

JAPAN INTERNATIONAL COOPERATION AGENCY

**NEPAL ELECTRICITY AUTHORITY
ENGINEERING SERVICES
PROJECT DEVELOPMENT DEPARTMENT**

**THE UPGRADING FEASIBILITY STUDY
ON THE DEVELOPMENT OF
THE KULEKHANI III HYDROPOWER PROJECT
IN
THE KINGDOM OF NEPAL**

FINAL REPORT

**VOLUME I
MAIN REPORT**

FEBRUARY 2003

**NIPPON KOEI CO., LTD.
TOKYO, JAPAN**

This Report consists of

EXECUTIVE SUMMARY

Volume I Main Report

Volume II Supporting Report (1)
(Engineering Study)

Volume III Supporting Report (2)
(Environmental Impact Assessment)

The Cost estimate is based on the price of December 2002 and the exchange rates in December 2002 are:

US\$ 1.00 = NRs. 77.0 = Yen 120

PREFACE

In response to a request of His Majesty's Government of Nepal, the Government of Japan decided to conduct the Upgrading Feasibility Study on the Development of the Kulekhani III Hydropower Project in the Kingdom of Nepal, and entrusted the study of Japan International Cooperation Agency (JICA).

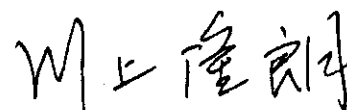
JICA sent a study team, led by Mr. Tsutomu Kodama of Nippon Koei Co., Ltd. to the Kingdom of Nepal five times from September 2001 to February 2003.

The team held discussions with the officials concerned of the Majesty's Government of Nepal, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the plan and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of His Majesty's Government of Nepal for their close cooperation throughout the study.

February 2003



Takao KAWAKAMI

President

Japan International Cooperation Agency

February 2003

Mr. Takao KAWAKAMI
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit you the Final Report of the Upgrading Feasibility Study on the Development of the Kulekhani III Hydropower Project in the Kingdom of Nepal.

The main objectives of the Upgrading Feasibility Study is to formulate the optimum development plan of the Kulekhani III Hydropower Project which is planned to be built in the Rapti River about 40km southwest of Kathmandu in liner distance. To attain the purpose, the Study Team performed the survey, investigation and studies during the period from September 2001 to February 2003. In conclusion, the Upgrading Feasibility Study proposed to develop a peak power station of regulating pond type with an installed capacity of 45MW from technical, environmental and economic/financial viewpoints. It was also recommended to implement the Project as early as possible by proceeding to the detailed design following this Study in order to supply the reliable peak power in the dry season in the fiscal year of 2007. The implementation of the Project contributes to the development of the national economy in Nepal and the regional development around the Project by effective utilization of the water resources in Nepal.

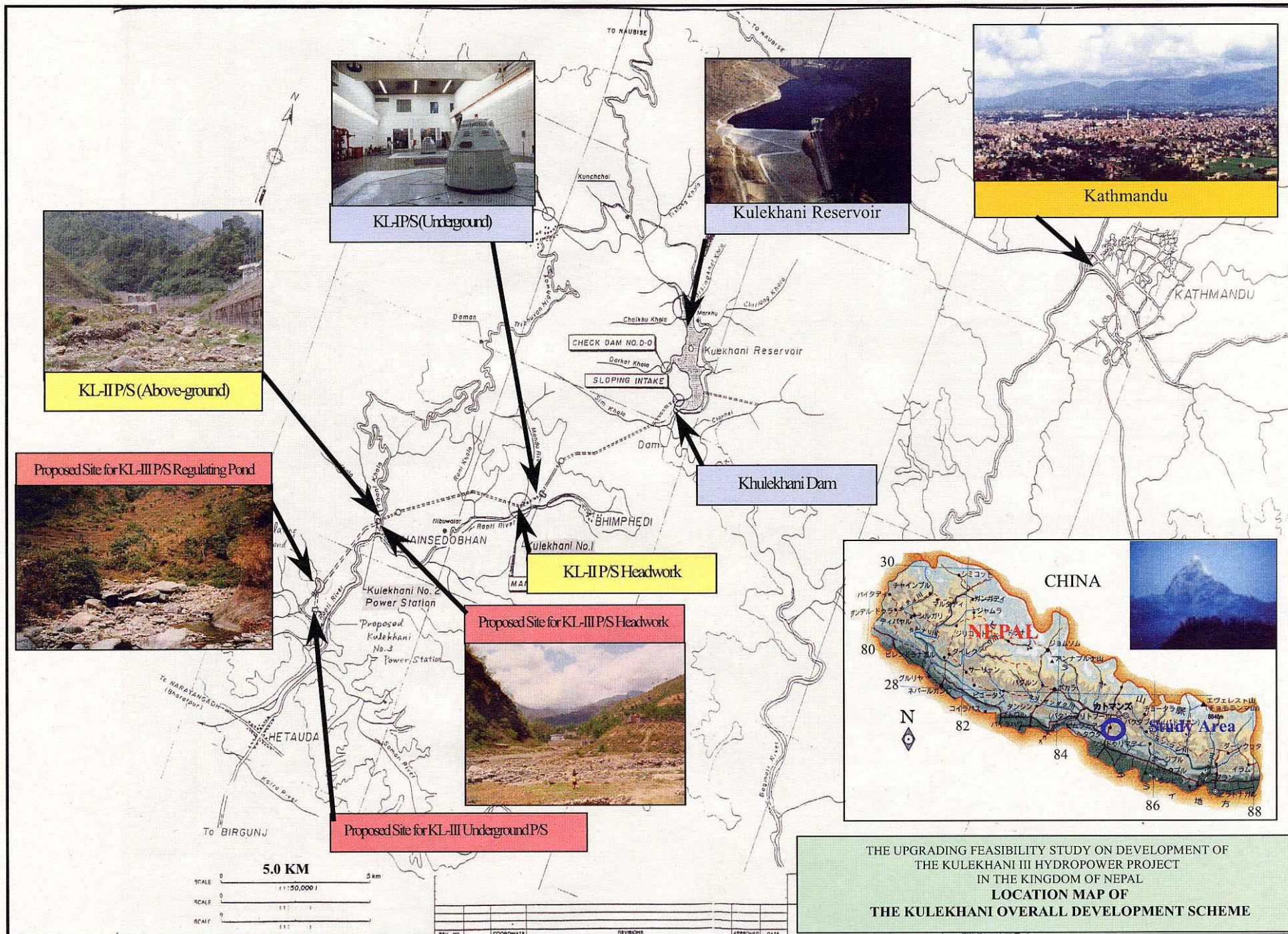
The Report consists of four Volumes, Main Report, Executive Summary and two Supporting Reports. The Main Report covers all the investigation and study results including field investigation and results, plan formulation, environmental impact assessment and resettlement action plan, cost estimates and project evaluation. The Executive Summary presents main outputs of the Study. The Supporting Reports give additional and supporting information and data to the Main Report.

