. The operation during dry season mainly focuses on how to preserve water storage and supply water effectively. On the other hand, the operation during rainy season has to include the emergency operation during flood and to show how to operate the gate effectively in order to secure the safety of the structure.

(2) Operation Rule during Dry Season

The existing Los Laureles reservoir and the new Los Laureles II reservoirs have to be operated systematically so that they will fully utilize their storage volume. When several reservoirs are located in on river system, the principle of their operation rule during dry season is as follows:

- A reservoir at lower side should be used first
- The reservoirs are operated such that the ratio between the vacant storage volume and the catchment area becomes equal among the reservoirs

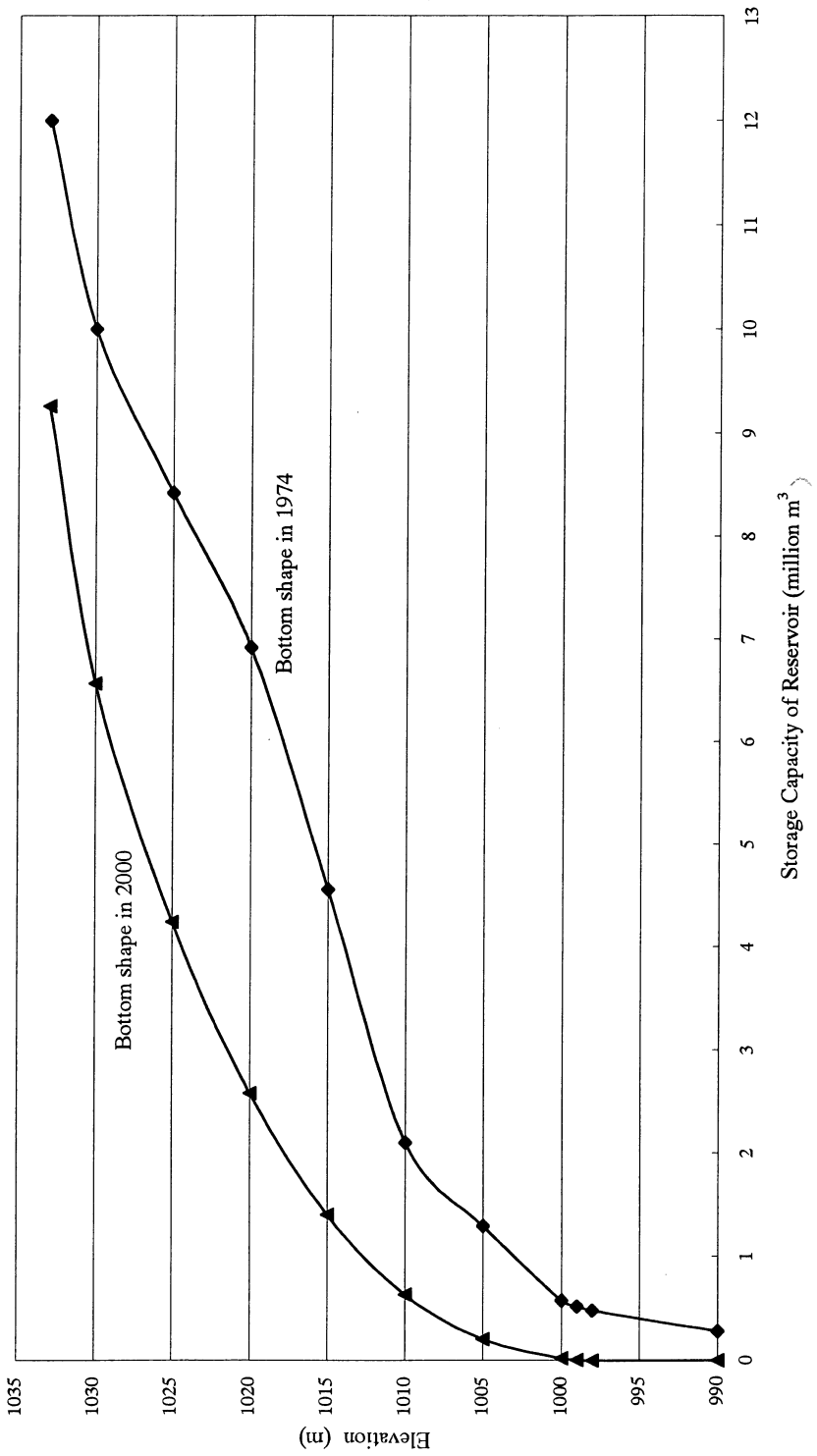


Figure 7.4	Sediment Distribution In Los Laureles Reservoir

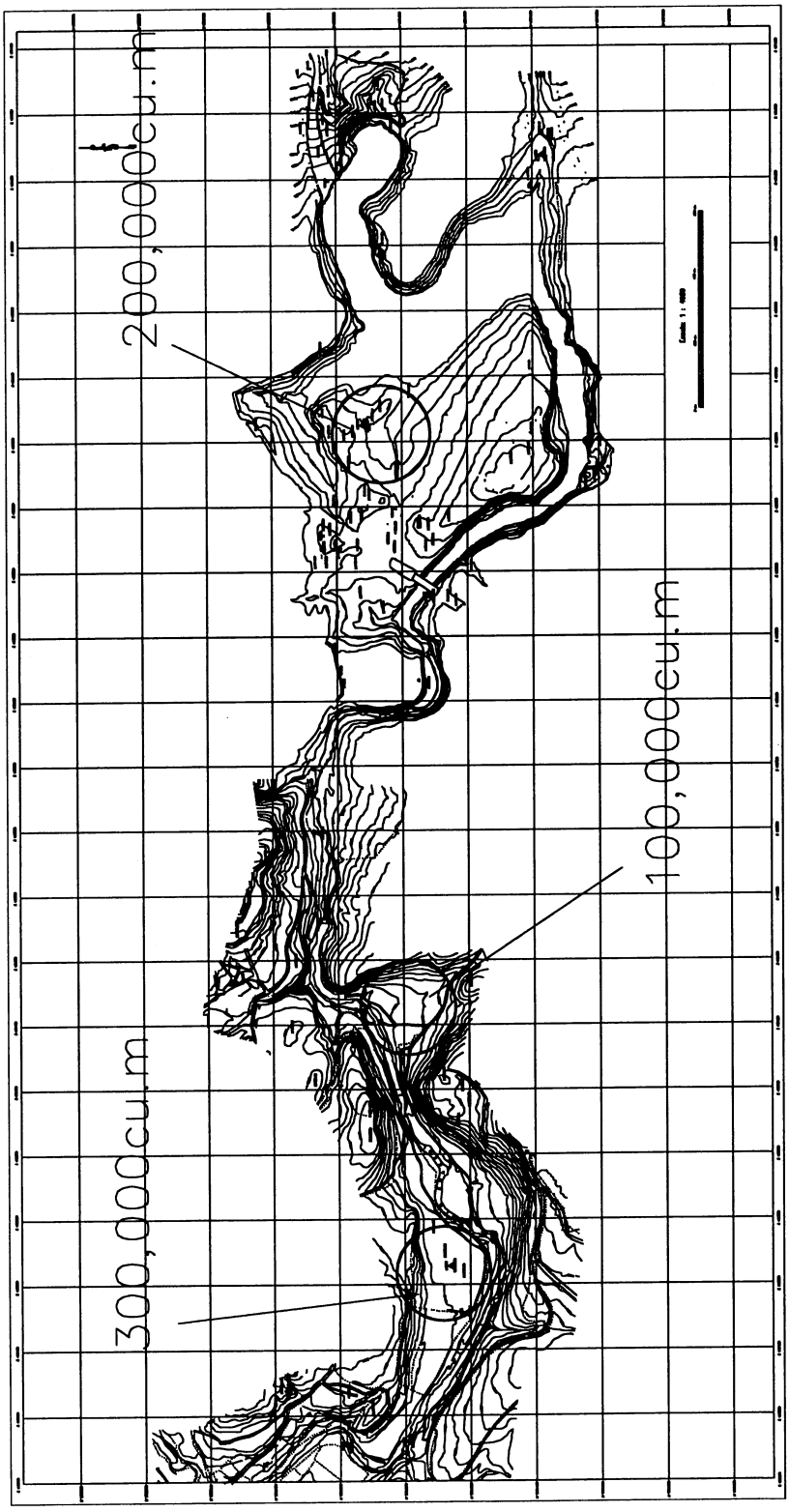


Figure 7.5	Location of Sediment Excavation

As Los Laureles and Los Laureles II reservoirs are located at almost same place and the catchment areas are almost same and the water is taken from the Los Laureles reservoir. Therefore, all the gates and the valve of Los Laureles II are closed and the inflow is stored in the reservoir. When the water level goes down and there is not enough storage in Los Laureles reservoir, the valve of Los Laureles II dam is opened and the water is released from the service spillway and fed into Los Laureles reservoir for intake.

(3) Operation Rule during Rainy Season

During rainy season, it is necessary for the dam structures to release flood discharge to downstream safely. However, it is needed to catch small flood discharge for the use during the next dry season. Considering this contradiction, it is proposed to keep the gate closed during rainy season and to control the gates and try to maintain the water level as the normal maximum water level.

