DOMINICAN REPUBLIC

CORPORACION DOMINICANA DE ELECTRICIDAD

DIRECCION DE DESARROLLO HIDROELECTRICO

EL TORITO - LOS VEGANOS

HYDROELECTRIC COMPLEX DEVELOPMENT PROJECT

ON UPPER YUNA RIVER

FEASIBILITY REPORT

VOL. I MAIN REPORT

JULY 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

REPORT

Volume I MAIN REPORT

Volume II ANNEX

A. General Economic Background

B. Demand and Supply of Electric Power

C. Hydrometeorology

Volume III ANNEX

D. Geology

E. Construction Materials

Volume IV ANNEX

F. Alternative Plans

G. Preliminary Design

H. Program for Implementation

I. Project Evaluation

Volume V APPENDIX

I. Piedra Gorda and Hydroelectric Project

II. Pinalito Hydroelectric Project

PREFACE

In response to the request of the Government of the Dominican Republic, the Government of Japan decided to conduct a feasibility study on El Torito - Los Veganos Hydroelectric Complex Development Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent a study team headed by Mr. Hiroyasu Sonoda from June 1982 to August 1983.

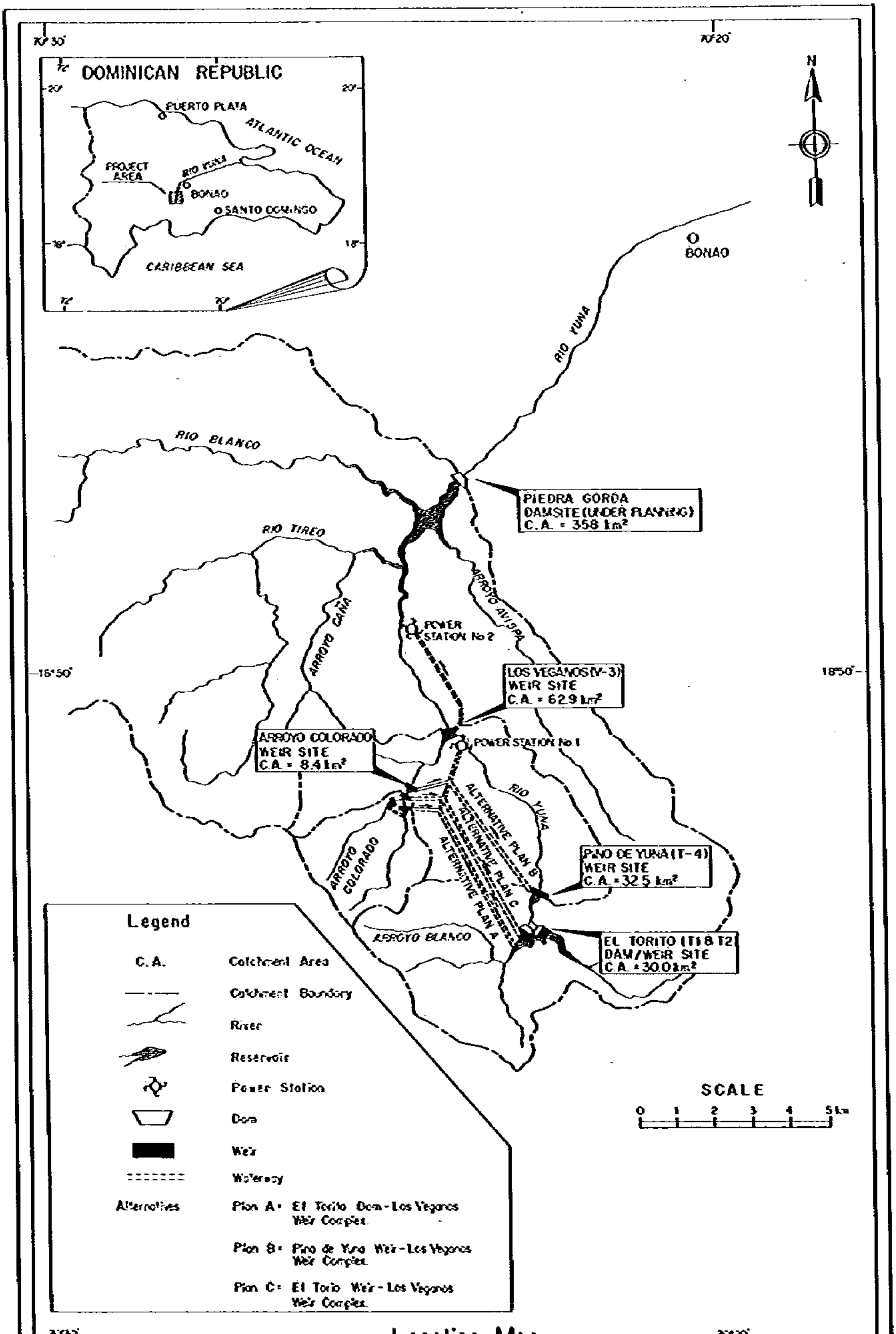
The team exchanged views with the officials concerned of the Government of the Dominican Republic and conducted a field survey on the Upper Yuna River. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contributed to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Dominican Republic for their close cooperation extended to the team.

Tokyo, July 1984.

Keisuke Arita
President
Japan International Cooperation Agency



Location Map

SUMMARY

Background

01 Development of the Dominican economy has been stagnated in recent years. Although the gross domestic product increased at an average rate of 4.6% per annum in 1975-79, the growth rate decreased to 2.5% per annum in 1980-82 which was lower than the rate of population increase. One of the major burdens imposed on the national economy is the unfavorable trade balance which is appreciably caused by increasing import of petroleum and its products. The Dominican Republic depends entirely on imported petroleum, and the oil import value represented 59% of total export value of the country in 1982. Under such economic situations, development of indigenous resources for import substitution is of prime significance for the national economy in a short and long run.

02 In the power sector, dependence on the imported oil has been substantial. About 89% of the electric power was generated by thermal plants with imported fuel in 1982. CDE had to pay 67% of its total revenue in 1983 for purchase of fuel to feed the thermal plants. Despite the fact that the Republic is well endowed with the water resources, development of hydroelectric power has been lagged behind. The firm installed capacity of hydro-power is approximately 88 MW or about 15% of the total firm installed capacity of 600 MW over the country. Although CDE has recently exerted its efforts toward the development of hydroelectric power, the hydro-power development projects should be implemented in a more accelerated way.

03 Power consumption grew steadily in 1970's with an average annual growth rate of 10.8%. The sending end energy increased at a higher rate, and it reached at around 3,122 GWh with the maximum demand of 538 MW in 1983. It is forecasted that the power demand will reach at 920-970 MW in 1987 and 1,460-1,720 MW in 1992. On the other hand, power expansion plan is being executed by CDE with the principal strategy to develop coal-fired power to cover the base load, to develop hydro-power to the maximum extent and to gradually substitute them for steam, gas and diesel power. The power supply situation will, however, remain critical even after the completion of the on-going installation of two 125 MW coal-fired plants by 1987, and it is required to implement the hydro-power projects at the earliest possible time.

Project Area

04 El Torito - Los Veganos hydroelectric complex is located in the uppermost part of the Yuna river basin where rainfall is relatively abundant, with the annual mean precipitation ranging from 1,900 mm to over 3,000 mm. The river has steep gradient or about 1/40 along the mainstream of the Yuna river upstream of its confluence with the Blanco river. Major technical constraint for hydroelectric development along the Yuna mainstream is the relatively limited catchment area at the possible intake sites and the geologic faults extensively developed in the area. One of the principal faults on tectonic line in the Republic, called the Bonao fault, extends in the north-south direction through the study area.

05 Since the catchment area at the possible intake sites is limited (about 30 km^2 at the confluence of the Yuna mainstream and Arroyo Blanco and about 63 km^2 at the confluence with Arroyo Colorado), available discharge at each intake site is to be assessed with utmost care. However, a long-term hydrological record is only available at Los Quemados, and the discharge at each intake site has to be estimated by proportionally distributing Los Quemados discharge on the basis of discharge measurement executed at various spots. It is estimated that 90% dependable discharge is around 0.62 m^3/s at the confluence of the Yuna mainstream and Arroyo Blanco and 1.72 m^3/s at the confluence with Arroyo Colorado.

Alternative Plan

06 Water available in the Yuna mainstream is planned, in principle, to be developed in two steps. In the upstream reach, possible alternative dam/weir sites are found near El Torito. The dam/weir sites in the middle reach are identifiable near Los Veganos. Water is harnessed by utilizing a total gross head of 330-400 m available in the combined El Torito - Los Veganos complex. A total of 70 case studies have been made comparatively on the alternative combination of dam and weir schemes, as well as combination of water diversion from tributaries in order to increase available discharge for power generation. As a result, three alternative plans have been selected for further detailed study. They are:

a) El Torito dam - Los Veganos weir complex,

b) El Torito weir - Los Veganos weir complex, and

c) Pino de Yuna weir - Los Veganos weir complex.

Construction of a high dam near Los Veganos is not found geotechnically and economically recommendable. In any case, El Torito and Los Veganos power stations will be operated to cover the peak load for 6 hours a day at minimum.

07 For El Torito dam plan, construction of combined fill-type dams at T-1 and T-2 damsites is contemplated. Water stored in El Torito reservoir, with a high water level set at EL. 755.0 m, is led through a 5.3 km long headrace tunnel to the power station to be located on the left bank of the Yuna mainstream immediately upstream of the confluence with Arroyo Colorado. Water in the upper A. Colorado tributary basin is diverted to the headrace tunnel from El Torito reservoir. By utilizing a firm discharge estimated at 1.23 m^3/s and the maximum discharge of 4.92 m^3/s, as well as an effective head of 250.3 m, the power station (Yuna No. 1) will have an installed capacity of 10.3 MW. The annual primary energy output is estimated at 22.2 GWh and the secondary energy output at 15.8 GWh.

08 As an alternative to El Torito dam plan, two diversion weirs are planned at T-1 and T-2 sites in El Torito. Water of the Yuna mainstream is diverted by T-1 weir (17 m in height) to Arroyo Blanco where T-2 weir (22 m in height) is constructed for intake of water estimated at 0.62 m^3/s in 90% dependable discharge. A headrace tunnel of 5.2 km in length is constructed to reach Yuna No. 1 power station to be located at the same site as proposed for El Torito dam plan. Water diversion from Arroyo Colorado (0.31 m^3/s) is also contemplated. By utilizing the maximum discharge estimated at 3.72 m^3/s and the effective head of 229.2 m, El Torito weir plan will have an installed capacity of 7.2 MW, with the annual primary energy output of 15.2 GWh and the secondary energy output of 16.9 GWh.

09 As an alternative to El Torito weir plan, it is contemplated to construct an intake weir at Pino de Yuna (T-4 site) located at about 800 m downstream from the confluence with Arroyo Blanco. By constructing a 21 m high concrete weir and a 4.4 km long headrace tunnel, as well as an intake and tunnel for water diversion from Arroyo Colorado, the maximum discharge of 4.04 m^3/s is led to the power station to be located at the same place as in the case of El Torito dam weir plan. An effective head is 184.3 m. The installed capacity is planned to be 6.3 MW, and the annual primary and secondary energy output is estimated at 12.7 GWh and 13.7 GWh, respectively.

10 Los Veganos weir plan envisages to construct a 32 m high intake weir at a gorge immediately downstream from the Yuna No. 1 power station and the confluence with Arroyo Colorado. Water regulation for 6-hour peak operation is led to a 3.3 km long headrace tunnel to be aligned on the right bank of the Yuna river. The powerhouse (Yuna No. 2) is located on the terrace deposit, with a tail water level set at EL. 350.0 m. An effective head is 134.0 m. In case Los Veganos weir plan is combined with El Torito dam plan, the maximum discharge of 7.84 m^3/s is made available for Los Veganos plan and the Yuna No. 2 power station will have an installed capacity of 8.8 MW with annual energy output of 41.7 GWh. In case the plan is combined with El Torito weir or Pino de Yuna weir plan in the upstream, the maximum discharge of 6.88 m^3/s is available and the Yuna No. 2 power station is designed to have an installed capacity of 7.7 MW with annual energy output of 35.4 GWh.

Implementation

11 Under El Torito dam - Los Veganos weir complex, a total installed capacity will be 19.1 MW and the annual energy output is estimated at 79.7 GWh. The alternative to construct El Torito weir - Los Veganos weir complex will have an installed capacity of 14.9 MW, with the annual energy output of 67.5 GWh. While the Pino de Yuna weir - Los Veganos weir complex will have a total installed capacity of 14.0 MW with the annual energy output of 61.8 GWh. The period required for construction of El Torito dam - Los Veganos weir complex or El Torito weir - Los Veganos weir complex is scheduled to be 51 months and 36 months, respectively, from the award of contracts. In case of the Pino de Yuna weir - Los Veganos weir plan, 49 months for the Yuna No. 1 station and 36 months for the Yuna No. 2 station will be required for construction. If the construction works are started in July 1985, the Yuna No. 2 power station is planned to be committed for commercial operation in June 1988 and the Yuna No. 1 power station in July-September 1989.

12 Construction cost of El Torito dam - Los Veganos weir complex, including physical and price contingencies, is estimated at around RD$106.1 million, which comprises RD$59.9 million in foreign currency portion and RD$46.2 million in local currency portion. On the other hand, El Torito weir - Los Veganos weir complex will cost RD$57.1 million, consisting of RD$33.8 million in foreign currency and RD$23.3 million in local currency. Further, construction cost of the Pino de Yuna weir - Los Veganos weir complex is estimated at RD$51.5 million (RD$30.9 million in foreign currency and RD$20.6 million in local currency). In addition to this construction cost, fund is required for execution of the associated programs for resettlement and watershed control, which will amount to around RD$3.3 million for El Torito dam - Los Veganos weir complex and RD$2.2 million for El Torito weir/Pino de Yuna weir - Los Veganos weir complex.

Evaluation

13 Economic feasibility of each complex is evaluated in terms of economic internal rate of return (EIRR). Capacity benefit and the primary energy benefit are valued by assuming an alternative gas turbine power, while the secondary energy benefit is valued in terms of steam and coal-fired power. EIRR of El Torito dam - Los Veganos weir complex is calculated at 8.7%, while EIRR of El Torito weir - Los Veganos weir complex is estimated at 12.9%. EIRR of the Pino de Yuna weir - Los Veganos weir complex is estimated at 12.8%. (EIRR of each component of the complex is estimated at 5.2% for El Torito dam scheme, 10.4% for El Torito weir scheme, 10.0% for the Pino de Yuna weir scheme and 15.6% for Los Veganos weir scheme.) The comparative study revealed that El Torito weir - Los Veganos weir complex is economically most advantageous. El Torito weir - Los Veganos weir complex is evaluated to be economically feasible, in the light of the opportunity cost of capital estimated at around 12% in the Dominican Republic.

14 Financial viability of the complex is evaluated through analysis of a financial internal rate of return (FIRR) and repayability of loans. FIRR of El Torito dam - Los Veganos weir complex is estimated at 6.1%, while FIRR of El Torito weir - Los Veganos weir complex and the FIRR of the Pino de Yuna weir - Los Veganos weir complex are estimated at 10.1% respectively. (FIRR of each component is 2.7% for El Torito scheme, 7.9% for El Torito weir scheme, 7.5% for the Pino de Yuna weir scheme and 13.0% for Los Veganos weir scheme.) Through the repayability analysis, it is vertified that loans to be extended for the implementation of El Torito weir - Los Veganos weir complex are repayable if they are extended on concessional terms. Financial viability and repayability of El Torito dam - Los Veganos weir complex are marginal, and it will make it difficult for CDE to maintain sound financial position.

Conclusion and Recommendation

15. Through the investigation and feasibility study on the hydroelectric development along the Yuna mainstream, it has been clarified that the implementation of El Torito dam - Los Veganos weir complex is economically and financially less attractive. Further, it has also been clarified that El Torito weir - Los Veganos weir complex is more advantageous, economically and financially, than the alternative to implement Pino de Yuna weir - Los Veganos weir complex. The selected El Torito weir - Los Veganos weir complex is technically sound, economically feasible and financially viable. It is therefore recommended to take up El Torito weir (Yuna No. 1 power station) - Los Veganos weir (Yuna No. 2 power station) complex for implementation. In view of the power demand-supply situation in the late 1980's it is recommended that the Yuna No. 1 power station and No. 2 power station be implemented at the earliest possible time.

16. El Torito weir - Los Veganos weir complex, if it is realized, will contribute among others to save the foreign exchange by substituting it for the thermal power generation by imported fuels. Such savings in foreign exchange is estimated at RD$4.7 million per annum.

17. For the implementation of the Yuna No. 1 - No. 2 power stations, it is suggestible to immediately proceed to the preparation of tender documents for construction, in parallel with the arrangement of construction funds. Such preparatory works as access road construction are to be promoted at the same time.

PRINCIPAL FEATURE OF RECOMMENDED PLAN

El Torito Weir Plan (Yuna No. 1 Power Station)

Catchment Area	38.4 km^2
Direct area	30.0 km^2
Stream diversion	8.4 km^2
Firm discharge	0.93 m^3/s
Maximum discharge	3.72 m^3/s

Diversion Weir (T-1):

Type	non-gated concrete gravity
Height	17.0 m
Crest Length	50.0 m
Volume	6,400 m^3

Intake Weir (T-2):

Type	gated concrete gravity
Height	22.0 m
Crest length	86.0 m
Volume	8,700 m^3
High water level	EL. 726.0 m
Low water level	EL. 723.4 m

Waterway:

Headrace tunnel,	Diameter	2.0 m
	Length	5.2 km
Surge tank,	Type	restricted orifice type
Penstock,	Diameter	2.0 - 1.0 m
	Length	615 m

Arroyo Colorado Diversion:

Intake,	Height	7.5 m
	Crest length	67.0 m
Diversion tunnel, Length		1.45 km

Yuna No. 1 Power Station:

Tail water level		EL. 490.8 m
Effective Head		229.2 m
Turbine,	Type	Vertical shaft Francis type
	Rated capacity	7.2 MW
Generator,	Voltage	8.0 MVA
	Power factor	0.9
Energy output,	Primary	15.2 GWh
	Secondary	16.9 GWh
	Total	32.1 GWh
Transmission line,	Voltage	69 kV
	Length	8.0 km

Los Veganos Weir Plan (Yuna No. 2 Power Station)

Catchment Area	62.9 km^2
Firm discharge	1.72 m^3/s
Maximum discharge	6.88 m^3/s

Intake Weir and Storage:

Type	gated concrete gravity
Height	32.0 m
Crest length	68.0 m
Volume	18,140 m^3
High water level	EL. 493.0 m
Low water level	EL. 488.5 m

Waterway:

Headrace tunnel,	Diameter	2.0 m
	Length	3.3 km
Surge tank,	Type	restricted orifice type
Penstock	Diameter	2.0 - 1.0 m
	Length	290 m

Yuna No. 2 Power Station:

Tail water level		EL. 350.0 m
Effective head		134.0 m
Turbine,	Type	vertical shaft Francis type
	Rated capacity	7.7 MW
Generator,	Voltage	9.0 MVA
	Power factor	0.9
Energy output,	Primary	16.4 GWh
	Secondary	19.0 GWh
	Total	35.4 GWh
Transmission line,	Voltage	69 kV
	Length	4.0 km

El Torito Weir - Los Veganos Weir Complex

Installed Capacity		14.9 MW
Energy output,	Primary	31.6 GWh
	Secondary	35.9 GWh
	Total	67.5 GWh

Construction Period:

Yuna No. 1 power station	49 months
Yuna No. 2 power station	36 months

Construction Cost (Financial):

Foreign currency	RD$33.8 million
Local currency	RD$23.3 million
Total	RD$57.1 million
Associated programs	RD$ 2.2 million

Economic Internal Rate of Return:

Yuna No. 1	10.4%
Yuna No. 2	15.6%
Total	12.9%

ABBREVIATIONS

LENGTH

m = millimeter
cm = centimeter
m = meter
km = kilometer

AREA

ha = 10^4 m^2 = hectare
km^2 = square kilometer

VOLUME

ℓ = lit = litre
kℓ = kilolitre
m^3 = cubic meter
MCM = million cubic meters
bbl = barrel

WEIGHT

mg = milligram
g = gram
kg = kilogram
t = ton = 1,000 kg

TIME

s = second
min = minute
hr = hour

MONEY

RD$ = Dominican peso
US$ = US dollar

OTHERS

GDP = Gross Domestic Product
GNP = Gross National Product
CDE = Corporacion Dominicana de Electricidad
DDH = Direction de Desarrollo Hidroelectrico
INDRHI = Instituto National de Recursos Hidraulicos
JICA = Japan International Cooperation Agency

ELECTRICAL MEASURES

Hz = Hertz (cycle)
KW = Kilowatt
MW = Megawatt
KWh = Kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
KVA = Kilovolt ampere
MVA = Megavolt ampere
rpm = revolution per minute
P.F. = Power Factor

OTHER MEASURES

ppm = parts per million
% = per cent
pH = scale for acidity
°C = degree centigrade
kcal = kilocalorie
10^3 = thousand
10^6 = million
10^9 = billion
EL. = elevation above mean sea level

DERIVED MEASURES

m^3/S = cubic meter per second
cm/S = centimeter per second
t/m^2 = ton per square meters
t/m^3 = ton per cubic meters
t/ha = ton per hectare

MAIN REPORT

TABLE OF CONTENTS

List of Tables

List of Figures

List of Drawings

I. INTRODUCTION

1.1 Objective and Scope of Study

For the economic and social development of the Dominican Republic, utilization of resources of the country has been and will continue to be a target of prime importance. In the sector of electric power, which is one of the infrastructures of vital significance, the Dominican government is making its utmost effort to utilize national water resources to the maximum extent and to improve the present situation heavily dependent on imported fuels for power generation.