We would like to express our grateful acknowledgement to the personnel of your Agency, your Branch Office in Nepal, and the Embassy of Japan in Nepal, and also to officials and individuals of His Majesty's Government of Nepal and Nepal Electricity Authority for their assistance and advice extended to the Study Team. We sincerely hope that the results of this Study would contribute to the national and regional development of the country.

Yours sincerely,



Tsutomu Kodama
Team Leader
Upgrading Feasibility Study
on
Kulekhani III Hydropower Project



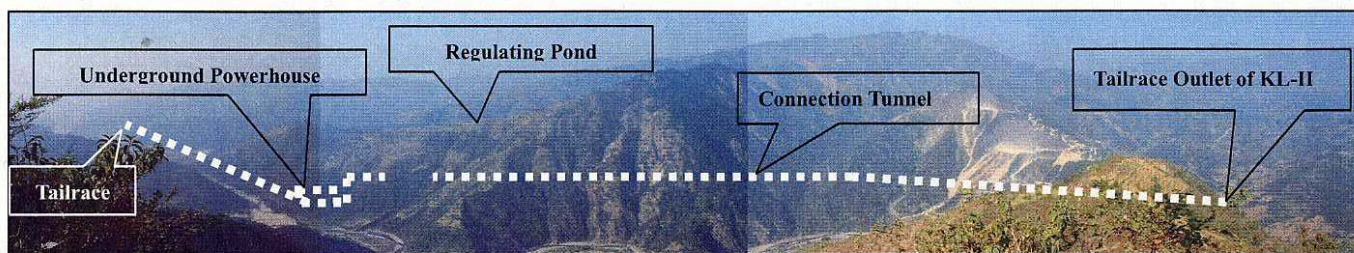


Photo 1 Distant View of the Kulekhani III Project

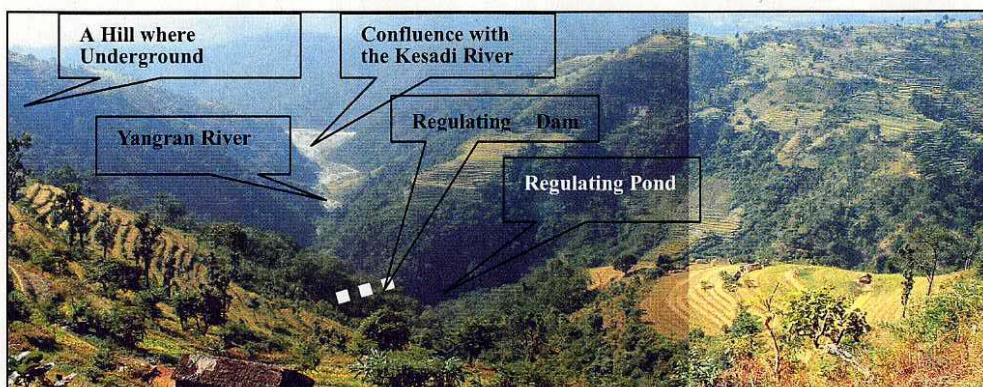


Photo 2 Distant View of the Proposed Regulating Pond Site on the Yangran River



Photo 3 General View of Sanutar Village for Access Road Site



Photo 4 Irrigation Canal in Yangran River



Photo 5 Water Supply Point

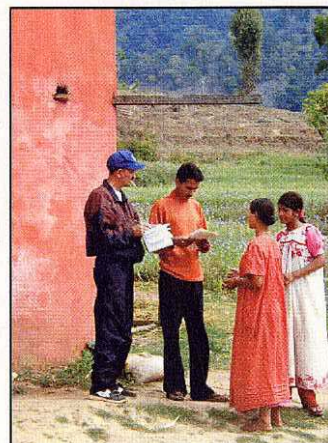


Photo 6 Interviewing Sanutar Women's Savings Group

Principal Features of Kulekhani III Hydropower Project

1. Hydrology and Regulating Pond

Catchment Area	: 8.1 km ²
Full Supply Level (FSL)	: EL.597.0 m
Minimum Operation Level (MOL)	: EL.577.0 m
Gross Storage Capacity	: 652,000 m ³
Effective Storage Capacity	: 475,000 m ³
Surface Area	: 0.049 km ²
Surface Length	: 650 m
Design Flood of Regulating Dam	: 280 m ³ /sec
Design Flood of Khani Headwork	: 470 m ³ /sec
Sedimentation	: 19,000 m ³ /yr

2. Power Output

Installed Capacity	: 44.8 MW (22.4 MW × 2 units)
Maximum Plant Discharge	: 43.1 m ³ /sec
Rated Head	: 117.8 m
Annual Average Energy	: 47.3 GWh
Firm Peak Energy	: 29.5 GWh
Secondary Energy	: 17.8 GWh

3. Main Structures
 - (1) Khani Headwork

Maximum Intake Discharge	: 2.0 m ³ /sec
Normal Operating Water Level	: EL. 601.0 m
 - (2) Connection Tunnel

Type	: Concrete lined horseshoe section, free flow tunnel
Diameter	: 3.25 m
Length	: 3,500 m
 - (3) Regulating Dam

Type	: Roller compacted concrete dam (RCC)
Crest Elevation	: EL.600.0 m
Foundation Elevation	: EL.548.0 m
Crest Length	: 110.0 m
Sand Flush Gate	: 3.0m wide × 2.0 m high × 1 no, High pressure slide gate
Spillway Type	: Non gated spillway
 - (4) Headrace Tunnel

Type	: Concrete lined circular section, Pressure tunnel
Diameter	: 4.1m
Length	: 350 m