It is possible to operate the gates using the record of the existing gauging station at Mateo Bridge. However, it is proposed to install a new rainfall/gauging station at the confluence of Guacerique River and Mateo River, which will dispatch early warning of flood and will collect streamflow data to reinforce the plan of Quiebra Montes Project. It is also proposed to transmit the water level record to the proposed Water Supply Department of the Metropolitan Division as well as the operation office of Los Laureles II dam.

7.2.2 MAINTENANCE PLAN

(1) Sediment Excavation

In order to maintain the storage volume of the reservoir, it is desirable to excavate the sediment stored at the sediment control structure. The design amount of sediment to be removed is 10,000 m^3 as one fourth of the total sediment inflow into the reservoir. According to the material survey of the sediment, a part of it will be utilized as concrete aggregate and it is possible to let concrete plant companies or construction companies take out the sediment for their own use. In the maintenance cost of the dam, cost of sediment excavation is included with the amount of 10,000 m^3/year.

(2) Painting

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

(3) Periodical Inspection and Maintenance

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

(4) Water Quality Monitoring of Reservoir

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

In the Guacerique River basin, the Ciudad Mateo project was planned and a part of the construction work was done. The project has been suspended because of the anticipated effect on the reservoirs. For reference, a rough water quality simulation was made as a part of the environmental study. The result is shown in *Figure 7.6*. According to the figure, if the Ciudad Mateo project is resumed and its wastewater is discharged into the reservoir without treatment, there is a great fear of deterioration of the reservoir water by eutrophication.

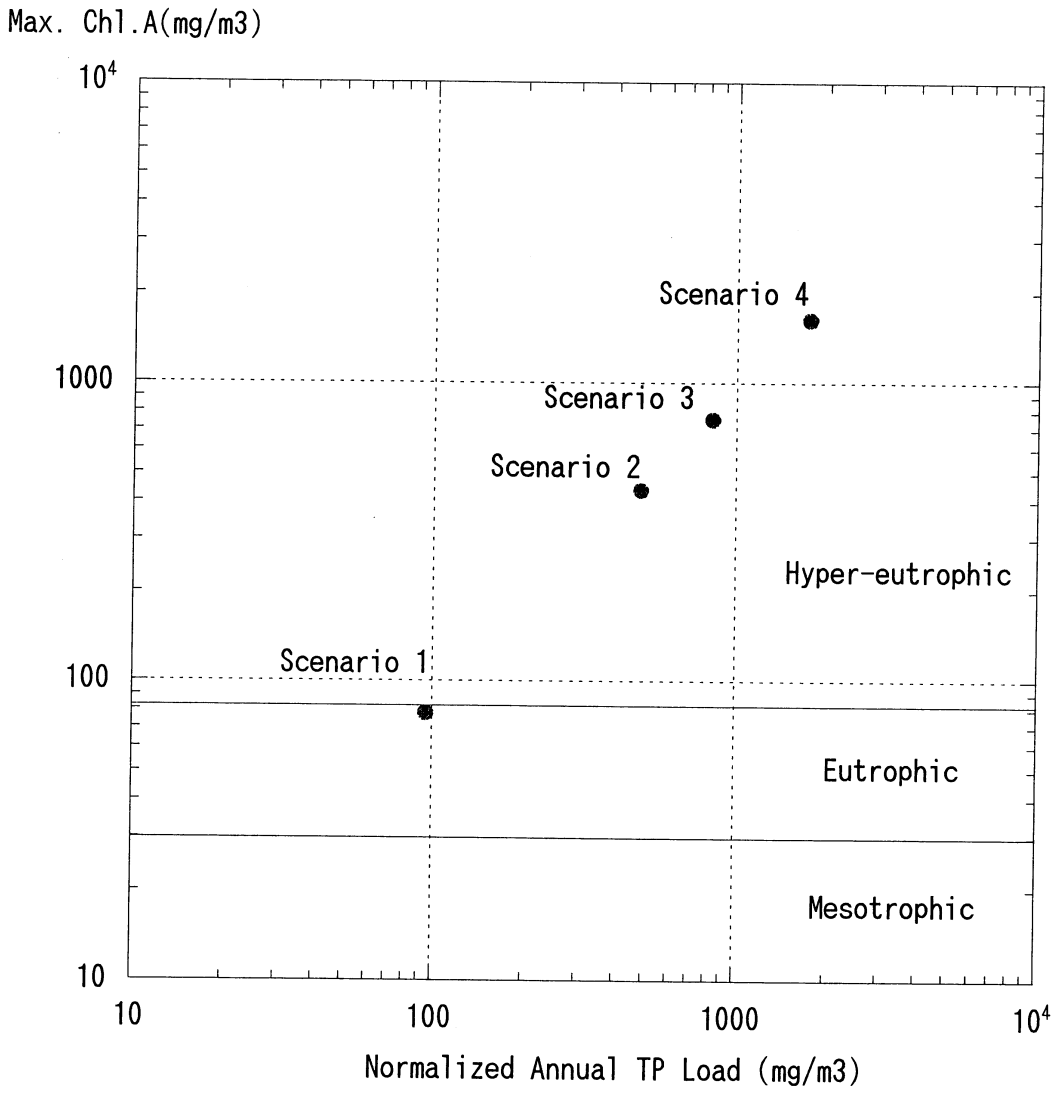


Figure 7.6	Result of Water Quality Simulation for Ciudad Mateo Project

7.3 PROJECT COST ESTIMATE

7.3.1 COST CONSTITUENTS

Project cost is composed of direct construction cost, engineering service cost, compensation cost, administration cost, and contingency.

