14. ECONOMIC AND FINANCIAL EVALUATION

CONTENTS

14. Economic and Financial Evaluation

14.1 Economic Evaluation

14.1.1 Methodology

(1) Methodology

Economic evaluation aims at measuring the "economic" impact brought about to a country by implementing a project from a viewpoint of national economy. Here, a comparison of costs and benefits expressed in terms of economic prices will be made by applying the Discount Cash Flow Method, which is widely adopted for such purposes.

The basic approach for this method is as follows. First, the cash outflow (costs) and inflow (benefits) are developed on an annual basis over the project life. Secondly the amount generated during different years will be discounted to the start year of the project and expressed it as an accumulated present value at the same standard year. Then a comparison will be made between the costs and benefits. Evaluation indices to be obtained will be the Net Present Value, the Benefit/Cost Ratio, and the Economic Internal Rate of Return (EIRR). The EIRR is a discount rate at which the present values of the two cash flows become equal. This rate shows the return to be expected from the project. EIRR is expressed in the following equation:

$$\sum_{t=0}^{n} C_t / (1+r)^t - \sum_{t=0}^{n} B_t / (1+r)^t = 0\,0$$

where, Ct = Cost
Bt = Benefit
t = year
n = project life (year)
r = discount rate (= EIRR)

(2) Basic Conditions

According to the discussions with CEL, as well as in line with the existing reports for other projects in El Salvador, the following basic conditions were adopted.

- Opportunity cost of capital:

  Opportunity cost of capital refers to an interest rate at which the appropriateness of investment can be justified. A rate of 10 % was used in view of the rates used for other projects in El Salvador.

- Discount rate:

  A discount rate of 10 % will be used. This rate of 10 % is also used by the World Bank, and it has the advantage of easy comparison with the opportunity cost of capital. 8 % and 6 % were also used for sensitivity analysis.

- Conversion factor:

  Standard conversion factor of 0.9, adopted by the Inter-American Development Bank, was used to calculate the economic price of the domestic price portion.

- Service life:

  Service life of each facility, according to the experience of the Consultant, are as follows:

  - 50 years for civil works
  - 35 years for hydro-mechanical and electro-mechanical equipment
  - 30 years for transmission lines

Replacement costs of the facilities, of which service life expires during the following project life, were considered.

- Project life (Calculation period)

  Calculation period for evaluation are 53 years: 50 years of service life of civil facilities and 3 years of construction works. It is assumed that the power plant will become commercially operational in August.

- Evaluation Point

  Evaluation was made at the entrance of the 15 de Septiembre Substation to which the transmission line from El Chaparral Project is connected. It is also assumed that the alternative thermal power plant would be constructed here.

- Cost Estimate

  Estimation of cost was based on the price level of 2003.

14.1.2 Economic Costs of the Project

The economic costs of the Project were calculated from the market price as presented in the Chapter 12. Construction cost and Operation and Maintenance cost were included in the cost stream. The method of economic pricing is as follows:

Foreign portion

- Exclusion of transfer items such as taxes and subsidies (import tax, value added tax)

Local portion 2

- Exclusion of transfer items such as taxes and subsidies
- Use of market prices (applying standard conversion factor)

Import tax is generally exempted for the equipment for generation and for substations in El Salvador. The cost estimate in Chapter 12 does not include taxes; therefore, the foreign currency portion is used as the economic price without conversion.

(1) Initial Investment Costs

Initial investment costs by facility are shown in Table 14.1. The annual investment amount for major items, including the engineering and administration Cost as well as Contingency, is summarized below. (The fourth year includes the payment of retention money):

Economic cost of initial investment (Unit: 1000US$)

	Environment and land acquisision cost	Civil and preparatory works	Hydromechanical and electromechanical equipment	Transmission lines	Total Cost
1st year	12,305	11,618	4,183	455	28,561
2nd year	2,037	18,317	8,074	1,061	29,490
3rd year	2,037	33,075	14,412	1,212	50,737
4th year	2,037	9,409	8,213	303	19,962
Total	18,418	72,418	34,883	3,030	128,749

(2) Operation and Maintenance Cost

The operation and maintenance cost was calculated by multiplying the construction cost of each work item by a certain rate, which was determined according to the experiences with similar projects by the Consultant.

402

Economic cost of O&M (Unit: 1000US$)

Item	Construction Cost	Rate	Amount
Civil Works	729,418	0.5%	362
Equipment	34,883	1.5%	523
Transmission Line	3,030	1.5%	46
Total			931

14.1.3 Economic Benefit of the Project

For the purpose of this study, the following two categories of benefits conceivable for this type of projects were adopted: one is the saved cost of alternative thermal power project from a viewpoint of "with project" and "without project", and the other is income from electricity sale using a marginal cost. In addition, benefits derived from CO_2 emission trading (Certificate of Emission Rights) in accordance with the Kyoto Mechanism were estimated.

(1) Cost of Alternative Thermal Power Plants

Economic benefit can be measured from a viewpoint of "with project" and "without project". For the present case under review, instead of constructing a hydropower station, it is possible to set up a thermal power station to generate the energy with quality and quantity equivalent to the El Chaparral Project. In order to calculate the cost required for this type of alternative thermal plant, the following two-stage process were taken. First, the annual cost was studied for various power plants with different generation systems. Then, the generation plant with the least annual cost was selected for the estimation of its construction cost and O&M cost including fuel.

In light of the existing thermal power plants and the possibility of procurement of fuel in El Salvador, the following four types of thermal-based generation systems were studied to serve as a possible alternative to the planned hydropower project: Gas Turbine; Steam (coal-fired); Slow Speed Diesel; and Combined Cycle.

1) Comparison of Alternative Thermal Power Plants

Annual Cost of Alternative Thermal Power Plants

Item	Unit	Gas Turbine	Steam Coal	Slow Speed Diesel	Combined Cycle
Investment cost	$/kW	450	1,300	1,000	700
Project life	Year	15	20	20	20
Interest rate	Percent	10%	10%	10%	10%
Capital recovery factor	---	0.13147	0.11746	0.11746	0.11746
Annual cost	US$	59.2	152.7	117.5	82.2
O&M cost/kW/year	US$	11.0	69.0	25.0	44.0
Total cost/kW	$/kW	70.2	221.7	142.5	126.2

- Gas Turbine

  Investment cost: US$450/kW was adopted. This is used in the pre-F/S report (Harza, 1998) as the conservative price. "Plan Indicativo Regional de Expansión de la Generación" (CEAC, 2002) also uses US$450/kW.

  Thermal efficiency and calorific value: 11,500Btu/kWh and 0.133Btu/gallon respectively were adopted. These are taken from the conservative values in the pre-F/S report.

  Fuel cost (diesel oil): US$0.1937/litter (=US$0.73/gallon) was adopted. This is the leveled cost for the coming 15 years from 2003 through 2017 provided by CEL.

  O&M cost: US$0.0055/kWh for the variable cost was adopted. This value was taken from the Monenco-Agra report (1995). US$11/kW/year was adopted for the fixed cost. This value was taken from the CEAC report.

- Steam (Coal-fired thermal)

  Investment cost: US$1300/kW was adopted. The Pre-F/S report uses US$1400/kW as the conservative value. Values used in the CEAC reports vary between US$1200/kW to $1500/kW. Based on the experience of the Consultant with extensive experiences in coal-fired thermal power projects, a conservative but reasonable value of $1300/kW was adopted.

  Thermal efficiency and calorific value: 10,000Btu/kWh and 21.6MBtu/ton respectively were adopted. These were taken from the conservative values used in the Pre-F/S report.

  Fuel cost (coal): US$33.982/tm was adopted. This is the leveled cost for the coming 15 years from 2003 through2017 provided by CEL.

O&M cost: US$0.0036/kWh for the variable cost was adopted. This was taken from the Monenco-Agra report. US$69/kW/year was adopted for the fixed cost. This was taken from the CEAC report.