- | | | |
|------|------------------------------------|--|
| (5) | Penstock | |
| | Type | : Tunnel type |
| | Diameter | : 3.4 m-2.2m |
| | Length | : 190 m |
| (6) | Powerhouse | |
| | Type | : Underground type |
| | Building Dimension | : 17 m wide × 31 m high × 74 m long |
| (7) | Tailrace Tunnel | |
| | Tunnel Section | |
| | Type | : Concrete lined vertical leg horseshoe section,
Free flow tunnel and conduit |
| | Diameter | : 4.4 m |
| | Length | : 1,750 m (tunnel) and 350 m (conduit) |
| (8) | Turbine | |
| | Type | : Vertical shaft Francis, 2 nos. |
| | Rate Speed | : 500 rpm |
| (9) | Generator | |
| | Type | : Conventional (Suspended), 2 nos. |
| | Rated Capacity | : 26.4 MVA |
| | Frequency | : 50 Hz |
| (10) | Main Transformer | |
| | Type | : Indoor, Special 3-phase, 2 nos. |
| | Voltage Ratio | : 11 kV/132 kV |
| (11) | 132 kV Switchgear | : Indoor GIS with single bus for incoming |
| 4. | Transmission line | |
| | Length | : 1.7 km |
| | Number of Circuit | : Double circuit |
| | Voltage | : 132 kV |
| | Conductor | : ACSR 260 mm ² |
| 5. | Construction Period | : 3.5 years |
| 6. | Construction Cost | |
| | (US\$ Million as of November 2002) | |
| | Direct Construction Cost | : 62.1 |
| | Administration Cost | : 1.6 |
| | Engineering Service Cost | : 4.7 |
| | Environmental Cost | : 1.8 |
| | Physical Contingency | : 6.0 |
| | <u>Price Contingency</u> | <u>: 1.5</u> |
| | Total Cost | : 77.7 |

**THE UPGRADING FEASIBILITY STUDY ON THE DEVELOPMENT
OF THE KULEKHANI III HYDROPOWER PROJECT
IN THE KINGDOM OF NEPAL
FINAL REPORT**

Preface

Letter of Transmittal

Principal Feature of the Project

TABLE OF CONTENTS

	<u>Page</u>
CHAPTER 1 INTRODUCTION	
1.1 Conclusion and Recommendation	1-1
1.2 Background of the Project	1-2
1.3 The Project	1-4
1.4 Objectives of the Study	1-5
1.5 Stages and Schedule of the Study	1-6
1.6 Final Report	1-6
1.7 Acknowledgement	1-7
CHAPTER 2 SOCIO-ECONOMIC CONDITION	
2.1 Geographic Features	2-1
2.2 Administration Situation	2-2
2.3 Population	2-2
2.4 Macro Economic Performance	2-4
2.5 Status of National Development Plan	2-6
2.6 Macro Frame Analysis for Development Forecast	2-10
CHAPTER 3 SITE CONDITIONS	
3.1 Location and Topography	3-1
3.2 Meteorology and Hydrology	3-2
3.2.1 Objectives	3-2
3.2.2 Climatic Conditions	3-2
3.2.3 Rainfall	3-3
3.2.4 Sedimentation of Kulekhani Reservoir	3-4
3.2.5 Runoff Analysis	3-4
3.2.6 Flood Analysis	3-10
3.2.7 Sediment Analysis	3-15
3.3 Geology	3-20
3.3.1 Introduction	3-20
3.3.2 Regional Geology	3-21
3.3.3 Geology of the Project Site	3-22
3.3.4 Geological Investigation	3-25
3.3.5 Engineering Geology	3-31

3.3.6	Seismicity and Seismic Risk.....	3-39
3.3.7	Further Study	3-42
3.4	Landslides and Sedimentation in Project Area.....	3-44
3.4.1	Introduction	3-44
3.4.2	Landslides in Regulating Pond	3-44
3.4.3	Slope Failure in Yangran Watershed	3-46
3.5	Erosion and Sediment Control in Kulekhani Watershed.....	3-48
3.6	Construction Materials	3-50

CHAPTER 4 ENVIRONMENTAL ASSESSMENT

4.1	Introduction	4-1
4.1.1	Environmental and Social Background	4-1
4.1.2	Nepal Legal and Administrative Framework.....	4-2
4.1.3	Japan International Cooperation Agency (JICA) and Japan Bank for International Cooperation (JBIC) Impact Assessment Guidelines	4-2
4.1.4	World Commission on Dams (WCD) Report and Recommendations.....	4-2
4.2	Review and Status of Existing EIA Documents	4-2
4.2.1	NEA's EIA	4-2
4.2.2	Supplemental EIA Field Studies	4-4
4.3	Natural Environment Assessment	4-5
4.3.1	Project Impact Zones.....	4-5
4.3.2	Inventory of Natural Environment	4-5
4.3.3	Impacts during Construction.....	4-9
4.3.4	Impacts during Operation Phase.....	4-14
4.4	Social Environment Assessment.....	4-19
4.4.1	Social Impact Assessment.....	4-19
4.4.2	Resettlement and Land Acquisition.....	4-24
4.4.3	Downstream Impacts from Outflow of Tailrace Outlet	4-26
4.4.4	Social Environmental Impacts during Construction.....	4-27
4.5	Mitigation Measures	4-29
4.5.1	Environmental Management Plan (EMP)	4-29
4.5.2	Resettlement Plan (RP)	4-31
4.5.3	Social Action Plan (SAP) Framework	4-34
4.6	Public Consultation (PC) Program.....	4-36
4.7	Recent Hydrological Events in the Rapti Watershed.....	4-38
4.8	Summary of Total Environmental Management Costs.....	4-38

