KHEPCL

KAMALA HYDRO ELECTRIC POWER COMPANY LTD. (KHEPCL)

Kamala Hydroelectric Project (1800 MW)

DETAILED PROJECT REPORT

VOLUME-I
MAIN REPORT

Part-A
Chapters 1 to 9

AUGUST 2013

SNC·LAVALIN
Engineering India

Power Division

161109-40ER-0006-00

NOTICE

This document contains the expression of the professional opinion of SNC-Lavalin Engineering India Pvt. Ltd. ("SNC-Lavalin") as to the matters set out herein, using its professional judgment and reasonable core. It is to be read in the context of the agreement dated January 21st, 2011 (the "Agreement") between SNC-Lavalin and Kamala Hydro Electric Power Company Ltd. (KHEPCL) [formerly known as Subansiri Hydro Electric Power Company Ltd. (SHEPCL)] (the "Client"), and the methodology, procedures and techniques used, SNC-Lavalin's assumptions, and the circumstances and constrains under which its mandate was performed. This document is written solely for the purpose stated in the Agreement, and for the sole and exclusive benefit of the Client, whose remedies are limited to those set out in the Agreement. This document is meant to be read as a whole, and sections or parts thereof should thus not be read or relied upon out of context.

SNC-Lavalin has, in preparing estimates, as the case may be, followed methodology and procedures, and exercised due care consistent with the intended level of accuracy, using its professional judgment and reasonable care, and is thus of the opinion that there is a high probability that actual values will be consistent with the estimate(s).

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KAMALA HYDRO ELECTRIC POWER COMPANY LTD. (KHEPCL)

KAMALA HYDROELECTRIC PROJECT (1800 MW)

DETAILED PROJECT REPORT

EXECUTIVE SUMMARY

VOLUME I	:	**MAIN REPORT**
VOLUME II	:	**HYDROLOGICAL STUDIES**
VOLUME III	:	**GEOLOGICAL & GEOTECHNICAL STUDIES**
VOLUME IV	:	**DESIGN (CIVIL, HM AND E&M)**
VOLUME V	:	**CONSTRUCTION METHODOLOGY AND INFRASTRUCTURE PLANNING**
VOLUME VI	:	**COST ESTIMATE & FINANCIAL ANALYSIS**
VOLUME VII	:	**DRAWINGS (CIVIL, HM AND E&M)**
VOLUME VIII	:	**CONSTRUCTION MATERIAL SURVEY AND INVESTIGATIONS**
VOLUME IX	:	**APPENDICES**

AUGUST 2013

SNC·LAVALIN Engineering India

Power Division

DPR CONTENTS – VOLUME WISE

Volume-IV : Design (Civil, HM and E&M)

- Part-A : Civil Design
  - Chapter 1 : River Diversion
  - Chapter 2 : Reservoir
  - Chapter 3 : Dam
  - Chapter 4 : Power Intake
  - Chapter 5 : Headrace Tunnel
  - Chapter 6 : Pressure Shaft
  - Chapter 7 : Transient Studies
  - Chapter 8 : Powerhouse Complex
  - Chapter 9 : Dam-Toe Powerhouse
- Part-B : Hydromechanical Design
- Part-C : Electromechanical Design

Volume-V : Construction Methodology and Infrastructure Planning

- Part-A : Construction Methodology and Equipment Planning
- Part-B : Infrastructure Planning

Volume-VI : Cost Estimate & Financial Analysis

Volume-VII : Drawings (Civil, HM and E&M)

Volume-VIII : Construction Material Survey and Investigations

Volume-IX : Appendices

- Appendix-A : Hydrometeorological & Silt Data
  - Part-A : Rainfall Data
  - Part-B : G&D, Sediment and Temperature Data
- Appendix-B : Report on Transportation Studies
- Appendix-C : Report on Site Specific Design Earthquake Parameters

CHECK LIST PROFORMA

CHECK LIST -1

(to be examined in the office of Secretary, CEA)

S.No.	ITEM	REMARKS	
1	Name of the Project	Kamala Hydroelectric Project	
2	Location		
	a) State (s)	Arunachal Pradesh	
	b) Districts (s)	Lower Subansiri & Kurung Kumey	
	c) Taluka (s)/ Tehsil (s)	-	
	d) Basin	Subansiri	
	e) River	Kamla	
	f) Longitude/ Latitude	93º 59' 19" E / 27º 46' 18" N (Dam Axis)	
	g) Survey of India Topographical Map reference No. (s)	82H/12, 83E/9, 83E/10, 82H/16, 83E/13, 83E/14, 83I/1 and 83I/2	
	h) Earthquake Zone Number	Zone-V	
	i) Complete Address for correspondence along with pin code / email, FAX, Telephone number.	Kamala Hydro Electric Power Company Limited (KHEPCL) Jindal Centre, 5th Floor, Tower – B, Plot No. 2, Sector-32, Gurgaon, Haryana, Pin - 122001 E-mail: satishcsharma@jindalsteel.com Tel: 0124-6612000 Fax: 0124-6612525	
3	Whether the scheme is included in the National Electricity Plan. If so, whether the capacity and type of scheme are same as given in NEP.	* Yes/ No	Yes, the scheme is included in the National Electricity Plan (NEP) - 2007. Type of the scheme is the same as given in NEP. Tentative IC indicated in NEP is 1600MW, as against 1800MW presently envisaged in the DPR
4	Category of the project		
	a) Power Project		NA
	b) Power Project having reservoir for flood moderation.		Power Project having reservoir for flood moderation.
	c) Multipurpose Project		NA
5	In case of category 4 (c) above, whether the clearance of Technical	* Yes/ No	NA

S.No.	ITEM	REMARKS	
	Advisory Committee of Ministry of Water Resources is available.		
6	Mode of formation of the Generating Company in terms clause-2 (28) of Electricity Act, 2003	*	The JV Company, Kamala Hydro Electric Power Company Limited (KHEPCL) was formed under an Agreement between Jindal Power Limited (JPL) & Hydro Power Development Corporation of Arunachal Pradesh Limited (HPDCAPL) (copy of the agreement enclosed at **Annexure-1**).
7	Whether the Generating Company is Registered with the Registrar of the Company. Whether Article of Association has Generation as one of the objectives of the Company.	* Yes/ No	Yes, Generating Company registered with Registrar of Companies (Certificate of Incorporation of the company enclosed at **Annexure-2**). Yes, Memorandum and Articles of Association has Generation as one of the objectives of the Company (enclosed at **Annexure-3**).
8	What is the mode of allocation of the scheme whether through i) MOU route up to 100 MW. ii) Tariff based bidding. iii) MOU route with equity participation of State Govt. If so, %age of State Govt. equity. iv) any other mode	*	The Government of Arunachal Pradesh (GoAP) had allotted the Kamala Hydroelectric Project (Kamala HEP) to Hydro Power Development Corporation of Arunachal Pradesh Limited (HPDCAPL), (a public sector undertaking set up by the State Govt. of Arunachal Pradesh for development of Hydro Power Projects in Arunachal Pradesh) under Joint Venture (JV) with Jindal Power Limited (JPL) for its implementation. An Agreement to this effect was subsequently executed on 29th August 2009. Kamala Hydro Electric Power Company Limited (KHEPCL) {formerly Subansiri Hydro Electric Power Company Ltd. (SHEPCL)} was incorporated as a Joint Venture company for development / implementation of the Project. Pursuant to the change in the name of the SPV, addendums to the MoA and JV were executed on 28.09.2012 and 27.11.2012 respectively (copies enclosed at

S.No.	ITEM		REMARKS	
				Annexure-4 and **5,** respectively). Equity Share: HPDCAPL - 26% & JPL- 74%
9	Whether authorization of the Competent Government in favour of the Company to establish, operate and maintain specific Power Station available		* Yes/ No	Yes, the State Govt. of Arunachal Pradesh has granted permission to the JV company to undertake preliminary investigation for preparation of the Pre-feasibility report, detailed investigation for DPR preparation, financing and subsequent development, commissioning, implementation, operation and maintenance of the Project (copy of MoA available at **Annexure-6**).
10	Whether land availability Certificate from State Government available		* Yes/ No	Yes, Land Availability Certificate obtained from Deptt. of Land Management, Govt. of Arunachal Pradesh vide Letter No. LM-83/2010/3630 dated 02.03.2012 (copy of Land Availability Certificate is available at **Annexure-7)**
11	Whether State Govt. authorized the Company to utilize water of that stretch of river		* Yes/ No	Water Resources Deptt., Govt. of Arunachal Pradesh vide letter dated 11.01.2013 communicated No Objection from Irrigation Angle fro execution of the Project (copy of No Objection Certificate is available at **Annexure-8)**
12	Whether power/ energy benefits have been estimated on the updated hydrological series.		* Yes/ No	Yes • Concurrence of Hydrological studies obtained fron CEA in Mar' 2012. • CEA concurred Installed Capacity of 1800 MW in Oct' 2012
13	Whether Cost Estimates enclosed		* Yes/ No	Yes (Volume VI)
	a)	Completed Cost - For private generating companies		Yes
	b)	Present Day Cost - For SEBs & State power Utilities		NA

S.No.	ITEM		REMARKS	
	c)	Present & Completed Cost - For Generating Companies in Public Sector		NA
14	How the project is going to be financed.			The project will be financed at a Debt to Equity Ratio of 70:30.
15	Whether arrangement for absorption/ dispatch of power made		Yes/ No	No
16	Whether arrangements for wheeling/ evacuation of power made		Yes/ No	No
17	Whether any arrangement with the transmission Company to provide evacuation system made. If so, details of the agreement.		Yes/ No	No
18	Whether consent of STU/ State Govt. for availability of off peak power/ energy (pump storage scheme) is obtained.		Yes/ No	Not Applicable
19	Whether salient features of the Project filled up in the prescribed format.		Yes/ No	Yes
20	Status of CWC/ other affected States clearance from inter-state angle, if applicable		*	No inter-state issue. However, clearance from ISM Directorate, CWC shall be obtained.
21	Status of Defence clearance, if required		*	Request for accord of Defence Clearance for implementation of the Project sent to Ministry of Defence, Govt. of India through Secretary (Power), GoAP during Jan' 2013. Clearance is awaited.
22	Whether the area is likely to have any Environmental and Ecological problems due to the altered surface water pattern. If yes, whether the preventive measures have been discussed.		Yes/ No	Yes, certain impacts are envisaged due to the construction of the project and suitable mitigation measures have been discussed in the DPR (Volume-1, Part-B), which shall be detailed in the Environmental Impact Assessment / Environmental Management Plan report.
23	Status of MOEF Clearance from Environmental/ Forest angle			MoEF accorded clearance for pre-construction activities (TOR approval) in the proposed sites during Dec' 2010 (enclosed at **Annexure-9**). Extension in ToR validity & Name change of the

S.No.	ITEM	REMARKS	
			project/company communicated by MoEF during Feb' 2013 (enclosed at **Annexure-10**).Field Survey for environmental base data for all three seasons completed. Field Survey to study the requirement of water release for aquatic life in progress. R&R and Social Impact Assessment study to be taken up after property survey by Distt. Administration.
24	Status of Clearance from Indian Board of Wild Life		Neither Wildlife Sanctuary nor National Park is present in the vicinity of the project area.
25	Status of Clearance from Ministry of Social Justice & Enforcement/ Tribal Affairs (In case Scheduled Tribe population is affected)		Not applied.
26	Whether Rehabilitation and Resettlement Plan from State Revenue Department enclosed.	Yes / No	State Resettlement & Rehabilitation Policy (SRRP) 2008 of Arunachal Pradesh is enclosed.

Note: In case marked "yes" in the check list, attach the supporting documents.

*: Must for examination of DPR

CHECK LIST -2

(to be examined in HPA/ TCD Division)

A. Following chapters/ documents should be available in the DPR

S.No.	Documents	Described in DPR Chapters
i)	Basin Planning	Chapter-3 (Volume-I, Part-A)
ii)	Hydrology	Chapter-7 (Volume-I, Part-A) and Volume-II
iii)	Power Potential Studies	Chapter-9 (Volume-I, Part-A)
iv)	Power evacuation aspects	Chapter-12 (Volume-I, Part-B)
v)	Design of civil structures	Chapter-10 (Volume-I, Part-B) and Volume-IV
vi)	Design of Electrical & Mechanical Equipments	Chapter-11 (Volume-I, Part-B) and Volume-IV
vii)	Geology	Chapter-6 (Volume-I, Part-A) and Volume-III
viii)	Environment and Ecology	Chapter-16 (Volume-I, Part-B)
ix)	Estimated Cost along with basis of preparation of cost, documentary support.	Chapter-17 (Volume-I, Part-B) and Volume-VI
x)	Financial analysis	Chapter-17 (Volume-I, Part-B) and Volume-VI
xi)	Project Layout map and drawing	Volume-VII
xii)	Power Supply position in the state and justification of the scheme from power demand- supply considerations.	Chapter-2 (Volume-I, Part-A)
xiii)	Set of drawings giving general layout of the project, civil components, E&M equipment, Single Line switching scheme	Volume-VII

B. Completeness and relevance of material given in the above chapters needs to be checked.

Annexure-1

Joint Venture Agreement between Jindal Power Limited (JPL) and Hydro Power Development Corporation of Arunachal Pradesh Limited (HPDCAPL)

अरुणाचल प्रदेश ARUNACHAL PRADESH 029244

NO. 04/HPDC/MD/2009-10 dt- 29/8/09

JOINT VENTURE AGREEMENT BETWEEN

JINDAL POWER LIMITED

AND

HYDRO POWER DEVELOPMENT CORPORATION OF ARUNACHAL PRADESH LIMITED

This Joint Venture Agreement ("**Agreement** ") is made at **Itanagar** on this the **29th** day of **August, 2009.**

By and Between:

Jindal Power Limited, a public company incorporated under the Companies Act, 1956 and having its registered office at **Kharsia Road, Raigarh (Chhattisgarh)** through **Mr. Vinod Kumar Abbey, CEO (Hydro Power)**, who is duly authorised by the company to sign and execute this Agreement (hereinafter referred to as **"Jindal"**, which expression shall unless repugnant to the context or meaning thereof be deemed to include its successors and permitted assigns);

AND

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited

JINDAL POWER LIMITED

Hydro Power Development Corporation of Arunachal Pradesh Limited, a public sector undertaking set up by the State Government of Arunachal Pradesh for development of hydro power projects in the State and having its registered office at **Tahunk Tatak Building, Near APPSC, MLA Cottage Road, Itanagar**, acting through **Sri Taru Siga, Managing Director**, who is duly authorised by the Corporation to sign and execute this Agreement (hereinafter referred to as **"Hydro Corporation"**, which expression shall unless repugnant to the context or meaning thereof be deemed to include its successors and permitted assigns);

Jindal and Hydro Corporation shall collectively be referred to as the "Parties" and individually as "Party".

WHEREAS:

(A) The State Government of Arunachal Pradesh has announced Hydro Power Policy 2008 which interalia stipulates that the State would seek private sector participation for development of hydro power potential in the State through Joint Venture model on BOOT basis. The policy further mentions that the Joint Venture model has ostensible benefits, wherein the State becomes partner in the development of the project and thus enjoys the fruits of return on equity as well as that of free power.

(B) The State Government has allotted the 1600 MW Middle Subansiri Hydroelectric Project to Hydro Corporation for developing the Projects under Joint Venture route under the Hydro Policy – 2008.

(C) Jindal has approached the state government for development of the Project in Joint Venture with Hydro Corporation. State Government has approved the development of the Project through Joint Venture Company between Hydro Corporation and Jindal.

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Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Ar.Pr. Undertaking

JINDAL POWER LIMITED

(D) Hydro Corporation and Jindal will incorporate a joint venture company for development of the Project and have agreed to execute this Agreement for establishing a joint venture company by name as may be approved by the ROC under the provisions of the Companies Act, 1956;

(E) Upon incorporation of the JV Company, the JV Company shall become a party to this Agreement by executing a Deed of Adherence in order to comply with the terms and conditions of this Agreement insofar they relate to the JV Company .

(F) The State Government has permitted the JV Company to undertake review of DPR prepared by NHPC, submission of revised DPR and subsequent implementation, operation and maintenance of the Projects in the State. Incase, NHPC does not handover the record / DPR, fresh investigation and DPR preparation shall be done by JV Company.

(G) State Government has allotted the Subansiri Middle HEP (1600 MW) to Hydro Corporation and has also approved the development of the Project through Joint Venture route as per terms and conditions of the tripartite agreement executed between the State Govt, Hydro Corporation and M/s Jindal Power Ltd. The tripartite agreement is annexed as Annexure A and shall form part of this Agreement. The terms or conditions of the tripartite agreement contained in Annexure A can be altered or amended by way of an amendment to be ratified by all the parties..

NOW THEREFORE, in consideration of the premises and the mutual covenants set forth herein, the Parties agree as follows:

1. DEFINITIONS & INTERPRETATIONS

1.1 In this Agreement (including the recitals above and the Schedules and Annexures hereto), except where the context otherwise requires, the following words and expressions shall have the following meanings:

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
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"Agreement"	means this Agreement including any annexures and any amendment thereto made in accordance with the provisions of this Agreement.
"Associate"	means in respect of any Party, its holding company, subsidiaries, as the case may be.
"AoA"	means the Articles of Association of the JV Company, as amended from time to time.
"Act"	means the Companies Act, 1956, as amended from time to time.
"Board"	means the Board of Directors of the JV Company, as constituted from time to time in accordance with the terms hereof.
"Business"	has the meaning ascribed to it in clause 4 of this Agreement.
"CEO"	means the Chief Executive Officer of the JV Company.
"CFO"	means the Chief Financial Officer of the JV Company.
"Directors"	means the directors of the JV Company for the time being and shall include their duly appointed alternates.
"Equity Capital"	means the equity share capital of the JV Company.
"MoA"	means the memorandum of articles of the JV Company, as amended from time to time.
"Parties" / "Party"	means the "Parties" to this Agreement collectively and "Party" shall mean any of the Parties to this Agreement individually.
"Project"	means 1600 MW Middle Subansiri hydro electric project proposed to be established in the State of Arunachal Pradesh including complete hydroelectric power generating facility covering all components such as dam,

Managing Director

JINDAL POWER LIMITED

	intake works, water conductor system, power station, generating units, project roads, bridges, offices, residential facilities store, guest houses, security office and other connected facilities including the interconnection facilities;
"PPA"	means power purchase agreement to be executed between the JV Company and the State Government.
"ROC"	means the Registrar of Companies, Arunachal Pradesh.
"Shareholders"	means the Party or the Parties, for so long as they hold Shares and includes any other person who becomes a Party to this Agreement, in terms of this Agreement.
"Shares"	means equity shares of par value of Rs. 10/- each of the issued, subscribed and paid up Equity Capital of the JV Company.
"State Government"	means the government
"State"	means the state of Arunachal Pradesh.

1.2 In this Agreement (unless the context requires otherwise):

(a) reference to the singular includes a reference to the plural and vice versa, and reference to any gender includes a reference to all other genders.

(b) reference to an individual shall include his legal representative, successor, legal heir, executor and administrator;

(c) reference to statutory provisions shall be construed as meaning and including references also to any amendment or re-enactment (whether before or after the date of this Agreement) for the time being in force and to all statutory instruments or orders made pursuant to statutory provisions;

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Hydro Power Development Corporation of Arunachal Pradesh Limited

JINDAL POWER LIMITED

(d) references to any statute or regulation made using a commonly used abbreviation, shall be construed as a reference to the short title of the statute or full title of the regulation; and,

(e) references to any Article, Clause, Schedule, Annexure or Exhibit shall be deemed to be a reference to such Article, Clause, Schedule, Annexure or Exhibit of or to this Agreement.

1.3 The terms and conditions of tripartite agreement which is annexed as annexure A to this agreement shall be deem to form an integral part of this agreement.

2. SCOPE AND TERM OF THE AGREEMENT

2.1 This Agreement sets out the framework of understanding between the Parties as to the formation of the JV Company for the development and operation and maintenance of the Project in the State, which includes complying with the respective obligations of each Party and such obligations of each Party as mentioned in terms and conditions contained in Annexure A.

2.2 This Agreement shall come into force on the date of execution of this Agreement by the Parties and shall, subject to Clause 14 of this Agreement, continue in full force till the completion of the Project.

2.3 This Agreement supersedes any previous agreements or arrangements between the Parties in regard to formation of JV Company for execution of Subansiri Middle HEP (1600 MW) in the State and represents the entire understanding between the Parties.

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3. JV COMPANY

3.1 Form of the JV Company

The JV Company shall be incorporated as a limited company with the name as may be approved by the ROC, under the Act, for the purposes of this Agreement. The Parties will endeavor to incorporate the JV Company within a period of 3 months from the signing of this Agreement and in this respect agree to share the responsibility, cost and burden of work associated with the formation of the JV Company.

3.2 Location of its registered office

The registered office of the JV Company shall at all times be in the State of Arunachal Pradesh.

3.3 MoA and AoA of the JV Company

The MoA and AoA of the JV Company shall be as agreed between the Parties and shall be printed in English. The MoA and AoA shall be consistent with and will, to the extent possible, incorporate the substantive provision of this Agreement and terms and conditions contained in Annexure A.

3.4 Capital Structure of the JV Company

3.4.1 Authorised Capital

The initial proposed authorized capital of the JV Company shall be **Rs 5.00 crores** divided into **50,00,000** shares of Rs. 10 each.

3.4.2 Paid-Up Capital

The initial Paid-Up Capital of the JV Company shall be **Rs. 1.00 crore** divided into **10,00,000** shares of Rs. 10 each.

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3.4.3 **Capital Contribution of Parties**

3.4.3.1 Initially the shareholding of the Parties in the JV Company will be as follows:

Jindal: 74%

Hydro Corporation: 26%

3.4.3.2 Each Party shall arrange the equity shareholding as above. In the event the HPDCAPL is unable to arrange adequate loan for funding its contribution in the Joint Venture Company even with the State Government guarantee as security, the equity share of the HPDCAPL in the Joint Venture may be reviewed proportionately with the approval of the State Government.

4. BUSINESS OF THE JV COMPANY, OBLIGATIONS OF PARTIES

4.1 The State Government has awarded the Project to Hydro Corporation to be implemented on joint venture route basis under the Hydro Policy - 2008 and the State Government has approved the joint venture between Hydro Corporation and Jindal and incorporation of JV Company for development and operation of the Project. The State Government has granted permission to Hydro Corporation and Jindal to undertake review of DPR prepared by NHPC, submission of revised DPR and subsequent implementation, operation and maintenance of the Project in the State.

4.2 Further each Party agrees to comply with its respective obligations, for the purposes of successful continuation and completion of the Project in the State and agrees to place at the disposal of the other Party the benefit of its experience, knowledge and skill to secure optimum benefit for the Project.

4.3 The JV Company, subject to the MoA and AoA, may undertake such other activities as the Board may approve from time to time with prior approval of State Govt.

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5. MANAGEMENT OF THE JV COMPANY

5.1 The Board shall comprise of minimum of 5 Directors. So long as the board comprises 5 Directors, Jindal shall be represented by 4 Directors. In case the number of Directors is increased beyond 5, Jindal shall at all times be represented by at least 50% of the board strength (any fraction rounded off to 1) + 1 Director. Hydro Corporation shall be represented by 1 Director. Any increase in the total number of Directors shall be subject to prior approval of the Board in writing. The Chairman, at all times, of the Board shall be elected from the Directors represented by Jindal. The Chairman of the Board shall also act as Chairman of the General Meetings and if he is not present, the Directors may choose one among them to be the Chairman. The Chairman shall have a second or casting vote.

5.2 If financial institutions/ banks as a condition of lending require the appointment of their nominee as a Director for the period their loans is outstanding the parties hereby agree to appoint such nominee as an additional Director.

5.3 In case the public/ financial institution/ banks/ mutual funds subscribe to the equity stake in the company offered to them and they require the appointment of their nominee(s) as Director(s), then the parties hereby agree to appoint such directors as additional director.

5.4 The Parties shall ensure that the JV Company shall indemnify each Director against all claims and liabilities incurred by reason of his or her being a Director of the JV Company, provided that the Director's acts or omissions giving rise to such claim or liability did not constitute intentional misconduct or gross negligence or a violation of applicable laws.

5.5 Directors shall not be paid any salary by the JV Company unless the JV Company directly or indirectly employs the Director(s) for whom salary may be paid as decided by the Management.

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5.6 The Board shall appoint the CEO, CFO and other key officials of the JV Company.

5.7 The Parties including their nominees and Associates shall ensure that the individuals nominated by either of the Parties to be the Directors of the JV Company are duly elected and for this purpose shall use the voting rights attached to the respective Shares held by them in favour of the election of such individuals as Director.

5.8 The Parties shall be entitled from time to time to remove their respective Directors and nominate others in place of the Directors so removed in the JV Company

6. MEETINGS OF THE JV COMPANY

6.1 Board Meetings

6.1.1 The Board shall meet regularly at least four times a year, i.e., once in each quarter.

6.1.2 At least 5 days prior notice shall be given to all Directors of the Board whether residing in India or otherwise. In case of Directors residing outside India, notice shall be sent by telex/fax/email. Each notice shall set out in sufficient detail, the agenda of items to be transacted at each meeting. A meeting may be held at short notice if it is agreed by all the Directors present in meeting.

6.1.3 The quorum necessary for transacting any business of or taking any decision of the Board shall be as per relevant provisions of companies Act, 1956.

Managing Director
Hydro Power

6.1.4 If a director nominated by a Party is unable to attend the meetings of the Board, such Party shall be entitled to nominate in his place any alternate director as per the provisions of Section 313 of the Act to attend such meetings.

6.1.5 The Parties on their behalf and on behalf of their Associates and nominees undertake with each other as follows:-

a) to exercise voting rights and powers available to them in relation to the JV Company so as to give full effect to the terms and conditions of this Agreement, AoA and terms and conditions contained in Annexure A.

b) to ensure that the Directors nominated by them and other representatives shall support and implement all reasonable proposals which come before the general meetings, board meetings or committee of the JV Company for the proper development and conduct of the Business as contemplated in this Agreement; and

c) use all reasonable endeavors to promote the Business and the interests of the JV Company.

6.1.6 The decisions in the meetings of the Board shall be valid and effective if approved by majority of the Directors present and voting in the meeting.

6.1.7 The minutes of the meeting shall be circulated to all the Directors of the Board.

6.2 **Shareholders Meeting**

6.2.1 An annual general meeting of the JV Company shall be held annually in accordance with the Act, but not later than 6 months from the end of financial year.

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JINDAL POWER LTD

6.2.2 An extra ordinary meeting of the shareholders of the JV Company may be held at any time upon passing a Board resolution to this effect subject to the provisions of the Act.

6.2.3 Subject to the Act, general meetings shall be held at the registered office of the JV Company, or at such other place as may be decided by the Board of the JV Company and shall be specified in the notice calling the meeting.

6.2.4 Except in respect of matters which are required pursuant to the Act to be approved at a general meeting by a special resolution, all decisions in general meeting of JV Company's shareholders shall be approved by ordinary resolution.

6.3 **Matters requiring consent of the Parties**

The JV Company shall not give effect to any decision or resolution in respect of any of the following matters except upon the affirmative vote of each of the Parties in the Shareholders meeting and/or Board meeting, as applicable:-

a) Dissolution, liquidation or winding up of the JV Company.

b) Commencement of any new business or any diversification from the core Business of the JV Company.

c) Merger or amalgamation with any other entity or split/division of the JV Company.

d) Closure of the Business or activities of the JV Company or sale or transfer or any of its undertaking.

e) Creation of mortgage, charge, lien or encumbrance on the movable and immovable assets of the JV Company except in the normal course of business of the JV Company for securing loans from the lenders.

f) Any sale, lease or transfer of the whole or substantial part of the undertaking or assets of the JV Company.

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JINDAL POWER LIMITED

7. FINANCIAL AFFAIRS AND ACCOUNTING

7.1 Fiscal Year

The fiscal year ("**Fiscal Year**") of the Company shall be from first day of April every calendar year to the thirty first day of March of the following calendar year (both days inclusive). The first Fiscal Year will begin from the date of incorporation of the Company and end on immediately following thirty first day of March (both days inclusive).

7.2 Accounting

(a) The accounting system of and procedures to be adopted by the JV Company shall be approved by the Board and shall be in accordance with accepted accounting standards and the laws of India.

(b) The JV Company shall maintain complete and accurate financial and accounting books and records.

(c) All financial statements, reports and accounting documents shall be in English language.

7.3 Audit

(a) Management will nominate a recognized accounting firm in India to be the statutory auditor of the JV Company and who shall be appointed by the JV Company, in accordance with the Act, as its statutory auditor.

(b) The JV Company shall cause an audit of the books of account, records and affairs of the JV Company each year as soon as practicable following the close of the Fiscal Year. Each Party shall be furnished a copy of report of each Fiscal Year's audit not later than 10 days after the submission of such report by the statutory auditor.

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited

JINDAL POWER LIMITED

8. TRANSFER OF SHARES

8.1 Each Party shall hold shares in the JV Company in accordance with this Agreement and shall be entitled to transfer shares in accordance with the AoA of the JV Company.

8.2 Jindal will be at liberty to transfer its Shares in JV Company to its holding or subsidiary company or associates. Similarly Hydro Corporation will be at liberty to transfer its Shares in JV Company to its holding or subsidiary company or associates.

8.3 Save as otherwise permitted under Clause 8.1 above, Hydro Corporation shall be free to transfer all or part of the Shares to any person, subject to such Shares being first offered for sale to Jindal (**'Right of First Offer**) in the manner specified below.

8.3.1 Hydro Corporation shall send a written notice to Jindal (**"Notice"**), indicating its desire to sell the Shares, and setting forth the price, the number of shares and the material terms at which the Shares are offered for sale.

8.3.2 Upon receipt of the Notice, Jindal shall have the option, but not the obligation, to purchase the Shares offered for sale upon the terms and conditions to be agreed between the Parties. The Right of First Offer shall be exercised by Jindal within thirty (30) days of receipt of such Notice by Jindal.

8.3.3 If Jindal exercises the Right of First Offer under Clause 8.3.1 and 8.3.2 above, it shall be entitled to acquire such number of Shares as it agrees to buy.

8.3.4 If Jindal does not exercise its Right of First Offer, then Hydro Corporation shall be free to transfer the Shares to any third party at a price and terms and conditions stated in the Notice. Any change in price or terms and conditions will entitle a fresh Right of First Offer. Further, such sale by the Hydro Corporation shall be completed within 60 days from the date of the Notice.

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited

JINDAL POWER LTD

8.3.5 The above conditions from 8.3 to 8.3.4 will be applicable mutatis mutandi to Jindal also except when the Shares are transferred to its holding or subsidiary company or associates.

9. SECRECY

A Party shall at no time, without the prior written agreement of the other Party.

a) Disclose to any third party, or enable any third party to note any information pertaining to this Agreement.

b) Reproduce, copy, disclose to, place at the disposal of, use on behalf of or enable any third party to use any information pertaining to or incorporated within this Agreement except as may be required to be furnished under any laws; and

c) Make any publicity releases or announcements concerning any aspect of this Agreement.

10. CONFIDENTIALITY

Each Party hereto agrees that it shall not divulge any trade, commercial or technical secrets or confidential matters of one another to any third party, save and except for the purpose of implementation, operation and maintenance of the Project.

11. LIABILITY

11.1 Each Party warrants that it will indemnify and keep indemnified the other Party against all legal liabilities arising out of or in connection with the performance, or otherwise, of its obligations under this Agreement.

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of AP Undertaking)

JINDAL POWER LIMITED

11.2 In the event of it being alleged by one Party in writing that any legal liability is attributable to the other Party, the Parties shall jointly use reasonable endeavours to reach agreement on the liabilities to be borne by the defaulting Party, and in the event of the Party failing to agree, such dispute shall be determined by arbitration in accordance with clause 16.4 of this Agreement.

12. INTELLECTUAL PROPERTY RIGHTS

No transfer of any intellectual property rights held by the individual Parties is implied or intimated under this Agreement.

13. SOLICITING OF PERSONNEL

Each Party agrees that during the tenure of this Agreement, it shall not solicit any personnel employed by the other Party in an attempt to employ or engage on any other basis or offer such employment or engagement without the other Party's prior agreement in writing.

14. TERMINATION

14.1 Termination

This Agreement shall terminate if at any time entire transfer of Shares is made in accordance with Clause 8 by any Party.

14.2 Mutual Termination

This Agreement shall terminate if mutually agreed between the Parties.

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Ar.Pr. Undertaking

JINDAL POWER LIMITED

14.3 Winding up

If a resolution is passed to wind up the JV Company or if a liquidator is otherwise appointed, this Agreement shall terminate on the dissolution of the JV Company pursuant to such resolution or appointment, liquidator as the case may be. For winding up of or dissolution of the JV Company, prior approval of the State Govt shall be required notwithstanding any resolution.

14.4 Consequences of Termination

Upon termination of this Agreement, the Parties shall be relieved and discharged from all liabilities, obligations or claims under this Agreement, except for such rights, obligations and liabilities of the Parties which have accrued under this Agreement prior to termination.

15. REPRESENTATIONS OF THE PARTIES

15.1 Each Party represents, severally and not jointly, to the other Party hereto that:

(a) it has the full power and authority to enter into, execute and deliver this Agreement and to perform the transaction contemplated hereby and that it is duly incorporated and existing under the laws of India and that the execution and delivery by it of this Agreement and the performance by it of the transactions contemplated hereby have been duly authorized by the board of directors of the Party;

(b) this Agreement constitutes the legal, valid and binding obligation of such Party, enforceable against such Party in accordance with its terms; and,

(c) the execution, delivery and performance of this Agreement by such Party and the consummation of the transactions contemplated hereby will not

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
Govt. of A.P. Undertaking

JINDAL POWER LIMITED

(i) violate any provision of the organizational or governance documents of such Party;

(ii) conflict with or result in any material breach or violation of any of the terms and conditions of, or constitute (or with notice or lapse of time or both constitute) a default under, any instrument, contract or other agreement to which such Party is a party or by which such Party is bound;

(iii) violate any order, judgement or decree against, or binding upon such Party.

16. MISCELLANEOUS

16.1 Severability

Each of the provisions contained in this Agreement shall be severable and the unenforceability of one shall not affect the enforceability of any other or the remainder of this Agreement.

16.2 Waiver

The failure of any Party to enforce any condition or part of this Agreement at any time shall not be construed as a waiver of that condition or part, nor shall it forfeit any rights to future enforcement thereof.

16.3 Governing Law and Jurisdiction

This Agreement shall be construed and enforced in accordance with and governed by the laws of India and the Courts in Itanagar shall have exclusive jurisdiction.

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Arunachal Pradesh Undertaking)

JINDAL POWER LIMITED

16.4 Dispute Resolution

16.4.1 In the event of any difference / dispute arising between the Parties ("the Dispute") under this Agreement, the same shall be resolved in accordance with the provisions of the Arbitration and Conciliation Act, 1996, as amended from time to time or replaced by any other statute, unless the same has not been resolved amicably by mutual consultations within 90(Ninety) days of the reference of Dispute by any Party. The venue of the arbitration shall be Itanagar. The language of arbitration shall be English. The cost of arbitration shall be shared equally.

16.4.2 The Arbitration shall be conducted by a panel of three arbitrators, one each to be appointed by Hydro Corporation and by Jindal within 21 days from the date of arbitration notice by a Party and the third arbitrator to be appointed by two appointed arbitrators within 30 days of their appointment. In the event, arbitrators on the arbitration panel cannot be appointed as mentioned above, the arbitrators shall be appointed as per provisions of the Arbitration and Conciliation Act, 1996.

16.4.3 The arbitral tribunal will not have the jurisdiction to grant interest till the date of the award on any amount and in respect of any period.

16.5 Counterparts

More than one counterparts of this Agreement may be executed by the Parties and all such counterparts shall be deemed originals and shall be deemed to be a single Agreement.

16.6 Save and except as provided aforesaid, none of the Parties hereto shall assign their respective rights and obligations hereunder without prior consent in writing of the other Party hereto.

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited

JINDAL POWER

16.7 Violation of terms

The Parties agree that each of the Parties shall be entitled to an injunction, restraining order, right for recovery, suit for specific performance or such other equitable relief as a court of competent jurisdiction may deem necessary or appropriate to restrain the other Party or from committing any violation or enforce the performance of the covenants, representations and obligations contained in this Agreement. These injunctive remedies are cumulative and are in addition to any other rights and remedies that such Parties may have at law or in equity, including without limitation a right for damages.

16.8 Fees and Expenses

Each Party shall bear its own fees and expenses in connection with the preparation, execution and performance of this Agreement and the transactions contemplated hereby and thereby, including, without limitation, all fees and expenses of agents, representatives, counsel and accountants.

16.9 Notices

All communications, notices and consents provided for herein shall be in writing and be given in person or by means of telex, telecopy or other wire transmission with request for assurance of receipt in a manner typical with respect to communications of that type or by registered or certified mail, returned receipt requested and shall become effective: (a) on delivery if given in person; (b) on the date of transmission if sent by telex, telecopy, or other wire transmission or (c) on receipt if sent by mail.

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Arunachal Pradesh Undertaking)

JINDAL POWER LIMITED

Notice shall be addressed as follows:-

To Jindal:

1) The Director
Jindal Power Ltd.
Jindal Centre, 12 Bhikaji Cama Place, New Delhi – 66
Phone – 011-26188340
Fax – 011-26180254

To Hydro Corporation:

2) The Managing Director
Hydro Power Development Corporation of Arunachal Pradesh Limited
Tahunk Tatak Building
Near APPSC
MLA Cottage Road
Itanagar.

16.10 Independent Rights

Each of the rights of the Parties hereto under this Agreement are independent, cumulative and without prejudice to all other rights available to them, and the exercise or non-exercise of any such rights shall not prejudice or constitute a waiver of any other right of the Party, whether under this Agreement or otherwise.

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited

JINDAL POWER LIMITED

16.11 Force Majeure

Neither Party shall be responsible in any manner for the time delays and/or losses arising out of the Force Majeure situation such as war, earthquake, flood, fire, explosion, epidemic, cyclone, external invasion, civil commotion, riots, terrorism, Governmental acts/ embargoes etc., which are beyond the reasonable control of the affected Party. However, the Party so affected, upon serving notice thereof to the other Party setting out therein particulars thereof shall be excused from performance of its obligations to the extent prevented, delayed or interfered with for the period Force Majeure conditions persist. The Party so affected shall make its best efforts to remove such cause of Force Majeure as expeditiously as possible and shall continue performance hereunder with due dispatch whenever such cause(s) is removed.

17. With conformity to clause no.23 of the MOA signed among Govt. of Arunachal Pradesh, Hydro Power Development Corporation of Arunachal Pradesh Limited and Jindal Power Limited, this agreement shall be effective after receipt of Hon'ble Supreme Court's Order lifting the blanket ban on upstream Projects in Subansiri Basin in I.A.No.1362-63 in 966 & 1012 in W.P. (C) No.202/1995 and on receipt of upfront premium including processing fee by the State Govt. from the Jindal Power Limited on behalf of the JV Company

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Gov[illegible])

JINDAL POWER LIMITED

IN WITNESS WHEREOF this Agreement has been entered into the date and year first before written.

SIGNED for and on behalf of

1. Jindal Power Limited:

Wednesday 29/08/07

(Mr. Vinod Kumar Abbey)
CEO, Hydro Power.

JINDAL POWER LIMITED

2. Hydro Power Development Corporation of Arunachal Pradesh Limited:

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Pr. Undertaking

Managing Director

WITNESSES:

1. Mantri
KAPIL MANTRI
C/o Jindal Centre
12, Bhikaji Place
New Delhi - 66

2. (N. MATHESWARAN)
Asst. Manager (C)
H.P.D.C.A.P. Ltd.,
Itanagar. A.P.,

Annexure-2

Certificate of Incorporation of Company

भारत सरकार-कॉर्पोरेट कार्य मंत्रालय

कम्पनी रजिस्ट्रार कार्यालय, असाम, त्रिपुरा, मणिपूर, नागालैंड, मेघालय, अरुणाचल प्रदेश, मिजौराम

नाम परिवर्तन के पश्चात नया निगमन प्रमाण-पत्र

कॉर्पोरेट पहचान संख्या : U40102AR2010PLC008301

मैसर्स SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

के मामले मे, मैं एतदद्वारा सत्यापित करता हूँ कि मैसर्स
SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

जो मूल रुप में दिनांक बारह मार्च दो हजार दस को कम्पनी अधिनियम, 1956 (1956 का 1) के अतंर्गत मैसर्स
SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

के रुप में निगमित की गई थी, ने कम्पनी अधिनियम, 1956 की धारा 21 की शर्तों के अनुसार विधिवत आवश्यक विनिश्चय पारित करके तथा लिखित रुप में यह सूचित करके की उसे भारत का अनुमोदन, कम्पनी अधिनियम, 1956 की धारा 21 के साथ पठित, भारत सरकार, कम्पनी कार्य विभाग, नई दिल्ली की अधिसूचना सं. सा. का. नि 507 अ दिनांक 24.6.1985 एस.आर.एन. B37396991 दिनांक 25/04/2012 के द्वारा प्राप्त हो गया है, उक्त कम्पनी का नाम आज परिवर्तित (रुपे में मैसर्स
KAMALA HYDRO ELECTRIC POWER COMPANY LIMITED

हो गया है और यह प्रमाण-पत्र, कथित अधिनियम की धारा 23(1) के अनुसरण में जारी किया जाता है।

यह प्रमाण-पत्र शिलांग में आज दिनांक पच्चीस अप्रेल दो हजार बारह को जारी किया जाता है।

GOVERNMENT OF INDIA - MINISTRY OF CORPORATE AFFAIRS

Registrar of Companies, Assam, Tripura, Manipur, Nagaland, Meghalaya, Arunachal Pradesh and Mizoram

Fresh Certificate of Incorporation Consequent upon Change of Name

Corporate Identity Number : U40102AR2010PLC008301

In the matter of M/s SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

I hereby certify that SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED which was originally incorporated on Twelfth day of March Two Thousand Ten under the Companies Act, 1956 (No. 1 of 1956) as SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED having duly passed the necessary resolution in terms of Section 21 of the Companies Act, 1956 and the approval of the Central Government signified in writing having been accorded thereto under Section 21 of the Companies Act, 1956, read with Government of India, Department of Company Affairs, New Delhi, Notification No. G.S.R 507 (E) dated 24/06/1985 vide SRN B37396991 dated 25/04/2012 the name of the said company is this day changed to KAMALA HYDRO ELECTRIC POWER COMPANY LIMITED and this Certificate is issued pursuant to Section 23(1) of the said Act.

Given at Shillong this Twenty Fifth day of April Two Thousand Twelve.

Validity unknown

Registrar of Companies, Assam, Tripura, Manipur, Nagaland, Meghalaya, Arunachal Pradesh and Mizoram

कम्पनी रजिस्ट्रार, असाम, त्रिपुरा, मणिपूर, नागालैंड, मेघालय, अरुणाचल प्रदेश, मिजौराम

*

digitally signed by the Registrar through a system generated digital signature under rule 5(2) of the Companies (Electronic Filing and Authentication of Documents) Rules, 2006.

The digitally signed certificate can be verified at the Ministry website (www.mca.gov.in).

कम्पनी रजिस्ट्रार के कार्यालय अभिलेख में उपलब्ध पत्राचार का पता :
Mailing Address as per record available in Registrar of Companies office:

KAMALA HYDRO ELECTRIC POWER COMPANY LIMITED
TAHUNG TATAK BUILDING, NEAR APPSC, MLA COTTAGE ROAD,
ITA NAGAR - 791111,
Arunachal Pradesh, INDIA

Annexure-3

Memorandum and Articles of Association

भारत सरकार–कॉर्पोरेट कार्य मंत्रालय

कम्पनी रजिस्ट्रार कार्यालय, असाम, त्रिपुरा, मणिपूर, नागालैंड, मेघालय, अरुणाचल प्रदेश, मिजौराम

नाम परिवर्तन के पश्चात नया निगमन प्रमाण–पत्र

कॉर्पोरेट पहचान संख्या : U40102AR2010PLC008301

मैसर्स SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

के मामले मे, मैं एतदद्वारा सत्यापित करता हूँ कि मैसर्स
SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

जो मूल रुप में दिनांक बारह मार्च दो हजार दस को कम्पनी अधिनियम, 1956 (1956 का 1) के अतंर्गत मैसर्स
SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

के रुप में निगमित की गई थी, ने कम्पनी अधिनियम, 1956 की धारा 21 की शर्तों के अनुसार विधिवत आवश्यक विनिश्चय पारित करके तथा लिखित रुप में यह सूचित करके की उसे भारत का अनुमोदन, कम्पनी अधिनियम, 1956 की धारा 21 के साथ पठित, भारत सरकार, कम्पनी कार्य विभाग, नई दिल्ली की अधिसूचना सं. सा. का. नि 507 अ दिनांक 24.6.1985 एस.आर.एन. B37396991 दिनांक 25/04/2012 के द्वारा प्राप्त हो गया है, उक्त कम्पनी का नाम आज परिवर्तित (रुप) में मैसर्स
KAMALA HYDRO ELECTRIC POWER COMPANY LIMITED

हो गया है और यह प्रमाण–पत्र, कथित अधिनियम की धारा 23(1) के अनुसरण में जारी किया जाता है।

यह प्रमाण–पत्र शिलांग में आज दिनांक पच्चीस अप्रेल दो हजार बारह को जारी किया जाता है।

GOVERNMENT OF INDIA - MINISTRY OF CORPORATE AFFAIRS

Registrar of Companies, Assam, Tripura, Manipur, Nagaland, Meghalaya, Arunachal Pradesh and Mizoram

Fresh Certificate of Incorporation Consequent upon Change of Name

Corporate Identity Number : U40102AR2010PLC008301

In the matter of M/s SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

I hereby certify that SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED which was originally incorporated on Twelfth day of March Two Thousand Ten under the Companies Act, 1956 (No. 1 of 1956) as SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED having duly passed the necessary resolution in terms of Section 21 of the Companies Act, 1956 and the approval of the Central Government signified in writing having been accorded thereto under Section 21 of the Companies Act, 1956, read with Government of India, Department of Company Affairs, New Delhi, Notification No. G.S.R 507 (E) dated 24/06/1985 vide SRN B37396991 dated 25/04/2012 the name of the said company is this day changed to KAMALA HYDRO ELECTRIC POWER COMPANY LIMITED and this Certificate is issued pursuant to Section 23(1) of the said Act.

Given at Shillong this Twenty Fifth day of April Two Thousand Twelve.

Validity unknown
Digitally signed by Gulab Chetri
Date: 2012.04.25 17:12:50 GMT+05:30

Registrar of Companies, Assam, Tripura, Manipur, Nagaland, Meghalaya, Arunachal Pradesh and Mizoram

कम्पनी रजिस्ट्रार, असाम, त्रिपुरा, मणिपूर, नागालैंड, मेघालय, अरुणाचल प्रदेश, मिजौराम

*| 1

digitally signed by the Registrar through a system generated digital signature under rule 5(2) of the Companies (Electronic Filing and Authentication of Documents) Rules, 2006.

The digitally signed certificate can be verified at the Ministry website (www.mca.gov.in).

कम्पनी रजिस्ट्रार के कार्यालय अभिलेख में उपलब्ध पत्राचार का पता :
Mailing Address as per record available in Registrar of Companies office:

KAMALA HYDRO ELECTRIC POWER COMPANY LIMITED
TAHUNG TATAK BUILDING, NEAR APPSC, MLA COTTAGE ROAD,
ITA NAGAR - 791111,
Arunachal Pradesh, INDIA

सत्यमेव जयते

प्रारुप 1

पंजीकरण प्रमाण–पत्र

कॉर्पोरेट पहचान संख्या : **U40102AR2010PLC008301** **2009-2010**

मैं एतदद्वारा सत्यापित करता हूँ कि मैसर्स

SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

का पंजीकरण, कम्पनी अधिनियम 1956 (1956 का 1) के अंतर्गत आज किया जाता है और यह कम्पनी लिमिटेड है ।

यह निगमन–पत्र आज दिनांक बारह मार्च दो हजार दस को मेरे हस्ताक्षर से शिलांग में जारी किया जाता है ।

Form 1

Certificate of Incorporation

Corporate Identity Number : **U40102AR2010PLC008301** **2009-2010**

I hereby certify that SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED is this day incorporated under the Companies Act, 1956 (No. 1 of 1956) and that the company is limited.