At the request of the Dominican government, the Japanese government decided to cooperate in developing hydroelectric power, by extending technical cooperation for the study on hydro-power development in the upper Yuna river basin. In February 1982, an agreement was reached between Corporacion Dominicana de Electricidad (CED) and Japan International Cooperation Agency (JICA) to carry out a feasibility study on El Torito - Los Veganos hydroelectric complex which is located on the mainstream of the upper Yuna river. The objective of the study is to formulate an optimum development plan and to evaluate technical, economic and financial feasibility of the hydroelectric complex.

More specifically, the study encompasses the scope of works an summarized hereunder.

1) To review previous studies and background of the project
2) To investigate topographic, hydrometeorologic, geologic, geophysical and geotechnical conditions in the field
3) To formulate and select an optimum plan for development of El Torito - Los Veganos hydroelectric complex
4) To evaluate technical, economic and financial feasibility of the complex

In addition to the feasibility study on El Torito - Los Veganos hydroelectric complex, CDE requested JICA study team to review on the previous studies on the Piedra Gorda scheme located immediately downstream from Los Veganos scheme and on the Pinalito scheme located on a tributary of the Yuna river. Such a review and preliminary study have also been executed in parallel to the feasibility study on El Torito - Los Veganos complex.

1.2 Execution of Study

To execute the feasibility study on El Torito - Los Veganos hydroelectric complex in the upper Yuna river basin, JICA appointed a study team composed of experts specialized in various expertise. On the other hand, CDE's Department of Hydroelectric Development (DDH) nominated counterparts to jointly execute the investigation and studies of the hydroelectric complex. A list of CDE-JICA members of the study team is shown on Table 1-01.

The field investigations by CDE-JICA team started at the end of June 1982. After inception works and ground control survey for aerial photo mapping until August 1982, a topographic map on the scale of 1/5,000 was prepared to cover the study area. The detailed field survey resumed in November 1982 and lasted until March 1983. A part of geologic and geotechnical survey was also conducted in May-August 1983. A major part of detailed studies has been carried out in Japan, but CDE's counterparts also took part in the studies by sending engineers to Japan, three times at CDE's cost and twice at JICA invitation, thus enabling joint study by CDE counterparts and JICA study team.

1.3 Report

In the course of the study, an Inception Report, Interim Report and Progress Reports, as well as some working papers, have been prepared. The Final Report, submitted herein, presents all the results of investigations and studies executed for El Torito - Los Veganos hydroelectric complex. The Final Report comprises Main Report (Volume I) and Annexes (Volume II to IV). The substance of the studies is described in Main Report in a summarized form, and detailed explanation and supporting data are compiled in Annex-A to Annex-I

In addition, the result of review and preliminary study on the Piedra Gorda scheme and the Pinalito scheme in the upper Yuna river basin in separately compiled in Appendix to this Final Report.

1.4 Acknowledgement

During the execution of the investigations and studies, the Study Team, both JICA team and CDE counterparts, received a kind assistance and cooperation from the people living in and around the study area, as well as agencies and institutions of the Dominican Republic. The Team takes this opportunity to express its heartfelt gratitude to all the personnel and institutions concerned. Without their assistance and cooperation, the study could not be completed so successfully within a study period initially scheduled. Cooperation of the Ministry of International Trade and Industry and Ministry of Foreign Affairs of the Japanese government, as well as the Japanese Embassy to the Dominican Republic, is also greatly acknowledged. The study team sincerely hopes that the joint effort and cooperation extended to the study will contribute to the future development of hydroelectric power and eventually to the socio-economic development of the Dominican Republic.

II. BACKGROUND OF THE PROJECT

2.1 General Economic Background

2.1.1 Population and Employment

The Dominican Republic has, within its territory of 48,442 km^2, population of 5.75 million in mid 1983. Population is increasing at an annual rate of 2.9%, and it is predicted to reach 6.1 million in 1985 and 6.8 million in 1990, as shown on Table 2-01. Urbanization is salient in recent years. Urban population increased from 40% of total population in 1970 to 52% in 1981. It is estimated that urban population will represent nearly 59% in 1990. (Refer to Annex A.1.1)

About 45% of urban population of the country are resided in the National District, Santo Domingo. In other provinces of the Southeast region, about 11% of total urban population are concentrated in such major cities as San Cristobal, San Pedro de Macoris and La Romana. Another concentration of population is observed in the Central Cibao sub-region, where 16% of urban population are resided. These provinces and districts concentrated with urban population are linked by a national main grid of power transmission, as shown on Fig. -01.

Out of total households estimated at around 1.1 million over the country, the households served with electric power are limited to 29.8%. It is noted, further, that approximately 75% of power customers are resident in urban areas. Although rural electrification has been promoted in recent years, electrification programs have been hampered due substantially to the shortage of power generation, as discussed in Chapter 2.2.

Economically active population (EAP) accounted for around 30% of total population. EAP in the agricultural sector has been decreasing rapidly, and it is mainly absorbed in the service sector. The employment in the manufacturing sector has not demonstrated a notable increase.

Unemployment rate has been substantially high. According to the 1970 census, about 24% of EAP were unemployed (23.9% in urban area and 24.1% in rural area). It is also noted that the rate of underemployment was as high as 43% in urban area, according to a sample survey in 1980. Efforts have to be taken further to activate national economy and to create employment opportunities in every sector over the country. (Refer to Annex A.1.2)

2.1.2 Gross Domestic Product

Gross domestic product (GDP) increased at an average rate of 3.6% per annum in 1976-78, but the growth rate decreased to 2.5% per annum in 1980-82 which was lower than the rate of population increase. The Central Bank predicted in August 1983 that GDP would grow at 3.1% in 1983. (Refer to Annex A.2.1 and A.2.2)

The agricultural sector contributed for 17-19% of GDP in the last 5 years as shown on Table 2-02. Contribution of the mining sector, which was over 5% in the late 1970's, dropped to 3.2% in 1982 principally due to the suspension of ferronickel smelting at Falconbridge. The suspension of Falconbridge, though temporary as it was, is said to be mainly attributable to the unfavorable market situation worldwide, but it might be partly attributable to the increased fuel cost for thermal power generation.

GDP in the manufacturing sector increased at a rate much lower than expected, or 3.5% a year on an average in 1978-82. Such a stagnation might have been caused by multiplex national and international economic situation. However, a fact is that many industries are suffering from unstable supply and increased cost of electric power. Numbers of factories had to install in-house generators to cope with frequent black-out of power supply. It is fundamental requirement for the acceleration of the industrial development to secure stable supply of electric power at reasonable prices.

2.1.3 Balance of Payment

Trade balance of the Republic remains unfavorable in recent years, due primarily to the rapid increase in import. In 1982, the trade balance showed a deficit amounting to RD$480 million as shown on Table 2-03. Although measures are taken by the government to restrict import, the unfavorable trade balance would not improve substantially in 1983.

Import of petroleum and its products has been one of the principal reasons in increasing import value and aggravating the trade balance, because the Dominican Republic depends entirely on imported petroleum. In 1982, import value of petroleum and its products amounted to RD$450 million, which was equivalent to 36% of total import or 59% of total export of the country. In this context, too, development of national resources to substitute the import of fossil energy is of prime significance for the national economy in a short and long run. (Refer to Annex A.2.3 and A.2.4)

2.2 Situation of Power Demand and Supply

2.2.1 Trend of Demand

Past and future trend of power demand is reviewed in the light of the Expansion Plan of CDE Electric System in 1979-92 prepared by CDE-SOFRELEC and by incorporating updated information up to the end of 1982.

Consumption of electric power grew steadily in 1970's as shown on Table 2-04 and Fig.-02. The energy sold by CDE increased from 684 GWh in 1970 to 1,914 GWh in 1980, with an average annual growth rate of 10.8%. Although the growth rate slightly decreased to 8.9% in 1981, the potential demand remained considerably high. The sold energy dropped to 1,890 GWh in 1982, due to extraordinary increase in energy loss in transmission and distribution.

Power consumption by sector demonstrates little historical change since 1970. The residential sector consumed 38-39% of total energy sold, while the commercial sector consumed 12-13%. The energy sold in the industrial sector acocunted for 35-38% of CDE sold energy. The growth rate of consumption in respective sector was 8.8%, 6.9% and 7.1% per annum on an average in 1977-81. (Refer to Table 2-05)

Total sending end energy, inclusive of energy purchased from the state-owned hydro power plants and the Falconbridge steam power, increased at an average rate of 11.7% per annum in 1970's, and it reached 2,849 GWh in 1982. The maximum demand, on the other hand, increased from 181 MW in 1970 to 462 MW in 1980, with an average growth rate of 9.9% per annum. It reached at 504 MW in 1982. An average load factor was around 65% in 1978-82. (Refer to Annex B.2.1)

Under the Expansion Plan of CDE Electric System, SOFRELEC predicted that the sold energy would reach around 3,238 GWh in 1985 and 7,614 GWh in 1992, with an average growth rate of 12.4% in 1979-92. It also forecasted that the energy loss would decrease to 20% in 1983 and 16% in 1992, with the result that the sending end energy would reach 3,983 GWh in 1985 and 9,060 GWh in 1992. A load factor of 62.5-62.7% was applied, and it was estimated that the maximum demand would eventually reach 728 MW in 1985 and 1,661 MW in 1992. (Refer to Annex B.3.1)

Despite the facts that economic activities in recent years were more stagnated than expected by the Expansion Plan and there were notable variations in macroeconomic parameters, the forecast of the sold energy under the Expansion Plan demonstrated fairly good value in 1979-81 if they were compared with the actual record. A salient variation between the actual record and the forecast under the Expansion Plan is an energy loss factor. The loss factor was actually 25.2% in 1981. Although the loss factor of 33.6% in 1982 was extraordinary, it will in no way drop to 20% in 1983 as predicted by SOFRELEC, in view of the delayed improvement in distribution systems. Another point of notable variation is the load factor. The load factor was predicted at around 62.6% throughout the period of Expansion Plan, but it would be more realistic to consider that the load factor would remain at a higher rate.

By incorporating the two salient variations as noted above, case studies have been made to evaluate their sensitivity on the forecast of the maximum demand. In these case studies, the energy loss factor is presumed to be gradually improved at a slower pace or to be lowered to 22.5% in 1992. While, the load factor is assumed at around 65% which was nearly an average factor in 1978-82.

The Case-1 study applied the sold energy predicted by the Expansion Plan. With the modified energy loss factor and load factor, the maximum demand is estimated to reach 771 MW in 1985 and 1,725 MW in 1992. On the other hand, the Case-2 study is made on the basis of sold energy forecasted by means of evolution by regression in 1970-81. The sold energy is estimated at 3,200 GWh in 1985 and 6,449 GWh in 1992, and the maximum demand is predicted to be 762 MW in 1985 and 1,461 MW in 1992. The above estimated maximum demand is higher under the Case-1 study and much lower under the Case-2 study than the prediction by the Expansion Plan, as shown on Table 2-06 and Fig.-03. (Refer to Annex B.3.2)

2.2.2 Present Situation of Power Supply

Electric power is fed by CDE-owned hydro, steam, gas and diesel plants and by purchase from the state-owned hydro power plants and the Falconbridge steam power. Total rated capacity of the plants, including the state-owned hydro and Falconbridge, is 907 MW. The firm generating capacity, 2-07. Out of total firm capacity for power generation, about 85% or 512 MW is thermal power, and hydro power represents only 15%.

In terms of sending end energy, hydro power contributed 10.9% (311 GWh) in 1982 and 18.4% (512 GWh) in 1981. Gas turbine and diesel plants generated less than 10% total sending end energy. The remaining energy (79% in 1982 and 72% in 1981) was fed by steam power plants. Steam plants are located in Haina (256 MW in firm capacity), Santo Domingo (38 MW) and Puerto Plata (34 MW). Haina power station, having 5 steam units, is the principal power source, and it contributed for nearly a half of the total sending end energy of CDE. In case a unit of Haina station is shut down due to repair or shortage of fuel, which has been rather frequent, the power supply situation faces with a critical condition. Such an instable power supply causes serious problem in the industrial sector, as well as residential and commercial sectors. (Refer to Annex B.2.2)

Heavy dependence on thermal power has aggravated CDE's financial situation. CDE had to pay about RD$136 million in 1981 and RD$127 million in 1982 for purchase of fuel for thermal power generation. Such an amount is equivalent to 67% and 62% of total operation cost, or 58% and 50% of total CDE operational revenue, respectively. Such a payment in foreign currency is equivalent, in another sense, to 11.4% and 16.5% of total export earning of the Republic in 1981 and 1982. (Refer to Annex B.6.3)

Development of hydro power has been lagged behind. CDE-owned hydro power is presently limited to rather small plants, like Las Damas (7.5 MW) and Constanza (0.25 MW). Major hydro plants, including Tavera-Bao (80 MW), Valdesia (54 MW), Sabana Yegua (13 MW), Rincon (10.1 MW) and Sabaneta (7.5 MW), are state-owned plants developed under multipurpose dam projects. In recent years, CDE is making its utmost effort to develop hydro power by studying, designing and implementing various hydro projects.

Power is sent to major consuming centers through 138 kV and 69 kV transmission line networks. The principal grid of 138 kV lines links Puerto Plata station, Tavera-Bao station, Santiago (Canabacoa substation), Valdesia station and Santo Domingo (Palamara substation). It is extended further to San Pedro de Macoris. On the other hand, 69 kV grids extend for about 2,000 km in total. Improvement of power distribution system has been planned and studied in major cities. The first stage improvement in Santo Domingo is, at present, in the design stage. (Refer to Fig.-04)

2.2.3 Power Expansion Program

The Expansion Plan proposed by CDE-SOFRELEC has basic strategies to 1) develop coal-fired thermal power plants with higher combustion efficiency to cover the major part of base load, 2) minimize the use of thermal power plants with low combustion efficiency, and 3) develop hydro power to the maximum extent, as illustrated on Fig.-05. For the development of coal-fired power, the Plan envisages to install 4 units of 115 MW plants at Itabo by 1987, and additional 3 units of 115 MW by 1992. Since the coal deposit in the Republic is limited, they have to depend principally on imported coal. By early 1983, the first unit is under construction and a contract for the second unit has been awarded. They are scheduled to complete in 1984 and 1987, respectively.

All the hydroelectric projects identified by 1979 are inventoried and incorporated in the Expansion Plan. It is expected that hydro power to be developed by 1992 will reach at the mean capacity of 620 MW or about 510 MW in the drought years. Several hydro power schemes are scheduled to be implemented by 1989, with the firm capacity of about 197 MW. Implementation of other hydro power schemes has not been scheduled yet, and is considered as rather panoramic at this moment.

If the power situation in 1987 is checked under the implementation program scheduled at the moment, the total firm generating capacity will reach around 860 MW, which consists of 199 MW of hydro, 559 MW of steam and 102 MW of gas plants. While, the peak power demand in 1987 is estimated to reach in the range of 967 MW (Case-1 study) to 916 MW (Case-2). This implies that additional installation of power plants will have to be implemented unless the third unit of Itabo coal-fired plant is hastened to be initiated to start its operation in 1987. (Refer to Fig.-06).

2.2.4 Role of El Torito - Los Veganos Complex

As it has been reviewed in the foregoing paragraphs, CDE has to accelerate development of hydro power to meet the growing demand, as well as to improve financial situation of the Corporation and the national economy as a whole.

In line with the basic policy to develop coal-fired power to cover the base load, El Torito - Los Veganos hydroelectric complex is to be developed to cover, in principle, the peak load. In view of the daily load curve, as well as the daily and annual load duration curve, the complex is designed to guarantee the minimum operation of 6 hours a day. It is also recommendable to device the operation of the complex so as to utilize the available discharge of the river to the maximum extent.

In view of the fact that the power supply in 1987 is predicted to be critical as reviewed before, and that the expansion program of hydro power after 1988 is still panoramic, it is desirable that El Torito - Los Veganos complex will be implemented, as far as economically feasible, and completed at the earliest possible time.

III. PHYSICAL CONDITIONS OF THE PROJECT AREA

3.1 Physiography

The study area is located in the uppermost part of the Yuna river basin, which drains a total area of about 5,498 km^2. The mainstream of the Yuna river originates in the Cordillera Central and flows down rapidly until it enters into Bonao valley. The catchment area of the Yuna mainstream at the confluence with the Blanco river is approximately 157 km^2. El Torito - Los Veganos hydroelectric complex is planned to be developed along this mainstream of the Yuna river.

The mountain ranges in the southern watershed show an open hyperbolic curve, dividing La Vega province to the north and Perevia province to the south. The mountain slopes in the range of 30° to 40° in the western part of the study area where the Duarte Formation and the Tireo Formation are geologically dominant. In the eastern part where the Plutonic igneous rocks prevail, the mountain shows gentle appearance of slopes.

The Yuna river was intensively incised during the uplift movement in the Quaternary period, which was accompanied by intermittent stable duration of the land. The Yuna mainstream is confluent from such tributaries as Arroyo Blanco, Arroyo Colorado, A. Tireo and Arroyo Avispa. Sporadic terrace deposits are developed along the river course. The riverbed elevation of the Yuna mainstream at the confluence with Arroyo Blanco is 691 m above mean sea level, and it is 293 m above mean sea level at the confluence with the Blanco river. The average river gradient is around 1/40 in this section. (Refer to Fig.-07)

3.2 Vegetation and Land Use

In the upper Yuna river basin of mountaneous topography, shifting cultivation by settlers has substantially changed vegetation and land use. In the southwestern part, or in the sub-basin of Arroyo Blanco and Arroyo Colorado, the land is extensively deforested. The deforested land is covered mainly with pasture. In the central part along the Yuna mainstream, the land use shows more variety. Forest is conserved along the river course and it is mainly used for cultivation of coffee. Narrow river terraces are utilized for crop cultivation. The southeastern part of the upper Yuna river basin is less desolate of vegetation, and forest is rather extensively conserved together with coffee cultivation.

In the upper basin upstream of the confluence of the Yuna mainstream and Arroyo Colorado (inclusive of the upper basin of Arroyo Avispa), the coverage of forests represents around 48%. Although the area cultivated by coffee is not discernible accurately by aerial photo interpretation, it accounts for around 14%. The pasture and grass land, including land of shifting cultivation, represent nearly 35% of the upper Yuna river basin. Such a vegetation and land use in the basin has substantial effects on water conservation, erosion, sediment yield, etc.

3.3 Meteorology

The study area has basically a tropical climate. The predominant NE trade wind, getting humid in the Atlantic Ocean, brings rainfall when it collides with the mountain ranges. The wet season usually lasts from April to November or December, but it is interrupted by relatively dry months in June-July. Hurricanes usually attack in August-October.

The meteorological gauging station, located nearest to the study area having a recording period over 10 years, is Juma Bonao station in the Bonao valley. At Juma Bonao, the annual mean temperature is around 24°C, with least seasonal fluctuation. The mean monthly minimum and maximum temperature ranges between 19°C and 32°C. The relative humidity also demonstrates little seasonal variation, and it ranges from 84% in March and June to 88% in December. The annual mean evaporation is around 4 mm/day at Juma Bonao.

Rainfall records are available at the pluviometric gauging stations in and around the study area. However, the recording period is limited to 3-4 years, except for the record at Rancho Arriba (1,275 mm on 36 years' average), Constanza (1,020 mm in 52 years), Los Quemados (1,940 mm in 17 years) and Juma Bonao (1,840 mm in 13 years). Among these gauging stations, Los Quemados station located about 3.7 km downstream from the confluence of the Yuna mainstream and the Blanco river, presents the most representative precipitation records. The daily rainfall record available at Los Quemados will be utilized to estimate probable precipitation in flood discharge analysis.

The probable maximum precipitation is estimated at 412 mm/day, and the probable precipitation is estimated at 304 mm/day for the return period of 100 years and 337 mm/day for the return period of 200 years.

3.4 Hydrology

There is a limited number of hydrological gauging stations in the upper Yuna river basin. Although two automatic water level gauges were installed in the course of this study, the only station that has over 10 years' record is Los Quemados gauging station, which has a catachment area of 369 km^2. At Los Quemados, discharge records in 1962-79 (18 years) are available.

At a site immediately upstream of Los Quemados gauging station, water has been taken for irrigation use in theBonao valley. By adding such a water intake, synthetic discharge at Los Quemados is calculated on a daily basis. The monthly mean synthetic discharge is estimated at 19.25 m^3/s, as shown on Table 3-01. It ranges from 13.96 m^3/s in March to 29.19 m^3/s in December. (Refer to Annex C.4.1)

Discharge of each tributary and at each site proposed for the development of El Torito - Los Veganos complex is estimated on the basis of spot discharge measurement at 11 sites and their relation with discharge recorded at Los Quemados. Based on such a discharge ratio, the daily discharge at each structure site is calculated. For instance, discharge of the Yuna mainstream and Arroyo Blanco is estimated respectively at around 0.04 of discharge recorded at Los Quemados. At the confluence with Arroyo Colorado 0.22 of Los Quemados discharge is estimated as available. (Refer to Table 3-02 and Annex C.4.2) 90% dependable discharge is thus estimated of 0.31

m^3/s at a dam/weir site on the Yuna mainstream in El Torito, 0.31 m^3/s at a dam/weir site on Arroyo Blanco, and 1.72 m^3/s at the confluence with Arroyo Colorado.