Engineering service cost, administration cost and contingency are calculated by ratios which are expressed in percentage to other cost items.

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

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

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

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

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

7.3.2 COMPONENT OF DIRECT CONSTRUCTION COST

The direct construction cost is composed of direct and indirect cost.

Direct cost

The estimate for direct costs is performed based on the quantities of all construction tasks shown on drawing and described in project requirements. The direct cost includes all of countable element for each work item.

Indirect Cost

The indirect cost on the project consists of "General Temporary Works" and "Overhead Expense".

7.3.3 COST ESTIMATE METHOD

(1) Price Level and Foreign Exchange Rate

The cost estimate is made on the price level as of the end of July 2000, since the cost data of materials, laborers, equipment and other necessary items for the cost estimate are collected in this period. The foreign exchange rate applied to the cost estimate is USD 1.0 = Lps 14.87 = JPY 107.9.

(2) Currency Component

The project cost is divided into the foreign currency components and local currency component. Both currency components are calculated in USD so that it will eliminate the variation of exchange rate between Lps and USD.

(3) Cost Estimate Result

The result of the cost estimate is shown in *Table 7.1*. The total project cost of the priority project is USD 25,722,007.

7.4 PROJECT IMPLEMENTATION PROGRAM

7.4.1 IMPLEMENTATION PROGRAM

The implementation schedule is prepared to achieve prompt construction of the project so as to ease the problem of water shortage in Tegucigalpa. Necessary undertakings and activities are incorporated in the implementation schedule as shown in *Figure 7.7*.

The financial preparation will take the year 2001 and the detailed design will finish in 2002 and 2003. During the detailed design stage, environmental impact assessment and inventory survey for compensation such as land acquisition and house evacuation are simultaneously undertaken. Furthermore, the preparation works for loan or grant acquisition (foreign currency portion) and local fund for compensation will be executed as a pre-construction works. Then, construction works will be executed during the period between January 2004 and December 2006.

7.4.2 WORKS REQUIRED FOR PROJECT IMPLEMENTATION

(1) Clearance of Environmental Issue

According to the Environmental Law, it is necessary to assess the environmental impact of the project at every stage of the project. As the environmental impact assessment (EIA) has been completed at the F/S stage in this Study, it is necessary to continue the process in the detailed design stage prior to the implementation of the project.

At the detailed design stage, the construction plan will be studied more precisely and the location of the spoil bank will be fixed and the temporary road plan will be made. Therefore, more precise environmental impact study will be made based on the detail construction plan.

(2) Resettlement and Compensation Works

There are around 20 houses to be relocated in the reservoir area. A part of the existing road should be relocated to the new location above the reservoir water level. It is essential to solve the problem of resettlement and compensation works prior to the commencement of the construction work. In the case of the previous Concepcion dam project, it took one (1) year to have discussion with the people to be resettled. Therefore, the resettlement plan should be prepared without delay and start the procedure according to the implementation schedule.

Table 7.1 Result of Cost Estimate of Los Laureles II Project

Description		Unit	Quantity	Local Portion (USD)		Foreign Portion (USD)		Remarks	Labour Cost (USD)	
				Unit Price	Amount	Unit Price	Amount		Skilled	Common
Mobilization and Demobilization		l.s.	1		532,945		685,314	7 % of Construction Cost		
Excavation	Common (Riverbed)	m^3	4,820	2.2	10,406	3.1	15,023		0	0
	Common	m^3	5,630	2.3	13,037	3.4	18,864		0	0
	Rock (Riverbed)	m^3	3,400	6.6	22,311	9.7	32,922		0	0
	Common (Rock)	m^3	51,150	11.4	580,764	16.8	861,370		0	0
	Disposal	l.s.	1		126,328		41,226		1,950	4,233
	Summation	m^3	65,000		752,846		969,405	1,722,251	1,950	4,233
Concrete	Dam Concrete of Main body	m^3	26,313	62.0	1,630,201	40.5	1,066,323	Mass concrete, σ ck = 180 kg/cm2	44,212	41,631
	Structure Concrete	m^3	13,589	107.3	1,458,140	99.1	1,346,993	Reinforced concrete, σ ck = 240 kg/cm2	16,212	100,868
	Miscellaneous	m^3	2,198	62.0	136,175	40.5	89,073	Rip-rap, By-pass Closing, etc.	3,693	3,478
	Summation	m^3	42,100		3,224,516		2,502,389	5,726,905	64,117	145,977
Curtain Grout	+ Consolidation Grout	m	5,000	94.4	472,066	149.5	747,558	1,219,624	19,284	16,349
Crest Gates		l.s.	1		300,000		2,700,000	3,000,000	-	-
Crest Bridges		l.s.	1		178,860		146,340	325,200	87,094	165,804
Outlet		l.s.	1		36,000		324,000	360,000	-	-
Upper-stream Cofferdam		l.s.	1		105,895		79,943	185,838	2,337	10,129
Down-stream Cofferdam		l.s.	1		30,820		25,782	56,601	536	6,463
Diversion Channel		l.s.	1		69,942		59,899	129,842	1,057	4,076
Sub-total of Construction Cost of Dam		(1)			5,703,890		8,240,630	**13,944,520**	176,375	353,032
Excavation of Existing Reservoir and Disposal		m^3	600,000		1,748,016		2,036,826	3,784,842	6,000	23,662
Administration Office Building		l.s.	1		18,000		0	18,000	-	-
Relocation of Road		l.s.	1		160,310		147,442	307,752	1,379	12,040
Sand Deposit Dam		l.s.	1		116,226		50,610	166,836	2,339	5,921
Riverwater Direct Purification Facility		l.s.	1		400,000			400,000	-	-
Sub-total of Dam-related Construction		(2)			2,442,552		2,234,878	**4,677,430**		
Engineering Cost (10 % of Construction Cost (1) + (2))					814,644		1,047,551	1,862,195		
Physical Contingency (10 % of Construction Cost (1) + (2))					814,644		1,047,551	1,862,195		
Sub-total of Project Related Expenses		(3)						**3,724,390**		
Total		(1) + (2) + (3)						**22,346,340**		
Administration Cost (5 % of Construction Cost)		l.s.	1		931,097					
Relocation of Household		l.s.	1		944,570					
Compensation of Submerged Land		l.s.	1		1,500,000					
Cost for Administration and Compensation		(4)			3,375,667		0	**3,375,667**		
Total		(1) + (2) + (3) + (4)						**25,722,007**		