Given under my hand at Shillong this Twelfth day of March Two Thousand Ten.

कम्पनी रजिस्ट्रार REGISTRAR OF COMPANIES NORTH EAST REGION SHILLONG उत्तर पूर्व क्षेत्र शिलांग

Sd/-
(DIP NARAYAN CHOWDHURY)
सहायक कम्पनी रजिस्ट्रार / Assistant Registrar of Companies
असाम, त्रिपुरा, मणिपूर, नागालैंड, मेघालय, अरूणाचल प्रदेश, मिजौराम
Assam, Tripura, Manipur, Nagaland, Meghalaya,
Arunachal Pradesh and Mizoram

कम्पनी रजिस्ट्रार के कार्यालय अभिलेख में उपलब्ध पत्राचार का पता :
Mailing Address as per record available in Registrar of Companies office :
SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED
TAHUNG TATAK BUILDING, NEAR APPSC, MLA COTTAGE ROAD,
ITA NAGAR - 791111,
Arunachal Pradesh, INDIA

सत्यमेव जयते

व्यापार प्रारंभ करने का प्रमाण-पत्र

कम्पनी अधिनियम 1956 की धारा 149 (3) के अनुसरण में

कॉर्पोरेट पहचान संख्या : **U40102AR2010PLC008301**

मैं एतदद्वारा सत्यापित करता हूँ कि मैसर्स
SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED

जिसका निगमन, कम्पनी अधिनियम, 1956 (1956 का 1) के अंतर्गत दिनांक बारह मार्च दो हजार दस को किया गया था और जिसने निर्धारित प्रपत्र में घोषणा प्रस्तुत की है या विधिवत सत्यापित किया है कि उक्त कम्पनी ने, अधिनियम की धारा 149 (2) (क) से (ग) तक की शर्तों का अनुपालन कर लिया है और व्यापार करने के लिए हकदार है ।

यह प्रमाण-पत्र आज दिनांक पांच मई दो हजार दस को मेरे हस्ताक्षर से शिलांग में जारी किया जाता है ।

Certificate for Commencement of Business

Pursuant of Section 149(3) of the Companies Act, 1956

Corporate Identity Number : **U40102AR2010PLC008301**

I hereby certify that the SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED which was incorporated under the Companies Act, 1956 (No. 1 of 1956) on the Twelfth day of March Two Thousand Ten, and which has this day filed or duly verified declaration in the prescribed form that the conditions of the Section 149 (2) (a) to (c) of the said act, have been complied with and is entitled to commence business.

Given under my hand at Shillong this Fifth day of May Two Thousand Ten.

कम्पनी रजिस्ट्रार REGISTRAR OF COMPANIES NORTH EAST REGION SHILLONG उत्तर पूर्व क्षेत्र शिलांग

Sd/-
(GULAB CHAND YADAV)
कम्पनी रजिस्ट्रार / Registrar of Companies
असाम, त्रिपुरा, मणिपूर, नागालैंड, मेघालय, अरूणाचल प्रदेश, मिजौराम
Assam, Tripura, Manipur, Nagaland, Meghalaya,
Arunachal Pradesh and Mizoram

कम्पनी रजिस्ट्रार के कार्यालय अभिलेख में उपलब्ध पत्राचार का पता :
Mailing Address as per record available in Registrar of Companies office :
SUBANSIRI HYDRO ELECTRIC POWER COMPANY LIMITED
TAHUNG TATAK BUILDING, NEAR APPSC, MLA COTTAGE ROAD,
ITA NAGAR - 791111,
Arunachal Pradesh, INDIA

(THE COMPANIES ACT, 1956)

(COMPANY LIMITED BY SHARES)

MEMORANDUM OF ASSOCIATION

OF

KAMALA HYDRO ELECTRIC POWER COMPANY LIMITED

I. The Name of the Company is Kamala Hydro Electric Power Company Limited.

II. The Registered Office of the Company will be situated in the State of Arunachal Pradesh.

III. The objects for which the Company is established are :

(A) THE MAIN OBJECTS TO BE PURSUED BY THE COMPANY ON ITS INCORPORATION ARE:–

1. To promote, develop, operate, maintain and own Kamala Hydro Electric Power Project and to acquire, erect, construct, establish, improve, manage, operate, alter, carry on, control, take on hire/lease power plants, co-generation power plants, energy conservation projects, power houses, transmission and distribution system for generation, distribution, transmission and supply of electrical energy and to carry on the business of general electric power supply in any or all of its branches and to construct, lay down, establish, fix and carry out all power stations, cables and wires, lines, accumulators, lamps and works and to generate, accumulate, distribute and supply electricity and to light cities, towns, villages, street, docks, markets, theaters, buildings, industrial complexes and any other places.

2. To carry on the business of generation, storage, transmission, distribution, supply, purchase, sale of hydro electricity / energy and of its kind.

3. To function as a licensee and deals in hydro power to state electricity boards, state governments, appropriate authorities, licensees, specific industrial units and others consumers for industrial, commercial, agricultural, household and any other purpose in India and elsewhere in any area.

4. To carry on the business of electrician and electrical, mechanical engineers, suppliers of electricity, or other power / energy for the purpose of light, heat, motive power or otherwise, and manufacturer and dealers of apparatus and things required for or capable of being used in connection with the generation, distribution, supply, accumulation and employment of electricity, galvanism, magnetism or non-conventional, renewable or new energy / power.

(B) THE OBJECTS INCIDENTAL OR ANCILLARY TO THE ATTAINMENT OF THE MAIN OBJECTS STATED IN CLAUSE ABOVE (A):–

1. To purchase, otherwise acquire, own, import all materials, substances, appliances, machines, containers and such other articles and apparatus and things capable of being used in the main business and to own, lease and otherwise acquire and use facilities of whatever kind as may be conducive to the effective working of the main business or any part thereof.

2. To buy, dispose off repair, alter, improve, exchange, let out on hire, import in all factories, work plants, machinery tools, utensils, appliances, apparatus, products, materials, substances, articles and things capable of being used in any business which this company is competent to carry on and experiment with render market and deal in all products residual and by-products incidental to or obtained in the main business carried on by the Company.

3. To purchase, take on lease or tenancy or in exchange, hire, take options over or otherwise acquire any estate or interest whatsoever and to hold develop work, cultivate, concessions, grants decrees, licences, privileges, claims, options, leases, property, real or personal rights or powers of any kinds which may appear to be necessary for the business of the Company.

4. To dispose off exchange, mortgage, let on lease, royalty or tribute, grant licences, easements, options and other rights over or and in other manner deal with or dispose of the whole or any part of the undertaking, property, assets, rights and effects of the Company for consideration as may be thought fit and in particular for stocks, shares, debentures whether fully or partly paid-up or securities of any other company having main objects whole or in part similar to those of the Company.

5. To lend and advance money, in connection with the main business either with or without security and give credit, to such persons (including Government) and upon such terms and conditions as the Company may think fit, provided that the Company shall not carry on banking business within the meaning of Banking Regulations Act, 1949.

6. To undertake financial and commercial obligations, transactions and operations of all kinds in connection with the main business of the Company.

7. To guarantee the performance of any contract or obligations and the payment of money or dividends an d interest on any stock, shares or securities of any company, corporation, firm or person in any case in which such guarantee may be considered directly or indirectly to furthering the objects of the Company.

8. To draw, make, accept, endorse, negotiate, execute and issue bills of exchange, promissory notes, bills of lading, debentures and such other negotiable or transferable instruments or securities of all types.

9. To do all or any of the main object either as principals, agents, trustees, contractors or otherwise and either alone or in conjunction with others and either by or through agents, sub-contractors, trustees or otherwise.

10. To acquire and takeover all or any part of the business, property and liabilities of any person, firm or company carrying on or proposing to carry on any business which this Company is authorised to carry on or possess property suitable for the main business of the Company.

11. To form, incorporate or promote any company or companies whether in India or elsewhere having amongst its or their objects the acquisition of all or any of the assets or controls management or development of the Company or any other objects which in the opinion of the Company could or might directly or indirectly assist the Company in the management of its main business or the development of its properties or otherwise prove advantageous to the Company and to pay all or any of the costs and expenses incurred in connection with any such promotion or incorporation and to remunerate any person or company in any manner it shall think fit, for services rendered or to be rendered in or about the formation or promotion of the Company or the conduct of its main business or in or about the promotion of any other such company in which the Company may have an interest.

12. To enter into any arrangements and take all necessary or proper steps with Governments or with other authorities supreme, national, local, municipal or otherwise of any place in which the Company may have interests and to carry on any negotiations or operations for the purpose of directly or indirectly carrying out the main objects of the Company or effecting any modification in the constitution of the Company or for furthering the interests of the members and to oppose any such steps taken by any other Company, any firm or person which may be considered likely, directly or indirectly to prejudice the interest of the Company or its members and to assist in the promotion whether directly or indirectly of any legislation which may seem advantageous to the company and to obtain from any such Government authority and company any charters, contracts, decrees, rights, grants, loans, privileges, or concessions which the company may think fit desirable to obtain and carry out, exercise and comply with any such arrangements, charters, decrees, rights, privileges or concessions.

13. To apply the assets of the Company in any way in or towards the establishment, maintenance or ex tension of any association, institution or fund in any way connected with any particular trade or business or with trade or commerce and particularly with the trade, including any association, institution or fund for the interest of masters, owners and employers against loss by bad debt, strike, combustion, fire, accident or otherwise or for the benefit of any employee, workman or others at any time employed by the Company or any of its predecessors in business or their families or dependents and whether or not in common with other persons or classes of persons and in particular of friendly, co-operative and other society, reading rooms, libraries, educational and charitable institutions, dining and recreation rooms, churches, chapels, schools, and hospitals and to grant gratuities, pensions and allowances and to contribute to any funds raised by public or local subscription for any purpose.

14. To establish and maintain or procure the establishment and maintenance of any contributory or noncontributory pension or superannuation funds for the benefits of and give, procure the giving of donations, gratuities, pensions allowances or emoluments to any persons who are or were at any time in the employment or service of the Company or are allied to or associated with the Company or with any such subsidiary Company or who are or were at any time Directors or officers of the Company as aforesaid and the wives, widows, families and dependents of any such persons and also establish and subscribe to any institutions, associations, clubs or funds calculated to be for the benefit of or to advance the interest and well-being of the Company or of any such other Company as aforesaid and make payments to or towards the insurance of any such persons as aforesaid and do any of the matters aforesaid either alone or in conjunction with any such other Company as aforesaid.

15. To do all such other things as may be deemed incidental or conducive for the attainment of the main objects or any of them.

(C) OTHER OBJECTS :–

1. To carry on, in any mode, the business of store-keepers in all its branches and in particular to buy, sell and deal in goods, stores, consumable articles, chattels and effects of all kinds, both wholesale or retail.

2. To carry on business as importers and exporters of goods of merchandise of any description or to act as shippers, commission agents, advertising agents, travelling agents, transport agents, forwarding and clearing agents, brokers, estates agents hardware merchants.

3. To carry on the business of manufacturers and dealers of automobile parts, accessories, ancillaries, stores and spares and to engineer, develop, design, assemble, manufacture, produce import and export, buy, sell and otherwise deal in Tractors, Cars, Motorbikes, Cycles, Mopeds, petroleum and petroleum products, glass and glass products, industrial, mining, agricultural and such other machines and all types of tools, plants equipments, instruments, appliances and hardware of all kinds, general fittings, accessories and appliances of all description made of metal, alloy, glass, synthetic and other such fibres, chemical and PVC compounds, plastics or any other such material related thereof.

4. To carry on the business of electrical engineers, air conditioner contractors, electricians, engineers, contractors, manufacturers, contractors, suppliers and dealers in electrical and other appliances, cable, wire-lines, dry-cells, accumulators, lamps and works and to generate, accumulate, distribute and supply electricity for the purpose of light, heat, motor power and for all other purposes for which electrical energy can be employed and to manufacture and deal in all apparatuses and required for or capable of being used in connection with the generation, distribution, supply accumulation and employment of electricity, including in the term electricity all power that may be directly or indirectly derived therefrom or may be incidentally hereinafter discovered in dealing with electricity.

5. To manufacture and/or produce and/or otherwise engage in the manufacture or production of or dealing in electrical kilowatt hour meters, magnets, electromagnets, power cables, industrial jewels ammeters, voltmeters and other types of measure instruments, electrical or non-electrical, diecastings, screws, nuts and bolts, transformers of all types, circuit-breakers, punched card machines, computers and calculators and their accessories hoists, elevators, trolleys and coaches, winches, power generators, magnetic separators, winders, air compressors, welders, fans of all types, switches and motors of all types, drills, electric grinders, air-conditioners, refrigerators, washing machines, television and wireless apparatus including radio receivers and transmitters, electronic instruments, videos, transistors and allied items, watches and clocks, cameras and any house-hold appliances and any equipment used in the generation, transmission and receiving of sound, light and electrical impulses and components or parts thereof.

6. To carry on the business as mechanical engineers, machinists, fitters, mill-wrights, founders, wire drawers, tube metallurgist, saddlers, galvanizers, japanners, annealers, enamellers, electroplaters and painters.

7. To carry on a general business of providing comparative information about the characteristics, interest or other attributes of individuals, communities, organisations, countries or other social units and of any articles or commodities or economic trends or persons whatsoever, to design, invest, prepare, own, make and lease, sell or otherwise dispose of and generally to deal in and with computers, data processing machines, tapes, cards, memory equipment or any other equipment and materials of every kind and description useful in connection with the business, to licence or otherwise authorise others to engage in the foregoing and to engage in general research and development in areas related to or involving the foregoing.

8. To grow, take on lease, acquire, develop, deal in plantations and to process in all aspects timber wood, plywood and all kinds of wood and to make products where wood is a constituent part and to design, develop, fabricate any products involving the use of wood.

9. To produce, manufacture, use, or otherwise acquire, sell, distribute, deal in and dispose of, alkalies and acids, gases, compounds, fertilizers, chemicals and chemical products of every nature and description and compounds, intermediates, derivatives and by-products thereof and products to be made therefrom (hereinafter for convenience referred to generally as, chemicals and products) including specifically, but without limiting the generality of the foregoing, calcium carbide, calcium cynamide, vat, solubilised vat, azoic salts, naphthols, all types of flotation reagents, wetting agents, insecticides and fumigants, plastics and resins, dyestuffs, explosives, catalytic agents, foods, direct colours, basic and rapid fast colours, pigments, drugs, biologicals, pharmaceuticals, serums, vitamin products, harmones, sutures, ligatures, drugs for disease or disabilities, in men or animals and pro ducts derived from phosphate mines, limestones, quarries, bauxite-mines, petroleum, natural gas and such other natural deposits useful or suitable in the manufacture of chemicals and chemical products as herein above defined.

10. To manufacture, produce, refine, prepare, store, sell and to trade and deal in petroleum and all kinds of mineral oils, all products and byproducts thereof including wax, paraffin, soap, paint, varnish, lubricants, illuminants and butter substitutes, oil cloth, candles, glycerine, stearing and in connection therewith to acquire, construct, repair, operate and use oil and such other refineries, buildings, mills, factories, oil wells, derricks, distilleries, ghanies, rotaries, expellers, mechanical or hydraulic press.

11. To carry on the business of manufacturers and dealers, importers and exporters of natural and synthetic resins, moulding powders, adhesives and cements, oil paints, distempers, cellur paints, colours, varnishes, enamels, gold and silver leaf enamels, spirits tobacco, cigars, snuff, soap, cosmetics, perfumes, medicines, drugs, dyes, fats, waxes, hides, Skins and leather and such other allied articles thereof.

12. To carry on development and research work and to manufacture process, import, export, buy, sell and deal in petroleum coke, calcined, coke and coaltar, anthracite coal and to draw out, manufacture and deal in coaltar, canlion products and such other by-products as may be possible and to utilise waste gases for industrial uses and purposes.

13. To engineer, develop, design, assemble, manufacture, produce, import, export, buy, sell, operate, run, let on hire and otherwise deal in :-

    (a) all kinds of earthmoving and agricultural machines, petrol and diesel engines, tools, plants, tractors, equipments, spares, appliances, implements, accessories, mobile or otherwise.

    (b) heavy vehicles and machines for agricultural and land reclamation, drainage, irrigation, water works, engineering, forest clearing, pumping and such other purposes thereof.

    (c) spraying machines, vehicles and equipment whether mobile or otherwise.

    (d) mobile workshops and garage equipments for repair and service machinery.

    (e) tubewells, pumps, floating or otherwise, motors and irrigation machinery.

    (f) transportation equipments for movements of its products or stores, machines or personnel as general purpose freight carriers.

14. To undertake the business of distribution and application of chemicals, fertilizers and pesticides, aerial or otherwise and to maintain and run vehicles, aeroplanes and equipments for spraying and to run the said vehicles and aeroplanes for hire and as passenger carrying crafts also.

15. (a) To construct a cinematograph theatre and such other building and works and conveniences, for purpose thereof said and to manage, maintain and carry on the said theatre an d to let out such other buildings when so erected or constructed.

(b) To carry on the business as proprietors and managers of theatre (cinemas, picture places and concert halls) and to provide for the production, representation and performance (whether by mechanical means or otherwise) of operas, stage plays, operettas, burlesques, vaudeviles, revues, ballets, pantomimes, spectacular pieces, promenade and such other concerts, musical and all types of musical and dramatic performances and entertainments of all types.

(c) To carry on the business of restaurant keepers, wine and spirit merchants, licensed victuallers, theatrical agents, box office keepers, dramatic and musical literature publishers and printers.

(d) To manufacture films and such other appliances and machines in connection with mechanical reproduction or transmission of pictures, movements, music and sounds and to organise and conduct theatrical production and entertainment of all kinds.

(e) To enter into agreements with author or such other persons, for the dramatic or other rights of operas, plays, films, operatus, burlesque vaudeviles, revues, ballet, pantomimes, spectacular pieces, musical compositions and other dramatic and musical performances and entertainments or for the representation thereof in India and elsewhere, as well as of foreign rights and to enter into engagements of all kinds with artists and such other persons related thereto.

16. To carry on business as tourist's agents and contractors and to facilitate travelling and to provide for tourists and travellers and promote the provision of conveniences of all kinds in the ways of through tickets, circular tickets sleeping cars or berths, reserved places, hotels and lodging accommodation, guides, safe deposits, inquiry bureaus, libraries, lavatories, reading room, baggage transport and otherwise.

17. To carry on business of hotel, cafe, restaurant tavern, beer house, restaurant room boarding and lodging house keepers, beer merchants, maltsters, manufacturers of aerated minerals and artificial waters an d other drinks, surveyors, caterers, for public amusements, general coach cab, carriage and motor car proprietors; livery stable and garage-keepers, importers and brokers of food, live and dead stock, hairdressers, perfumers chemists, proprietors of clubs, baths, dressing rooms, laundries reading, writing and newspaper rooms, libraries, grounds and places of amusements and recreation, sports, entertainment and instruction of all kinds, tobacco and cigar merchants, agents for railways, road, air and shipping companies and carriers, theatrical and opera-box office proprietors and general agents and to provide services and facilities of all kinds commercial basis that may be required for the tourist and entertainment industry.

18. To promote, establish acquire and run or otherwise carry on the business of any plastic or rubber industry or business of manufacture of materials for use in such industries or business such as wax, paper, bakelite, plywood, celluloid products, chemicals of all sorts and such other articles or things and similar or allied products, or pro cess thereof.

19. To carry on business of processors, combers, spinners, weavers knitters, manufacturers, dyers, bleachers, finishers, laminators, balers and pressers of any fibrous or textile material whether an agricultural or animal or natural product or its bye-products or chemical or synthetic fiber and specially jute, hemp, silk, cotton, wool, mesta, nylon, terene terylene, staple fiber or other synthetic fibre and to manufacture and produce from such raw material or textile material and to carry on the business of buyers, sellers and dealers of all such raw or processed or semi- processed material and to transact all manufacturing cutting and preparing, process and mercantile business that may b e beneficial to the said business.

20. To carry on the business of transport, cartage and haulage contractors, garage proprietors owners and charters of road vehicles, aircrafts, ships, tugs, barges, and boats of every description, lightermen, carriers of goods and passengers by road, rail, water or air, carmen, cartage contractors, stevedores, wharfingers, cargo superintendents, packers, haulers, warehousemen store-keepers, and jobmasters.

21. To carry on the business of farming, horticulture, floriculture, sericulture, dairies cultivators, of all kinds of foodgrains, seeds, fruits, proprietors of orchards and traders, exporters, dealers, sellers of the products, of farming, dairy, horticulture, floriculture, sericulture and pisciculture and fishing and manufacturers of drinks, alcoholic or otherwise, and beverages produced from such products or otherwise, to carry on the business of cultivators, growers, manufacturers, millers, grinders, rollers, processors, cold stores, canners and preservers and dealers of food grains and such other agricultural, dairy, horticultural and poultry products, fruits, vegetables, herbs, medicinal flowers, drinks, fluids and such other fresh and preservable products and to extract bye-products and derivatives whether edibles, pharmaceutical medicines or any other such kind or nature whatsoever and food preparations of every kind and description and generally the business or manufacture of and trading in preserved, dehydrated, canned or converted agricultural products, fruits and vegetables, foods, dairy and poultry products and articles and other derivatives of all kinds and descriptions and to set up and run machinery for processing and preserving the same.

22. To establish experimental farms and research stations anywhere in India for conducting experiments, tests and research for developing better qualities of foodgrains and agricultural products and for developing milk strain in cattle by cross breeding or otherwise and increasing eggs laying capacity in poultry and also for finding such other ways and means of improving other such agricultural crops, produce, seeds, fodder crops and cattle feed of all kinds.

23. To manufacture, process, chemically, electrically or by any other such means refine, extract, hydrolize, manipulate, mix, deodarise, grind, bleach, hydrogenerate, buy, sell, import, export, produce or otherwise deal in seeds and agricultural products, food products, dietic products and preparations of patent drugs and proprietory articles of all kinds, whether basic or derived and in all forms and in particular protein foods of all kinds and all such other ingredients thereof.

24. To buy, sell, deal in shares and securities, foreign exchange, gold, silver, cotton, jute, hessian, oil, oils-seeds and hold them as permitted under the law, from time to time, in force.

25. To organise, run, maintain operate, promote the business of interior decorators, furniture and carpet designers and manufacturers, boutiques, operators of fashion centres, fashion shows and to make, acquire, deal in any way in handicrafts, objects of art, precious stones, jewellery whether artificial or otherwise and articles wherein precious metals or precious stones may b e used, in textile fabrics and to manufacture and deal in any products as are dealts in by boutiques, fashion shows and interior decorators.

26. To establish, provide, maintain and conduct research and such other laboratories, training colleges, schools and other institutions for the training, education and instruction to students and others who may desire to avail themselves of the same and to provide for the delivery and holdings of lectures, demonstrations, exhibitions, classes, meetings and conferences in connection therewith.

27. To be interested in promoting or undertaking the formation and establishment and to take, hold and dispose of shares in such organisations, institutions, businesses or companies, whether industrial, hoteliers, restaurants, agricultural trading, manufacturing or otherwise as may be considered to be conducive to the profit and interest of the company and also to acquire, promote, aid, foster, subsidise or acquire interests in any such industry or undertaking.

28. To acquire from or sell to any person, firm or body corporate or unincorporated whether in India or elsewhere technical and managerial information, know how, processes, engineering, manufacturing, operating and commercial data, plants, layouts and blue prints useful for the design, erection and operation of any plant or process of manufacture and to acquire and grant or licence other rights and benefits in the foregoing matters and things and to render any kind of management and consultancy services.

29. To carry on business as general commercial, colour, craft and graphers, photographers, engravers, die-makers, publishers of newspapers, books, magazines, art and musical productions, plan and chart printers, press and advertising agents, contractors, ink, die, and colour manufacturers, manufacturers and dealers in containers and components and dealers in printing machines, type and all printers supplies, book binders and stationers and dealers in all kinds of supplies and equipments for mercantile and such other uses thereof.

30. To carry on the business of manufacturers of all dealers in all kinds of classes of paper and pulp such as sulphate and sulphate wood, pulp, mechanical pulp and soda pulp and paper including transparent, vellum, writing, printing, glazed, absorbent, news print, wrapping, tissue, cover, blotting filter, bank or band, badami, brown, buff or coloured lined, azure, laid, grass or water-proof, hand-made, parchment, drawing, craft, carbon, envelope and box and straw duplex and triplex board and all kinds of articles in the manufacture of which any pulp, paper or boards is used and also to deal in or manufacture artificial leather of all varieties, grades and colour.

31. To acquire and hold shares, stocks, debentures, debenture stocks, bonds, obligations and securities issued or guaranteed by any Company constituted or carrying on business in the Republic of India or elsewhere any debentures, debentures-stocks, bonds, obligations and securities issued or guaranteed by any government, sovereign ruler, commissioners, public body or authority, supreme, municipal, local or otherwise, whether at home or abroad, to acquire any such shares, stocks, debentures, debenture stocks, obligations or securities by original subscription, tender, purchase, exchange or otherwise and subscribe for the same either conditionally or otherwise and to guarantee the subscription thereof and to exercise and enforce all right and powers conferred by or incidental to the ownership thereof, to issue shares, debenture stocks, bonds, obligations and securities of all kinds and to frame, constitute and secure the same, as may seem expedient, with full power to make the same transferable by delivery or by instrument of transfer or otherwise and either perpetual or terminable and either redeemable or otherwise and to charge or secure the same by trust deed or otherwise on the undertaking of the company, or upon any specific property and rights, present and future of the company (including if thought fit, uncalled capital) or otherwise however to export, import, buy, sell, barter, exchange, pledge, make advance upon, invest in and otherwise deal in gold, silver, bullion, stocks, shares, securities of all kinds and description.

32. To secure sound investments of foreign capital in Indian undertakings and enterprises and Indian Capital in foreign undertakings and enterprises.

33. To carry on the profession of consultants on management, employment, engineering industry and technical matters to industry and business and to act as employment agents.

34. To carry on the business as manufacturers of or dealers in glass products such as sheet and plate glass, optical glass, glass wool, laboratory ware and thermometers.

35. To carry on the business as manufacturer of, agents or dealers in textiles and grains such as man-made fibres, cotton, silk, jute, woollen, synthetics, foodgrains and products thereof oils of all kinds, seeds and pulses.

36. To undertake and transact all kinds of agency business and to carry on and promote any business, commercial or otherwise, under sound principles and or to act as distributors, agents, underwriters, brokers, estate agents, middleman, contract man, representatives and indenting agents on commissions allowance, as may be deemed fit in all commodities, merchandise and other allied articles and lines of business.

37. To undertake, manage finance or otherwise carry on either individually or in association in any manner with any other person or Government authority, programme or Rural Development in India including any programme for promoting the social and economic welfare of, or the uplift of the public in any rural area and without prejudice to the generality of the foregoing to subscribe, donate, establish, provide, maintain, conduct, subsidise, undertake, associate with carry on and promote studies, research, experimental work and application of technology, in any field of human endeavour, by establishing, endowing or

assisting workshops, laboratories, schools, hospitals, first-aid centres and other technical, scientific, agricultural or any other institutions and bodies for the development of education, medicine, human welfare, agriculture, horticulture, animal husbandry, dairy products, cottage small-scale and other industry and in order to implement any of the above mentioned objects or purposes, transfer without consideration or at such fair or concessional value as the Directors may think fit and divest the ownership of any property of the company to or in favour of any Public or Local Body or Central or State Government or any Public institution or Trusts of Funds recognised or approved by the Central or State Government or established under any law for the time being enforce.

38. To undertake, carry out, promote and sponsor or associate with or assist any activity for the promotion and growth of national economy and for discharging what the Directors may consider to be social and moral responsibilities of the company to the Public or any section of the Public as also any activity which the Directors consider likely to promote national welfare or social, economic or moral uplift of the Public or any section of the public and in such manner and by such means as the Directors may think fit and the Directors may without prejudice to the generality of the foregoing, undertake, carry out, promote and sponsor any activity for publication of any books, literature, newspapers or for organising lectures or seminars likely to advance these objects or for giving merit awards, for giving scholarships, loans or any other assistance to deserving students or other scholars or persons to enable them to pursue studies or academic pursuits of their researches and for establishing, conducting or assisting any institution fund, trust, person or Government authority having any one of the aforesaid objects as one of the objects by giving donations or otherwise in any other manner, and the Directors may at their discretion, in order to implement any of the above mentioned objects or purposes, transfer without consideration or at such fair or concessional value as the Directors may think fit and divest the ownership of any property of the company to or in favour of any Public or Local Body or Authority or Central.

39. To install the Electric furnace for melting steel scrap and for producing steel castings and for re-rolling mild steel sections.

40. To manufacture steel castings of all kinds such as used for Textile Machine parts, Railways, Tramways, motor parts, Tractors, sugar Industry and Cement industry machinery parts.

41. To manufacture bolts, nuts, buckets, kerais, gate channels and to carry on the business of fabrication of steel and its by products.

42. To weld steel tubes and boring of different steel and galvanising iron sections.

43. To manufacture utensils and such other goods of all kinds of brass, bronzer, copper and such other metals and alloys of all types.

44. To carry on the business of importing and exporting machinery, plants, tools, implements, metal goods, hardware and plumbing material and to sell, let out or otherwise deal in such imported goods or articles.

45. To carry on the business as financiers (not amounting to banking business within the meaning of Banking Regulation Act, 1949) by way of loaning, lending, and advancing money, to industrials, individuals, commercials and such other enterprises of all types.

46. To carry on the business of mechanical fitters, wire drawers, galvanizers japaneers, annealers, enamellers and packing case makers.

47. To carry on the business of a leasing and hire purchase company and to acquire, to provide on lease or to be provided on hire purchase basis all types of industrial and offices, plants, equipments, machinery, vehicles, buildings and real estate, required for manufacturing, processing, transportation and trading business and such other commercial and service business.

48. To build, contract, establish, own, purchase, sell, take on lease or exchange or otherwise acquire, hold, maintain and manage industrial, commercial or residential buildings and plots, apartment houses, hotels, motels, hostels, restaurants, factory premises godowns, glass, warehouses, flats, hostels, boarding houses, clubs, pleasure grounds and amusement parks, theatres, cinemas or other show houses, meeting or lecture halls, libraries, dharamshalas and saris, health resorts and sanatoriums, gardens, swimming pools and baths, huts, Bazaar and markets, meals and exhibition and to let, sublet, give on lease or otherwise to permit use and occupation of the same for rent or hire charges and to provide for the tenants an d occupiers thereof all or any of the conveniences commonly provided in residential, commercial and industrial quarters.

49. To acquire, build, construct, alter, maintain, enlarge, pull down, remove or replace and to work, manage and control any buildings, offices, factories, mills, shops, machinery, engines roadways, tramways, railways, branches or siding, bridges, reservoir, water courses wharves electric, works and such other work and conveniences which may seem necessary to achieve the main objects of the company.

50. To pay for preliminary and pre-incorporation expenses of the Company.

51. To pay for any rights or property acquired by the Company and to remunerate any person, firm or body corporate rendering services to the Company either by cash payment or by allotment to him or them of shares or securities of the Company as paid up in full or in part otherwise.

52. To guarantee the payment of money unsecured or secured or payable under or in respect of promissory notes, bonds, debentures, stocks, contracts, mortgages, or charges, obligations, instruments, securities of any company or of any authority, supreme, municipal, local or of any persons whether incorporated or not incorporated and generally to guarantee or become sureties for the performance of any contracts or obligations as may be necessary for the business of the Company.

53. To subscribe for acquire hold and dispose off shares, share stocks, debentures, debenture-stocks, bonds, mortgages, obligations, securities of any kind issued or

guaranteed by any company (body corporate undertaking) of whatever nature and howsoever constituted or carrying on the business and to subscribe for acquire hold and dispose off shares, debentures and debenture-stocks and debenture-bonds, mortgages, obligations and other securities issued or guaranteed by any Government sovereign-ruler Commissioners, Trust, Municipal Local or other Authority or body of whatever nature, whether in India or elsewhere as may be conducive to the business of the Company.

54. To invest in other than investment in Company's own shares any money of the Company not immediately required, in any investments, movable or immovable as may be deemed proper and to hold, sell, or otherwise deal with investment invest in shares or stock in the company as may be necessary for the business of the Company.

55. Subject to Section 58A and 292 of the Companies Act, 1956 and the Regulation there under and the directions issued by Reserve Bank of India, to receive money on deposit or loan and borrow or money in such manner as the Company shall think fit and in [particular by the issue of debentures or debenture-stock (perpetual or otherwise) and to secure the payment of any money borrowed, raised or owing on the mortgage, charge or lien upon all or any of the property or assets of the Company (both present or future) including its uncalled capital and also by similar mortgage, charge or lien to secure and guarantee the performance by the Company, or any other such person or Company, or any obligation undertaken by the Company.

56. To apply for, purchase or otherwise acquire and protect, prolong and renew in any part of the world, any patents and patent rights, brevets d'inventions trade marks, designs, licences, protections and concessions conferring any exclusive or non-exclusive or limited right to their use or other information as to any invention, process or privileges which may seem capable of being used for any of the main objects business of the Company or the acquisition of which may seem calculated directly or indirectly, to benefit the company and to use, exercise, develop or grant licences or privileges in respect of the property, rights and information so acquired.

57. To spend money in experimenting upon and testing and in improving or seeking to improve any patents, rights inventions, discoveries, processes or information of the Company or which the Company may acquire or purpose to acquire.

58. To procure the registration or recognition of the company in or under the laws of any place outside India.

59. Subject to the provisions of Section 391 to 394 of the Companies Act, 1956, to amalgamate or to enter into partnership or any arrangement for sharing profits, union of interest, co-operation, joint venture or reciprocal rights with any person or persons or company or companies carrying on or engaged in the main business of the company.

60. To adopt such means of making known the main business of the Company as may seem expedient and in particular by advertising in the press by circulars, by purchase and

exhibition of works of art or interest, by publication of books and periodicals and by granting prizes, rewards and donations.

61. (a) To undertake and execute any trust, the undertaking of which may seem to the Company desirable and either gratuitously or otherwise and vest any real or personal property, rights or interests acquired by or belonging to the Company in any person or Company on behalf of or for the benefit of the Company and with or without any declared trust in favour of the Company.

(b) To accept gifts including by way of Awards/prizes from Govt. and semi Govt. bodies and to give gifts and donations to create trusts for the welfare or employees, members, directors and/or their dependents, heirs and children for deserving objects and such other persons; also to act as trustees.

62. To aid pecuniarily or otherwise, any association, body or movement having for an object the solution, or settlement of industrial or labour problems or troubles or the promotion of industry or trade.

63. To subscribe or guarantee money for any national, charitable, benevolent public general or useful object or for any exhibition subject to the provisions of section 293A of the Act.

64. Subject to the provisions of the Gift Tax Act, 1958 and the Statutory amendments, thereof, the Company has power to make and receive gifts either in cash or other such movable or immovable properties.

65. To distribute among the members in specie or otherwise any property of the Company, or any proceeds of sale or disposal of any property of the Company, in the event of its winding-up but so that no distribution amounting to a reduction of capital be made except with the sanction (if any) for the time being required by the Companies Act, 1956.

IV. The liability of the members is Limited.

V. The Authorised Share Capital of the Company is Rs. 225,00,00,000/- (Rupees Two Hundred Twenty Five Crore) divided into 22,50,00,000 (Twenty Two Crore Fifty Lacs) Equity Shares of Rs. 10/- (Rupees Ten) each.

We the several persons, whose names and addresses are subscribed hereto, are desirious to being formed into a company in pursuance of this Memorandum of association, and we respectively agree to take the number of shares in the capital of the company, set opposite our respective name

Sl. No.	Name, Address, Description and occupation of Each subscriber	Number & Type of Shares Equity	Signature of Subscriber	Name, Address, Description & signature of witness
1.	Jindal Power Limited Reg. office : Khorsia Raod Post Box No. 16, Raigarh-496001 Through : Mr. Anand Goel S/o Late Chajju Ram Goel B-3/15, Safdarjung Enclave New Delhi - 110029 (Business)	7,39,995 Equity Shares	Sd/-	Sd/- (UMESH C. PANDEY) CHARTERED ACCOUNTANT M. No. 055252 D-26, Sector-3 Noida, U.P.-201301
2.	Hydro Power Development Corporation of Arunachal Pradesh Limited, Reg. office : Tahung Tatak Building, Near APPSC, MLA Cottage Road, ITA Nagar (Business) Through, Taru Siga S/o Sh. Takia Siga ITA Nagar - 791111	2,60,000 Equity Shares	Sd/-	
3.	Sushil Maroo S/o Shri Nand Singh Maroo C-20, Pamposh Enclave, G. K. - I New Delhi-110048. (Service) (As nominee of Jindal Power Ltd.)	1 Equity Shares	Sd/-	
4.	Rajeev Jain S/o Shri Sumer Chand Jain R/o 1885A/139A, Tri Nagar Delhi-110035 (Service) (As nominee of Jindal Power Ltd.)	1 Equity Share	Sd/-	
5.	Rajender Prasad Singh S/o Shri Hriday Narain Singh R/o A-1, PWO Hriday Deep, Sector-43, Gurgaon, Haryana-122002 (Service) (As nominee of Jindal Power Ltd.)	1 Equity Share	Sd/-	
6.	Kapil Mantri S/o Shri Shyam Sunder Mantri R/o D 281, Ground Floor, Sarvodaya Enclave, New Delhi-110017 (Service) (As a nominee of Jindal Power Ltd.)	1 Equity Share	Sd/-	
7.	Vinod Kumar Abbey S/o Late Sh. Raj Kumar Abbey A-46 Sector-36, Noida, U.P.-201303 (Service) (As A Nominee of Jindal Power Ltd.)	1 Equity Share	Sd/-	
	Total	10,00,000 Equity shares		

Dated : 17/02/2010
Place : New Delhi

(THE COMPANIES ACT, 1956)

(COMPANY LIMITED BY SHARES)

ARTICLES OF ASSOCIATION

OF

KAMALA HYDRO ELECTRIC POWER COMPANY LIMITED

PRELIMINARY

Interpretation

1. "The Company" or "the JV Company" means **KAMALA HYDRO ELECTRIC POWER COMPANY LIMITED**

"JV Agreement" means the joint venture agreement dated 29th day of August 2009 entered into between Jindal Power Limited and Hydro Power Development Corporation of Arunachal Pradesh Limited.

"Joint Venture Parties" means Jindal Power Limited and Hydro Power Development Corporation of Arunachal Pradesh Limited.

"These Articles" means these Articles of Association as originally framed or as altered by Special Resolution from time to time.

"The Company" means **Kamala Hydro Electric Power Company Limited.**

"The Directors" means the Directors of the Company for the time being.

"The Office" means the Registered Office of the Company for the time being.

"The Register" means the Register of Members to be kept pursuant to Section 150 of the Act.

"Dividend" includes bonus.

"Month" means Calendar month.

"Year" means a calendar year and "Financial Year" shall have the meaning assigned thereto by Section 2(17) of the Act.

"Proxy" includes Attorney duly constituted under a power of Attorney.

"Seal" means the Common Seal of the Company.

"In Writing" and "Written" shall include printing, lithography and other modes of representing or reproducing words in a visible form words importing the singular number only include the plural number and vice versa.

Words importing the masculine gender only include the feminine gender.

Words importing persons include corporations.

Table "A" not to apply

2. Save as provided herein, the regulations contained in Table "A" in Schedule 1 of the Act shall not apply to Company.

SHARES

Share-Capital

3. The Authorised Share Capital of the Company shall be such as given in the Clause V of the Memorandum of Association or altered, from time to time, thereat. The Company shall have power to increase, consolidate, subdivide, reduce or otherwise alter its share capital, subject to the provisions of the Act. The minimum paid up capital of the Company will be Rs. Five Lakhs.

Redeemable Preference Shares

4. The Company shall have power to issue Preference Shares carrying right to redemption out of profits which would otherwise be available for dividend, or out of the proceeds of a fresh issue of shares made for the purpose of such redemption, or liable to be redeemed at the option of the Company, and the Board may subject to the provisions of Section 80 of the Act, exercise such power in such manner as it thinks fit.

Allotment of Shares

5. Subject to the provisions of these Articles, the shares shall be under the control of the Directors who may allot or otherwise dispose off the same on such terms and condition, and at such time as the Directors think fit an d with power to issue any shares as fully paid up in consideration of services rendered to the Company in its formation or otherwise, provided that where the Directors decide to increase the issued capital of the Company by the issue of further shares, the provisions of Section 81 of the Act will be complied with. Provided further that the option or right to call of shares shall not be given to any person except will the sanction of the Company in general meeting.

Issue of Shares at a discount

6. Subject to the provisions of the Act it shall be lawful for the company to issue at a discount, shares of a class already issued.

Commission for placing shares

7. The Company may, subject to compliance with the provisions of Section 76 of the Act, exercise the powers of paying commission on

the issue of shares and debentures. The commission may be paid or satisfied in cash or shares, debentures or debenture stock of the Company.

Brokerage

8. The Company may pay a reasonable sum of brokerage, subject to the ceiling prescribed under the Act.

Trusts not recognised

9. Subject to Section 187C of the Act, the Company shall be entitled to treat the registered holder of any share as the absolute owner thereof and accordingly shall not, expect as ordered by a Court of competent jurisdiction or as by law required, be bound to recognise any trust, benami or equitable or other claim to or interest in such shares on any fractional part of a share whether or not it shall have express or other notice thereof.

CERTIFICATE

Certificate

10. The certificate of title to shares shall be issued under the Seal of the Company.

Member's right to certificate

11. Every member shall be entitled free of charge to one certificate for all the shares of each class registered in his name or, if any member so wishes, to several certificate each for one or more of such shares. Unless the Conditions of issue of any shares otherwise provide, the Company shall either within three months after the date of allotment and on surrender to the Company of its letter making the allotment or of its fractional coupons of requisite value (save in the case of issue against letters of acceptance or of renunciation or in case of issue of bonus shares) or within one month of receipt of the application for registration of the transfer, sub division, consolidation renewal or exchange of any of its shares, as the case may be, complete, and have ready for delivery the certificates of such shares. Every certificate of shares, shall specify the name of the person in whose favour the certificate is issued, the shares to which it relates and the amount paid up thereon. Particulars of every certificate issued shall be entered in the Register maintained in the form set out in the Companies, (issue of Share Certificates) Rules, 1960.

As to issue of new certificates

12. (1) If any certificate of any share or shares be surrendered to the Company for subdivision or consolidation or if any certificate be defaced, torn or old, decrypt, worn-out or where the cages on the reverse for recording transfer have been duly utilised, then upon surrender thereof to the Company, the Board, may order the same to be cancelled and may issue a new certificate in lieu thereof, and if any certificate be lost or destroyed, then upon proof thereof to the satisfaction of the Board, and on such indemnity as the Board thinks fit being given a new certificate in lieu thereof, shall be given to party

entitled to the shares to which such lost or destroyed certificate relate. Where a new certificate has been issued as aforesaid it shall state on the face of it and against the stub or counterfoil that it is issued as aforesaid in lieu of a shares certificate or is a duplicate issued for the one so replaced and, in the case certificate issued in place of one which has been lost or destroyed, the world "duplicate" shall be stamped or punched in bold letters across the face thereof. For every certificate issued under this Article, there shall be paid to the Company such out of pocket expenses incurred by the Company in investigating evidence as the Board may determine.

(2) No fee shall be charged for subdivision and consolidation of shares and debenture certificates and for subdivision of letters of allotment and spirit, consolidation, renewal and pucca transfer receipts into denominations corresponding to the market units of trading, for sub-division of renounceable letters of rights, for issue of new certificate in replacement of those which are old, decrepit or worn out, or where the cages on the reverse for recording transfers have been fully utilised. Provided that the Company may charge such fees as may be agreed by it with the Stock Exchange with which its shares may be enlisted for the time being for issue of new certificates in replacement of those that are torn, defaced, lost or destroyed, and for subdivision and consolidation of share and debenture certificates and for sub-division of letter of allotment and split, consolidation, renewal and pucca transfer receipts into denominations other than those fixed for the market units of trading.

JOINT-HOLDERS OF SHARES

Fee on subdivision of shares, issue of new certificates etc.

13. Where two or more persons are registered as the holders of any share they shall be deemed to hold the same as joint-tenants with benefit of survivorship subject to provisions following and to the other provision of these Articles relating to joint holders :-

Maximum number

(a) The Company shall not be bound to register more than four persons as the joint-holder of any share.

Liability several as well as joint

(b) The joint holders of a share shall be liable severally as well as jointly in respect of all payments which ought to be made in respect of such shares.

Survivors of joint holders only recognised

(c) On the death of any one of such joint-holders the survivor or survivors shall be the only person recognised by the Company as having any title to or interest in such share but the Board may require such evidence of death as it may deem fit.

Delivery of certificates

(d) Only the person whose name stands first in the Register as one of the joint-holders of any share shall be entitled to delivery of the certificate relating to such share.

CALLS

Calls

14. The Directors may, from time to time, subject to the terms on which any shares, may have been issued, make such calls as they think fit upon the members in respect of all moneys unpaid on the shares held by them respectively, and not by the conditions of allotment thereto made payable at fixed times, and each member shall pay the amount of every call so made on him to the persons and at the times and places appointed by the Directors. A call may be made payable by installments.

When call deemed to have been made

15. A call shall be deemed to have been made at the time when the resolution of the Directors authorising such call was passed.

Notice to call

16. Not less than 30 (Thirty) days notice of any call shall be given specifying the time and place of payment and to whom such call shall be paid.

Amount payable

17. If by the terms of issue of any share or otherwise, the whole or part of the amount of issue price thereof is made payable at any fixed time or by installments at fixed times, every such amount of issue price of installment thereof shall be payable as if it was a call duly made by the Directors and of which due notice had been given and all the provisions herein contained in respect of calls shall apply to such amount or issue price or installments accordingly.

Interest to be charged on nonpayment of call

18. If the sum payable in respect of any call or installment be not paid on or before the day appointed for the payment thereof, the holder for the time being of the share in respect of which the call shall have been made or the installment shall be due, shall pay interest for the same at the rate of 12 (Twelve) percent per annum, from the day appointed for the payment thereof to the actual payment or at such other rate as the Directors may determine but they shall have power to waive the payment thereof wholly or in part.

Evidence in actions by Company against shareholders

19. On the trial or hearing of any action or suit brought by the Company against any member or his representative to recover any debt or money claimed to be due to the Company in respect of his shares, it shall be sufficient to prove that the name of the defendant is, or was, when the claim arose, on the Register of the Company as a holder, or one of the holders of the number of shares in respect of which such claims is made, that the resolution making the call is duly recorded in the minute book and that the amount claimed is not entered in paid in the books of the Company, and it shall not be necessary to prove the appointment of the Directors who made any

call nor that a quorum of Directors was present at the meeting at which any call was made nor that such meeting was duly convened or constituted, nor any other matter whatsoever; but the proof of the matters aforesaid shall be conclusive evidence of the debt.

Payment of calls in advance

20. The Board may, if it thinks fit, receive from any member willing to advance the same, all or any part of the money due upon the shares held by him beyond the sums actually called for, and upon the money so paid or satisfied in advance, or so much thereof as from time to time exceeds the amount of calls then made upon the share in respect of which such advance has been made, the Company may pay interest at such rate not exceeding, unless the Company in general meeting shall otherwise direct, 6 per cent per annum as the member paying such sum as advance and the Board agree upon. Money so paid in excess of the amount of call shall not rank for dividends or confer a right to participate in profits. The Board may at any time repay the amount so advanced upon giving such member not less than three months notice in writing.