4.9	Further Studies Required	4-39
CHAPTER 5	POWER SURVEY	
5.1	Present Power Sector	5-1
5.1.1	Institution of Power Sector	5-1
5.1.2	Organization of Power Sector	5-3
5.1.3	Power Development Policy	5-5
5.1.4	Power Balance	5-6
5.1.5	Power Tariff	5-7
5.2	Present Power System and Development Plan	5-7
5.2.1	Existing Power System	5-7
5.2.2	Existing Generation and Transmission Facilities	5-8
5.2.3	Activities of Independent Power Producers	5-9
5.2.4	Generation Expansion Plan	5-9
5.2.5	Transmission Expansion and Other Plan	5-13
5.3	Power Demand Forecast	5-16
5.3.1	Review of NEA's Demand Forecast	5-16
5.3.2	Power Exchange	5-18
5.3.3	Losses	5-19
5.3.4	Energy Demand Forecast	5-19
5.3.5	Demand Side Management	5-25
5.3.6	Load Factor	5-26
5.3.7	Peak Demand Forecast	5-27
5.3.8	Demand and Supply Balance	5-28
5.4	Transmission Line for the Kulekhani III Hydropower Project	5-28
5.5	Operation and Maintenance Program of Existing Hydropower Stations	5-30
5.5.1	Organization for Operation and Maintenance	5-30
5.5.2	Budgetary Arrangement for Operation and Maintenance	5-31
5.5.3	Training of NEA Staff for Operation and Maintenance	5-31
5.5.4	Power Generation Performance	5-33
5.5.5	Maintenance Works	5-33
5.5.6	Recommendation on Administration of Maintenance	5-34

CHAPTER 6	OPTIMUM DEVELOPMENT PLAN	
6.1	General	6-1
6.2	Adequacy of the Development of the Kulekhani III Hydropower Project	6-2
6.2.1	General	6-2
6.2.2	Daily Load Curve	6-3
6.2.3	Adequacy of Input of the Kulekhani III Hydropower Project.....	6-4
6.3	Optimum Development Plan	6-6
6.3.1	General	6-6
6.3.2	Review of Existing Feasibility Study Report.....	6-6
6.3.3	Optimum Project Layout	6-15
6.3.4	Optimum Development Scale	6-23
6.4	Study on Optimum Input Timing	6-25
6.4.1	Long-term Power Source Development Plan	6-25
6.4.2	Conditions and Assumptions	6-25
6.4.3	Optimum Input Timing of the Project.....	6-26
CHAPTER 7	OPTIMUM RESERVOIR OPERATION	
7.1	Introduction	7-1
7.2	Reservoir Operation Analysis.....	7-1
7.3	Optimum Reservoir Operation	7-4
CHAPTER 8	FEASIBILITY GRADE DESIGN	
8.1	General	8-1
8.2	Khani Headworks	8-1
8.2.1	Optimum Intake Discharge from Khani River.....	8-1
8.2.2	Khani Headworks	8-2
8.2.3	Connection Tunnel	8-3
8.3	Regulating Dam	8-3
8.3.1	Comparison of Dam Axis	8-3
8.3.2	Design of Regulating Dam.....	8-4
8.3.3	Sabo Structures on Yangran River	8-5
8.3.4	Countermeasures against Landslide	8-7
8.3.5	Countermeasures against Slope Failure	8-8
8.4	Power Tunnel	8-8
8.4.1	Headrace Tunnel	8-8
8.4.2	Penstock	8-8
8.5	Powerhouse	8-9
8.5.1	General	8-9
8.5.2	Layout	8-9

	8.5.3	Stability of Powerhouse Cavern	8-10
	8.5.4	Drain Holes.....	8-12
8.6		Tailrace	8-12
	8.6.1	Tailrace Chamber	8-12
	8.6.2	Tailrace Tunnel and Culvert.....	8-13
	8.6.3	Tailrace Outlet.....	8-13
8.7		Access Tunnel	8-13
8.8		Hydro-Mechanical Equipment	8-14
	8.8.1	General	8-14
	8.8.2	Intake Gate	8-14
	8.8.3	Intake Fixed Trashrack.....	8-14
	8.8.4	Sand Flush Gate.....	8-15
	8.8.5	Bottom Outlet Gate	8-15
	8.8.6	Diversion Gate.....	8-15
	8.8.7	Penstock	8-15
	8.8.8	Draft Tube Gate and Monorail Hoist.....	8-15
8.9		Generating Equipment.....	8-16
8.10		Transmission Line and Switchyard.....	8-18
8.11		Access Roads and Temporary Facilities	8-19

CHAPTER 9 CONSTRUCTION PLAN AND COST ESTIMATE

9.1		General	9-1
9.2		Construction Plan and Schedule.....	9-1
	9.2.1	Basic Conditions.....	9-1
	9.2.2	Construction Method.....	9-3
	9.2.3	Construction Schedule.....	9-10
9.3		Cost Estimate.....	9-12
	9.3.1	Basic Conditions and Assumptions	9-12
	9.3.2	Preparatory Works	9-12
	9.3.3	Civil Works	9-12
	9.3.4	Metal Works.....	9-14
	9.3.5	Generating Equipment.....	9-15
	9.3.6	Transmission Line	9-15
	9.3.7	Environmental Cost.....	9-15
	9.3.8	Administration Expenses.....	9-15
	9.3.9	Engineering Services	9-15
	9.3.10	Contingency	9-16
	9.3.11	Total Project Cost.....	9-16
	9.3.12	Annual Disbursement Schedule.....	9-17

CHAPTER 10 PROJECT EVALUATION

10.1		Introduction	10-1
------	--	--------------------	------

10.2	Economic Evaluation	10-1
10.2.1	Conditions of Economic Evaluation.....	10-1
10.2.2	Economic Benefit and Cost.....	10-2
10.2.3	Economic Evaluation	10-3
10.2.4	Sensitivity Analysis.....	10-4
10.3	Financial Evaluation.....	10-5
10.3.1	Financial Cost and Benefit	10-5
10.3.2	Financial Evaluation.....	10-5
10.3.3	Sensitivity Analysis	10-6
10.3.4	Loan Repayability	10-7
10.4	The Results of the Economic and Financial Analysis and Recommendation	10-10
 CHAPTER 11 TRANSFER TECHNOLOGY		
11.1	On-the-job Training	11-1
11.2	Presentation	11-1
11.3	Counterpart Training in Japan	11-1
 CHAPTER 12 IMPLEMENTATION PROGRAM		
12.1	Implementation Program	12-1
12.2	Project Risk	12-1
12.3	Further Investigation of Detailed Design	12-3