- Slow Speed Diesel

  Investment cost: US$1000/kW was adopted. This is used in the Pre-F/S report (Harza, 1998) as the very conservative price. Bahamas Electricity Corporation reports the cost of US$1333/kW (in 2002) for the diesel power plant as 30MW. Therefore, the cost of US$1000 is still considered conservative.

  Thermal efficiency and calorific value: 8200Btu/kWh and 0.133Btu/gallon respectively were adopted. These were taken from the conservative values used in the Pre-F/S report.

  Fuel cost (bunker C): US$0.1585/litter (=US$0.60/gallon) was adopted. the leveled cost for the coming 15 years from 2003 through 2017 provided by CEL.

  O&M cost: US$0.0055/kWh for the variable cost was adopted. This was taken from the Monenco-Agra report. US$25/kW/year was adopted. This was taken from the Pre-F/S report.

- Combined Cycle

  Investment cost: US$700/kW was adopted. US$800 is used in the Pre-F/S report; however, a more conservative cost of $700 was taken from the CEAC report.

  Thermal efficiency and calorific value: 8,200Btu/kWh and 0.133Btu/gallon respectively were adopted. These were taken from conservative values used in the pre-F/S report.

  Fuel cost (diesel oil): US$0.1937/litter (=US$0.73/gallon) was adopted. This is the leveled cost for the coming 15 years from 2003 through 2017 provided by CEL.

  O&M cost: US$0.0045/kWh for the variable cost was adopted. This was taken from the Monenco-Agra report. US$44/kW/year was adopted for the fixed cost. This was taken from the CEAC report.

Based on these conditions, the annual cost was calculated for each power plant and the unit generation cost at various plant utilization factors. As a result of the comparison at a utilization factor of 40%, which corresponds to that of El Chaparral Project, it was found that the plants costing least are the Slow Speed Diesel and the Steam Power Plant. Here, the Slow Speed Diesel was selected for further comparison, given the past accumulation of technology in El Salvador as well as the fuel handling.

Energy Production Cost of Alternative Thermal Power Plants

Plant	Fuel	Thermal efficiency Btu/kWh	Calorific value Mbtu/ton or Btu/gallon	Fuel cost $/ton or $/gallon	Fuel cost $/kWh	O&M cost $/kWh	Energy cost $/kWh
Gas Turbine	Diesel	11,500	0.133	0.73	0.0634	0.0055	0.0689
Steam	Coal	10,000	21.6	33.98	0.0157	0.0036	0.0193
Slow Speed Diesel	Bunker	8,200	0.133	0.60	0.0369	0.0055	0.0424
Combined Cycle	Diesel	8,200	0.133	0.73	0.0452	0.0045	0.0497

Total Energy Cost for Alternative Thermal Plants (Unit: US$/kWh)

Utilization factor	Hour per year	Gas Turbine	Steam	Slow Speed Diesel	Combined Cycle
20%	1,752	0.109	0.146	0.124	0.122
25%	2,190	0.101	0.121	0.107	0.107
30%	2,628	0.096	0.104	0.097	0.098
35%	3,066	0.092	0.092	0.089	0.091
40%	3,504	0.089	0.083	0.083	0.086
45%	3,942	0.087	0.076	0.079	0.082
50%	4,380	0.085	0.070	0.075	0.079
55%	4,818	0.083	0.065	0.072	0.076
60%	5,256	0.082	0.062	0.070	0.074
65%	5,694	0.081	0.058	0.067	0.072
70%	6,132	0.080	0.055	0.066	0.070
75%	6,570	0.080	0.053	0.064	0.069
80%	7,008	0.079	0.051	0.063	0.068

Note: The shaded parts correspond to the less energy cost.

2) Cost Estimation

Characteristics of alternative thermal plant

Item	Slow Speed Diesel
Installed capacity	46.0MW
Unit cost	US$ 1,000
Construction cost	US$ 46,000,000
Service life	20 years

The installed capacity of the alternative thermal power plant was calculated, which took into account the loss rates described in the Table 14.2, based on the effective dependable capacity of the El Chaparral Project. In this Project, due to fluctuating water discharge by season, the effective dependable capacity is very small compared to the installed capacity. Therefore, from a conservative viewpoint, which requires excessive benefits to be excluded from the estimation, the installed capacity of alternative thermal was set lower than that of the El Chaparral Project.

a) Construction Cost for Alternative Thermal Plant

The alternative thermal power plant would be constructed in 18 months, and its initial investment cost is as follows:

Construction cost of alternative thermal

Item		Slow Speed Diesel
1st year	60%	US$ 27,600,000
2nd year	40%	US$ 18,400,000
Total		US$ 46,000,000

b) O&M Cost for Alternative Thermal Plant

The annual O&M cost for the alternative thermal was estimated by the following fixed and variable costs:

O&M cost for alternative thermal

Item	Unit cost	Number	O&M cost
Fixed cost	US$ 25/kW	46,000 kW	US$ 1,150,000
Variable cost	US$ 0.0055/kWh	234,590 MWh	US$ 1,290,000
Total	---	---	US$ 2,440,000

c) Fuel Cost for Alternative Thermal Plant

The annual fuel cost for alternative thermal will be outlined below. The basic price for Bunker C is the unit cost at Acajutla Port (US$0.6/gallon). Inland transportation cost, which corresponds to five percent of the fuel price, is added to the basic price, based on the report on past projects; thus, the unit price is US$0.63/gallon.

Fuel cost

Item	Unit cost	Fuel cost
Bunker C	US$ 0.63 / gallon	US$ 9,112,000/year

(2) Power Sale Revenue

With the progress of the liberalization of the power sector in El Salvador, the power pool market, known as "UT," has been in operation since its establishment in 1998. All electric power supplies except for those contracted as bulk contracts, may be tendered and traded at the price determined by the market mechanism. The following table shows the monthly average unit cost of energy for the last five years. The average price for the entire period was US$67.65/MWh. Therefore, this average price was used as a unit energy price for power sale, and was multiplied by the annual available energy of 233.21GWh, including an energy increase of 2GWh at 15 de Septiembre Power Station. As a result, the annual income of US$ 15,776,700 was derived.

Average electricity tariff (Unit: US$/MWh)

Month / Year	2003	2002	2001	2000	1999
January	75.11	67.69	64.08	86.99	61.33
February	78.87	70.75	66.35	91.84	57.87
March	78.60	56.06	66.84	*78.60	61.94
April	78.27	64.85	72.51	*78.27	61.46
May	70.26	69.12	70.49	74.39	65.75
June	60.16	53.05	70.77	65.34	76.81
July	72.03	63.91	73.61	58.12	64.94
August	74.47	70.01	69.88	63.97	57.21
September	65.46	66.57	54.53	64.84	61.39
October	68.52	67.43	58.32	58.87	56.92
November	66.19	71.98	63.14	60.50	67.34
December	-	72.79	69.83	59.58	74.42
Average	71.63	66.18	66.70	70.11	63.95
Average monthly price for the period studied					67.65

(Source: UT)

**Note: Average tariff for March 2000 and April 2000 was 106.66 and 173.71 respectively. These values are exceptionally expensive, therefore, in order to avoid over-estimate of the average tariff, the average registered in the same months in 2003, which even represents the highest in the last five years, was applied*

(3) Benefit from CO_2 Emission Trade

The Kyoto Protocol was adopted at the Third United Nations Framework Convention on Climate Change (COP-3) held in Kyoto, Japan, in 1997. It stipulates that the parties included in Annex I shall ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases do not exceed their assigned amounts, with a view to reducing their overall emissions of such gases by at least 5 per cent below the 1990 level in the commitment period from 2008 to 2012.

The Kyoto Mechanism is a system that facilitates cost efficient global measures through a market mechanism, and it is used as a complement to domestic measures designed to attain reduction objectives. Three mechanisms are involved:

- Joint Implementation (JI),
- Clean Development Mechanism (CDM), and
- Emission Trading (ET)

Emission Trading is a system which allows the acquisition or transfer of emission volume (credit) among the Annex I countries with reduction targets for the greenhouse gasses emission volume. With this system, a country can reach its reduction target by purchasing credit from other countries. On the other hand, the country that has sold its creditneeds to face a reduction in the corresponding credit available to itself. There are four types of credit that can be obtained or transferred within the scheme of emission trading. Such transactions will be allowed starting 2008:

- Assigned Amount Unit (AAU)
- Emission Reduction Unit (ERU)
- Certified Emission Reduction (CER)
- Removal Unit (RMU)

Among these, CER is applicable to the El Chaparral Project. This is a scheme to accrue emission reduction volume in developing countries to a developed country through technical and financial assistance by the developed country to implement the project. Transactions involving CER are discussed below.