FORFEITURE AND LIEN

Notice may be given for calls or installment not paid

21. If any member fails to pay any call or installment on or before the day appointed for the payment of the same, the Directors may at any time thereafter, during such time as the call or installment remains unpaid, serve notice on such member requiring him to pay the same together with any interest that may have accrued and expenses, they may have been incurred by the Company by reasons of such non-payment.

Form of notice

22. The notice shall name a day (not being less than 30 days from the date of the notice) and a place or places on and at which such call or installment and such interest and expenses as aforesaid are to be paid. The notice shall also state that in the event of nonpayment at or before the time, and at the place or places appointed, the shares in respect of which such call was made or installment is payable will be liable to be forfeited.

If notice not complied with shares may be forfeited

23. If the requirement of any such notice as aforesaid be not complied with, any shares in respect which such notice has been given may, at any time thereafter before payment of all calls or installments, interest an d expenses due in respect thereof, be forfeited by a resolution of the Directors to that effect. Such forfeiture shall include all dividends declared in respect of the forfeited share not actually paid before the forfeiture. Neither the receipt by the Company of a portion of any money which shall from time to time be due from any member of the Company in respect of his shares, either by way of principal or interest, nor any indulgency granted by the Company in respect of the payment of any such money shall preclude the

Company from thereafter proceeding to enforce a forfeiture of such share as herein provided.

Notice after forfeiture

24. When any shares shall have been so forfeited, notice of the forfeiture shall be given to the member in whose name it stood immediately prior to the forfeiture, and an entry of the forfeiture with the date thereof, shall forthwith be made in the Register but no forfeiture shall be in any manner invalidated by any omission or neglect to give such notice or to make such entry as aforesaid.

Forfeited share to become property of the Company

25. Any share so forfeited shall be deemed to be the property of the Company, and the Directors may sell, reallot or otherwise dispose off the same in such manner as they think fit.

Power to annual forfeiture

26. The Directors may, at any time before any share so forfeited shall not be sold, reallotted or otherwise disposed off, annul the forfeiture thereof upon such conditions as they think fit.

Arrears to be paid notwithstanding forfeiture

27. Any member whose shares have been forfeited shall notwithstanding such forfeiture, be liable to pay and shall forthwith pay to the Company all calls, installments, interest and the expenses, owing upon or in respect of such shares at the time of all installments interest and the forfeited together with interest thereupon, from the time of the forfeiture until payment at 12 per cent per annum or such other rate as the Directors may determine and the Directors may enforce the payment thereof without any deduction of allowance for the value of shares at the time of forfeiture but shall not be under any obligation to do so.

Effect to forfeiture

28. The forfeiture of a share shall involve the extinction of all interest in and also of all claims and demands against the Company in respect of the share, and all other rights incidental to the share except only such of those rights as by these Articles are expressly saved.

Evidence of forfeiture

29. A duly verified declaration in writing that the declarant is a Director of the Company and that certain shares in the Company have been duly forfeited on a date stated in the declaration shall be conclusive evidence of the facts therein stated as against all persons claiming to be entitled to the shares and the receipt of the Company for the consideration, it any given for the shares on the sale or disposition thereof, shall constitute a given title to such shares.

Company's lien on shares

30. The Company shall have a first and paramount lien upon all the shares (not fully paid up) registered in the name of each member (whether solely or jointly with others), and upon the proceeds of sale thereof for all moneys (whether presently payable or not) called or payable at a fixed time in respect of such shares, and no equitable interest in any share shall be created except upon the footing and condition that Article 9 hereof is to have full effect. Unless otherwise

agreed, the registration of a transfer of shares, shall operate as a waiver of the Company's lien, if any, on such shares.

Intention as to enforcing lien

31. For the purpose of enforcing such lien, the Directors may sell the shares subject thereto in such manner as they think fit, but no sale shall be made until such period as aforesaid shall have elapsed and until notice in writing of the intention to sell shall have been served on such member, his committee, curator bonis or other person recognised by the Company as entitled to represent such member and default shall have been made by him or them in the payment of the sum payable as aforesaid for thirty days after such notice. The net proceeds of any such sale shall be applied in or towards satisfaction of such part of the amount in respect of which the lien exists as is presently payable by such member, and the residue (if any) paid to such member, his executors, administrators, or other representatives or persons so recognised as aforesaid.

Validity of Shares

32. Upon any sale after forfeiture or for enforcing a lien in purported exercise of the powers by these presents given, the Directors may appoint some person to execute an instrument of transfer of the shares sold and cause the purchaser's name to be entered in the register in respect of the shares sold and after his name has been entered in the Register in respect of such shares his title to such shares shall not be affected by any irregularity or invalidity in the proceedings in reference to such forfeiture, sale or disposition, not impeached by any person and the remedy of any person aggrieved by the sale shall in damages only and against the Company exclusively.

Power to issue new certificate

33. Where any shares under the powers in that behalf herein contained are sold by the Directors and the certificate thereof has not been delivered to the Company by the former holders of the said shares the Directors may issue new certificate in lieu of certificate not so delivered up.

TRANSFER AND TRANSMISSION OF SHARES

Restrictions on transfer Shares

34. I. Each joint venture party shall hold shares in the JV Company in accordance with JV Agreement and be entitled to transfer shares in accordance with the Articles of this company.

II. Jindal Power Limited will be at Liberty to transfer its shares in JV company to its holding or subsidiary company or associates. Similarly Hydro Power Development Corporation of Arunachal Pradesh Limited will be at liberty to transfer its shares in JV Company to its holding or subsidiary company or associates.

III. Save as otherwise permitted under Clause 34.1 above, Hydro Power Development Corporation of Arunachal Pradesh Limited shall be free to any person, subject to such shares being first offered for sale Jindal Power Limited **("Right of first offer")** in the manner specified below:

a) Hydro Power Development Corporation of Arunachal Pradesh Limited shall send a written notice to Jindal Power Limited **("Notice")** indicating its desire to sell the shares, and setting froth the price, the number of shares and the material terms at which the shares are offered for sale.

b) Upon receipt of the Notice, Jindal Power Limited shall have the option but not the obligation, to purchase the shares offered for sale upon the terms and conditions to be agreed between the Parties. The Right of First Offer shall be exercised by Jindal Power Limited within 30 days of receipt of such Notice by Jindal Power Limited.

c) If Jindal Power Limited exercise the Right of First Offer under Clause (a) and (b) above, it shall be entitled to acquire such number of shares as it agrees to buy.

d) If Jindal Power Limited does not exercise its Right of First Offer, then Hydro Power Development corporation of Arunachal Pradesh Limited shall be free to transfer the shares to any third party at a price and terms and conditions stated in the Notice. Any change in price or terms and conditions will entitle a fresh Right of First Offer. Further, such sale by the Hydro Power development Corporation of Arunachal Pradesh Limited shall be completed within 60 days from the date of the Notice.

Application for transfer

35. Application for the registration of the transfer of a share may be made either by the transferor or the transferee provided that, where such application is made by the transferor, no registration shall in the case of partly paid shares be effected unless the company gives notice of the application to the transferee in the manners prescribed by the Act, and, subject to the provisions of Articles hereof, the company shall unless objection is made by the transferee within two weeks from the date of receipt of the notice, enter in the Register the name of the transferee in the same manner and subject to the same conditions as if the application for registration was made by the transferee.

Notice of transfer to Registered holder

36. Before registering any transfer tendered fro registration the Company may, if it so thinks fit, give notice by letter posted in the ordinary course to the registered holder that such transfer Deed has been lodged and that, unless objection is taken, the transfer will be registered And if such registered holder fails to lodge an objection in writing at the office of the Company within two weeks from the posting of such notice to him he shall be deemed to have Admitted the validity of the said transfer.

Register of transfer

37. The Company shall keep a "Register of Transfers" and therein shall be fairly and therein shall be fairly and distinctly entered particular of every transfer of any share.

In what case to decline to register transfer of shares

38. Subject to the provisions of section 111 of the Act, the Board, without assigning any reason for such refusal, may within one month from the date on which the instrument of transfer was delivered to the company, refuse to register any transfer of a share upon which the Company has a line and, in the case of a share not fully paid up, may refuse to register a transfer to a transferee of whom the Board does not approve.

Provided that the registration of a transfer of share shall not be refused on the ground of the transferor being either alone or jointly with any other person or persons indebted to the Company on any account whatsoever.

No transfer to minor etc.

39. (1) No transfer shall be made to a minor or person of unsound mind.

No fee for registration for transfer etc.

(2) No fee shall be charged for registration of transfer, grant of probate, grant of letter of administration, certificate to death or marriage, Power of Attorney or similar other instruments.

When instrument of transfer to be retained

40. All instruments of transfer duly approved shall be retained by the Company and in case of refusal, instruments of transfer shall be returned to the person who lodges the transfer deeds.

Notice of refusal to register transfer

41. If the Directors refuse to register the transfer of any shares, the Company shall, within one month from the date on which the instrument of transfer was lodged with the Company or intimation given, send to the transferor and the transferee or the person giving intimation of such transfer notice of such refusal.

Power to close transfer books and register

42. On giving seven days notice by advertisement in a newspaper circulating in the District in which the Office of the Company is situated the Register of Members may be closed during such time as the Directors think fit not exceeding in the whole forty five days in each year but not exceeding thirty days at a time.

Transmission of registered shares

43. The executors or administrators or the holder of a succession certificate in respect of shares of a deceased member (not being one of several joint holders) shall be the only person whom the Company shall recognise as having any title to the shares registered in the name of such member and, in case of the death of any one or more of the joint-holders of any registered shares the survivors shall be only persons recognised by the Company as having any title to or interest in such share but nothing herein contained shall be taken to release the estate of a deceased joint-holder from any liability on shares held by him jointly with any other person. Before recognising any legal representative or heir or a person otherwise claiming title to the shares the Company may require him to obtain a grant of probate or letters of administration or succession certificate, or other legal representation, as the case may be from a competent Court, provided nevertheless that in any case where the Board in its ab solute discretion think fit it shall be lawful for the Board to dispense with production of probate or letters of administration or a succession certificate or such other legal representation upon such terms as to indemnity or otherwise as the Board may consider desirable.

As to transfer of shares of deceased or involvent members

Transmission Article

Notice of election to be registered

All rights of executors and trustees

44. Any person becoming entitled to or to transfer shares in consequence of that death or insolvency of any member, upon producing such evidence that he sustains the character in respect of which he proposes to act under this article, or of his title as the Directors think sufficient, may with the consent of the Directors (which they shall not be under any obligation to give), be registered as a member in respect of such shares or may, subject to the regulations as to transfer hereinbefore contained transfer such shares. This article is hereinafter referred to as "The transmission Article". Subject to any other provisions of these Articles if the person so becoming entitled to shares under this or the last preceding Article shall elect to be registered as a member in respect of the share himself he shall deliver or send to the company a notice in writing signed by him stating that he so elects. If he shall elect to transfer to some other person he shall execute an instrument of transfer in accordance with the provisions of these articles relating to transfer of shares. All the limitations, restrictions and provisions of these Articles elating to the rights to transfer and the registration of transfers of shares shall be applicable to any such notice of transfer as aforesaid.

45. Subject to any other provisions of these Articles if the Directors in their sole discretion are satisfied in regard thereof, a person becoming entitled to a share in consequences of the death or insolvency of a member may receive and give a discharge for any dividends or other money payable in respect of the share.

Provisions of articles relating to transfer applicable

46. The instrument of transfer shall be in writing and all the provision of Section 108 of the Companies Act, 1956 and of any statutory modification thereof for the time being shall be duly complied with in respect of all transfers of shares and the registration thereof.

SHARE WARRANTS

Power to issue share warrants

47. Subject to the provisions of Section 114 and 115 of the Act and subject to any directions which may be given by the Company in General Meeting the Board may issue share-warrants in such manner and on such terms and conditions as the Board may deem fit. In case of such issue Regulations 40 to 43 of table A in Schedule 1 to the Act, shall apply.

STOCKS

Stocks

48. The Company may exercise the power of conversion of its shares into stock and in that case regulations 37 to 39 to table "A" in Schedule 1 to the Act shall apply.

ALTERATION OF CAPITAL

Power to subdivide and consolidate

49. The Company may by ordinary resolution from time to time alter the condition of Memorandum of Association as follows :-

(a) Increase the Share Capital by such amount to be divided into shares of such amount as may be specified in the resolution.

(b) Consolidate and divide all or any of its share capital into shares of larger amount than its existing shares.

(c) Subdivide its existing shares or any of them into shares of smaller amount than is fixed by the Memorandum, so however, that in the sub-division the proportion between the amount paid and the amount if any unpaid on each reduced share shall be the same as it was in the share from which the reduced share is derived, and

(d) Cancel any shares which, at the date of the passing of the resolution, have not been taken or agreed to be taken by any person and diminish the amount of its share capital by the amount of the share so cancelled.

Surrender

50. Subject to the provisions of Sections 100 to 104 inclusive, of the Act, the Board may accept from any member the surrender of all or any of his shares on such terms and conditions as shall b e agreed.

MODIFICATION OF RIGHTS

Power to modify rights

51. If at any time the share capital is divided into different classes of shares the rights attached to any class (unless otherwise provided by the terms of issue of the shares of that class) may, whether or not the Company is being wound up, be carried with consent in writing of the holders of three-fourths of the issued shares of that class, or with the sanction of a Special Resolution passed at a Separate Meeting of the holders of the shares of that class. To every such Separate Meeting the provisions of these Articles, relating to general meeting shall apply, but so that the necessary quorum shall be two persons atleast holding or representing by proxy one-tenth of the issued shares of the class but so that if at any adjourned meeting of such holders a quorum as above defined is not present, those members who are present shall be a quorum and that any holder of shares of the class present in person or by proxy may demand a poll and on a poll, shall have one vote for each shares of the class of which he is the holder. The Company shall comply with the provisions of Section 192 of the Act as to forwarding a copy of any such agreement or resolution to the Registrar.

BORROWING POWERS

Power to borrow

52. The Board may, from time to time, at its discretion, subject to the provisions of Section 58A, 292 and 293 of the Act, raise or borrow, either from the Directors or from elsewhere and secure the payment of any sum of money for the purposes of the Company.

Condition on which money may be borrow

53. The Board may raise or secure the repayment of such sum or sums in such manner and upon such terms and conditions in all respects as it thinks fit, and in particular, by the issue of bonds, perpetual or redeemable debenture or debenture-stock, or any mortgage, or other security on the undertaking of the whole or of the property of the Company (both present and future), including its uncalled capital for the time being, provided that debentures with the rights to allotment of or conversion into shares shall into be issued except with the sanction of the Company in general meeting and subject to the provisions of the Act.

Issue at discount etc. or with special privileges

54. Any debentures, debenture-stock, bonds or other securities may be issued at a discount, premium or otherwise and with any special privileges, as to redemption, surrender, drawings, allotment of shares appointment of Directors and otherwise, debentures, debenture stock, bonds and other securities may be made assignable free from any equities between the Company and the person to whom the same may be issued.

Instrument of transfer

55. Save as provided in Section 108 of the Act, no transfer of debenture shall be registered unless a proper instrument of transfer duly

stamped and executed by the transferor and transferee has been delivered to the Company together with the certificate or certificates of debentures.

56. If the Board refuses to register of any debentures the Company shall, within two months from the date on which the instrument of transfer was lodged with the Company, sent to the transferee and to the transferor notice of the refusal.

RESERVES

Reserves

57. Subject to the provisions of the Act, the Board shall in accordance with Section 205 (2A) of the Act, before recommending any dividend, set aside out of the profits of the Company such sums as thinks proper as reserves which shall, at the discretion of the Board be applicable for any purpose to which the profits of the Company may be properly applied and pending such application may at the like discretion, either be employed in the business of the Company or be invested in such investments (other than shares of the Company as the Board may from time to time think fit). The Board may so carry forward any profit which it may think prudent not to divide without setting them aside as a reserve.

Capitalisation

58. Any General Meeting may resolve that the whole or any part of the undivided profits of the Company (which expression shall include any premiums received on the issue of shares and any profits or other sums which have been set aside as a reserve or reserves have been carried forward without being divide) be capitalised and distributed amongst such of the members as would be entitled to receive the same if distributed by way of dividend and in the same proportions on the footing that become entitled thereto as capital and that all or any part of such capitalised amount be applied on behalf of such members in paying up in full any unissued shares of the Company which shall be distributed accordingly or in or towards payment of the uncalled liability on any issued shares, and that such distribution or payment shall be accepted by such member in full satisfaction of their interest in the said capitalised amount. Provided that any sum standing to the credit of a share premium account or a capital redemption reserve account may, for the purposes of this Article only be applied in the paying up of unissued shares to be issued to members of the company as fully-paid bonus shares.

Fractional certificate

59. For the purpose of giving effect to any resolution under two last preceding Articles the Directors may settle any difficulty which may arise in regard to the distribution as they think expedient and in particular may issue fractional certificate.

GENERAL MEETINGS

Extra ordinary General Meeting

60. The Directors may, whenever they think fit, call an extra ordinary general meeting provided however if at any time there are not in India Directors capable of acting who are sufficient in number to form a quorum any Directors present in India may call an extra ordinary general meeting in the manner as nearly as possible as that in which such a meeting may be called by the Board.

Calling of Extra ordinary General Meeting on requisition

61. The Board of Directors of the Company shall on the requisition of such member or members of the company as is specified in sub-section (4) of Section 169 of the Act forthwith proceed to call an extra ordinary general meeting of the Company and in respect of any such requisition and of any meeting to be called pursuant thereto, all the other provisions of section 169 of the Act and of any statutory modification thereof for the time being shall apply.

Quorum

62. The quorum for a general meeting shall be five members present in person.

Chairman

63. At every General Meeting the Chair shall be taken by the Chairman of the Board of Directors. If at any meeting the Chairman of the Board of Directors be not present within fifteen minutes after the time appointed for holding the meeting or, though present be unwilling to act as chairman, the members present shall choose one of the Directors present to be Chairman or if no Director shall be present and willing to take the Chair than the members present shall choose one of their member, being a member entitled to vote, to be Chairman.

Sufficiency of ordinary resolutions

64. Any act of resolution which, under the provision of this article or of the Act, is permitted shall be sufficiently so done or passed if effected by an ordinary resolution unless either the act or the articles specifically require such act to be done or resolution passed by a special resolution.

When if quorum be not present, meeting to be dissolved and when adjourned

65. If within half an hour from the time appointed for the meeting a quorum be not present, the meeting, if convened upon a requisition of share holders shall be dissolved but in any other case it shall stand adjourned to the same day in the next week at same time and place, unless the same shall be public holiday when the meeting shall stand adjourned to the next day not being a public holiday at the same time and place and if at such adjourned meeting a quorum be not present within half an hour from the time appointed for the meeting those members who are present and not being less than two persons shall be a quorum and may transact the business for which the meeting was called.

How question of resolutions to be decided at meetings

66. In the case of an equality of votes the Chairman shall both on a show of hands and a poll have a casting vote in addition to the vote or votes to which he may b e entitled as a member.

Power to adjourn General Meeting

67. The Chairman of a General Meeting may adjourn the same from time to time and from place to place, but no business shall be transacted at any adjourned meeting other than the business left unfinished at the meeting from which the adjournment took place. If shall not be necessary to give notice to the members of such adjournment or of the time, date and place appointed for the holding of the adjourned meeting.

Business may proceed notwithstanding demand of poll

68. If a poll be demanded, the demand of a poll shall not prevent the continuance of a meeting for the transaction of any business other than the question on which a poll has been demanded.

VOTES OF MEMBERS

General Obligation Of parties and Their nominees under JV Agreement

69. The JV Parties on their behalf and on behalf of their associates and nominees shall ensure as follows:

a) to exercise voting rights and powers available to them in relation to the JV Company so as to give full effect to the terms and conditions of JV Agreement, Articles of Association and terms and conditions contained in Annexure A to JV Agreement.

b) to ensure that the Directors nominated by them and other representatives shall support and implement all reasonable proposal which come before the proper development and conduct of the business as contemplated in JV Agreement.

c) use all reasonable endeavors to promote the business and the interests of the JV company.

Matters requiring consent of the JV Parties

70. The JV company shall not give effect to any decision or resolution in respect of any of the following matters except upon the affirmative vote of each of the JV Parties in the shareholders meeting and/or Board meeting, as applicable.

a) dissolution, liquidation or winding up of the JV Company.

b) Commencement of any new business or any diversification from the core business of the JV Company.

c) Merger or amalgamation with any other entity or split/division of the JV Company.

d) Closure of the business or activities of the JV Company or sale or transfer of any of its undertaking.

e) Creation of mortgage, charge, live or encumbrance of the movable and immovable assets of the JV Company except in the normal course of business of the JV Company for securing loans from the lenders.

f) Any sale, lease or transfer of the whole or substantial part of the undertaking or assets of the JV Company.

Joint holders

71. Where there are joint holders of any share any one of such persons may vote at any meeting either personally or by proxy in respect of such shares as if he were solely entitled thereto and if more than one of such joint- holders be present at any meeting either personally or by proxy then that one of the said persons so present whose name stands prior in order on the register in respect of such share shall alone be entitled to vote in respect thereof. Several executor or administrators of deceased member in whose name any share stands shall for the purpose of this Article be deemed joint holders hereof.

Instrument appointing proxy too in writing

72. The instrument appointing a proxy shall be in writing under the hand of the appointer or of his Attorney duly authorised in writing or is such appointer is a corporation under its common seal or the hand of its Attorney.

Instrument appointing proxy to be deposited at the office

73. The instrument appointing a proxy and the power-of-attorney or other authority (if any) under which it is signed or a notarially certified copy of that power of authority shall be deposited at the office not less than forty eight hours before the time for holding the meeting at which the person named in the instrument proposes to vote in default the instrument of proxy shall not be treated as valid.

When vote by proxy valid though authority revoked

74. A vote given in accordance with the terms of an instrument appointing a proxy shall be valid notwithstanding the previous death or insanity of the principal or revocation of the instrument of transfer of the share in respect of which the vote is given. Provided no intimation in writing of the death, insanity, revocation or transfer of the share shall have been received at the office or by the Chairman of the Meeting before the vote is given. Provided nevertheless that the Chairman of any meeting shall be entitled to require such evidence as he may in his discretion think fit of the due execution of an instrument of proxy and that the same has at been revoked.

Form of instrument appointing proxy

75. Every instrument appointing a proxy shall, as nearly as circumstances will admit, be in the form set out in Schedule IX to the Act.

Validity of vote

76. No objection shall be taken to the validity of any vote except at the meeting or poll at which such vote shall be tendered and every vote not disallowed at such meeting or poll and whether given personally or by proxy or otherwise shall be deemed valid for all purposes.

Restrictions on voting

77. No member shall be entitled to exercise any voting rights either personally or by proxy at any meeting of the Company in respect of any shares registered in his name on which any calls or other sums presently payable by him have not been paid or in regard to which the Company has and has exercised any right or lien.

DIRECTORS GENERAL PROVISIONS

Number of Directors

78. The Board shall comprise of minimum of 5 and not more than 12 Directors. So long as the Board comprises 5 Directors, Jindal Power Limited shall be represented by 4 Directors. In case the number of Directors is increased beyond 5, Jindal Power Limited shall at all times be represented by at least 50% of the Board strength (any fraction rounded off to 1) + 1 Director. Hydro Power Development Corporation of Arunachal Pradesh Limited shall be represented by 1 Director. Any increase in the total number of Directors shall be subject to prior approval of the Board in writing.

First Directors

79. The following shall be the first Directors of the Company :-

1. Dr. Rajendra Prasad Singh
2. Vinod Kumar Abbey
3. Rajeev Jain
4. Kapil Mantri
5. Taru Singh

Power of Directors to add its number

80. The Directors shall have power at any time and from time to time to appoint any person as a Director as an addition to the Directors but so that the total number of Directors shall not at any time exceed the maximum number fixed by the Articles, any director so appointed shall hold office only until the next Annual General Meeting of the Company and shall be eligible for re election.

Share qualification of Directors

81. A Director shall not be required to hold any share qualification.

Remuneration of Directors

82. (1) Subject to the provisions of the Act, a Director, who is in the whole-time employment of the Company, may be paid remuneration either by way of a monthly payment, fee for each meeting or participation in profits or by any or all these modes and/ or any other mode not expressly prohibited by the Act.

(2) Subject to the provisions of the Act, a Director, who is neither in the whole time employment nor a Managing Director may be paid remuneration either:

(i) by way of monthly, quarterly or annual payment with the approval of the Central Government; or

(ii) by way of commission if the Company by a special resolution authorised such payment.

(3) The fee payable to the Directors for attending meetings of the Board or Committee thereof shall, from time to time, be determined by the Board of Directors of the Company.

(4) The Board may allow and pay to any Director, who is not a bonafide resident of the place where the meetings of the Board are ordinarily held and who shall come to such place for the purpose of attending any meeting, such sum as the Board may consider fair compensation or for travelling, boarding, lodging and other expenses, in addition to his fee for attending such meeting as above specified; and if any Director be called upon to go or reside out of the ordinary place of his residence on the Company's business, he shall be entitled to be repaid and reimbursed any travelling or other expenses incurred in connection with the business of the Company.

Continuing Directors may act

83. The continuing Directors may act notwithstanding any vacancy in their body but so that if the number falls below the minimum number above fixed, the Directors shall not except for the purpose of filling vacancies or of summoning a General Meeting act so long as the number is below the minimum.

Directors may contract with Company

84. Subject to the provisions of section 297, 299, 300 and 314 of the Act, the Directors (including Managing Director) shall not be disqualified by reason of his or their office as such, from holding office under the Company or from contracting with the Company either as vendor, purchaser lender, agent, broker, lessor or otherwise nor shall any such contract or any contract or arrangement entered into by or behalf of the Company with a relative of such Directors or the Managing Director or with any firm in which any Directors or the Managing Director or with any firm in which any Director or a relative shall be a partner or with any other partner or with a private company in which such Director is a member or director interested be avoided, nor shall any Director or otherwise so contracting or being such member or so interested be liable to account to the Company for any profit realised by such contract or arrangement by reason only of such Director holding that office or of the fiduciary relation thereby established.

APPOINTMENT OF DIRECTORS

Appointment of Directors

85. a) The Company in General meeting, may subject to the provisions of these Articles and the Act, at any time elect any person to be a Director and may from time to time increase or reduce the number of directors.

b) The Joint Venture Parties including their nominees and Associates shall ensure that the individuals nominated by either of the Parties to be the Directors of the JV Company are duly elected and for this purpose shall use the voting rights attached to the respective shares held by them in favour of the election of such individual as Director.

c) The Joint Venture Parties shall be entitled from time to time to remove their respective Directors and nominate others in place of the Directors so removed in the JV company.

Board may fill up Casual Vacancies

86. If any Director appointed by the Company in general meeting vacates office as a Director before his term of office will expire in the normal course the resulting casual vacancy may be filled up by the Board at a meeting of the Board, but any person so appointed shall retain his office so long only as the vacating Director would have retained the same if no vacancy had occurred. Provided that the Board may not fill such a vacancy by appointing thereto any person who has been removed from the office of Director under Section 284 of the Act.

Nominee Directors

87. The Company shall subject to the provisions of the Act, be entitled to agree with any person, firm or corporation that or it shall have the right to appoint his or its nominee on the Board of Directors of the Company upon such terms and conditions as the Company may deem fit. The Corporation, firm or person shall be entitled from time to time to remove any such Director or Directors and appoint another or others in his or their places. He shall be entitled to the same right and privileges and be subject to the same obligation as any other Director of the company.

Alternate Directors

88. Subject to the provisions of section 313 of the Act the Board may appoint any person to act as an alternate director for a director during the latter's absence for a period of not less than three months from the state in which meeting of the Board are ordinarily held and such appointment shall have effect and such appointee, whilst he holds office as an alternate shall have effect and such appointee, whilst he holds office as an alternate director, shall b e entitled to notice of meeting of the Board and to attend and vote thereat accordingly, but he shall ipso facto vacate office if and/when the absent director returns to state in which meeting of the Board are ordinarily held or the absent Director vacates office as a Director.

ROTATION OF DIRECTORS

Rotation of Directors

89. (1) Not less than two-third of the total number of Directors shall be persons whose period of office is liable to determination by retirement of Director by rotation.

(2) At each Annual General Meeting of the Company one third or such of the Directors for the time being as are liable to retire by rotation or if their number is not three or a multiple of three, then the number nearest to one-third shall retire from office.

(3) The Directors to retire by rotation at every Annual General Meeting shall be those who have been longest in office since their last appointment, but as between persons who become Directors on the same day those to retire shall in default of and subject to any agreement among themselves b e determined by lot.

(4) If at any Annual General Meeting all the Directors appointed under Article 87 and 108 here by are not exempt from retirement by rotation under Section 255 of the Act then to the extent permitted by the said Section the exemption shall extend to the Director or Directors appointed under Article 87.

Subject to the foregoing provisions as between Directors appointed under any of the Articles referred to above, the Director or Directors who shall not be liable to retire by rotation shall be determined by and in accordance with their respective seniorities as may be determined by the Board.

Retiring Director eligible for reelection

90. A retiring Director shall be eligible for reelection and shall act as a Director throughout the meeting at which he retires.

91. Subject to any resolution for reducing the number of Directors, if at any meeting at which an election of Directors ought to take place, the places of the retiring Directors not filled up, the meeting shall stand adjourned till the next succeeding day which is not a public holiday at the same time and place and if at the adjourned meting, the places of the retiring Directors are not filled up, the retiring Directors or such of them as have not had their places filled up shall (it will to continue in office) be deemed to have been reelected at the adjourned meeting.

PROCEEDINGS OF DIRECTORS

Meeting of Directors

92. a) The Board shall meet regularly at least four times a year i.e. once in each quarter.

b) At least 5 days prior notice shall be given to all Directors of the Board whether residing in India or otherwise. In case of Directors residing outside India, notice shall be sent by telex/ fax/email. Each notice shall be sent in sufficient detail, the agenda of items to be transacted at each meeting. A meeting may be hold at short notice if it is agreed by all the Directors present in the meeting.

Quorum

93. The quorum for a meeting of the Directors shall be determined from time to time in accordance with the provisions of Section 287 of the Act. If a quorum shall not be present within fifteen minutes from the time appointed for holding a meeting of the Directors, it shall be adjourned until such date and time as the Directors present shall appoint.

Summoning a meeting of Directors

94. The Secretary may at any time, and upon request of and two Directors shall summon a meeting of the Directors.

Voting at Meeting

95. Subject to the provisions of Section 316, 372(5) and 386 of the Act, questions arising at any meeting shall be decided by a majority of votes, each director having one vote and in case of an equality of votes, the Chairman shall have second or casting vote.

Chairman of Meeting

96. The Chairman of the Board shall, at all times, be elected from the directors represented by Jindal Power Limited. The Chairman of the Board of Directors shall be the Chairman of the meetings of Directors. Provided that if the Chairman of the Board of Directors is not present within five minutes after the appointed time for holding the same, the Directors present shall choose one of the Directors represented by Jindal Power Limited to be the Chairman of such meeting.

Act of meeting

97. A meeting of Directors for the time being at which a quorum is present shall be competent to exercise all or any of the authorities, powers and discretions by or under the Articles of the Company and the for the being vested in or exercisable by the Directors generally.

To appoint Committee and to delegate power and revoke it

98. The Directors may subject to compliance of the provisions of the Act from time to time delegate any of their powers to Committees consisting of such member or members of their body as they think fit, an d may from time to time revoke such delegation. Any Committee so formed shall in the exercise of the powers so delegated confirm to any regulations that may from time to time be imposed on it by the Directors. The meeting and proceedings of any such Committee, if consisting of two or more members, shall be governed by the provisions herein contained for regulating the meetings and proceedings of the Directors so far as the same are

applicable thereto and are not superseded by any regulation made by the Directors under this Article.

Validity of acts

99. All acts done at any meeting of Directors or of a Committee of the Directors or by any person acting as a Director shall be valid notwithstanding that it be afterwards discovered that there was some defect in the appointment of any such Directors, Committee or person acting as aforesaid or that they or any of them were is disqualified.

Resolution by circulation

100. The minutes of the meeting shall be circulated to all the Directors of the Board.

And any such minutes of any meeting of Directors or of any Committee or of the Company if purporting to be signed by the Chairman of the such meeting or by the Chairman of next succeeding meeting shall be receivable as prima facie evidence of the matters in such minutes.

POWERS OF DIRECTORS

General power of the Company vested in the Directors

101. Subject to the provisions of the Act, the control of the Company shall be vested in the Directors who shall be entitled to exercise all such powers and do all such acts and things as may be exercised on done by the Company and are not hereby or by law expressly required or directed to be exercised or done by the Company in General Meeting but subject nevertheless to the provisions of any law and of these presents from time to time made by the Company in General Meeting provided that no regulation so made shall invalidate any prior act of the Directors which would have been valid if such regulation had not been made.

Power to delegate

102. Without prejudice to the general powers conferred by the preceding article the Directors may from time to time and at any time subject to the restrictions contained in the Act, delegate to managers, secretaries, officers assistants and other employees or other persons (including any firm or body corporate) any of the powers authorised and discretions for the time being vested in the Directors.

Power to authorise sub-delegation

103. The Directors may authorise any such delegate or attorney as aforesaid to sub-delegate all or any of the powers, authorities and discretion for the time being vested in them.

Signing of documents

104. All deeds, agreements and documents and all cheques, promissory notes, drafts, hundies, bills of exchange and other negotiable instruments, and all receipts for moneys paid to the Company, shall be signed, drawn, accepted or endorsed or otherwise executed, as the case may be by such persons (including any firm or body

corporate) whether in the employment to the Company or not and in such manner as the Director shall from time to time by resolution determine.

Management abroad

105. The Directors may make such arrangement as may be thought fit for the management of the Company's affairs abroad, any may for this purpose (without prejudice to the generality of their powers) appoint local bodies, and agents and fix their remuneration, and delegate to them such powers as may be deemed requisite or expedient. The foreign seal shall be affixed by the authority and in the presence of and instruments sealed therein shall be signed by such persons as the Directors shall from time to time by writing under the common seal appoint. The Company may also exercise the powers of keeping Foreign Registers. Such regulations not being in consistent with the provisions of Section 157 and 158 of the Act, the board may from time to time make such provisions as it may think fit relating thereto and may comply with the requirements of any local law.

Manager or Secretary

106. A manager or secretary may be appointed by the Directors on such terms, at such remuneration and upon such conditions as they may think fit, and any Manager or Secretary appointed may be removed by the Directors.

A director may be appointed as Manager or Secretary, subject to Section 314, 197A, 387 & 388 of the Act.

CEO, CFO and Other key officials

107. The Board shall appoint the Chief Executive Officer, Chief Financial Officer and other key officials of the JV Company.

MANAGING DIRECTORS

Power to appoint Manager Director

108. Subject to the provisions of sections 197A, 269, 316 and 317 of the Act, the Board may, from time to time appoint one or more Directors to be Managing Director or Managing Directors of the Company and may, from time to time (subject to the provisions of any contract between him or them and the Company, remove or dismiss him or them from office and appoint another or others in his place or their places.

To what provisions he shall be subjected

109. Subject to the provisions or Section 255 of the Act and Article 89 (4) hereof, a Managing Director shall not, while he continues to hold that office, be subject to retirement by rotation, but (Subject to the provisions of any contract between him and the Company) he shall be subject to the same provisions as to resignation and removal as the other Directors, and he shall, ipso facto and immediately, cease to be a Managing Director if he ceases to hold the office of Director from any cause.

Remuneration of Managing Director

110. Subject to the provisions of Sections 198, 309, 310 and 311 of the Act, a Managing Director shall, in addition to the remuneration payable to him as a Director of the Company under the Articles, receive such additional remunerations as may from time to time be sanctioned by the Company.

Power of Managing Director

111. Subject to the provisions of the Act, in particular to the prohibitions and restrictions contained in Section 292 thereof, the Board may, from time to time, entrust to and confer upon a Managing Director for the time being such of the powers exercise able under these presents by the Board as it may think fit, and may confer such powers for such time, and be exercised for such objects and purposes, and upon such terms and conditions and with such restrictions as it thinks fit, and the Board may confer such powers, either collaterally with, or to the exclusion of, and in substitution for any of the powers of the Board in that behalf and may, from time to time, revoke, withdraw, alter or vary all or any of such powers.

COMMENCEMENT OF BUSINESS

Compliance before commencement of new business

112. The Company shall not at any time commence any business out of other objects of its Memorandum of Association unless the provisions of sub- section 2(B) of Section 149 of the Act have been duly complied with by it.

Custody of seal

113. The Directors shall provide for the safe custody of the Seal and the Seal shall never be used except by the authority of the Director or a Committee of the Directors previously given and one Director at least shall sign every instrument to which the seal is affixed provided nevertheless that any instrument bearing the Seal of the Company any issued for valuable consideration shall be binding on the Company notwithstanding any irregularity touching the authority of the Directors to issue the same.

DIVIDENDS

How profits shall be divisible

114. Subject to Rights of members entitled to shares (if any) with preferential or special rights attached to them, the profits of the Company from time to time determined to be distributed as dividend in respect of any year of other period shall be applied for payment of dividend on the shares in proportion to the amount of capital paid up on the Shares provided that unless the Board otherwise determines all dividends shall be apportioned and paid proportionately to the amounts paid or credited as paid up on the shares during any portion or portions of the period in respect of which dividend is paid. Provided always that subject as aforesaid any capital paid up on a share during the period in respect of which a dividend is declared shall (unless the Board otherwise determines or the terms of issue otherwise provide, as the case may be), only entitle the holder of

such share to an apportioned amount of such dividend as from the date of payment but so that where capital is paid up in advance of calls such capital shall not confer a right to participate in profits.

Declaration of Dividends

115. The Company in General Meeting may declare a dividend to be paid to the members according to their rights and interest in the profits and may subject to the provisions of Section 207 of the Act fix the time for payment.

Restrictions on amount of dividends

116. No larger dividend shall be declared than is recommended by the Directors, but the Company in General Meeting may declare a smaller dividend.

Dividend out of profit only

117. No dividend shall be payable except out of the profits of the Company of the year or any other undistributed profits and no dividend shall carry interest as against the Company.

What to be deemed net profits

118. The declaration of the Directors as to the amount of the net profits of the Company for any year shall be conclusive.

Interim dividends

119. The Directors may from time to time pay to the members such interim dividends as in their judgment the position of the Company justifies.

Debts may be deducted

120. The Director may retain any dividends on which the Company has a lien and may apply the same in or towards satisfaction of the debts, liabilities or engagements in respect of which the lien exists subject to Section 205A of the Act.

Dividend and call together

121. Any General Meeting declaring a dividend may make a call on the members of such amount as the meeting fixes but so that the call on each member shall not exceed the dividend payable to him and so that the call be made payable at the same time as the dividend and the dividend may, if so arranged between the company and the member, be set off against the call.

122. A transfer of shares shall not pass the rights to any dividend declared thereon before the registration of the transfer.

Retention in certain cases

123. The Directors may retain the dividends payable upon shares in respect of which any person is under the transmission Article entitled to become a member or which any person under the Article is entitled to transfer until such person shall duly become a member in respect thereof or shall transfer the same.

Dividend to joint holders

124. Any one of the several persons who are registered as a joint-holders of any share may give effectual receipts of all dividends and payments on account of dividends in respect of such shares.

Payment be post

125. Unless otherwise directed, any dividend may be paid by cheques or warrant sent through the post to the registered address of the member or person entitled thereto, or in the case of joint-holders to the registered address of that one whose name stands first on the Register in respect of the joint holding or to such person and such address and the member or person entitled or such joint holders and the case may be, may direct and every cheques or warrant so sent shall be made payable at par to the person or to the order of the person to whom it is sent or to the order of such other person as the member or person entitled or such joint-holders, as the case may be, may direct.

When payment a good discharge

126. The payment of every cheques or warrant sent under the provisions of the last preceding Article shall, if such cheques or warrant purports to be duly endorsed, be a good discharge to the Company in respect thereof, provided nevertheless that the Company shall not be responsible for the loss of any cheques, dividend, warrant or postal money order which shall be sent by post to any member or by his order to any other person in respect of any dividend.

Any dividend remaining unpaid or unclaimed after having been declared shall be dealt in accordance with Section 205(A) of the Companies Act in respect of such dividend.

BOOKS AND DOCUMENTS

Where to be kept

127. The Books of Account shall be kept at the registered office or at such other place as the Directors think fit, and shall be open to inspection by the Directors during business hours.

Inspection by members

128. The Directors shall from time to time determine whether and to what extent at what times and places and under what conditions or regulations the accounts or books or documents of the Company or any of them shall be open for inspection to members not being Directors, and no member (not being a Director) shall have any right of inspecting any books of account or documents of the Company except as conferred by law or authorized by the Directors or by the Company in General Meeting.

Balance Sheet and Profit and Loss Account

129. Balance Sheet and Profit and Loss Account will be audited once in a year by a qualified auditor for correctness as per provisions of the Act.

Audit

130. The first auditors of the company shall be appointed by the Board of Directors within one month after its incorporation who shall hold office till the conclusion of first annual general meeting.

131. The directors may fill up any casual vacancy in the office of the auditors.

132. The remuneration of the auditors shall be fixed by the company in general meeting except as otherwise decided or that remuneration of the first or any auditors appointed by the directors may be fixed by the directors.

NOTICES

How notices served on members

133. The Company shall comply with the provisions of Sections 53, 172 and 190 of the Act as to the serving of notices.

Transferee etc., bound by prior notices

134. Every person who, by operation of law, or by transfer or by other means whatsoever, shall become entitled to any share shall be bound by every notice in respect of such share which previously to his name and address being entered on the register shall be duly given to the person from who m he derives his title to such share.

Notice valid though member deceased

135. Any notice or document delivered or sent by post to or left at the registered address of any member in pursuance of these presents shall notwithstanding such member be then deceased and whether or not the Company has notice of his demise, be deemed to have been duly served in respect of any registered shares whether held solely or jointly with other persons by such member, until some other person be registered in his stead as the holder or joint-holders thereof and such service shall for all purposes of these presents be deemed a sufficient service of such notice or document on his or her heirs, executors or administrators, and all persons, if any, jointly interested with him or her in any such share.

How notice to be signed

136. The signature to any notice to be given by the Company may be written or printed.

RECONSTRUCTION

Reconstruction

137. On any sale of the undertaking of the Company, the Directors or the Liquidators on a winding up may, if authorised by a special resolution, accept fully paid or partly paid up shares; debentures or securities of any other Company whether incorporated in India or not other than existing or to be formed for the purchase in whole or in part of the property of the Company, and the Directors (if the profits of the Company permit), or the Liquidators (in a winding up) may distribute such shares or securities or any other property of the Company amongst the members without realisation or vest the same in trustees for them and any special resolution may provide for the distribution or appropriations of the cash, shares or other securities, benefits or property, otherwise than in accordance with the strict legal rights of the members or contributories of the Company and for the valuation of any such securities or property at such price and in such manner as the meeting may approve and all

holders of shares shall be bound to accept and shall be bound by any valuation or distribution so authorised, and waive all rights in relation thereto save only in case the Company is proposed to be or is in the course of being wound up, such statutory rights, if any, under Section 494 of the Act as are incapable of being varied or excluded by these presents.

SECRECY

No shareholder to enter the premises of the company without permissions

138. Subject to the provisions of law of land and the Act, no member or other person (not being a Director) shall be entitled to enter upon the property of the company or to inspect or examine the Company's premises or properties of the Company without the permission of the Directors, or subject to article 126 to require discovery or any information respecting any detail of the Company's trading or any matter which is or may be in the nature of a trade secret, mystery of trade, or secret process or of any matter whatsoever which may relate to the conduct of the business of the Company and which in the opinion of the Directors it will be inexpedient in the interest of the members of the Company to communicate.

WINDING UP

Distribution of assets

139. If the Company shall be wound up and the assets available for distribution among the members as such shall be insufficient to repay the whole of the paid-up capital such assets shall be distributed so that as nearly as may be the losses shall be born by the members in proportion to the capital paid up or which ought to have been paid-up at the commencement of the winding-up on the shares held by them respectively. And if in a winding- up the assets available for distribution among the members shall be more than sufficient to repay the whole of the capital paid-up at the commencement of the winding up, the excess shall be distributed amongst the members in proportion to the capital at the commencement of the winding-up, paid up or which ought to have been paid up on the shares held by them respectively. But this Article is to be without prejudice to the rights of the holders of shares issued upon special terms and conditions.

Distribution of assets in specie

140. In the event of Company being wound up, whether voluntarily or otherwise, the liquidators may with the sanction of a Special Resolution divide among the contributories, in specie or in kind any part of the assets of the Company and may with the like sanction vest any part of the assets of the Company in Trustees upon such trusts for the benefit of the contributories or any of them, as the liquidators, with like sanction, shall think fit.

INDEMNITY

Indemnity

141. Subject to the provisions of Section 201 of the Act, every Director, Manager, Secretary and other officer or employee of the Company shall be indemnified against and it shall be the duty of the Directors to pay out of the funds of the Company all bonafide costs, losses and expenses (including travelling expenses) which any such Directors, Manager or Secretary or other officer or employee may incur or become liable to by reason of any contract entered into or any way in the discharge of his or their duties and in particular, and so as not to limit the generality of the foregoing provisions, against all liabilities incurred by him or by them as such Director, Manager, Secretary, Officer or employee in defending any proceeding whether civil or criminal in which judgement is given in his or their favour or he or they is or are acquitted, or in connection with any application under Section 633 of the Act in which relief is granted by the Court and the amount, for which such indemnity is provided shall immediately attach as a lien on the property of the Company and have priority as between the members over all other claims.

Individual responsibility of Directors

142. Subject to the provisions of the act and so far as such provisions permit, no Director, Auditor or other Officer of the Company shall be liable for acts, receipts, neglects or defaults of any other Director or Officer, or for joining in any receipt or act for conformity, or for any loss or expense happening to the Company through the insufficiency or deficiency or title to any property acquired by order of the Director for or on behalf of the Company or for the insufficiency or deficiency of any security in or upon which any of the moneys of the Company shall be invested, or for any loss occasioned by any error of judgement, omission, default, or oversight on his part, or for any loss, damage or misfortune whatever which shall happen in the execution of the duties of his office or in relation thereto, unless the same happens through his own dishonesty.

Sl. No.	Name, Address, Description and occupation of Each subscriber	Signature of Subscriber	Name, Address, Description & signatures of witness
1.	Jindal Power Limited Reg. office : Khorsia Raod Post Box No. 16, Raigarh-496001 Through : Mr. Anand Goel S/o Late Chajju Ram Goel B-3/15, Safdarjung Enclave New Delhi - 110029 (Business)	Sd/-	Sd/- (UMESH C. PANDEY) CHARTERED ACCOUNTANT M. No. 055252 D-26, Sector-3 Noida, U.P.-201301
2.	Hydro Power Development Corporation of Arunachal Pradesh Limited, Reg. office : Tahung Tatak Building, Near APPSC, MLA Cottage Road, ITA Nagar (Business) Through, Taru Siga S/o Sh. Takia Siga ITA Nagar - 791111	Sd/-	
3.	Sushil Maroo S/o Shri Nand Singh Maroo C-20, Pamposh Enclave, G. K. - I New Delhi-110048. (Service) (As nominee of Jindal Power Ltd.)	Sd/-	
4.	Rajeev Jain S/o Shri Sumer Chand Jain R/o 1885A/139A, Tri Nagar Delhi-110035 (Service) (As nominee of Jindal Power Ltd.)	Sd/-	
5.	Rajender Prasad Singh S/o Shri Hriday Narain Singh R/o A-1, PWO Hriday Deep, Sector-43, Gurgaon, Haryana-122002 (Service) (As nominee of Jindal Power Ltd.)	Sd/-	
6.	Kapil Mantri S/o Shri Shyam Sunder Mantri R/o D 281, Ground Floor, Sarvodaya Enclave, New Delhi-110017 (Service) (As a nominee of Jindal Power Ltd.)	Sd/-	
7.	Vinod Kumar Abbey S/o Late Sh. Raj Kumar Abbey A-46 Sector-36, Noida, U.P.-201303 (Service) (As A Nominee of Jindal Power Ltd.)	Sd/-	

Dated : 17/02/2010
Place : New Delhi

Annexure-4

Addendum to Agreement between Govt. of Arunachal Pradesh, Hydro Power Development Corporation of Arunachal Pradesh Ltd. and Jindal Power Limited

भारतीय गैर न्यायिक

बीस रुपये

रु.20

भारत

Rs.20

TWENTY RUPEES

सत्यमेव जयते

INDIA

INDIA NON JUDICIAL

अरूणाचल प्रदेश ARUNACHAL PRADESH

00AA 401263

JINDAL POWER LIMITED

Itanagar

ADDENDUM

Addendum Dated.....28th.....September 2012 to the Agreement dated 28th August 2009 between Govt. of Arunachal Pradesh and Hydro Power Development Corporation of Arunachal Pradesh Limited (HPDCAPL) and M/s Jindal Power Limited (JPL) (JV Company).