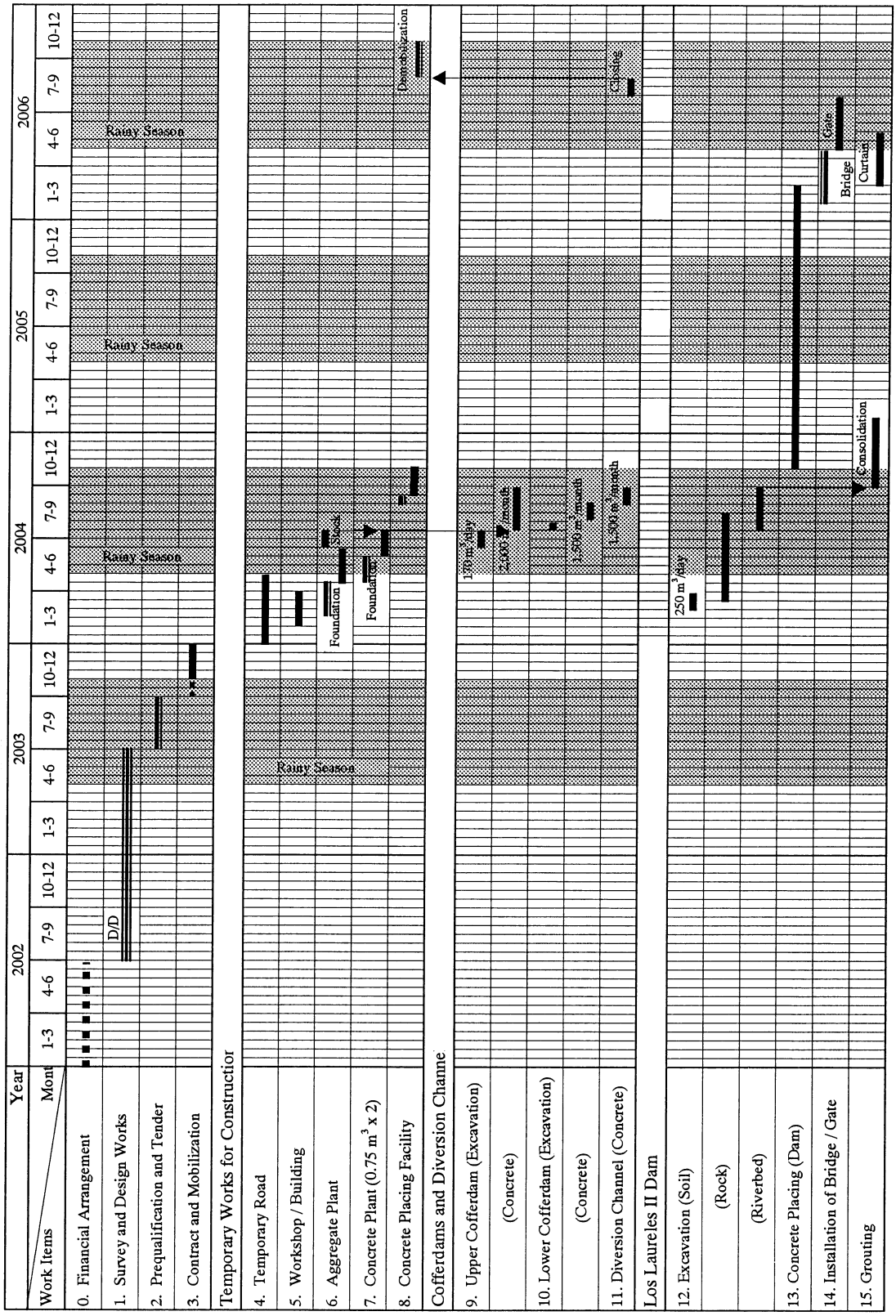


Figure 7.7 **Construction Schedule of Los Laureles II Project**

7.5 PROPOSED FINANCIAL ARRANGEMENT

7.5.1 PROJECT COST AND LOAN AMOUNT

The total project cost is estimated at USD 25,722,000. The breakdown is shown in *Table 7.2.*

Table 7.2 Project Cost

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

It is realistic to apply foreign loan or grant to absorb the required project costs, judging from the economic situation and financial sources of previous projects in Honduras. From the table above, compensation cost and administration cost are not covered by foreign loan or grant. Therefor, the total project cost subject to loan or grant is USD 22,346,000. Remaining USD 3,376,000 should be prepared by SANAA or Honduran government.

7.5.2 DISBURSEMENT SCHEDULE

The disbursement schedule is prepared as discussed below.

(1) Annual Disbursement Schedule

Annual disbursement schedule for Los Laureles II Project is prepared in accordance with the implementation schedule as presented in *Figure 7.7*. The disbursement schedule is shown in *Table 7.3.*

(2) Operation and Maintenance Cost

Operation and maintenance cost were estimated as follows shown in *Table 7.4.*

Table 7.4 Operation and Maintenance Cost

Annual operation and maintenance cost for salary, maintenance, and operation	277,000 USD/year
Annual operation and maintenance cost for sediment excavation	53,000 USD/year
Total (Percentage to total direct constriction cost)	330,000 USD/year (1.6 %)

Table 7.3 Disbursement Schedule of Los Laureles II Project

(Unit: USD)

Description	2002		2003		2004		2005		2006		Summation	
	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign
Construction of Dam											5,703,890	8,240,630
Mobilization and Demobilization			380,675	489,510					152,270	195,804	532,945	685,314
Excavation Works					752,846	969,405					752,846	969,405
Concrete Works					403,064	312,799	2,418,387	1,876,792	403,064	312,799	3,224,516	2,502,389
Consolidation Grout + Curtain Grout					212,429.8	336,401	70,810	112,134	188,826	299,023	472,066	747,558
Crest Gates									300,000	2,700,000	300,000	2,700,000
Crest Bridges									178,860	146,340	178,860	146,340
Outlet									36,000	324,000	36,000	324,000
Upper-stream Cofferdam					105,895	79,943					105,895	79,943
Down-stream Cofferdam					30,820	25,782					30,820	25,782
Diversion Channel					69,942	59,899					69,942	59,899
Dam-related Construction											2,442,552	2,234,878
Excavation of Existing Reservoir and Disposal					582,672	678,942	582,672	678,942	582,672	678,942	1,748,016	2,036,826
Administration Office Building									18,000	0	18,000	0
Relocation of Road									160,310	147,442	160,310	147,442
Sand Deposit Dam									116,226	50,610	116,226	50,610
Riverwater Direct Purification Facility									400,000	0	400,000	0
Project Related Expenses												
Engineering Cost	162,929	209,510	151,614	194,961	176,506	226,969	176,506	226,969	147,089	189,141	814,644	1,047,551
Physical Contingency					271,548	349,184	271,548	349,184	271,548	349,184	814,644	1,047,551
Total of Construction	162,929	209,510	532,289	684,471	2,605,724	3,039,324	3,519,923	3,244,021	2,954,865	5,393,284	9,775,730	12,570,609
Compensation and Administration Cost												
Administration Cost			77,591		310,366		310,366		232,774		931,097	0
Relocation of Household			472,285		472,285						944,570	0
Compensation of Submerged Land			750,000		750,000						1,500,000	0
	2002		2003		2004		2005		2006			
Total of Project	162,929	209,510	1,832,166	684,471	4,138,375	3,039,324	3,830,289	3,244,021	3,187,640	5,393,284	13,151,398	12,570,609