- Reduction Volume of Greenhouse Gasses Emission

In Chapter 13, it is calculated that 168,000 CO_2-ton/year of greenhouse gasses emission will be reduced by implementing the El Chaparral Project. On the other hand, the newly created reservoir will generate 18,917.4 CO_2-ton for 50 years (i.e. 378.4 tons/year). Therefore, the net reduction can be estimated as 167,621.6 CO_2 tons/year.

- Transaction Price

The emission-trading price (unit price) has eroded very much since the declaration by the United States to exit from the Kyoto Protocol. In fact, it is now traded in the range of US$2 to $3 per CO_2-ton. The price is expected to rise in the near future as the transaction system becomes more primed operationally and as the Kyoto Protocol comes into force. Here, the analysis was made using US$3 as a base price, and the sensitivity was studied for US$5 and US$10.

- Transaction Cost

The following cost is required for the transaction of the emission right:

- Cost for CDM executive board (2% for the issued CER)
- Operating cost of CEM scheme
- Application cost and monitoring cost

It is difficult to calculate the cost at this moment, since the transaction scheme has just been put into place; therefore, 5% of CER was estimated as the cost.

In light of the above, the following benefit was calculated. This benefit can be considered as the saved expenditure of foreign currency. According to the rules of CDM, the period for this credit is limited to 21 years.

Benefit of CER

Item	Case 1	Case 2	Case 3
a) Unit price	US$3	US$5	US$10
b) Reduction volume	116,000.0	116,000.0	116,000.0
c) Net captive capacity (t-CO_2)	- 801.1	- 801.1	- 801.1
d) Net reduction volume (b - c)	115,198.9	115,198.9	115,198.9
e) Credit price (a x d)	$ 345,596.7	$ 575,994.5	$ 1,151,989.0
f) Transaction cost (e x 5%)	$ 17,279.8	$ 28,799.7	$ 57,599.5
g) Benefit (e – f)	$ 328,316.9	$ 547,194.8	$ 1,094,389.6

14.1.4 Economic Evaluation

The total present value of the economic cost during the initial year of the project amounts to US$109,614,000 (with a discount rate of 10%; the same will be applied to the following calculations). The total present value of the economic benefit with the alternative thermal is US$120,294,000. The net present value (B-C) is calculated as US$10,680,000, and the benefit cost

410

ratio (B/C) was 1.12. The economic internal rate of return (EIRR) was calculated as 11.0%. (See Table 14.3 for details.)

On the other hand, the total present value of the economic benefit with the power sale revenue is US$111,237,000. The net present value (B-C) was calculated as US$1,623,000, and the benefit cost ratio (B/C) came out to be 1.01. The economic internal rate of return (EIRR) has been worked out to be 10.2%. (See Table 14.4 for details.)

Evaluation indices like the Net Present Value (B-C) and Benefit Cost Ratio (B/C) at various discount rates, as well as EIRR are summarized below (see Appendix 14.1):

Result of evaluation

	Benefit		Criteria	Discount rate
	Alternative thermal	Power sales		
NPV	72,822	74,637	> 0	6 %
	34,388	29,323	> 0	8 %
	10,680	1,623	> 0	10 %
B/C	1.57	1.59	> 1	6 %
	1.29	1.25	> 1	8 %
	1.10	1.01	> 1	10 %
EIRR	11.3%	10.2%	> costo de oportunidad de capital	

If the value exceeds the criteria, it is judged to be feasible. It was found that the evaluation indices using the power sale revenue as benefit became lower than those with the alternative thermal. Notwithstanding, all evaluation indices, including those with lower values, still exceed the evaluation criteria, and the Project can be judged as sound from the economic point of view.

It is obvious, however, that the economic values will be lower than the evaluation criteria when the sensitivity analysis is conducted for more inferior conditions. Generally speaking, a low EIRR does not necessarily lead to the rejection of the project, because the EIRR that falls short of the opportunity cost of capital by a few percentage points still remains within the range that is considered only as "questionable". Results of the sensitivity analysis for inferior conditions fall in this range. In the event that an executive agency decides to implement the project despite this risk, a political judgment, in which the difference with the opportunity cost of capital is viewed as a cost (subsidy) to encourage the development of clean energy and/or rural development, will be required.

The results of calculation that factored in the emission trading of CDM are as follows (see Appendix 14.1 for details):

Result of evaluation with CER

	Benefit		Criteria	Unit price
	Alternative thermal	Power sales		
NPV (i = 10%)	12,713	3,656	> 0	US$3
	14,069	5,011	> 0	US$5
	17,457	8,399	> 0	US$10
B/C (i = 10%)	1.12	1.03	> 1	US$3
	1.13	1.05	> 1	US$5
	1.16	1.08	> 1	US$10
EIRR	11.6%	10.3%	> OCC	US$3
	11.7%	10.5%	> OCC	US$5
	12.1%	10.8%	> OCC	US$10

Since the unit price of emission right has remained depressed, the utilization of this system has little effect on the results of the evaluation. However, when the unit price goes up beyond US$10, it will have a favorable effect on the project.

14.1.5 Sensitivity Analysis

The sensitivity of economic evaluation indices was analyzed for cases with different basic conditions. A discount rate of 10% was used for this analysis.

- Benefit 1 (Alternative thermal)

The following assumptions were made using alternative thermal cost as benefit:

1) 10% decrease in alternative thermal cost
2) 10% decrease in construction cost
3) 10% decrease in alternative thermal cost and 10% reduction in construction cost
4) 10% increase in alternative thermal cost
5) 10% decrease in construction cost

Sensitivity analysis (1)

Item	NPV	B/C	EIRR
Case 1	-1,349	0.99	9.8 %
Case 2	-281	1.00	10.0 %
Case 3	-12,310	0.90	8.7 %
Case 4	22,710	1.21	12.8 %
Case 5	21,642	1.22	13.0 %

- Benefit 2 (Power sale revenue)

The following assumptions were made:

1) 10% decrease in annual available energy
2) 10% increase in construction cost
3) 10% decrease in annual available energy and 10% increase in construction cost
4) 10% increase in annual available energy
5) 10% decrease in construction cost

Sensitivity analysis (2)

Item	NPV	B/C	EIRR
Case 1	- 13,944	0.87	8.7 %
Case 2	- 13,619	0.89	8.8 %
Case 3	- 24,249	0.80	7.9 %
Case 4	7,316	1.07	10.7 %
Case 5	6,991	1.07	10.7 %

14.2 Financial Evaluation

14.2.1 Methodology

Financial analysis aims at measuring the expected return on investment from a viewpoint of an implementing body. Here, the Discounted Cash Flow method was adopted. The basic approach for this method is as follows. First, the cash outflow (costs) and inflow (benefits) are developed on an annual basis over the project life. Secondly the amount generated during different years will be discounted to the start year of the project and expressed it as an accumulated present value at the same standard year. Then a comparison will be made between the costs and benefits. The evaluation index to be obtained is the Financial Internal Rate of Return (FIRR) on investment.

413

FIRR on investment is not affected by financing conditions; therefore, it is appropriate to evaluate the profitability of the project itself.

14.2.2 Financial Cost and Benefit of the Project

(1) Financial Cost

The financial cost of the Project includes the initial investment cost, the cost for replacement of equipment, and operation and maintenance cost expressed in terms of the market price. The initial investment and the replacement cost were taken from the cost estimation in Chapter 12.