Flood runoff model is developed in line with the storage function method, and it is reviewed by comparing the calculated and observed hydrographs at the time of selected storm records available at Los Quemados, Los Veganos and Pino de Yuna. The probable flood for the return period of 200 years is calculated at around 460 m^3/s at El Torito, 490 m^3/s at Pino de Yuna, 920 m^3/s at the confluence with Arroyo Colorado and 2,700 m^3/s at Piedra Gorda located at about 2 km upstream of Los Quemados. (Refer to Annex C.5.2)

Sediment yield in the watershed is substantially large, due to the vegetation and land use as explained in Chapter 3.2. Through the aerial photo interpretation, land use and experimental method of analysis, it is estimated that the specific sediment yield in the area upstream of the confluence with Arroyo Colorado is around 2,000 $m^3/km^2/year$. Water quality is acceptable and will not present any specific problem in hydroelectric development.

3.5 Geology

Geology in the study area is divided into the Duarte Formation, Tireo Formation, Plutonic igneous rocks, terrace deposit, debris and riverbed, in an ascending order. The stratigraphic sequence is shown on Table 3-03 and the geologic map is illustrated on Fig.-08. (Refer to Annex D.2)

The Duarte Formation is composed of three rock facies; a) gneiss, b) amphibolite, foliated diorite and peridotite, and c) green schist. Gneiss shows the highest grade of metamorphism of the Duarte Formation and Crops out in the vicinity of Pino de Yuna and T-1 damsite on the Yuna mainstream. Gneiss has extremely foliated texture, and it is in fault contact with green schist. On the other hand, amphibolite associated with subordinate foliated diorite and peridotite is distributed in the uppermost part of the Yuna river basin and in the vicinity of El Torito. The rock is cut by several faults trending north to south. Further, green schist is distributed throughout the study area from El Torito to Piedra Gorda, having a general trend of schistosity of NW to SE in the upstream and N to S in the downstream area.

The plutonic igneous rock, or quartz diorite, is generally coarse-grained hollocrystalline and leucocratic. The rock is distributed in the eastern part of the study area where watershed ranges form gentle slopes. It is widely decomposed into red clay in the adjoining area of Los Pejes village, and the residual red clay is appropriate for borrow area of earth materials for embankment.

The Tireo Formation crops out in the downstream part of the study area, extending from Los Veganos to Piedra Gorda. It is made up mostly of pyroclastic and volcanic rocks such as tuff, tuff breccia, lapilli tuff and dacite, with subsidiary well-bedded sediments of limestone, slate, conglomerate, chert and sandstone. The Tireo Formation is inferred to be thrust over by the older Duarte Formation along the Bonao fault which is traceable from Piedra Gorda to Los Veganos. Many lineaments are recognizable, and most of them are explicable as the results of faulting. A number of landslides are also distinguishable throughout the area of the Tireo Formation. Further, the rock distributed near Los Veganos is characterized by the alternation of limestone and green pyroclastic rocks.

The terrace deposit is mostly distributed along the Yuna mainstream and is made up of uncemented loose mixture of sand, silt and gravel. The terrace deposit will offer sites for powerhouses because of its flat topography, or will be used for aggregate and embankment materials. Debris, on the other hand, consists of loose and unconsolidated deposit of rock and soil, and is distributed in the toes of landslide massif and in the gentle slope fan. River deposit is also made up of uncemented loose mixture of sand, silt and gravel, and it is utilized as aggregate and embankment materials.

The geology of the study area is characterized by faults developed extensively. The Bonao fault, which is one of the principal fault on tectonic line in the Republic, extends in the north-south direction through the study area. The fault is inferred to bevel the Yuna river at Piedra

Gorda and stretch to the right bank. Further, it crosses Arroyo Avispa, and presumably extends up to Los Veganos, bordering the Duarte Formation and Tireo Formation. The fractured zone of the Bonao fault reaches about 12 m in thickness at Piedra Gorda, but it gradually pinches out to reach around 5 m in thickness near Los Veganos. Another major fault runs in parallel with the Yuna mainstream in its upstream reach. The fault dips nearly vertically, and it is accompanied by the fractured zone of approximately 30 m in width at maximum.

3.6 Construction Materials

Availability of such construction materials as earth and rock materials, filter and concrete aggregates is investigated qualitatively and quantitatively in and around the major structure sites.

Earth borrow areas in and around El Torito are identified to locate around the col dividing the Yuna mainstream and Arroyo Blanco basins and around the village of Los Pejes. It is estimated that the available quantity of earch materials will be around 1.5 million m^3 in these borrow areas. Soil properties in the borrow area around Los Pejes are found suitable for core materials. In case of earth materials obtainable around the col, it is desirable to improve its soil properties by mixing it with sandy materials which lain at the lower part of the clayey soil layer. (Refer to Fig.-09 and Annex E.2.1)

Earth materials in and around Los Veganos are rather limited in availability. However, in the borrow areas at the toe of mountain slope near the village of Los Veganos and on the hill-top extending to the right abutment, about 700,000 m^3 of earth materials are available for use as core materials of a rock-fill dam construction. (Refer to Fig.-10 and Annex E.3.1)

Rock materials are available in El Torito area at a quarry site located on the right bank of Arroyo Blanco located at about 1.6 km upstream of the confluence with the Yuna mainstream. The rocks, identified as amphibolite of the Duarte Formation, have sufficient durability, hardness, and soundness as materials for a rock-fill type dam construction, and are estimated to exceed over 1 million m^3 in volume. Rock materials are also obtainable in Los Veganos area at a quarry site located on the left bank of the Yuna river immediately upstream of the confluence with Arroyo Colorado. The rock is estimated to be more than 1 million m^3 in volume, and is suitable for use as rock/rip rap materials. (Refer to Annex E.2.3 and E.3.3)

Sand and gravel for filter and concrete aggregates are obtainable from the riverbed. In the vicinity of El Torito, the borrow areas are identified at a site immediately downstream from the confluence with Arroyo Blanco, and along Arroyo Blanco 0.5 km and 2 km upstream of its confluence with the Yuna mainstream. Available quantity of sand and gravel in these borrow area is estimated at around 190,000 m^3. It will be sufficient for use as filter materials of rock-fill type dam, or for use as concrete aggregates of gravity weir. However, it will not be sufficient for construction of a large scale concrete gravity dam. In and around Los Veganos area, sand and gravel have to be obtained at several borrow areas identified along the Yuna mainstream. A total of some 90,000 m^3 of filter and concrete aggregates are estimated to be available. Sand and gravel available in the borrow areas in El Torito area and Los Veganos area are qualitatively adequate for use as filter and concrete aggregates. (Refer to Annex E.2.2 and E.3.2)

IV. ALTERNATIVE PLANS

4.1 General

4.1.1 Schemes

The mainstream of the Yuna river flows down rapidly until it joins with the Blanco Yiver. A head of approximately 400 m is available in the section between ghe confluence with Arroyo Blanco (EL. 691 m) andthe confluence with the Blanco river (EL. 293 m). To harness water available in the upper Yuna river basin, various alternative development plans are conceivable.

Basically, water in the Yuna mainstream is harnessed in two steps, taking into account the topographic conditions and tributary systems. In the upper reach, dam and reservoir sites, as well as alternative weir sties, are found near El Torito. In the middle reach, near confluence with Arroyo Colorado, alternative dam or weir sites are identified near Los Veganos. The scheme to be developed in the upper reach is called El Torito scheme, and the scheme in the middle reach is called Los Veganos scheme. The previous study by CDE-ENEL also proposed to construct a dam and reservoir on the Yuna mainstream near El Torito and another dam near Los Veganos.

In view of the fact that water available in the mainstream at each intake site is rather limited, study is to be made on water diversion from the nearby tributaries. Such a water diversion has also an effect on the alignment of the headrace tunnel for each scheme. Further, selection of alternative plans is greatly affected by the geologic conditions at the structure sites, particularly by faults extensively traceable in the upper Yuna river basin.

Outline of each alternative plan, as well as screening of the conceived alternatives, is explained in a summarized form in Chapter 4.2 to 4.4 A schematic diagram of representative alternative plans is illustrated on Fig.-11.

4.1.2 Water Use

In evaluating the alternative plans, operation of reservoir for dam-type power generation or storage for weir-type power generation is defined in accordance with the operation rules as briefly explained hereunder. (Refer to Annex F.1.2)

In case of dam-type power generation, firm discharge is determined through the analysis of mass curve based on the estimated daily mean discharge and the storage capacity. The discharge in the second worst drought year is adopted in calculating the firm discharge.

Intake of water for power generation is practised in such a way that the firm discharge is utilized for peak hour operation when a reservoir water level is inbetween the high water level and low water level, and that the inflow discharge is used to the maximum extent for peak hour and off-peak hour operation when a reservoir water level is at the high water level. In case that a reservoir water level is at the low water level, intake water is the inflow discharge and rated generating capacity is not obtainable. (Refer to Fig.-12)

In case of weir (run-of-river) type power generation, the firm discharge is calculated at 90% dependable discharge. Intake for power generation is, in principle, the daily inflow discharge and storage water level at the weir is daily maintained at a full supply level. When daily inflow is over the plant peak discharge, power plant is operated at full scale, maintaining the full supply level at the storage. At the time of drought, when discharge is lower than the firm discharge, the power plant is operated at a lower capacity, but maintaining the operation for the peak hours. (Refer to Fig.-13)

4.2 El Torito Scheme

4.2.1 Alternative Dam Plans

In and around El Torito in the upper reach of the Yuna river, a damsite is identified on the mainstream at a site about 500 m upstream of the confluence with Arroyo Blanco (called T-1 damsite).

T-1 damsite presents V-shaped valley in topography, sloping 35° in the left abutment and 40° in the right abutment. Both abutments, as well as riversides, are occupied by foliated and microcrystalline amphibolite, which strikes ENE to WSW and dips 30°S in general trend of foliated plane. Joint is developed, but it is inferred to be tight in the intact rock. Debris and overburden are about 5 m in depth in the left abutment and they are shallower in the right abutment. Judging from topographic and geologic conditions, it appears possible to construct both concrete gravity dam and rock-fill type dam at T-1 damsite.

T-1 damsite commands a catchment area of 15.7 km^2. Water available at T-1 damsite is estimated at the ratio of 0.04 of discharge recorded at Los Quemados. To increase water to be stored in T-1 reservoir, water diversion from Arroyo Blanco is contemplated. Water of Arroyo Blanco is taken by constructing a diversion weir at a site about 1.2 km upstream of its confluence with the Yuna mainstream (about 13.0 km^2 of catchment area at the weir site).

T-1 dam plan involves major structures as follows:

a) T-1 dam (gravity or fill-type dam).

b) A gated diversion weir (about 8 m in height) and intake structure on Arroyo Blanco, together with an access road to the weir site.

c) A tunnel (about 1.4 km in length) from the diversion weir to T-1 reservoir. (The tunnel crosses a zone fractured by the fault with a width of about 70 m.)

d) A saddle dam at T-3 site. (A low fill-type dam construction is possible at T-3 site, but attention is to be paid to the decomposed zone as deep as 25 m from the ground surface in both abutments.)

e) An aqueduct or steel lining of a headrace tunnel (about 171 m in length) and a supporting structure to cross over Arroyo Blanco.

f) A headrace tunnel of 5.7 km on the left bank of the Yuna river.

An alternative plan is conceived to construct another dam on Arroyo Blanco at a site about 400 m upstream of the confluence with the Yuna mainstream (called T-2 damsite), to store water of Arroyo Blanco in combination with T-1 reservoir. T-1 and T-2 reservoirs are combined by excavating an open channel at T-3 site.

At T-2 damsite, topographic condition permits to construct a fill-type dam. A primary concern at the damsite is the extent and effect on the foundation rock (foliated and microcrystalline amphibolite) affected by the fault which extends on the left abutment. On the basis of seismic exploration and core drillings at T-2 damsite, the major fault is inferred to be approximately 20 m in width, and the fault has no serious effect on the surrounding rock near the damsite. It is revealed that construction of a fill-type dam is possible within a limited dam height of 50-60 m. It is noted, however, that the rocks around the site are more deeply decomposed and weathered if compared with T-1 damsite. The basement rock will have to be excavated down to approximately 17 m at maximum. A great care should also be paid on curtain grouting treatment for water stop of the dam axis.

The combined T-1 and T-2 dams command a total catchment area of 30 km^2 (15.7 km^2 at T-1 site and 14.3 km^2 at T-2 site). Water available from the combined catchment area is estimated at the ratio of 0.08 (0.04 at T-1 and 0.04 at T-2) of discharge recorded at Los Quemados. The gross storage capacity is estimated at 6.1 million m^3 at the high water level of EL. 755 m and 8.4 million m^3 at EL. 760 m. The alternative to construct T-1 and T-2 dams involves major structures as follows:

a) T-1 dam (gravity or fill-type dam)

b) T-2 dam (fill-type dam)

c) A headrace tunnel of 5.3 km in length (shorter by 430 m than T-1 single dam plan) on the left bank of the Yuna river.

To alternative plans, T-1 single dam or T-1 and T-2 combined dams, are compared economically under the condition that both alternatives have the same gross storage capacity. Consequently, it is found that the alternative to construct the combined T-1 and T-2 dams is economically more recommendable. The scale of reservoir to be constructed by T-1 and T-2 dams is finally decided through making an optimization study. (Refer to Annex F.)

4.2.2 <u>Alternative Weir Plans</u>

An alternative plan is conceived to construct weirs, instead of dams, at T-1 and T-2 site in El Torito having a storage capable of regulating daily discharge for generation of peak power for the minimum of 6 hours a day. Water diverted by T-1 weir is led to the storage of T-2 weir on Arroyo Blanco through a 360 m long open channel to be excavated at T-3 site. An intake structure is constructed at T-2 weir, and water is led to a headrace tunnel of 5.2 km in length. 90% dependable discharge is estimated at 0.31 m^3/s at T-1 site and 0.31 m^3/s at T-2 site. An effective head of 229.2 m is obtained for power generation.

The other alternative weir plan is to construct a diversion weir at a site near Pino de Yuna, about 800 m downstream from the confluence with Arroyo Blanco (called T-4 site). At T-4 site, the riverbed is about 15 m in width and the abutment dips 40° on the right bank and 30°-35° on the left bank. The site is geologically composed of gneiss, showing a remarkable foliation dipping to the right abutment. The left abutment has a decomposed zone of about 6 m in thickness. A fault of about 20 m in width is inferred to run in a higher portion of the left abutment. However, the geologic conditions permit to construct a concrete weir with a height of 20-25 m at maximum.

A catchment area at T-4 site is approximately 32.5 km^2. 90% dependable discharge at this site is estimated at 0.70 m^3/s. A headrace tunnel of about 4.4 km in length (shorter by 800 m than T-1 and T-2 weir plan) is aligned on the left bank, and a head of about 184.3 m (lower by about 45 m than T-1 as T-2 weir plan) is obtainable in case the powerhouse is located near V-1 damsite in Los Veganos.

The two alternative weir plans have been preliminarily evaluated economically. However, the preliminary evaluation has turned out to be quite marginal in the benefit/cost ratio, and it is decided that selection will be made through detailed comparison by preparing design and cost estimate of both alternative weir plans in El Torito area.

4.2.3 Water Diversion from A. Colorado

Arroyo Colorado is a major tributary, having a catchment area of about 15.3 km^2 at the confluence with the Yuna mainstream. The Arroyo Colorado basin has comparatively higher specific discharge and steeper river gradient. Consequently, a plan is conceived to divert water available in the upper basin of Arroyo Colorado to the headrace tunnel, either from the combined T-1 and T-2 dams or from the alternative intake weir.

To this end, two diversion weirs are constructed on the bifurcated small tributaries of Arroyo Colorado, to take water at around EL. 775 m. At these weir sites, the catchment area is approximately 8.1 km^2, and 90% dependable discharge is estimated at 0.31 m^3/s. Water is diverted through a tunnel of about 1.6 km in length to join the headrace tunnel from El Torito dams. In case of water intake at T-1 and T-2 sites, or alternative weir at T-4 site a single Colorado diversion weir is constructed at a site downstream from the bifurcation of tributaries. The diversion tunnel is 1.45 km in length for T-1 and T-2 weir plan, and 1.3 km for T-4 weir plan.

The water diversion will substantially increase available discharge for power generation. One of the major constraints, however, is the construction of an access road to the diversion weir sites. Through the economic comparative study between with and without water diversion from

Arroyo Colorado, it is recommended to utilize Arroyo Colorado water even though the total construction cast is obliged to increase.

4.3 Los Veganos Scheme

4.3.1 Dam Plan

In the middle reach of the Yuna mainstream near Los Veganos, a damsite is identified to locate at about 400 m upstream of the confluence with Arroyo Colorado (called V-1 damsite). The site forms a V-shaped valley, sloping 30° in the left abutment and 40° in the right abutment. The dam is capable of impounding around 6.4 million m^3 of water at the dam height of about 72 m.

Water stored by V-1 dam is led through a headrace tunnel to be aligned on the left bank or alternatively on the right bank of the Yuna river. In case the headrace tunnel is alighed on the left bank, water diversion from Arroyo Caña (Catchment area of about 7.7 km^2 at the diversion weir site) is technically possible. However, the comparative study with and without water diversion from Arroyo Caña indicates that such a water diversion is not economically beneficial. It is mainly because the headrace tunnel on the right bank is shorter by about 1.6 km than the alignment on the left bank. It is also planned to divert water available in Arroyo Avispa and in the downstream basin of Arroyo Colorado. Arroyo Avispa has a catchment area of about 9.3 km^2 at the diversion weir site and Arroyo Colorado downstream, from the weirs to be constructed for El Torito scheme to the point of the planned site, has an area of about 6.4 km^2. 90% dependable discharge at these diversion weir sites is estimated at 0.26 m^3/s and 0.24 m^3/s, respectively.

Geologic condition of V-1 damsite has been intensively investigated. The site consists of green rock in the right abutment and well-bedded limestone (partly muddy or tuffaceous) in the left abutment. Both are in fault contact with a thin fractured zone. A notable phenomenon is found on the left abutment. A water table in the limestone is located at a lower level than the river level, with the indication that the phreatic water leakage is possible to occur through a high permeability zone, such as cave and open crack of the limestone mass. Further, the water pressure tests verify that a part of the vadose zone between top soil and the phreatic water table possesses high permeability, and water will leak from the reservoir to a large extent. It is ultimately concluded that V-1 damsite is geotechnically and economically not recommendable for construction of a large dam.

In the upstream and downstream of V-1 damsite, no alternative site for construction of a large dam and reservoir is obtainable from the viewpoint of topographic and geotechnical conditions.

4.3.2 Alternative Weir Plan

The alternative weir site is identified to locate at a site immediately downstream from the confluence with Arroyo Colorado (called V-3 site). The site forms a narrow gorge. The steep cliff on both abutments is composed of well-bedded marl (calcareous clayey stone) and calcareous green tuff. The rock is durable enough for construction of a gravity weir with a height of 20-30 m.

A catchment area at V-3 weir site is about 63 km^2. 90% dependable discharge at the site is estimated at 1.72 m^3/s. For daily regulation of discharge, a gated weir of 32 m in height is to be designed. A headrace tunnel of 3.3 km in length is aligned on the right bank of the Yuna river. A gross head of 140.8 m is available to reach a powerhouse to be located on the old river terrace deposit near Boca de Tireo.

4.4 El Torito - Los Veganos Complex

Through the comparative study as described in the foregoing section, alternative plans are scrutinized as follows:

El Torito		Los Veganos
Dams (T-1 and T-2)	+	Weir (V-3)
Weirs (T-1 and T-2)	+	Weir (V-3)
Weir (T-4)	+	Weir (V-3)

These alternative plans are illustrated on DWG-01 and DWG-02.

Detailed technical and economic studies are made on the screened alternative plans. Likewise, the optimum reservoir scale of the combined dams at El Torito is to be discussed further in the subsequent Chapter.

V. PRELIMINARY DESIGN

5.1 El Torito Dam Plan

Through the comparative study on alternative plans as explained in the foregoing Chapter, a plan to construct combined dams at T-1 and T-2 damsites in El Torito is selected as an alternative for further detailed study and preliminary design. Under this alternative plan, a reservoir is constructed to store water of the Yuna mainstream (15.7 km^2) and Arroyo Blanco (14.3 km^2), and water is led through a 5.3 km long headrace tunnel aligned on the left bank of the Yuna river to reach the Yuna No. 1 power station to be located near Los Veganos. An outline of the preliminary design for major structures envisaged under El Torito dam plan is described hereunder in a summarized form.