LIST OF TABLES

CHAPTER 2

Table 2.4.1	Some Important Macro Economic Indicators, 1990/91 to 2000/01	2-T-1
Table 2.4.2	National Accounts Summary, 1990/91 to 2001/02	2-T-2
Table 2.4.3	Gross Domestic Product by Industrial Origin at Constant Prices, 1990/91 to 2000/01	2-T-3
Table 2.4.4	Price Deflators of the Gross Domestic Product, 1990/91 to 2000/01	2-T-4
Table 2.4.5	Percentage Contribution to Total GDP by Sector, 1990/91 to 2000/01	2-T-5
Table 2.4.6	Annual Growth Rates of the Gross Domestic Product by Major Industrial Divisions, 1990/91 to 2000/01	2-T-6
Table 2.4.7	Overall Budgetary Position of His Majesty's Government, 1990/91 to 2000/01	2-T-7
Table 2.4.8	Urban Consumer Price Index by Group and Sub-group of Commodities, 1996/97 to 2000/2001	2-T-8
Table 2.4.9	Monetary Survey	2-T-9
Table 2.4.10	Balance of Payments	2-T-10
Table 2.4.11	Direction of Foreign Trade	2-T-11
Table 2.4.12	Nepal: External Debt and Debt Service, 1994/95-1999/00.	2-T-12
Table 2.4.13	Foreign Exchange Holdings	2-T-13

CHAPTER 3

Table 3.2.1	Record at Adjacent Observatory Stations	3-T-1
Table 3.2.2	Temperature at Daman and Hetauda N.F.I	3-T-2
Table 3.2.3	Monthly Evaporation Record at Chisapani Gadhi	3-T-2
Table 3.2.4	Monthly Mean Rainfall	3-T-3
Table 3.2.5	Maximum Daily Rainfall	3-T-4
Table 3.2.6	Daily Rainfall during Storm of July 1993	3-T-5
Table 3.2.7	Daily Rainfall during Storm of July 2002	3-T-5
Table 3.2.8	Sedimentation of Kulekhani Reservoir	3-T-5
Table 3.2.9	Monthly Runoff at Kulekhani G.S.	3-T-6
Table 3.2.10	Monthly Runoff at Rajaya G.S.	3-T-7
Table 3.2.11	Runoff Coefficient and Specific Runoff at Rajaya G.S.	3-T-8
Table 3.2.12	Specific Runoff at Adjacent G.S.	3-T-8
Table 3.2.13	Calibration of Tank Model	3-T-8
Table 3.2.14	Monthly Inflow into Kulekhani Reservoir	3-T-9
Table 3.2.15	Evaluation of Reservoir Inflow	3-T-10
Table 3.2.16	Annual Maximum Floods at Rajaya G.S. and	

	Kulekhani G.S.....	3-T-11
Table 3.2.17	Probable Floods at Rajaya G.S.....	3-T-12
Table 3.2.18	Probable Rainfall of Kulekhani Reservoir Basin.....	3-T-12
Table 3.2.19	Probable Flood at Kulekhani G.S.....	3-T-12
Table 3.2.20	Estimated Sediment Load from Kulekhani Reservoir Basin	3-T-13
Table 3.2.21	Estimated Average Annual Sediment Load from Kulekhani Reservoir Basin.....	3-T-13
Table 3.3.1	Rating for the Six Q System Parameters	3-T-14
Table 3.6.1	Results of Sieve Analysis.....	3-T-15
 CHAPTER 4		
Table 4.2.1	Supplemental Natural Environmental Impact Assessment Survey	4-T-1
Table 4.2.2	Supplemental Social Environmental Impact Assessment Survey	4-T-2
Table 4.3.1	Summary Results from Spring Survey in Wet and Dry Seasons	4-T-4
Table 4.3.2	Main Results for Fish Sampling Surveys	4-T-5
Table 4.3.3	List of Protected Species in the Project Area.....	4-T-6
Table 4.5.1	Natural Environmental Mitigation & Monitoring Plan Cost	4-T-7
Table 4.5.2	Social Environmental Mitigation & Monitoring Plan Cost.....	4-T-8
Table 4.5.3	Entitlement Matrix	4-T-11
Table 4.5.4	Summary Table of SAP Program.....	4-T-15
 CHAPTER 5		
Table 5.1.1	Demand and Supply of National Grid from FY1971.....	5-T-1
Table 5.1.2	Power Tariff Rates	5-T-2
Table 5.1.3	Record of Power Tariff Revision	5-T-3
Table 5.2.1	Existing Generation Facilities of National Grid	5-T-4
Table 5.2.2	Licenses Given for Power Business and Survey	5-T-5
Table 5.3.1	Domestic Load Forecast	5-T-6
Table 5.3.2	Industrial Load Forecast.....	5-T-7
Table 5.3.3	Commercial Load Forecast	5-T-8
Table 5.3.4	Other Load Forecast	5-T-9
Table 5.3.5	Irrigation Load Forecast	5-T-10
Table 5.3.6	Export Load Forecast	5-T-11
Table 5.3.7	Energy and Peak Demand Forecasts (Base Case).....	5-T-12
Table 5.3.8	Energy Balance (with Kulekhani III)	5-T-13
Table 5.3.9	Energy Balance (without Kulekhani III)	5-T-14

Table 5.3.10	Capacity Balance (with Kulekhani III)	5-T-15
Table 5.3.11	Capacity Balance (without Kulekhani III)	5-T-16
Table 5.5.1	Summary of Budget Allocation for Operation and Maintenance in the Existing Power Stations	5-T-17
Table 5.5.2	Features of Major Existing Power Stations in Nepal.....	5-T-18
Table 5.5.3	History of Maintenance Works	5-T-19
Table 5.5.4	Present Status of Maintenance Observed and Measures	5-T-20
Attachment A5.1	Energy and Peak Demand Forecasts (High Case)	5-T-21
Attachment A5.2	Energy and Peak Demand Forecasts (Low Case)	5-T-22
 CHAPTER 6		
Table 6.3.1	Main Structures of Each Alternative Scheme	6-T-1
Table 6.3.2	Technical Issues of Each Alternative	6-T-2
Table 6.3.3	Comparison Study on Existing Alternative Option	6-T-3
Table 6.3.4	Alternatives of Regulating Pond.....	6-T-4
Table 6.3.5	Alternatives of Powerhouse	6-T-5
Table 6.3.6	Alternatives of Tailrace	6-T-6
 CHAPTER 7		
Table 7.1.1	Monthly Effective Inflow into Kulekhani Reservoir.....	7-T-1
 CHAPTER 8		
Table 8.2.1	Design Criteria.....	8-T-1
Table 8.5.1	Design Values	8-T-2
Table 8.8.1	Design Data of Hydro-mechanical Equipment.....	8-T-3
 CHAPTER 9		
Table 9.2.1	Summary of Rainfall Record at Nibuwater Rainfall Gauging Station	9-T-1
Table 9.2.2	Monthly Mean Rainy Day	9-T-1
Table 9.2.3	Monthly Workable Days	9-T-2
Table 9.3.1	Labor Wage	9-T-3
Table 9.3.2	Material Cost	9-T-3
Table 9.3.3	Environmental Cost	9-T-4
Table 9.3.4	Breakdown of Construction Cost of Civil Works.	9-T-5
Table 9.3.5	Disbursement Schedule	9-T-9
 CHAPTER 10		
Table 10.2.1	Project Costs and Disbursement Schedule	10-T-1
Table 10.2.2	Capacity Value and Energy Value of the	