Chapter 8 Project Evaluation

CHAPTER 8 PROJECT EVALUATION

8.1 EFFECTS OF PROJECT

Los Laureles II Project develops 160 l/s of water, which comprises a part of water to be developed by 2015. Although this is not a large part of the total required water amount, which is 1,133 l/s, this is the most cost-effective water source development among the other potential water source developments and the required water amount will be never satisfied without this water.

From the viewpoint of water supply, the water developed by Los Laureles II Project fully utilizes a dormant treatment capacity of Los Laureles WTP and increases water supply amount to the present distribution areas of Los Laureles WTP. The water supply capacity of Los Laureles WTP even after strengthened by Los Laureles II Project would not be able to satisfy the required water amount of the distribution areas, however, Los Laureles II Project increases the water production capacity by 24% of the present capacity and benefits 210,000 to 400,000 people (present population base) in the distribution areas receiving water from Los Laureles WTP.

In the long run, Los Laureles II Project increases the water source capacity towards the targets of the Master Plan, and improves the current shortage of the water supply in the limited distribution areas in the short run.

8.2 ECONOMIC FEASIBILITY

8.2.1 GENERAL

Los Laureles II Project is one of the components of the proposed Master Plan. The fact that the economic feasibility of the Master Plan was fully verified as the aforementioned proves the economic feasibility of Los Laureles II Project, of which necessity and priority in the Master Plan was justified. In addition, the economic feasibility of Los Laureles II Project as an independent project was evaluated as follows.

8.2.2 ECONOMIC BENEFIT

Los Laureles II Project has the following two (2) objectives.

- To mitigate the water shortage by maximizing the use of the existing facilities of Los Laureles subsystem.
- To prevent the existing Los Laureles reservoir from sedimentation, which reduces the yield capacity of the reservoir continuously.

The Master Plan proposes optimization of the whole water supply system such as reorganization of distribution areas only with the implementation of Quiebra Montes WTP. Therefore, the beneficiaries of the project are confined to the users of Los Laureles subsystem. Based on the assumption that the average unit water consumption of each subsystem is the same, the number of domestic users of each subsystem becomes proportional to the existing production rate of each subsystem, which was shown in *Table 2.28*. It is estimated that the domestic users of Los Laureles subsystem share 28.9 % of the total domestic users. Thus, the number of beneficiaries is estimated at 280,756 persons in 2007, when Los Laureles II Project will be completed.

The economic benefits born by the sedimentation prevention effects was estimated based on a prevention cost method, in which necessary costs to prevent sedimentation of the existing Los Laureles reservoir without Los Laureles II Project was regarded as the economic benefits. Available prevention method without Los Laureles II Project is dredging of sediments. It is necessary to dredge 115,000 m^3 of sediments a year, which will cost USD 1,782,500 per year.

The project will improve the water service level but can not achieve the target level, namely 24-hour water supply with enough water pressure. The degree of improvement is roughly speaking around 24 % based on the increase of water supply capacity, however, it is difficult to estimate the economic benefit born by this improvement in monetary term. To apply the aforementioned additional willingness to pays born by the Master Plan to estimation of the economic benefits of the service improvement, a concept of achievement ratio was introduced. The concept is explained in *Figure 8.1*.

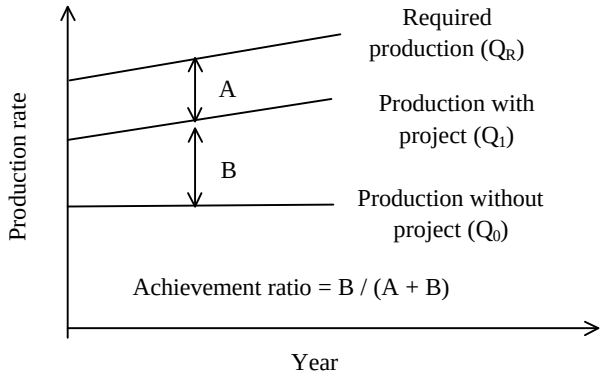


Figure 8.1 Explanation of Achievement Ratio

Then, annual economic benefits born by service improvement were estimated by the following calculations.

- Domestic users: Annual economic benefit = $\Sigma (N_{LL} \times WTP_{Dave}) \times 12 \times R$
- Non-domestic users: Annual economic benefit = $T_{ND0} \times WTP_{ND} \times C_{ND} \times 365 \times R$

Where,

N_{LL} :	number of domestic users of Los Laureles subsystem [household],
WTP_{Dave}:	average additional willingness to pay of domestic users [Lps/household/month],
R :	achievement ratio, $R = (Q_1 - Q_0) / (Q_R - Q_0)$
Q_1 :	production rate with Los Laureles II Project [m^3/day]
Q_0 :	production rate with Los Laureles II Project [m^3/day]
Q_R :	required production rate for Los Laureles subsystem [m^3/day]
T_{ND0}:	the existing tariff level for non-domestic users [Lps/m^3],
C_{ND}:	additional water consumption of non-domestic users due to the project [m^3/day] , and
WTP_{ND} :	additional willingness to pay of non-domestic users [times].

8.2.3 ECONOMIC COSTS

The economic costs of Los Laureles II Project were estimated based on the said cost estimates with the same preconditions and assumptions applied in the evaluation of the Master Plan.

8.2.4 RESULT OF ECONOMIC EVALUATION

The economic internal rate of return (EIRR) of Los Laureles II Project was calculated 14.7 % as shown in *Table 8.1*. The calculated EIRR is much higher than the assumed opportunity cost of capital (OCC) of 4 %. This results shows that the proposed Los Laureles II Project is feasible from the economic viewpoint.