Through the discharge mass curve analysis, the firm discharge at El Torito dam-reservoir plan is estimated for each alternative scale of reservoir capacity. At the high water level at EL. 750.0 m, 755.0 m and 760.0 m, the firm discharge is 1.05 m^3/s, 1.23 m^3/s and 1.36 m^3/s respectively. (Refer to Fig.-14)

5.1.1 Dam and Reservoir

The scale of El Torito reservoir is determined through an optimization study. Geotechnical limitation at T-2 damsite is also taken into account. Through the economic comparative study, the high water level at EL. 755.0 m is evaluated to be most advantageous. Under this optimum reservoir scale, the effective storage capacity is determined at 4.6 million m^3 and the firm discharge for power generation is estimated at 1.23 m^3/s. Further, the optimum installed capacity is determined through comparative study on different hours of peaking operation. As a result, 6-hour operation with the installed capacity of 10.3 MW is found to be recommendable. (Refer to Annex G.2.1)

Two different types of dam at T-1 damsite are comparatively studied, i.e., a concrete gravity dam and rock-fill type dam. Both types of dam are technically possible to be constructed at T-1 site, as noted in Chapter 4.2.1. As explained in detail in Annex G.3.3, construction of a gravity dam is inevitably higher in construction cost. It is partly because the available sand and gravel for concrete aggregates are limited in El Torito area, as noted in Chapter 3.6. Consequently, it is recommended to construct a rock-fill type dam at T-1 damsite. Both T-1 and T-2 dams are, therefore, designed as fill-type dams.

Preliminary design of fill-type dams is prepared as outlined hereinafter.

1) Dam Axis and Crest:

T-1 dam axis is located at 550 m upstream of the confluence with Arroyo Blanco, and T-2 dam axis is lined at 500 m upstream of the confluence. T-2 dam axis is designed to be arch to facilitate the access in the right abutment. At the time of design flood discharge extimated at 560 m^3/s, the water level rises 2.8 m over the high water level. Besides, a free board of 2.2 m in height is designed in the light of probable maximum flood discharge estimated at 580 m^3/s. Consequently, the crest elevation of T-1 and T-2 dams is set at EL. 760.0 m. The dam height from the foundation is 55 m at T-1 damsite and 60 m at T-2 damsite. (Refer to DWG-03, DWG-04 and Annex G.3.4)

2) Dam Zoning and Stability:

Dam zoning is determined in the light of design earthquake acceleration estimated at 0.15 g, design value and available quantity of embankment materials, dam slope stability analysis by means of slip-circle method, etc. (Refer to Annex G.3.4)

Impervious core zone is designed to be 4.0 m in crest width. The bottom width is 46% of the dam height. The slope is determined at 1:0.2 on both upstream and downstream sides. A single filter zone is designed on upstream and downstream sides, having a crest width of 3.0 m. A random zone is designed to minimize the embankment cost, by utilizing riverbed deposit to the maximum extent. According to the stability analysis, upstream slope of the random zone is designed to be 1:1.8 and downstream slope at 1:1.4. The rock zone is designed with the slope of 1:2.7 in the upstream and 1:1.9 in the downstream side. (Refer to DWG-03 and Annex. G.3.4)

3) River Diversion and Spillway:

River diversion is made by cofferdams and diversion tunnels. Cofferdams are designed on the basis of probable flood discharge of 300 m^3/s. Diversion tunnels are aligned in the left abutment of both T-1 and T-2 damsites. The tunnel at T-1 damsite is designed to function as a tunnel type spillway in its lower section. The tunnel spillway is designed to be 9.4 m in inside diameter to allow free flow of design flood discharge estimated at 560 m^3/s. (Refer to DWG-05)

5.1.2 Waterway and Diversion from Tributary

An intake of the headrace tunnel is located on the left bank of Arroyo Blanco at 400 m upstream of T-2 dam axis, by avoiding sites susceptible to landslides. The intake is equipped with a trush rack and a roller gate. The sill crest is set at EL. 738 m.

The headrace tunnel of 5.3 km in length is aligned on the left bank of the Yuna mainstream. The tunnel is designed to be 2.0 m in diameter, which is the minimum size for excavation by conventional equipment. A surge tank is designed at the end of headrace tunnel. A restricted orifice type surge tank is 4.0 m in inside diameter and 46.0 m in height. Penstock is aligned on the ridge of a slope in the left bank near Los Veganos. The penstock is designed to be 560 m in length and 2.0-1.0 m in diameter. (Refer to DWG-06, 07 and Annex G.3.5)

Diversion of water from Arroyo Colorado is planned to be incorporated into El Torito scheme. Two diversion weirs are designed on tributaries (A. Chiquito and A. Pringamosa) at about 100 m upstream from their confluence. Two weirs are connected by an open channel of 121 m in length, and water is led through a diversion tunnel of 1.6 km in length until it joins the headrace tunnel from El Torito reservoir. (Refer to DWG-08, DWG-09 and Annex G.3.6)

5.1.3 Power Station and Transmission Line

An open type powerhouse (Yuna No. 1 power station) is located on the left bank of the Yuna mainstream, about 400 m upstream of the confluence with Arroyo Colorado. The site is covered with talus deposit, and the foundation is green rock durable enough for a powerhouse construction. Dimension of powerhouse is designed to be 22.0 m x 18.5 m x 27.5 m. The turbine is designed to be of Francis type, with a capacity of 10.3 MW under the effective head of 250.3 m and the maximum discharge of 4.92 m^3/s. The generator is rated at 12.7 MVA to deliver 10.3 MW of power at 0.9 power factor in lagging. (Refer to DWG-10)

A main transformer, with a capacity of 12.7 MVA, is installed in the outdoor switchyard. Power generated at the Yuna No. 1 power station is stepped up and sent to a switching station of the Rio Blanco power station, through a transmission line of 69 kV. The line is about 8 km in length.

5.1.4 Energy Output

In accordance with the conditions for operation of reservoir and power station, as explained in Chapter 4.1.2, the annual energy output of El Torito dam plan is calculated as summarized hereunder.

Installed capacity	:	10.3 MW
Primary energy	:	22.2 GWh
Secondary energy	:	15.8 GWh
Total energy output	:	38.0 GWh

5.2 El Torito Weir Plan

As an alternative to construct El Torito dam and reservoir, it is planned to intake water by constructing two weirs at T-1 and T-2 sites in El Torito. Water of the Yuna mainstream; estimated at 0.31 m^3/s in 90% dependable discharge, is diverted to Arroyo Blanco by constructing a diversion weir at T-1 site and excavating an open channel through T-3 site. On Arroyo Blanco, a weir is constructed at T-2 site to intake flow of Arroyo Blanco, estimated at 0.31 m^3/s in 90% dependable discharge, as well as water diverted from T-1 weir. 90% dependable discharge at T-1 and T-2 site is estimated at 0.62 m^3/s. (Refer to Fig.-15) Water diversion from Arroyo Colorado is also planned under this alternative plan.

Through an otpimization study, the storage capacity of T-2 weir is defined at 110,000 m^3. The optimum installed capacity and peak operation hours are also determined through comparative study. It is recommended to design for 6-hour operation with the maximum discharge of 3.72 m^3/s. The installed capacity is 7.2 MW. Preliminary design of major structures is prepared as summarized hereunder.

5.2.1 Intake Weir

T-1 weir is located at about 130 m upstream of T-1 dam on the mainstream. It is designed to be free-overflow type. A non-gated concrete gravity weir is designed to be 17.0 m in height and 50.0 m in crest length. The diversion channel from T-1 weir to Arrogo Blanco is 360 m in length, and it is excavated up to the bottom elevation at EL. 722 m. (Refer to DWG-11 and DWG-12)

T-2 weir is located at immediately upstream of T-2 dam axis on Arroyo Blanco. To store 110,000 m^3 of water for 6-hour peak operation, the high water level is set at EL. 726.0 m and low water level at EL. 723.4 m. The weir is designed to be a gated concrete weir of 22.0 m in height and 86 m in crest length. The gated overflow section and two ogee sections are designed to allow passage of a probable flood for the return period of 100 years, which is estimated at 420 m^3/s. Two vertical lift type gates (12 m x 7.75 m x 2 sets) are installed to flush out sediment in the pondage. An intake is constructed at EL. 720.5 m in the left abutment. (Refer to DWG-11, DWG-12 and Annex G.4.1)

5.2.2 Waterway and Diversion from Tributory

A headrace tunnel is aligned on the left bank of the Yuna river. The tunnel is 5.2 km in length and 2.0 m in inside diameter. The excavation through the rock mass of green schist is planned to be divided into 3 sections, having the excavation length of 1,700 m, 2,200 and 1,400 m. (Refer to DWG-13 and Annex G.4.2)

Diversion of Arroyo Colorado water is planned to divert water of 0.31 m^3/s in dependable discharge. Since the intake water elevation is lowered to EL. 736.5 m, if compared with El Torito dam plan, the location of the diversion weir is found immediately downstream from the confluence of Arrogo Chiquito and Arroyo Pringamosa. The weir is 7.5 m in height and 67 m in crest length. A diversion tunnel of 1,450 m in length is connected to the headrace tunnel from T-2 weir at a point about 300 m from the surge tank. (Refer to DWG-14 and Annex G.4.3)

The surge tanks is constructed at the downstream end of the headrace tunnel. It is designed to have a concrete lined vertical shaft of 4.0 m in diameter and 44.0 m in height. An orifice is 0.8 m in diameter. A penstock is designed on the same alignment as El Torito dam plan, with 615 m in length and 2.0-1.0 m in inside diameter. (Refer to DWG-15)

5.2.3 Power Station

Powerhouse is located at the same place as designed for El Torito dam plan. The dimension of powerhouse is designed to be 22.0 m in length, 18.5 m in width and 27.0 m in height. The turbine is of a vertical-shaft Francis type, with the rated capacity of 7.2 MW under the rated head of 229.2 m and rated discharge of 3.72 m^3/s. The generator is rated at 8.0 MVA to deliver 7.2 MW at 0.9 power factor. Transmission line is 69 kV in voltage and 8 km in length.

5.2.4 Energy Output

In accordance with the conditions for operation of storage and power station as explained in Chapter 4.1.2, the annual energy output of El Torito weir plan is calculated as summarized hereunder.

Installed capacity	:	7.2 MW
Primary energy	:	15.2 GWh
Secondary energy	:	16.9 GWh
Total energy output	:	32.1 GWh

5.3 Pino de Yuna Weir Plan

As an alternative to the construction of El Torito weirs (T-1 & T-2), it is planned to intake water by construction a weir at Pino de Yuna (T-4 site) located at 800 m downstream from the confluence with Arroyo Blanco.

At the weir site, riverbed is 15 m in width, and the foundation rock composed of gneiss is covered with alluvial river deposit of about 4.5 m in thickness.

At Pino de Yuna (T-4 site), the daily mean discharge is estimated at the conversion rate of 0.09 of daily discharge recorded at Los Quemados. On the basis of discharge duration curve at Pino de Yuna a 90% dependable discharge (Q_{90}) is estimated at 0.70 m^3/s. (Refer to Fig.-16) With water diversion from Arroyo Colorado, dependable water for power generation is estimated at 1.01 m^3/s.

The scale of weir is determined through an optimization study. The storage capacity is optimized by analysing ratio of weir height and gate height and by economic comparison. It is recommended to define the storage capacity of the Pino de Yuna (T-4) weir at 95,000 m^3. The optimum installed capacity and peak operation hours are also determined through optimization study. It is recommended to design for 6-hour operation with the installed capacity of 6.3 MW. The maximum discharge is 4.04 m^3/s. Preliminary design of major structures is prepared as summarized hereunder.

5.3.1 Intake Weir

To store 95,000 m^3 of water for 6-hour peak operation, the high water level is set at EL. 680.0 m and low water level at EL. 677.5 m. The weir is designed to be a gated concrete weir with a crest length of 74 m. The gated overflow section and two ogee sections are designed to allow passage of a probable flood for the return period of 100 years, which is estimated at 440 m^3/s. Two gates of vertical lift type (12 m x 7.75 m) are installed to flush sedimentin the storage. The upstream section of the weir will be filled out by sediment in a relatively short period after the construction of weir, but the storage capacity is secured by installation of such gates. A sand flushing channel is also desinged to be provided in the weir. An intake is constructed at EL. 674.5 m in the left abutment. (Refer to DWG-16 and Annex G.5.1)

5.3.2 Waterway and Diversion from Tributary

A headrace tunnel is aligned on the left bank of the Yuna river, with a total length of 4.4 km. The rock mass along the tunnel route is inferred to be green schist. The tunnel is designed to have circular cross section with an inside diameter of 2.0 m. The excavation is planned to be made from 3 adits, each having the excavation length of 1,500 m, 1, 050 m and 1,850 m. (Refer to DWG-17)

Water diversion from Arroyo Colorado is also planned for the alternative weir plan. Arroyo Colorado water is taken at a diversion weir located at EL. 695 m, or about 300 m downstream from the two weirs planned for El Torito dam plan. The weir is 7.5 m in height and 71 m in crest length. A connecting tunnel of 1,300 m in length is connected to the headrace tunnel from the Pino de Yuna weir at a point of about 200 m from the surge tank. (Refer to DWG-18)

The surge tank is installed at the downstream end of the headrace tunnel. It is designed to have a concrete lined vertical shaft of 4.0 m in diameter and 32.0 m in height. An orifice is 0.8 m in diameter. A penstock is designed on the same alignment as El Torito dam plan. It is 467 m in length and 2.0-1.0 m in diameter. (Refer to DWG-19 and Annex G.5.2 and G.5.3)

5.3.3 Power Station

Powerhourse is located at the same place as designed for El Torito weir plan. The turbine is of a vertical-shaft Francis type, with the rated capacity of 6.3 MW under the rated head of 184.3 m and the rated discharge of 4.04 m^3/s. The generator is rated at 7.5 MVA to deliver 6.3 MW at 0.85 power factor in lagging. The transmission line is constructed in the same way as designed for El Torito dam plan.

5.3.4 Energy Output

In accordance with the conditions for operation of storage and power station, as explained in Chapter 4.1.2, the annual energy output of the Pino de Yuna weir plan (Yuna No. 1 power station) is calculated as summarized hereunder.

Installed capacity	:	6.3 MW
Primary energy	:	12.7 GWh
Secondary energy	:	13.7 GWh
Total energy output	:	26.4 GWh

5.4 Los Veganos Weir Plan

Under Los Veganos scheme, construction of a run-of-river type power station with an intake weir at V-3 site is only contemplated, because an alternative to construct a large dam at V-1 site has been geotechnically and economically not recommended. The proposed weir site is located at 100 m downstream from the confluence with Arroyo Colorado, or about 500 m downstream from the proposed Yuna No. 1 power station. The site forms a gorge, with both abutments composed of well-bedded marl and calcareous green tuff steeply dip for about 15 m in height.

At V-3 site in Los Veganos, the daily mean discharge is estimated at the conversion rate of 0.22 of daily discharge recorded at Los Quemados. On the basis of discharge duration curve (Refer to Fig.-17), a 90% dependable discharge at Los Veganos weir is estimated at 1.72 m^3/s. If combined with El Torito dam plan, the dependable discharge is increased to 1.96 m^3/s.

Through an optimization study, the storage capacity of Los Veganos (V-3) weir is determined at 169,000 m^3 (with El Torito dam) or 149,000 m^3 (with El Torito or Pino de Yuna weir) for daily regulation of 6-hour peaking operation. The maximum discharge is estimated at 7.84 m^3/s (with El Torito dam) or 6.88 m^3/s (with El Torito or Pino de Yuna weir). The installed capacity is defined at 8.8 MW or 7.7 MW. Preliminary design of major structures for Los Veganos weir plan is prepared as summarized hereunder.

5.4.1 Intake Weir

The optimum scale of storage caapcity is secured between the high water level at EL. 494.0 m and the low water level at 489.5 m in case of combination with El Torito dam, and between EL. 493.0 m and EL. 488.5 m in case of combination with El Torito on Pino de Yuna weir. The weir is 32 m in height from the foundation, and 68 m in crest length. It is designed to have a gated overflow section, a non-gated overflow section, and a side channel, capable of discharging a design flood estimated at 820 m^3/s. Two gate of vertical lift type (12 m x 9.75 m) are installed to flush sediment in the storage. A sand flushing channel (3 m x 3 m) is also provided in the weir beside the gates. (Refer to DWG-20 and Annex G.6.1)

5.4.2 Waterway

As explained in Chapter 4.3.2, a headrace tunnel is aligned on the right bank of the Yuna river. The tunnel alignment is proposed in due consideration of faults that bevel twice in the course. A total length of the tunnel is approximately 3.3 km. The pressure tunnel is designed with a circular cross section of 2.0 m in diameter. It is proposed that the tunnel is excavated from 3 adits, dividing it into two sections. (1.9 km and 1.4 km) (Refer to DWG-21)

A surge tank is constructed at the downstream end of the headrace tunnel at EL. 510 m. It is designed to have a concrete-lined vertical type shaft of 6.0 m in diameter and 30.0 m in height. An orifice is 0.8 m in diameter. A penstock is planned to lay on the ridge of slope behind the powerhouse to be located at about 1.8 km upstream from the confluence with Arroyo Tireo. The penstock is 200 m in length and 2.0-1.0 m in inside diameter. (Refer to DWG-22)

5.4.3 Power Station and Transmission Line

Power station (Yuna No. 2) is constructed on the old river terrace deposit developed on the right bank. The generating equipment is one unit of 8.8 MW or 7.7 MW. The turbine is of a vertical-shaft Francis type. The rated capacity is obtained under the rated head of 134.0 m and the rated discharge of 7.84 m^3/s or 6.88 m^3/s. The generator is rated at 9.8 MVA or 9.0 MVA to deliver 8.8 MW or 7.7 MW of power at 0.9 power factor in lagging. An outdoor switchyard is designed besides the powerhouse, and a main step-up transformer with a capacity of 9.8 MVA or 9.0 MVA is installed in the switchyard. (Refer to DWG-23)

Generated power is transmitted through a 69 kV line to the switching station in the yard of the Rio Blanco project. Distance of transmission line is approximately 4.0 km.

5.4.4 Energy Output

In accordance with the conditions for operation of storage and power station, as explained in Chapter 4.1.2, the annual energy output of Los Veganos weir plan (Yuna No. 2 power station) is calculated as summarized hereunder.

	With El Torito Dam	With El Torito or Pino de Yuna Weir
Installed capacity :	8.8 MW	7.7 MW
Primary energy :	18.9 GWh	16.4 GWh
Secondary energy :	22.8 GWh	19.0 GWh
Total energy output:	41.7 GWh	35.4 GWh

5.5 El Torito-Los Veganos Complex Energy Output

As a result, the total energy output of alternatives designed for El Torito-Los Veganos complex is estimated as summarized hereunder.

(El Torito Dam) + (Los Veganos Weir)

Installed capacity :	19.1 MW
Primary energy :	41.1 GWh
Secondary energy :	38.6 GWh
Total energy output:	79.7 GWh

(El Torito Weir) + (Los Veganos Weir)

Installed capacity :	14.9 MW
Primary energy :	31.6 GWh
Secondary energy :	35.9 GWh
Total energy output:	67.5 GWh

(Pino de Yuna Weir) + (Los Veganos Weir)

Installed capacity :	14.0 MW
Primary energy :	29.1 GWh
Secondary energy :	32.7 GWh
Total energy output:	61.8 GWh

VI. CONSTRUCTION PLAN AND SCHEDULE

6.1 Construction Plan and Method

On the basis of the preliminary design, a construction plan is elaborated for each component of the alternatives, namely El Torito dam plan, El Torito weir plan, Pino de Yuna weir plan and Los Vegonos weir plan. The construction plan is integratedly studied with the construction schedule explained in the subsequent Chapter 6.2, with a view to implement the complex in the shortest possible time and in the most economical manner.

The construction plan elaborated for each component of the complex is summarized hereunder.

6.1.1 El Torito Dam Plan

Major construction works of El Torito dam plan involves i) diversion tunnels and cofferdams, ii) T-1 and T-2 dams, iii) headrace tunnel, iv) surge tank v) penstock, vi) Arroyo Colorado intake weirs and diversion, vii) powerhouse and generating equipment, and viii) transmission line and substation. (Refer to Annex H.2.1)

Diversion tunnel at T-1 damsite is planned to be excavated by applying a top head and bench cut method, using drill jumbo for top heading, crawler drill for bottom bench cut and leg hammer for side wall. While, a full face attack method is planned to be applied for T-2 damsite diversion tunnel excavation. For concrete-lining, an arch-side wall and then invert methods are recommended to be applied for T-1 tunnel and an arch and then invert method is recommended for T-2 tunnel. A batcher plant (0.75 m^3 x 2 mixer) is installed near the damsite, and concrete will be transported by agitators and placed by concrete pump car.

Foundation excavation of T-1 and T-2 dams is planned to be executed by bulldozers with ripper. Rock excavation will be made by crawler drill. Foundation excavation mainly for the impervious earth portion will take about 6 months after the river diversion. Blanket and curtain grouting is performed in parallel with the foundation excavation, and curtain grouting will be carried out in advance to the impervious earth embankment.