1) Initial investmet

Financial construction cost (Unit: 1000 US$)

	Environment and land acquisition cost	Civil and preparatory works	Hidromechanical/ electromechanical equipment	Transmission Line	Total Cost
1st year	13,431	12,432	4,244	468	30,574
2nd year	2,133	19,463	8,205	1,091	30,892
3rd year	2,133	35,090	14,632	1,247	53,102
4th year	2,133	9,997	8,326	312	20,769
Total	19,830	76,982	35,407	3,117	135,336

2) Operation and Maintenance Cost

The operation and maintenance cost was calculated by multiplying the construction cost of each work item by a certain rate, which was determined according to the experiences with similar projects by the Consultant:

Financial O&M cost (Unit: 1000US$)

Item	Construction Cost	Rate	Amount
Civil Works	76,982	0.5 %	385
Equipment	35,407	1.5 %	531
Transmission Line	3,117	1.5 %	47
Total			963

The O&M cost was calculated by multiplying the initial investment by certain rate according to the experience of the Consultant.

414

(2) Financial Benefit

The financial benefit of the Project is the revenue to be earned by the electricity sale. The Commercialization Unit and Study Department of CEL elaborated a report entitled "Proyecciones de Generación e ingresos corrientes de la Central Hidroeléctrica El Chaparral, Período 2009-2024", using the optimization model of SDDP. According to this report, the annual salable energy is calculated as 180.2GWh, and the annual average sale price is US$58.08/MWh. Here, the annual revenue was calculated as US$10,466,000 based on these values.

14.2.3 Financial Evaluation

The Financial Internal Rate of Return (FIRR) on investment was calculated based on the financial revenue. (See Table 14.5). The results are shown below. It was found that softer loan conditions are required to implement the project.

Result of evaluation

Item	Result	Criteria
FIRR	6.4 %	> interest rate

14.2.4 Sensitivity Analysis

Sensitivity was analyzed for the cases with different basic conditions. Benefit from emission trading scheme was also considered. For the analysis, a discount rate of 10% is used.

1) 10 decrease in annual available energy
2) 10% increase in construction cost
3) 10% decrease in annual available energy and 10% increase in construction cost
4) 10% increase in annual available energy
5) 10% increase in annual available energy and 10% increase in construction cost
6) Use of emission trading scheme with a unit price of US$3
7) Use of emission trading scheme with a unit price of US$5
8) Use of emission trading scheme with a unit price of US$10

Sensitivity analysis

Case	1	2	3	4	5	6	7	8
FIRR	5.7 %	5.8 %	5.1 %	7.1 %	6.4 %	6.6 %	6.7 %	7.0 %

Results of the analysis show that FIRR varies around the 5%-to-7% range: therefore, there is no item that presents particular sensitivity to a change in conditions.

415

14.3 Cash Flow Analysis

In this section, a cashflow analysis was conducted based on different financing scenarios. Additionally, the IRR for the cashflow was calculated.

14.3.1 Financial Repayment Plans

In order to implement the El Chaparral Project, the following three cases were considered:

1) Borrowing from commercial banks
2) Borrowing from international financing institutes such as the World Bank
3) Borrowing from bilateral financial cooperation

- Basic Conditions (applicable to all cases)
  1) Price level: As of 2003
  2) Annual energy sale: 180.2GWh*)
  3) Average sales price: US&58.08/MWh*)

  *) *Commercialization Unit and Study Department of CEL elaborated a report "Proyecciones de Generación e ingresos corrientes de la Central Hidroeléctrica El Chaparral, Período 2009-2024", using the optimization model of SDDP. According to this report, annual salable energy was calculated as 180.2GWh, and the average sale price is US$58.08/MWh. Here, calculation was made based on these values.*

  4) O&M cost: US$820,000/year
  5) Depreciation: Straight-line method. Life year is 50 years for civil facilities; 30 years for electromechanical and hydromechanical equipment, and 35 years for transmission line.

	Life year	Cost	Contingency	Total	Annual
Civil works	50 years	57,114	5,711	62,825	1,257
Hydromechanical Equip	35 years	11,720	586	12,306	352
EléctriOmechanical Eqp.	35 years	17,786	899	18,675	534
Transmission Lines	30 years	2,597	130	2,727	91

  6) Related payment: UT: US$0.27/MWh; SIGET: US$0.40/MWh; ETESAL: US$2.77 /MWh (Source: CEL Memorandum 24/09/2003)
  7) Calculation period: 30 years from commissioning, considering shorter life years of the transmission line.
  8) General expenses: The expenses are calculated in proportion to the Ateos Project.
  9) Financing conditions: The condition is assumed as follows:

Financing conditions

	Case A Comm. Bank	Case B Int'l Financing	Case C Bilateral loan
(1) Interest rate	8 %	6 %	1.5%
(2) Commitment fee	0.75 %	0.75%	0.75%
(3) Loan period	10 years	15 years	25 years
(4) Repayment period	7 years	12 years	18 years
(5) Grace period	3 years	3 years	7 years
(6) Debt/Capital	70/30	70/30	70/30

Calculation was made based on the above-mentioned conditions.

Result of evaluation

Item	Unit price US$/MWh	Energy GWh	Case A		Case B		Case C	
			IRR	Accum. MUS$	IRR	Accum. MUS$	IRR	Accum. MUS$
Base case	58.08	180.6	3.4 %	68.28	3.4 %	65.34	2.9 %	86.46

Following tables are shown in Appendix 14.2-14.4. (1) Calendar of annual disbursements for debt service; (2) Statement of results; (3) Source and use of funds; (4) Annual projected balance; (5) IRR after financial cost; (6) IRR before financial cost; (7) Sensitivity analysis, all for the basic case. Generally debt service is made by CEL biannually, but here annual debt service is applied for simplicity.

14.3.2 Sensitivity Analysis

Sensitivity was analyzed for the cases with different basic conditions. Analyzed items are shown below:

(1) 10% increase in energy sale price
(2) Average sale price of US$70.11
(3) 10% increase in construction cost
(4) 10% decrease in construction cost
(5) Salable energy is annual available energy
(6) Salable energy is annual available energy and average sale price

47

Sensitivity Analysis

	Item	Unit price US$/MWh	Energy GWh	Case A		Case B		Case C	
				IRR	Accum. MUS$	IRR	Accum. MUS$	IRR	Accum. MUS$
0	Base case	58.08	180.6	3.4 %	68.28	3.4 %	65.34	2.9 %	86.46
1	10% increase in energy price	63.89	180.6	4.2 %	91.75	4.2 %	88.60	3.7 %	109.66
2	Average energy price	67.65	180.6	4.7 %	106.94	4.7 %	103.65	4.2 %	124.68
3	10% increase in construction cost	58.08	180.6	2.7 %	55.06	2.7 %	51.93	2.2 %	75.08
4	10% decrease in construction cost	58.08	180.6	4.2 %	81.50	4.2 %	78.75	3.6 %	97.59
5	Annual available energy	58.08	231.2	5.5 %	130.75	5.4 %	126.63	4.9 %	148.07
6	Annual available energy and average price	67.65	231.2	7.1 %	180.35	6.9 %	175.67	6.3 %	197.27

Note: IRR was calculated for the cashflow before financial payment. Accumulation refers to the accumulated cashflow amount at the 30th year.

14.3.3 Results of Analysis

IRR for each case is not very sensitive to the items analyzed. The amount of accumulated cash flow for the base case remains in the red for 30 consecutive years for Case A, turns into black in the 30th year for Case B, and turns into black in the 13th year for Case C. The unsatisfactory results derived from the cashflow analysis may be attrributable a larger investment cost due to great seasonal fluctuations in water discharge by the Torola river, as well as to the introduction of less expensive power supplies with the completion of the region-wide power interconnection through the SIEPAC arrangements expected in the near future. This situation makes it difficult for the private sector to implement this project. On the other hand, if the project is developed by CEL, it is essential for it to seek softer loan terms to secure a sufficient annual cashflow.