Pursuant to the approval of the Government of Arunachal Pradesh, conveyed vide letter Ref. No.CE(M)/HPD/W-128/2011-12/155-58 dated 20/04/2012, it is hereby mutually agreed between the parties as follows:

The name of "Subansiri Middle (1600 MW) Hydro Electric Project" stands changed to "Kamala Hydro Electric Project (1600 MW)" and the name of the project wherever appearing in the agreement(s) as "Subansiri Middle Hydro

Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar

HPDCAPL 28/9/12

अरूणाचल प्रदेश ARUNACHAL PRADESH

00AA 401264

Electric Project (1600 MW)" shall be substituted with and be read as "Kamala Hydro Electric Project (1600 MW)" on Kamala river in Arunachal Pradesh.

All other terms and conditions of the aforestated agreement dated 28th August 2009 shall remain unchanged.

IN WITNESS WHEREOF THE PARTIES THROUGH THEIR AUTHORISED REPRESENTATIVES HAVE SIGNED THOSE PRESENTS ON THE DAY MONTH AND YEAR MENTIONED ABOVE.

Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar

Managing Director
HPDCAPL, Itanagar
28/9/16

अरूणाचल प्रदेश ARUNACHAL PRADESH

00AA 401266

FOR AND ON BEHALF OF THE
GOVERNOR OF ARUNACHAL PRADESH

28.9.2012

(S.K.Saxena)
Secretary(Power)
Govt. of Arunachal Pradesh
Itanagar.

Signature with seal
Witness

28-9-12

FOR AND ON BEHALF OF THE
Hydro Power Development Corporation of Arunachal Pradesh Limited

28/9/12

(Toko Onuj)
Managing Director
Hydro Power Development Corporation of Arunachal Pradesh Limited

Signature with seal
Witness

Dhananjoy Biswas
UDC, HPDCAPL
S/o- Sushil Biswas
C. Sector Power House
Itn - 791111.

FOR AND ON BEHALF OF THE
M/s Jindal Power Ltd.

(Kapil Mantri)
Sr. DGM
M/s Jindal Power Limited

Signature with seal
Witness

(AMAL DUTTA)

Annexure-5

Addendum to Joint Venture Agreement between Hydro Power Development Corporation of Arunachal Pradesh Ltd. and Jindal Power Limited

अरूणाचल प्रदेश ARUNACHAL PRADESH 00AA 392920

ADDENDUM TO JV AGREEMENT DATED 29th AUG' 2009
(1 of 5)

Addendum dated ...27th.....November, 2012 to the Joint Venture Agreement dated 29th August 2009 between Hydro Power Developemnt Corporation of Arunachal Pradesh Limited (HPDCAPL) and M/s Jindal Power limited (JPL).

JINDAL POWER LIMITED

अरूणाचल प्रदेश ARUNACHAL PRADESH 00AA 392921

ADDENDUM TO JV AGREEMENT DATED 29th AUG' 2009
(2 of 5)

Pursuant to the approval of the Government of Arunachal Pradesh, conveyed vide letter Ref. No. CE(M)/HPD/W-128/2011-12/155-58 dated 20/04/2012, it is hereby mutually agreed between the parties as follows:

JINDAL POWER LIMITED

भारतीय गैर न्यायिक

बीस रुपये

रु.20

भारत

Rs.20

TWENTY RUPEES

सत्यमेव जयते

INDIA

INDIA NON JUDICIAL

अरूणाचल प्रदेश ARUNACHAL PRADESH

00AA 392922

ADDENDUM TO JV AGREEMENT DATED 29th AUG' 2009

(3 of 5)

The name of "Subansiri Middle (1600 MW) Hydro Electric Project" stands changed to "Kamala Hydro Electric Project (1600 MW) and the name of the project wherever appearing in the agreement(s) as "Subansiri Middle Hydro Electric Project (1600 MW)" shall be substituted with and be read as "Kamala Hydro Electric Project (1600 MW)" on Kamala River in Arunachal Pradesh.

DAL POWER LIMITED

भारतीय गैर न्यायिक

भारत

बीस रुपये

Rs.20

रु.20

TWENTY RUPEES

सत्यमेव जयते

INDIA

INDIA NON JUDICIAL

अरूणाचल प्रदेश ARUNACHAL PRADESH 00AA 392959

ADDENDUM TO JV AGREEMENT DATED 29th AUG' 2009
(4 of 5)

All other terms and conditions of the aforestated agreement dated 29th August 2009 shall remain unchanged.

IN WITNESS WHEREOF THE PARTIES THROUGH THEIR AUTHORISED REPRESENTATIVES HAVE SIGNED THOSE PRESENTS ON THE DAY MONTH AND YEAR MENTIONED ABOVE.

JINDAL POWER LIMITED

भारतीय गैर न्यायिक

बीस रुपये

रु.20

भारत

सत्यमेव जयते

INDIA

Rs.20

TWENTY RUPEES

INDIA NON JUDICIAL

अरूणाचल प्रदेश ARUNACHAL PRADESH 00AA 392958

ADDENDUM TO JV AGREEMENT DATED 29th AUG' 2009

(5 of 5)

FOR AND ON BEHALF OF THE

Hydro Power Development Corporation of
Arunachal Pradesh limited,

(Toko Onuj)

Managing Director,
Hydro Power Development Corporation of
Arunachal Pradesh limited

Witness

(Dhananjoy Biswas)

FOR AND ON BEHALF OF THE

M/s Jindal Power Limited

(Kapil Mantri)
Sr. DGM,
M/s Jindal Power Limited

Witness

(J. Henry Robertson)

Annexure-6

Memorandum of Agreement between Govt. of Arunachal Pradesh, Hydro Power Development Corporation of Arunachal Pradesh Ltd. and Jindal Power Limited

अरुणाचल प्रदेश ARUNACHAL PRADESH 029220

MEMORANDUM OF AGREEMENT BETWEEN

GOVERNMENT OF ARUNACHAL PRADESH

AND

HYDRO POWER DEVELOPMENT CORPORATION OF ARUNACHAL PRADESH

LIMITED AND M/S JINDAL POWER LIMITED (JV COMPANY)

FOR EXECUTION OF SUBANSIRI MIDDLE (1600 MW) HYDRO ELECTRIC

PROJECT ON ~~SUBANSIRI~~ KAMLA RIVER IN ARUNACHAL PRADESH.

Managing Director Hydro Power Development Corporation of Arunachal Pradesh Limited

Turnke Bagra Secretary (Power)

This agreement is made on this 28th day of August 2009 between the Governor of Arunachal Pradesh, represented by the Secretary (Power), Government of Arunachal Pradesh, hereinafter referred to as "State Government" which expression shall, unless repugnant to the context or meaning thereof, include its successors and assign(s), on **ONE PART.**

JINDAL POWER LIMITED

AND

Managing Director Hydro Power Development Corporation of Arunachal Pradesh Limited (A Govt. of Ar.Pr. Undertaking)

Secretary (Power) Govt. of Arunachal Pradesh Itanagar

JINDAL POWER LIMITED

Hydro Power Development Corporation of Arunachal Pradesh Limited, a public sector undertaking set up by the State Government of Arunachal Pradesh for development of Hydro Power Projects in the State and having its registered office at Tahung Tatak Building, near APPSC, MLA Cottage Road, Itanagar, acting through Mr. Taru Siga, Managing Director, Hydro Power Development Corporation of Arunachal Pradesh Limited (hereinafter referred to as "**HPDCAPL**" which expression shall, unless repugnant to the context or meaning thereof, include its successor(s), Administrator(s) and permitted assign(s) on the **SECOND PART.**

AND

M/s Jindal Power Ltd. a company incorporated under the Companies Act, 1956, having its registered office at Kharsia Road, Raigarh (Chattisgarh) through Mr. Vinod Kumar Abbey, CEO (Hydro) of M/s Jindal Power Ltd. (hereinafter referred to as "**JPL**" which expression shall, unless repugnant to the context or meaning thereof, include its successor(s), Administrator(s) and permitted assign(s) on the **THIRD PART.**

"GoAP" , "JPL." and "HPDCAPL" Shall be individually referred to as "Party" and collectively as "Parties". **"JPL" And "HPDCAPL"** Shall be collectively referred to as "**JV Company**".

WHEREAS

1. The Government of India ("GoI") has launched the "50,000 MW Hydro-electric Initiative" with the objective of increasing the hydro power capacity in India (Country) out of which more than half the capacity has been identified in the State of Arunachal Pradesh ("State") itself.

2. GoAP has earmarked certain Projects for allocation to private developers, Central Sector developers, State Sector developers for the development of Hydro Power Projects in the State, which will generate economic activity in the State leading to its growth and will also serve as an engine to achieve

JINDAL POWER LIMITED

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Ar.Pr. Undertaking

the objective of promoting all round development in the State and the Country ; and

3. The Subansiri Middle Hydroelectric Project (1600 MW) on Subansiri river in Lower Subansiri District of the State of Arunachal Pradesh with an installed capacity of 1600 MW is contemplated to be taken up for implementation by JV Company.

4. The Govt. of Arunachal Pradesh has agreed for executing of the Subansiri Middle Project (1600 MW) in the state by the Hydro Power Development Corporation of Arunachal Pradesh Limited in Joint Venture with M/s Jindal Power Limited as per Hydro Power Policy 2008.

NOW, THEREFORE, AND IN CONSIDERATION OF PREMISES AND MUTUAL CONVENANTS AS SET FORTH HEREIN, THE PARTIES HEREBY IRREVOCABLY AGREE AS FOLLOWS:

Article I

INTERPRETATIONS AND DEFINITIONS.

1. INTERPRETATIONS

1.1.1 The nomenclature of this Agreement, headings and paragraph numbers are only for the convenience of reference and shall be ignored in construing or interpreting this Agreement.

1.1.2 Reference to persons and words denoting natural persons shall include bodies, corporate, partnerships, joint ventures, statutory and other authorities and entities ("Persons").

1.1.3 Reference to any enactment, ordinance or regulation or any provision thereof shall include any amendment thereof or any replacement in whole or in part.

1.1.4 Reference to Recitals, Articles, Clauses, or Sub-clauses shall unless the context otherwise requires, be deemed to include the Recitals, Articles,

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Ar. Pr. Undertaking)

clauses, or Sub-clauses of this Agreement.

1.1.5 The words importing singulars shall include plurals and vice-versa, as the case may be.

1.1.6 Terms beginning with capital letters and defined as per Clause 1.2 of this Agreement shall have the same meaning ascribed thereto, and any terms not defined in the Agreement would have the same definitions as available in the Electricity Act, 2003 **("The Act")**.

1.1.7 Any reference at any time to any agreement, deed, instrument license or document of any description shall be construed as reference to that agreement, deed, instrument, license or other document as amended, varied, supplemented, modified or suspended at the time of such reference provided that this Clause shall not operate to increase liability or obligations of any Party hereunder or pursuant hereto in any manner whatsoever.

1.1.8 Any agreement, consent, approval, authorization, notice, communication, information or report required under or pursuant to this Agreement from or by any Party shall be valid and effectual only if it is in writing and under the hands of duly authorized representatives of such Party in this behalf and not otherwise.

1.1.9 Any reference to any period commencing 'from' a specified day or date and "till" or "until" a specified day or date shall include both such days or dates.

1.2. DEFINITIONS.

In this Agreement the following words and expressions and unless repugnant to the context or meaning thereof, shall have the meanings hereinafter respectively assigned to them:

1.2.1 **"Agent"** means the authorized representative or such other Authority as

JINDAL POWER LIMITED

Managing Director
Haryana
Development Corporation of
Arunachal Pradesh Limited

may be appointed by the State Government for the purpose of this Agreement.

1.2.2 **"Agreement"** means this agreement together with any amendments made thereto in accordance with the provisions herein contained;

1.2.3 **"Agreement period"** shall have the meaning as specified in Article 2;

1.2.4 **"Central Govt."** means the Government of India;

1.2.5 **"CEA"** means the Central Electricity Authority constituted under Section 3 of the Electricity (Supply) Act 1948 and which has been defined to be Central Electricity Authority under section 70 (2) of Electricity Act, 2003 or its successors, administrators or assignees.

1.2.6 **"CERC"** means Central Electricity Regulatory Commission.

1.2.7 **"Commercial Operation"** means the state of Unit/Project when Unit/Project is capable of delivering Active power and Reactive Power on a regular basis after having successfully completed the commissioning tests as per Prudent Utility Practices.

1.2.8 **"Commercial Operation Date (COD)"** means the date on which the commercial operation of Project achieved by the JV Company and shall be as per CERC regulations .

1.2.9 **"JV Company"** will mean Hydro Power Development Corporation of Arunachal Pradesh Limited and M/s Jindal Power Limited collectively.

1.2.10 **"Company"** will mean a company incorporated under the companies Act 1956.

1.2.11 **"Detailed Project Report (DPR)"** means the Detailed Project Report pertaining to the project under this Agreement to be submitted by the JV Company and to be approved by the competent authority of the State Govt.

JINDAL POWER LIMITED

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Ar.Pr. Undertaking)

Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar

1.2.12 **"Dispute"** shall have the meaning as specified in Article 13;

1.2.13 **"Evacuation System"** means the network of power transmission lines and sub-stations for transmitting the electrical output from the Interconnection Point up to main load centre(s);

1.2.14 **"Financial closure"** means the date on which the Financing Agreements have been duly executed and the JV Company has access to such funding under the Financing Agreements;

1.2.15 **"Financing Agreement"** means the loan agreements, notes, indentures, security agreements, letters of credit equity arrangements and other documents relating to the financing(including refinancing) of the project and the capital cost or any part thereof, as amended, supplemented or modified from time to time and approved by the competent authority;

1.2.16 **"Force Majeure"** shall have the meaning as ascribed thereto in article 11;

1.2.17 **"GOI"** means the Government of India;

1.2.18 **"Interconnection Facilities"** means all the facilities which shall include without limitation, switching equipment communication, protection, control and metering devices etc. at the Interconnection Point(s) in the switchyard of the generating stations to be installed and maintained at the cost of the JV Company to enable evacuation of Power output from the Project in accordance with this Agreement;

1.2.19 **"Law"** means any act, rule regulation, notification, order or instruction having the force of Law enacted or issued by any competent legislature. Government or statutory authority in India and pronouncement of judicial /quasi judicial authorities;

1.2.20 **"Month"** means the English Calendar month;

JINDAL POWER LIMITED

1.2.21 **"Parties"** mean the State Government and the JV Company collectively;

1.2.22 **"Party"** means the State Government and / or the JV Company individually;

1.2.23 **"Power Purchase Agreement (PPA)"** means a contractual agreement to be signed by the JV Company with an electricity consumer, trader or any other parties permitted under the statute to purchase the power generated from the project;

1.2.24 **"PFR"** means the pre feasibility report pertaining to the project under this Agreement;

1.2.25 **"Project"** means the Subansiri Middle Hydro Electric Project (1600 MW) proposed to be established on ~~Subansiri~~ river in the Lower Subansiri District of Arunachal Pradesh between EL +477 m and Lower Subansiri HEP(2000 MW) being developed by NHPC, including complete hydroelectric power generating facility covering all components such as dam, intake works, water conductor system, power station, generating units, project roads, bridges, offices, residential facilities store, guest houses, security office and other connected facilities including the Interconnection Facilities; The level is indicative of tentative outer boundary only.

1.2.26 **"Prudent Utility Practices"** means those practices, methods, techniques and standards that are generally accepted internationally from time to time by electric utilities for the purpose of ensuring safe, efficient and economic design, engineering, construction, commissioning, testing, operation and maintenance of various component of the project of the type specified in this agreement and which practices, methods and standards shall be adjusted as necessary to take account of

I. Installation, operation and maintenance guidelines recommended by the manufacturers of the plant and equipments to be

Tumke Bagra
Secretary (Power)

Kamla

JINDAL POWER LIMITED

JINDAL POWER LIMITED

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Ar.Pr. Undertaking)

incorporated in the project.

II. The requirement of Indian Law.

III. Physical conditions at the site.

IV. Practices, methods, techniques and standards as changed from time to time that are generally accepted internationally for use in electric utility and for power generation in India.

1.2.27 **"Site"** means the site of the project appurtenances, generating plant including land, waterways, roads and rights acquired or to be acquired by the JV Company for the purposes of the project.

1.2.28 **"State"** means the State of Arunachal Pradesh.

1.2.29 **"State Government"** means the Govt. of Arunachal Pradesh;

1.2.30 **"SPV"** means a body/organization to be constituted by the JV Company for implementation of the project while performing the obligations and duties under this agreement;

1.2.31 **"Unit"** means one /more hydro generator (s) including ancillary equipment and facilities thereto forming the part of the project;

1.2.32 **"Year"** means the English Calendar year comprising of 365 days in a non-leap year and 366 days in a leap year.

Article 2

GENERAL TERMS AND CONDITIONS OF THE AGREEMENT.

2.1 The State Govt. hereby grants permission to the JV Company to undertake preliminary investigation for preparation of the Pre- feasibility Report, detailed investigation for DPR preparation, financing and subsequent development, commissioning, implementation, operation and maintenance

JINDAL POWER LIMITED

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Arunachal Pradesh Undertaking)

of **Subansiri Middle HEP (1600 MW)** in Lower Subansiri Distt., Arunachal Pradesh.

2.2 The project shall be implemented by the JV Company on BOOT (Build, Own, Operate and Transfer) basis for an initial lease period of *40(Forty)* years from the Commercial Operation Date (COD). However, the lease period can be extended beyond 40 years period by the State Govt. on mutually acceptable terms and conditions. The project shall be reverted to the State Govt. on expiry of above lease period, free of cost, in good working condition.

2.3 The entire cost of investigation, DPR preparation, project implementation and subsequent operation and maintenance of the project will be borne by the JV Company.

2.4 The project shall be developed as a run-of-the river / Storage Scheme in tune with the State Govt. policy to develop the project in the most environment, eco, and people friendly manner.

2.5 The PFR and the DPR of the project shall be submitted by JV Company for approval of CEA under the Electricity Act, 2003, a copy of which would also be submitted to the State Govt. The State Govt. undertakes to obtain permission / clearances in respect of any interstate issue/ diversion of water and would also render all the necessary assistance to the JV company in obtaining the concurrence of CEA under the Electricity Act, 2003. However, the consent of the State Govt. shall be required before submitting the DPR to the CEA for TEC.

2.6 All clearances required from the Central Govt. including clearance from Standing Committee of the National Board of Wild Life if required in connection with the project implementation shall be arranged by the JV Company itself. The State Govt. shall accord necessary clearances under its purview within a reasonable period. The State Govt. shall extend all need based assistance in obtaining such clearances including licenses, approvals, sanctions, permits etc. as may be required for the project.

JINDAL POWER LIMITED

2.7 The JV Company shall be responsible for upkeep of the ecology of the project area and its surroundings by preventing deforestation, water pollution and defacement of natural landscape. The JV Company shall take all reasonable measures to prevent any destruction of flora and fauna, scarring or defacement of the natural surroundings within and in the vicinity of the project sites. The JV Company shall abide by the conditions laid down in the forest, wildlife and environmental clearances accorded by the competent authority.

2.8 The JV Company shall make available information regarding water discharge regularly to the State Govt.

2.9 The State Govt. or its agents or a person authorized by the State Govt. in that behalf shall be free to investigate, survey and implement other projects of any nature either upstream or downstream as the case may be of the project, provided that it shall not have any adverse impact on implementation, operation and maintenance of the Project.

2.10 The JV Company shall allow the State Govt. its officers/staffs or authorized agents to use the roads and facility such as Post Office, School and Dispensary etc., that may be provided by the JV Company as a part of the project. The State Govt. and its authorized agent shall be allowed to inspect the project and its site(s) upon advance notice.

2.11 The JV Company shall not incur any kind of financial liabilities in the name of the State Govt., in the execution and subsequent operation and maintenance of the project unless mentioned herein.

2.12 The JV Company will not be allowed to sell and transfer the power plant to any other party/parties without the prior permission of the State Govt. However, the JV Company shall be allowed to mortgage the power plant to the Lenders for availing financial assistance to meet the cost of the project with prior consent of the State Govt. Further, the JV Company shall not be permitted to transfer the project under this agreement to any third party without the consent of the State Govt.

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2.13 The JV Company shall ensure that the execution, operation and maintenance of the project is in conformity with Prudent Utility Practices and the manufacturer's specifications.

2.14 The JV Company shall ensure proper quality control and safety measures during implementation of the project including any geological study, construction and testing at sites. The State Govt. shall have the right to institute an appropriate mechanism to ensure the compliance by the JV Company in this regard.

2.15 The JV Company shall make suitable financial provision in the project cost, if required, for the catchments area treatment plans in consultation with the State Forest & Environment and Wild Life Management Department as approved by the Ministry of Environment & Forests, Govt. of India. The cost involved on this account shall be paid by the JV Company to the concerned authorities of the Govt.

2.16 The JV Company shall carry out Environmental Impact Assessment (EIA) in association with the State Environment & Forest Department and Wildlife Department as required under the Environment (Protection) Act, 1986 through consultant(s) drawn from a reputed organization and obtain the consent of State Pollution Control Board.

2.17 The JV Company shall ensure such minimum flow of water immediately downstream of the dam/barrage for downstream requirements as shall be specified in the environmental clearance. The JV Company shall take appropriate steps as may be required for the protection of fish culture as per environmental requirement.

2.18 The JV Company shall ensure that the water requirement for the construction of the project including potable drinking water shall be generally arranged and harnessed by them from the river source. The local sources of water supply may be utilized by the JV Company only to the extent it does not adversely affect the local people.

2.19 The JV Company shall ensure that the materials excavated from the site shall be dumped in the area duly approved by the State Pollution Control Board.

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2.20 The JV Company shall ensure that the taxes as per law are deducted at source from the payments made to the contractors and deposit the same to State Govt. / other statutory authorities.

2.21 The JV Company shall be totally responsible for all related issues including safety aspect for implementation of the project.

2.22 In case the JV Company decides not to implement the Project for reasons attributable to the JV Company, it shall hand over the Project back to State Government along with all the reports and other documents free of cost **"As is where is Basis".**

2.23 The JV Company shall be liable and responsible for complying with all the environmental obligations and conditions.

2.24 Any and all correspondence/ demands made or notice to be sent or required to be made under this Agreement shall be in writing in English language, signed by the Party giving such notice (Claim or demand) and shall be delivered personally or by any feasible mode or transmission coupled with sending original or registered post or E-mail to other parties at their addresses set forth herein below or at such other addresses as either party may subsequently notify.

2.25 The inspection and approval of the works and electric accidents will be as per the provisions of the Electricity Act, 2003 read with the latest amendments and rules framed there under.

2.26 The Locally produced / manufactured materials including steel (except the bulk requirement etc.) available in the State fulfilling all technical specifications as may be required by the construction agency should be given preference in case the price of such material is competitive.

2.27 The Headquarters of Subansiri Middle (1600 MW) shall be located inside Arunachal Pradesh and all the business activities of the Project at the Project level shall be transacted from Headquarters in Arunachal Pradesh or any other office of the JV Company.

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Article 3

LAND ACQUISITION AND PERIOD OF AGREEMENT / LEASE

3.1 The Site required for the construction, operation and maintenance of the project and for the associated works as will be assessed by the Company shall be transferred by the State Govt. to the Company on lease basis against payment of land revenue as per approved rate of State Govt. The period of lease will cease with the project getting reverted to the State Govt. The Company shall be entitled to mortgage the land to the lenders/financers of the project with prior consent of the State Govt. subject to the condition that such period of mortgage shall not exceed the lease period. The State Govt. shall acquire for the Company under the land acquisition Act, 1894 as in force and as per Bengal Eastern Frontier Regulation, 1873 (5 of 1873) at the expense of the Company such private lands within the State of Arunachal Pradesh, as may be required from time to time by the Company for the construction, operation and maintenance of the project.

3.2 This agreement shall automatically expire on completion of the Lease Period as defined in Clause 2.2

3.3 The JV Company shall ensure that the land is used only for the project and activities ancillary to the project.

Article 4

ADHERENCE TO REGULATIONS OF THE CENTRAL & STATE GOVT.

4.1 The JV Company shall strictly comply with the following statutory regulations of the Central Govt. and the State Govt. while implementing the project.

4.1.1 The JV Company shall strictly comply with the provision of the Forest (Conservation) Act, 1980. The JV Company shall also pay the cost of raising the Compensatory Afforestation including payment of the Net Present Value (NPV) of the forest land being diverted for non-forest purpose under the Forest (Conservation) Act, 1980. The JV Company

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shall also pay the royalty on the forest produces such as timber, ballies, and all river bed materials etc. as per prescribed rates of the State Govt. in force from time to time. If any precious and semi-precious minerals/stone etc is found from the river beds and/or from the land acquired for and transferred to or leased out to the JV Company for the purpose of construction and maintenance of the project or in case any object of archaeological importance is found by the JV Company or any of its employees / contractors / sub-contractors during the course of construction/operation of the project, the JV Company shall hand over the same to the Govt. of Arunachal Pradesh.

4.1.2 The provision relating to labour welfare existing as in force under the labour Laws/Acts shall be strictly adhered to by the JV Company during the implementation/operation and maintenance of the project.

4.1.3 The provisions of the Electricity Act, 2003 will be diligently adhered to during implementation and subsequent operation and maintenance of Hydro-electric station.

4.2 The fishing, recreational and navigational rights, tourism prospects in the river, water channel, reservoir, lake, etc. shall remain vested in the Govt. of Arunachal Pradesh subject only to such restrictions as may be necessary for the operational requirements and safety and security of the project and the general guidelines of the Govt. of Arunachal Pradesh.

4.3 The JV Company shall comply with the Hydro Electric Power Policy-2008 of the State Govt. during the course of implementation and subsequent operation and maintenance of the hydel station.

Article 5

FREE POWER TO THE STATE, EVACUATION & TRADING OF POWER

5.1 From the Commercial Operation Date (COD), the State Govt. shall be given free power @ **12 %** in lieu of the distress caused. The free power

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shall be calculated at the bus bar and all taxes, duties, levies and costs in respect of the free power and towards its evacuation shall be borne by the State Government.

5.2 Over and above the free power, the State Govt. will have the first right to purchase the power upto 5% generated from the project if the State Govt. so desire on mutually agreed terms and conditions. The State Govt. shall exercise its aforesaid right within 90 days of the receipt of such offer from the JV Company after the DPR is approved from all angles. A separate Power Purchase Agreement (PPA) will be entered into for such purchase of the power between the State Govt. and the JV Company on mutually agreed terms and conditions. In case the JV Company and the State Govt. do not arrive at a mutually agreed terms and conditions for the said PPA within 90 days of receipt of the offer, the JV Company shall be entitled to sell the power from the project to any other party at its discretion.

5.3 The JV Company shall be responsible for developing evacuation system for the project and liaise with the appropriate authorities for the evacuation of the power from the generating point However, in the event of utilizing the infra-structure of the State Govt., necessary charges as mutually agreed shall be paid to the State Govt. The entire cost of grid interfacing, if so required, including cost of maintenance of the evacuation system will be the responsibility of the JV Company. However, in case the power generated from the project is purchased by the State Govt., the State Govt. shall be responsible for evacuation of power from the bus bar onwards at its own cost.

5.4 The JV Company shall allow the State Govt. to use its evacuation system and other infrastructures to the extent feasible, after accounting for the JV Company's requirements for evacuation of power generated from the project(s), if required by the State Govt. on payment of necessary charges by the State Govt. Such charges shall be mutually decided

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subsequently and a separate agreement entered into.

5.5 It shall be the responsibility of the JV Company for the trading and sale of the power generated from the project The State Govt. will not be in any manner responsible for the sale and trading of the power on behalf of the JV Company.

Article 6

REIMBURSEMENT OF EXPENDITURE

6.1 The JV company shall re-imburse duly certified and verifiable expenditures incurred by the National Hydro Power Corporation Ltd. for the survey & investigation works and the cost of DPR preparation against the project or any other bonafide expenditure incurred against the project on mutually agreed terms & conditions and price between the JV company and NHPC Ltd. Reasonable assistance shall be provided by the State Government in the process of re-imbursement.

Article 7

RECRUITMENT OF PROJECT PERSONNEL / AWARD OF WORK

7.1 The JV Company shall reserve the following categories of posts against the project to be filled up by the local tribal people, subject to the incumbents fulfilling the job requirements and considered suitable by the JV Company as per the criteria given below.

(a) Managerial/Professional post	...	25%
(b) Ministerial/Clerical post.	...	50%
(c) Skilled jobs.	...	25%
(d) Unskilled jobs.	...	75%

7.2 The JV Company shall give preference to the local contractors fulfilling the eligibility criteria in the award of the work except for the specialized jobs.

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7.3 The project affected eligible candidates shall be given preference over others against the above mentioned reservation in various categories of posts/jobs.

7.4 Subject to the job requirements and fulfilment of job criteria, willing technical and non-technical personnel of the State Government may be taken on deputation by the developer on recommendations of the State Government.

Article 8

REHABILITATION & RESETTLEMENT OF PROJECT AFFECTED FAMILIES

8.1 The JV Company shall earmark a reasonable amount for the social works in accordance with the National Policy on Rehabilitation & Resettlement in force. The JV Company shall also adhere/conform to the local laws of the State.

8.2 Rehabilitation & Resettlement plan if any, of the oustees from the project/project affected families shall be executed by the State Government as per the approved rehabilitation and re-settlement plan at the cost of the JV Company, keeping in view the latest guidelines issued by Govt. of India on the subject. The R&R plan shall in any case be not inferior to the National Policy on Rehabilitation & Resettlement of the Central Govt in force.

8.3 It will also be mandatory for the JV Company to follow the provisions of the Rehabilitation and Resettlement Policy, 2008 of Government of Arunachal Pradesh scrupulously.

Article 9

LAW & ORDER

9.1 The State Government would make arrangement to maintain general

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law and order in and around project area for security and safety of properties of the project, protection of life of the workers and experts/ Engineers/Officers during execution, commissioning and subsequent operation and maintenance. However, if any special security arrangement is required by the JV Company within the project premises, such arrangements shall be made by the State Govt. at the cost of the JV Company.

Article 10
INDEMNITY

10.1 The JV Company shall be fully responsible for any damage or loss arising out of the construction, operation or maintenance of the project to any property or person and the JV Company also undertakes to indemnify the Govt. of Arunachal Pradesh on such account.

10.2 The widening, strengthening and construction of the National Highways, State Highways and Bridges and other roads, other than those sanctioned under Road Development Programme of Govt. of India, if required by the JV Company, shall be executed by the appropriate State Govt. or Central Govt. agency on payment of reasonable cost and departmental charges in advance by the JV Company as per the estimate to be prepared by the executing State / Central Govt. agency. However, if the JV Company so desires to do the above activities at its own cost and if permissible under rule, the JV Company shall be permitted to do so. If any damage to the road and other Govt. and/or public property is done for which only the JV Company is responsible, it shall be got repaired by the JV Company at its own cost.

10.3 The JV Company shall be liable and responsible for all its acts, neglects, omissions and commissions and for the neglects, omissions and commissions of its contractors and employees.

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Article 11

FORCE MAJEURE

11.1 The Force Majeure situation such as earth quake, flood, fire, explosion, epidemic, cyclone, external invasion, civil commotion, riots, landslide etc., which are beyond the reasonable control of the JV Company shall excuse the JV Company from performance of its obligations to the extent prevented, delayed or interfered with for the period of Force Majeure conditions persist. The JV Company shall make its best efforts to remove such cause of Force Majeure as expeditiously as possible and shall continue performance hereunder with due diligence whenever such causers is removed.

Article 12

TERMINATION OF AGREEMENT AND TAKING OVER OF THE PROJECT

12.1 The JV Company shall achieve the financial closure within a period of 12 (twelve) months (or further period as the State Govt. may agree) from the date of receipt of the Techno-economic Clearance (TEC), if required, from the Central Electricity Authority(CEA), approvals from Ministry of Environment and Forest (MoEF) and other statutory clearances. In the event that it is confirmed as impossible or impractical to achieve Financial Closure or if the Financial Closure is not achieved on or before the expiry of twelve months from the aforesaid date, for the reasons other than those attributable to the Government of Arunachal Pradesh, the Govt. of Arunachal Pradesh reserves the right to terminate the agreement.

12.2 In the event of stoppage of the construction works of the project by the JV Company, for a period of more than 12(twelve) months for reasons not covered under Force Majeure and for reasons attributable to the Company and/or abandonment of the project by the Company, the State Govt. shall, after giving due opportunity to the JVCompany to resume the work, have the right to terminate the agreement. In the

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event of termination of the agreement under this clause, the Govt. of Arunachal. Pradesh shall have the right to take over the project on **"As is where is"** basis and no claim of the Company shall be entertained. The Govt. of Arunachal Pradesh shall, also have the exclusive right to re-allot such project to any other developer.

12.3 In case the Company does not commence implementation of the project within a period of 4(Four) years from the date of signing of this agreement or within a period of 1 (One) year from the date of receipt of all the statutory clearances, such as Forest & Environment, Techno-economic clearance etc, **whichever is earlier**, the project shall be reverted to the State Govt. on "As is where is" basis along with all the reports, other documents etc, free of cost. However, the above time period shall be automatically extended by the aggregate of the period during which the Company could not take steps to commence implementation by reason of Force Majeure conditions. Thereafter, the State Govt. shall have the exclusive right to re-allot the project to any third party for further development of the project. The Company, if interested, on its own may take necessary steps for reimbursement of its expenditures from such third party without any involvement of the State Govt.

12.4 In the event of failure to obtain statutory clearances within 4(Four) years period, for the reasons not attributable to the company, then the company shall apply in writing for further extension of time to the Govt. of Arunachal Pradesh. The Govt. of Arunachal Pradesh shall consider granting extension of time beyond 4(Four) years period on merit to start the implementation of the project.

12.5 If the project does not come up due to the reasons attributable to the JV Company, the State Govt. shall have the absolute right to forfeit the upfront payment but if the project does not come up due to the

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reasons not attributable to the JV Company the upfront payment shall be refunded to the JV Company without any interest on it notwithstanding Clause No. ~~15.5~~ 15.1

Article 13

RESOLUTION OF DISPUTES & ARBITRATION THEREOF

In the event of any difference / dispute arising between the Parties, the same shall be resolved in accordance with the provisions of the Arbitration and Conciliation Act, 1996, unless the same has been resolved amicably by mutual consultations within 90(Ninety) days of the reference of dispute by either Party. The venue of the arbitration shall be Itanagar. The language of arbitration shall be English. The cost of arbitration shall be shared equally. In case of any litigation, the Gauhati High Court, Itanagar Permanent Bench shall have the sole jurisdiction.

Article 14

CONFIDENTIALITY

14.1 Each party hereto agrees that it shall not divulge any trade, commercial or technical secrets or confidential matters of one another to any third party, save and except for the purpose of implementation, operation and maintenance of the Project.

Article 15

PROCESSING AND UPFRONT FEES

15.1 **For Subansiri Middle HEP (1600 MW), M/s Jindal Power Limited** on behalf of the JV Company will deposit a sum of Rs. 80.00 Crores (Rupees Eighty Crores) only @ Rs. 5,00,000/- (Rupees Five Lakh) per MW of the proposed installed capacity vide Demand Draft drawn on State Bank of India payable at Itanagar towards non refundable upfront premium including the processing fee in favour of Secretary (Power), Govt. of Arunachal Pradesh within 7(Seven) days

from the date order of Hon'ble Supreme Court in I.A.No.1362-63 in 966 & 1012 in W.P. (C) No.202/1995.

15.2 In the event of reduction in the capacity of the project, the State Govt. shall not refund the proportionate reduction in the amount of the upfront premium including the processing fee. However, in the event of capacity addition in the installed capacity of the project, the Company shall obtain approval of the State Govt. for the increased capacity and upon approval of State Govt. shall pay the upfront premium for the increased capacity of the project as prescribed by the State Government and as per the State Hydro Power Policy in force.

15.3 The JV Company shall provide and earmark an additional 1(one) % free power from the project for Local Area Development Fund, as per State Hydro Power Policy 2008.

15.4 The JV Company shall deposit 0.1% subject to a maximum ceiling limit of Rs. 10.00 (ten) crores of the Project Cost as Project Monitoring, Evaluation and Coordination (both technical and financial) fee by Demand Draft in favour of the Secretary (Power), Govt. of Arunachal Pradesh, Itanagar within one month of the finalization of the Detailed Project Report by the CEA/State Govt. as the case may be.

15.5 The JV Company shall provide 100 units of electricity per month to each Project Affected Family (PAF) for a period of 10(ten) years through concerned distribution Company from the date of commissioning of the project. In case the Project Affected Family (PAF) consumes less than 100 units/month, the cost of balance unused electricity, if any would be made available to PAF in cash or kind or a combination of both at the rate to be determined by the State Electricity Regulatory Commission.

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15.6 The JV Company shall bear the State Government's share of 10(ten) % of the project cost of RGGVY (Rajiv Gandhi Grameen Vidyutikaran Yojana) within a radius/surface distance from the Power House/Dam site of 10 km.

15.7 That the JV Company shall pay to the State Govt. royalty on forest produces, river bed materials and any other construction materials where such royalty / monopoly fee shall be applicable, as per prevalent rates applicable to Central Govt. Departments/ Project in terms of State Govt. in force from time to time.

Article 16
PENALTY.

16.1 The Company shall commission the project within a period of 8 (Eight) years from the date of receipt of all statutory clearances from State/Central Govt. agencies/authorities, achieving of Financial Closure and availability of land required for the project. In the event of failure on the part of the Company to commission the project within the targeted period, the Company shall be liable to pay penalty @ **Rs. 40,000/- (Rupees Forty Thousand) per MW** per month to the Govt. of Arunachal Pradesh for the extended period of commissioning, except when such delay is caused by Force Majeure events.

Article 17
PROJECT MONITORING COMMITTEE

17.1 The State Govt. shall constitute a Project Monitoring Committee with the Secretary (Power), Govt. of Arunachal Pradesh or any other appropriate State Govt. authority as the Chairperson for the purpose of overseeing the progress of the project and sort out the difficulties and issues that could arise with respect to implementation of the project.

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The JV Company shall be represented by a senior executive of the JV Company. The JV Company shall submit a copy of monthly progress to the State Govt. for their information.

Article 18

EQUITY PARTICIPATION AND EXECUTION OF PROJECT WORKS

18.1 The Hydro Power Development Corporation of Arunachal Pradesh Limited (HPDCAPL) will have 26% equity share in the JV Company.

18.2 In case HPDCAPL arranges its own equity and / or through its authorized agency, then HPDCAPL and / or such agency shall be allowed to do so, provided that such arrangement shall not entail any liabilities towards State Government.

18.3 The JV Company shall be permitted to incorporate a Special Purpose Vehicle (SPV) for the purposes of this Agreement and the implementation of the Project under this Agreement. However, the rights and obligations of the respective Parties shall remain unaltered and each Party shall continue to perform their obligations diligently.

Article 19

OBLIGATIONS OF THE STATE GOVT.

The Govt. of Arunachal Pradesh hereto recognizes that:

19.1 Subansiri Middle HEP (1600 MW) being a run-off-the- river / storage project shall utilize the flowing water of the river to generate electricity. Such right to utilize water available upstream of the project are granted by the Govt. of Arunachal Pradesh for non-consumptive use only without charging any royalty, duty, cess or levy of any kind of such use of water.

19.2 The tariff/or the energy generated at the project during pre-commissioning stage shall be fixed as per the specific guidelines of Govt.

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of India for such energy for hydro-electric projects.

19.3 The State Govt. shall provide assistance, wherever required, to the JV Company to obtain, in accordance with the prevailing Law and regulations, necessary permits to install and use suitable radio communication systems including satellite communication equipment and walkie-talkies. Any system connecting with the national telecommunication system or any international telecommunication system will be subject to approval / license from the relevant authorities for the issuance of which the State govt. shall assist.

19.4 The State Govt. shall provide assistance, wherever required, to the JV Company under the Law and regulations, to obtain permission to procure, store and use such explosives which are required for the project; provided that the responsibility of obtaining such a clearance and making the necessary arrangements shall rest with the JV Company.

19.5 The State Govt. shall provide assistance, wherever required, to the JV Company in obtaining all necessary import licenses for the project from the relevant Central Govt. authorities to the extent permissible by Law. The JV Company shall submit a list of such equipments required to be imported for the project to the State Govt. for approval. The State Govt. shall provide necessary need based assistance in obtaining the concessions and incentives given by the Central Govt. for setting up of projects in North Eastern States.

19.6 The State Govt. can impose an environment cess, according to the Law, which shall not be more than one paisa per unit of electricity sold and shall be collected at the source by the JV Company and deposited with the State Govt. No other taxes/duties/cess will be levied on the sale of electricity by the JV Company within the State or outside the State.

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20. Save and except as provided aforesaid none of the parties hereto shall assign their respective rights and obligations hereunder without prior consent in writing of the other party hereto.

21. The JV Company shall be governed and bound by the guidelines as may be notified by the Govt. of India or the State Govt. under the relevant Acts from time to time.

22. The JV Company hereby covenants that on demand from the Govt. of Arunachal Pradesh, it shall pay the amounts, if any payable hereunder by it to the Govt. of Arunachal Pradesh failing which the Govt. of Arunachal Pradesh may recover the same from the JV Company in any legal manner as arrears of land revenue.

23. This agreement shall be effective after receipt of Hon'ble Supreme Court's Order lifting the blanket ban on upstream Projects in Subansiri Basin in I.A.No.1362-63 in 966 & 1012 in W.P. (C) No.202/1995 and on receipt of upfront premium including processing fee by the State Govt. from the Jindal Power Limited on behalf of the JV Company.

24. The M/s Jindal Power Limited on behalf of the JV Company shall bear the stamp duty on the execution of this agreement.

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IN WITNESS WHEREOF THE PARTIES THROUGH THEIR AUTHORISED REPRESENTATIVES HAVE SIGNED THOSE PRESENTS ON THE DAY MONTH AND YEAR MENTIONED ABOVE.

Signed By :
For and behalf of Governor of Arunachal Pradesh

28/08/2009

(Tumke Bagra)
Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar, Arunachal Pradesh

Date

Witness

1. _____

Signature
(Name & Designation)
KAPIL MANTRI
C/o JINDAL CENTRE
12, BHIKAJI CAMA PLACE
N DELHI-66

Signed By :
For and behalf of M/s Jindal Power Limited

(Vinod Kumar Abbey)
CEO(Hydro), M/s Jindal Power Ltd.

Date

JINDAL POWER LIMITED

Signed By :
For and behalf of Hydro Power Development Corporation of Arunachal Pradesh Limited

(Tara Biga)
Managing Director
Hydro Power Development Corporation of Arunachal Pradesh Limited, Itanagar

Managing Director
Hydro Power
Development Corporation of
Arunachal Pradesh Limited
(A Government of Ar.Pr. Undertaking)

Date

Witness

1. _____

Signature (N. MAHESWARAN)
(Name & Designation) Asst. Manager (C), H.P.D.C.A.P. Ltd., ITANAGAR.

Witness

1. _____ 28/8/09

K.P. Balachandran
Signature Under Secretary, Power
(Name & Designation) A.P. Secttt Itanagar

Annexure-7
Land Availability Certificate

GOVERNMENT OF ARUNACHAL PRADESH
DEPARTMENT OF LAND MANAGEMENT
ITANAGAR.

Sl.No. 19

No.LM-83/2010/13630 Dated Itanagar, the 22nd..March'2012.

TO WHOM IT MAY CONCERN

This is to certify that land for execution of **Subansiri Hydro Electric Power Company Limited (1600 MW)** on the River **Kamla,** in the District of Lower Subansiri will be available subject to acquisition of required land on payment of compensation at rates to be decided by the Appropriate Authority by the Power Company executing the Hydro Power Project.

Govt. Of Arunachal Pradesh ★ Civil Secretariat, Itanagar ★
सत्यमेव जयते

Seal & Date

(T. Taloh) IAS
Commissioner (Land Management),
Govt. of Arunachal Pradesh,
Itanagar.

* * * *

Annexure-8

No Objection Certificate by Water Resources Deptt., Govt. of Arunachal Pradesh

GOVERNMENT OF ARUNACHA PRADESH
THE CHIEF ENGINEER::: WATER RESOURCES DEPARTMENT
ITANAGAR

No.WRD/4/140/2004-05 *Dated Itanagar the 11th Jan'2013*

NO OBJECTION CERTIFICATE

This is to Certify that the Water Resources Department, Govt. of Arunachal Pradesh has No Objection from irrigation angle for execution of proposed Kamala HE Project (1600MW) in place of Subansiri Middle HEP (1600 MW), Lower Subansiri District, Arunachal Pradesh. This supersedes earlier NOC No. WRD/4/140/2004-05/7018-19, dtd the 12th January'2012.

(Er. L. Angu)
Chief Engineer
Water Resources Department
Itanagar

Memo.No.WRD/4/140/2004-05/1056-60 *Dated Itanagar the 1st March'2013*

Copy to:-.

1. *The Superintending Engineer (Monitoring), Department of Hydro Power Development, Itanagar.*
2. *The Executive Engineer (M)- cum- Nodal Officer, Department of Hydro Power Development, Itanagar.*
3. *M/s Kamala Hydro Electric Power Company Ltd.1st Floor, Tahom Taloh Building, Daying Ering Colony, ESS –Sector, Itanagar-791111, Arunachal Pradesh for information please.*
4. *M/S Jindal Power Ltd. Jindal Centre, 12 Bhikaji Cama Place, New Delhi-110066 for information please.*
5. *Hydro Power Development Corporation of Arunchal Pradesh, T.T. Building , near APPSC, MLA Cottage road, Itanagar for information please.*
6. *Office Copy.*

Annexure-9

Clearance for Pre-construction Activities (TOR approval) by MoEF

No. J-12011/11/2010-IA-I
Ministry of Environment & Forests
Government of India
(IA.I Division)

Paryavaran Bhavan
CGO. Complex, Lodi Road
New Delhi – 110 003

Dated : 27.12.2010

Shri. V. K. Abbey
CEO, Hydro Power
Jindal Power Ltd
2nd Floor, DCM Building
Plot No.4, Sector-32
Gurgaon – 122 001 (Haryana)

Subject: Subansiri Middle Hydroelectric Project (1600 MW) in Lower Subansiri District, Arunachal Pradesh by M/s. Jindal Power Limited- for TOR - regarding

Sir,

This has reference to your letter no. SHEPCL/002/MOEF1/2009-10/001 dated 4.3.2010, 27.8.2010, 6.9.2010 and 8.10.2010 on the above mentioned subject.

2. The project envisages construction of a 217 m high concrete dam across river Kamla (tributory of Subansiri river), 4.12 km upstream of Tamen Village in the District Lower Subansiri of Arunachal Pradesh to generate 1600 MW hydropower. The total submergence is about 1200 ha. An underground Powerhouse is proposed with 8 units of 200 MW each. 75 families consisting of 235 population likely to be displaced due to this project. The total cost of the project is Rs. 12897.02 Crores and will be completed in 90 months.