Table 8.1 EIRR of Los Laureles II Project

(Unit: USD)

Year	Economic benefits	Economic costs	Cost benefit stream	Present value		
				Benefits	Costs	NPV
2001	0	0	0	0	0	0
2002	0	403,123	-403,123	0	372,710	-372,710
2003	0	2,694,537	-2,694,537	0	2,395,433	-2,395,433
2004	0	7,728,858	-7,728,858	0	6,606,660	-6,606,660
2005	0	7,627,533	-7,627,533	0	6,269,276	-6,269,276
2006	0	9,310,682	-9,310,682	0	7,358,367	-7,358,367
2007	5,041,033	349,714	4,691,319	3,830,771	265,754	3,565,017
2008	4,936,915	369,489	4,567,427	3,607,356	269,982	3,337,374
2009	4,972,156	370,261	4,601,895	3,493,371	260,140	3,233,230
2010	5,008,389	371,049	4,637,339	3,383,488	250,668	3,132,820
2011	5,045,546	371,854	4,673,691	3,277,490	241,550	3,035,941
2012	5,083,567	372,676	4,710,890	3,175,181	232,772	2,942,408
2013	5,122,399	373,516	4,748,883	3,076,380	224,324	2,852,056
2014	5,161,996	374,373	4,787,623	2,980,924	216,191	2,764,733
2015	5,202,316	375,249	4,827,067	2,888,661	208,362	2,680,299
2016	5,263,874	376,144	4,887,730	2,810,426	200,826	2,609,599
2017	5,324,981	377,059	4,947,922	2,733,703	193,572	2,540,131
2018	5,385,649	377,995	5,007,654	2,658,508	186,589	2,471,919
2019	5,445,891	378,952	5,066,940	2,584,851	179,867	2,404,984
2020	5,505,720	379,931	5,125,790	2,512,739	173,396	2,339,343
2021	5,565,148	380,933	5,184,215	2,442,174	167,166	2,275,008
2022	5,624,186	381,958	5,242,228	2,373,155	161,169	2,211,986
2023	5,682,844	383,008	5,299,836	2,305,679	155,396	2,150,283
2024	5,741,134	384,083	5,357,051	2,239,740	149,839	2,089,901
2025	5,799,066	385,184	5,413,882	2,175,327	144,489	2,030,838
2026	5,856,650	386,312	5,470,337	2,112,430	139,339	1,973,092
2027	5,913,895	387,469	5,526,425	2,051,037	134,381	1,916,656
2028	5,970,810	388,655	5,582,155	1,991,130	129,608	1,861,523
2029	6,027,404	389,871	5,637,533	1,932,696	125,013	1,807,683
2030	6,083,686	391,119	5,692,566	1,875,714	120,589	1,755,124
2031	6,139,663	392,400	5,747,263	1,820,166	116,331	1,703,835
2032	6,195,345	393,715	5,801,630	1,766,032	112,232	1,653,801
2033	6,250,737	395,065	5,855,672	1,713,291	108,285	1,605,006
2034	6,305,849	396,453	5,909,396	1,661,920	104,486	1,557,434
2035	6,360,687	397,879	5,962,808	1,611,896	100,829	1,511,068
2036	6,415,257	399,345	6,015,912	1,563,197	97,308	1,465,890
2037	6,469,567	400,853	6,068,714	1,515,799	93,919	1,421,880
2038	6,523,622	402,405	6,121,218	1,469,677	90,656	1,379,021
2039	6,577,430	404,002	6,173,428	1,424,807	87,515	1,337,292
2040	6,630,997	405,647	6,225,349	1,381,164	84,492	1,296,672
2041	6,684,327	407,342	6,276,985	1,338,723	81,582	1,257,141
2042	6,737,427	409,089	6,328,337	1,297,459	78,780	1,218,679
2043	6,790,302	410,891	6,379,411	1,257,348	76,084	1,181,264
2044	6,842,958	412,750	6,430,208	1,218,364	73,489	1,144,875
2045	6,895,399	414,669	6,480,730	1,180,481	70,991	1,109,491
2046	6,947,631	416,651	6,530,980	1,143,676	68,586	1,075,090
2047	6,999,658	418,698	6,580,960	1,107,924	66,273	1,041,651
2048	7,051,485	420,816	6,630,670	1,073,199	64,046	1,009,153
2049	7,103,117	423,006	6,680,112	1,039,478	61,903	977,575
2050	7,154,558	425,273	6,729,286	1,006,737	59,841	946,895
Total	263,841,268	44,988,535	218,852,732	92,104,269	29,231,055	62,873,214

EIRR=	14.7%
OCC=	4%

A sensitivity analysis on EIRR of Los Laureles II Project was conducted with 10 % variation of the costs and revenues. The results are shown in *Table 8.2*.

Table 8.2 Results of Sensitivity Analysis of EIRR

Economic cost variation	Economic benefits variation		
	+10 %	0 %	-10 %
-10 %	17.4 %	16.1 %	14.7 %
0 %	15.9 %	14.7 %	13.3 %
+10 %	14.7 %	13.5 %	12.2 %

It is confirmed that Los Laureles II Project is economic feasible even under the severest condition with 10 % increased economic costs and 10 % decreased economic benefits.

8.3 FINANCIAL FEASIBILITY

8.3.1 GENERAL

Financial evaluation for the priority projects has different objectives from that for the proposed Master Plan. Financial viability of the Master Plan, which includes not only facility development but also institutional and managerial proposals, is evaluated from the viewpoint of the service provider's financial and managerial soundness, on the other hand financial feasibility of the priority project is evaluated from the viewpoint of the funding sources who concern recovery of credits.

Therefore, financial feasibility of Los Laureles II Project was evaluated based on financially severe conditions with the tariff level excluding sewerage tariff but without tariff increase proposed in the Master Plan. Applied financial indicators are same as those for the Master Plan, namely financial rate of return (FIRR) and the accumulated amount of net cash flow.

8.3.2 FINANCIAL COSTS

Adopted preconditions and assumptions were same as those applied in the financial plan of the Master Plan, however only the additional costs due to Los Laureles II Project are dealt in the financial evaluation. The costs are as follows.

- Investment costs for Los Laureles II dam construction and Los Laureles reservoir excavation
- Additional operation costs accrued by the production increase of Los Laureles WTP

8.3.3 REVENUE

Revenue of Los Laureles II Project was estimated based on additional revenue borne by an increment of water supply volume. The increment of water supply volume was obtained by comparing water supply rates between with and without project.

The adopted tariff level is as follows. 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. The existing tariff levels for domestic and non-domestic users were estimated based on the tariff levels in 1999.

8.3.4 RESULT OF FINANCIAL EVALUATION

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

A sensitivity analysis on FIRR of Los Laureles II Project was conducted with 10 % variation of the costs and revenues. The results are shown in *Table 8.3*.

Table 8.3 Results of Sensitivity Analysis of FIRR

Cost variation	Revenue variation		
	+10 %	0 %	-10 %
-10 %	13.5 %	12.4 %	11.1 %
0 %	11.7 %	10.7 %	9.6 %
+10 %	10.3 %	9.4 %	8.4 %

It is confirmed that Los Laureles II Project is financially feasible even under the severest condition with 10 % increased costs and 10 % decreased revenue.