	Alternative Gas Turbine Power Plant.....	10-T-2
Table 10.2.3	Economic Analysis Calculation on Kulekhani III Hydropower Project	10-T-3
Table 10.3.1	Estimation of Gate Price	10-T-4
Table 10.3.2	Financial Analysis Calculation on Kulekhani III Hydropower Project	10-T-5
Table 10.3.3	Loan Repayment Analysis Case a) Foreign Soft Loan Case	10-T-6
Table 10.3.4	Loan Repayment Analysis Case b) Foreign Soft Loan with Local Finance.....	10-T-7
Table 10.3.5	Loan Repayment Analysis Case c) Local Loan with Equity Investment	10-T-8
Table 10.3.6	Loan Repayment Analysis Case d) Local Loan with Equity Investment and Principal Conversion to Equity	10-T-9
Table 10.3.7	Loan Repayment Analysis Case e) Local Loan.....	10-T-10
Table 10.3.8	Loan Repayment Analysis Case f) Local Loan with Equity Investment and 10 Year Grace Period.....	10-T-11
Table 10.3.9	Loan Repayment Analysis Case g) Local Loan with Equity Investment and Principal Conversion with 10 Year Grace Period.....	10-T-12
Table 10.3.10	Loan Repayment Analysis Case h) Local Loan with 10Year Grace Period.....	10-T-13
Table 10.3.11	Loan Repayment Analysis: 85 % of Foreign Loan and 15 % of Local Loan with Equity Investment and 10 Year Grace Period	10-T-14
Table 10.3.12	Loan Repayment Analysis: Reference Case (Local Loan with Equity Investment as Current Practice).....	10-T-15
CHAPTER 12		
Table 12.2.1	Project Risk and Parties Concerned Risk.....	12-T-1

LIST OF FIGURES

CHAPTER 3

Figure 3.2.1	Location Map of Observatory Stations	3-F-1
Figure 3.2.2	Original Storage Capacity Curve and Estimated Curve as of 1995	3-F-2
Figure 3.2.3	Consistency of Record at Rajaya G.S.	3-F-3
Figure 3.2.4	Comparison of Specific Runoff at Rajaya G.S. and Adjacent G.S.....	3-F-3
Figure 3.2.5	Tank Model	3-F-4
Figure 3.2.6	Estimated Runoff by Tank Model	3-F-5
Figure 3.2.7	Duration Curves of Reservoir Inflow and Tributary Runoffs	3-F-7
Figure 3.2.8	Frequency Curve of Annual Maximum Flood at Rajaya (1963-1995).....	3-F-8
Figure 3.2.9	Unit-hydrograph and Hourly Rainfall Distribution at Tistung	3-F-9
Figure 3.2.10	Frequency Curve of Annual Maximum Rainfall in Kulekhani Reservoir Basin (1972-2000,2002).....	3-F-10
Figure 3.2.11	Recorded Maximum Floods in Nepal.....	3-F-11
Figure 3.2.12	Relationship between Annual Maximum Rainfall and Sediment Volume.....	3-F-12
Figure 3.3.1	Schematic Feature of Geomorphology in Nepal.....	3-F-13
Figure 3.3.2	Geological Map of Project Area.....	3-F-14
Figure 3.3.3	Geology along Waterway	3-F-15
Figure 3.3.4	Geological Profile along Waterway.....	3-F-16
Figure 3.3.5	Location Map of Geological Investigation	3-F-17
Figure 3.3.6	Investigation Alignment of Electrical Resistivity Prospecting	3-F-18
Figure 3.3.7	Electrical Resistivity Profiles around Underground Structure Site (ERP3)	3-F-19
Figure 3.3.8	Electrical Resistivity Profiles around Underground Structure Site (ERP2)	3-F-20
Figure 3.3.9	Electrical Resistivity Profiles around Underground Structure Site (ERP1)	3-F-21
Figure 3.3.10	Test Result of Plate Load Test (1/3)	3-F-22
Figure 3.3.11	Test Result of Plate Load Test (2/3)	3-F-23
Figure 3.3.12	Test Result of Plate Load Test (3/3)	3-F-24
Figure 3.3.13	Test Result of Rock Shear Test	3-F-25
Figure 3.3.14	Correlation of Q system and CRIEPI Rock Classification	3-F-26
Figure 3.3.15	Geological Condition around Underground	