3. The proposal was considered by the EAC at its meeting held on 22.3.2010, 21.8.2010 and 25.9.2010.

4. The Ministry of Environment and Forests hereby accord clearance for pre-construction activities in the proposed sites as per the provisions of Environmental Impact Assessment Notifications, 2006 along-with the following "Terms of Reference (TOR)" for preparation of EIA report :

The baseline studies should consist of 3 season field data i.e. Pre-monsoon, Monsoon & Winter (lean) Seasons covering one calendar year.

The EIA report should cover the following aspects:

1. General introduction giving details of the salient features of the proposed project.
   - Layout map of the project to be given along with contours with project components clearly marked with a proper scale and printed at least on A3 scale for clarity
   - Study area to be demarcated properly on the appropriate scale map

- Sampling sites to be depicted on map for each parameter with proper legends

2. The study area should comprise of the following:
   - Catchment area up to the dam site
   - Submergence area
   - Intermediate catchment between dam site and tailrace outfall and the river stretch downstream of dam up to tailrace outfall.
   - Project area or the direct impact area should comprise of area within 10 km radius of the main project components like dam, power house, etc. and also area within 10 km upstream of reservoir tail & 10 km distance from the reservoir rim along both the river banks.
   - Study area for downstream impacts on water, land & human should be upto the confluence of Kamla river with Subansiri river
3. Detailed methodology followed for the analysis of various parameters required for EIA.
4. Various details regarding the project layout etc., should be depicted in proper scale maps at least at 1:50,000 like:
   - Location map of proposed HE project
   - Location map of the project area with contours indicating main project features,
   - Drainage map of the river catchment up to the proposed project site,
   - Soil map of the project area.
   - Geological and Seismo-tectonic maps of the area surrounding the proposed project site showing location of dam site and powerhouse site, and
   - False Color Composite (FCC) generated from satellite data of project area and land-use / land-cover prepared from these images.
5. **Baseline Studies**

The baseline studies should consist of three season field data i.e. Pre-monsoon, Monsoon & Winter (lean) Seasons covering one calendar year.

- The report should also include Salient Features of the project.

The details of baseline data/ information that should be collected are as follows:

Physical-Chemical Environment

i. Physical geography, Topography, Stratigraphy, Regional Geology of the catchment area. Landslide zone or areas prone to landslide existing in the study area especially along the periphery of the reservoir should be examined.
ii. Tectonics and seismicity of the study area.
iii. Presence of important economic mineral deposit if any.
iv. Ambient air quality with parameters, viz. suspended particulate matter (SPM), Respirable Particulate Matter (RPM) Sulphur Dioxide (SO_2) and Oxides of Nitrogen (NO_x) in the study area.
v Existing noise levels and traffic density in the area.
vi. Soil classification, physical parameters viz. texture, moisture content, porosity, bulk density and water holding capacity and chemical characteristics viz. pH, electrical conductivity, sodium, potassium, calcium, magnesium, nitrogen, total nitrogen, exchangeable sodium percentage (ESP), organic matter, phosphorus, etc. should be analysed for the samples collected from different locations in the study area.
vii. Identification of free draining/directly draining catchment.

viii. Remote Sensing & Studies - Generation of thematic maps viz. slope map, drainage map, soil map, land use land cover map, etc. Based on these, thematic maps, an erosion Intensity map should be prepared.

x. Delineation of sub and micro watershed, their location and extent based on Soil and Land use Survey of India (SLUSoI), Deptt. of Agriculture, Govt. of India. Erosion levels in each micro-watershed and prioritization of micro-watersheds through Silt Yield Index (SYI) method of SLUSoI.

Water Environment

i Hydro-Meteorology of the project (viz. precipitation (snowfall, rainfall), temperature, relative humidity, etc.)

ii Run off, discharge, water availability for the project, sedimentation rate, etc.

iii Basin Characteristics

iv Physical and Chemical parameters of surface water quality. Physical parameters include temperature, pH, electrical conductivity, total dissolved solids (TDS), DO, turbidity. Chemical parameters are salinity, alkalinity, Ca, Mg and total hardness, chlorides, nitrate nitrogen, phosphate, silicates, and total coliforms.

Biological Environment

i. Characterization of forest types in the study area and should be based upon Forest Working Plan.

ii. General vegetation pattern and floral diversity viz. trees, shrubs, grasses, herbs, etc. Vegetation should cover lower groups of plants like Bryophytes, lichens, etc. in addition to angiosperms, gymnosperms and pteridophytes.

ii. Species frequency, density, abundance to be detailed. Biodiversity index (Shannon–Wiener Diversity index) and Importance Value Index (IVI) of the species to be provided. Methodology used for calculating the various diversity indices along with details of locations of quadrats, size of quadrats, etc. to be reported.

iv. Economically important species viz. medicinal, timber, fuel wood etc.

v. Flora under Rare, Endangered and Threatened (RET) categories should be documented using International Union for the Conservation of Nature and Natural Resources (IUCN) criteria and Botanical Survey of India's Red Data list along with economic significance.

vi. Cropping pattern and Horticultural practices in the study area.

vii. Faunal Elements
   a) Inventorisation of terrestrial wildlife including reptiles and herpetofauna, their present status in the project area
   b) Zoogeographic distribution/affinities, Endemic, threatened and endangered species.
   c) Avifauna
      1. Status
      2. Resident/Migratory/Passage migrants
      3. Impact of project on threatened/endangered taxa, if any
   d) Butterflies, if any found in the area

viii. For RET species, voucher specimens should be collected along with GPS readings to facilitate rehabilitation. RET faunal species are to be classified in two ways viz. as per IUCN Red Data list and as per different schedule of Indian Wilde Life (Protection) Act, 1972.

ix. To document the existence of barriers and corridors (if any) for wild animals, the habitat fragmentation and destruction of wild animals due to project.
x. Effect on fish migration and habitat degradation due to project.
xi. Existence of National Park, Sanctuary, Biosphere, Reserve Forest etc. in the study area if any, should be detailed.

Aquatic Biology

i. Aqua-fauna like macro-invertebrates, zooplankton, phytoplanktons, benthos, etc.
ii. Conservation Status
iii. Fish and Fisheries
iv. Fish migrations, if any
v. Breedihg grounds
vi. Impact of dam building on fish migration and habitat degradation

Socio-economic Environment

i. Land details*
ii. Demographic profile
iii. Ethnographic profile
iv. Economic structure
v. Development profile
vi. Agricultural practices
vii. Cultural and aesthetic sites
viii. Infrastructure facilities: education, health and hygiene, communication network, etc.

*Report should include list of all the Project Affected Families with their names, education, land holdings, other properties, occupation, source of income, land and other properties to be acquired, etc.

In addition to Socio-economic aspects of the study area, a separate chapter on socio-cultural aspects based upon study on Ethnography of the area.

6. **Impact Prediction**

Impact prediction is a way of 'mapping' the environmental consequences of the significant aspects of the project and its alternative. Environmental Impact ca never be predicted with absolute certainty and this is all the more reason to consider all possible factors and take all possible precautions for reducing the degree of uncertainty. The following impacts of the project should be assessed:

- **Air**
  A. Changes in ambient levels and ground level concentrations due to total emissions from point, line and area sources
  B. Effects on soils, material, vegetation, and human health
  C. Impact of emissions DG sets used for construction power if any, on air environment.
- **Noise**
  a. Changes in ambient levels due to noise generated from equipment, blasting operations and movement of vehicles
  b. Effect on fauna and human health
- **Water**
  a) Changes in quality
  b) Sedimentation of reservoir
  c) Impact on fish fauna

d) Impact of sewage disposal

- **Land**
  a) Changes in land use and drainage pattern
  b) Changes in land quality including effects of waste disposal
  c) Riverbank and their stability
  d) Impact due to submergence
- **Biological**
  a) Deforestation and shrinkage of animal habitat
  b) Impact on fauna and flora (including aquatic species if any) due to decreased flow of water
  c) Impact on rare and endangered species, endemic species, and migratory path/route of animals, if any
  d) Impact on breeding and nesting grounds, if any
  e) Impact on animal distribution, migration routes (if any), habitat fragmentation and destruction due to dam building activity
- **Socio-economic Aspects**
  A social Impact Assessment (SIA) study should be carried out in line with the state policy. This should, among other requirements as per the policy, cover the following:
  a) Impact on the local community including demographic changes
  b) Impact on economic status
  c) Impact on human health
  d) Impact on increased traffic
  e) Impact on Holy Places and Tourism

  Positive as well as negative impacts likely to be accrued due to the project are to be listed.
- **Downstream Impacts**
  - **Study on minimum environmental flow requirement** - ***Environmental flow release is to be decided based on a site specific study considering the depth and velocity of four consecutive leanest months of the 90% dependable year***
  - To assess the possibility of running a dedicated unit of lower capacity to maintain a higher riverine flow in the lean season for benefiting the aquatic ecology.
  - the study area should be extended beyond 10 km downstream of the project area. In this case, as the reservoir tip of lower Subansiri HEP is around 15 km downstream of the Middle Subansiri HEP, the study area be extended up-to that point and the same be included in the study area.

7. **Environmental Management Plan (EMP)**

i. **Resettlement and Rehabilitation** (R&R) plan need to be prepared with due consultation with Project Affected Families (PAFs). It should include community development strategies and a list containing name of PAFs, age, educational qualification, family size, sex, religion, caste, source of income, house with type and amount of land holding, house/land to be acquired, any other property, possession of cattle, etc. The provision of the prepared R&R plan should be according to the National Resettlement and Rehabilitation Policy (NRRP – 2007) as well as State Resettlement and Rehabilitation Policy (SRRP 2008). Detailed budgetary estimates are to be provided.

ii. **Muck Disposal Plan** to be prepared for rehabilitation of sites where the muck is proposed to be dumped. Cross sections of muck disposal sites also to be given.

iii. **Catchment Area Treatment** (CAT) plan should be prepared micro-watershed wise. Areas/watersheds falling under 'very severe' and 'severe' erosion categories are required to be treated. Both biological and engineering measures should be proposed in consultation with State Forest Department. Year-wise schedule of work and monetary allocation should be provided. CAT plan is to be completed prior to reservoir impoundment.

iv. **Reservoir Rim Treatment Plan** for stabilization of land slide/land slip zones if any, around the reservoir periphery to be prepared. Suitable engineering and biological measures for the identified land slip zones treatment to be provided with physical and financial schedule.

v. **Public Health Delivery Plan** including the provisions for drinking water facility for the local community.

vi. **Compensatory Afforestation** in lieu of the forest land required for the project needs to be proposed. Choice of plants should be made in consultation with State Forest Department.

vii. **Green Belt Development Plan** along periphery of reservoir, colonies, approach road, canals etc. to be prepared.

viii. **Biodiversity conservation & management plan** to be prepared in consultation with State Forest Department.

ix. **Plan for Restoration of quarry** sites and landscaping of colony areas, working areas, roads, etc.

x. **Fisheries Conservation & Management Plan** for conservation/management of fishes. Probability of having fish pass is to be examined in case there is any migratory fish species in the area..

xi. **Dam Break Analysis and Disaster Management Plan**. The outputs of Dam Break Model should be illustrated with appropriate graphs and maps clearly bringing out the impact of Dam break scenario.

xii) Study of Design Earthquake Parameters: A site specific study of earthquake parameters should be done. The results of the site specific earth quake design parameters should be sent for approval of the NCSDP (National Committee of Seismic Design Parameters, Central Wate Commission, New Delhi

xiii) Construction Methodology and Equipment Planning including the tunnel driving operations, machinery and charge density, etc.

xiv) Management during the Road Construction

xv) **Solid Waste Management Plan** for domestic waste from colonies and labour camps, etc.

xvi) **Water and Air Quality & Noise Environment Management plan** to be implemented during construction and post-construction periods.

xvii) **Local Area Development Plan** to be formulated in consultation with the Revenue Officials and Village Panchayats.

xviii) **Tribal area development plan** as the area is predominantly tribal inhabited.

xix) Mitigations measures to check shifting cultivation in the catchment area with provision for alternative and better agricultural practices. CAT Plan should cover impact of shifting cultivation.

xx) **Energy Conservation Measures**

xxi) Local skill development scheme

xxi) **Environmental Monitoring Programme** (With physical & financial details covering all the aspects form EMP).

5. In case of change of scope of the project; fresh 'Scoping' clearance has to be taken.

6. For accreditation, the concerned consultant who should be engaged for preparation of EIA/EMP report is requested to register them with Quality Council of India (QCI)/NABET under the scheme of accreditation & register.

7. Consultants should include a "Certificate" in EIA/EMP report regarding portion of EIA/EMP prepared by them and data provided by other organization(s)/Laboratories including status of approval of such laboratories.

8. As per the provisions of the EIA Notifications of 2006, you are requested to submit draft EIA / EMP report as per above terms of references to the State Pollutions Control Board/Committee for conducting the Public Hearing / Public Consultation.

9 All the issues discussed in the Public Hearing / Public Consultations should be addressed to and incorporated in the final EIA / EMP report and submitted to the Ministry for considering the proposal for Environment Clearance.

10. The prescribed TORs would be valid for a period of 2 years for submission of EIA/EMP reports, after public consultation.

Yours faithfully,

(Dr. S. Bhowmik)
Additional Director &
Member Secretary,EAC

Copy to:

1. Secretary, Ministry of Power, Shram Shakti, Bhawan, Rafi Marg, New Delhi-1.
2. The Advisor (Power), Planning Commission, Yojna Bhavan, New Delhi-110 001
3. Secretary, Department of Power, Govt. of Arunachal Pradesh, Itanagar, Arunachal Pradesh – 791 111.
4. Secretary, Department of Forest, Environment & Wildlife Management, Government of Arunachal Pradesh, Forest Secretariat, Itanagar-791 111.
5. The Chief Engineer, Project Appraisal Directorate, Central Electricity Authority, Sewa Bhawan, R.K. Puram, New Delhi-110066.
6. The CCF, Regional Office, Ministry of Environment & Forests, Upland Road, Laitumkhrah, Shillong, Meghalaya – 793003.
7. The Member Secretary, State Pollution Control Board, Department of Forests, Environment & Wildlife Management, Itanagar, Arunachal Pradesh – 791 111.
8. EI- Division, Ministry of Environment & Forests, New Delhi-110003.
9. Guard file.

(Dr. S. Bhowmik)
Additional Director &
Member Secretary,EAC

No.J-12011/11/2010-IA.I
Government of India
Ministry of Environment & Forests
[IA.I – Division]

Paryavaran Bhavan
CGO. Complex, Lodi Road
New Delhi – 110 003

Dated : 24.1.2011

CORRIGENDUM

Subject: Subansiri Middle HEP (1600 MW) in Arunachal Pradesh- for TOR – regarding.

Attention is invited to this Ministry's sanction letter of even number dated 27.12.2010, the following correction in the TOR in para-2 (i); line-4 under reference may be incorporated:

1. " The total submergence is 2707 ha, out of which about 1200 ha. is forest land"

   Instead of

   " The total submergence is about 1200 ha."

2. All other items remain unchanged.

Yours faithfully,

(Dr. S. Bhowmik)
Additional Director

Copy to:

1. Secretary, Min. of Power, Shram Shakti, Bhawan, Rafi Marg,New Delhi-1
2. The Advisor(Power), Planning Commission, Ypjna Bhavan, New Delhi-1
3. The Secretary, Department of Power, Govt. of Arunachal Pradesh, Itanagar.
4. Secretary, Department of Forest, Environment & Wildlife Management, Government of Arunachal Pradesh, Forest Secretariat, Itanagar-791 111.
5. The Chief Engineer, Project Appraisal Directorate, Central Electricity Authority, Sewa Bhawan, R.K. Puram, New Delhi-110066.
6. Shri. V. K. Abbey, CEO-Hydro Power, Jindal Power Ltd, 2nd Floor, DCM Building, Plot No.4, Sector-32, Gurgaon – 122 001 (Haryana)
7. The CCF, Regional Office, Ministry of Environment & Forests, Upland Road, Laitumkhrah, Shillong-793003, Meghalaya.
8. The Member Secretary, State Pollution Control Board, Department of Forests, Environment & Wildlife Management, Itanagar (Arunachal Pradesh)-791 111.
9. EI- Division, Ministry of Environment & Forests, New Delhi-110003.
10. Guard file.

Annexure-10

Extension in ToR Validity and Name change of the Project/Company by MoEF

No. J-12011/11/2010-IA-I
Ministry of Environment & Forests
Government of India
(IA-I Division)

Paryavan Bhavan
CGO Complex, Lodi Road
New Delhi – 110 003
Date: 8th February, 2013

To

The President- Hydro,
M/s. Kamala Hydro Electric Power Company Ltd,
2nd Floor, DCM, Building,
Plot No. 94, Sector-32,
Gurgaon-122001,
Haryana

Subject: Kamala HEP (1600 MW) in Lower Subansiri District of Arunachal Pradesh by M/s Kamala Hydro Electric Power Company Ltd – Extension of Validity period of TOR and change of name project/company – regarding".

Sir,

This is with reference to your letter No. HEPCL/MoEF/ToR/2012-13/02 dated 23.08.2012 and 11.10.2012 on the above mentioned subject. The Terms of Reference (TOR) for Subansiri Middle project was accorded on 27.12.2010 for preparing EIA/EMP. Your request for extension of the validity period of TOR for further 1 year, change of name of the project & company has been examined in the Ministry as well as considered by the Expert Appraisal Committee (EAC) for River Valley & Hydroelectric Projects in its meeting held on 12-13th October, 2012.

2. The EAC, duly considered the relevant documents submitted by you and have recommended extension of the validity of TOR for further 1 year for the above project. Accordingly, the Ministry hereby accords extension of validity of the TOR for further 1 year i.e. from 27.12.2012 to 27.12.2013 to Kamala HEP (1600 MW) project in Arunachal Pradesh by M/s. Kamala Hydro Electric Power Company Ltd. It may be noted that no further extension will be considered by the Ministry and you may therefore ensure completion of all activities within this time.

3. The Ministry also noted the following change in the name of the project and company:

I. Kamala HEP (1600 MW) project which was hitherto "Subansiri Middle HEP (1600 MW) project"
II. M/s. Kamala Hydro Electric Power Company Ltd which was hitherto "M/s. Subansiri Middle Hydro Electric Power Company Ltd

4. All other terms and conditions of the TOR Letter no.J-12011/11/2010-IA-I dated 27.10.2010 remains unchanged.

5. This issues with the approval of the Competent Authority.

Yours faithfully,

(B. B. Barman)
Director

Copy to:

1. The Secretary, Ministry of Power, Shram Shakti Bhawan, Rafi Marg, New Delhi -1.
2. The Advisor (Power), Planning Commission, Yojna Bhawan, New Delhi-110001
3. The Secretary, Department of Power, Government of Arunachal Pradesh, Itanagar-791111
4. The Secretary, Department of Forest, Environment & Wildlife Management, Government of Arunachal Pradesh, Forest Secretariat, Itanagar-791111.
5. The Chief Engineer, Project Appraisal Directorate, Central Electricity Authority, Sewa Bhawan, R. K. Puram, New Delh-110066
6. The CCF, Regional Office, Ministry of Environment & Forests, Upland Road, Laitumkhrah, Shillong-793003 (Meghalaya)
7. Member Secretary, Arunachal Pradesh State Pollution Control Board, Environment & Forest Office Complex, Sector-P, Itanagar-791111, Arunachal Pradesh
8. EI-Division, Ministry of Environment & Forests, New Delhi-110003.
9. PS to JS (AT)/ Director (BB)/ PVS Rao (Sci. B)
10. Guard File.

(B. B. Barman)
Director

SALIENT FEATURES

SALIENT FEATURES

Location

▪ State	Arunachal Pradesh
▪ District(s)	Project components in Lower Subansiri district; Reservoir in Lower Subansiri & Kurung Kumey districts
▪ River	Kamla
▪ Dam Site	4km upstream of Tamen Village 27º46'18"N, 93º59'19"E

Hydrology

▪ Catchment Area	7213km^2
▪ Probable Maximum Flood (PMF)	17416 cumec
▪ River Diversion Flood (1 in 25)	7520 cumec
▪ Ecological release	48.56 cumec

Reservoir

▪ Maximum Water Level (MWL)	El. 470.00m
▪ Full Reservoir Level (FRL)	El. 455.00m
▪ Minimum Draw Down Level (MDDL)	El. 430.00m
▪ Gross Storage at MWL	2365.68 MCM
▪ Gross Storage at FRL	1927.60 MCM
▪ Gross Storage at MDDL	1304.04 MCM
▪ Surcharge Storage	438.08 MCM
▪ Live Storage	623.58 MCM
▪ Area under Submergence at FRL	2775 Ha

Diversion Tunnels

- Number — 3 nos.
- Diameter — 13.5m, Circular
- Length — 915m to 1315m

Cofferdams

- Type — Rockfill with central clay core
- Height of upstream cofferdam — 64m
- Height of downstream cofferdam — 26m

Dam

- Type — Concrete Gravity
- Average river bed level — El. 275.00m
- Deepest Foundation level — El. 259.00m
- Top of Dam — El. 475.00m
- Height above deepest foundation — 216m
- Length of dam at top — 628m

Spillway

- **Main Spillway**
  - Number of bays — 7 nos.
  - Crest Elevation — El. 370.00m
  - Opening Size — 6.0m (W) x 10.5m (H)
  - Energy Dissipation — Trajectory Bucket

- **Auxiliary Spillway**
  - Number — 1 no.
  - Crest Elevation — El. 446.00m
  - Opening Size — 6.0m (W) x 13.0m (H)

Power Intake

▪ Number	4 nos.
▪ Invert elevation	El. 406.00m
▪ Size of Gate opening	6.0m (W) x 7.0m (H)

Headrace Tunnel

▪ Number	4 nos, concrete lined
▪ Diameter & Shape	10m, Circular
▪ Length	515m to 815m
▪ Design discharge	308.5 cumec each

Pressure Shaft

▪ Number	8 nos, steel lined
▪ Diameter & Shape	5.7m, Circular
▪ Design discharge	154.25 cumec each
▪ Length	270m each

Powerhouse (Main)

▪ Type	Underground
▪ Installed Capacity	1728 MW
▪ Type of Turbine	Vertical Axis Francis
▪ Number of Units	8 x 216 MW
▪ Cavern Size	302m (L) x 23m (W) x 56.5m (H)
▪ Turbine centerline elevation	El. 275.00m
▪ MIV Floor level	El. 270.00m
▪ Turbine Floor level	El. 278.70m
▪ Generator Floor level	El. 283.70m
▪ Operating Floor & Service Bay level	El. 289.20m

- Rated Net Head — 154.17m
- Annual Energy in 90% dependable year — 6739.0 MU

Transformer Cavern

- Size — 297m (L) x 16.5m (W) x 25.5m (H)
- Transformer floor level — El. 289.20m
- GIS floor level — El. 301.20m

Collection Gallery

- Size — 212m (L) x 15m (W) x 65m (H)
- Maximum Surge Level — El. 307.50m
- Minimum Surge Level — El. 273.40m
- Gate operation level — El. 309.00m
- Gate Numbers and Size — 8 nos, 8m (W) x 8m (H)

Tailrace Tunnels

- Number — 4
- Diameter & Shape — 10m, Circular shape
- Lengths — 415m to 555m
- High Flood Level — El. 306.20m
- Normal Tailwater Level — El. 285.50m
- Gate Numbers and Size — 8 nos, 6m(W)x10m(H)

Pothead yard

- Type — Outdoor
- Elevation — El. 430.00m
- Size — 150m (L) x 55m (W)

Dam-Toe Scheme

- **Intake Structure**
  - o Number — 1 no.
  - o Invert level — El 418.00m
  - o Size of Gate Opening — 3.25m (W) x 4m (H)
  - o Design Discharge — 48.56 cumec

- **Penstock**
  - o Number, Diameter and Length
  - o Main Penstock — 1 no., 4m dia, Circular, 166m
  - o Unit Penstock — 2 nos., 2.8m dia, Circular, 68m & 76m

- **Powerhouse (Auxiliary)**
  - o Type — Surface
  - o Size — 30.5m (L)x19.5m (W)x48.1m(H)
  - o Installed Capacity — 72MW
  - o Type of Turbine — Vertical Axis Francis
  - o Number of Units — 2 x 36 MW
  - o Turbine centerline elevation — El. 274.00m
  - o Annual Energy in 90% dependable year — 599.0 MU

Energy Benefits

- Main Powerhouse — 6739.0 MU
- Auxiliary Powerhouse — 599.0 MU
- Total Design Energy — 7338.0 MU

Project Economics

- **Project as envisaged with Flood Moderation**
  - Basic Cost at June-2013 Price Level (with Surcharge Storage) ₹ 10358.00 Crores
  - Escalation ₹ 4232.95 Crores
  - IDC & FC ₹ 5549.82 Crores
  - Total Completed Cost of Project ₹ 20140.77 Crores
  - Levellized Tariff (with free power to state) (including cost of flood moderation) ₹ 6.06 Unit
- **Cost Apportionment to Flood Moderation**
  - Basic Cost at June-2013 Price Level (without surcharge storage) ₹ 9893.20 Crores
  - Escalation ₹ 3729.22 Crores
  - IDC & FC ₹ 4320.14 Crores
  - Total Completed Cost ₹ 17888.56 Crores
  - Cost Apportionment to Flood Moderation
    - a) Cost due to additional height of dam & appurtenances including effect of reduction in construction period ₹ 2252.21 Crores
    - b) Cost due to energy loss ₹ 419.00 Crores
    - c) Total Cost apportionment to Flood Moderation ₹ 2671.21 Crores
  - Effective Completed Cost of Project (for sale rate of power) ₹ 17469.56 Crores
  - Levellized Tariff (with free power to state) after apportioning cost to flood moderation ₹ 5.25 Unit

CHAPTER 1
INTRODUCTION

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1 INTRODUCTION

1.1 General

The state of Arunachal Pradesh is endowed with vast hydropower potential. Brahmaputra river is the primary river basin in the state and offers significant irrigation and power benefits. One of the major tributaries of the Brahmaputra is river Subansiri which contributes about 7.9% of the flows of river Brahmaputra. River Kamla is a major tributary of river Subansiri.

Kamala Hydroelectric Project (formerly Subansiri Middle Hydroelectric Project) is proposed for development on Kamla river. The project is located just upstream of Tamen village in Lower Subansiri District; Tamen is about 55km from Ziro, the district headquarter. The project is conceived as a multipurpose project with the twin objectives of power generation and flood moderation. To meet these objectives a 216m high concrete gravity dam is envisaged which is designed to provide storage for power generation and is also provided with a 15m exclusive cushion above the full reservoir level to facilitate flood moderation. The main power plant, comprising eight generating units of 216 MW, each, is housed in an underground cavern located in the left bank about 500m downstream from the dam. Two additional generating units of 36 MW each are proposed in a dam toe surface powerhouse on the right bank. These units will utilize the mandatory environmental release from the dam. The total installed capacity of the project is 1800 MW - 1728 MW in the underground powerhouse and 72 MW in the surface powerhouse.

Power generated from the project is planned to be brought to a pooling point through a 400kV double circuit transmission line. The power is proposed to be ultimately transmitted to the National Grid.

1.2 Project Background

The project was initially identified and planned by the Brahmaputra Board in consultation with CWC and GSI and was subsequently assigned to NHPC for development (a more detailed description of this is given in a subsequent section). As a first step, NHPC carried out a Feasibility Study and confirmed the general suitability of the identified area to develop the project. A comprehensive field investigation program was ensued by NHPC and a Detailed Project Report was prepared wherein a 221m high Concrete Faced Rockfill Dam was proposed along with an underground powerhouse arrangement with an installed

capacity of 1600 MW. The Report was however not submitted for statutory clearances as the Government of Arunachal Pradesh decided to get the project implemented through private participation.

Development rights of the project have subsequently been accorded by the Government of Arunachal Pradesh to Kamala Hydro Electric Power Company Limited (KHEPCL) (formerly Subansiri Hydro Electric Power Company Ltd.), a joint venture between Jindal Power Ltd and Hydro Power Development Corporation of Arunachal Pradesh Ltd. The concession period of the project is for 40 years on Build, Own, Operate and Transfer (BOOT) basis.

KHEPCL has engaged SNC-Lavalin Engineering India Pvt. Ltd. (SLEI) to act as its engineering consultant for updation and preparation of the DPR.

1.3 Project Area

1.3.1 Location and Accessibility

The project is located on river Kamla, a major right bank tributary of Subansiri river in Lower Subansiri District of Arunachal Pradesh and falls in the Lower Himalaya region. Kamla river valley is almost entirely hilly and mostly covered by dense forests.

The dam site as proposed in the present DPR is located around 4km upstream of Tamen village. Tamen village is around 55km from Ziro, the headquarter of Lower Subansiri district. Ziro is about 130km from North Lakhimpur, the headquarter of Lakhimpur district. A paved road in good condition goes from North Lakhimpur to Ziro and further to Daporijo via Tamen. North Lakhimpur is connected to Guwahati by road as well as by air; the airport is at Lilabari, about 5 km from North Lakhimpur.

The dam site is approachable through a black-topped road on left bank of Kamla; an unmetalled road also exists on the right bank at a higher elevation. Both these roads take off from the Tamen-Daporijo road near Tamen village. The roads are being maintained by Border Road Organization (BRO).

The project location map is shown in Figure 1-1 and schematic diagram showing project access with distances is shown in Figure 1-2.

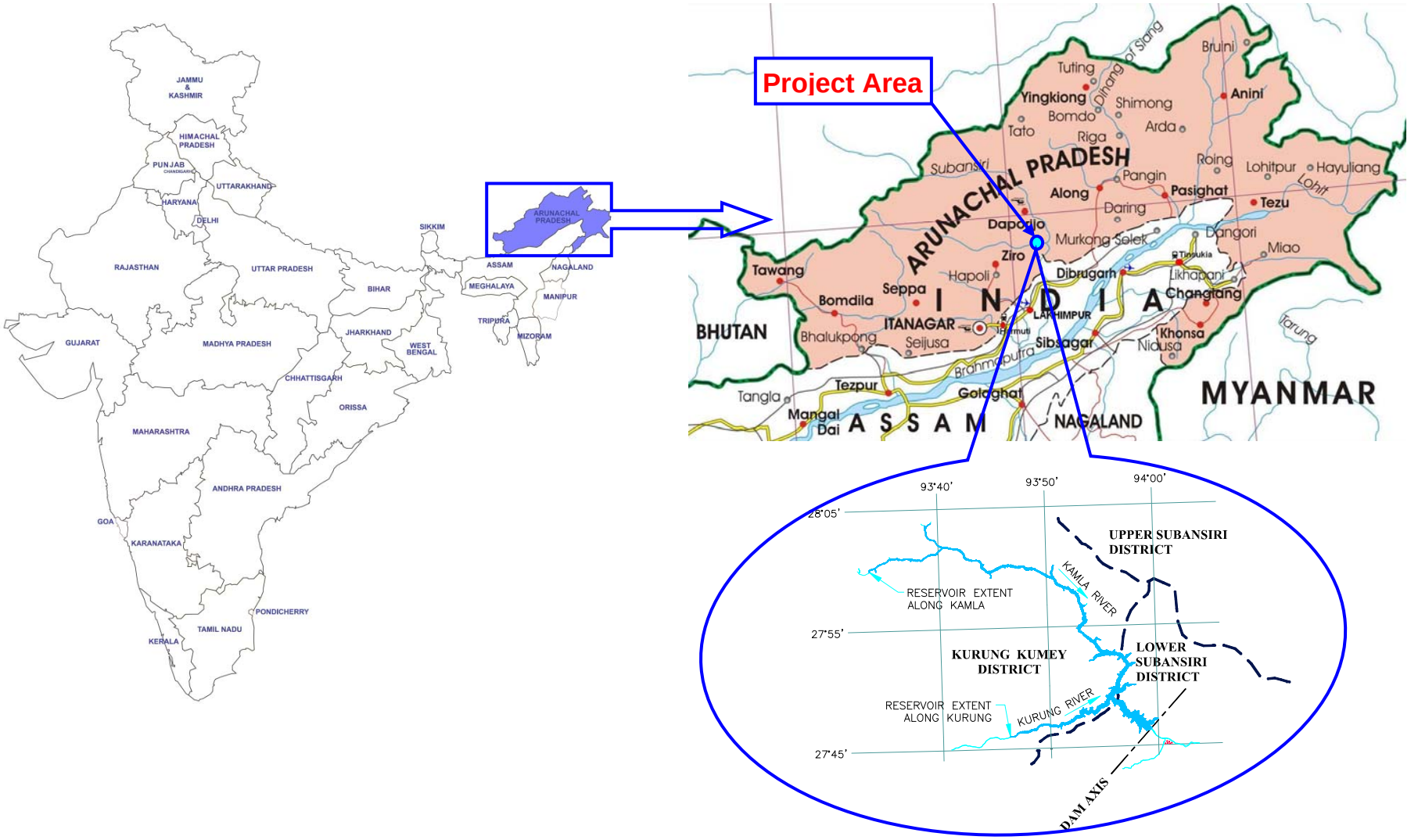

Figure 1-1: Project Location Map

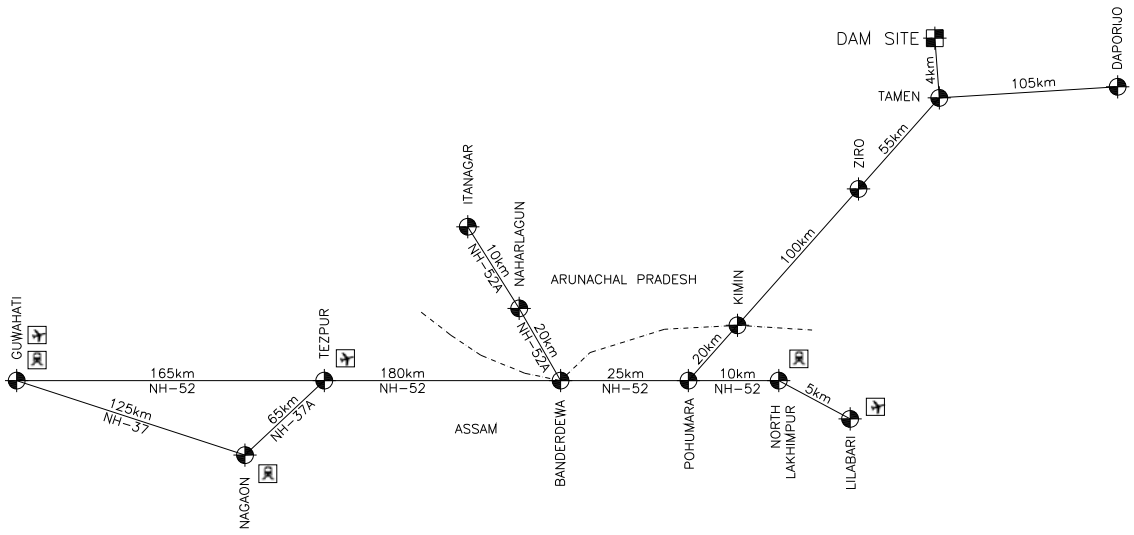

Figure 1-2: Schematic Diagram Showing Project Access with Distances

1.3.2 General Climatic Conditions

The project area experiences wide variation in temperature as well as humidity. Maximum and minimum temperatures as observed at Tamen are 43ºC and 8ºC, respectively. Relative humidity ranges from a maximum of 100% to a minimum of 35%. The average annual rainfall of the basin is more than 3000mm.

The project area has four different seasons over the year. The period from end of March to May is characterized by occasional pre-monsoon thunderstorms. The onset of monsoon is generally between May and June. Monsoon lasts till September, after which its influence begins to decrease, the weather becomes clearer and temperatures start to decrease. Winter season lasts from November to February, characterized by low temperatures and minimal precipitation. Temperatures begin to rise again from February onwards.

1.3.3 Geographical Features and Topography

The Subansiri River, in the basin of which the Project is located, is a prominent right bank tributary of Brahmaputra. It originates in Tethys Himalaya in Tibet as Tsari Chu and cutting through Higher Himalaya, it drains about 30,000 sq.km area in Lesser and Sub-Himalayan parts of Miri and western parts of Abor Hills. It debouches into Brahmaputra Plains near Dulangmukh in Assam (El. 152m above msl). The river in Himalayan sector has a length of about 208km and riverbed falls from an altitude of 4206m to 152m in this reach. The Subansiri river and its tributaries in the plains flow along a straight braided to highly meandering course.

The Kamla river, on which the proposed project is envisaged, is a main right bank tributary of Subansiri river. It rises at an altitude of 6488m in Higher Himalaya and flows in southeasterly direction almost parallel to the course of Subansiri River. It drains approximately 7000 sq.km. area in Miri Hills and joins the main Subansiri river at Leling. Kurung river is a major right bank tributary of Kamla that flows in NW direction and joins it east of Bala village at about 280m above msl.

In broad geomorphic classification, the area around the Kamala Hydroelectric Project lies in Lesser Himalayan physiographic unit wherein mountain ranges are characterized by moderately dissected, fine drainage textured, sharp crested ridges and is defined as S1e geomorphic unit of structural origin. The trunk river Kamla in the project area flows along a meandering course towards SE through a moderately wide valley with moderately steep valley slopes. The river, downstream of the project area, near Tamen, turns towards east and follows WE course beyond that. The relief in the area is moderate and valley slopes are generally covered with slopewash deposits that support dense vegetation. The terrain is moderately dissected by various streams. The drainage pattern is sub-dendritic to dendritic and drainage density moderate.

At the proposed dam site river Kamla flows towards SE through a symmetrical V-shaped valley. The river width at various stretches in the area varies between 60m and 100m. Both the abutments rise above riverbed at about 40° slopes except in short stretches where steeper or gentle slopes have been observed locally. However, the valley attains a slightly asymmetric shape as one moves upstream of the dam axis, where left abutment is comparatively steep as compared to right abutment.

The project area exposes the gneissic rocks belonging to Daparijo/Ziro Gneiss. The granite gneiss extends monotonously from Ziro-Hapoli region in the south to ENE towards Daparijo. This sequence constitutes a part of Bomdilla Group and has been variously called as Daparijo/Ziro/Palin/Chakoo Gneiss.

The rock of Ziro Group consists of mainly biotite gneiss, augen gneiss, garnetiferous sillimanite hornblende gneiss, mica schist, leucogranite and amphibolite. They are bounded by Sippi thrust in the north-west, which has brought the low grade metasedimentaries of Niumi Formation in juxtaposition with high grade gneiss. The south-east boundary is defined by unconformable contact with the low grade metasedimentary rocks of Khetabari Group.

The gneisses exposed in the project area are foliated and traversed by three prominent sets of joints in addition to those oriented along the foliation. These are folded in isoclinal and overturned folds.

As per the seismic zoning map of India (IS 1893: Part-I (2002)), the area around the proposed project is located in Zone-V. The seismic Zone-V is broadly associated with seismic intensity IX and above on MMI scale.

1.4 Project Conception and Previous Developments

To exploit the available power potential and ensure benefits of flood moderation in the Brahmaputra basin two large projects were conceived by the Brahmaputra Board, one each in the river basins of Subansiri and Dihang (Siang) Rivers. Detailed survey and investigation works were conducted and Detailed Project Reports for the two projects, named Subansiri Dam Project (4800 MW) and Dihang (Siang) Dam Project (20000 MW), were prepared in April and May 1983, respectively. However, the projects could not be taken up for execution as the Arunachal Pradesh Government objected to large submergence of land, including some main towns, and consequent displacement of inhabitants.

In case of the Subansiri Dam project, three major towns, namely Daporijo, Dumporijo and Tamen, were being affected. In order to avoid their relocation while still exploiting the power potential of Subansiri and ensuring benefits of flood moderation, Brahmaputra Board came up with an alternative scheme which involved development of the following three independent projects:

- The 2500 MW Subansiri Upper Project, which was proposed on the main Subansiri River near Menga and envisaged construction of a 265m high dam.
- The 2000 MW Subansiri Middle Project (now renamed as Kamala Hydroelectric Project), which was proposed on Kamla River near Tamen and envisaged construction of a 213m high dam.
- The 2800 MW Subansiri Lower Project, which was proposed on the main Subansiri River near Gerukamukh and envisaged construction of a 116m high dam.

Following a prima-facie confirmation of feasibility of the schemes, further investigations were initiated by a team of experts from the Brahmaputra Board, Central Water Commission (CWC) and Geological Survey of India (GSI). Subsequently, in the year 2000, the projects were transferred to NHPC, which embarked on the preparation of the DPRs and carried out

detailed field investigations. Given the better logistics (being the downstream-most project), investigations and other preparatory works on the Subansiri Lower Project were completed by 2004 and construction work on the project was started. Although NHPC had done substantial exploratory work on Subansiri Upper and Subansiri Middle projects as well, and had compiled their DPRs, Arunachal Pradesh Government decided to allocate these projects to private developers for implementation on BOOT basis.

1.4.1 Previous Studies on the Project

The project has been studied previously by Brahmaputra Board (pre-feasibility level), NHPC (feasibility and DPR level) and KHEPCL (preliminary assessment). While the project development stretch was kept unchanged in these studies, the location and type of the dam varied from concrete gravity dam to a CFRD and back to a concrete gravity dam.

A brief synopsis of the schemes considered in these studies is given below.

Studies by Brahmaputra Board

Brahmaputra Board started investigating the project in 1996. Two alternative dam sites were identified on river Kamla, and were designated as Site-A and Site-B. The former was located 3.5km upstream of Tamen while the latter was identified some 12.5km upstream of Tamen.

Brahmaputra Board in consultation with CWC and GSI considered Site-A as a better option from geological, topographical and construction material point of view and decided to focus further investigations at this site. Subsurface explorations were initiated and two exploratory bore holes, one each on either bank at the proposed dam site, were drilled. However, before any further progress could be made, the project was transferred to NHPC for preparation of Feasibility and Detailed Project Reports.

Studies by NHPC

NHPC first carried out a feasibility level study of the project and then initiated detailed field investigations and studies for preparation of the DPR. The Feasibility Study Report indicates that NHPC did not consider the Brahmaputra Board axis (Site-A) as suitable citing presence of thick overburden on the right bank and abundance of mica schist bands and shear zones in the rockmass on the left bank. Instead, after detailed inspection of the area, NHPC identified two other axes (located about 450m and 500m upstream of the Site-A axis selected by Brahmaputra Board) and initiated detailed investigations at these axes. Narrower valley section and relatively better quality of rock exposures at road level were

cited as positive features of the selected area. These axes were designated as A-5 (450m upstream of Site-A) and A-6 (500m upstream of Site-A).

A concrete gravity dam was planned near A-5/ A-6 axis and the powerhouse was proposed underground inside the left bank of Kamla river. The powerhouse comprised 8 units of 200 MW, totalling an installed capacity of 1600 MW. Two alternatives with different FRL's (and thus different dam heights) were studied. Although the design head for the alternatives were different, the installed capacity and number of units was kept unchanged by keeping different power discharges. Size of the water conductor system was accordingly adjusted.

Upon approval of the Feasibility Report, NHPC embarked on preparation of the DPR. Through detailed investigations and studies, NHPC concluded that the site selected during the feasibility stage (near Axis A-5/A-6) was not suitable for a concrete dam - as per NHPC's assessment the site would require extensive stripping of abutments for founding a concrete gravity dam. Changing the dam type to rockfill was contemplated but it was concluded that the topography around this axis was not conducive for a fill type dam. Investigations were started on another axis located about 250m upstream of A-6; this axis was designated as A-11. The investigation works comprised surface geological mapping, detailed geological and geophysical investigations, remote sensing studies, subsurface investigations through drilling and drifting, in-situ and laboratory rock mechanic testing etc.

Based on subsurface investigations, the geological conditions at the two alternative axes i.e. A-6 and A-11, when compared, suggested that while there was significant improvement in the rockmass on the left bank at A-11 axis, the right bank did not show any improvement. In fact, the bedrock in the river bed at A-11 was found to be highly fractured and sheared. In view of favourable rock conditions on left bank, dam axis was located near axis A-11 (nearly 20m downstream of A-11).

This site near A-11 was not considered suitable for placing a concrete gravity dam as the shear zone in the river bed and slumping/sheared rockmass on the right abutment would have required considerable excavation and foundation treatment. Accordingly, NHPC considered a Concrete Face Rockfill Dam (CFRD) at this site citing the following advantages:

- Complete removal of overburden/slumped rock is not necessary for a CFRD
- Rock condition at left bank is favourable for laying spillways and other appurtenant structures

- Puku nallah which meets river Kamla upstream of the dam axis provides topographical advantage of positioning spillway and diversion tunnels on the left bank
- Any special foundation treatment in the riverbed shear zone shall not be required in case of CFRD
- CFRD would be a better choice in highly seismic area

Diversion tunnels and water conductor system were proposed on the left bank with the underground powerhouse located at the same location on the left bank as in the Feasibility Report. The Full reservoir Level for the project was kept at El 460m and an exclusive flood cushion of 15m above FRL was finalized through Integrated Flood Moderation Studies of the basin[1]. Rule curve defined as a part of the Integrated Flood Moderation Studies of the Subansiri basin projects was specified to regulate the reservoir level during monsoons. Adequate spillway capacity was ensured by providing surface spillway bays and tunnel spillways, both located on the left bank.

Salient features of the project scheme proposed in NHPC DPR are as follows:

(i) **Reservoir**

- MWL : 475m
- FRL : 460m
- MDDL : 410m

(ii) **Dam**

- Type : CFRD
- Top Elevation : 480m
- Dam height : 221m (from deepest foundation level)

(iii) **Spillway**

- PMF : 14896 cumec
- Design Flood : 10000 cumec
- Type : 3 nos. surface bays 10m x 11m and

  3 nos. tunnel spillways of 10m dia horseshoe shaped

[1] Although the Integrated Flood Moderation Studies were presented to the statutory authorities, they remained inconclusive.

(iv) **River Diversion**

- Diversion Flood : 10350 cumec (1 in 100 year monsoon)
- Diversion Tunnels : 4 nos. 11.5m dia horseshoe shaped

(v) **Water Conductor System**

- 4 nos. intakes
- 4 nos. 9.5m diameter horse-shoe shaped headrace tunnels
- 4 nos. 24m diameter surge shafts
- 4 nos. 7.5m diameter pressure shafts, each feeding two units
- 4 Nos. 9.5m diameter horse-shoe shaped tailrace tunnels

(vi) **Powerhouse**

- Type : Underground on left bank
- Installed capacity : 1600 MW (8 x 200)
- Rated Net Head : 144 m

Initial Studies by KHEPCL

After the transfer of the project to KHEPCL, Tojo-Vikas International Pvt. Ltd. (TVIPL) was engaged to undertake a review of the previous studies on the project and to prepare a Project Report that could be used as an updated project document for submission to MoEF along with the application for clearance of Terms of Reference for the EIA studies.

All three sites (Site-A by Brahmaputra Board and Axes A-5/A-6 and A-11 of NHPC) were examined by the TVIPL experts who recommended that the dam axis should be located at NHPC DPR axis i.e. 20m downstream of the A-11 axis. Apparently, TVIPL considered that geological conditions at this site were better than the other sites; albeit for a concrete gravity dam.

TVIPL recommended that the dam type should be changed to a concrete gravity dam and provided with two levels of spillway. The powerhouse was however proposed to be maintained underground, at the same location as proposed by NHPC. The installed capacity was retained at 1600MW (8 x 200MW) commensurate with the hydrological assessment given in NHPC DPR, which was not re-evaluated.

The diversion tunnels were proposed to be located on the right bank to avoid excessive tunnelling through the left bank.