Tabla 14.1 Initial Investment Cost (Economic Cost)

(Unit: US$1000)

Year		1	2	3	4	Total
1. Preparatory works	FC	313	89	0	45	447
	LC	2,535	725	0	362	3,622
Civil works	FC	2,661	5,731	10,962	2,949	22,303
	LC	3,739	8,051	15,399	4,142	31,330
Engineering and administration	FC	1,019	1,596	2,877	820	6,313
	LC	425	666	1,200	342	2,633
Contingency	FC	297	582	1,096	299	2,275
	LC	627	878	1,540	450	3,495
Total	FC	4,291	7,998	14,936	4,112	31,338
	LC	7,327	10,318	18,139	5,296	41,080
	Total	11,618	18,317	33,075	9,409	72,418
2. Hydromechanical equipment	FC	1,582	551	3,771	4,644	10,548
	LC	158	55	377	464	1,055
Engineering and administration	FC	180	63	429	529	1,201
	LC	75	26	179	221	501
Contingency	FC	79	28	189	232	527
	LC	7.9	2.8	18.9	23.2	53
Total	FC	1,842	642	4,389	5,405	12,277
	LC	241	84	575	708	1,609
	Total	2,083	726	4,964	6,113	13,885
3. Electromechanical equipment	FC	1,530	5,354	6,883	1,530	15,296
	LC	224	784	1,008	224	2,241
Engineering and administration	FC	182	638	820	182	1,823
	LC	76	266	342	76	760
Contingency	FC	76	268	344	76	765
	LC	11	39	50	11	112
Total	FC	1,788	6,259	8,048	1,788	17,884
	LC	311	1,090	1,401	311	3,113
	Total	2,100	7,349	9,449	2,100	20,997
4. Transmission line	FC	284	663	758	190	1,895
	LC	95	221	253	63	632
Engineering and administration	FC	40	93	107	27	266
	LC	17	39	44	11	111
Contingency	FC	14	33	38	9	95
	LC	5	11	13	3	32
Total	FC	338	790	902	226	2,256
	LC	116	271	310	77	775
	Total	455	1,061	1,212	303	3,030
5. Environmental measures	FC	986	986	986	986	3,942
	LC	783	783	783	783	3,130
Engineering and administration	FC	190	190	190	190	760
	LC	79	79	79	79	317
Total	FC	1,176	1,176	1,176	1,176	4,702
	LC	862	862	862	862	3,447
	Total	2,037	2,037	2,037	2,037	8,150
6. Land acquisition and resettlement	FC	0	0	0	0	0
	LC	8,841	0	0	0	8,841
Engineering and administration	FC	1,007	0	0	0	1,007
	LC	420	0	0	0	420
Total	FC	1,007	0	0	0	1,007
	LC	9,261	0	0	0	9,261
	Total	10,268	0	0	0	10,268
7. Total Construction Cost	FC	9,245	16,674	29,260	12,517	67,696
	LC	17,619	12,546	21,208	7,176	58,549
	Total	28,561	29,490	50,737	19,962	128,749
Conversion factor for LC:	0.9					

Tabla 14.2 Alternative Thermal Power Plant for Evaluating Economic Justification

Item	Unit	Slow Speed Diesel		El Chaparral	
				Principal	Sub
Installed Capacity	MW	46.0		64.4	1.3
Dependable Capacity	MW	46.0		38.4	
Losses	%	21.3%		5.8%	
Effective Dependable Capacity	MW	36.2		36.2	
Annual Energy Production	MWh	234,590		(total)	233,210
				Principal	220,610
				Sub	10,600
				15 Sept.	2,000
Losses		kW	kWh	kW	kWh
Station use	%	5.0%	5.0%	0.3%	0.3%
Forced outage	%	10.0%	-	0.3%	0.3%
Scheduled outage	%	8.0%	-	2.0%	2.0%
Transmission	%	0.0%	0.0%	3.3%	1.9%
Annual Available Energy	MWh	222,860		222,860	
Service Life	year	20		50 (civil)	
				30 / 35 (equipment)	
Thermal efficiency	Btu	8,200 /kWh		-	
Calorific value	Btu	0.133 /gallon			
Unit cost of fuel	US$	0.63 /gallon		-	
Unit construction cost	US$/kW	1,000		-	
Construction cost	1000US$	45,985		-	
Variable O&M cost	US$	0.0055 /kWh		-	
Fixed O&M cost	US$	25 /kW/year			
Annual O&M cost	1000US$	2,440		-	
Annual variable O&M cost	1000US$	1,290			
Annual fixed O&M cost	1000US$	1,150			
Annual fuel cost	1000US$	9,112		-	

Table 14.3 Economic Evaluaation

El Chaparral Project

Installed capacity	65.7	MW		
Dependable capacity	38.4	MW		
Energy generation	233,210	MWh		
Construction cost	128,749	1000US$	100%	128,749

Discount rate: 10%

Alternative thermal plant

Installed capacity	46.0	MW		
Investment cost	46,000	1000US$	100%	44,200
Fuel price	0.63	US$/galo	100%	0.63

CO$_2$ credit (CER price): 0 US$/CO$_2$ton

NPV	10,680
EIRR	11.3%
B / C	1.10

(unidad: US$1000)

No.		Year	EL CHAPARRAL PROJECT				BENEFIT									(B) - (C)
						(C)	CO$_2$ CREDIT				ALTERNATIVE THERMAL				(B)	
			Construction Cost	Transmission Line	O&M Cost	TOTAL COST	Benefit Volume	Cost	CER Price US$/ton	Subtotal	Construct. Cost	O&M Cost	Fuel Cost	Subtotal	TOTAL BENEFIT	
1		2007	28,106	455		28,561				0				0	0	-28,561
2		2008	28,429	1,061		29,489				0	0			0	0	-29,489
3		2009	49,524	1,212		50,737				0	27,600			27,600	27,600	-23,137
4	1	2010	19,659	303	388	20,350	48,000	-2,400	0.000	0	18,400	1,017	3,797	23,213	23,213	2,863
5	2	2011			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
6	3	2012			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
7	4	2013			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
8	5	2014			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
9	6	2015			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
10	7	2016			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
11	8	2017			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
12	9	2018			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
13	10	2019			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
14	11	2020			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
15	12	2021			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
16	13	2022			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
17	14	2023			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
18	15	2024			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
19	16	2025			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
20	17	2026			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
21	18	2027			931	931	115,199	-5,760	0.000	0		2,440	9,112	11,552	11,552	10,621
22	19	2028			931	931	115,199	-5,760	0.000	0	0	2,440	9,112	11,552	11,552	10,621
23	20	2029			931	931	115,199	-5,760	0.000	0	27,600	2,440	9,112	39,152	39,152	38,221
24	21	2030			931	931	115,199	-5,760	0.000	0	18,400	2,440	9,112	29,952	29,952	29,021
25	22	2031			931	931	67,199	-960	0.000	0		2,440	9,112	11,552	11,552	10,621
26	23	2032			931	931				0		2,440	9,112	11,552	11,552	10,621
27	24	2033			931	931				0		2,440	9,112	11,552	11,552	10,621
28	25	2034			931	931				0		2,440	9,112	11,552	11,552	10,621
29	26	2035			931	931				0		2,440	9,112	11,552	11,552	10,621
30	27	2036			931	931				0		2,440	9,112	11,552	11,552	10,621
31	28	2037		455	931	1,385				0		2,440	9,112	11,552	11,552	10,167
32	29	2038		1,061	931	1,991				0		2,440	9,112	11,552	11,552	9,561
33	30	2039		1,212	931	2,143				0		2,440	9,112	11,552	11,552	9,409
34	31	2040		303	931	1,234				0		2,440	9,112	11,552	11,552	10,318
35	32	2041			931	931				0		2,440	9,112	11,552	11,552	10,621
36	33	2042	4,183		931	5,113				0		2,440	9,112	11,552	11,552	6,439
37	34	2043	8,075		931	9,005				0		2,440	9,112	11,552	11,552	2,547
38	35	2044	14,412		931	15,343				0		2,440	9,112	11,552	11,552	-3,791
39	36	2045	8,213		931	9,144				0		2,440	9,112	11,552	11,552	2,408
40	37	2046			931	931				0		2,440	9,112	11,552	11,552	10,621
41	38	2047			931	931				0		2,440	9,112	11,552	11,552	10,621
42	39	2048			931	931				0	0	2,440	9,112	11,552	11,552	10,621
43	40	2049			931	931				0	27,600	2,440	9,112	39,152	39,152	38,221
44	41	2050			931	931				0	18,400	2,440	9,112	29,952	29,952	29,021
45	42	2051			931	931				0		2,440	9,112	11,552	11,552	10,621
46	43	2052			931	931				0		2,440	9,112	11,552	11,552	10,621
47	44	2053			931	931				0		2,440	9,112	11,552	11,552	10,621
48	45	2054			931	931				0		2,440	9,112	11,552	11,552	10,621
49	46	2055			931	931				0		2,440	9,112	11,552	11,552	10,621
50	47	2056			931	931				0		2,440	9,112	11,552	11,552	10,621
51	48	2057			931	931				0		2,440	9,112	11,552	11,552	10,621
52	49	2058			931	931				0		2,440	9,112	11,552	11,552	10,621
53	50	2059	-19,933	-1,010	931	-20,012				0	-23,000	2,440	9,112	-11,448	-11,448	8,564
TOTAL			140,668	5,051	45,996	191,715	#######	-118,559	0	0	115,000	120,589	450,283	685,872	685,872	494,157
Present Value i = 10%					PV (Cost):	109,614								PV (Benefit):	120,294	10,680
															NPV	10,680
															EIRR	11.3%
															B / C	1.10