Structures.....	3-F-27
Figure 3.3.16 Permeability around Underground Structures	3-F-28
Figure 3.3.17 Geological Map around Damsite and Regulating Pond.....	3-F-29
Figure 3.3.18 Geological Profile of Proposed Damsite	3-F-30
Figure 3.3.19 Geological Profile of Proposed Damsite (Rock Grade).....	3-F-31
Figure 3.3.20 Geological Profile of Upstream Damsite (BD-4, 5, 6).....	3-F-32
Figure 3.3.21 Geological Condition of Connection Tunnel.....	3-F-33
Figure 3.3.22 Geological Condition along Tailrace Tunnel	3-F-34
Figure 3.3.23 Rock Condition along Waterway	3-F-35
Figure 3.3.24 Epicenters around Project Site (1973-2001)	3-F-36
Figure 3.3.25 Relationship between Seismic Intensity and Frequency	3-F-37
Figure 3.4.1 Geological Map of Yangran River Basin.....	3-F-38
Figure 3.4.2 Hazard Map in Yangran River Basin.....	3-F-39
Figure 3.4.3 Sketch of Landslide R-1	3-F-40
Figure 3.4.4 Cross Sections of Landslide in Yangran Regulating Pond and Countermeasure Work	3-F-41
Figure 3.4.5 Sketch of Landslide R-2	3-F-42
Figure 3.5.1 Geology and Slope Collapse in Project Area.....	3-F-43
Figure 3.6.1 Sampling Point of Rock Materials.....	3-F-44
 CHAPTER 4	
Figure 4.2.1 Supplemental EIA Survey	4-F-1
Figure 4.3.1 Project Layout.....	4-F-2
Figure 4.3.2 Location Map Showing Water Quality Sampling Sites.....	4-F-3
Figure 4.3.3 Location Map Showing Vegetation and Wildlife Sampling Sites.....	4-F-4
Figure 4.3.4 Location Map Showing Fish and Phytoplankton Sampling Sites.....	4-F-5
Figure 4.4.1 GIS Map	4-F-6
Figure 4.4.2 Affected Area of the Rapti River at Peak Discharge from Tailrace Outlet	4-F-7
 CHAPTER 5	
Figure 5.1.1 Organization of NEA	5-F-1
Figure 5.2.1 Nepal National Grid	5-F-2
Figure 5.3.1 Energy Balance	5-F-3
Figure 5.3.2 Capacity Balance	5-F-4
Figure 5.5.1 Organization Chart for Kulekhani I Power Station	5-F-5
Figure 5.5.2 Organization Chart for Kulekhani II Power Station	5-F-6

Figure 5.5.3	Organization Chart for Marsyangdi Power Station	5-F-7
Figure 5.5.4	Organization Chart for Kali Gandaki A Power Station	5-F-8
CHAPTER 6		
Figure 6.2.1	Daily Load Curve and Power Supply on January 18, 2001	6-F-1
Figure 6.2.2	Daily Load Curve and Power Supply in FY2008	6-F-2
Figure 6.3.1	Plan of Alternatives of Existing F/S Report	6-F-3
Figure 6.3.2	Plan of Dam Type Regulating Pond (Alternative A).....	6-F-4
Figure 6.3.3	Profile of Dam Type Regulating Pond (Alternative A).....	6-F-5
Figure 6.3.4	Details of Dam Type Regulating Pond (Alternative A).....	6-F-6
Figure 6.3.5	Plan of Underground Type Regulating Pond (Alternative B).....	6-F-7
Figure 6.3.6	Profile of Underground Type Regulating Pond (Alternative B).....	6-F-8
Figure 6.3.7	Details of Underground Type Regulating Pond (Alternative B).....	6-F-9
Figure 6.3.8	Plan of Dispersion Type Regulating Pond (Alternative C).....	6-F-10
Figure 6.3.9	Profile of Dispersion Type Regulating Pond (Alternative C).....	6-F-11
Figure 6.3.10	Details of Dispersion Type Regulating Pond (Alternative C).....	6-F-12
Figure 6.3.11	Profile of Alternative A (Underground Powerhouse + Pressure Tailrace Tunnel)	6-F-13
Figure 6.3.12	Details of Underground Powerhouse (Alternative A)	6-F-14
Figure 6.3.13	Profile of Alternative A-1 (Semi-Underground Powerhouse + Tailrace Culvert)	6-F-15
Figure 6.3.14	Details of Semi-Underground Powerhouse (Alternative A-1)	6-F-16
Figure 6.3.15	Profile of Alternative A-2 (Underground Powerhouse + Tailrace Culvert).....	6-F-17
Figure 6.3.16	Alternatives of Tailrace Tunnel.....	6-F-18
Figure 6.3.17	Comparative Study of Project Scale (EIRR).....	6-F-19
CHAPTER 7		
Figure 7.1.1	Monthly Mean Load Demand	7-F-1
Figure 7.2.1	Results of 1st Screening.....	7-F-2
Figure 7.2.2	Results of 2nd Screening	7-F-2
CHAPTER 8		
Figure 8.5.1	Geological Conditions	8-F-1

Figure 8.5.2	Analysis Meshes	8-F-2
Figure 8.5.3	Stress Distribution.....	8-F-3
Figure 8.5.4	Relaxed Zone.....	8-F-4
Figure 8.9.1	Single Line Connection Diagram.....	8-F-5
Figure 8.10.1	132kV Transmission Line Route	8-F-6
Figure 8.10.2	Connection of New Lines with Existing 132KV Conductors	8-F-7
Figure 8.10.3	Transmission Lines Typical Steel Tower (Angle up to 30 deg.) and Insulator Strings.....	8-F-8

CHAPTER 9

Figure 9.2.1	Major Construction Equipment for Each Work Item	9-F-1
Figure 9.2.2	Construction Schedule of Kulekhani III Hydropower Project	9-F-2

LIST OF DRAWINGS

Drawing 1	Project Plan	D-1
Drawing 2	Project Profile.....	D-2
Drawing 3	Khani Headworks	D-3
Drawing 4	Typical Section of Connection Tunnel	D-4
Drawing 5	Regulating Dam	D-5
Drawing 6	Check Dam No.2 (Siltation Dam).....	D-6
Drawing 7	Countermeasures against Landslide (Plan).....	D-7
Drawing 8	Countermeasures against Landslide (Profile).....	D-8
Drawing 9	Slope Protection Works on Surface Erosion Area.....	D-9
Drawing 10	Profile and Typical Section of Headrace Tunnel and Penstock	D-10
Drawing 11	Details of Access Tunnel.....	D-11
Drawing 12	Details of Underground Powerhouse	D-12
Drawing 13	Cavern Supporting System.....	D-13
Drawing 14	Tailrace Chamber	D-14
Drawing 15	Typical Section of Tailrace Tunnel.....	D-15
Drawing 16	Plan and Typical Section of Access Road	D-16

MAIN ABBREVIATION

Table of Terms (1/4)