Following are the main features of the scheme contemplated by TVIPL:

- River diversion works through right bank of the river and comprising 3 nos. 11.5m diameter diversion tunnels with upstream and downstream cofferdams.
- A 222m high concrete gravity dam with 9 bays of spillway with crest at El 448m and 3 low level sluices of 6m x 9m size in the body of the dam at El 350m
- Water conductor system comprising
    - 4 nos. Intakes, located on the left bank, 60m upstream from dam axis
    - 4 nos. 9.5m diameter, horse-shoe shaped headrace tunnels
    - 4 nos. 25m diameter surge shafts
    - 4 nos. 8.5m diameter pressure shafts, each bifurcating into two pressure shafts of 5.5m diameter
    - 4 nos. 8.5m diameter, horse-shoe shaped tailrace tunnels
- An underground powerhouse cavern, 24m x 58m x 270m, to house 8 Francis units of 200 MW capacity, each

1.5 Present Study

The present study commenced with an independent review of all previous study reports including the investigation results. A few reconnaissance visits were undertaken and the project area was thoroughly assessed. Drifts and core logs from drill holes were examined.

As a first step, it was confirmed that the project should be developed on the left bank as proposed in the previous studies. Accessibility, relatively better geology and availability of substantial amount of investigation results clearly weighed in favor of a left bank development.

Location of the dam axis was finalized after a detailed assessment of all the alternative axes and also considering the type of dam that suited a given location. As discussed in subsequent sections of the report, a concrete dam is considered more suitable from flood management as well as other perspectives. The geology at the selected axis, near Axis A-5/A-6, is considered suitable for a concrete dam.

Study of alternative powerhouse arrangements comprised a dam toe option and an underground alternative. As described in the report, underground location inside the left bank just downstream of the dam location is proposed.

Alternative/optimization studies have also been undertaken for other project components to arrive at the proposed layout and designs.

1.5.1 Proposed Scheme

The selected scheme features a 216m high concrete gravity dam with axis located in the vicinity of axes A5/A6. The dam axis is about 4km upstream of Tamen. Crest of the dam is proposed at El 475m, which is arrived at by considering a flood cushion of 15m above the FRL (El. 455m, as approved by MoEF) and an appropriate freeboard. The dam comprises 37 concrete gravity blocks (non-overflow and overflow) and measures 628m along the crest. Minimum Draw Down Level (MDDL) of the reservoir is fixed at El 430m, thus providing live storage of 623.58 MCM for peaking requirement. The total area of submergence at FRL is 2775 Ha.

Kamala Hydroelectric Project, as mentioned earlier, envisages a diversion structure and water conductor system on the left bank of Kamla river. The proposed scheme also envisages a small hydroelectric scheme located near the toe of the dam on right bank, utilizing the environmental release from the dam. With installed capacities of 1728 MW in the main powerhouse and 72 MW in the dam-toe powerhouse, the total installed capacity of project is 1800 MW.

The intake is located on the left bank of Kamla river, just upstream of the dam axis. Four intakes are envisaged, one at the start of each HRT. Each intake is provided with an independent set of trash racks, intake gates and maintenance gates. Four 10m diameter circular headrace tunnels offtake from the intakes and bifurcate into two pressure shafts, each. Tunnel lengths vary from 515m to 815m. Each 5.7m diameter pressure shaft is steel lined and 270m long.

The underground powerhouse is proposed to accommodate eight (8) Francis Turbines of 216 MW each. The dimensions of the proposed powerhouse are 302m (L) x 23m (W) x 56.5m (H). The rated net head for the units is 154.17m.

The powerhouse complex also includes two other underground caverns - one for transformers and GIS and the other to act as downstream surge gallery. The pothead yard is

on the hill slope. Tailrace tunnels emanating from the downstream surge gallery bring the turbined water back to Kamla river.

In addition to the main powerhouse, an auxiliary surface powerhouse is provided at the toe of the dam on the right bank. This powerhouse would use the mandatory environmental releases from the dam. Two units of 36 MW are proposed.

The project is expected to be commissioned in March 2024.

1.6 Organization of the Report

The Detailed Project Report is organized in nine volumes and an executive summary:

- Executive Summary
- Volume I : Main Report
- Volume II : Hydrological Studies
- Volume III : Geological & Geotechnical Studies
- Volume IV : Design (Civil, HM and E&M)
- Volume V : Construction Methodology and Infrastructure Planning
- Volume VI : Cost Estimate & Financial Analysis
- Volume VII : Drawings (Civil, HM and E&M)
- Volume VIII : Construction Material Survey and Investigations
- Volume IX : Appendices

1.7 Acknowledgement

SNC-Lavalin Engineering India Pvt. Ltd. (SLEI) sincerely acknowledges the trust reposed by the management of Kamala Hydro Electric Power Company Limited (KHEPCL) in mandating this important work and sincerely thanks KHEPCL's team for their support, cooperation and assistance. SLEI team also gratefully acknowledges support, cooperation and assistance received from KHEPCL's team during the various site visits.

CHAPTER 2
JUSTIFICATION OF THE PROJECT FROM POWER SUPPLY ANGLE

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2 JUSTIFICATION OF PROJECT FROM POWER SUPPLY ANGLE

2.1 General

Hydro power is the richest renewable and environmentally benign source of energy. Hydroelectric stations have the inherent ability of instantaneous starting, stopping and managing load variations, which helps in improving reliability of the power system. Hydroelectric stations are the natural choice for meeting peak demand. The generation cost is inflation free and, in fact, reduces over time. A hydroelectric project has a useful life extending to well over 35 years and helps in conserving scarce fossil fuels.

Development of hydro power projects also provides the added advantage of opening up avenues for development of remote and backward areas of the state. Despite being recognised as a renewable source of energy, the share of hydro power in the overall generating capacity in the country has been steadily declining since 1963. The share of hydro power has declined from 44% in 1970 to about 17.5% today.

Several constraints have affected the pace of hydro power development, including non-availability of long term financing and viability of tariff. Many hydro projects have been adversely affected by geological surprises, especially during underground excavation. Other problems arising out of the inaccessible and remote location of the site, delays in land acquisitions and in resettlement of families affected by the projects have also slowed the pace of hydro power development in the country.

Government of India has now accorded high priority to the development of hydro potential and has taken a number of policy initiatives to address the issues impeding hydro power development. In accordance with the latest hydro power policy (2008), the Government of India is encouraging substantial private investment in hydro power development.

In order to hasten the progress of hydroelectric generation, a large number of projects have been identified and their viability has been confirmed through pre-feasibility studies. Many of these projects have been awarded to private developers who are actively engaged in their implementation.

2.2 The Kamala Hydroelectric Project

Kamala Hydroelectric project is being developed on Kamla river in Arunachal Pradesh and is conceived as a multipurpose project with twin objectives of power generation and flood moderation. The project comprises a 216m high dam which is designed to provide storage

that would ensure generation of daily peaking power for minimum 3 hours and is provided with a 15m exclusive cushion above the Full Reservoir Level to facilitate moderation of floods. The main powerhouse is located underground in the left bank about 500m downstream of the dam axis, and houses eight generating units of 216 MW, each. In addition, a surface powerhouse is also planned at the toe of the dam to generate power utilizing the environmental releases from the dam. This powerhouse is equipped with two generating units of 36 MW, each. Total installed capacity of the project is thus 1800 MW.

2.3 Justification of Project from Power Supply Angle

2.3.1 Hydro Potential and Its Development

The total installed capacity in the country, as on 30th June, 2013, is 225,793 MW of which hydroelectric schemes contribute 39,623 MW (17.5%). All India and Region-wise installed capacity of power utilities are given below in Tables 2-1 and 2-2.

Table 2-1: Sector-wise Installed Capacity of Power Utilities as on June 2013

(Figures in MW)

Sector	Hydro	Thermal				Nuclear	R.E.S	Total
		Coal	Gas	Diesel	Total			
State	27,437.00	51,378.00	5,926.32	602.61	57,906.93	0	3,748.19	89,092.12
Private	2,694.00	36,635.38	7,368.00	597.14	44,600.52	0	23,793.52	71,088.04
Central	9,492.40	44,275.01	7,065.53	0	51,340.54	4780.00	0	65,612.94
Total	**39,623.40**	**132,288.39**	**20,359.85**	**1,199.75**	**153,847.99**	**4,780.00**	**27,541.71**	**225,793.10**

Source: CEA Website

Table 2-2: Region-wise Installed Capacity of Power Utilities as on June 2013

(Figures in MW)

Sector	Hydro	Thermal				Nuclear	R.E.S	Total
		Coal	Gas	Diesel	Total			
Northern	15,467.75	33,073.50	5,031.26	12.99	38,117.75	1,620.00	5,589.25	60,794.75
Western	7,447.50	50,244.51	8,988.31	17.48	59,250.30	1,840.00	8,986.93	77,524.73
Southern	11,353.03	25,182.50	4,962.78	939.32	31,084.60	1,320.00	12,251.85	56,009.48
Eastern	4,113.12	23,727.88	190.00	17.20	23,935.08	0.00	454.91	28,503.11
N Eastern	1,242.00	60.00	1,187.50	142.74	1,390.24	0.00	252.68	2,884.92
Islands	0.00	0.00	0.00	70.02	70.02	0.00	6.10	76.12
All India	**39,623.40**	**132,288.39**	**20,359.85**	**1,199.75**	**153,847.99**	**4,780.00**	**27,541.71**	**225,793.10**

Source: CEA website

Re-assessment Studies of hydroelectric potential of the country, completed by Central Electricity Authority in 1987, have assessed the economically exploitable hydro power potential in terms of installed capacity as 148,701 MW, of which 145,320 MW is from schemes having capacity above 25 MW. Only about 23.74% of the hydro potential has been harnessed so far while another 8.22% is under various stages of development.

2.3.2 Power Demand and Supply Scenario in the Country

The country has been facing growing shortages of power over the past five years. During the 11th Plan (2007 - 2012), the average energy shortage in the country was about 400 Billion kWh (10%). During the ongoing 12th Plan, the peak deficit was about 12,000 MW (9%) and the average energy shortage in the country was about 50 Billion kWh (8.6%).

Details of peak and energy shortages in the country from 7th Plan onwards are given in Table 2-3 below:

Table 2-3: Actual Power Supply Position of India

	Peak Demand	Peak availability	Surplus/Deficit		Energy Requirement	Energy Availability	Surplus/ Deficit	
	(MW)	(MW)	(MW)	(%)	(MU)	(MU)	(MU)	(%)
At the end of 7th Plan (1989-90)	40385	33658	-6727	-16.7	247762	228151	-19611	-7.9
At the end of 8th Plan (1996-97)	63853	52376	-11477	-18.0	413490	365900	-47590	-11.5
At the end of 9th Plan (2001-02)	78441	69189	-9252	-11.8	522537	483350	-39187	-7.5
At the end of 10th Plan (2006-07)	100715	86818	-13897	-13.8	690587	624495	-66092	-9.6
11th Plan								
2007-08	108866	90793	-18073	-16.6	705724	628016	-77708	-11.0
2008-09	109809	96685	-13124	-12.0	774324	689021	-85303	-11.0
2009-10	119166	104009	-15157	-13.8	830594	746644	-83950	-10.1
2010-11	122287	110256	-12031	-9.8	861591	788355	-73236	-8.5
2011-12	130006	116,191	-13,815	-10.6	937,199	857,886	-79,313	-8.5
12th Plan								
2012-13	135,453	123,294	-12,159	-9.0	998,114	991,209	-89,905	-8.7
Apr 2013 – Jun 2013	135,561	126,964	-8,597	-6.3	259,181	243,683	-15,498	-6.0

Source: CEA Website

One of the major objectives of the National Electricity Policy was that demand should be fully met by the year 2012 with all peaking and energy shortages to be removed. It was with this objective in mind that a capacity addition of 78,700 MW was targeted for the 11th Five Year Plan. Against this capacity of 54,964 MW was commissioned during the 11th Plan. The details are as below:

Table 2-4: Status of projects commissioned during 11th Plan

(Figures in MW)

Sector	Hydro	Thermal				Nuclear	Total
		Coal	Gas	Lignite	Total		
Central	1550.0	11550.0	740.0	500.0	12790.0	880.0	15220.0
State	2702.0	11695.0	1885.4	450.0	14030.0	0.0	16732.4
Private	1292.0	18649.0	2530.5	540.0	21720.0	0.0	23012.5
Total	5544.0	41894.0	5155.9	1490.0	48540.0	880.0	54963.9

Source: Power Scenario at a Glance, CEA, November 2012

A capacity addition of 88537 MW has been targeted for the 12th Five Year Plan break-up for which is as below:

Table 2-5: Capacity addition target during the 12th Plan (in MW)

Sector	Hydro	Thermal				Nuclear	Total
		Coal	**Lignite**	**Gas/LNG**	**Total**		
Central Sector	6004	13800	250	827.6	14878	5300	26182
State Sector	1608	12210	0	1712	13922	0	15530
Private Sector	3285	43270	270	0	43540	0	46825
All India	**10897**	**69280**	**520**	**2539.6**	**72340**	**5300**	**88537**

Source: CEA Website

As per the draft report of the 18th Electric Power Survey, demand projections for next five and ten years, i.e. by the end of 12th and 13th Plan are as follows:

Table 2-6: Demand adopted for generation planning studies

	Energy Requirement (GWh)	Peak Load (MW)
2016-17 (12th Plan end)	1354874	199540
2021-22 (13th Plan end)	1904861	283470

Source: CEA Website

Rigorous advance planning/action is clearly required to achieve these formidable targets.

2.3.3 Hydro Power Potential of the North-East

The North-Eastern Region (NER) of the country comprises seven states: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura. The area is endowed with bountiful water resources with Brahmaputra flowing in the northern part and the Barak (Meghna) flowing through the southern margins. These two rivers, along with their numerous tributaries, have created a very dynamic and powerful hydrologic regime in the region.

Hydro potential of the north-eastern region in terms of installed capacity has been estimated as 58,971 MW (58,356 MW of schemes above 25 MW capacity) i.e. almost 40% of the country's total hydro potential. Out of the above, 1242 MW (schemes above 25 MW capacity) have been harnessed, while projects amounting to 2810 MW are under construction, as on June 2013.

The state-wise estimated hydroelectric potential of the north-eastern region and its status of development, as on June 2013, is given below:

Table 2-7: State-wise estimated hydroelectric potential of North-Eastern Region

State	Identified Potential as per Re-assessment Study (MW)	Capacity Developed (schemes above 25 MW capacity) (MW)	Capacity Under Construction (schemes above 25 MW capacity) (MW)
Arunachal Pradesh	50328	405	2710
Assam	680	375	0
Manipur	1784	105	0
Meghalaya	2394	282	40
Mizoram	2196	0	60
Nagaland	1574	75	0
Tripura	15	0	0
Total	**58971**	**1242**	**2810**

Source: CEA Website

Additionally, the region also has abundant resources of coal, oil and gas for thermal power generation.

2.3.4 Power Scenario of North-Eastern Region

With respect to the total available power potential of the region, the actual installed capacity and power supply position are given below in Table 2-8 to 2-10.

Table 2-8: State-wise Installed Capacity of North-Eastern Region as on June 2013

(Figures in MW)

State	Hydro	Thermal				Nuclear	RES	Total
		Coal	Gas	Diesel	Total			
Arunachal Pradesh	97.57	0.00	32.05	15.88	47.93	0.00	103.94	249.44
Assam	429.72	60.00	598.52	20.69	679.21	0.00	31.11	1140.04
Manipur	80.98	0.00	46.96	45.41	92.37	0.00	5.45	178.80
Meghalaya	356.58	0.00	65.61	2.05	67.66	0.00	31.03	455.27
Mizoram	34.31	0.00	27.28	51.86	79.14	0.00	36.47	149.92
Nagaland	53.32	0.00	32.84	2.00	34.84	0.00	28.67	116.83
Tripura	62.37	0.00	328.84	4.85	333.69	0.00	16.01	412.07
Central	127.15	0.00	55.40	0.00	55.40	0.00	0.00	182.55
TOTAL	**1242.00**	**60.00**	**1187.50**	**142.74**	**1390.24**	**0.00**	**252.68**	**2884.92**

Source: CEA website

Table 2-9: Sector-wise Installed Capacity of North-Eastern Region as on June 2013

(Figures in MW)

State	Hydro	Thermal				Nuclear	RES	Total
		Coal	Gas	Diesel	Total			
State	382.00	60.00	424.70	142.74	627.44	0.00	252.65	1262.09
Private	0.00	0.00	24.50	0.00	24.50	0.00	0.03	24.53
Central	860.00	0.00	738.30	0.00	738.30	0.00	0.00	1598.30
Total	**1242.00**	**60.00**	**1187.50**	**142.74**	**1390.24**	**0.00**	**252.68**	**2884.92**

Source: CEA website

Table 2-10: Actual power supply position in North-Eastern Region

Period	Peak Demand (MW)	Peak Met (MW)	Peak Deficit/ Surplus (MW)	Peak Deficit/ Surplus (%)	Energy Requir-ement (MU)	Energy Availa-bility (MU)	Energy Deficit/ Surplus (MU)	Energy Deficit/ Surplus (%)
9th Plan end	1148	1403	-105	-9.1	5935	5855	-80	-1.3
2002-03	1209	1135	-74	-6.1	6350	6195	-155	-2.4
2003-04	1259	1071	-188	-14.9	6640	6288	-352	-5.3
2004-05	1272	1128	-144	-11.3	7119	6674	-445	-6.3
2005-06	1385	1192	-193	-13.9	7534	6888	-646	-8.6
2006-07	1477	1166	-311	-21.1	7782	7012	-770	-9.9
2007-08	1742	1347	-395	-22.7	8799	7713	-1086	-12.3
2008-09	1820	1358	-462	-25.4	9407	8134	-1273	-13.5
2009-10	1760	1445	-315	-17.9	9332	8296	-1036	-11.1
2010-11	1,913	1,560	-353	-18.5	9,861	8,992	-869	-8.8
2011-12	1,920	1,782	-138	-7.2	11,011	9,964	-1047	-9.5
2012-13	1,998	1,864	-134	-6.7	11,566	10,718	-848	-7.3
Apr 2013 – Jun 2013	2,101	1,900	-201	-9.6	2,987	2,735	-252	-8.4

Source: CEA Website

Likely addition of power from different resources in the region is as follows:

Table 2-11: Likely capacity addition during the 12th Plan (2012-17)

(Figures in MW)

State	Hydro (MW)	Thermal (MW)				Total (MW)
		Coal	Gas	Total	Nuclear	
Ar. Pradesh	2710	0	0	0	0	2710
Assam	0	250	100	350	0	350
Manipur	0	0	0	0	0	0
Meghalaya	40	0	0	0	0	40
Mizoram	60	0	0	0	0	60
Tripura	0	0	826	826	0	826
Sikkim	1367	0	0	0	0	1367
Total (NER)	**2810**	**250**	**926**	**1176**	**0**	**3986**
Total (All India)	**9204**	**62695**	**1086**	**63781**	**2800**	**75785**

Source: Report of "The Working Group on Power for Twelfth Plan (2012-17)", Ministry of Power, GoI

2.3.5 Hydropower Potential of Arunachal Pradesh

The topography of the state provides very ideal conditions for developing hydroelectric projects. There are five major river basins in the state, namely Kameng, Subansiri, Siang, Dibang and Lohit. There are also many smaller river systems in the state which offer very attractive sites for hydroelectric projects. Almost all the major river systems flow in the north-south direction and ultimately drain into the Brahmaputra. Apart from the major rivers, the state has many small perennial rivulets providing ideal conditions for developing micro/mini and small hydroelectric projects. As per the preliminary ranking study done by the Central Electricity Authority (CEA), the total power potential from hydro projects in the north-eastern region is estimated to be about 58,971 MW, of which 50328 MW is in Arunachal Pradesh

2.3.6 Power Situation in Arunachal Pradesh

Despite availability of such huge potential, the state has so far developed only 97.57 MW under the state sector from various micro/mini/small hydroelectric projects, as on June 2013. Other projects, Kameng HEP, Subansiri Lower HEP and Pare HEP with installed capacities of 600 MW, 2000 MW and 110 MW, respectively, are under construction and likely to be completed during the 12th Plan period. During the year 2012-13, energy requirement in Arunachal Pradesh was 589 MU out of which 554 MU was met and peak demand was 116 MW out of which 114 MW was met.

2.3.7 Necessity and Justification for Implementing the Project

The state plans to harness its enormous natural resource of hydro power and exploit its mineral wealth to usher in an era of economic development and raise the per capita electricity consumption.

Comparing the projected growth of peak power demand, energy requirement anticipated and increase in the generating capacity on the basis of new projects proposed and/or under construction/consideration during 12th Five Year Plan, it is evident that there is a dire need to provide additional power to the National Grid. New schemes have to be taken up immediately and implemented to derive timely benefits. The most important source of power development in the north-eastern region is Arunachal Pradesh and other sister states.

The power from hydro projects in the north-eastern region would be in excess of the demand in the region and would have to be exported for utilization in other regions of the country. Presently there is no problem in the availability of transmission systems beyond the north-eastern power region for distribution of power as the five power regions of the country are in the process of greater integration within a national grid.

Considering the growth of peak demand and anticipated addition of generating capacity in the state, the region and the country, and also from the current status of development of hydro power potential of Arunachal Pradesh, it is pragmatic that earnest efforts are made for developing the hydro power sector of the state. Implementation of Kamala Hydroelectric Project of 1800 MW capacity would contribute significantly towards meeting this objective.

CHAPTER 3
BASIN DEVELOPMENT

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FIGURES:

3 BASIN DEVELOPMENT

3.1 Introduction

Arunachal Pradesh is the largest state in North-East India and has national as well as international borders. Nationally, it shares its border with Assam to the south and Nagaland to the southeast. Countries that share border with Arunachal Pradesh are Myanmar (on the east), Bhutan (on the west), and Tibet (on the north). The state is divided into sixteen districts and its terrain is mostly mountainous. Himalayan range lies along the northern borders of the state and is criss-crossed with other mountains running north-south. The north-south mountain ranges divide the state into five river valleys. Traversing from west to east these river basins are: the Kameng, the Subansiri, the Siang, the Lohit and the Tirap. All these rivers are fed by snow from the Himalayas and, below the snow line, their flow is augmented by countless rivers and rivulets.

Brahmaputra is the major river traversing the southern border of the state; the Subansiri river is a major right bank tributary of Brahmaputra. Subansiri originates beyond the Great Himalayan Range (Central Himalaya) at an altitude of around 6850m and after traversing a length of about 520km, it joins Brahmaputra river. Throughout its journey from origin to the confluence with Brahmaputra, Subansiri is joined by numerous big and small tributaries. River Kamla is one of the major tributaries of river Subansiri joining it at a distance of about 98km upstream of the Subansiri-Brahmaputra confluence.

3.2 Subansiri Basin Projects

To exploit the hydro power potential of Subansiri river and to moderate floods in the Subansiri basin, Subansiri Dam Project (4800 MW) was conceived by the Brahmaputra Board. Detailed Project Report of the project was prepared in April 1983. However, the project could not be taken up for execution as the Arunachal Pradesh Government objected to large submergence of land, including the main towns of Daporijo, Dumporijo & Tamen, and consequent displacement of inhabitants.

To avoid large submergence and relocation of these towns, Brahmaputra Board identified another option wherein the hydropower potential of Subansiri river basin was proposed to be developed in cascade. Three schemes were identified and, following a site visit by a team of experts from the Brahmaputra Board, Central Water Commission (CWC), Geological Survey of India (GSI) and representatives of the Arunachal Pradesh Government, preliminary

feasibility of the schemes was established. Further investigations were recommended and the projects were allotted for development to NHPC.

The three projects were named the Subansiri Upper, the Subansiri Middle (now called the Kamala project) and the Subansiri Lower Hydroelectric Projects. While the Subansiri Lower project was planned predominantly as a power generation project, the other two projects were proposed with twin objectives of generating power and ensuring moderation of floods that reach the downstream-most project. Large dams were consequently considered at the two upstream projects.

The Subansiri Upper Project was proposed on Subansiri river itself and featured a 265m high dam located near Menga. The Kamala project (then called Subansiri Middle) was planned on Kamla river (a tributary of Subansiri) and featured a 213m high dam located near Tamen. Reservoirs of both these projects were envisaged to have additional storage for flood moderation; sufficient cushion in dam heights were to be built accordingly. The downstream most project on the basin, the Subansiri Lower Project, was planned at Gerukamukh, in the same general area as the original large dam project. The total generating capacity of the three projects was preliminarily estimated at 7300MW, which far exceeded the originally estimated capacity of the Subansiri Dam Project.

3.3 Trans-Basin Diversion of Waters

Since releases from the Kamala project will pass through Kamla river itself and then join the Subansiri flows upstream of the reservoir of Subansiri Lower project, there would be no trans-basin diversion of water in this project.

3.4 Effect of Future Upstream/Downstream Developments on Proposed Scheme

Kamala Hydroelectric Project is being planned in accordance with the reservoir operation rule curve approved by Central Water Commission (CWC) and, in conjunction with the other Subansiri Basin projects, it will provide flood moderation benefits to the downstream reaches of Subansiri basin and areas in Assam located further downstream. The installed capacity of the project has also been fixed following the reservoir operation rule curve. The salient reservoir levels of Kamala project are given below:

- FRL : El. 455m
- MWL : El. 470m
- MDDL : El. 430m

Pre-feasibility report was prepared for Kurung Hydroelectric Project (combined Stages-I and II) by NHPC. The project is located upstream of Kamala HEP on river Kurung, a tributary of river Kamla. The tailwater level of Kurung HEP has been envisaged at El. 565m and thus has no interference with Kamala Project. Schematic cascade development of the Subansiri Basin is given below in Figure 3-1.

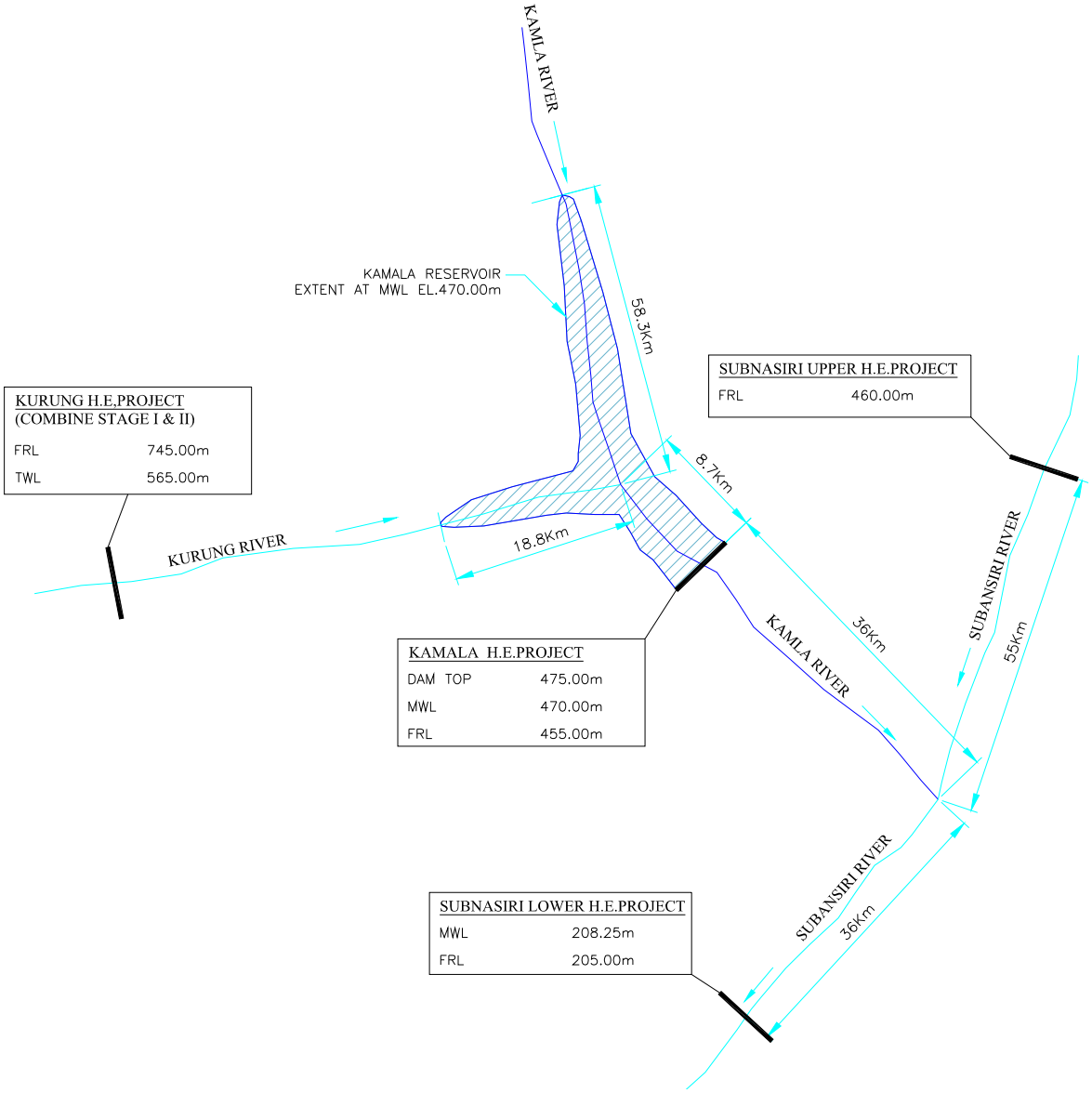

Figure 3-1: Schematic Cascade Development of Subansiri Basin

CHAPTER 4
INTER-STATE/INTERNATIONAL ASPECTS

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4 INTER-STATE / INTERNATIONAL ASPECTS

Kamala Hydroelectric Project is proposed on Kamla river, a right bank tributary of Subansiri river. Subansiri river in turn is a right bank tributary of Brahmaputra river.

Kamla river originates in Arunachal Pradesh at an elevation of around 6488m and has a total length of about 175km from origin to its confluence with Subansiri river. The proposed dam site of Kamala project is located nearly 36km upstream of the Kamla-Subansiri confluence. The catchment area of Kamla upto dam site is 7213km^2. The entire catchment of Kamla river lies in Arunachal Pradesh.

The main stem of Subansiri river originates beyond the great Himalayan Range at about El. 6850m in China and has a total length of 520km[1] from origin to its confluence with Brahmaputra. After flowing for a length of about 190km[1] in China, it enters India. The river continues its journey through the Himalayan range for nearly 200km[1] in Arunachal Pradesh and enters into the plains of Assam, where it flows further for a length of about 130km before meeting Brahmaputra. Subansiri river drains a basin of about 37000km^2. Subansiri river basin is bound by Tibet in the north, Siang basin in the east, Kameng and Dikrong basins in the west and Brahmaputra river in the south. The total length of the known and well defined tributaries of Subansiri is 1960km.

Kamala project is one of the three large projects conceived by Brahmaputra Board in the Subansiri basin with flood moderation as one of the key objectives. The project is being designed using the reservoir operation rule curve approved by the Central Water Commission (CWC); the rule curve forms the basis for power generation as well as flood moderation. The latter objective will be achieved in conjunction with the other two projects (Subansiri Upper and Subansiri Lower Projects) being developed in the Subansiri basin.

The reservoir of project planned with FRL of El. 455m at dam site, will have a gross storage of 1927.62 MCM, live storage of 623.58 MCM. The annual average flow of Kamla river at dam site is 22672 MCM.

The live storage of the project is a very small proportion (2.7%) of the annual flows and to that extent withholding of monsoons flows will, in general, have no impact on the flow regime of Subansiri or the Brahmaputra. In respect of flood management, the peaks of flood flows

[1] Source: Lower Subansiri Hydroelectric Power Project and future of the Subansiri River Ecosystem, Ranjit Dutta, Sarada Kanta Sharma, Department of Botany, Guwahati University, Assam

upto a flood of 100 years frequency will either be absorbed or released after moderation and to that extent the area of Arunachal Pradesh and Assam downstream of the dam will be protected from floods.

As far as the interstate aspects impacting the development of this project are concerned, since there is no interstate agreement/award, there are no interstate issues. Also, there is no treaty in respect of the basin and thus no international issues are involved in development of this project.

CHAPTER 5
SURVEY AND INVESTIGATIONS

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5 SURVEY AND INVESTIGATIONS

5.1 General

Survey and Investigation works were carried out for the project to meet the following objectives:

- To evaluate and optimize the layout of the project and finalize the location of components on topographical and geological considerations
- To collect sufficient qualitative and quantitative geological and geotechnical information for designing the project components
- To collect adequate data to plan suitable construction methodology and assess bankable project cost

5.2 Background

Investigations for the Kamala project (formerly Subansiri Middle project) were started by Brahmaputra Board in 1996. Two alternative sites for locating dam axis were examined on river Kamla namely Site-A (nearly 3.5km upstream of Tamen) and Site-B (nearly 12.5km upstream of Tamen). Brahmaputra board in consultation with CWC and GSI considered Site-A as a better option and carried out two exploratory drill holes, one each on either bank at the proposed dam site. The project was transferred to NHPC for preparation of Feasibility and Detailed Project Report during May 2000.

During the feasibility level study, NHPC after detailed inspection of the area, did not consider Brahmaputra Board axis (Site-A) as suitable and identified two other axes located about 450m and 500m upstream of the Site-A axis and initiated detailed investigations at these locations. These axes were designated as A-5 (450m upstream of Site-A) and A-6 (500m upstream of Site-A). A concrete gravity dam was planned near Axis A-5/ A-6 and the powerhouse was proposed underground inside the left bank of Kamla river. Upon approval of the Feasibility Report, NHPC embarked on preparation of the DPR. Through further investigations and studies, NHPC considered that the site selected during the feasibility stage (near Axis A-5/6) was not suitable for a concrete dam. Changing the dam type to rockfill was contemplated but it was concluded that the topography around this axis was not conducive for a fill type dam. Investigations were started on another axis located about 250m upstream of the A-6 axis. This axis was designated as A-11. A Concrete Face Rockfill Dam

(CFRD) was planned near Axis A-11 and the powerhouse was kept unchanged from the feasibility studies.

Extensive investigation works were carried by NHPC around A-5, A-6 and A-11 axis since taking over the project in May 2000. The investigations included topographical survey, satellite imagery studies, geological mapping of project components and reservoir area, petrography of the samples, exploratory drilling, exploratory drifting, groutability tests, geophysical exploration, in-situ & laboratory rock mechanic tests and construction material survey. The project was further transferred to Kamala Hydroelectric Power Company Ltd. (KHEPCL) during Aug. 2010. All the survey and investigation data collected by NHPC was handed over to KHEPCL.

KHEPCL commenced the studies with an independent review of all previous study reports including the investigation results and after detailed assessment envisaged a concrete gravity dam near A-5/6. The powerhouse is proposed underground inside the left bank of Kamla river about 150m u/s of the NHPC location. KHEPCL continued further investigations required for the present project configuration and supplemented the earlier investigations with topographical survey, geological mapping of the project and reservoir area, exploratory drilling, exploratory drifting, groutability tests, in-situ & laboratory rock mechanic tests, site specific seismic studies, transportation logistics survey and review of the construction material survey.

The investigations carried out for the project during various stages is discussed in following sections.

5.3 Investigations by Brahmaputra Board

Brahmaputra Board carried out subsurface explorations comprising two exploratory drill holes, one each on either bank of Site-A axis. Location of drill hole BH-1 is summarized in **Table 5-1;** however the details of second drill hole could not be located.

5.4 Investigations by NHPC

5.4.1 Topographic Surveys

- Preliminary topographic contour plans covering the areas of various alternative dam sites and proposed project components were prepared by State Remote Sensing Agency, Itanagar.

- Detailed topographic survey of the project was conducted by Survey of India (SOI), Shillong and NHPC's survey unit that comprised the project area, reservoir area, quarry & borrow areas, infrastructure & muck disposal areas and river cross-sections.

5.4.2 Remote Sensing Studies

Remote sensing studies of Kamla basin on regional scale were conducted by State Remote Sensing Application Centre; Itanagar using IRS1D (LISS III + PAN) merged data. These studies formed a database for understanding the geological and structural setup of the basin. Besides this general appreciation of the geomorphological features, landuse pattern and drainage system of the basin were made through satellite data studied by SRSAC, Itanagar.

For detailed geological evaluation of project and reservoir area, National Remote Sensing Agency (NRSA), Hyderabad was engaged. High resolution IKONOS data was used for study of dam area on 1:5000 scale. The entire project area and major part of reservoir on 1:25000 scale, using PAN +LISS-III data was studied by NRSA.

5.4.3 Geological Mapping

Detailed geological mapping of various components of the project and reservoir area was carried.

5.4.4 Geophysical Explorations

Seismic refraction surveys were carried to ascertain the depth and type of overburden and to assess the quality of subsurface strata.

Seismic profiling with total length of 1300m was carried out in the following areas:

- Two profiles, one each on left and right bank at A-6 axis (P-1 & P-2 respectively)
- One profile in shoal area on the right bank upstream of A-11 axis (P-3)
- Two profiles in probable/ alternative Diversion Tunnel Inlet area on right bank (P-4 & P-5)
- Two profiles, one each on right & left bank river edges near A-6 axis (P-6 & P-7, respectively)
- Three profiles near Puku Kro in Power Intake area of CFRD alternative (SP1, SP2 & SP3)

- One profile on left bank in Diversion Tunnel Inlet area of CFRD alternative (SP4)
- One profile on right bank terrace at proposed Brahmaputra board (Site-A) Axis (SP5)
- One profile on right bank upstream of A-6 axis (SP6)

Resistivity imaging was also done along lines SP1, SP2 and SP4 to compliment the seismic surveys.

5.4.5 Exploratory Drilling

42 numbers of exploratory drill holes aggregating to 2685.35m cumulative depth were executed at alternative dam axes and other project component areas to assess the depth of overburden and quality of bedrock. Permeability tests for overburden were conducted in drill holes using constant head method and water pressure tests in bedrock were conducted using single/double packer. One set of groutability test was conducted on the left bank, upstream of A-6 axis.

Location details of exploratory drill holes are summarized in **Table 5-1** and drill hole logs are enclosed in DPR Volume-IIIC.

5.4.6 Exploratory Drifts

Eleven (11) numbers exploratory drifts were executed on both the banks at the proposed alternative dam axes and powerhouse location.

- A-5/A-6 axis was explored by two drifts (LDR-1 and LDR-2) on left abutment aggregating to 181m cumulative length and three drifts (RDR-1, RDR-2 & RDR-3) on the right abutment aggregating to 250m length
- A-11 axis was explored by two drifts (LDR-4 and LDR-5) on left abutment, aggregating to 100m cumulative length and by three drifts (RDR-4, RDR-5 and RDR-6) on right bank aggregating to 151m length
- Underground powerhouse location was explored by a 260m long drift (LDR-3)

Location details of the exploratory drifts are summarized in **Table 5-2** and drift logs are enclosed in DPR Volume-IIID.

5.4.7 In-situ Field Tests

Following in-situ rock mechanic tests were conducted by National Institute of Rock Mechanics, Bangalore, Karnataka.

- Plate Load tests to determine deformability parameters of rock in drifts LDR-4, LDR-5 & RDR-6 (drifts at Axis A-11) and LDR-3 (Powerhouse drift).
- Shear tests in drifts LDR-4 and LDR-5 (drifts at Axis A-11) for determining shear parameters of rock to rock and rock to concrete interface.

Reports on In-situ Field Tests are enclosed in DPR Volume-IIIE.

5.4.8 Laboratory Tests

Petrological and Chemical Studies

Petrographical studies of rock/core samples from project and reservoir area were carried out by Geological Survey of India (GSI), Shillong and Central Petrological Laboratories, GSI, Kolkata. X-ray diffraction and chemical analysis of few rock samples were also carried out at AMD, Hyderabad.

Rock Mechanic Testing

Laboratory tests on core samples were conducted by North Eastern Hydraulic and Allied Research Institute (NEHARI), Guwahati and National Institute of Rock Mechanics (NIRM), Bangalore to determine the physical and engineering properties of the rock mass.

Reports on Laboratory Tests are enclosed in DPR Volume-IIIE.

5.4.9 Seismic Studies

Study of site-specific seismic design parameters was carried by Department of Earthquake Engineering (DEQ), IIT Roorkee.

5.4.10 Construction Material Survey

Construction material surveys were carried out to estimate quality and quantity of coarse and fine aggregates for concrete, impervious material for coffer dams and rock fill material for the CFRD. Fourteen rock quarries (SMR-1 to SMR-9) and six impervious soil borrow areas (SMC-1 to SMC-6) were identified.

Representative samples from the quarries/ borrow areas were tested for various physical tests conducted by North East Hydraulics and Allied Research Institute (NEHARI), Guwahati, Central Soil and Material Research Station (CSMRS), New Delhi and Central Mining Research Institute (CMRI), Dhanbad. Alkali aggregate reactivity tests on coarse and fine aggregates were conducted by National Council for Cement and Building Material (NCCBM), Ballabhgarh, Haryana.

Details of Construction Material survey and tests have been discussed in DPR Volume-VIII.

5.5 Investigations by KHEPCL

KHEPCL extended the works carried by NHPC with further investigations and supplemented the earlier investigations with following:

5.5.1 Topographical Survey

A confirmatory survey of the project area was conducted. The established bench marks in the project area were verified by taking a closed traverse survey. The survey extended from riverbed upto El 600m on either bank in dam area, upto El 550m on either bank in reservoir area and upto El 700m in powerhouse area. The survey details are given below:

(i) Dam area - 1:1000 scale with contour interval of 2m

(ii) Powerhouse Area - 1:500 scale with contour interval of 1m

(iii) Reservoir area - 1:10000 scale with contour interval of 5m

(iv) Topographic survey of quarry and borrow areas - 1:2000 scale with contour interval of 2m

(v) Topographic survey for infrastructure development and muck disposal area - 1:2000 scale with contour interval of 2m

(vi) River cross-sections at 50 to 100m c/c from 900m upstream to 1150m downstream of present dam axis

5.5.2 Geological Mapping

Geological mapping of the project and reservoir area was carried with a view to:

- verify the previous mapping
- assess the physical and structural characteristics of the rockmass

- delineate rock-overburden contact
- collect geotechnical parameters of each outcrop for rock mass characterization

5.5.3 Exploratory Drilling

The drilling explorations carried by NHPC were reviewed in detail with respect to the present project configuration. Need of supplementary exploratory drill holes emerged in view of conducting certain confirmatory drill holes to ascertain the depth of overburden & quality of bedrock and also due to reconfigured project layout. Additional 19 exploratory drill holes including 4 grout holes were proposed out of which 17 holes have been completed. Cumulative length of drilling executed so far (including in progress drill holes) is 1472.5m. Permeability tests for overburden and water pressure tests for rock were also conducted in the drill holes. Location details of exploratory drill holes are summarized in **Table 5-1** and drill hole logs are enclosed in DPR Volume-IIIC.

5.5.4 Groutability Test

As the groutability test conducted earlier by NHPC was not conclusive, additional set of groutability test is being conducted near dam axis on left abutment to determine the groutability characteristics of the rock mass. The groutability test is currently under progress at the site.

5.5.5 Exploratory Drifting

2 drifts on the left abutment and 3 drifts on the right abutment of Axis A-5/6 were carried earlier by NHPC. The height of proposed dam is 216m from the deepest foundation level, so it was considered essential to have one more exploratory drift to encompass the lower section of the left abutment and assess rock mass characteristics by drift logging and in-situ tests.

Also, with the change in location of powerhouse by around 150m, the drift for powerhouse (LDR-3) needed extension into the present location of the powerhouse. The following supplementary exploratory drifts were executed.

- LDR-6 on left abutment of present dam axis (near A-5/6)
- Extension of powerhouse drift LDR-3 (presently in progress at site)

Location details of the exploratory drifts are summarized in **Table 5-2** and drift logs are enclosed in DPR Volume-IIID.

5.5.6 In-situ Field Tests

Rock Mechanic Testing

The following in-situ rock mechanic tests have been conducted by AECS Engineering & Geotechnical Services, Noida.

- Uniaxial Jacking Tests and Plate Load Tests for determination of deformation parameters of the rockmass in drifts LDR-6 and RDR-1
- Direct shear test for determination of shear parameters of concrete-rock and rock-rock interface in drifts LDR-6 and RDR-1

Hydrofracture Testing

To determine state of in-situ stress of rockmass, Hydraulic fracture test has been conducted in powerhouse drift LDR-3 by National Institute of Rock Mechanics (NIRM), Bengaluru

Reports on In-situ Field Tests are enclosed in DPR Volume-IIIE.

5.5.7 Laboratory Rock Mechanic Tests

Laboratory rock mechanic tests on core samples of drill holes were conducted by AECS Engineering & Geotechnical Services, Noida. to determine the physical and engineering properties of the rock mass.

Reports on Laboratory Tests are enclosed in DPR Volume-IIIE.

5.5.8 Seismic Studies

The earlier site specific seismic study incorporated the seismic data collected upto year 1998 and was done with deterministic approach only.

As per the guidelines of “National Committee on Seismic Design Parameters”, site specific seismic studies by both the approaches namely probabilistic seismic hazard assessment and deterministic seismic hazard assessment incorporating the updated seismic data upto year 2009 were again conducted by Department of Earthquake Engineering, IIT Roorkee.

The report on Site Specific Earthquake parameters is enclosed in DPR Volume-IX.

5.5.9 Construction Material Survey

The requirement of construction material and its suitability was re-assessed for the proposed project components.

The details regarding testing and suitability of the required construction material are enclosed in DPR Volume-VIII.

5.5.10 Transportation Logistics Survey

The project is well connected to the district headquarters through an all weather road maintained by the state PWD. The adequacy of this highway to transport heavy, over-dimensioned equipment and machines has been assessed through a specialized agency ABC India Ltd., Kolkata. The report is enclosed in DPR Volume-IX.