Note: The 53rd year corresponds to the residual price of the works and equipment.

421

Table 14.4 Economic Evaluation (2)

El Chaparral Project
Installed capacity 65.7 MW
Dependable capacity 38.4 MW
Energy generation 233,210 MWh 100% 233,210
Construction cost 128,749 1000US$ 100% 128,749

Discount rate: 10%

Average tariff
Salable energy 233.2 MWh
Energy cost 67.65 US$/MWh

CO_2 credit (CER price):
0 US$/$CO_2$ton

NPV	1,623
EIRR	10.2%
B / C	1.01

(Unit: US$1000)

No.		Year	EL CHAPARRAL PROJECT				BENEFIT								(B) - (C)
						(C)	CO_2 CREDIT				ENERGY SALES			(B)	
			Construction Cost	Transmission Line	O&M Cost	TOTAL COST	Benefit Volume	Cost	CER Price US$/ton	Subtotal	Salable Energy	Unit Price	Subtotal	TOTAL BENEFIT	
1		2007	28,106	455		28,561				0			0	0	-28,561
2		2008	28,429	1,061		29,489				0			0	0	-29,489
3		2009	49,524	1,212		50,737				0			0	0	-50,737
4	1	2010	19,659	303	388	20,350	48,000	-2,400	0.000	0	97,171	0.06765	6,574	6,574	-13,777
5	2	2011			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
6	3	2012			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
7	4	2013			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
8	5	2014			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
9	6	2015			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
10	7	2016			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
11	8	2017			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
12	9	2018			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
13	10	2019			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
14	11	2020			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
15	12	2021			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
16	13	2022			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
17	14	2023			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
18	15	2024			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
19	16	2025			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
20	17	2026			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
21	18	2027			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
22	19	2028			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
23	20	2029			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
24	21	2030			931	931	115,199	-5,760	0.000	0	233,210	0.06765	15,777	15,777	14,846
25	22	2031			931	931	67,199	-960	0.000	0	233,210	0.06765	15,777	15,777	14,846
26	23	2032			931	931				0	233,210	0.06765	15,777	15,777	14,846
27	24	2033			931	931				0	233,210	0.06765	15,777	15,777	14,846
28	25	2034			931	931				0	233,210	0.06765	15,777	15,777	14,846
29	26	2035			931	931				0	233,210	0.06765	15,777	15,777	14,846
30	27	2036			931	931				0	233,210	0.06765	15,777	15,777	14,846
31	28	2037		455	931	1,385				0	233,210	0.06765	15,777	15,777	14,391
32	29	2038		1,061	931	1,991				0	233,210	0.06765	15,777	15,777	13,785
33	30	2039		1,212	931	2,143				0	233,210	0.06765	15,777	15,777	13,634
34	31	2040		303	931	1,234				0	233,210	0.06765	15,777	15,777	14,543
35	32	2041			931	931				0	233,210	0.06765	15,777	15,777	14,846
36	33	2042	4,183		931	5,113				0	233,210	0.06765	15,777	15,777	10,663
37	34	2043	8,075		931	9,005				0	233,210	0.06765	15,777	15,777	6,771
38	35	2044	14,412		931	15,343				0	233,210	0.06765	15,777	15,777	434
39	36	2045	8,213		931	9,144				0	233,210	0.06765	15,777	15,777	6,633
40	37	2046			931	931				0	233,210	0.06765	15,777	15,777	14,846
41	38	2047			931	931				0	233,210	0.06765	15,777	15,777	14,846
42	39	2048			931	931				0	233,210	0.06765	15,777	15,777	14,846
43	40	2049			931	931				0	233,210	0.06765	15,777	15,777	14,846
44	41	2050			931	931				0	233,210	0.06765	15,777	15,777	14,846
45	42	2051			931	931				0	233,210	0.06765	15,777	15,777	14,846
46	43	2052			931	931				0	233,210	0.06765	15,777	15,777	14,846
47	44	2053			931	931				0	233,210	0.06765	15,777	15,777	14,846
48	45	2054			931	931				0	233,210	0.06765	15,777	15,777	14,846
49	46	2055			931	931				0	233,210	0.06765	15,777	15,777	14,846
50	47	2056			931	931				0	233,210	0.06765	15,777	15,777	14,846
51	48	2057			931	931				0	233,210	0.06765	15,777	15,777	14,846
52	49	2058			931	931				0	233,210	0.06765	15,777	15,777	14,846
53	50	2059	-19,933	-1,010	931	-20,012				0	233,210	0.06765	15,777	15,777	35,789
TOTAL			140,668	5,051	45,996	191,715	#######	-118,559	0	0			779,630	779,630	587,915
Present Value i = 10%					PV (Cost):	109,614							PV (Benefit):	111,237	1,623
														NPV	1,623
														EIRR	10.2%
														B / C	1.01

Note: The 53rd year corresponds to the residual price of the works and equipment.

422

Table 14.5 Financial Evaluation

El Chaparral Project
Installed capacity 65.7 MW
Dependable capacity 38.4 MW
Energy generation 180,200 MWh 100% 180,200
Construction cost 135,336 1000US$ 100% 135,336

Discount rate: 10%

Average tariff
Salable energy 180,200 MWh
Energy cost 58.08 US$/MWh

CO_2 credit (CER price):
0 US$/$CO_2$ton

FIRR	6.4%

(Unit: US$1000)