Embankment of impervious earth materials (48,000 m^3 for T-1 dam and 75,000 m^3 for T-2 dam) is planned to be borrowed from the borrow areas and T-3 connection channel excavation, spread by bulldozers and compacted by tamping rollers. Filter embankment (37,000 m^3 for T-1 and 58,000 m^3 for T-2 dam) will be carried out in parallel with the impervious earth embankment. Filter materials are taken from the quarry sites, hauled by dump truck, spread by bulldozers and compacted by vibrating rollers. Rock embankment (284,000 m^3 for T-1 and 418,000 m^3 for T-2) will be carried out by materials excavated at the rock quarry site, transported by 20-ton class dump trucks and compacted by self-travelling vibrating roller. All the embankment works will take around 20 months after completion of the most part of blanket and curtain grouting.

A headrace tunnel (No. 1-1) of 5.3 km in length is planned to be divided into 4 tunnel sections by 3 adits. An additional adit is excavated to branch from No. 3 adit for Arroyo Colorado diversion tunnel excavation. A full-face attack method and arch-then-invert method are recommended for work adit construction, and a full-face attack method is applied for the headrace tunnel excavation. Hauling is planned to be carried out by the rail method, using muck car with battery locomotive. Concrete-lining is planned to be made by a full-circle method, with backfill grouting. Construction of the headrace tunnel, inclusive of grouting works, will take about 3.5 years.

A vertical shaft concrete-lined surge tank is constructed at the downstream end of No. 1-1 headrace tunnel. A shaft sinking method is recommended for shaft excavation. Concrete is placed by using concrete hopper and chute. The surge tank construction will take around 4 months. For installation of a steel penstock, open cut excavation is carried out along the penstock line. Steel pipes, fabricated at the constructor's workshop with an unit length of 6 m, are planned to be installed by using truck crane and rail-method carrier, and welded at site. Construction and installation of the penstock will take around 13 months.

Arroyo Colorado intake weirs will be constructed, upon completion of the diversion tunnel. After the foundation excavation, concrete will be placed by using a concrete pump car. The weir construction will take about 6 months.

Powerhouse (Yuna No. 1) of reinforced concrete structure is constructed on the foundation excavated by bulldozers. Concrete work is executed in two stages. At first, concrete for substructure is placed for installation of overhead crane, and it will be followed by installation of draft-tube liners. Subsequently, installation of 10.3 MW turbine and generator will be executed. The second stage concrete work is made for concrete around the draft-tube liners and other building works. Construction of the powerhouse is planned to be completed in 15 months.

6.1.2 El Torito Weir Plan

Major construction works of El Torito weir plan include i) T-1 and T-2 weirs, ii) open channel to divert water from T-1 to T-2 weir, iii) headrace tunnel, iv) surge tank, v) penstock, vi) Arroyo Colorado intake weir and diversion, vii) power house and generating equipment, and viii) transmission line and substation. (Refer to Annex H.2.2)

A non-gated diversion weir (17 m in height, 50 m in crest length and 6,400 m^3 in concrete volume) is constructed at T-1 site. Further, a gated intake weir (22 m in height, 86 m in crest length and 8,700 m^3 in concrete volume) is constructed at T-2 site. Excavation of weir foundation, as well as excavation of 360 m long open channel from T-1 weir to T-2 weir, is planned to be executed by means of 32-ton class bulldozers, 2.3 m^3 tractor shovel and 11-ton dump trucks. Consolidation and curtain grouting is carried out by using rotary drill and grout injection pumps. A batcher plant (0.75 m^3 x 2 mixers) is installed, andconcrete will be transported by agitators and placed by pump car. The construction of T-1 and T-2 weir will take around 2 years.

A headrace tunnel (No. 1-2) of 5.2 km is planned to be excavated in 4 tunnel sections by 3 work adits. In addition, the 4th work adit is branched from the 3rd adit for excavation of Arroyo Colorado diversion tunnel. A full-face attack method is planned for the headrace tunnel excavation, and a full-circle method for concrete lining. Whole construction period of the headrace tunnel, including grouting works, is planned to be around 3.5 years.

Construction of a vertical shaft surge tank and a steel penstock is planned in a similar way to be applied for El Torito dam plan. Construction of the surge tank will take about 7 months, and the penstock work will take about 13 months. Construction of Arroyo Colorado intake weir is also performed in the same manner as applied for El Torito dam plan.

A powerhouse of reinforced concrete structure is constructed to accommodate 7.2 MW turbine and 8 MVA generator, at the same place and in the same manner as proposed for El Torito dam plan. All the construction works in the field will take about 15 months.

6.1.3 Pino de Yuna Wier Plan

The plan is an alternative to El Torito weir plan. The gated intake weir (21 m in height, 74 m in crest length and 8,740 m^3 in concrete volume) is constructed at Pino de Yuna. Foundation excavation is planned to be executed by using 32-ton class bulldozer, and consolidation-curtain grouting is carried out by means of rotary drill and grout injection pump. A batcher-plant (0.75 m^3 x 2 mixers) is installed, and concrete will be transported by agitators and placed by pump car. The weir construction will take around 21 months. (Refer to Annex H.2.3)

A headrace tunnel (No. 1-3) of 4.4 km in length is planned to be excavated in 4 tunnel sections by 3 work adits. In addition, the 4th work adit is planned to be branched from the 3rd adit for excavation of Arroyo Colorado diversion tunnel, as in the case of headrace tunnel No. 1-2. A full-face attack method is applied for the headrace tunnel excavation, and a full-circle method for concrete-lining, as in the case of No. 1-2 headrace tunnel. By means of three tunnel headings attacked simultaneously, the tunnel construction is planned to be completed in around 2.5 years.

A vertical-shaft surge tank and a steel penstock are constructed in a similar way to be applied for El Torito dam weir plan. The construction period of surge tank and penstock is scheduled to be around 4 months and 11 months, respectively. Construction of Arroyo Colorado intake weir is also performed in the same manner as applied for El Torito dam weir plan.

Powerhouse to accommodate 6.3 MW turbine and 7,500 kVA generator is located at the same place and constructed in the same manner as the powerhouse proposed for El Torito dam weir plan. All the construction works in the field will take around 15 months.

6.1.4 Los Veganos Weir Plan

Los Veganos weir plan is planned to be implemented in combination with El Torito dam plan or alternatively with El Torito weir or Pino de Yuna weir plan. It may also be constructed independently. The plan involves construction of V-3 intake weir, No. 2 headrace tunnel, surge tank, penstock, powerhouse, generating equipment and transmission line.

The intake weir at V-3 site (32 m in height, 68 m in crest length and 18,140 m^3 in concrete volume) is constructed in a similar way to be applied for El Torito weir or Pino de Yuna weir. A batcher plant of 0.75 m^3 x 2 mixers will be installed near the weir site, and concrete is placed by concrete pump car. Prior to concrete works, consolidation and curtain grouting works are elaborately executed in the light of geological conditions. Inclusive of foundation excavation, all the weir construction works will take around 2 years.

A headrace tunnel No. 2 of 3.3 km in length is excavated by dividing into three tunnel sections (adits No. 5 and No. 6), in order to shorten the construction period. The tunnel excavation by a full-face attack method and concrete-lining by a full-circle method with backfull grouting will be executed in the same manner as applied for the No. 1 headrace tunnel. Construction period of the tunnel is estimated at around 2.5 years.

A surge tank is constructed at the downstream end of No. 2 headrace tunnel. A shaft sinking method is recommended for shaft excavation, and shaft mucking will be carried out by truck crane with much skip. A steel penstock of 200 m in length consists of the upper horizontal tunnel portion and the inclined open portion. Installation of penstock will be conducted in the same manner as applied to the Yuna No. 1 station. All the installation works are scheduled to be completed one month before the best operation.

The Yuna No. 2 powerhouse to accommodate 8.8 MW or 7.7 MW turbine and 10 MVA or 9 MVA generator is constructed on the river terrace deposit. After the foundation excavation, concrete work will be carried out in two stages, as in the case of No. 1 power station. Installation of draft-tube liners, turbine and generator will be executed after the first stage concrete works. (Refer to Annex H.2.4)

6.2 Construction Schedule

A tentative construction schedule is programmed for the implementation of El Torito dam - Los Veganos weir complex, El Torito weir - Los Veganos weir complex, and Pino de Yuna weir - Los Veganos weir complex, in the light of the preliminary design, estimated work quantity and construction plan and method proposed in the foregoing Chapters. The schedule is programmed to complete the complex at the earliest possible time in view of the electric power situation forecasted as explained in Chapter 2.2.

6.2.1 Pre-construction Stage

The pre-construction works will involve i) preparation of tender documents and construction design, ii) pre-qualification, tendering, evaluation, negotiation and contracting, iii) construction of access road and extension of lines for construction power supply, and iv) planning and implementation of resettlement program.

In order to shorten the period required for the pre-construction works, preparation of tender documents is scheduled to be initiated as soon as the feasibility study is finalized. Tendering, evaluation and contracting are scheduled to be executed in parallel with the preparation of construction design. It is provisionally scheduled that the award of construction contracts will be made by the end of June 1985. Construction of access road to the work site is to be scheduled to complete by that time. (Refer to Annex H.3.1)

6.2.2 El Torito Dam - Los Veganos Weir Complex

In the light of the preliminary design and construction plan, as well as power supply situation by CDE, a target for the construction of El Torito dam - Los Veganos weir complex is scheduled as summarized hereunder:

Commencement of construction:	By July 1985
Construction period and target commissioning:	
No. 1 power station (El Torito) :	Within 51 months or by September, 1989
No. 2 power station (Los Veganos) :	Within 36 months, or by June 1988

A tentative construction schedule is illustrated on Fig.-18. In general, construction of Los Veganos weir scheme will be advanced in scheduling. It is noted that a critical path is primarily traced on the schedule of the excavation and concrete-lining of the headrace tunnels. (Refer to Annex H.3.2.)

6.2.3 El Torito Weir - Los Veganos Weir Complex

A target for the construction of El Torito weir - Los Veganos weir complex is scheduled as follows:

Commencement of construction: By July 1985

Construction period and target commissioning:

No. 1 power station (El Torito)	:	Within 51 months, or by September 1989
No. 2 power station (Los Vegonos)	:	Within 36 months, or by June 1988

A construction schedule is illustrated on Fig.-19. As in the case of El Torito dam - Los Veganos weir complex, construction of Los Veganos weir scheme will be advanced, and a critical path in the construction schedule is primarily traceable on the schedule of the headrace tunnel construction. (Refer to Annex H.3.3)

6.2.4 Pino de Yuna Weir - Los Veganos Weir Complex

A target for the construction of the Pino de Yuna weir - Los Veganos weir complex is scheduled as summarized hereunder:

Commencement of construction: By July 1985

Construction period and target commissioning:

No. 1 power station (Pino de Yuna)	:	Within 49 months, or by July 1989
No. 2 power station (Los Veganos)	:	Within 36 months, or by June 1988

A construction schedule of the alternative complex is illustrated on Fig.-20. As in the case of El Torito weir - Los Veganos weir complex, construction of Los Veganos weir scheme will be advanced. (Refer to Annex H.3.4)

6.3 Organization for Implementation

CDE, as an autonomous corporation, will have an overall responsibility for the implementation. During the stage of construction, the Department of Hydroelectric Development (DDH) will be in charge of pre-construction engineering and supervision of the complex. DDH will establish a field office for the complex, which will be managed by a project supervisor. Consultants will be retained to prepare tender documents and construction design, to assist CDE-DDH in tendering and evaluation, and to supervise the construction works. Construction works are carried out by contractors to be selected by competitive biddings. Package of contracts will be decided in the course of preparation of tender documents. An organization chart during the construction stage is illustrated, in a simplified form, on Fig.-21.

After completion of the construction works, commercial operation of power station will be shifted to the Department of Production, which is responsible for operation and maintenance of all the CDE power plants. The Yuna No. 1 and No. 2 stations, if and when implemented, should be operated as a complex. Further, they are desirably operated in close coordination with the Rio Blanco power station (completion scheduled for 1987), to which a transmission line from El Torito - Los Veganos complex is to be connected. It is additionally noted that an operation center of the power station in the upper Yuna river basin will be desirably shifted to the Piedra Gorda power station if it is realized in future.

VII ENVIRONMENT AND ASSOCIATED PROGRAM

7.1 Environmental Conditions

Vegetation and land use in the catchment area has been substantially affected by shifting cultivation by settlers and deforestation, although nearly a half of the area is still covered with forest or coffee plantation. The deforested land consists of pasture land, upland fields, barren lands, naked lands, collapsed area, etc. In the pasture land or upland field, crops like beans (habichuelas) and maize are mainly planted by shifting cultivation. Such a pattern prevailing in the catchment area will cause environmental problems. One of the major problems is a decrease in water retention capacity which will result in increase in flood magnitude and reduction of firm river discharge. Another problem is the erosion and increase in sediment yield. In order to prevent aggravation and to improve protection of watershed in the basin, some countermeasures are proposed to be taken as explained in Chapter 7.3.

Landslides and collapse are rather remarkable in the catchment area, especially along the river courses. In the area of Arroyo Blanco sub-basin, for instance, eroded slopes at around 200 spots are observed after the hurricane David in 1979. Out of this eroded slopes in the sub-basin, landslides at 15 spots are major in scale, having an affected area over 2,000 m^2. In the sub-basin of the Yuna mainstream upstream of T-1 damsite, the eroded slopes are relatively minor in scale. (less than 500 m^2 in majority), but the number of eroded spots are substantial. In Arroyo Colorado sub-basin, about 240 eroded slopes are observed with a total estimated area of about 20.6 ha. The eroded slopes are more salient in the catchment area between T1-T2 damsites and Los Veganos. Over 420 eroded slopes are counted in this sub-basin.

Number, area and scale of eroded slopes observed after the hurricane David demonstrates their relation with vegetation and land use in the catchment area. The erosion is more remarkable in the sub-basin of Arroyo Blanco and Arroyo Colorado where deforestation is more advanced. In the sub-basin of Arroyo Avispa where forests are still conserved, the eroded slopes are small in number and areas (46 spots with less than 2 ha. in total).

The erosion is also related with the physiography and geology in the area. The Arroyo Avispa sub-basin is primarily composed of the Plutonic igneous rocks with relatively gentle slopes, while Arroyo Colorado and Arroyo Avispa sub-basins are dominated by the Tireo Formation and Duarte Formation with steeper slopes.

Water flowing in the Yuna river is good in quality, though it is slightly alkaline with pH ranging from 7.0 to 8.3. Alkalinity may be caused by a relatively high content of Na., and attention is to be paid if such water is utilized for irrigation purpose. However, no indication harmful for piping and electro-mechanical works for the hydroelectric project is observed through water quality analysis.

In the upstream Yuna river, there lives little number and variety of fishes. It is observed that fresh water crabs are living in the downstream reaches but in a limited scale. Under such circumstances, it appears to be unnecessary to design a fish ladder in the weir to be constructed for water diversion. Notable wild animal is not observed in the area to be affected by the project. Some varieties of hummingbirds are observed in the area, though environment for birds has been aggravated by forest burning for shifting cultivation.

7.2 Environmental Impacts

The impacts of the implementation of El Torito dam - Los Veganos weir complex or alternatively El Torito/Pino de Yuna weir - Los Veganos weir complex are relatively limited with respect to ecological and other natural environment. The impacts of the project implementation are rather appreciable in aspects related to social conditions. Major consequences of the project implementation are summarized as follows:

1) Inundated Area:

El Torito dam plan contemplates to create a reservoir with the surface area of about 96.5 ha. at the high water level of EL. 755.0 m. Some of the adjacent area will also be affected by the reservoir construction. According to the socio-economic survey conducted in El Torito area, about

64 families with a total population of around 360 are living in the area affected by the project (assumed below EL. 770 m). Majority of the settlers came from San Jose de Ocoa province. Most of the land are owned by families, with or without titles, but some of the land are borrowed. Besides, there are lands which belong to landowners living outside of the area or the country. It is estimated that about 50 families are to be resettled in case that the alternative to construct El Torito dams and reservoir is selected for implementation. (Refer to Annex H.5)

In and around El Torito weir and storage site about 15 families are living on the land to be affected by the project, while in the area of Pino de Yuna weir, 11 families with population of 65 are living on the land below EL. 690 m. In the area of Los Veganos weir and storage, around 6 families are living on the land below EL. 500 m. Peoples living in Los Veganos area were mainly settled from the Cibao region. (Refer to Annex H.5.2)

A preliminary plan for resettlement of families in the area to be inundated by the construction of reservoir or storage is described in the following Chapter 7.3.

2) Water Diversion:

Water stored by El Torito dams or El Torito/Pino de Yuna weir and Los Vegonos weir, is diverted for power generation. Intake of water at such points will have effects on water flow along the river in the section between the dam/weir site and power station site. In case of El Torito dam plan, river flow is stored and the period of overflow from spillway is limited. Consequently, river flow and water supply to the families living along the river immediate downstream from the damsite is affected. However, in and around Los Veganos village, water from the remaining basin is available at around 0.5 m^3/s. It is contemplated to prepare detailed plan for resettlement of the inundated area, and the plan will incorporate detailed survey if resettlement is required for the families living in the immediate downstream of El Torito dam. The alternative plan to construct the Pino de Yuna weir and the weir plan at Los Veganos will have least effect on the river flow in the downstream section, because overflow at the weir is frequent.

3) Effects of Water Regulation:

In case of El Torito dam plan, flood discharge is regulated to some extent by the reservoir. However, the controllable basin is substantially limited (30 km^2 at El Torito, against 358 km^2 at Piedra Gorda and 1,192 km^2 at Hatillo) and little benefit from flood control will accrue in the Bonao valley. Its effect in the further downstream is absorbed by the Hatillo dam and reservoir (700 million m^3 in storage capacity).

On the other hand, water regulation at El Torito reservoir will have an effect to increase firm discharge for power generation if the Piedra Gorda dam and reservoir is constructed in the downstream. It is preliminarily estimated that the firm discharge is increased by 0.5 m^3/s, and that the installed capacity of the Piedra Gorda power station is increased by 2 MW. The primary energy output will also be increased by 4.1 GWh, but the secondary energy output will be decreased by 3.2 GWh. This effect will be taken into account in evaluating El Torito dam plan in comparison with El Torito weir or Pino de Yuna weir plan.

4) Transportation:

Access road is to be constructed for the implementation of the project. Total length of the access road is as long as 30.5 km for El Torito dam - Los Veganos weir complex and 22.2 km for the Pino de Yuna weir - Los Veganos weir complex. The road will link El Torito and Los Quemados. It will serve for communication among villages and for transportation of products. Although a reduction of transportation cost of coffee will not be appreciable, such a road will induce other economic activities in the area.

It is planned that the access road for construction will run, as far as possible, along the river course in order to minimize the construction cost and to prevent the environmental deterioration by slope cutting and inducible landslides.

7.3 Associated Program

As programs associated to the implementation of the project, it is envisaged to execute the resettlement plan and the pilot plan for watershed protection. A preliminary plan on these associated programs is formulated as summarized hereunder.

1) Resettlement Plan:

As noted in the foregoing Chapter, it is necessary to resettle around 50 families living in the inundated area in case that El Torito dam plan is selected for implementation. In view of the fact that a large part of the families are natives of San Juan de Ocoa province, it is preferable to find a possible site for resettlement in this province. The Office of Resettlement, CDE made a preliminary study and selected six candidate locations; i.e. Loma Cagueyes near El Torito; Monte Negro, Banilejo and Font Gamundi in the Rancho Arriba valley; El Callejón near Nizao, and Sabana Grande near San Jose de Ocoa city. It is planned to distribute 3.125 ha. (50 tarea) of land per family. A preliminary estimate of cost is made for land acquisition and preparation, housing, infrastructures and integrated social programs. Although such an associated cost is precluded from economic evaluation, it will be taken into account in estimating a fund requirement and in preparing a financial statement of the project. (Refer to Annex H.5)

2) Pilot Plan for Watershed Management:

In view of the environmental conditions as noted in Chapter 7.1, a plan for watershed management is recommended to be taken up as an associated program for the implementation of the project. The plan, though conceptual as it is, envisages to take measures to prohibit shifting cultivation, to promote reforestation, and to protect the collapsed areas from further erosion. A pilot area for execution is selected in Arroyo Colorado sub-basin where deforestation and landslides are remarkable as noted before. An intensive reforestation by planting suitable trees, including pine, eucalyptus, fruits and coffee, is recommended. Collapsed areas will be examined to find proper measures for protection. For instance, provision of drains in the upper area or cribwork at the immediate downstream of the collapsed areas will be effective in some areas. (Refer to Annex H.6)

VIII. CONSTRUCTION COST ESTIMATE

8.1 Basis of Cost Estimate

The construction cost of the complex is estimated on the basis of the preliminary design prepared as explained in Chapter V, as well as the construction plan and schedule programed in Chapter VI. Quantity of works involved in each item of construction is measured, and the unit construction price is assessed at the price prevailing in the middle of 1983. The cost of materials and services to be procured in the Republic is estimated in local currency, and the cost of equipment, materials and services to be imported for the complex is estimated in foreign currency. (Refer to Annex I.2)

The unit price of civil works will cover such direct costs as labor, materials and equipment, as well as indirect cost of contractor's general expenses and profit. Labor cost is estimated on the basis of 48-hour work week. Locally available materials, including cement, timbers, concrete aggregates, etc. are estimated at market prices, and imported materials are quoted at CIF prices. The cost of equipment involves depreciation, maintenance and repair, as well as administration costs, estimated on the basis of plan of equipment to be mobilized for construction.