Table 5-1: Details of Exploratory Drilling

S.No.	Drill Hole	Location
Exploratory Drill Holes by Brahmaputra Board		
1	BH-1	Left bank river edge near d/s coffer dam
2	BH-2	-Not available-
Exploratory Drill Holes by NHPC		
1	DDH-A5/1	A-5 Axis - Left bank near river
2	DDH-A5/2	A-5 Axis - Left bank near river
3	DDH-A5/3	A-5 Axis - Left bank
4	DDH–1	A-6 Axis - Right bank river edge
5	DDH-3	A-6 Axis - Right bank
6	DDH-4	A-6 Axis - Left bank
7	DDH-5	Left Bank hill in power intake area (A-6 Axis)
8	DDH-6	A-6 Axis - Right bank
9	DDH-7	A-6 Axis - Right abutment
10	DDH-8	Right bank hill above downstream coffer dam (between dam axis and Brahmaputra board Axis)
11	DDH-9	Right bank of plunge pool
12	DDH-10	Downstream Coffer dam - Midstream

S.No.	Drill Hole	Location
13	DDH-11	A-6 Axis - Midstream
14	DDH-12	Right bank of plunge pool near Brahmaputra board Axis
15	DDH-13	TRT Outlet - Left Bank river edge
16	DDH-19	Groutability Test Hole - Left Bank between dam axis and u/s coffer dam
17	DDH-20	Groutability Test Hole - Left Bank between dam axis and u/s coffer
18	DDH-21	Groutability Test Hole - Left Bank between dam axis and u/s coffer dam
19	DDH-22	Groutability Test Hole - Left Bank between dam axis and u/s coffer dam
20	DDH-24	Left Bank hill near Diversion Tunnel
21	DDH-28	Right bank between dam axis and A-11
22	DDH-29	A-6 Axis - Left Bank near river
23	DDH-30	A-5 Axis - Right Bank
24	DDH-31	A-5 Axis - Left Bank river edge
25	DDH-32	Tail pool of dam-toe auxiliary powerhouse – Right Bank river edge
26	DDH-33	Left bank river edge near d/s cofferdam
27	DDH-34	Right bank hill above dam-toe powerhouse
28	DDH-35	Upstream cofferdam (A-11 axis) - Left bank river edge
29	DDH-36	Upstream cofferdam (near A-11 axis) - Right bank river edge
30	DDH-37	Upstream cofferdam (near A-11 axis) - Right bank
31	DDH-38	Right bank hill above u/s coffer dam
32	DDH-39	Upstream cofferdam (A-11 axis) - Midstream
33	DDH-40	Between dam axis and upstream cofferdam - Midstream
34	DDH-41	Between dam axis and upstream cofferdam - Right bank river edge
35	DDH-42	Left Bank hill near diversion tunnel
36	DDH-43	Left Bank hill near powerhouse
37	DDH-44	Left bank of Puku kro
38	DDH-45	Left bank of Puku kro
39	DDH-46	Left bank of Puku kro

S.No.	Drill Hole	Location
40	DDH-47	Left bank of Puku kro
41	PDH-1	Diversion Tunnel Outlet - Left Bank river edge
42	PDH-2	Tailrace Tunnel Outlet - Left Bank river edge
Exploratory Drill Holes by KHEPCL		
1	NDH-1	Dam Axis - Right Abutment
2	NDH-2	Dam Axis - Right Bank river edge
3	NDH-3	Dam Axis - Right Bank river edge
4	NDH-4	Dam Axis - Left bank near river
5	NDH-5	Dam Axis - Left Abutment
6	NDH-6	Dam toe Bucket Area - Left Bank river edge
7	NDH-7	Plunge Pool - Mid Stream
8	NDH-8	Dam-toe auxiliary powerhouse - Right Bank
9	NDH-9	Dam toe - Left Bank
10	NDH-10	Diversion tunnel Inlet - Left Bank
11	NDH-11	Dam Toe - Right bank
12	NDH-11S	Dam Toe - Right bank
13	NDH-12	Dam Toe auxiliary powerhouse - Right Bank (in progress)
14	NDH-13	Dam Axis - Mid stream
15	NDH-14	Pothead Yard (in progress)
16	P-1	Groutability Test Hole near dam axis – Left Bank
17	P-2	Groutability Test Hole near dam axis – Left Bank
18	P-3	Groutability Test Hole near dam axis – Left Bank
19	P-4	Groutability Test Hole near dam axis – Left Bank

Table 5-2: Details of Exploratory Drifts

S.No.	Drift	Location	Invert Elevation (m)
Exploratory Drifts by NHPC			
1	LDR-1	Left Bank near Dam axis	350.00
2	LDR-2	Left bank near Dam axis	395.00
3	LDR-3	Left bank underground powerhouse	306.00
4	LDR-4	Left bank near A-11 axis	390.00
5	LDR-5	Left bank near A-11 axis	310.00
6	RDR-1	Right bank near Dam axis	322.00
7	RDR-2	Right bank near Dam axis	400.00
8	RDR-3	Right bank near Dam axis	431.00
9	RDR-4	Right bank near A-11 axis	345.00
10	RDR-5	Right bank near A-11 axis	415.00
11	RDR-6	Right bank near A-11 axis	300.00
Exploratory Drifts by KHEPCL			
1	LDR-6	Left Bank near dam axis	319.85
2	Extension of LDR-3	Left bank underground powerhouse	In progress

CHAPTER 6
PROJECT GEOLOGY

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6 GEOLOGY

6.1 Introduction

The proposed 1800MW installed capacity Kamala Hydroelectric Project is envisaged on the river Kamla, a major tributary of Subansiri about 4km upstream of Tamen village in Lower Subansiri District of Arunachal Pradesh and about 55km from Ziro, the district headquarter.

With the objective of harnessing the hydro-power potential of Subansiri river and moderate the flood hazard in downstream areas, DPR of Subansiri Dam Project (4800 MW) was prepared by Brahmaputra Board during April 1983. However, the project could not be taken up for further development due to objections from Arunachal Pradesh Govt. on account of large submergence of land and consequent displacement of inhabitants. Subsequently, cascade development over river Subansiri was planned. It included three projects namely Subansiri Lower Hydroelectric Project at Gerukamukh over river Subansiri (2000 MW), Subansiri Middle Hydroelectric Project near Tamen over the river Kamla (1600 MW) and Subansiri Upper Project at Menga over river Subansiri (2000 MW). CEA approval for taking up of Subansiri Lower HE Project was accorded and as such project is under construction. The techno-commercial viability of Subansiri Upper and Subansiri Middle projects was accepted by CEA for taking up further development.

A joint team including officers from CWC, GSI, PWD, Arunachal Pradesh and Brahmaputra Board, inspected the alternative sites in 1996. Two alternative dam sites located 3.5 km (Site A) and 12.5 km (Site B) upstream of Tamen Bridge were preliminarily identified. Site A was considered a better option on topographical and geological considerations. It was initially explored by drilling two bore holes on either bank of proposed dam site by Brahmaputra Board. Thereafter, the project was handed over to NHPC for further development in May 2000 by Ministry of Power, Government of India.

NHPC first carried out a feasibility level study of the project and then initiated detailed field investigations and studies for preparation of the DPR. During the feasibility studies, NHPC identified two other axes A-5 & A-6 located about 450m and 500m upstream of the Site-A axis selected by Brahmaputra Board, respectively and initiated detailed investigations at these axes. A concrete gravity dam was planned and the powerhouse was proposed underground inside the left bank of Kamla river. The powerhouse comprised 8 units of 200 MW, totalling an installed capacity of 1600 MW. Upon approval of the Feasibility Report, NHPC started detailed investigations for preparation of DPR and selected another axis A-11

located about 250m upstream of the A-6 axis. A CFRD was planned at this axis and the powerhouse was kept unchanged from the feasibility studies.

However, the development rights of the project were transferred by Government of Arunachal Pradesh in the year 2010 to Kamala Hydro Electric Power Company Limited (KHEPCL), a joint venture of Jindal Power Ltd and Hydro Power Development Corporation of Arunachal Pradesh Ltd.

6.2 Geomorphology and Geology

6.2.1 Physiography

Arunachal Pradesh has been divided into four distinct physiographic and geotectonic divisions, each characterized by distinct geological history and separated from each other by major tectonic lineament (**Figure 6-1**). These are as follows:

i) Arunachal Himalaya

ii) Mishmi Hills

iii) Naga - Patkoi Ranges

iv) Brahmaputra Plains

The Kamala hydroelectric project lies in Arunachal Himalaya.

Arunachal Himalaya

Arunachal Himalaya forms the easternmost part of the Himalaya. The Himalayan Ranges rise abruptly from the Brahmaputra plains at around 100m elevation above msl to heights of more than 7000m above msl and merge with the Tibetan Plateau in the north. The southern boundary of the Himalayan Ranges in the region is defined by Himalayan Foothill Thrust (HFT) or Himalayan Frontal thrust that separates Himalaya from Brahmaputra Plains. The Arunachal Himalaya in the east abuts against Mishmi Hills belonging to Arakan Youma ranges of Myanmar along Tidding Suture zone. Arunachal Himalaya, in the west passes in to Bhutan. The Himalaya consists of rocks ranging in age from Proterozoic to Quaternary and has attained the present heights during different phases of orogenic movements. Broadly, based on orographical features, as elsewhere, Arunachal Himalaya has been sub-divided into four parallel NE-SW trending linear zones. From south to north, these are:

- Outer or Sub Himalaya
- Lesser Himalaya

- Higher or Great Himalaya
- Tethys or Trans Himalaya

The project under discussion is located in Lesser Himalaya sub-division.

Lesser Himalaya

Located between Higher Himalaya in the north and Sub-Himalaya in the south, the Lesser Himalaya has elevation ranging between 2500m and 4000m above msl. This zone is much wider as compared to neighbouring Sub-Himalayan and Higher Himalayan Zones and varies between 80 and 90km in general. Its northern boundary against Higher Himalaya is defined by Main Central Thrust (MCT) and southern one against Sub-Himalaya by MBT. In the east it abuts against Mishmi Hills along Tidding Suture and passes into Bhutan Himalaya in the west. This zone exposes late Paleoprotorozoic unfossiliferous sediments with a narrow belt of Upper Paleozoic along its southern margin in western part in Kameng and Subansiri valleys and those of Proterozoic, Paleozoic, Mesozoic and Cenozoic ages in eastern part in Siang valley.

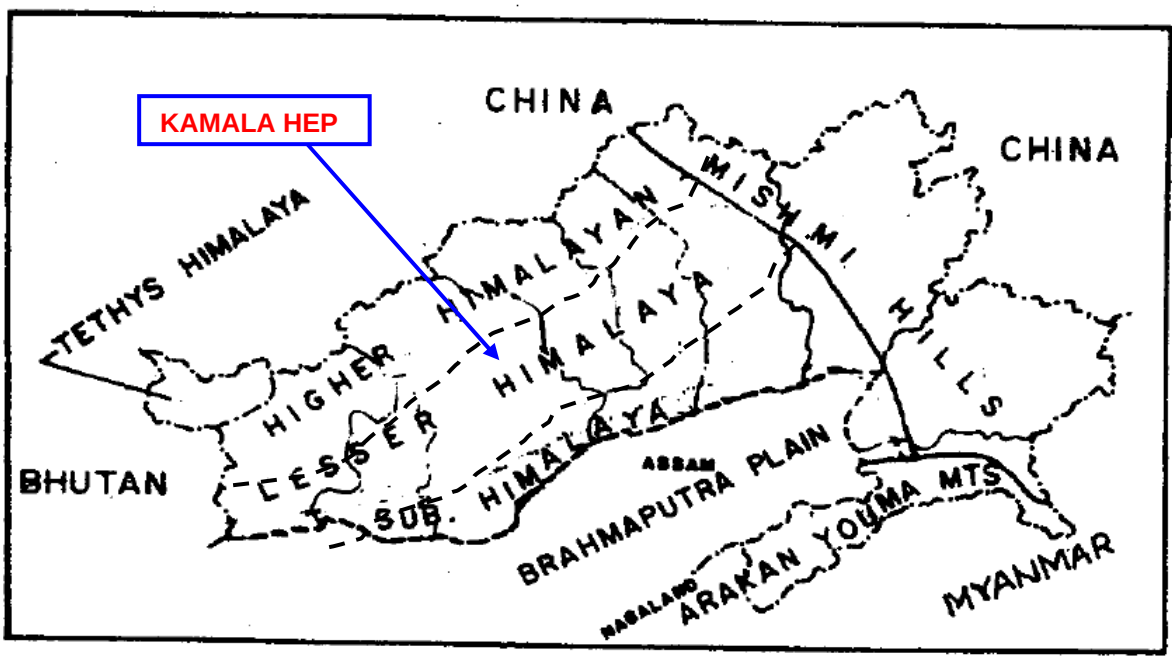

Figure 6-1: Map showing Physiographic Divisions of Arunachal Pradesh

6.2.2 Geomorphology

In broad geomorphic classification, the area around the Kamala Hydroelectric Project lies in Lesser Himalayan physiographic unit (S1) wherein Mountain ranges are characterized by moderately dissected, fine drainage textured, sharp crested ridges and is defined as S1e

geomorphic unit of structural origin (Ghosh et. al., 1989). The conspicuous geomorphic features observed in the area are that the rivers flow mostly transverse to the NW-SE, E-W and NE- SW regional trend. This unit is frequently traversed by strong transverse lineaments which often appear to offset the ridges. The southern boundary of this geomorphic unit with Siwalik Hills is very sharp and often marked by local longitudinal lineaments of prominence, indicative of faults/thrusts. The western boundary of this unit is gradational and the eastern boundary is marked by a syntaxial bend along the river Dihang or Siang, and also by the NW- SE lineament representing Lohit Thrust.

The Subansiri River, in the basin of which Kamala Hydroelectric Project is located, is a prominent north bank tributary of Brahmaputra. It originates in Tethys Himalaya in Tibet as Tsari Chu and cutting through Higher Himalaya, it drains about 30,000 sq.km area in Lesser and Sub-Himalayan parts of Miri and western parts of Abor Hills. It debouches into Brahmaputra Plains near Dulangmukh in Assam (El. 152m above msl).

The Kamla river, on which the proposed project is envisaged, is a main right bank tributary of Subansiri river. It rises at an altitude of 5200m in Higher Himalaya and flows in southeasterly direction almost parallel to the course of Subansiri River. It drains approximately 7000 sq.km area in Miri Hills and joins the main Subansiri river at Leling. Kurung river is a major right bank tributary of Kamla that flows in NW direction and joins it east of Bala village at about 280m above msl.

6.2.3 Regional Geology

The Arunachal Himalaya mainly encompasses Proterozoic Crystallines, the Proterozoic folded covers, Paleozoic cover sequence and volcanics, tectonically reworked during Himalayan fold thrust movements. The most prominent geological feature in Arunachal Himalayas towards east is the Eastern Syntaxial Bend (ESB), across which the tectonic belts take a sharp bend and swerve from NE–SW in the west to NW–SE in the east across the Siang gorge. This syntaxial bend is built up of Proterozoic to Cenozoic rocks characterized by distinct lithotectonic belts. However, in the west of Eastern Syntaxial Belt (ESB) in Subansiri and Kameng basins, the Tethyan belt towards south is followed by rocks belonging to Se La group of Paleoproterozoic age in Higher or Central Himalayan belt, the rocks belonging to Bomdila Group of Paleo-Proterozoic and Dirang Formation of Meso-Proterozoic age in Lesser Himalaya. These are intruded by ultramafic dykes and sills, biotite granite episodically.

The stratigraphic succession as established by Kumar (1997), geoscientists of GSI and those of other organisations in western and central parts of Arunachal Himalaya is presented in the **Table 6-1**.

Table 6-1: Stratigraphic Succession in Arunachal Himalaya (After Kumar, 1997 &others)

Enothem	Erathem	System	Series	Group	Formation	Lithology
Phanerozoic		Quaternary	Holocene		Newer Alluvium	Channel Alluvium Terrace Alluvium Alluvial Fans
			Pleistocene		Older Alluvium	High Level Terraces
---------- Himalayan Foothill Thrust (HFT) ----------						
	Cenozoic	Neogene	Pliocene	Siwalik	Kimin	Alternate bands of conglomerate, soft sandstone and clays.
					Subansiri	Salt and pepper textured coarse to medium grained sandstone.
					Dafla	Alternate bands of sandstone shale and clay.
			Miocene		Kimi	Hard, grayish white to greenish sand stone, calcareous sand stone and red shale.
---------- Main Boundary Thrust (MBT) ----------						
Phanerozoic		Paleogene	Oligocene			Tourmaline Granite
			Eocene			
			Paleocene			
			Miocene	Yinkiong	Dalbuing Geku	Hard, grayish white to greenish sandstone, calc. sandstone and red shale. Mafic Volcanics
	Mesozoic	Cretaceous				
		Jurassic				
		Triassic				
	Paleozoic	Permian	Upper		Yamne	Dark grey Dimictite with minor quartzite
			Lower	Lower Gondwana	Abor Volcanics	Mafic Volcanics
					Bhareli	Grey to dark Grey felspathic sandstone and grey to black carbonaceous shales with lenticular coal beds.

Enothem	Erathem	System	Series	Group	Formation	Lithology
					Bichom	A sequence of conglomerate, sandstone/ quartzite, purple shale and dimictite
					Miri	Basal garnetiferous schist with quartzite, phyllite, ochre schist, calc schist, and marble
	---------- Thrust (Bomdila) ----------					
		Carboniferous				Biotite Granite
		Devonian				
		Silurian				
		Ordovician				
		Cambrian				
Proterozoic	Neo Proterozoic	Terminal				Biotite Granite
		Cryogenian				
		Tonian				
	Meso Proterozoic				Dirang (and equivalent Lum La and Takshing formations of Tethys Himalaya)	Granite Gneiss Basal garnetiferous schist with quartzite, phyllite, ochre schist, calc schist, and marble
	Paleoproterozoic			Bomdila	Chilliepam	Bomdila Gneiss Ultramafic Dykes and sills Alternate sequence of grayish white dolomite/ limestone and grey and purple carbonaceous phyllite.
					Tenga	White to grayish white quartzite with intercalation of phyllite; inter bedded sequence of quartzite and pene-contemporaneous mafic volcanics and occasionally thin bands of marble/ dolomite
					Khetabari	Quartzite, garnet-mica schist, para-ampholite, acidic tuff, carbonaceous and graphitic phyllite, marble and calc silicate.
	----------Main Central Thrust (MCT) ----------					

Enothem	Erathem	System	Series	Group	Formation	Lithology
				Sela	Galensiniak	Kyanite-sillimanite ± staurolite gneisses and schists and quartzite; migmatite.
					Taliha	Calc silicate, marble, graphitic schist, amphibolite, sillimanite and bands of hard quartzite

Geological map of Arunachal Pradesh after G.K. Kesari (GSI, 2010) is appended as Figure 6-2.

In the Kamla valley, the project area around Tamen located in Lesser Himalaya exposes the gneisses belonging to Daporijo/Ziro Gneiss of Bomdila Group. The granite gneiss extends monotonously from Ziro-Hapoli region in the south to ENE towards Daporijo. These are best exposed along the road section between Hapoli -Tamen and Daparijo in Kamla/Subansiri valley. This sequence constitutes a part of Bomdilla Group and has been variously called as Daparijo/Ziro/Palin/Chakoo Gneiss.

In Kamla valley, the rocks of Ziro Gneisses consist of mainly biotite gneiss, augen gneiss, garnetiferous sillimanite hornblende gneiss, mica schist, leucogranite and amphibolite. They are bounded by Sippi thrust in the north-west, which has brought the low grade metasedimentaries of Niumi Formation in juxtaposition with high grade gneiss. The south-east boundary is defined by unconformable contact with the low grade metasedimentary rocks of Khetabari Formation of Bomdila Group. Jain and Singh (NHPC DPR), however, considered this contact as thrusted one and named it as Tamen Thrust whereas others like Kumar (1997), Kumar and Singh (1980) and GSI (2010) do not consider it as thrusted one.

The gneisses are composed of quartz, biotite, oligoclase, occasional microcline. Muscovite, tourmaline, epidote, hornblende and apatite constitute the minor minerals. Both coarse and fine grained gneisses are present in the area. These gneisses are intruded by tourmaline granite, smoky quartz bearing pegmatite and silica veins at certain places. The biotite gneiss exposed in the area shows development of augen structures and garnet at several places. These are intercalated with thin schist bands that vary in thickness from 1 to 5m. The bedrock is weathered on the surface at places.

The gneisses exposed in the project area are foliated and traversed by three prominent sets of joints in addition to those oriented along the foliation. These are folded in isoclinal and overturned folds.

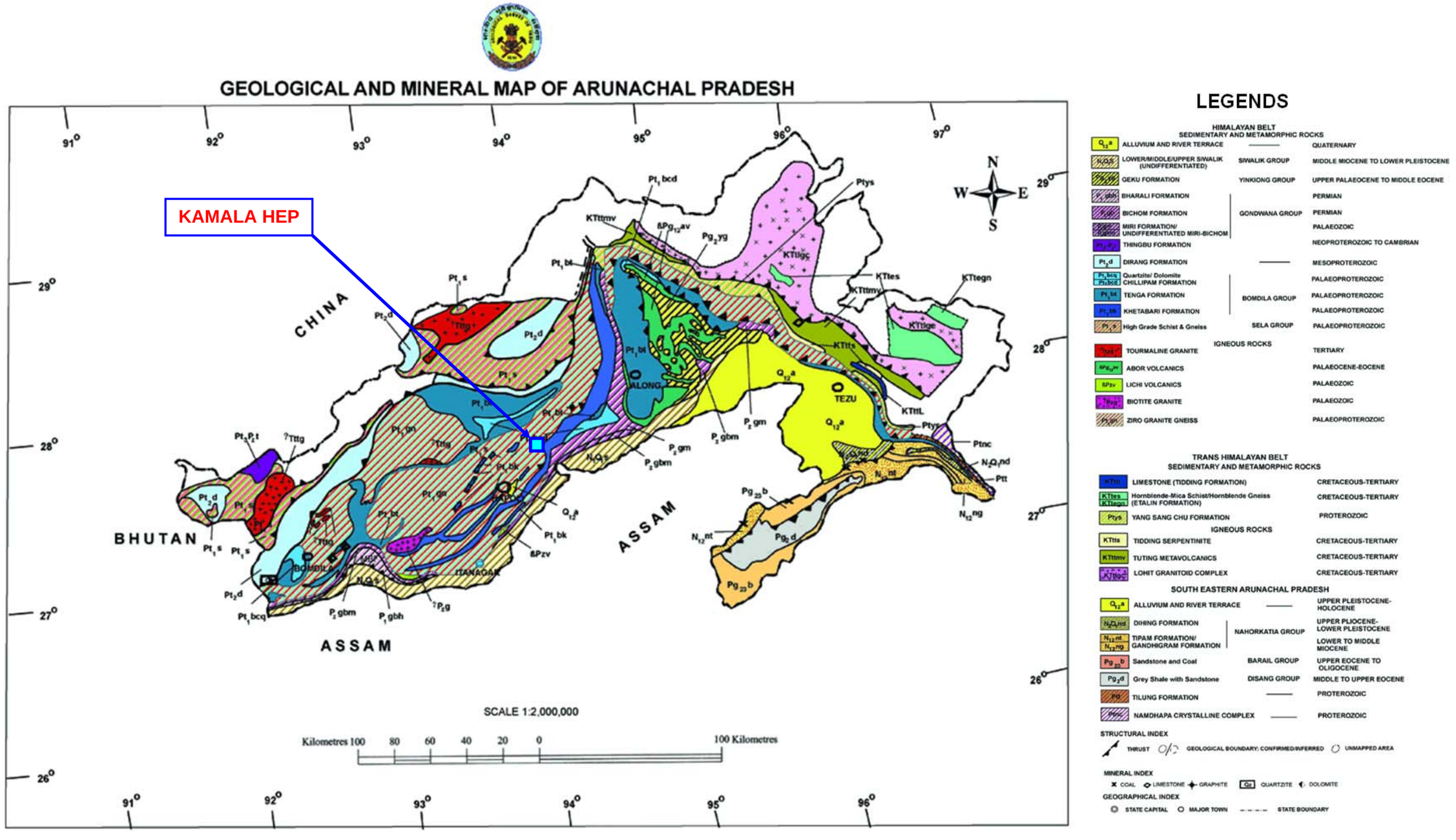

Figure 6-2: Regional Geological Map of Arunachal Pradesh (After G.K.Kesari, GSI, 2010)

6.3 Field Investigations

From conceptual stage of the project to till detailed Project Report preparation, various surface and sub-surface investigations have been carried out at site to optimize the project layout and finalise the sites of different project components. The investigations at various stages of the project were undertaken by Brahmaputra Board, NHPC and then KHEPCL.

The surface investigations carried out at various stages include detailed geological mapping of project area and reservoir area, remote sensing studies, petrography study of samples and construction material survey. Subsurface investigations include geophysical explorations (1300m seismic profiling and 185m of resistivity imaging), exploratory drilling (62 nos. of drill holes with cumulative length of 4214.45m) and exploratory drifting. At dam site area 11 drifts at both abutments have been done with aggregating length of 744.60m and the powerhouse drift has so far been excavated 260m towards old powerhouse and about 88.50m for new powerhouse bifurcating the drift at RD 112m. In addition, satellite imageries of project area including reservoir area were analysed on different scales with a view to delineate lineaments traversing the area and study the geomorphology and geology.

6.3.1 Surface Investigations

Geological Mapping

Detailed geological mapping of the project area on 1:1000 scale was carried out covering the entire project area including dam site and sites of other appurtenants. The reservoir area was mapped on 1:10,000 scale. Efforts were made to collect geotechnical parameters from all the accessible outcrops and delineate the bedrock overburden contact. The geological maps of the project and reservoir area are presented in 1: 2000 and 1: 25,000 scales, respectively in Volume-IIIB of DPR.

Remote sensing Studies

Remote sensing studies on regional scale were got conducted through State Remote Sensing Application Centre; Itanagar using IRS1D (LISS III + PAN) merged data. These studies have formed a database for understanding the geological and structural setup of the basin. Besides this general appreciation of the geomorphological features, landuse pattern and drainage system of the basin were made through satellite data studied by SRSAC, Itanagar. For detailed geological evaluation of proposed project site and reservoir area, National Remote Sensing Agency (NRSA), Hyderabad was engaged. High resolution IKONOS data was used for study of dam area on 1:5000 scale and for entire project area on

1:25000 scale, using PAN +LISS-III data. Detail report on the studies carried out by NRSA is appended in **Volume-IIIE.**

6.3.2 Sub-Surface Investigations

Geophysical Investigation

Geophysical investigation comprising seismic refraction profiling and resistivity imaging at the project area was carried out in two phases. The seismic refraction survey indicated that the P-wave velocity for compact strata comprising overburden or highly weathered rock varies from 2650 to 3370 m/s. The detail report is appended in **Volume-IIIE.** The details of seismic refraction profile are summarized in **Table 6-2**.

Table 6-2: Location Details of Geophysical Exploration Lines

Seismic Profile	Resistivity Imaging Profile	Length (m)	Location	Remarks
P1	-	35	Left bank- Dam Axis A5	For Concrete Dam at Axis A5
P2	-	90	Right bank- Dam Axis A5	-Do-
P3	-	110	River shoal near DT inlet	-Do-
P4	-	60	Nallah bed- near DT inlet	-Do-
P5	-	110	River bank – near DT inlet	-Do-
P6	-	65	Along river edge on right bank at Dam site	-Do-
P7	-	65	Along river edge on left bank at Dam site	-Do-
SP1	RI 1	130	HRT intake	Alternative Axis A 11
SP2	RI 2	120	HRT intake	-Do-
SP3	-	110	HRT intake	-Do-
SP4	RI 3	110	DT inlet	-Do-
SP5	-	130	Right bank of the river	-Do-
SP6	-	110	Right bank of the river	

Exploratory Drilling

Drilling explorations carried out at the sites of various appurtenants in different phases include 63 drill holes. Details of the drill holes are given in **Table 6-3 & Table 6-4.** Out of these 2 drill holes namely NDH-12 & 14 are in progress.

Table 6-3: Details of Exploratory Drilling by Brahmaputra Board and NHPC

S.No.	Drill Hole No.	Location/Feature	Co-ordinates	Collar Elevation (m)	Depth (m)	Depth of Overburden
					Elevation (m)	Elevation(m)
1	*BH-1	Left bank river edge. DT outlet (Brahmaputra Board Axis).	N 16443.41 E 36199.28	281.95	56.60 (El. 225.40)	19.55 (El. 262.45)
2	DDH-A5/1	Left bank, river edge, Inclined - 50º (A-5 axis).	N 16633.49 E 35965.57	294.65	75.00 (El. 237.20)	43.50 (El. 261.33)
3	DDH-A5/2	Left bank, river edge. (A-5 axis).	N 16639.58 E 35976.22	303.79	90.00 (El. 213.79)	11.90 (El. 291.89)
4	DDH–A5/3	Left bank. Spillway tunnel outlet (A-5 axis).	N 1664.02 E 35991.21	323.70	85.50 (El. 238.20)	4.50 (El. 319.20)
5	DDH–1	Right bank river edge, Inclined - 60^0 Dam toe (A-6 axis).	N 16587.36 E 35891.67	285.37	70.20 (El. 224.57)	21.50 (El. 266.48)
6	DDH-3	Right bank on hill slope. Dam toe (A-6 axis).	N 16544.49 E 35881.82	316.20	40.00 (El. 276.20)	29.00 (El. 287.20)
7	DDH-4	Left bank. Dam toe (A-6 axis).	N 16662.24 E 35931.30	305.71	70.20 (El. 235.51)	22.50 (El. 283.21)
8	DDH-5	Left bank hill. Diversion Tunnel & Spillway Tunnel	N 16835.37 E 36017.27	465.60	73.00 (El. 392.46)	22.25 (El. 443.21)
9	DDH-6	Right bank. (A-6 axis)	N 16488.93 E 35847.83	375.55	80.10 (El. 295.50)	4.50 (El. 371.10)
10	DDH-7	Right bank. (A-6 axis)	N 16433.94 E 35812.64	434.21	60.00 (El. 374.21)	14.00 (El. 420.21)
11	DDH-8	Right bank. R/B spillway w.r.t A-5/A-6 axis.	N 16245.29 E 36029.25	425.44	70.20 (El. 355.24)	5.00 (El. 420.44)
12	DDH-9	Right bank. R/B spillway w.r.t A-5/A-6 axis.	N 16199.06 E 36179.50	336.10	50.00 (El. 286.10)	18.00 (El. 318.10)
13	DDH-10	Midstream. D/T outlet area	N 16399.14 E 36198.78	274.91 (riverbed level)	51.30 (El. 223.61)	16.50 (El. 258.41)
14	DDH-11	Midstream. Dam toe & D/S cofferdam.	N 16615.94 E 35902.30	274.20 (riverbed level)	62.50 (El. 211.70)	5.00 (El. 269.20)
15	DDH-12	Right bank terrace. R/B spillway w.r.t A-5/A-6 axis.	N 16168.28 E 36267.81	310.12	70.30 (El. 239.82)	27.00 (El. 283.12)
16	DDH-13	Left bank. D/s of TRT Outlet	N 16068.41 E 36486.26	285.44	50.00 (El. 235.44)	13.50 (El. 271.94)
17	DDH-19	Left bank. Grout Hole	N 16733.80 E 35788.79	299.28	80.00 (El. 219.28)	12.70 (El. 286.58)
18	DDH-20	Left bank. Grout Hole	N 16743.33 E 35780.79	299.50	80.00 (El. 219.50)	6.00 (El. 293.50)
19	DDH-21	Left bank. Grout Hole	N 16745.04 E 35790.68	301.43	80.00 (El. 221.44)	15.00 (El. 286.44)
20	DDH-22	Left bank. Central grout test hole	N 16729.10 E 35792.33	298.94	80.00 (El. 218.94)	10.500 (El. 288.44)
21	DDH-24	Left bank, Near surge shaft.	N 16728.54 E 36316.85	476.70	60.20 (El. 416.50)	5.00 (El. 471.70)
22	DDH-28	Right bank. 150 m d/s of A-11 Axis.	N 16599.22 E 35784.54	307.40	76.00 (El. 231.40)	48.00 (El. 259.40)

S.No.	Drill Hole No.	Location/Feature	Co-ordinates	Collar Elevation (m)	Depth (m)	Depth of Overburden
					Elevation (m)	Elevation(m)
23	DDH-29	Left bank river edge. (A-6 axis)	N 16647.68 E 35928.16	291.35	39.00 (El. 252.35)	16.50 (El. 274.85)
24	DDH-30	Right bank, inclined - 70^0. D/S cofferdam (A-5 axis)	N 16530.72 E 35908.75	313.85	64.00 (El. 253.71)	1.50 (El. 312.44)
25	DDH-31	Midstream drill hole towards left bank river edge. D/S cofferdam (A-5 axis).	N 16614.96 E 35962.21	275.77 Riverbed level	61.50 (El. 214.27)	11.00 (El. 264.77)
26	DDH-32	Right bank, river edge. Inclined – 55°.	N 16414.37 E 36105.13	295.49	92.60 (El. 219.60)	23.00 (El. 276.60)
27	DDH-33	Left bank river edge. Inclined hole -55°. DT outlet area	N 16486.86 E 36191.39	295.27	110.00 (El. 205.16)	32.40 (El. 268.73)
28	DDH-34	Right bank hill. R/B spillway w.r.t A-5/A-6 axis.	N 16347.12 E 35932.74	424.71	58.00 (El. 366.71)	18.30 (El. 406.41)
29	PDH-1	Left bank river edge. TRT Outlet area	N 16184.79 E 36406.18	287.42	61.45 (El. 225.97)	4.00 (El. 283.42)
30	PDH-2	Left bank river edge. TRT Outlet area	N 16118.23 E 36472.17	289.93	66.00 (El. 223.93)	13.40 (El. 276.53)
31	DDH-35	Left bank, river edge. A-11 axis	N 16748.35 E 35699.28	284.28	47.00 (El. 237.28)	10.00 (El. 274.28)
32	DDH-36	Right bank, river edge. A-11 axis	N 16695.51 E 35669.77	283.13	68.50 (El. 214.83)	14.5 (El. 268.63)
33	DDH-37	Right bank hill. A-11 axis	N 16656.07 E 35630.26	323.88	50.20 (El. 273.68)	20.00 (El. 303.88)
34	DDH-38	Right bank hill. A-11 axis	N 16577.01 E 35597.64	377.90	37.70 (El340.20)	18.00 (El. 359.90)
35	DDH-39	Mid stream. A-11 axis	N 16731.89 E 35687.13	277.15 Riverbed elevation	59.25 (El. 218.21)	18.10 (El. 259.36)
36	DDH-40	Mid stream, 130m d/s of A-11 axis.	N 16669.96 E 35809.20	278.75 Riverbed elevation	38.00 (El. 240.75)	14.50 (El. 264.25)
37	DDH-41	Right bank. 130m d/s of A-11 axis.	N 16619.93 E 35779.68	295.04	80.00 (El. 215.15)	33.00 (El. 262.15)
38	DDH-42	Left bank hill. Surge shaft area.	N 16624.67 E 36416.47	490.56	59.00 (EL431.56)	10.80 (El. 479.76)
39	DDH-43	Left bank hill. Surge shaft area.	N 16553.07 E 36590.74	560.26	100.00 (El. 460.26)	15..00 (El. 545.26)
40	DDH-44	Left bank of Puku Nallah. HRT Intake area.	-	459.97	35.50 (El. 424.47)	23.00 (El. 436.97)
41	DDH-45	Left bank of Puku Nallah. HRT Intake area	-	464.50	43.15 (El. 421.35)	14.50 (El. 449.50)
42	DDH-46	Left bank of Puku Nallah. Spillway tunnel intake area	N 17338.225 E 35727.063	448.12	24.00 (El. 424.12)	3.00 (El. 445.12)
43	DDH-47	Left bank of Puku Nallah. Spillway tunnel area	N 17291.975 E 35653.998	475.30	36.00 (El. 439.30)	10.50 (El. 464.80)

***** *This hole was drilled by Brahmaputra Board and details of another drill hole drilled by Brahmaputra Board could not be located.*

Table 6-4: Details of Drill Holes by KHEPCL

S.No	Drill Hole No.	Location/ Feature/ Co-ordinates	Inclination of hole (º)	Ground/ Collar Elevation (m)	Depth (m) Elevation (m)	Depth of Overburden (m) Elevation (m)
1	NDH-1	Dam Axis-Right Abutment (16452.060N : 35736.340E)	Vertical	413.957	70.5 El. 343.45	12.00 El. 401.957
2	NDH-2	Dam Axis-Right Bank near river edge (16573.830N : 35901.050E)	Vertical	287.978	150.00 El. 137.97	1.50 El. 286.478
3	NDH-3	Dam Axis- Right Bank, river edge (16581.123N : 35908.59E)	Inclined by 50° towards N 015°	284.051	63.00 El. 221.05	20.50 Inclined El. 268.347
4	NDH-4	Dam Axis – left bank river edge (16637.810N : 35968.720E)	Vertical	296.982	150.00 El. 146.98	19.5 El. 277.48
5	NDH-5	Dam Axis-Left abutment (16759.67N : 36080.64E)	Vertical	435.769	36.5 El. 399.269	6.00 El. 429.77
6	NDH-6	Bucket/Powerhouse Area-Left Bank, River edge (16513.027N : 36119.989E)	Inclined by 60° towards N 215°	283.215	40.50 El. 242.71	24.0 Inclined El. 262.43
7	NDH-7	Plunge Pool-Mid Stream (16302.936N : 36303.46E)	Vertical	282.415	35 El 247.415	12 El 268.65
8	NDH-8	Dam Toe auxiliary Powerhouse-Right Bank (16452.908 N: 36018.041 E)	Vertical	320.416	50.00 El 270.416	15.50 El 304.916
9	NDH-9	Dam Toe-Left Bank (16555.970 N: 36122.730 E)	Vertical	296.698	50.00 El. 246.7	15.00 El. 281.7
10	NDH-10	Diversion tunnel intake (16907.981 N: 35585.912 E)	Vertical	316.12	50.00 El 266.12	4.5 El 311.62
11	NDH-11	Dam Toe - Right Bank (16444.019 N: 35921.990 E)	Vertical	321.253	36m El 285.253	9m El 312.253
12	NDH-11S	Dam Toe - Right Bank N 16429.977 E 35933.218	Vertical	319.253	90m El 249.253	12m El 307.25
13	NDH-12	Dam Toe auxiliary powerhouse - Right Bank (16422.821 N: 36022.836 E)	Vertical	335.102	27	in progress
14	NDH-13	Dam Axis, riverbed (16621.052 N: 35926.315 E)	Vertical	283.672	150	9m El 270.32
15	NDH-14	Pothead Yard (in progress) (16330.530 N: 36677.390 E)	Vertical	±490	10m into bedrock	In progress
16	P-1	Groutability Test Hole near dam axis – Left Bank (16666.811 N: 35907.45 E)	Vertical	296.662	114m into bedrock	Completed; logging in progress
17	P-2	Groutability Test Hole near dam axis – Left Bank (16661.155 N: 35907.391 E)	Vertical	295.139	120m into bedrock	Completed; logging in progress
18	P-3	Groutability Test Hole near dam axis – Left Bank (16663.611 N: 35912.650 E)	Vertical	296.79	120m into bedrock	Completed; logging in progress
19	P-4	Groutability Test Hole near dam axis – Left Bank (16664.672 N: 35908.768 E)	Vertical	296.249	120m into bedrock	Completed; logging in progress

Detailed logs of the drill holes are appended in **Volume III C.**

Exploratory Drifting

Different alternative dam axes and underground powerhouse site were explored through 12 exploratory drifts. The details of the exploratory drifts are given below in **Table 6-5**.

Table 6-5: Details of Exploratory Drifts

S.No.	Drift	Location	Invert Elevation (m)	Length/Alignment	
				Main Drift (m)	Cross Cuts (m)
1.	LDR-1	Left Bank above road level, A-6 dam axis	350	68.6 (N 020°)	D/S: 40 (N 090°)
2.	LDR-2	Left bank on hill slope, A-6 dam axis	395	60 (N 034°)	U/S – 4 (N 290°) D/S - 8 (N 112°)
3.	LDR-6#	Left Bank below road level, Dam axis	319.85	33 (N 015°)	U/S – 13.4 (N 285°) D/S – 13.6 (N 105°)
4.	LDR-3	Left bank powerhouse drift	306	260 RD 0 to 112m (N 055°) & RD 112m to 260m (N 090°)	-
5.	LDR-3 Extn. #	Left bank powerhouse drift extension	-	RD 112m to 200.5m (N 050°)	-
6.	RDR-1	Right bank, A-6 dam axis	322	60 (N 206°)	U/S – 6 (N 288°) D/S - 6 (N 107°)
7.	RDR-2	Right bank, A-6 dam axis	400	60 (N 220°)	U/S – 30 (N 310°) D/S – 30 (N 138°)
8.	RDR-3	Right bank A-6 dam axis	431	60 (N 210°)	-
9.	LDR-4	Left Bank at A-11 dam axis (above Road Level)	390	60 (N 025°)	-
10.	LDR-5	Left bank at A-11 dam axis (Below road level)	310	40 (N 035°)	-
11.	RDR-4	Right bank at A-11 dam axis	345	31 (N 205°)	-
12.	RDR-5	Right bank at A-11 dam axis	415	40 (N 215°)	-
13.	RDR-6	Right bank at A-11 dam axis	300	81 (N 195°)	-

 # Exploratory Drift LDR-6 & LDR-3 Extension has been excavated during present phase of investigationsby KHEPCL

Detailed geological logs of drifts are appended in **Volume-IIIC.**

Rock Mechanic Testing

In-situ and Laboratory rock mechanic tests were conducted in exploratory drifts and on core samples of drill holes to determine physio-mechanical properties of rock mass and intact

rock. Rock mechanic testing was carried out by National Institute of Rock Mechanics (NIRM), Bangalore. Laboratory tests were conducted by North Eastern Hydraulic and Allied Research Institute (NEHARI), Guwahati. The results of these tests are summarized in **Table 6-6, Table 6-7** and **Table 6-8.** The test reports are annexed in **Volume-IIIE.**

Table 6-6: Laboratory Test Results of Rock Mechanic - Average Values

		NEHARI	NIRM	
Identification & Water-related Properties				
Bulk Density, Dry (kg/m³)		2545	2670	
Bulk Density, Saturated (kg/m³)		2550	2677	
Grain Density (kg/m³)		2640	2690	
Water Content at Saturation (%)		0.20%	0.27%	
Porosity percentage		0.52%	0.73%	
Triaxial Strength Parameters				
Cohesion, “c” (MPa)		3.79 (saturated)	24.86 (saturated)	
		-	19.38 (dry)	
Angle of Shearing Resistance,		54.25°(saturated)	42.02° (saturated)	
“Ø” (Degrees)		-	49.21° (dry)	
Uniaxial Compressive Strength (MPa)				
Saturated Condition		75.46	90	
Dry Condition		--	96	
Deformability Characteristics				
Modulus of Deformation (GPa)		-	05.19	
Modulus of Elasticity, (GPa)		-	10.56	
Slake Durability Index		-	99.33	
Poisson’s Ratio		0.29(sat)	0.18(dry)	
			0.20(sat)	
Shear Test			Peak	Res.
Rock/Rock	C (kg/cm^2)		6.5	5.9
	Ø (degree)		40.12	37.9
Concrete/Rock	C (kg/cm^2)		3.8	3.2
	Ø (degree)		48.39°	46.37°

Table 6-7: Plate Load Test Results in Drifts near A-11 axis

S.No	Location	Elevation (m)	RD (m)	Ed (GPa)	Ee (GPa)	Ee/Ed
1.	LDR-4	390	46-49	4.378	9.350	2.568
2.	LDR-5	310	10-13	6.759	15.248	2.518
3.	RDR-6	300	30-33	4.446	7.099	1.572

Table 6-8: Shear Test Results in Drifts near A-11 axis

Type of test	Peak shear parameters	Residual Shear parameters
Concrete to Rock LDR-4	$\tau = 1.126\sigma$ n+3.8067	$\tau = 1.0489\sigma$ n+3.24
	C= 3.8 kg/cm^2	C= 3.2 kg/cm^2
	ϕ= 48.39°	ϕ= 46.37°
Rock to Rock LDR-5	$\tau = 0.8429\sigma$ n+6.5094	$\tau = 0.7775\sigma$ n+5.9947
	C= 6.5 kg/cm^2	C= 5.9 kg/cm^2
	ϕ= 40.12°	ϕ= 37.9°

In addition to rock mechanic studies, petrography studies of rock samples were carried out by Geological Survey of India. For this purpose the rock samples were collected from the drill cores, drifts, shoal deposits and rock exposures in an around project area. The reports are appended in **Volume-IIID** and **Volume-VIII.**

Due to reconfigured project layout, besides the above testing, additional field tests and laboratory tests of rock samples were conducted by KHEPCL through AECS, Noida. The results of different tests are tabulated below.

Table 6-9: Summary of Laboratory Test Results of Rock mechanic properties of rock cores from drill holes

S.No.	Drill hole No	Rock type	Average Uniaxial Compressive Strength (MPa)		Point Load Index (MN/m^2)		Tensile Strength (Mpa) (Brazilian Test)	Modulus of Elasticity, Es (GPa)		Poisson's Ratio, ν		Dry/ Wet Condition		Shear Velocity (M/s)	Dynamic Modulus Ed (GPa)
			Dry	Wet	Dry	Wet		Dry	Wet	Dry	Wet	C MPa	ϕ°		Dry
Dam Area															
1	NDH-1	Biotite Gneiss	41.82	38.38		3.25	7.30	18.97	10.96	0.14	0.30	4.0 / -	59	2213	29.38
2	NDH-1	Biotite Gneiss	33.24	32.68											
3	NDH-2	Biotite Gneiss	62.24	50.00	6.07		8.63 - 9.90	13.07	19.44	0.20	0.16	- /3.0	/54	1859	21.89
4	NDH-3	Biotite Gneiss	35.21	28.94	8.63	4.93	6.23 – 9.65	13.24	28.23	0.14	0.29			2315	32.13
5	NDH-3	Biotite Gneiss	73.47	75.47			15.08	14.99	27.31	0.11	0.28			2172	30.78
6	NDH-4	Biotite Gneiss	55.74	54.54	8.92	8.75	2.84 – 7.23	25.56	22.87	0.22	0.28	- /9.00	/48	2118	29.22
7	NDH-4	Biotite Gneiss	89.55	53.63				16.75	15.90	0.20	0.22			1650	18.11
8	NDH-5	Biotite Gneiss					7.71								
Bucket Area															
9	NDH-6	Biotite Gneiss					5.55	15.23	27.05	0.10	0.20			1889	20.97
10	NDH-9	Biotite Gneiss	117.12	94.62	11.05		5.46	24.14	22.79	0.07	0.12			2202	27.18
Powerhouse Area															
11	DDH-42	Biotite Gneiss	78.91	62.59	8.65			16.93	30.49	0.18	0.11			2142	28.16
12	DDH-43	Biotite Gneiss	48.51	30.66	4.67	3.14	5.51-6.03	7.02	20.43	0.27	0.32	5.0 / -	57	1096	7.87
13	DDH-43	Biotite Gneiss	74.30	56.98											
Diversion Tunnel															
14	NDH-10	Biotite Gneiss	22.77	11.92	4.50	4.20	4.20	8.41	24.77	-	0.23			1760	20.28
Power Intake															
15	DDH-5	Biotite Gneiss	53.99	46.78	8.54	5.64	6.28-6.65	18.01	20.08	0.19	0.32			2371	35.46

Table 6-10: Results of Bulk Density, Specific Gravity, Water Content, Porosity, Void Index & Slake Durability Index of Rock Sample

S.No	Bore Hole No.	Depth (m)	Bulk Density (g/cc)		Specific Gravity	Water Content at Saturation (72 hours) (%)	Void Index (%)	Porosity (%)	Slake Durability Index (%)
			Dry	Saturated					
Dam Area									
1	NDH-1	52.10	2.63	2.64	2.83	0.89	0.65	1.30	99.50
2	NDH-2	41.75	2.64	2.65	-	-	-	-	-
3	NDH-3	24.00	2.63	2.64	2.75	0.27	0.20	0.36	99.25
4	NDH-4	61.00	2.67	2.68	2.74	0.37	0.25	0.48	99.75
5	NDH-5	34.00	2.67	2.68	2.78	0.19	0.16	0.87	-
Bucket Area									
6	NDH-6	38.70	2.66	2.67	2.77	0.32	0.23	0.65	98.90
7	NDH-9	18.60	2.62	2.63	-	-	-	-	-
Powerhouse Area									
8	DDH-42	20.30	2.60	2.61	-	-	-	-	-
9	DDH-43	66.30	2.58	2.60	2.70	0.63	0.45	1.43	98.75
Diversion Tunnel									
10	NDH-10-DT	49.25	2.66	2.67	2.70	0.44	0.36	0.82	99.00
Power Intake									
11	DDH-5	36.00	2.65	2.67	2.74	0.95	0.78	1.80	98.50

Plate load test and Plate Jacking tests are conducted by AECS, Noida during 2012 in the dam site drifts. The test results of PLT and PJT carried out in drift RDR1 and LDR 6 are given in **Table 6-11** and **Table 6-12**. Although deformation modulus of rock mass have been worked out through PLT and PJT but as PJT is done in an area of undisturbed zone of rock mass and is more reliable so the result of PJT for deformation modulus of rock mass may be considered in further design work.

Table 6-11: Plate Load Test Results in Dam Site Drifts

S.No	Location	Elevation (m)	Ed (GPa)	Ee (GPa)	Ee/Ed
1.	LDR-6	319.85	3.37	4.52	1.34
2.	RDR-1	322	3.72	5.17	1.39

Table 6-12: Plate Jacking Test Results in Dam Site Drifts

S.No.	Depth below loaded rock surface(cm)	Ed, GPa
1	50 - 100	7.65
2	100 - 200	8.00
3	200 - 300	8.00
4	300 - 600	8.25

The above test had been performed in drifts RDR-1 and LDR-6 located at elevations El 322m and 319.85m respectively on right and left abutments of the dam body. The above values of Ed are considered representative and may be used in design by suitably moderating the values based on geological conditions, stress levels and their orientation.

The results of in-situ shear parameter tests conducted by AECS during 2012 have been given in the **Table 6-13**.