8.4 TECHNICAL FEASIBILITY

8.4.1 DAM CONSTRUCTION

SANAA constructed Los Laureles dam (37.8 m, a rockfill dam with a free flow spillway) in 1974 and Concepcion dam (68.0 m, a concrete dam with a free flow spillway) in 1992. Therefore, SANAA has good experience in construction of large dams.

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

8.4.2 OPERATION

SANAA has also abundant operation and maintenance experiences in dam and water supply facilities. In particular for the water supply facilities, there would be no change in operation because the project just increase the supply capacity of the existing facilities to the level of the original design capacity. However, increase of number of dams may increase the complexity of operation. After the completion of Los Laureles II dam, SANAA has to operate three (3) dams with crest gates, namely Los Laureles dam, Conception dam and Los Laureles II dam. The operation rule for Los Laureles II dam was drafted in the Study and the relationship between the gate opening ratio and the discharge capacity was prepared in the Study for reference of operation. Proposed flood warning system and flood forecasting system for Los Laureles II dam operation will ease the operation difficulty of SANAA.

8.5 ENVIRONMENT IMPACT ASSESSMENT

The environment impact assessment (EIA) was made based on the "National System of Environment Impact Assessment" to obtain the environmental license for the project. As this EIA corresponds to the Feasibility Study stage, another EIA with more detail information will be required in the design stage of the project. The result of EIA is summarized in *Table 8.4* showing environmental impacts and mitigation measures for Los Laureles II Project.

Table 8.4 Environmental Impacts and Mitigation Measures

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

Source: Borrador del Informe Final del Estudio de Impacto Ambiental (EIA) Preliminar del Proyecto de Abastecimiento de Agua para el Area Urbana de Tegucigalpa, September, 2000, JICA/SANAA/CINSA

EIA identified existence of 8 species of protected Fauna and 25 species of protected Flora in the Guacerique basin, but their existence is not identified in the proposed project site, except Otter and Alligator. Otter and alligator is reported to live in the present Los Laureles Reservoir. Since their dominant habitat is pool water, it is not expected that they have habitat in the proposed project site, which is running water area. Although possible impacts to them during the construction works may be deterioration of water quality of the Los Laureles Reservoir, it can be mitigated by proper countermeasures shown in the table above. Another possible impact may be their accidental appearance to the construction sites. Necessary actions shall be taken to avoid harming them during the construction stage.

8.6 SOCIAL IMPACT ASSESSMENT

8.6.1 RELOCATION OF PEOPLE

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

8.6.2 WATER USE REGULATION

In the Study, non-authorized water intake by the military base and private irrigation were identified in the Guacerique River basin. Water balance calculation for the Feasibility Study takes into account the present intake amount in a sense that the actual measurement discharge data was used in stead of generated run-off. However, further increase of intake of water upper reach will diminish the inflow amount into Los Laureles reservoir and Los Laureles II reservoir, making the water balance calculation invalid. Therefore it is necessary to regulate the water intake in the basin according to Law of National Water Exploitation.

8.6.3 CIUDAD MATEO PROJECT

The Ciudad Mateo project is located in the vicinity of Los Laureles II reservoir and restart of the project will give significant impact on water quality of the existing Los Laureles reservoir and planned Los Laureles II reservoir. Strict enforcement of Forestry Protected Zones and Law of National Water Exploitation is necessary to conserve the precious water resources for Tegucigalpa.

Chapter 9 Recommendation

CHAPTER 9 RECOMMENDATION

9.1 INTRODUCTION

The Study proposed the water supply master plan with target year 2015 and conducted a feasibility study on a priority project selected from the master plan projects. The proposed Master Plan comprises of three projects and it was confirmed that the implementation of the proposed projects would dissolve the present water shortage, address the expected future demand increase and improve the leakage problems.

Among the three projects, Los Laureles II Project, which mitigates the present water shortage in the present distribution areas of Los Laureles WTP and increases water source capacity towards the target of the Master Plan, was selected as a priority project for the feasibility study. The feasibility study concluded that Los Laureles Project would be feasible from technical, economical, financial, social and environmental viewpoints.

Therefore, it is strongly required to initiate the preparation work for the implementation of Los Laureles II Project and to formulate a policy to implement the Master Plan. Principally, SANAA should take actions as a responsible implementing organization. However, development of the water supply system is one of urban infrastructure developments and the implementation of the Master Plan relates to many aspects that exceed SANAA's competence and responsibility. In particular, the development of relating law system, financial arrangement and setting out of prevailing development plans are essential factors to realize the implementation of the Master Plan and to sustain stable and effective water supply operation following the Master Plan. In this regard, supports of the State Government and the Municipality of Tegucigalpa are indispensable for the implementation of the Master Plan.

This chapter presents required actions of the State Government and the Municipality, as responsible organizations for the provision of a platform of the project implementation, and of SANAA, as an responsible organization for the implementation and operation of the projects, to implement the priority project and to realize the Master Plan.

9.2 RECOMMENDATION TO THE STATE GOVERNMENT AND THE MUNICIPALITY

9.2.1 INSTITUTIONAL SUPPORTS

Reform of SANAA

There are active discussions concerning municipalization and privatization of SANAA involving various organizations concerned. There is a strong pressure to municipalize SANAA in short order, aiming to make a water supply entity of Tegucigalpa decentralized, financially independent and efficient. However, apparently it does not seem to work well because of issues regarding the cancellation of a collective contract between SANAA and its labor union and intention and capability of the Municipality. Therefore, the future form of SANAA is not clear and is assumed that SANAA will remain as it is in the Study.

Instead, the Study proposed SANAA's organization plan and financial plan to make it decentralized, financially independent and efficient, which pave the way to municipalization and privatization.

Even though it is a general tendency that water supply entities head for the privatization

ultimately, it will never reach to the goal without stepping necessary process. It would be more realistic to take time for the reform of SANAA and adjustment of surrounding conditions.

Guidelines for Tariff Setting

Tariff revision is one of important factors to secure financial independence. Nevertheless, the competence to set proper tariff has never given to SANAA. Originally it was subject to the approval by the National Congress, and since the creation of the National Supervising for the Public Services (CNSSP) in 1991, tariff revision is subject to the approval by CNSSP. Since 1991, the tariff revision took place only once in 1995. A proposal of SANAA submitted in 1999 with solid background has never approved yet by CNSSP.

CNSSP consists of nine (9) members, including three (3) state secretaries and two (2) congressmen, chaired by the state secretary of SOPTRAVI. It means the state government occupies the majority. In principle, any tariffs of public service require the government control to avoid monopolistic tariff setting. On the other hand, the government, either state or local, is naturally influenced by the political dynamics. Therefore, if this type of commission can not function properly in Honduran political context, the solution is to establish clear guidelines for tariff setting and to restrict the competence of the commission in appraisal of proposals according to the guidelines.