No.		Year	EL CHAPARRAL PROJECT				BENEFICIO					(B) - (C)
			Construct. Cost	Transm. Line	O&M Cost	(C) TOTAL COST	Salable Energy MWh	Sales Revenue Energía	Reduced CO_2 Emission	CER Transaction	(B) TOTAL BENEFIT	
1		2007	30,106	468	0	30,574						-30,574
2		2008	29,801	1,091	0	30,892						-30,892
3		2009	51,855	1,247	0	53,102						-53,102
4	1	2010	20,457	312	401	21,170	75,083	4,361	45,600	0	4,361	-16,809
5	2	2011			963	963	180,200	10,466	109,439	0	10,466	9,503
6	3	2012			963	963	180,200	10,466	109,439	0	10,466	9,503
7	4	2013			963	963	180,200	10,466	109,439	0	10,466	9,503
8	5	2014			963	963	180,200	10,466	109,439	0	10,466	9,503
9	6	2015			963	963	180,200	10,466	109,439	0	10,466	9,503
10	7	2016			963	963	180,200	10,466	109,439	0	10,466	9,503
11	8	2017			963	963	180,200	10,466	109,439	0	10,466	9,503
12	9	2018			963	963	180,200	10,466	109,439	0	10,466	9,503
13	10	2019			963	963	180,200	10,466	109,439	0	10,466	9,503
14	11	2020			963	963	180,200	10,466	109,439	0	10,466	9,503
15	12	2021			963	963	180,200	10,466	109,439	0	10,466	9,503
16	13	2022			963	963	180,200	10,466	109,439	0	10,466	9,503
17	14	2023			963	963	180,200	10,466	109,439	0	10,466	9,503
18	15	2024			963	963	180,200	10,466	109,439	0	10,466	9,503
19	16	2025			963	963	180,200	10,466	109,439	0	10,466	9,503
20	17	2026			963	963	180,200	10,466	109,439	0	10,466	9,503
21	18	2027			963	963	180,200	10,466	109,439	0	10,466	9,503
22	19	2028			963	963	180,200	10,466	109,439	0	10,466	9,503
23	20	2029			963	963	180,200	10,466	109,439	0	10,466	9,503
24	21	2030			963	963	180,200	10,466	109,439	0	10,466	9,503
25	22	2031			963	963	180,200	10,466	66,239	0	10,466	9,503
26	23	2032			963	963	180,200	10,466			10,466	9,503
27	24	2033			963	963	180,200	10,466			10,466	9,503
28	25	2034			963	963	180,200	10,466			10,466	9,503
29	26	2035			963	963	180,200	10,466			10,466	9,503
30	27	2036			963	963	180,200	10,466			10,466	9,503
31	28	2037		468	963	1,430	180,200	10,466			10,466	9,036
32	29	2038		1,091	963	2,054	180,200	10,466			10,466	8,412
33	30	2039		1,247	963	2,209	180,200	10,466			10,466	8,257
34	31	2040		312	963	1,274	180,200	10,466			10,466	9,192
35	32	2041			963	963	180,200	10,466			10,466	9,503
36	33	2042	4,244		963	5,207	180,200	10,466			10,466	5,259
37	34	2043	8,205		963	9,168	180,200	10,466			10,466	1,298
38	35	2044	14,632		963	15,595	180,200	10,466			10,466	-5,129
39	36	2045	8,326		963	9,289	180,200	10,466			10,466	1,177
40	37	2046			963	963	180,200	10,466			10,466	9,503
41	38	2047			963	963	180,200	10,466			10,466	9,503
42	39	2048			963	963	180,200	10,466			10,466	9,503
43	40	2049			963	963	180,200	10,466			10,466	9,503
44	41	2050			963	963	180,200	10,466			10,466	9,503
45	42	2051			963	963	180,200	10,466			10,466	9,503
46	43	2052			963	963	180,200	10,466			10,466	9,503
47	44	2053			963	963	180,200	10,466			10,466	9,503
48	45	2054			963	963	180,200	10,466			10,466	9,503
49	46	2055			963	963	180,200	10,466			10,466	9,503
50	47	2056			963	963	180,200	10,466			10,466	9,503
51	48	2057			963	963	180,200	10,466			10,466	9,503
52	49	2058			963	963	180,200	10,466			10,466	9,503
53	50	2059	-20,233	-1,039	963	-20,309	180,200	10,466			190,666	200,509
TOTAL			147,394	5,194	47,577	200,165	8,904,883	517,196	2,300,620	0	697,396	8,704,718
											FIRR	6.4%

Note: The 53rd year corresponds to the residual price of the works and equipment.

423'

15. ADDITIONAL INVESTIGATION

CONTENTS

426 (4272)

15. ADDITIONAL INVESTIGATION

In order to promote this project to the definite design stage, more detailed information is required on topographical, geological and geotechnical conditions of various civil structure sites proposed in the feasibility design. This chapter presents additional investigation works to be conducted.

15.1 Topographical Survey

Additional topographical survey for definite design is shown in Table 15.1.

Table. 15.1 Additional Topographical Survey Works

Site	Survey Method	Scale of Map	Remarks
Dam Power house	Topographical surveying	1/500	Includes diversion tunnel
Disposal area Temporary facility yard Access road Construction camp	Mapping by aero photograph	1/1,000	Permanent and temporary access roads
Roads around reservoir	Mapping by aero photograph	1/5,000	Includes a part of the reservoir area

15.2 Geological Investigation

(1) Dam site and its vicinity

The geological information necessary for DD and the suitable investigation method are as follows.

1) Geological structure

The strata at the dam site and its vicinity inclines gently toward the left bank. The continuity and the weathering degree of the intercalated tuff should be clarified in order to evaluate the stability of the foundation rock. The width and the material of fault along the river should be confirmed for the design of the foundation treatment.

Geological mapping and core boring are recommended.

2) Physical property and rockmass classification of the foundation rock

Based on the physical property and the rockmass classification, a stability analysis of the dam foundation will be conducted, as it is necessary to determine the excavation line of the dam foundation.

428

Core boring, adit and in-situ rock test are recommended.

3) Permeability of the rock seated at the depth below the riverbed

Permeability of the rock up to a depth equivalent to the height of the dam is necessary in determining the depth of the grout curtain.

Long core boring and the Lugeon test are recommended.

4) The thickness of weathering and permeability of the ridge on the right bank

The thickness of the strongly weathered layer is necessary in the evaluation of the stability of the ridge and slope after the impounding of the reservoir. The permeability of the underlying rock is necessary in determining the length and depth of the grout curtain.

5) Groundwater level on the mountain side

The groundwater level for the area further away from the point of dillholes surveyed for the FS and more toward the mountain side is necessary in the study of hydrogeology, which will indicate the area of the grout curtain.

6) Slope stability

The state and the depth of the weathered layer of the slope of the dam site on the right bank affects its stability after the impounding of the reservoir. Core boring is recommended. The high cut slope of the power station site requires information on the underlying rockmass in the evaluation of its stability and selection of suitable protection. Core boring is also recommended.

The location of additional investigation for DD are shown in Fig.15.1 and Fig.15.2. The quantity and purpose of each investigation is shown in Table 15.2.

Table 15.2 Additional Geological Investigation for DD at Dam Site and its Vicinity

Core boring and permeability test

Name of Core boring	CD-1	CD-2	CD-3	CD-4	CD-5	CD-6	CD-7	CD-8	CD-9	CD-10	CD-11	CD-12	CD-13	**Total**
Length (m)	100	30	100	100	70	100	100	100	100	30	30	50	70	**980**
Main purposes														
Geological structure	yes		yes	yes	yes	yes	yes	yes	yes			yes	yes	
Excavation line		yes	yes	yes		yes	yes			yes	yes			
Permeability at deeper portion			yes	yes	yes	yes	yes							
Permeability and depth of weathered zone on the right bank								yes						
Ground water level	yes		yes			yes	yes	yes	yes					
Slope stability												yes	yes	
Remarkes					Inclined 60 deg.								At power station site	
Permeability test (section)			18	18	18	18	18	18						**108**

Adit

Name of Adit	CA-1	CA-2	**Total**
Length (m)	50	100	**150**
Main purposes			
Geological structure	yes	yes	
Excavation line	yes	yes	
Block shear test	yes	yes	
Remarkes			

In-situ test

Block shear test	3 sets
Main purposes	
Excavation line	yes

(2) Construction material

The FS study shows a high possibility of obtaining enough quantity and quality of material for concrete aggregate from river deposits. The following investigation is necessary for DD.