Abbreviation	Terms
Nepal Agencies	
DHM	Department of Hydrology and Meteorology
DSC	Department of Soil Conservation
EEC	European Economic Community
GON	Government of Nepal
HCIL	Hetauda Cement Industries Limited
MOAC	Ministry of Agriculture and Cooperatives
MOF	Ministry of Finance
MOFSC	Ministry of Forest and Soil Conservation
MOPE	Ministry of Population and Environment
MORFD	Ministry of Foreign Affairs and Defense
MORPA	Ministry of Royal Palace Affairs
MOWR	Ministry of Water Resources
NEA	Nepal Electricity Authority
NEA-ED	NEA Environmental Department
NEC	Nepal Electricity Corporation
NEPECON	Nepal Engineering Consultancy Services Center Limited
NESS	Nepal Environmental & Scientific Services (P) Ltd.
Foreign Organization	
ADB	Asian Development Bank
CITES	Convention on International Trade in Endangered Species
CRIPI	Central Research Institute of Electric Power Industry
DANIDA	The Danish Agency for Development Assistance
EPRI	Electric Power Research Institute
GOJ	Government of Japan
IDA	International Development Association
IMF	International Monetary Fund
IUCN	International Union for Conservation of Nature and Natural Resources
JBIC (Former: OECF)	Japan Bank for International Cooperation (Overseas Economic and Cooperation Fund)
JICA	Japan International Cooperation Agency
JMA	Japan Meteorological Agency
KF	Kuwait Fund
KfW	German Development Bank
KOICA	Korea International Cooperation Agency
MIT	Massachusetts Institute of Technology
SIDA	Swedish International Cooperation Agency
UNDP	United Nation Development Program
USAID	The United States Agency for International Development
WB	World Bank
WCD	World Commission on Dams
WDS	The Wildlife Conservation Society
WHO	World Health Organization
Others	
ACRS	Acquisition, Compensation and Resettlement Section
AIDS	Acquired Immunodeficiency Syndrome
AP	Affected Person

Table of Terms (2/4)

Abbreviation	Terms
APP	Agriculture Perspective Plan
B/C	Benefit per Cost
BOD	Biochemical Oxygen Demand
CBO	Community Based Organizations
CCV	Community Consensus Valuation
CDC	Compensation Determination Committees
CDE	Community Development Expert
CDO	Chief District Officer
CF	Community Forest
CIF	Cost, Insurance, and Freight
CIWEC	Canadian International Water and Energy Consultants
CNPS	Central Nepal Power System
CO ₂	Carbon Dioxide
CPI	Consumer Price Index
D/D	Detailed Design
DFO	District Forest Office
DG	Diesel Generator
DMD	Deputy Managing Director
DMS	Detailed Measurement Survey
DO	Dissolved Oxygen
DoF	Department of Forest
DP	Dynamic Programming
DSM	Demand Side Management
EGEAS	Electric Generation Expansion Analysis System
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EM	Environmental Manager (Project side)
EMP	Environmental Management Plan
EO	Environmental Officer (Contractor side)
ESMS	Environmental and Social Monitoring Section
F.S.L.	Full Supply Water Level
F.W.L.	Flood Water Level
F/S	Feasibility Study
FC	Foreign Currency
FEM	Finite Element Method
FIRR	Financial Internal Rate of Return
FUG	Forest User Group
GS	Gauging Station
GDP	Gross Domestic Product
GIS	Global Information System
GIS	Gas-insulated Switchgear
GNP	Gross National Product
H.W.L.	High Water Level
HFT	Himalayan Front Thrust
HH	Household
HIV	Human Immunodeficiency Virus
HMG/N	His Majesty's Government of Nepal
HSD	High Speed Diesel

Table of Terms (3/4)

Abbreviation	Terms
ICB	International Competitive Bidding
IDC	Interest during Construction
IEE	Initial Environmental Examination
INGO	International Non-governmental Organization
INPS	Integrated National Power System
IPP	Independent Power Producer
IRR	Impoverishment Risks and Reconstruction
KESMU	Kulekhani III Hydropower Project Environmental and Social Management Unit
KGA	Kali Gandaki A Hydropower Project
KL I, II and III	Kulekhani I, II and III Hydropower Project
LAA	Land Acquisition Act
LC	Local Currency
LCG	Local Consultative Group
LDC	Overhead Travelling
LOLP	Loss of Load Probability
LRMC	Long Run Marginal Cost
LRO	Land Revenue Officer
M.O.L.	Minimum Operation Level
MBT	Main Boundary Thrust
MCT	Main Central Thrust
MF	Multi-fuel Diesel Generator
MIC	Most Impacted Communities
MOU	Minutes of Understanding
MT	Mahabharat Thrust
MUV	Manufacturing Unit Value
MWSP	Melamchi Water Supply Project
NEMP	Natural Environmental Mitigation and Monitoring Plan
NGO	Non Governmental Organization
NH ₃	Nitrogen Trioxegen (Ammonia)
NO ₂	Nitrogen Dioxide
NO ₃	Nitrogen Trioxide
NPV	Net Present Value
NRF	National Reserve Forest
O&M	Operation and Maintenance
ODA	Official Development Assistance
OFWF	Forced-oil-circulation Water-cooled
OHT	Overhead Travelling
OPGW	Optic Overhead Ground Wire
P/H	Powerhouse
P/S	Power Station
PAF	Project Affected Family
PC	Public Consultation
PIC	Project Impacted Communities
PICS	Project Information and Co-ordination Section
POE	Panel of Experts
PPA	Power Purchasement Agreement
PROR	Peaking Run-of-River

Table of Terms (4/4)

Abbreviation	Terms
PS	Pre-stressed
PTS	Plane Table Survey
RCC	Roller Compacted Concrete
RCP	Resettlement and Compensation Planner
RF	Resettlement Framework
ROR	Run-of-River
RP	Resettlement Plan
RSP	Resettlement and Social Specialist
S/S	Substation
S/W	Scope of Works
SAP	Social Action Plan
SAPS	Social Action Plan Section
SAPS	Special Assistance for Project Sustainability
SCF	Standard Conversion Factor
SEMP	Social Environmental Mitigation and Monitoring Plan
SIA	Social Impact Assessment
SPAF	Seriously Project Affected Family
ST	Storage Type
STD	Sexually Transmitted Diseases
T/L	Transmission Line
TLO	Tole/Lane Organization
TKN	Total Kjeldahl Nitrogen
TOR	Terms of Reference
TP	Total Phosphorus
TSS	Total Suspended Solids
VAC	Village Advisory Committee
VAG	Village Advisory Group
VDC	Village Development Committee
WASP III	Wien Automatic System Planning Program
WECS	Water and Energy Commission Secretariat
YWMP	Yangran Watershed Management Program
EL() m	Meters above mean sea level
NRs	Nepal Rupees
IRs	Indian Rupees
US\$	US Dollar
US ¢	US Cent