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

Formulation of Development Plan

Currently there is no authorized development plan that covers Tegucigalpa. This fact made the Study difficult to formulate the Master Plan with compliance to other infrastructure development plans.

A typical problem encountered in the course of the study was a conflict between the pressure of the urban development towards the west and the water source development sites. Although the Guacerique River basin is the protected area in the agreement between SANAA and Honduran Forestry Development Corporation (COHDEFOR), there are unauthorized plans to develop the basin. Also there is an unauthorized road construction plan to support the development axis towards west. The Master Plan proposed the water source developments in the Guacerique River basin for the reasons of their cost effectiveness and its assignment as the protection area. However, still there is a possibility that other projects plan to develop the basin causing a severe conflict in the implementation stage.

This could happen to other cases, too. Therefore, it is strongly required to formulate comprehensive development plan covering Tegucigalpa and its surrounding areas.

Establishment of Water Right

It was observed that there were unauthorized water intakes in the Guacerique River basin. The proposed Master Plan was prepared based on the present condition where the water balance in the Plan includes such unauthorized water intakes. However, further unauthorized water intakes may unset the basis of the water balance for the water development plan in the Master Plan. Therefore, it is required to execute the protection of the water right.

Regulation of Developing Community

Spatial expanse of the urban area in Tegucigalpa is formed as the emergence of the new neighborhoods. While some of them were developed by developers under certain plans approved by organization concerned, apparently some were formed spontaneously by constructing houses in the land not designated as a residential area. These neighborhoods are often referred as “developing community”.

This means some of the neighborhoods will be formed under no control, making public service infrastructure planning difficult. They exist outside of public services in the initial stage of the formation, and as time goes on, residents of those neighborhoods start to complain about no existence of public services and to put pressures to expand their services to their areas. Finally, they become parts of urban areas where ordinary public services are available. SANAA has been being forced to expand their service area for this reason for long time. Unfortunately, such housing used to occur in higher areas, SANAA was often forced to construct new reservoirs and pumping systems.

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

9.2.2 FINANCIAL SUPPORT

Financial Arrangement

Presently the State Government is paying all investment costs of water supply projects. In the Master Plan, SANAA takes over financial responsibility of project financing to realize finical independence.

The Master Plan is proposed on condition that SANAA borrows loans from international financing institutions such as World Bank, IDB and other foreign financing agencies in the implementation of the projects because required investment costs far exceed the SANAA's self financing capability. SANAA would act as a direct borrower to the financial institutions and would be exposed to their financial capability appraisals. This could require supports from the State Government to negotiate with the financing institutions. The State Government should provide the supports to obtain better financing conditions and the coordination to the financing institutions for easier access.

Governmental Subsidy

The financial plan proposed in the Master Plan is based on the governmental subsidy that covers one third of the construction costs for dams. Water supply system is one of urban infrastructures that support urban activities. Development of the water supply facility generally needs huge investment. Especially in Tegucigalpa due to its topographical and meteorological conditions water source development requires enormous costs. An increment of the cost by constructing dam to support the country's capital city's activities in such severe natural conditions should be considered to be a social cost. The Study assumed that the social cost corresponds to one third of the dam construction costs. The State Government or the Municipality should bear the social cost as a subsidy.

9.3 RECOMMENDATION TO SANAA

Early Implementation of the Projects

There exists a significant water supply deficit currently thus the Mater Plan proposed the earliest implementation schedule as possible from required work time for the preparation and construction works.

Therefore, SANAA is required to take prompt actions for the earlier implementation of the proposed projects. The actions include both internal preparation works and approaches to concerning organizations for the arrangement of basis of the project implementation such as requests to the state government for the financial arrangement and coordination of foreign financing agencies.

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

Necessity of Reviewing Master Plan

The proposed Master Plan is based on a scenario that is most probable judging from currently available information. There are uncertainties in occurrence of the adopted scenario. In case the actual conditions, such as population, water demands and so on, develop in a different direction from the scenario, the Master Plan must be modified or renewed according to the actual conditions. In other words, it may be able to say that the Master Plan shows one of possible directions of the development plan of the water supply system in Tegucigalpa. Therefore, the Master Plan shall be reviewed time to time in general.

In addition to the general uncertainties, there are two foreseeable uncertainties inherent in the proposed Master Plan. One of the most foreseeable uncertainties at present would be financial procurement. Quiebra Montes Project requires enormous costs. While it was judged to be financially feasible, there may be a difficulty in obtaining a proper financial instrument that can cover such a large scale construction costs. This will cause postponing or cancellation of the implementation of Quiebra Montes Project. In such case, the Master Plan should be reviewed by reconsidering the targeted service level.

Other uncertainty is a leakage control. It is a matter of fact that there exists a considerable physical loss by leakage in the system and reduction of leakage could ease the supply deficits, improving water supply conditions. Also it is a matter of fact that there are no reliable information that enables quantitative estimation of water leakage amount and no reliable information necessary for the planning of leakage repairing measures. That is why the Master Plan proposed Leakage Control Project that installs water flow measuring devices throughout the system and formulates a leakage control program.

Therefore, SANAA is required to implement Leakage Control Project and review the Master Plan depending on estimated effects of the leakage control program.

Structural Reform

The Master Plan proposed the organization plan in line with the former structural reform conducted by SANAA. The proposed plan will contribute to further decentralization of SANAA by strengthening the self-sustainability of SANAA Metropolitan Division.

The Master Plan supposes that a management style of SANAA will remain as it is and is not to

pursue the early municipalization or privatization. However, it is a general tendency that the management style of the water supply entities heads for the privatization ultimately, thus SANAA should proceed to the ultimate goal. This could benefit SANAA by improving their operation performance.

Leakage Control

There exists a considerable water leakage in the system. Because of limited available data, the Master Plan does not propose a specific leakage repairing program, instead, proposes the installation of the water measuring devices in order to understand the actual conditions of the leakage problems.

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

Tariff System

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

Meanwhile, the collection of tariff lies within SANAA's competence and responsibility even now. The Master Plan proposed the installation of a water meter to all the users as a part of Leakage Control Project. This will enable the tariff collection by the water consumption rate. SANAA is required to implement the installation of the water meter and to establish stronger tariff invoicing and collection system. The Master Plan has proposed the organization plan that includes the required departments and personnel for strengthening tariff invoicing and collection system.

Development of Sanitary System

The development of the water supply system proposed in the master plan could cause increase of the wastewater generation. Therefore, the development of the water supply system should be accompanied with the expansion of the wastewater collection system for the new water supply areas and strengthening of wastewater collection capacity for the existing sewage collection service areas.

On the other hand, the present sanitary system of Tegucigalpa has two major problems to be addressed urgently; a poor wastewater collection system damaged by Hurricane Mitch and a lack of wastewater treatment system. Therefore, SANAA is required to conduct a comprehensive study that covers the rehabilitation and strengthening of the wastewater collection system and the development of wastewater treatment system.