The cost of metal works is estimated for gates, stoplogs, trashracks, steel penstock, valves, drain pipes, etc. The cost is estimated on the basis of unit price per ton, quoted in the light of the current contract prices for similar works executed in the world. The labor cost for erection work and inland transportation is estimated in local currency. Likewise, the cost of such electrical works as generating equipment, switching station equipment, transmission line and substation, is estimated on the basis of current international contract prices of similar projects. The erection cost of electrical works is estimated at 60% of equipment prices. About 20% of the erection cost will be disbursed in local currency.

For the engineering services and administration, 7.5% of the direct construction cost of El Torito dam - Los Veganos weir complex and 10% of the direct cost of El Torito/Pino de Yuna weir - Los Veganos weir complex are estimated to cover the engineering fee for construction design and supervision, as well as the cost of CDE's field supervision office. In view of the physical uncertainties involved in the construction works, about 10% of the direct construction cost is estimated as physical contingency.

8.2 Estimated Cost

The total construction cost of El Torito dam - Los Veganos weir complex is estimated at around RD$80.3 million, as shown on Table 8-01. Likewise, the construction cost of El Torito weir - Los Veganos weir complex is estimated at RD$44.0 million in total, as shown on Table 8-02. Further, the construction of the Pino de Yuna weir - Los Veganos weir complex is estimated at RD$40.0 million, as shown on Table 8-03. The price contingency is not estimated in this construction cost. (Refer to Annex I.2)

About 65% of the total cost estimated for El Torito dam - Los Veganos weir complex and around 50% of cost for El Torito/Pino de Yuna weir - Los Veganos weir complex is incurred for civil works and building works. Out of the total estimated cost, the cost to be incurred in foreign currency is estimated at 58% - 60% for the alternative complex.

IX ECONOMIC EVALUATION

9.1 Economic Cost

Three alternative plans, i.e., El Torito dam - Los Veganos weir complex, El Torito weir - Los Veganos weir complex, and Pino de Yuna weir - Los Veganos weir complex, are economically evaluated on the basis of the economic cost and benefit. The economic cost is the cost to be required for the implementation of the complex from the viewpoint of national economy. It is estimated in terms of local currency, in the manner as explained hereunder.

1) Economic Construction Cost:

On the basis of the construction cost estimated in foregoing Chapter VIII, the economic cost of construction is calculated by applying some adjustment factors in order to evaluate the project economy from the standpoint of national economy. Such factors include taxes and subsidies which are transfered within the national economy, as well as some shadow rates to evaluate economic prices. (Refer to Annex I.3.1)

In the Dominican Republic, 5% tax is usually applicable in the purchase or transaction, and this tax is to be deducted in estimating the cost to be incurred in local currency. With respect to the labor wages, the skilled labors are relatively in shortage and their wages appear to reflect the market mechanism. However, the unskilled labors are in excess of the actual demand, and the opportunity cost of the unskilled labor is relatively low. It is evaluated that such a shadow wage rate is less than 0.745 of the wages to be actually paid to the unskilled labors in the region around the project area.

Another adjustment required to estimate the economic cost is a shadow exchange rate of foreign currency. The equipment, materials and commodities to be imported from foreign countries will be estimated at a higher rate when they are economically valued in local currency. An extra-bank market rate (also called a parallel rate) of foreign exchange is substantially higher than the official exchange rate. Although the parallel rate is not a shadow exchange rate in a true sense, it affects commodity pricing in the same way as taxes and subsidies would affect in determining the exchange rate. Consequently, the parallel rate of 1.60 prevailing in the middle of 1983 is applied as a shadow exchange rate in estimating the economic cost of the imported equipment, plants and materials.

By applying the adjustment as noted above, the economic construction cost is estimated at RD$105.6 million for El Torito dam - Los Veganos weir complex, RD$58.5 million for El Torito weir - Los Veganos weir complex, and RD$53.3 million for the Pino de Yuna - Los Veganos weir complex.

2) Operation and Maintenance Cost:

Operation and maintenance (O&M) cost will cover wages of employees for operation, regular maintenance cost and minor repair cost. By referring to CDE's past experience in operation and maintenance, the annual O&M cost is estimated at the rate of 0.5% of total construction cost. It is estimated at RD$527,700 for El Torito dam - Los Veganos weir complex RD$292,300 for El Torito weir-Los Veganos weir complex, and RD$266,300 for the Pino de Yuna weir - Los Veganos weir complex.

3) Replacement Cost:

The project life is assumed to be 50 years, in the light of the economic life of civil works. Since the economic life of the metal works, and electro-mechanical works is shorter, the replacement cost is estimated after their economic life of 35 years. The replacement cost is estimated at 90% of the construction cost, taking a salvage value of 10% into account.

9.2 Economic Benefit

The economic benefit of the hydroelectric complex is deemed to be the cost of the most likely alternative power to be selected in the absence of the project. Since the complex is planned and designed to cover the peak demand of less than 2,000 hours per annum, the most competitive alternative will be a gas turbine generator for its readiness in quick short and stop and easiness in construction. In the light of the installed capacity of El Torito - Los Veganos hydroelectric complex (10.3 MW to 6.3 MW in each scheme), a gas turbine unit of 10 MW is adopted to evaluate the capacity value and primary energy value of the alternative power. (Refer to I.3.2)

On the other hand, the secondary energy to be generated by the complex will be served, in general, for the base load demand which is principally fed by steam power plants. By the time when the complex is scheduled for completion, coal-fired plants will also be served. Consequently, the alternative source of the secondary energy is presumed to be 65 MW class plant and 130 MW class coal-fired plant. The economic value of the alternative power is estimated in such a manner as explained hereunder.

1) Capacity Value:

The capacity value of the alternative power is calculated on the basis of installation cost of 10 MW gas turbine, which is estimated at US$346.5/kW. By applying a shadow exchange rate to the foreign currency portion (90%), the economic installation cost is equivalent to RD$533.5/kW. A capacity adjustment factor of 1.026 will be further applied for adjustment of transmission loss, forced outage, station service and overhaul between the gas turbine power and hydro-power. Consequently, the economic installation cost, or capacity value, is estimated at RD$547.38/kW. It is presumed to be disbursed in two years.

2) Primary Energy Value:

Value of the primary energy generated by the complex is assessed on the basis of the fuel cost to be required for the operation of the gas turbine unit. On the basis of the financial price of fuel cost presumed at RD$44.50/bbl (average price of gas-oil purchased by CDE in January - June 1983), as well as by adjusting heating value and rate, the economic value of primary energy is estimated at RD$0.1626/kWh.

3) Secondary Energy Value:

On the basis of the financial fuel price presumed at RD$26.0/bbl for Bunker-C and RD$78.5/ton for imported coal, the energy value is estimated at RD$0.074/kWh for 65 MW class oil-fired plant and RD$0.0485/kWh for 130 MW class coal-fired plant. By applying an average value of oil-fired power and coal-fired power, the secondary energy value is presumed to be RD$0.06125/kWh.

4) Operation and Maintenance Cost:

The annual operation and maintenance cost comprises the fixed O&M cost related to the installed capacity and the variable O&M cost related to the generated energy. It is estimated that the fixed O&M cost of the gas turbine unit is RD$11.55/kW and that the variable O&M cost is RD$3.08/kWh for the gas turbine unit and RD$2.96/kWh for the steam and coal-fired units.

5) Replacement Cost:

The gas turbine unit has an economic life of 17 years. Consequently, the replacement cost is incurred after 17 years from installation. The replacement cost is assumed at 90% of installation cost, by accounting 10% of salvage value.

9.3 Economic Evaluation

The economic cost and benefit estimated in the foregoing Chapter 9.1 and 9.2 are summarized on the accrual flow in Table 9-01 for El Torito dam - Los Veganos weir complex, Table 9-02 for El Torito weir - Los Veganos weir complex, and Table 9-03 for the Pino de Yuna weir - Los Veganos weir complex. On the basis of this flow of economic cost and benefit, the economic internal rate of return is calculated to evaluate economic feasibility of the complex. (Refer to Annex I.3.3)

The economic internal rate of return (EIRR) is calculated as follows:

	EIRR (%)
El Torito dam - Los Veganos weir complex	8.7
El Torito weir - Los Veganos weir complex	12.9
Pino de Yuna weir - Los Veganos weir complex	12.8

EIRR of each component of the complex is calculated, for reference, at 5.2% for El Torito dam scheme, 10.4% for El Torito weir scheme, 10.0% for the Pino de Yuna scheme and 15.6% for Los Veganos weir scheme.

In case that the Piedra Gorda dam is constructed in the downstream (Refer to Appendix-I in Volume V), the effect of water regulation by El Torito dam is expectable. Such a regulation may increase the firm discharge available for the Piedra Gorda power station by 0.5 m^3/s, with the result that the installed capacity will be enlarged by 2 MW and the annual energy output by 0.9 GWh. If this effect in the downstream power station is counted as a benefit, EIRR of El Torito dam - Los Veganos weir complex is increased from 8.7% to 9.3%.

As a result of evaluation in terms of EIRR, it is appraised that El Torito weir - Los Veganos weir complex is economically feasible and it is superior to the Pino de Yuna weir - Los Veganos weir complex. EIRR of El Torito weir - Los Veganos weir is well over the opportunity cost of capital estimated at around 12% in the Dominican Republic.

On the other hand, the economic merit of El Torito dam - Los Veganos weir complex is found to be less expectable. It is apparent that El Torito dam scheme requires over-investment and it unfavorably affects the economic feasibility of the complex. It is concluded that the economic feasibility of El Torito dam - Los Veganos weir complex will turn out to be doubtful.

A sensitivity analysis is made by assuming some changes in variables. It is observed that an increase in costs is less sensitive, though slightly as it is, than the decrease in benefit. (Refer to Fig.-22 and Fig.-23) EIRR is relatively sensitive to the oil prices for the alternative power source. In case that the oil price is increased by 10%, for instance, EIRR will be increased to13.9% for El Torito weir - Los Veganos weir complex. If the shadow exchange rate of 1.60 is not counted and the foreign exchange is valued at parity, EIRR of El Torito weir - Los Veganos weir complex will be decreased to 11.0%.

X. FINANCIAL EVALUATION

10.1 Financial Internal Rate of Return

The financial viability and soundness are evaluated from the financial standpoint of the administrative agency of the complex (CDE). On the basis of the financial cost of construciton, operation and maintenance, as well as the revenue to accrue from power sales, the financial internal rate of return is calculated to evaluate financial viability of the complex. (Refer to Annex I.4.1)

1) Financial Construction Cost:

On the basis of the construction cost estimated in Chapter VIII, the financial construction cost is estimated, inclusive of the escalation of market prices. It is presumed that the price escalation is about 6% for the cost to be incurred in foreign currency and around 8% for the cost estimated in local currency. It is estimated that the financial construction cost will amount to RD$106.1 million (RD$59.9 million in foreign currency and RD$46.2 million in local currency) for El Torito dam - Los Veganos complex. In case of the El Torito weir - Los Veganos weir complex, the total cost will amount to RD$57.1 million (RD$33.8 million in foreign currency and RD$23.3 million in local currency). Likewise, the total cost of Pino de Yuna weir - Los Veganos weir complex is estimated at RD$51.5 million (RD$30.9 million in foreign currency and RD$20.6 million in local currency).

2) Operation and Maintenance Cost:

The operation and maintenance cost of the complex, including wages for employees, regular maintenance and minor repair costs, is estimated at the rate of 0.5% of the construction cost. On the other hand, the expenses for operation and maintenance of power transmission and distribution, as well as power sales, accounting and general administration are estimated on the basis of RD$0.017/kWh in 1982. The annual expenses for power sales is estimated at around RD$2.32 million for El Torito dam - Los Veganos weir complex, RD$1.97 million for El Torito weir - Los Veganos weir complex, and RD$1.80 million for the Pino de Yuna weir - Los Veganos weir complex.

The replacement cost of electro-mechanical facilities is also estimated to be incurred after their economic life of 35 years.

3) Revenues:

CDE's power sales revenue averaged at RD$0.1332/kWh in 1982. In view of the fact that the revenue per sold energy increased annually at the rate of about 27% in 1978-82, the average revenue is presumed at RD$0.16916/kWh in mid 1983. Further, power loss in transmission and distribution is presumed to be 23.5% of generated energy. Consequently, the annual revenue accruable from the sale of primary energy is estimated to amount to RD$5.32 million for El Torito dam - Los Veganos weir complex, RD$4.09 million for El Torito weir - Los Veganos weir complex, and RD$3.77 million for the Pino de Yuna weir - Los Veganos weir complex. In view of the critical situation of power supply in the country, as well as CDE's power tariff, it is presumed that the secondary energy is also sold at the rate of RD$0.16916/kWh. Consequently, the revenue of the secondary energy sale is estimated at RD$5.00 million for El Torito dam - Los Veganos weir complex, RD$4.65 million for El Torito weir - Los Veganos weir complex, and RD$4.23 million for the Pino de Yuna weir - Los Veganos weir complex.

The flow of the annual financial cost and revenue is shown on Table 10-01 and Table 10-02. On the basis of this statement, the financial internal rate of return (FIRR) of the complex is calculated as summarized hereunder.

	FIRR (%)
El Torito dam - Los Veganos weir complex	6.1
El Torito weir - Los Veganos weir complex	10.1
Pino de Yuna weir - Los Veganos weir complex	10.1

FIRR of each component of the complex is calculated, for reference, at 2.7% for El Torito dam scheme, at 7.9% for El Torito weir scheme 7.5% for the Pino de Yuna weir scheme and 13.0% for Los Veganos weir scheme. A sensitivity analysis implies that the decrease in revenue from power sales is relatively more sensitive than the increase in cost. (Refer to Fig.-24 and Fig.-25)

10.2 Repayability

For the implementation of the complex, CDE will count on the external finance by an international financial agency to cover, in principle, the cost to be incurred in foreign currency. It will also have to manage to raise a fund to cover the cost in local currency. A provisional financial plan is presumed in such a way that the external loan is extended in concessionary terms (3.5% of interest, 20 years of repayment period after 10 years' grace period) or in intermediate terms (8.0% of interest, 20 years of repayment period after 10 years' grace period) and that the local cost is secured by issuing a bond (10.0% of interest and 10 years of maturity period).

In case of El Torito dam - Los Veganos weir complex, it might be possible to repay the loan ultimately, but it will be required to issue again the bond to cover the deficit in the half way of the project operation for 50 years. (Refer to Table 10-03) Financial surplus from the complex is unexpectable for nearly 35 years. The loan and bond in intermediate terms and hardly be repayable.

On the other hand, the loan and bond for El Torito weir - Los Veganos weir complex are repayable in a relatively easy way, and it is possible to expect that a financial surplus will be credited in a relatively short period if the loan is concessionary in terms. Also, in case of intermediate terms, El Torito weir - Los Veganos weir complex still has repayability. (Refer to Table 10-04)

10.3 Financial Evaluation

Through the analysis of FIRR and repayability, the financial viability of El Torito dam - Los Veganos weir complex is appraised to be marginal and the repayability of external and internal loan is hardly found to be manageable. It is due principally to the over-investment in the construction of El Torito dams.

On the other hand, implementation of El Torito weir - Los Veganos weir complex is evaluated to be more beneficial than the Pino de Yuna weir -

Los Veganos weir complex. The selected complex if financially viable. The external and internal funds raised for the complex will be repayable, and it will be possible for CDE to maintain a sound financial position in executing the complex. Financially, it is recommendable for CDE to implement El Torito weir - Los Veganos weir complex.

Additionally, it is noted that El Torito weir - Los Veganos weir complex will contribute, if it is implemented, to save the foreign exchange in a substantial amount. Such savings in foreign exchange is estimated at RD$4.7 million per annum.

XI. CONCLUSION AND RECOMMENDATION

Through the investigation and studies on the hydroelectric development along the Yuna mainstream upstream of the confluence with the Blanco river, it has been clarified that the implementation of El Torito dam - Los Veganos weir complex is economically and financially less attractive, though it enables to install a slightly larger capacity of generating equipment. On the other hand, the implementation of El Torito weir - Los Veganos weir complex has been evaluated to be technically sound, economically feasible and financially viable. It is therefore recommended to take up El Torito weir (Yuna No. 1 power station) - Los Veganos weir (Yuna No. 2 power station) complex for implementation.

Under El Torito weir - Los Veganos weir complex, power generation of 14.9 MW in installed capacity and 67.5 GWh of annual energy output is expected, and it will contribute substantially for the improvement of CDE's power supply situation. In view of the situation of power demand and supply in the late 1980's, it is recommended that the proposed El Torito weir - Los Veganos weir complex be implemented at the earliest possible time. If appropriate actions are taken, it will be possible to expect that Yuna No. 1 and No. 2 power stations are commissioned for commercial operation in 1988-89.

For the implementation of the proposed complex, it is also recommended to take the following points into account:

a) In order to implement the proposed complex at the earliest possible time, it is suggested that CDE will start to prepare tender documents for construction as soon as possible.

b) In parallel with the preparation of tender documents, arrangement of external and internal funds for construction is to be promoted. It is desirable that the construction funds are made available by the time when the tender is called for the construction works. In view of the financial viability of the complex, as well as the financial position of CDE, it is desired that the funds are extended on such terms as concessionary as possible.

c) It is advisable that hydrological observation and measurement will be continued further, and it will be checked at the time of finalizing tender design.

d) It is also suggested that CDB will additionally take necessary action for the construction of access road to the major construction sites.

TABLES

[illegible]

Table 1-01 <u>MEMBER OF STUDY TEAM</u>
MIEMBROS DEL EQUIPO DE ESTUDIO

<u>CDE</u>

(Supervisory)

Ing. Marcelo Jorge Pérez	General Administrator
Ing. Fernando Luciano	Director, DDH
Ing. Eldon Garcia	Hydrologist, DDH
Ing. Ramon Marmolejos	Topographer, DDH

(Counterparts)

Ing. Otilio Martínez	Coordinator
Ing. Santiago Andujar	Civil Engineer
Ing. Josefina Turbides	Hidrologist
Ing. Tomas Pichardo	(do)
Ing. Miguel Burgos	Geologist
Ing. Jose A. Espinal	Surveyor
Ing. Artur Segadlo	Geophysist
Ing. Alcibiades Mota	(do)
Ing. Jose Mella	(do)

<u>JICA Team</u>

Mr. Hiroyasu Sonoda	Team Leader (Nippn Koei Co., Ltd.)
Mr. Hajime Koizumi	Sub-Leader (do)
Mr. Hirofumi Sasaki	Civil Engineer (do)
Mr. Kazuki Tsuji	Geologist (do)
Mr. Takao Nakano	Soil Mechanical Engineer (do)
Mr. Katsumasa Kawai	Electric Engineer (do)
Mr. Nobuaki Kinoshita	Power Surveyor (do)
Mr. Eiichiro Seki	Construction Planner (do)
Mr. Itsuo Maekawa	Boring Expert (do)
Mr. Tetsujiro Ochiai	Boring Expert (do)
Mr. Kojiro Osakabe	Topographic Surveyor (Kokusai Kogyo Co., Ltd.)
Mr. Kiyomi Terasono	Geophysist (Kyowa Keisoku Co., Ltd.)
Mr. Masashi Kushima	Geophysist (do)

Table 2-01 TOTAL POPULATION
POBLACIÓN TOTAL

Unit: 1,000 prs

Year	Total	Urban	Rural
1960 (1.9)*	3,047.1 (100.0%)	929.9 (30.5%)	2,117.2 (69.5%)
1970 (1.9)*	4,009.5 (100.0%)	1,593.3 (39.7%)	2,416.2 (60.3%)
1970	4,058.3	1,031.7	2,426.6
1971	4,165.0	1,716.2	2,448.8
1972	4,276.9	1,805.3	2,471.6
1973	4,396.2	1,899.3	2,496.9
1974	4,517.3	1,998.7	2,518.6
1975	4,646.4	2,103.5	2,542.9
1976	4,782.1	2,214.4	2,567.7
1977	4,923.4	2,331.0	2,592.4
1978	5,073.4	2,455.0	2,610.4
1979	5,230.9	2,585.6	2,645.3
1980	5,394.0	2,721.7	2,672.3
1981	5,569.5	2,869.6	2,699.9
1981 (12.5)*	5,648.0 (100.0%)	2,935.9 (52.0%)	2,712.1 (48.0%)
1982	5,753.8	3,024.9	2,728.9
1985 **	6,096 (100.0%)	3,337 (54.7%)	2,759 (45.3%)
1990 **	6,803 (100.0%)	3,990 (58.7%)	2,813 (41.3%)

Note: * Census year and date. Population in other years is the estimated mid year population.