1) The volume of sand and gravel

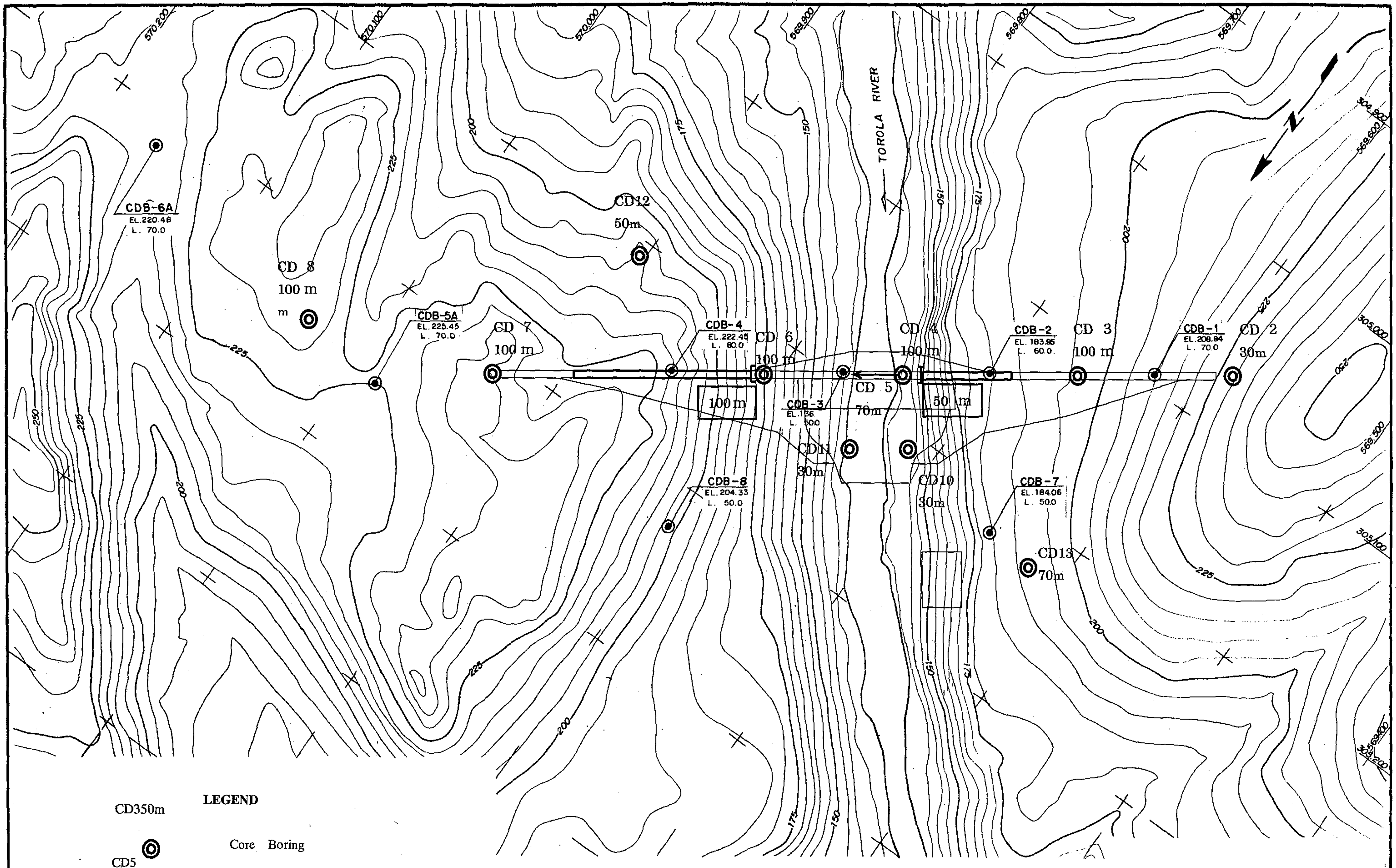
A terrace adjacent to the area investigated for the FS should be investigated to confirm that enough volume of sand and gravel can be obtained.

Core boring, seismic prospecting and pit are recommended.

2) Quality

The aggregate should be produced by sieving, crashing and washing from samples collected from the river and terrace deposits. Subsequently, they should be tested by the method shown in Table 7.12 in Chapter 7. Because these deposits have high possibility of alkali-aggregate reactivity, adequate testing for alkali-aggregate reaction will be needed. The test to confirm such alkali- aggregate reaction ~~is~~ controlled by fly-ash will also be necessary.

Concrete proportioning test is also recommended.



LEGEND

CD350m

◎ Core Boring

CD5 70m ← Inclined Core Boring

Adit

50m

Note) CD1 and CD9 are shown in Fig.15.2

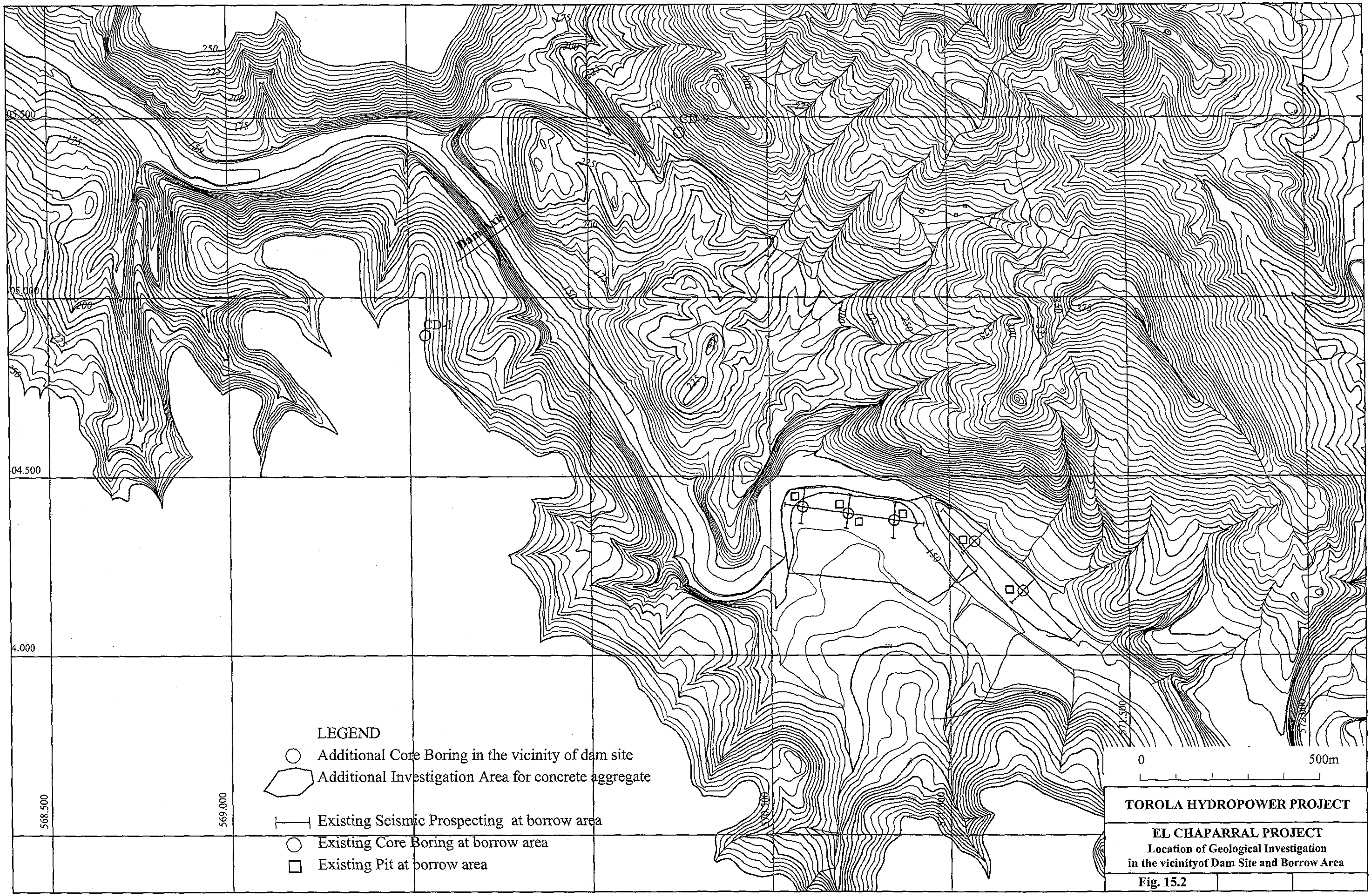
0 100m

TOROLA HYDROPOWER PROJECT

EL CHAPARRAL PROJECT
Additional Investigation at Dam Site

Fig 15.1 DATE

F - 1 SHEET NO. OF



TOROLA HYDROPOWER PROJECT

EL CHAPARRAL PROJECT

Location of Geological Investigation in the vicinityof Dam Site and Borrow Area

Fig. 15.2