** Estimated by Institute of Population and Development Studies.

Table 2-02 GROSS DOMESTIC PRODUCT BY SECTOR
PRODUCTO INTERNO BRUTO POR SACTORES

At 1970 Prices
Unit:Million RD$

	1976	1977	1978	1979*	1980*	1981**	1982**
Agriculture	429.2	436.8	456.8	461.7	483.3	509.1	592.8
Mining	146.7	143.0	114.3	146.5	124.8	136.2	95.9
Manufacturing	457.4	483.2	482.6	504.8	530.2	546.1	574.4
Construction	153.2	168.7	174.5	183.5	196.5	198.0	188.3
Commerce	414.0	429.8	438.8	451.5	473.6	491.6	508.8
Transport/Communic.	190.8	211.8	218.9	225.4	230.5	242.7	254.0
Electricity	30.9	39.3	42.9	43.7	49.0	53.4	48.3
Finance	58.2	63.4	66.4	67.9	70.4	73.2	76.5
Housing	156.8	169.8	177.2	186.0	198.1	199.7	197.9
Government	189.9	191.2	200.4	236.1	277.8	274.7	287.9
Others	215.8	227.4	246.8	234.5	265.4	278.1	287.8
Total	2,442.9	2,564.5	2,619.5	2,741.6	2,899.6	3,002.8	3,048.6

(%)

	1976	1977	1978	1979*	1980*	1981**	1982**
Agriculture	17.6	17.1	17.4	16.8	16.6	17.0	19.4
Mining	6.0	5.6	4.4	5.3	4.3	4.5	3.2
Manufacturing	18.7	18.8	18.4	18.4	18.3	18.2	18.8
Construction	6.3	6.6	6.7	6.7	6.8	6.6	6.2
Commerce	16.9	16.8	16.8	16.5	16.3	16.4	16.7
Transport/Communic.	7.8	8.2	8.3	8.2	8.0	8.1	8.3
Electricity	1.3	1.5	1.6	1.6	1.7	1.8	1.6
Finance	2.4	2.5	2.5	2.5	2.4	2.4	2.5
Housing	6.4	6.6	6.8	6.8	6.8	6.6	6.5
Government	7.8	7.4	7.6	8.6	9.6	9.1	9.4
Others	8.8	8.9	9.4	8.6	9.2	9.3	9.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: * Preliminary figures
** Estimated figures

Source: Central Bank, National Account 1976-80 and Monthly Bulletin

Table 2-03 EXPORT AND IMPORT
EXPORTACION E IMPORTACION

Unit:Million RD$

	Export (FOB)	Import (FOB)		Balance
	Total	Total	(Petroleum)	
1977	780.5	847.8	(187.8)	-67.3
1978	675.5	859.7	(199.0)	-184.2
1979	868.6	1,080.4	(314.9)	-211.8
1980	961.9	1,498.4	(448.8)	-536.5
1981*	1,188.0	1,450.2	(497.4)	-262.2
1982*	767.7	1,248.4	(449.5)	-480.7
1983**	785.2	1,250.0	(466.4)	-464.8

Note: * Preliminary figures
** Forecasted by the Central Bank in August 1983

Source: Central Bank

Table 2-04 ACTUAL POWER TREND
TENDENCIA DE ENERGIA

Year	Energy Send'g End (Gwh)	Energy Sold (Gwh)	Energy Loss (Gwh)	Max.Demand (Mw)	Energy Loss Factor (%)	Load Factor (%)
1970	871.5	684.4	187.1	180.9	21.5	55.0
1971	1,000.7	772.5	228.2	201.7	22.8	56.6
1972	1,138.4	871.1	267.3	209.4	23.5	62.0
1973	1,325.9	1,023.1	302.8	268.8	22.8	56.3
1974	1,447.6	1,097.0	350.6	287.2	24.2	57.5
1975	1,545.3	1,170.7	374.6	299.0	24.2	59.0
1976	1,639.2	1,207.9	431.3	340.8	26.3	54.9
1977	2,058.7	1,535.4	523.3	396.0	25.4	59.4
1978	2,300.3	1,674.0	626.3	411.0	27.2	63.9
1979	2,252.9	1,706.8	546.2	412.0	24.2	62.4
1980	2,629.8	1,913.6	716.2	462.0	27.2	64.9
1981	2,787.7	2,084.6	703.1	475.0	25.2	67.0
1982	2,849.1	1,890.6	958.3	504.0	33.6	64.5
1983*	3,122.3	1,962.8	1,159.4	538.0	37.1	68.4

Source: CDE

* Preliminary

Table 2-05 POWER CONSUMPTION BY SECTOR
CONSUMO DE LA ENERGIA POR SECTORES

Unit: GWh

Year	Residential	Commercial	Industrial	Government	Public ill.	Total
1970	263.6 (38.5%)	87.0 (12.7%)	243.8 (35.6%)	71.8 (10.5%)	18.0 (2.7%)	684.4 (100.0%)
1971	296.8	97.2	280.9	77.4	20.2	772.5
1972	344.4	114.4	311.5	80.3	21.0	871.5
1973	392.9	131.7	379.9	94.6	23.5	1,022.6
1974	415.8	139.9	419.3	102.0	20.0	1,097.0
1975	450.7	153.1	429.5	117.3	20.1	1,170.7
1976	459.6 (38.0%)	150.6 (12.5%)	461.2 (38.2%)	120.4 (10.0%)	16.1 (1.3%)	1,207.9 (100.0%)
1977	584.4	196.7	577.1	144.2	18.3	1,520.7
1978	639.4	214.1	617.5	181.8	29.9	1,673.7
1979	635.7	214.2	661.9	173.9	20.8	1,706.8
1980	723.9	230.6	719.5	214.9	24.6	1,913.6
1981	817.8	256.4	757.9	226.6	25.9	2,084.6
1982	732.3 (38.7%)	228.4 (12.1%)	673.2 (35.6%)	230.8 (12.2%)	25.5 (1.3%)	1,890.2 (100.0%)

Source: CDE, Basic Information Dept.

Table 2-06 FORECAST (CASE-1)
PROYECCION (CASO-1)

Year	Energy /1 Sold (GWh)	Energy Loss (GWh)	Energy Loss (%)	Sending End Energy (GWh)	Load Factor (%)	Maximum Demand (MW)
1983	2,539.6	958.5	27.4	3,498.1	65	614
1984	2,867.5	1,049.8	26.8	3,917.3	65	688
1985	3,238.0	1,149.5	26.2	4,387.5	65	771
1986	3,657.2	1,258.4	25.6	4,915.6	65	863
1987	4,130.8	1,376.9	25.0	5,507.7	65	967
1988	4,666.6	1,514.3	24.5	6,180.9	65	1,086
1989	5,272.9	1,665.1	24.0	6,938.0	65	1,218
1990	5,959.0	1,830.5	23.5	7,789.5	65	1,368
1991	6,735.1	2,011.8	23.0	8,746.9	65	1,536
1992	7,613.5	2,210.4	22.5	9,823.9	65	1,725

Note: /1 Sold energy predicted by CDE-SOFRELEC

FORECAST (CASE-2)
PROYECCION (CASO-2)

Year	Energy /1 Sold (GWh)	Energy Loss (GWh)	Energy Loss (%)	Sending End Energy (GWh)	Local Factor (%)	Maximum Demand (MW)
1983	2,619.8	988.7	27.4	3,608.5	65	634
1984	2,895.5	1,060.1	26.8	3,955.6	65	695
1985	3,200.4	1,136.2	26.2	4,336.6	65	762
1986	3,537.2	1,217.1	25.6	4,754.3	65	835
1987	3,909.7	1,303.2	25.0	5,212.9	65	916
1988	4,321.2	1,402.2	24.5	5,723.4	65	1,005
1989	4,776.1	1,508.2	24.0	6,284.3	65	1,104
1990	5,278.9	1,621.6	23.5	6,900.5	65	1,212
1991	5,834.7	1,742.8	23.0	7,577.5	65	1,331
1992	6,448.9	1,872.3	22.5	8,321.2	65	1,461

Note: /1 Estimated on the basis of regression analysis on the trend in 1970-81.

Table 2-07 POWER GENERATION
GENERACION DE LA ENERGIA ELECTRICA

	Power Station	Installed Capacity (MW) Rated	Installed Capacity (MW) Firm	Sending End Energy (GWh) 1981	Sending End Energy (GWh) 1982
HYDRO					
(CDE)	Las Damas	7.5	5.0	35.9	45.9
	Constanza	0.25	0.2	0.8	0.5
	Subtotal	7.75	5.2	36.7	46.4
(State)	Tavera	40 x 2	33.0	248.0	108.5
	Valdesia	27 x 2	36.0	119.5	68.1
	Rincon	10.1	6.0	35.8	18.6
	Sabana Yegua	13.0	5.7	53.1	34.4
	Sabaneta	7.5	2.1	19.1	35.1
	Subtotal	164.6	82.8	475.5	264.7
	Total HYDRO	172.4 (19.0%)	88.0 (14.7%)	512.2 (18.4%)	311.1 (10.9%)
STEAM	Haina	54 x 2, 84.9 x 3	255.9	1,384.4	1,456.5
	Santo Domingo	12.6 x 2, 26.5 x 1	38.4	293.9	278.2
	Puerto Plata	27.6, 36.8	34.4	123.1, -	39.7, 3.1
	Total STEAM	478.8 (52.8%)	328.7 (54.8%)	1,801.4 (64.6%)	1,777.5 (62.6%)
GAS	Los Minas	35 x 2	50.2	126.8	195.7
	Timbeque	21.1	14.2	17.0	40.9
	S.P. Macoris	28.3	17.9	90.8	2.4
	Weber	20.0	4.8	13.5	16.9
	Barahona	28.3	14.8	25.3	24.1
	Total GAS	167.7 (18.5%)	101.9 (17.0%)	273.5 (9.8%)	280.0 (9.9%)
DIESEL	Santiago (3)	6.0	1.8		
	Constanza (4)	2.45	1.1		
	Pedernales	1.45	0.4		
	Total DIESEL	9.9 (1.1%)	3.3 (0.6%)	6.6 (0.2%)	6.4 (0.2%)
(Falconbridge)		78.0 (8.6%)	78.0 (13.0%)	192.9 (6.9%)	466.1 (16.4%)
TOTAL		906.8	599.9	2,786.6	2,841.1

Source: CDE, Monthly Production Record

Table 3-01 **SYNTHETIC DISCHARGE AT LOS QUEMADOS**

CAUDAL SINTETICO EN LOS QUEMADOS

Unit: m^3/s

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1969	19.41	9.52	7.71	25.12	30.30	13.49	9.86	9.87	13.88	14.44	33.02	23.15	17.51
1970	9.52	11.03	10.51	6.35	34.95	28.19	16.10	21.61	24.18	23.37	41.11	56.91	23.74
1971	20.91	54.34	18.24	16.74	17.92	12.21	11.05	12.83	13.16	15.50	16.34	20.15	18.87
1972	20.06	12.08	20.41	14.32	17.88	19.93	20.41	25.42	22.10	30.24	12.74	35.72	21.03
1973	14.04	14.00	10.38	8.68	8.56	10.42	10.94	10.13	13.17	22.39	16.64	25.04	13.71
1974	27.59	25.32	28.53	18.89	14.14	10.04	7.17	25.99	31.39	34.41	14.23	15.24	21.07
1975	10.40	8.25	7.12	5.42	7.65	5.04	4.13	7.42	7.37	11.48	32.72	61.66	14.12
1976	13.75	21.85	24.15	38.32	46.08	18.93	52.22	56.33	64.97	53.64	15.30	17.43	35.33
1977	6.79	5.38	4.14	18.53	22.25	10.38	6.95	9.92	14.16	12.37	37.28	26.44	14.56
1978	18.85	9.55	8.38	23.50	18.37	11.16	8.91	15.26	10.93	8.26	9.13	10.20	12.72
MEAN	16.13	17.13	13.96	17.59	21.81	13.98	14.77	19.48	21.53	22.61	22.85	29.19	19.25

Table 3-02 **DISCHARGE CONVERSION RATIO**
(PROPORCION DE CAUDALES)

Station	Ratio of each Station to P.G. (Selected Data)	Ratio of each Station to L.Q.	Conversion Ratio (rounded)	C.A. Ratio	C.A. (km^2)
T1-Site	0.037 (0.49)	0.036	0.04	0.043	15.7
T2-Site	0.037 (0.66)	0.036	0.04	0.039	14.3
T4-Site	-	0.095	0.10	0.087	32.5
Arr. Colorado	0.072 (0.81)	0.070	0.07	0.042	15.3
Arr. Colorado Weir Site (Plan A)	-	0.037	0.04	0.022	8.1
Arr. Colorado Weir Site (Plan B)	-	0.038	0.04	0.023	8.4
Confluence Colorado	0.224 (0.81)	0.217	0.22	0.170	62.9

L.Q. : Los Quemados (C.A. = 369 km^2)
P.G. : Piedra Gorda (C.A. = 358 km^2)
( ) : Correlation Coefficient (r)

Table 3-03 STRATIGRAPHIC SEQUENCE OF UPPER YUNA PROJECT AREA
ORDEN ESTRATIGRAFICO EN EL AREA DE PROYECTO

Geologic Age		Formation	Lithology
Cenozoic	Quaternary	Alluvial deposit	Present river deposit Debris Middle & lower terrace deposit Upper terrace deposit
		(Unconformably)	
Mesozoic	Upper Cretaceous (Middle Albian) *1	Tireo formation	Limestone, Marl Andesite, Dacite, Tuff breccia, Limestone, Tuff, Sandstone, Slate, Chert
		(Fault)	
Age unknown	Pre-Middle Albian	Duarte Formation *2	Amphibolite, Foliated diorite, Peridotite Green schist Gneiss
		(Intrusion)	
Age unknown	Pre-Middle Albian (?)	Plutonic igneous rocks	Coorse grained quartz diorite (Partly foliated)

Note: *1 Uppermost of lower Cretaceous.
*2 Relation is not necessarily confirmed.

Table 8-01 ESTIMATED FINANCIAL CONSTRUCTION COST
(EL TORITO DAM - LOS VEGANOS WEIR COMPLEX)
ESTIMADO DEL COSTO FINANCIERO
(PRESA EL TORITO - DERIVADORA LOS VEGANOS)

Unit: $RD\$10^3$

Item	FC	LC	Total
1. General	1,507.6	1,234.4	2,742.0
2. Civil Works			
2.1 PS-1			
(1) Dam & Intake Weir	17,069.3	13,841.7	30,911.0
(2) Power Facilities	6,435.6	4,821.3	11,256.9
Sub-total (2.1)	23,504.9	18,663.0	42,167.9
2.2 PS-2			
(1) Intake Weir	1,603.6	1,700.3	3,303.9
(2) Power Facilities	3,503.8	2,680.3	6,184.1
Sub-total (2.2)	5,107.4	4,380.6	9,488.0
Sub-Total (2)	28,612.3	23,043.6	51,655.9
3. Building Works			
3.1 PS-1	123.9	68.3	192.2
3.2 PS-2	123.9	68.3	192.2
Sub-Total (3)	247.8	136.6	384.4
4. Metal Works			
4.1 PS-1	656.2	393.5	1,049.7
4.2 PS-2	1,561.0	649.7	2,210.7
Sub-Total (4)	2,217.2	1,043.2	3,260.4
5. Generating Equipment and Transmission Line			
5.1 PS-1	2,771.5	254.6	3,026.1
5.2 PS-2	2,758.0	225.2	2,983.2
Sub-Total (5)	5,529.5	479.8	6,009.3
6. Road Construction	1,535.1	1,645.5	3,180.6
7. Land Acquisition	0.0	676.3	676.3
8. Engineering Service and Administration	2,973.6	2,119.5	5,093.1
9. Physical Contingency	4,262.2	3,037.9	7,300.1
Total (1-9)	46,885.3	33,416.8	80,302.1
10. Price Contingency	13,011.9	12,796.1	25,808.0
TOTAL (1-10)	59,897.2	46,212.9	106,110.1

Table 8-02 **ESTIMATED FINANCIAL CONSTRUCTION COST**
(EL TORITO WEIR - LOS VEGANOS WEIR COMPLEX)
ESTIMADO DEL COSTO FINANCIERO
(DERIVADORA EL TORITO - DERIVADORA LOS VEGANOS)

Unit: RD$10[3]

Item	FC	LC	Total
1. General	680.4	579.2	1,259.6
2. Civil Works			
2.1 PS-1			
(1) Intake Weir	1,826.1	1,954.9	3,781.0
(2) Power Facilities	5,890.6	4,413.0	10,303.6
Sub-total(2.1)	7,716.7	6,367.9	14,084.6
2.2 PS-2			
(1) Intake Weir	1,359.3	1,422.0	2,781.3
(2) Power Facilities	3,467.5	2,652.9	6,120.4
Sub-total (2.2)	4,826.8	4,074.9	8,901.7
Sub-Total (2)	12,543.5	10,442.8	22,986.3
3. Building Works			
3.1 PS-1	123.9	68.3	192.2
3.2 PS-2	123.9	68.3	192.2
Sub-Total (3)	247.8	136.6	384.4
4. Metal Works			
4.1 PS-1	1,299.5	549.5	1,849.0
4.2 PS-2	1,412.2	580.5	1,992.7
Sub-Total (4)	2,711.7	1,130.0	3,841.7
5. Generating Equipment and Transmission Line			
5.1 PS-1	2,427.2	213.9	2,641.1
5.2 PS-2	2,588.8	211.5	2,800.3
Sub-Total (5)	5,016.0	425.4	5,441.4
6. Road Construction	1,063.9	1,138.9	2,202.8
7. Land Acquisition		243.2	243.2
8. Engineering Service and Administration	2,226.3	1,409.6	3,635.9
9. Physical Contingency	2,448.8	1,550.8	3,999.6
Total	26,938.4	17,056.5	43,994.9
10. Price Contingency	6,852.4	6,261.4	13,113.8
TOTAL	33,790.8	23,317.9	57,108.7

Table 8-03 ESTIMATED FINANCIAL CONSTRUCTION COST
(PINO DE YUNA WEIR - LOS VEGANOS WEIR COMPLEX)

ESTIMADO DEL COSTO FINANCIERO
(DERIVADORA PINO DE YUNA - DERIVADORA LOS VEGANOS)

Unit: RD$$10^3$

Item	FC	LC	Total
1. General	598.5	509.9	1,108.4
2. Civil Works			
2.1 PS-1			
(1) Intake Weir	1,073.1	1,118.6	2,191.7
(2) Power Facilities	5,116.0	3,844.4	8,960.4
Sub-total (2.1)	6,189.1	4,963.0	11,152.1
2.2 PS-2			
(1) Intake Weir	1,359.2	1,422.1	2,781.3
(2) Power Facilities	3,467.1	2,672.8	6,139.9
Sub-total (2.2)	4,826.3	4,094.9	8,921.2
Sub-Total (2)	11,015.4	9,057.9	20,073.3
3. Building Works			
3.1 PS-1	123.9	68.3	192.2
3.2 PS-2	123.9	68.3	192.2
Sub-Total (3)	247.8	136.6	384.4
4. Metal Works			
4.1 PS-1	1,299.5	549.5	1,849.0
4.2 PS-2	1,412.2	580.5	1,992.7
Sub-Total (4)	2,711.7	1,130.0	3,841.7
5. Generating Equipment and Transmission Line			
5.1 PS-1	2,312.5	200.7	2,513.2
5.2 PS-2	2,588.8	211.5	2,800.3
Sub-Total (5)	4,901.3	412.2	5,313.5
6. Road Construction	1,063.9	1,138.9	2,202.8
7. Land Acquisition	0.0	152.1	152.1
8. Engineering Service and Administration	1,995.1	1,257.8	3,252.9
9. Physical Contingency	2,194.6	1,383.6	3,578.2
Total	24,728.3	15,179.0	39,907.3
10. Price Contingency	6,144.1	5,426.4	11,570.5
TOTAL	30,872.4	20,605.4	51,477.8

Table 9-01 ECONOMIC INTERNAL RATE OF RETURN
(EL TORITO DAM - LOS VEGANOS WEIR COMPLEX)

TASA INTERNA DE RETORNO ECONOMICO
(PRESA EL TORITO - DERIVADORA LOS VEGANOS)

Unit: RD$10^3

Year	Costs/1				Benefit/2						Surplus
	Capital										
	F.C.	L.C.	O & M	Total	Capacity Value	Primary Energy	Secondary Energy	Fixed O & M	Variable O & M	Total	
1	2,158.4	1,380.2		3,538.6							-3,538.6
2	4,906.7	1,868.6		6,775.3							-6,775.3
3	12,788.5	5,453.4		18,241.9							-18,241.9
4	22,537.4	7,941.8		30,479.2	5,227.5					5,227.5	-25,251.7
5	24,435.0	8,953.5	131.9	33,520.4	5,227.5	1,536.6	698.3	50.8	62.9	7,576.1	-25,944.3
6	8,617.3	4,488.7	395.7	13,501.7		4,878.0	1,880.4	161.1	183.3	7,102.8	-6,398.9
7-20			527.7	527.7		6,682.9	2,364.3	220.6	240.8	9,508.6	8,980.9
21-22			527.7	527.7	4,704.7	6,682.9	2,364.3	220.6	240.8	14,213.3	13,685.6
23-36			527.7	527.7		6,682.9	2,364.3	220.6	240.8	9,508.6	8,980.9
37	1,470.9		527.7	1,998.6		6,682.9	2,364.3	220.6	240.8	9,508.6	7,510.0
38	1,167.3		527.7	1,695.0	4,704.7	6,682.9	2,364.3	220.6	240.8	14,213.3	12,518.3
39	5,883.5	419.0	527.7	6,830.2	4,704.7	6,682.9	2,364.3	220.6	240.8	14,213.3	7,383.1
40	4,669.4	563.8	527.7	5,760.9		6,682.9	2,364.3	220.6	240.8	9,508.6	3,747.7
41		476.1	527.7	1,003.8		6,682.9	2,364.3	220.6	240.8	9,508.6	8,504.8
42-50			527.7	527.7		6,682.9	2,364.3	220.6	240.8	9,508.6	8,980.9

Economic Internal Rate of Return: 8.7%

Note: /1: Refer to Table I-09 (1)
/2: Refer to Table I-19

Table 9-02 ECONOMIC INTERNAL RATE OF RETURN
(EL TORITO WEIR - LOS VEGANOS WEIR COMPLEX)
TASA INTERNO DE RETORNO ECONOMICO
(DERIVADORA EL TORITO - DERIVADORA LOS VEGANOS)

Unit: RD$10^3

Year	Costs/1				Benefits/2						Surplus
	Capital		O & M	Total	Capacity Value	Primary Energy	Secondary Energy	Fixed O & M	Variable O & M	Total	
	F.C.	L.C.									
1	1,359.2	844.0		2,203.2							-2,203.2
2	3,566.2	1,136.1		4,702.3							-4,702.3
3	7,095.1	2,595.2		9,690.3							-9,690.3
4	21,018.7	4,776.5		25,795.2	4,078.0					4,078.0	-21,717.2
5	7,999.9	4,577.5	73.1	12,650.5	4,078.0	1,333.3	581.9	44.5	53.4	6,091.0	-6,559.5
6	2,062.6	1,421.7	219.2	3,703.5		3,902.4	1,681.3	130.5	155.2	5,869.4	2,165.9
7 - 20			292.3	292.3		5,138.2	2,198.9	172.1	203.6	7,712.7	7,420.5
21 - 22			292.3	292.3	3,670.2	5,138.2	2,198.9	172.1	203.6	11,382.9	11,090.6
23 - 36			292.3	292.3		5,138.2	2,198.9	172.1	203.6	7,712.7	7,420.5
37	1,112.8		292.3	1,405.1		5,138.2	2,198.9	172.1	203.6	7,712.7	6,307.7
38	1,112.8		292.3	1,405.1	3,670.2	5,138.2	2,198.9	172.1	203.6	11,382.9	9,977.8
39	8,902.3	326.0	292.3	9,520.6	3,670.2	5,138.2	2,198.9	172.1	203.6	11,382.9	1,862.3
40		595.4	292.3	887.7		5,138.2	2,198.9	172.1	203.6	7,712.7	6,825.1
41		338.7	292.3	631.0		5,138.2	2,198.9	172.1	203.6	7,712.7	7,081.5
42 - 50			292.3	292.3		5,138.2	2,198.9	172.1	203.6	7,712.7	7,420.5

Economic Internal Rate of Return: 12.9%

Note: /1: Refer to Table I-09 (2)
/2: Refer to Table I-20

Table 9-03

ECONOMIC INTERNAL RATE OF RETURN
(PINO DE YUNA WEIR - LOS VEGANOS WEIR COMPLEX)

TASA INTERNA DE RETORNO ECONOMICO
(DERIVADORA PINO DE YUNA - DERIVADORA LOS VEGANOS)

Unit: RD$10³

Year	Costs/1 Capital F.C.	Costs/1 Capital L.C.	Costs/1 O & M	Costs/1 Total	Benefit/2 Capacity Value	Benefit/2 Primary Energy	Benefit/2 Secondary Energy	Benefit/2 Fixed O & M	Benefit/2 Variable O & M	Benefit/2 Total	Surplus
1	1,322.5	814.2		2,136.7							-2,136.7
2	3,429.4	1,092.8		4,522.2							-4,522.2
3	6,959.5	2,516.6		9,476.1							-9,476.1
4	19,849.4	4,384.6		24,234.0	3,831.7					3,831.7	-20,402.3
5	7,061.3	4,044.1	67.0	11,172.4	3,831.7	1,333.3	581.9	44.5	53.4	5,844.7	-5,327.7
6	943.0	853.9	199.7	1,996.6		3,699.2	1,583.3	125.3	146.6	5,554.4	3,558.2
7 - 20			266.3	266.3		4,731.7	2,002.9	161.7	186.4	7,082.7	6,816.4
21 - 22			266.3	266.3	3,448.5	4,731.7	2,002.9	161.7	186.4	10,531.2	10,264.9
23 - 36			266.3	266.3		4,731.7	2,002.9	161.7	186.4	7,082.7	6,816.4
37	1,105.0		266.3	1,371.3		4,731.7	2,002.9	161.7	186.4	7,082.7	5,711.4
38	1,105.0		266.3	1,371.3	3,448.5	4,731.7	2,002.9	161.7	186.4	10,531.2	9,159.9
39	8,839.3	316.8	266.3	9,422.4	3,448.5	4,731.7	2,002.9	161.7	186.4	10,531.2	1,108.8
40		592.9	266.3	859.2		4,731.7	2,002.9	161.7	186.4	7,082.7	6,223.5
41		344.0	266.3	610.3		4,731.7	2,002.9	161.7	186.4	7,082.7	6,472.4
42 - 50			266.3	266.3		4,731.7	2,002.9	161.7	186.4	7,082.7	6,816.4

Economic Internal Rate of Return: 12.8%

Note: /1: Refer to Table I- 09 (3)
/2: Refer to Table I- 21

Table 10-01 FINANCIAL INTERNAL RATE OF RETURN (1)
(EL TORITO DAM - LOS VEGANOS WEIR COMPLEX)

TASA INTERNA DE RETORNO FINANCIERO (1)
(PRESA EL TORITO - DERIVADORA LOS VEGANOS)

Unit: RD$10[3]

Year	Cost					Revenue			Surplus
	Capital/Replace. Cost (FC)	Capital/Replace. Cost (LC)	O&M Cost	Ener. Sales Cost	Total Cost	Primary Energy	Second-ary Ener.	Total Benefits	
1	1,434.4	1,660.8			3,095.2				-3,095.2
2	3,445.7	2,438.0			5,883.7				-5,883.7
3	9,519.6	7,650.6			17,170.2				-17,170.2
4	17,783.1	12,024.4			29,807.5				-29,807.5
5	20,074.3	14,617.5	132.6	607.5	35,431.9	1,222.9	1,475.2	2,698.1	-32,733.8
6	7,639.9	7,822.0	397.9	1,768.5	17,628.3	3,882.2	3,972.8	7,855.0	-9,773.3
7-36			530.6	2,322.1	2,852.7	5,318.6	4,995.1	10,313.7	7,461.0
37	1,032.8		530.6	2,322.1	3,885.5	5,318.6	4,995.1	10,313.7	6,428.2
38	868.9		530.6	2,322.1	3,721.6	5,318.6	4,995.1	10,313.7	6,592.1
39	4,642.4	633.4	530.6	2,322.1	8,128.5	5,318.6	4,995.1	10,313.7	2,185.2
40	3,905.6	920.5	530.6	2,322.1	7,678.8	5,318.6	4,995.1	10,313.7	2,634.[illegible]
41		839.3	530.6	2,322.1	3,692.0	5,318.6	4,995.1	10,313.7	6,621.7
42-50			530.6	2,322.1	2,852.7	5,318.6	4,995.1	10,313.7	7,461.0

Financial Internal Rate of Return: 6.1%

Table 10-02 FINANCIAL INTERNAL RATE OF RETURN (2)
(EL TORITO WEIR - LOS VEGANOS WEIR COMPLEX)

TASA INTERNA DE RETORNO FINANCIERO
(DERIVADORA EL TORITO - DERIVADORA LOS VEGANOS)

Unit: RD$10[3]

Year	Costs					Revenue			Surplus
	Capital/Replace. Cost(FC)	Capital/Replace. Cost(LC)	O&M Cost	Ener.Sales Cost	Total Costs	Primary Energy	Second-ary Ener.	Total Benefits	
1	900.4	1,012.8			1,913.2				-1,913.2
2	2,504.4	1,472.3			3,976.7				-3,976.7
3	5,281.5	3,632.4			8,913.9				-8,913.9
4	16,584.7	7,220.5			23,805.2				-23,805.2
5	6,691.1	7,473.2	71.4	515.7	14,751.4	1,285.6	1,429.4	2,715.0	-12,036.4
6	1,828.7	2,506.7	214.2	1,499.0	6,064.4	3,958.3	4,465.8	8,424.2	2,359.8
7-36			285.5	1,966.6	2,252.1	4,089.3	4,645.7	8,735.0	6,482.9
37	979.1		285.5	1,966.6	3,231.2	4,089.3	4,645.7	8,735.0	5,503.8
38	966.7		285.5	1,966.6	3,218.8	4,089.3	4,645.7	8,735.0	5,516.2
39	8,499.4	596.2	285.5	1,966.6	11,347.7	4,089.3	4,645.7	8,735.0	-2,612.7
40		1,176.3	285.5	1,966.6	3,428.4	4,089.3	4,645.7	8,735.0	5,306.6
41		722.5	285.5	1,966.6	2,974.6	4,089.3	4,645.7	8,735.0	5,760.4
42-50			285.5	1,966.6	2,252.1	4,089.3	4,645.7	8,735.0	6,482.9

Financial Internal Rate of Return: 10.1%

Table 10-03 FINANCIAL INTERNAL RATE OF RETURN (2)
(PINO DE YUNA WEIR - LOS VEGANOS WEIR COMPLEX)

TASA INTERNA DE RETORNO FINANCIERO
(DERIVADORA PINO DE YUNA - DERIVADORA LOS VEGANOS)

Unit: RD$$10^3$

Year	Cost					Revenue			Surplus
	Capital/Replace. Cost (FC)	Capital/Replace. Cost (LC)	O&M Cost	Ener. Sales Cost	Total Cost	Primary Energy	Second-ary Ener.	Total Benefits	
1	876.2	976.6			1,852.8				-1,852.8
2	2,408.3	1,416.2			3,824.5				-3,824.5
3	5,180.6	3,522.4			8,703.0				-8,703.0
4	15,665.1	6,579.4			22,244.5				-22,244.5
5	5,906.1	6,605.1	60.7	515.7	13,087.6	1,069.1	1,229.4	2,290.5	-10,797.1
6	836.0	1,505.7	182.1	1,416.0	3,939.8	2,944.0	3,345.2	6,289.2	2,349.4
7-36			242.8	1,800.5	2,043.4	3,765.8	4,231.6	7,997.4	5,954.1
37	979.1		242.8	1,800.5	3,022.4	3,765.8	4,231.6	7,997.4	4,975.0
38	952.5		242.8	1,800.5	2,995.8	3,765.8	4,231.6	7,997.4	5,001.6
39	8,439.5	596.2	242.8	1,800.5	11,079.0	3,765.8	4,231.6	7,997.4	-3,080.7
40		1,172.2	242.8	1,800.5	3,215.5	3,765.8	4,231.6	7,997.4	4,781.3
41		713.7	242.8	1,800.5	2,757.0	3,765.8	4,231.6	7,997.4	5,240.[illegible]
42-50			242.8	1,800.5	2,043.3	3,765.8	4,231.6	7,997.4	5,954.1

Financial Internal Rate of Return: 10.1%

Table 10-04 REPAYMENT ANALYSIS
(EL TORITO WEIR - LOS VEGANOS WEIR COMPLEX)

ANALISIS DE CAPACIDAD DE REEMBOLSO
(DERIVADORA EL TORITO - DERIVADORA LOS VEGANOS).

Unit: $RD\$10^3$

		Income						Expenditure									
		Int'l	Government Bond/2					Const. Work				Redemption for Government Bond					
S. No.	Year	Loan for Const. Work/1	For Const. Work	For Associated Cost	For Interest	Power Revenue	Gross Income (1)	F.C. Portion	L.C. Portion	Associated Cost	Loan Repayment/3	For Interest	For Principal	O & M Cost	Gross Expenditure(2)	Surplus (1)-(2)	Cumulative Surplus
1	1984	900.4	1,012.8				1,913.2	900.4	1,012.8						1,913.2	0	0
2	1985	2,504.4	1,472.3		101.3		4,078.0	2,504.4	1,472.3			101.3			4,078.0	0	0
3	1986	5,281.5	3,632.4	1,354.2	258.6		10,526.7	5,281.5	3,632.4	1,354.2		258.6			10,526.7	0	0
4	1987	16,584.7	7,220.5	1,462.5	783.2		26,050.9	16,584.7	7,220.5	1,462.5		783.2			26,050.9	0	0
5	1988	6,691.1	7,473.2		1,729.8		15,894.1	6,691.1	7,473.2			1,729.8			15,894.1	0	0
6	1989	1,828.7	2,506.7		431.0	2,290.5	7,056.9	1,828.7	2,506.7			2,650.1		71.4	7,056.9	0	0
7	1990					6,658.0	6,658.0					2,943.9	3,499.9	214.2	6,658.0	0	0
8	1991					8,735.0	8,735.0					2,593.9	5,875.6	265.5	8,735.0	0	0
9	1992					8,735.0	8,735.0					2,006.3	6,463.2	265.5	8,735.0	0	0
10	1993					8,735.0	8,735.0					1,364.2	7,105.3	265.5	8,735.0	0	0
11	1994					8,735.0	8,735.0				2,952.4	655.6	4,861.5	265.5	8,735.0	0	0
12	1995					8,735.0	8,735.0				2,952.4	169.5	1,655.0	265.5	5,042.4	3,652.6	3,652.6
13	1996					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	9,169.7
14	1997					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	14,686.8
15	1998					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	20,203.9
16	1999					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	25,721.0
17	2000					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	31,238.1
18	2001					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	36,755.2
19	2002					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	42,272.3
20	2003					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	47,789.4
21	2004					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	53,306.5
22	2005					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	58,823.6
23	2006					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	64,340.7
24	2007					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	69,857.8
25	2008					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	75,374.9
26	2009					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	80,892.0
27	2010					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	86,409.1
28	2011					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	91,926.2
29	2012					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	97,443.3
30	2013					8,735.0	8,735.0				2,952.4			265.5	3,217.9	5,517.1	102,960.4
31	2014					8,735.0	8,735.0							265.5	265.5	8,469.5	111,429.9
32	2015					8,735.0	8,735.0							265.5	265.5	8,469.5	119,899.4
33	2016					8,735.0	8,735.0							265.5	265.5	8,469.5	128,368.9
34	2017					8,735.0	8,735.0							265.5	265.5	8,469.5	136,838.4
35	2018					8,735.0	8,735.0							265.5	265.5	8,469.5	145,307.9
36	2019					8,735.0	8,735.0							265.5	265.5	8,469.5	153,657.4
37	2020					8,735.0	8,735.0	979.1						265.5	1,244.6	7,490.4	161,227.8
38	2021					8,735.0	8,735.0	965.7						265.5	1,262.2	7,472.8	168,650.6
39	2022					8,735.0	8,735.0	8,459.4	556.2					265.5	9,281.1	-546.1	167,954.5
40	2023					8,735.0	8,735.0		1,176.3					265.5	1,451.8	7,283.2	175,227.7
41	2024					8,735.0	8,735.0		722.5					235.5	1,008.0	7,727.0	182,954.7
42	2025					8,735.0	8,735.0							265.5	265.5	8,469.5	191,424.2
43	2026					8,735.0	8,735.0							265.5	265.5	8,469.5	199,853.7
44	2027					8,735.0	8,735.0							265.5	265.5	8,469.5	208,303.2
45	2028					8,735.0	8,735.0							265.5	265.5	8,469.5	216,752.7
46	2029					8,735.0	8,735.0							265.5	265.5	8,469.5	225,292.2
47	2030					8,735.0	8,735.0							265.5	265.5	8,469.5	233,651.7
48	2031					8,735.0	8,735.0							265.5	265.5	8,469.5	242,131.2
49	2032					8,735.0	8,735.0							265.5	265.5	8,469.5	250,550.7
50	2033					8,735.0	8,735.0							265.5	265.5	8,469.5	259,000.2

/1: International Loan Interest : 3.5%/annum; Grace period : 10 years; Repayment period: 20 years

/2: Government Bonds Interest : 10%/annum; Repayment period: 15 years

/3: Repayment of Interest and principal calculated by a capital recovery factor.

Table 10-05 REPAYMENT ANALYSIS

(EL TORITO WEIR - LOS VEGANOS WEIR COMPLEX)

ANALISIS DE CAPACIDAD DE REEMBOLSO

(DERIVADORA EL TORITO - DERIVADORA LOS VEGANOS)

Unit: RD$$10^3$

S. No.	Year	Income: Int'l Loan for Const. Work/1	Income: Government Bond/2 For Const. Work	Income: Government Bond/2 For Associated Cost	Income: For Interest	Income: Power Revenue	Gross Income (1)	Expenditure: Const. Work F.C. Portion	Expenditure: Const. Work L.C. Portion	Expenditure: Associated Cost	Expenditure: Loan Repayment/3	Expenditure: Redemption for Government Bond For Interest	Expenditure: Redemption for Government Bond For Principal	O & M Cost	Gross Expenditure (2)	Surplus (1)-(2)	Cumulative Surplus
1	1984	900.4	1,012.8				1,913.2	900.4	1,012.8						1,913.2	0	0
2	1985	2,504.4	1,472.3		101.3		4,078.0	2,504.4	1,472.3			101.3			4,078.0	0	0
3	1986	5,281.5	3,632.4	1,354.2	258.6		10,526.7	5,281.5	3,632.4	1,354.2		258.6			10,526.7	0	0
4	1987	16,588.7	7,229.5	1,452.5	783.2		26,053.9	16,588.7	7,229.5	1,452.5		783.2			26,053.9	0	0
5	1988	6,691.1	7,413.2		1,729.8		15,834.1	6,691.1	7,413.2			1,729.8			15,834.1	0	0
6	1989	1,828.7	2,506.7		431.0	2,290.5	7,056.9	1,828.7	2,506.7			2,650.1		71.4	7,056.9	0	0
7	1990					6,658.0	6,658.0					2,943.9	3,459.9	254.2	6,658.0	0	0
8	1991					8,735.0	8,735.0					2,593.9	5,875.6	265.5	8,735.0	0	0
9	1992					8,735.0	8,735.0					2,008.3	6,461.2	265.5	8,735.0	0	0
10	1993					8,735.0	8,735.0					1,384.2	7,085.3	265.5	8,735.0	0	0
11	1994					8,735.0	8,735.0				5,512.7	655.6	2,301.2	265.5	8,735.0	0	0
12	1995					8,735.0	8,735.0				5,512.7	427.5	2,529.3	265.5	8,735.0	0	0
13	1996					8,735.0	8,735.0				5,512.7	176.6	1,765.0	265.5	7,783.8	951.2	951.2
14	1997					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	3,908.0
15	1998					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	6,864.8
16	1999					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	9,821.6
17	2000					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	12,778.4
18	2001					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	15,735.2
19	2002					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	18,692.0
20	2003					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	21,648.8
21	2004					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	24,605.6
22	2005					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	27,562.4
23	2006					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	30,519.2
24	2007					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	33,476.0
25	2008					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	36,432.8
26	2009					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	39,389.6
27	2010					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	42,346.4
28	2011					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	45,303.2
29	2012					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	48,260.0
30	2013					8,735.0	8,735.0				5,512.7			265.5	5,778.2	2,956.8	51,216.8
31	2014					8,735.0	8,735.0							265.5	265.5	8,469.5	59,686.3
32	2015					8,735.0	8,735.0							265.5	265.5	8,469.5	68,155.8
33	2016					8,735.0	8,735.0							265.5	265.5	8,469.5	76,625.3
34	2017					8,735.0	8,735.0							265.5	265.5	8,469.5	85,094.8
35	2018					8,735.0	8,735.0							265.5	265.5	8,469.5	93,564.3
36	2019					8,735.0	8,735.0							265.5	265.5	8,469.5	102,033.8
37	2020					8,735.0	8,735.0	979.1						265.5	1,244.6	7,490.4	109,524.2
38	2021					8,735.0	8,735.0	965.7						265.5	1,231.2	7,503.8	117,028.0
39	2022					8,735.0	8,735.0	8,439.4	556.2					265.5	9,261.1	-526.1	116,501.9
40	2023					8,735.0	8,735.0		1,176.3					265.5	1,441.8	7,293.2	123,795.1
41	2024					8,735.0	8,735.0		742.5					265.5	1,008.0	7,727.0	131,522.1
42	2025					8,735.0	8,735.0							265.5	265.5	8,469.5	139,991.6
43	2026					8,735.0	8,735.0							265.5	265.5	8,469.5	148,461.1
44	2027					8,735.0	8,735.0							265.5	265.5	8,469.5	156,930.6
45	2028					8,735.0	8,735.0							265.5	265.5	8,469.5	165,400.1
46	2029					8,735.0	8,735.0							265.5	265.5	8,469.5	173,869.6
47	2030					8,735.0	8,735.0							265.5	265.5	8,469.5	182,339.1
48	2031					8,735.0	8,735.0							265.5	265.5	8,469.5	190,808.6
49	2032					8,735.0	8,735.0							265.5	265.5	8,469.5	199,278.1
50	2033					8,735.0	8,735.0							265.5	265.5	8,469.5	207,747.6

/1: International Loan: Interest : 8.6%/annum; Grace period : 10 years; Repayment period: 20 years

/2: Government Bond: Interest : 15%/annum; Repayment period: 15 years

/3: Repayment of interest and principal calculated by a capital recovery factor.