Table 6-13: Shear parameters obtained from Dam site Drifts

Type of test	Peak shear parameters	Residual Shear parameters
Concrete to Rock - RDR-1	τ = 1.90 to 8.30 MPa	τ = 1.90 to 8.30 MPa
	C= 0.67 MPa	C= 0.40 MPa
	ϕ= 52°	ϕ= 47°
Rock to Rock - RDR-1	τ = 2.17 to 8.90 Mpa	τ = 2.17to 8.90 Mpa
	C= 0.81 MPa	C= 0.56 MPa
	ϕ= 54°	ϕ= 50°

Water Pressure Tests/Permeability Tests

The water pressure tests were conducted in all the drill holes using double packer in ascending order at 3m interval for rock and by constant head method in overburden. All the data pertaining to respective drill holes are appended in geological logs in **Volume IIIC**. Permeability of slope wash material varies from $1x10^{-3}$cm/sec to 100 x 10^{-3} cm/sec and that of river borne material varies from 127 x 10^{-3} to 195 x 10^{-3} cm/sec. Permeability of closely jointed, fractured/ sheared rock mass is of the order of 8-10 lugeon and for moderately jointed rock permeability varies between 2 and 6 lugeon and permeability of shallow depth fractured and sheared rock mass, in contact with slumped rock is 15-25 lugeon.

Groutability Test

Groutability tests were carried out on left bank, about 80m downstream of A-11 alternative axis. The primary drill holes viz. DDH-19, DDH-20 and DDH-21 were drilled on apex of a 6m equilateral triangle and the test hole DDH-22 was at centre of triangle. Each hole is 80 m deep. The overburden depth in these holes ranges between 6 to 15m. The bedrock consists of slightly weathered to fresh biotite gneiss. Details logs of grout holes are given in **Volume IIIC**. On the basis of results of test sections, where permeability and groutabilty tests have been conducted simultaneously, following broad conclusions can be drawn:

1. Overall, the trend of groutability follows that of permeability
2. Rock mass is fairly accepting grout. The maximum grout intake is about 225kg in 3m test section (61-64 m of DDH-21)
3. Results of post grouting permeability in test hole are available only at limited sections (18-21 m and 56-80 m). In these sections the permeability in test hole is, by and large, has reduced.

Another groutability test has been planned at the finally proposed Dam axis. Four drillholes for this purpose (P1, P2, P3 & P4) have already been drilled on the left bank of river Kamala at triangular grid, 6m apart for three holes and one at centre of the grid and preserved for testing. Each drillhole is 120m deep except the centre one, which is about 114m. The detail result of groutability test will be appraised after completion.

6.4 Geotechnical Appraisal of Project Components

During long period of investigations, different alternative dam axes with different layouts and different types of dams were conceived and pursued at various times for

Kamala Hydroelectric Project. All these alternative axes are located in a stretch of 0.75km extending between 3.5km and 4.25km upstream of Tamen Bridge in Lower Subansiri district of Arunachal Pradesh. Principally the following three dam site locations were studied.

1. Brahmaputra Board axis
2. A-5/A-6 axis
3. A-11 axis

6.4.1 Dam Site

The dam site selected by Brahmaputra Board was not adopted by NHPC because of adverse geological environment around the site. Surface geology indicates presence of abundance mica schist bands, which are soft and prone to weathering and presence of shear zones in the rock mass on left bank with depth of overburden at river edge in the tune of 19m (BH-1). The sub-surface drilling data indicates considerable depth of overburden on the right bank, which is in the order of 27 to 30m as indicated from drill hole DDH-12. So this axis has not been taken up.

Subsequently, another alternative dam axis A5/A6 located about 450m upstream of Brahmaputra Board axis, where the valley profile is relatively narrow and a few outcrops are seen on right bank was studied by NHPC. A concrete gravity dam was planned during the feasibility studies. The valley at this site is symmetrical with abutments rising above the riverbed with a uniform slope of 40º on either bank. Here, the valley slopes on left bank are almost barren. The right abutment at the site is covered by thick overburden that supports dense vegetation. The site was explored through 18 drill holes and five exploratory drifts. The exploratory drifts indicated deep slumping on the right abutment above El 375m. NHPC concluded that the site selected during the feasibility stage (near Axis A-5/6) was not suitable for a concrete dam - as per NHPC's assessment as the site would require extensive stripping of abutments for founding a concrete gravity dam. Changing the dam type to rockfill was contemplated but it was concluded that the topography around this axis was not conducive for a fill type dam.

Investigations were started on another axis located about 250m upstream of the A-6 axis; this axis was designated as A-11. The dam site area was investigated through six seismic refraction profiles and 3 resistivity imaging profiles. Further the dam site was explored by 7 drill holes and six drifts on the abutments at various locations and elevations. Surface geology indicates that left abutment at the site rises moderately above riverbed along a

uniform slope and is occupied by slope wash deposits up to the road level at El 325m followed by exposed competent biotite gneiss with hornblende gneiss bands up to El 480m. The riverbed at this site is about 60m wide occupied by riverine deposits and the right bank has moderate slope covered by slope wash deposits with isolated rock outcrops. Close examination of these isolated outcrops indicated that there could be slumping on this abutment. Same was confirmed by exploratory drifts subsequently.

Geophysical profiling indicated depth of bedrock on right abutment is around 30m. The drilling data indicates depth of overburden at riverbed is about 19m and that to on the left and right abutments are 10m and 14m respectively. However the rock condition is not good up to considerable depth. The bedrock in the riverbed at A-11 was found to be highly fractured and sheared. Geological section along the dam axis Alternative A11 based on the results of exploratory drifting indicates that the slumping on the right abutment extends to 24m at lower elevations and more than 30m at middle elevations. The limit of slumping could not be demarcated in the middle drift RDR-4 as excavation in the same had to be discontinued due to construction constraints. However, no slumping has been observed in the upper most drift RDR-5. This indicated that slumping on this abutment is restricted below El 415m. Due to existence of slumping on the right abutment and presence of shear zone in the riverbed, it was not considered suitable for founding a concrete gravity dam as the shear zone in the riverbed and slumping/shearing on the right abutment would have required huge excavation and foundation treatment. Hence this site was not considered suitable for concrete dam. NHPC therefore thought of diversion structure as CFRD at this site.

However, keeping in view the narrow width of the valley with moderate abutment slopes, occurrence of bedrock at shallow depth in the riverbed and confinement of slumped rock mass to higher elevations, presence of competent rock mass in the riverbed and on the abutments, it was decided to pursue the site with Alternative Axes A5/A6 further for concrete dam as diversion structure.

Remote sensing studies indicated that this dam site area is surrounded by less dissected denudational hills with comparatively widely spaced lineaments and low drainage density. The dam site and sites of other appurtenants expose comparatively hard, massive and competent biotite gneiss.

Geological map of the project site indicates that the river width at various stretches in the area varies between 60m and 100m occupied by riverine deposits. The right bank valley slopes are covered by overburden comprising angular blocks and pieces of gneisses

embedded in silty and clayey matrix. One stream joining the main river from this bank has strikingly straight course indicating the influence of structure on the drainage. Isolated rock exposures have been observed on the right bank slope at the middle reaches and also near road as well as at the river edge. The left abutment slopes expose bedrock extensively and is mostly exposed along road section at around El 340m. In addition rock exposures are observed both above and below road level throughout the area upto left bank of Puku Kro. The bedrock exposed on both the abutments at the site includes biotite/ granite gneiss with intercalation of hornblende gneiss and biotite schist. The bedrock in the downstream part, around the site proposed for underground powerhouse, is profusely intruded by tourmaline bearing pegmatite and silica veins whereas the intensity of such intrusions reduces towards upstream exposures. The gneisses exposed in the area are slightly weathered on the surface, foliated and jointed. These are also traversed by shear zones varying in thickness. The discontinuity data collected during the course of detailed geological mapping from rock outcrops has been analyzed with the help of “DIPS” software and the details have been given in stetreoplots in **Figure 6-3 & Figure 6-4** and in **Table 6-14, Table 6-15, Table 6-16 & Table 6-17**.

Table 6-14: Range of Discontinuity Data - Left Bank

Joint Sets	Strike		Dip direction		Dip amount	
	Range	Average	Range	Average	Range	Average
J1*	157° - 195°	175°	247° – 285°	265°	51° - 73°	62°
J2	103° - 141°	124°	013° - 051°	034°	23° - 47°	38°
J3	171° - 231°	198°	081° - 141°	108°	20° - 51°	39°
J4	100° - 132°	116°	190° - 222°	206°	50° - 75°	64°

**J1 is oriented along foliation*

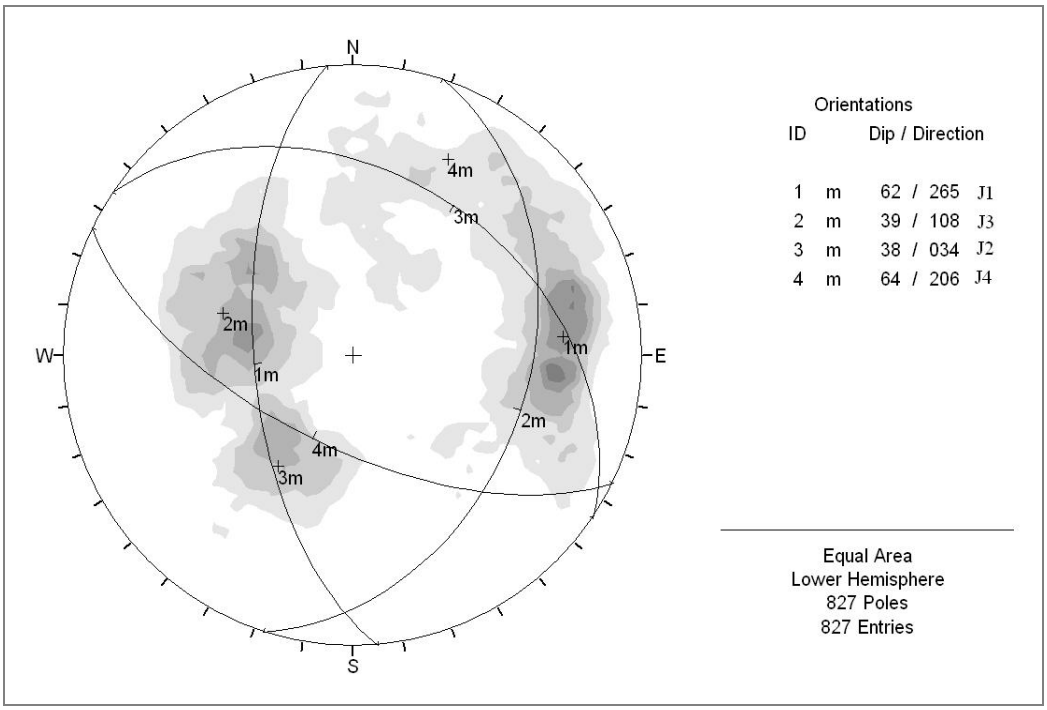

Figure 6-3: Stereographic Projection of Discontinuity Planes - Left Bank

Table 6-15: Details of Discontinuities - Left Bank

Set	Strike	Dip Amount	Dip Direction	Continuity (m)	Spacing (cm)	Aperture (mm)	Rough-ness	Alteration	Filling
J1*	157° - 195°	62°	265°	>10	2 to widely spaced	Tight to 2	RU	Slight on surface	Nil to sandy clay
J2	103° - 141°	38°	034°	2 to 20	2 to 50	Tight	RP & SP	Nil	Nil
J3	171° - 231°	39°	108°	1 to 4	20 to 50	Tight to 5	SP	Surface staining	NIL to Sandy clay
J4	100° - 132°	64°	206°	1 to 5	5 to widely spaced	Tight	RP & RU	Nil	Nil

J1* *oriented along foliation* ***RU*** *Rough Undulatory,* ***RP*** *Rough Planar,* ***SP*** *Smooth Planar,*

Table 6-16: Range of Discontinuity Data - Right Bank

Joint Sets	Strike		Dip direction		Dip amount	
	Range	Average	Range	Average	Range	Average
J1*	098° - 144°	121°	188° – 234°	211°	47° - 81°	63°
J2	065° - 100°	086°	335° - 010°	356°	47° - 80°	65°
J3	127° - 186°	156°	037° - 096°	066°	31° - 81°	58°
J4	085° - 133°	110°	175° - 223°	200°	16° - 42°	31°

**J1 is oriented along foliation*

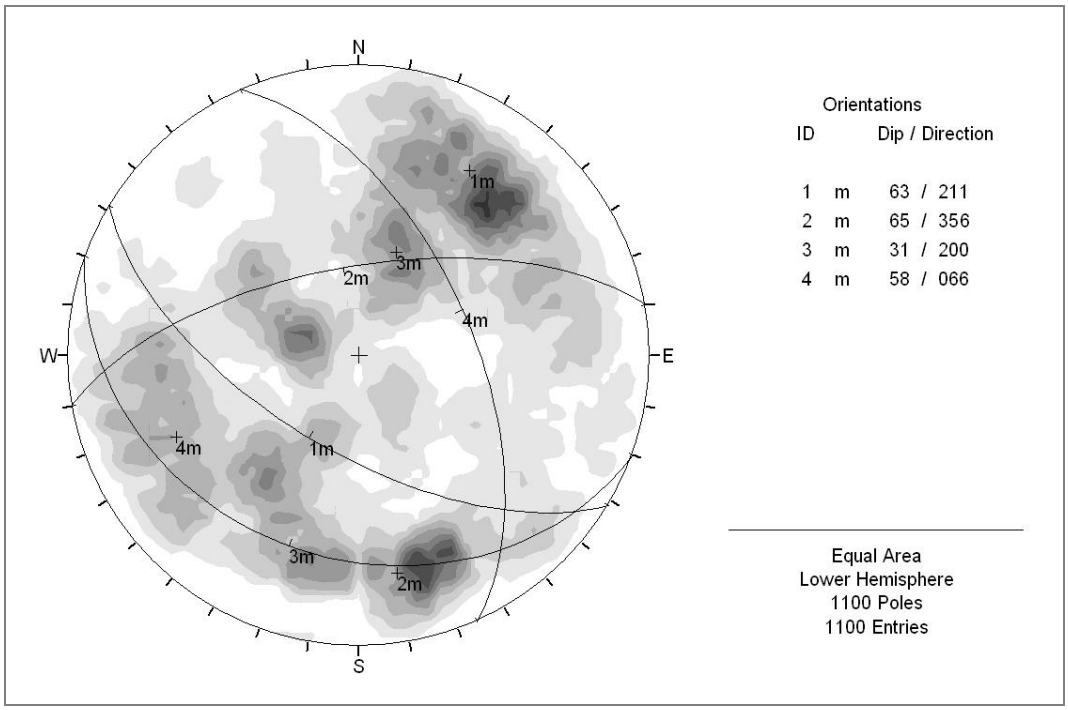

Figure 6-4: Stereographic Projection of Discontinuity Planes - Right Bank

Table 6-17: Details of Discontinuities - Right Bank

Set	Strike	Dip Amount	Dip Direction	Continuity (m)	Spacing (cm)	Aperture (mm)	Rough-ness	Alteration	Filling
J1*	098° - 144°	63°	211°	>10	2 to widely spaced	Tight to 2mm	RU	Slight on surface	Nil
J2	065° - 100°	65°	356°	2 to 20	2 to 50	Tight	RP & SP	Surface staining	Nil
J3	127° - 186°	58°	066°	1 to 4	20 to widely spaced	Tight to 5mm	RP	Surface staining	NIL to Sandy clay
J4	085° - 133°	31°	200°	1 to 5	5 to widely spaced	Tight	RP & RU	Nil	Nil

J1* *Foliation joints;* ***RU*** *Rough Undulatory,* ***RP*** *Rough Planar,* ***SP*** *Smooth Planar*

From the discontinuity data plotted in Figure 6-4 and Figure 6-5 and shown in Table 6-14, Table 6-15, Table 6-16 and Table 6-17, it is observed that the rock mass around dam site is traversed by four major discontinuities including those oriented along the foliation. The attitude of foliation, in general, strikes across the flow direction with dips towards upstream. However, variation in the attitude of foliation has been observed on both banks of the river and same may be attributed to local warping/folding. One of the major joint sets such as J3 in case of left abutment and J2 in case of right abutment dips at moderate angles towards valley and need proper attention during excavation of the abutments.

Geophysical profiling around the dam site indicates presence of 6.5m thick overburden on left bank slope above road, 9m depth on the right bank river edge and near DT inlet portals, however on river shoal the depth of overburden is of the order of 24m.

Further the dam complex area including spillway, plunge pool is probed by 27 drill holes located at riverbed, on the abutments and at the appurtenant structures to delineate the depth of overburden and to assess the sub-surface rock condition for founding each component structure. The detail geological logs of drill holes have been given in **Volume IIIC**. Geological sections developed along the dam axis A-5/A-6 based on the results of drilling explorations carried out at A-5/A-6 alternative dam site indicate that the left bank is, in general, covered by slope wash deposits. Thickness of overburden near river edge on the left bank varies between 11m and 24m i.e. bedrock is available at the river edge on left bank between El 261.83m and El 319.0m. The drilling explorations indicate that the thickness of the overburden on the left abutment varies between 4.50m and 22.50m. The drill holes drilled in the riverbed encountered bedrock between 5.0m and 11.0m depths i.e. between El 264.77m and El 274.20m. The drill holes drilled on the right bank of the river indicated that thickness of the overburden covering the bedrock near the river edge varies between 9.0m and 11.0m and that on the abutment at higher elevations varies between 11.5 and 21.8m. From the results of drilling explorations it may be concluded that bedrock is available at shallow depth in the riverbed and overburden covering the bedrock on the abutments is moderately thick at places. The bedrock likely to be encountered in the foundation is strong, foliated and jointed biotite gneiss and its variants, in general, except for 1.5 to 3 metres at top where it is slightly to moderately weathered at places. It is also indicated by drilling that the rock mass likely to be encountered in the foundation is traversed by thin shear/ fracture zones and schist bands that show moderate weathering. Water percolation tests carried out in drill holes indicate that, permeability ranges from nil to 7 lugeon in intermittent moderately jointed biotite gneiss rock. In fractured gneiss, permeability is in the range of 10-20 lugeon and in fractured schistose rock it is as high as 22-25.66 lugeon and sometimes as high as 30 lugeon.

Consequently drifting to the abutment of dam has also been carried out to delineate the stripping limit on both abutments. Altogether 7 drifts have been done on both abutments. The detail of drift logs have been given in **Volume IIID**. Exploratory drifting carried out on the left abutment indicates that foliated and jointed biotite gneiss with intercalations of thin mica schist traversed by thin shears below overburden (slopewash) shall be encountered in the foundation. It is also observed from the drifts that in order to found the selected dam on

sound foundation, abutment stripping between 15m and 19m will be required on the left bank.

Exploratory drifts RDR-2 excavated at El 400m on right abutment indicated the presence of slumped rock mass extending up to 35m (**Volume IIID**) whereas extension of same recorded up to 24m in the drift RDR-3 excavated at El 431m. However, no slumping was observed in the drift RDR-1 excavated at El 322m. This indicates that slumping in this area is confined to higher elevations above El 322m. This data along with a few indirect surface evidences was utilized to interpret the tentative boundaries of the slumped mass present on right abutment around alternative dam axes A-5/A-6. Since no slumping was observed in the exploratory drift RDR-1 excavated at El 322m, it is interpreted that the lower limit of the slumped mass is located around El 370m and upper limit of the slumped mass is located around El 450m below the existing road as no evidences of slumping were observed in the bedrock outcrops above road..

The bedrock encountered in the drifts beyond the limit of the slumping is strong, fresh, foliated and jointed biotite gneiss which is traversed by thin shears generally oriented along the foliation. Keeping the limit of slumping and condition of the rock mass, the stripping limit on the abutment above El 330m has been estimated to be varying between 34m at lower elevations around RDR-2 and 22m at higher elevations around RDR-3 and above for founding the structure on acceptable foundation.

Final Selection of Dam and Layout

The results of all the investigations were analyzed in detail and a thorough assessment was made by undertaking detailed surface mapping. It reveals the following:

i) In the riverbed, the overburden depth at axis A5/A6 is 5-10m whereas at axis A-11, it is about 18m. The intensity and extent of shear zones/ seams in the riverbed is more at A-11 and tends to improve further downstream. The bedrock is also more fractured at A-11 as compared to A5/A6.

ii) On the right bank, the toe of the slumped rock mass extends below the riverbed level at axis A-11 whereas it is restricted above El 330m at axis A5/A6. Below the slumped rock mass, bedrock comprising biotite gneiss is available which is traversed by shear seams at both the axis. The quality of rock mass on right bank at axis A5/A6, in general, appears to be better as compared to rock mass at axis A-11.

iii) The left bank is characterized by prominent foliations and significant schistosity. The intensity of shear seams on the left bank increases slightly from A-11 axis to A5/A6 axis.

iv) As per geotechnical investigation results, the modulus of deformation of rock (tested in drifts at A-11 axis) is nearly 4.4 GPa. Though these values are relatively low and do not reflect the observations during the surface mapping, but these are considered to be good enough for founding a +200m high concrete gravity dam.

v) The rock quality observed in the exploratory drifts appears better than that depicted by drill cores. It is felt that the predominantly low core recovery could be attributed to the quality of drilling carried rather than to the actual quality of the rock.

In general, the geological features indicate that though the condition of the rock mass on the left bank has improved slightly from A5/A6 to A-11 axis, but the condition of rock mass in the riverbed and on the right bank has deteriorated at A-11. Geological, topographical and technical considerations favour the option of locating a concrete gravity dam near Axis A-5 and A-6.

Thus, dam axis located in between Axes A-5 and A-6 and oriented slightly askew to both the axes was finalized for further studies. This identified Dam Axis is aligned in N41ºE- S41ºW direction. On assessment of prevailing topographical and geological conditions, it is confirmed that the stretch between Poku kro and Puru kro is generally favourable for laying out the project scheme.

It is noteworthy to mention here that the short-listed alternatives are developed to a detail where their important components could be sized and their cost could be assessed with a reasonable degree of confidence. One of the main conclusions brought out from this study is that a concrete gravity dam should be used as the diversion structure in this project. Use of a CFRD necessitates that the entire spillway arrangement, the temporary diversions works as well as the water conductor system be located on/inside the banks. Since, only one bank (the left bank) offers acceptable geological conditions, all these systems are to be located on this bank ending up with a complex, undesirable web of underground openings.

Considering the merits and demerits of all the alternatives, the option of **concrete gravity dam** is a better choice for diversion structure.

After considering several alternative locations, due to non availability of suitable space for locating the powerhouse on the surface, same has been proposed to be located

underground in the left abutment about 500m downstream of the dam and near to the powerhouse envisaged by NHPC during the earlier phase of DPR formulation. The final location of the underground powerhouse and other related caverns was slightly readjusted in view of accommodating all the ancillary structures safely keeping in view the geological environment and topography.

As regards powerhouse location it is to be noted that alternative studies carried out for powerhouse located close to the body of the dam and an underground powerhouse located on left bank. After developing these alternative schemes, it has been observed that both alternatives are comparable, but the concentration of all construction activities in a single area for the dam body alternative adversely affects the schedule and introduces additional schedule risks. On the contrary, the other alternative involving underground powerhouse, would entail significant underground works. It would involve some construction risks but these are not likely to affect the construction schedule because underground option offers taking up of all activities independently with sufficient float for construction of the powerhouse and other underground components (dam being on the critical path and deciding the project completion).

Based on the overall assessment, a conventional, straight axis concrete gravity dam located between Alternative Axes A5/A6 with underground powerhouse located about 500m downstream of dam axis in the vicinity of dam toe in the left abutment was preferred.

Geotechnical Evaluation of Finally Selected Dam Site

The detail geotechnical evolution of finally selected dam site near A5/A6 for construction of concrete gravity dam has been discussed here. Geological map of the site indicates that the river at the site flows towards SE through a fairly wide V-shaped symmetrical valley with both the abutments rising at an angle of about 40^0. Riverbed at the site is covered by riverine deposits comprising boulders, cobbles, pebbles and sand. Keeping in view the topography, river morphology, hydraulic requirements downstream of the dam and to accommodate the spillway arrangement properly, dam axis has been located in between earlier proposed dam axes A5 and A6 and oriented in N41ºE- S41ºW direction. It is also observed that general elevation of the riverbed at the site is at around 274m.

The left abutment at the site is generally covered by slope wash deposits and foliated and jointed biotite gneiss intercalated with occasional mica schist bands are exposed at road level. The abutment slopes above that are barren and covered by slope wash deposits.

The bedrock, by large appears to be competent. The rock mass is occasionally traversed by thin shears oriented along the major joint sets.

The riverbed at the site is covered by fluvial deposits comprising boulders, pebbles and cobbles of gneiss and quartzite with sand. Boulders measuring up to 3m in size have been observed.

The right abutment is, in general, covered by slope wash deposits that support dense vegetation. Isolated exposures of biotite gneiss surrounded by overburden are observed occasionally on this abutment. Rock mass is traversed by four sets of joints including foliation. Few random joints are also observed at places. The rock mass is occasionally traversed by thin shears oriented along the major joint sets.

Geological section along the proposed dam axis and along Kamala river on the basis of results of surface and sub-surface geological investigations indicates presence of bedrock in riverbed at Els varying between 264.77m and 274.20m with corresponding depth of 5m and 11m respectively. The left bank is covered by slopewash deposits. Thickness of overburden at river edge on the left bank varies between 11m and 24m corresponding to El 261.83m and El 319.0m. However, the thickness of overburden on the left abutment varies between 4.50m and 22.50m. The drill holes drilled on the right bank of the river indicated thickness of overburden near river edge varies between 9.0m and 11.0m and that on the abutment at higher elevations varies between 11.5 and 21.8m. The results of drilling explorations thus indicate that bedrock is available at shallow depth in the riverbed and at moderate depth in abutments. The bedrock likely to be encountered in the foundation is strong, foliated and jointed biotite gneiss and its variants except for top 1.5 to 3 metres where it is slightly to moderately weathered. Drilling results also indicate that rock mass in the foundation is traversed by thin shear/fracture zones and weathered schist bands. Based on the rock mass condition stripping up to 18-20m shall be required in the riverbed to reach the foundation grade bedrock at its deepest foundation level of El 259m. Water percolation tests results indicate that permeability of the bedrock at the site ranges between nil to 2.71 lugeon except in case of NDH-8 drilled on the right bank in plunge pool area where permeability ranging between 7.44 lugeon and 25.66 lugeon has been recorded. The drill holes drilled by NHPC during earlier phase of investigation indicated permeability range of 2 to 24 lugeon, in general, except at limited places it goes up to 30 lugeon. Exploration drifting results on dam abutments indicates that stripping on the left abutment is required between 5m and 19m and that for right abutment it would be between 22m and 34m to tie the concrete gravity dam on sound foundation.

Results of surface and subsurface explorations, laboratory and in-situ rock mechanics test indicate that the site appears suitable for locating concrete gravity dam with FRL at El 455m and dam top at El 475m with a view to moderate floods. The height of the dam above riverbed works out to **200m** and the same from deepest foundation level would be **216m.** The length of the dam at top El 475m works out to 628m by considering the stripping on the abutments and base width along the river flow would be 218m**.**

Foundation Treatment

The surface and subsurface studies indicate that the area exposes biotite gneiss intercalated with thin mica schist bands that are sheared and weathered. The rock mass is traversed by four sets of prominent joints in addition to some random joints. Of these, joints belonging to two sets dip towards valley on each abutment. In addition, bedrock comprising biotite gneiss is traversed by thin shear/ fracture zone varying in thickness from a few milimetres to about 50cm and these are oriented generally along foliation or joints belonging to other sets.

All the loose, weathered rock mass, all the overhangs and slumped rock mass will be removed to expose the sound in-situ rock mass in the foundation, fracture / shear zones shall be treated during preparation of foundation. The results of the permeability tests indicate that permeability of the foundation varies at different locations, especially in the riverbed and on the left abutment. It is required that the same has to be brought down to acceptable levels. It may be achieved through curtain grouting to be extended to suitable depth both in the riverbed and on the abutments. It is also felt that, since the rock mass is jointed; consolidation grouting may be carried out in the foundation to make it monolith. There is valley ward dipping joints on both the abutment along which slight opening has been manifested in the drifts. In order to avoid slope failure along vulnerable wedges and planes the same will be stabilized through rock bolting and shotcreting during the excavation wherever needed.

6.4.2 Spillway Arrangement

A sluice type of spillway arrangement located within the dam body with crest at El 370m along with auxiliary spillway with crest elevation at El 446m has been envisaged as surplus arrangement. Riverbed width at the site is about 80m, with symmetrical disposition of both abutments rising at about 40° angle and are covered by slope wash deposits. Isolated outcrops of biotite gneiss can be observed on the left bank above road. Bedrock is foliated and traversed by four sets of joints. Drill hole data indicates availability of bedrocks at

Els 261.83m, 305.50m and 281.70m in river section and right bank respectively. Bedrock comprises foliated and jointed biotite gneiss, porphyritic gneiss, garnetiferous biotite gneiss and porphyroblastic garnetiferous gneiss with intercalations of mica schist and emplaced silica veins. In order to accommodate about 120m wide structure in the riverbed, the abutments need to be excavated and keeping the hydraulic requirements, quantum of excavation will be more on the right abutment. The rock mass on both abutments is foliated and traversed by four prominent sets of joints besides some randomly oriented ones. It is apprehended that intersection of adversely oriented joints may result in formation of unstable wedges in the resultant slope cuts leading to occasional failures along unstable planes during excavation. This aspect shall be taken care of by designing the slope cuts appropriately and stabilizing them by providing shotcrete and rock bolts wherever required.

A preformed plunge pool, located about 450m downstream of dam axis has been proposed as a part of energy dissipation arrangement. At the site proposed for the plunge pool, left bank exposes bedrock comprising foliated and jointed biotite gneiss from the river edge and traversed by four prominent sets of joints in addition to some randomly oriented ones. Right bank at the site is covered by moderately thick slope wash deposits up to considerable height above the riverbed. Perusal of dill hole data indicates availability of bedrock on right abutment and in riverbed at El 332.10m and at El 270.415m respectively. As the rock mass is jointed, intersection of river ward dipping joints could result in the formation of unstable planes and wedges that could slide during the excavation. This aspect will be taken care of by designing the resulting slope cuts accordingly and stabilizing them with the provision of shotcrete and rock bolts.

6.4.3 Cofferdams

About 64m high cofferdam with top at El. 340m is proposed upstream of dam to facilitate river diversion. The coffer dam will be a rock fill structure with central impervious core. The drilling data indicates depth of overburden along the upstream coffer dam axis varies from 10m on left bank to 20m on right bank with 24m in the river centre. Moreover the rock condition has been interpreted as poor and fractured, jointed in nature. Geological section along the axis of the upstream coffer dam on the basis of surface and subsurface explorations carried out indicates presence of slumping, sheared and fractured rock mass on right abutment. In order to arrest the seepage through foundation and keep the area completely dry during construction period, the cut off in the foundation will have to be extended to 14m and 11m depths on the right and left banks respectively and 24.5m depth in the riverbed.

The downstream cofferdam is proposed to be of 26m high rock fill structure with central impervious core. Drill hole data indicates availability of bedrock at riverbed at 16.5m depth. Bedrock is slightly weathered to fresh, closely jointed and fractured biotite gneiss. The geological section indicates that cut off in riverbed will have to be taken to about 17m depth below the riverbed to make the structure water tight.

6.4.4 Diversion Tunnels

In order to divert river water during project construction, three 13.5m finished diameter circular shaped diversion tunnels have been proposed on left bank. The invert level of inlet structure is at El 278m, where as the outlet level is El 272m. Earlier it was attempted to propose the diversion tunnels on the right bank of Kamla River. However, keeping in view the presence of a large nala fan at inlet portals, thick overburden and slumping on the right bank resulting involvement of huge excavation and slope stabilization, it was decided to locate the diversion on the left bank. Geological sections along riverside and hill side diversion tunnels indicate that vertical rock cover varying between 48m and 248m is available above the diversion tunnels along with sufficient lateral cover. The foliated and jointed bedrock comprising biotite/ granite gneiss with intercalation of hornblende gneiss and biotite schist is extensively exposed along the alignments of proposed structures. It is expected to develop unstable wedge on the roof of tunnels due to intersection of joint sets and accordingly provision of suitable supports is recommended. During excavation valley facing joint sets require proper attention as regards failure along those planes. Preliminary assessment based on results of surface and sub-surface explorations it is anticipated that rock mass belonging to Classes II, III, IV and V may be encountered as 31.53%, 41.90%, 14.15% and 13.42% respectively along the lengths of the diversion tunnels.

6.4.5 Reservoir

A 216m high concrete gravity dam with Full Reservoir Level (FRL) at El 455m and MDDL at El 470m with a view to have a water cushion of 15m for flood moderation will result in formation of a large reservoir having submergence of about 2775 Ha (at FRL). The reservoir extends for 65km into the valley of Kamla River, for 17km into the valley of Kurung River, a major right bank tributary of Kamla. The proposed reservoir is located in a remote area and is very sparsely populated with small hamlets.

Geomorphologically, the reservoir area is characterized by high ridges with moderate to steep slopes and deep valleys dissected by many perennial and seasonal streams.

Lineaments of varying extent & nature have been identified mainly on the basis of remote sensing studies and these are classified as NE-SW lineaments, NW-SE lineament & North – South lineament. River Kamla, main tributary of river Subansiri and is the main drainage system in the area. Kamala is joined by many perennial tributaries from both the banks. The area around the proposed reservoir in the Kamala valley exhibits a dendritic drainage pattern. However, secondary nallahs joining Trunk River exhibit parallel to sub–parallel drainage indicating influence of structure in the development of drainage. The hill slopes in the area are moderate with some stretches of steep slopes and rock cliffs in and around Herin nallah. The topography is relatively gentle, wherever gneisses and schist are present. However, slopes are steep in the areas where quartzites are exposed. Intense and prolonged precipitation in the area has resulted in luxurious vegetation growth on hill slopes.

A large part of the reservoir rim exposes hard and competent gneissic rock. The interbedded sequence of phyllite, quartzite, slate & carbonates belonging to Chilliepam Formation of Bomdila Group extends beyond Luba up to the tail of reservoir and is well exposed in the river valley between the Luba village on downstream and beyond Gingba village on upstream. The slopes along the rim are steep and covered under dense forest. Some amount of erosion may take place initially from the degraded slopes. In general, reservoir rim and the slopes within the reservoir area appear to be stable except for small portion in downstream and upstream reaches where small slides above the reservoir rim have been observed.

Slumping on the right bank of the river just upstream of proposed dam axis (at alternative dam axis A11) has been observed. Since minimum drawdown level (MDDL) for the project has been proposed at around El 430m, this slumped mass will be completely submerged below MDDL. Since this slump zone is not affected by the reservoir fluctuations and therefore will not impact the reservoir rim stability at all, no treatment for this slump zone is considered necessary.

Some small landslides on the right bank of Telsi kro, Pate Kro and Pai nallah has been observed but as they are located below MDDL level will not be affected owing to reservoir impounding. Besides those, 20-30m active landslides zones have been observed on right & left banks of Pai Nallah near Bedak Bridge. These slides with crown located at about 500m elevation are overburden slides. It appears that left bank slide appears to have stabilised and dormant whereas the right bank slide appears to be active. Overburden comprising slope wash deposits in these zones is resting on moderately to steep slopes. These have potential of sliding during reservoir filling. Preliminarily, the treatment measures suggested to

stabilise slide include grading of slopes, soil nailing, provision of geo-synthetics and afforestation on the slopes once these stabilise to some extent. On the right bank of Palam Kro nallah a potential slide has developed in bedrock comprising quartzite. The crown of the slide is located at about El 525m and toe at the nallah bed at around El 375m. This slide may be affected during reservoir filling. Treatment measures envisaged for this slide include grading of slopes, provision of rock bolts/ anchors and covering the surface by shotcrete.

From the above it is concluded that no large landslides or potential unstable zones except for a few small slides around reservoir rim and along the road cuts have been observed in the area. It is also been observed that most of the small slides, except a few are confined below the MDDL of the reservoir and will get submerged completely. It therefore appears that no major reservoir rim stability problems are expected in case of this reservoir. Since the reservoir is surrounded by high hills on all sides, possibility of reservoir water escaping from the reservoir are nil. The limited field traverses, remote sensing studies and perusal of available literature indicate that no minerals of economic importance or structures of archeological importance are likely to be submerged due to reservoir impoundment.

6.4.6 Water Conductor System

The proposed water conductor system includes an intake structure consisting of four power intakes with invert at El 406m located on left bank of the river Kamla between 50m and 160m upstream of dam axis, four 10m diameter circular headrace tunnels with, 8 numbers 5.7m diameter circular steel lined pressure shafts and four 10m diameter circular tailrace tunnels.

Power Intake

Power Intake structure is proposed on the left bank, upstream and close to the proposed dam axis at around El 406m± to convey 308.5 cumecs of design discharge to each headrace tunnel. The slope on left bank is moderate and biotite gneiss rock intercalated with biotite schist bands is exposed above and below the road level. Due to paucity of rock exposures around intake portals the area was investigated by seismic profiling (P-1) and also by a drill hole DDH-5. Results of all the sub-surface data and surface geology indicate that that bed rock comprising foliated and jointed biotite gneiss would be available at about 25m depth corresponding to El 404.6m±. Besides, removal of overburden is also required in the tune of 40m laterally. This would require stabilisation of resultant cut slopes in overburden as well as in rockmass by providing soils nails / rockbolts with shotcrete depending on the materials.

Headrace Tunnel (HRT)

Four 10m finished diameter headrace tunnels have been envisaged on the left bank of Kamla River with a view to convey 308.5 cumecs of design discharge by each tunnel to powerhouse. The tunnel inverts are proposed to place at El 403m with a general gradient of 1 in 39.5 in HRT-1 and 1 in 62.5 in case of HRT-4. The geological map of HRT area indicates that hill slopes on the left bank of the Kamla river are extensively covered by overburden with occasional small patches of in-situ rock comprising biotite gneiss with intercalation of biotite schist. The bedrock is foliated, jointed and slightly weathered on the surface.

Based on the orientation of the tunnels in different reaches, these have been divided into three sectors: Sector 1 oriented in 221^0-041^0 direction, Sector 2 oriented in 278^0-98^0 direction and Sector 3 oriented in 343^0-163^0 direction. Geotechnical discussion has been given below.

- In sector 1, the ground cover over HRT will vary between 45m and 123m, which is considered adequate except the initial 25m part of HRT 1. The ground cover at the beginning will be less and require sufficient measure with respect to excavation and supporting the tunnel. The tunnel is expected to encounter rock mass comprising foliated and jointed biotite gneiss, however the last 36m stretch for HRT-1 will encounter fractured and sheared rock mass along with mica schist band between RDs 93 and 116m and in case of HRT-4 a small shear of about 10m stretch will encounter between RDs 165 – 175m. The relations between discontinuities and alignments of the tunnels indicates that HRT alignment is favourable with respect to joint sets J1, J2 and J4 but not very favourably disposed with respect to joint J3. As a whole the tunnel alignment for sector 1 would be in fair to good tunneling situation.
- In sector 2, the ground cover over HRT will vary between 73 and 289m and is considered adequate. The expected rock mass in tunnel would be biotite gneiss with thin mica schist bands. Rock mass between RDs 137 and 255m for HRT-1 and RDs 224– 395m for HRT-4 is interpreted as weak strata due to shearing and fracturing of rockmass and presence of thin mica schists. This adversely affected stretch could vary between 165m and 350m in length for all the tunnels. The relation between discontinuities and alignment of the tunnel indicates that the HRT alignment is favorable with respect to joint sets J1 and J3 but unfavourable with respect to joint sets J2 and J4. Overall, it may be commented that the alignment of the tunnels are oriented fair with respect to joints.

- In sector 3, ground cover over the tunnel would be in the tune of 190m and is considered adequate. Rock mass of biotite gneiss is supposed to be encountered in this stretch.
- In all the sectors, the orientation of tunnel is askew with respect to the discontinuities and is considered as fair situation of tunneling. However, intersection of joints will result in the formation of wedges on the crown and side walls which require adequate support for stabilization of tunnels and design accordingly.

Based on surface and sub-surface geology, a tentative assessment of rock class along the tunnels have been attempted which shows 26.97% class II rock, 46.32% class III, 17.69% class IV and 9.02% class V rock. Hence, considering the rock mass classes support design and construction methodology has to be planned.

Pressure Shafts

Each of the HRTs at their respective ends has been proposed to join with two underground pressure shafts of 5.7m diameter. There are altogether 8 steel lined pressure shafts of 270m length each. The area of pressure shaft is generally occupied by slope wash deposits with patchy occurrences of rock outcrop comprising biotite gneiss. Two nearby drill hole data on the slope indicated considerable extension of weathering in bedrock however it is found that pressure shafts are located below the weathered zone and will not be affected. Foliated and jointed biotite garnetiferous gneiss is expected to encounter in pressure shafts. No major problem is apprehended.

6.4.7 Powerhouse Complex

The proposed powerhouse complex is located on the left bank of the Kamla River about 500m downstream of proposed dam axis. It includes a 302m (L) x 23m (W) x 56.5m (H) size and 1728MW (8x216MW) installed capacity underground powerhouse and 297m (L)x 16.5m (W)x 25.5m (H) high transformer cavern. In addition four numbers of Tailrace Tunnels (TRT) for discharging the tailwater back into the river at El 278m± have also been envisaged.

The area surrounding the proposed powerhouse complex has rugged topography with high hills and deep and narrow transverse valleys. Powerhouse has been proposed inside the hill mass upstream of the confluence of Puru Kro nala with Kamla River. Geological map of the area indicates the left bank of the Kamla River has moderate slopes covered by overburden in general and isolated outcrops of bedrock at higher elevations. The bedrock is exposed extensively at lower elevations. Bedrock comprises fresh to slightly weathered, strong and

moderately to closely jointed biotite gneiss intercalated with thin schist bands. The discontinuity data collected during the course of detailed geological mapping of powerhouse complex area has been analyzed with the help of 'DIPS' software and are shown in **Figure 6-5** and tabulated in **Table 6-18 & Table 6-19**.

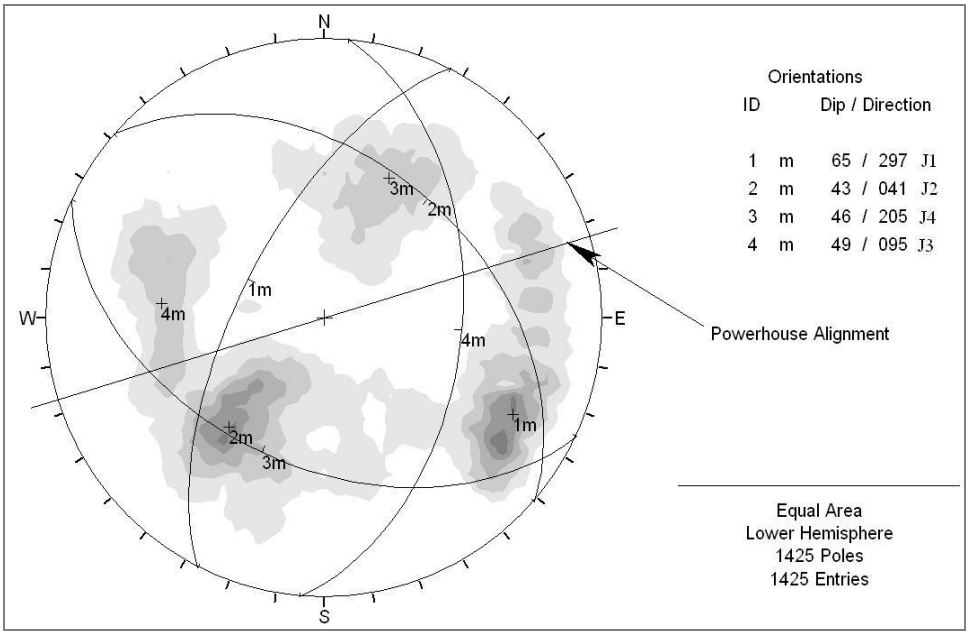

Figure 6-5: Stereographic plot of major planes around Powerhouse area

Table 6-18: Range of Discontinuity Data around powerhouse area

Set	Strike		Dip Direction		Dip Amount	
	Range	Average	Range	Average	Range	Average
J1*	182°-222°	207°	272° - 312°	297°	50°- 75°	65°
J2	112°-145°	131°	022° - 055°	041°	14°- 62°	43°
J3	152°-208°	185°	062° - 118	095°	40° - 62°	49°
J4	101°-128°	115°	191 - 218°	205°	30° - 56°	46°

Table 6-19: Details of Discontinuities around powerhouse area

Set	Strike	Dip Amount	Dip Direction	Continuity (m)	Spacing (cm)	Aperture (mm)	Rough-ness	Alteration	Filling
J1*	207°	65°	297°	>10	2 to widely spaced	Tight to 2	RU	Slight on surface	Nil to sandy clay
J2	131°	43°	041°	2 to 20	2 to 50	Tight	RP & SP	Nil	Nil
J3	185°	39°	095°	1 to 4	20 to 50	Tight to 5	SP	Surface staining	NIL to Sandy clay
J4	101°	46°	205°	1 to 5	5 to widely spaced	Tight	RP & RU	Nil	Nil

J1* *oriented along foliation* ***RU*** *Rough Undulatory,* ***RP*** *Rough Planar,* ***SP*** *Smooth Planar,*

Based on the discontinuity data, the long axis of the powerhouse has been aligned in N073^0-N 253^0 direction. So the long axis of the powerhouses and other caverns is askew with the strike of the joints oriented along the foliation and belonging to set J1 by 46^0 which can be considered a favorable orientation. With this orientation of powerhouse, the long axis remains askew by 58, 68 and 42 degrees with the strike of the other major joint sets J2, J3 and J4 and this can be considered fairly favorable situation. However, the orientation may be slightly optimized when more subsurface data from the ongoing drift and results of hydro-fracture to be conducted in the drift are available.

The area of powerhouse complex is investigated through two drill holes DDH-42 and DDH-43 and an exploratory drift (in progress). In-situ plate load test has also been carried out within the excavated drift to estimate modulus of deformation of the rock mass inside powerhouse. Drillhole data indicates depth of overburden as 10.8m but rock mass is deeply weathered and fractured/ sheared down to considerable depth (54m depth). However, powerhouse is located under superincumbent cover of 245m to 390m, i.e. far below the weathered zone. The exploratory drift (LDR-3) encounters granitic gneiss/ biotite gneiss in general. Schist band is also observed in between. Rock mass is traversed by four sets of discontinuities. The drift was in damp and dripping condition between RD 140m & 230m. Based on the intensity and nature of discontinuities, the RMR values calculated for the rock mass encountered in the drift has been estimated to vary from 43 to 69 indicating class III rock. However it is expected that at the powerhouse grade the rock mass would be better and is supposed to be encountered rocks of 45% Good and 55% Fair quality.

The plate load test conducted within drift indicates that the deformability modulus of biotite gneiss is higher than biotite schist and deformability modulii increases with increasing pressure, which indicates existence of fracture and joints at shallow depth. The trend of deformability modulii for both the rock is similar.

Keeping in view the large size of cavern and getting a preliminary idea about the support requirement, wedge analysis with the help of 'UNWEDGE' software has been carried out by taking unit weight of rock 2.70 ton/m^2, angle of internal friction as 38^0 and cohesion as 59 tons/m^2. The results of wedge analysis in case of powerhouse cavern indicate that the roof wedges (8) weighing 16.421 tons and having nil factor of safety, is unstable wedge. It is a falling wedge. Other wedges formed due to intersection of joints are stable and minimum factor of safety is 6.585 in case of upper left wedge [7]. Unstable roof wedges can be stabilised through properly designed supports comprising rock bolts and shotcrete with or without wire mesh.

Since other related caverns in the powerhouse complex like transformer Hall and downstream surge galley are aligned parallel to powerhouse cavern and are located in similar geological environs, their geotechnical assessments is similar to that of powerhouse cavern.

Main Access Tunnel (MAT)

Main Access Tunnel of size 8m x 8m to the powerhouse is proposed on the left bank of Kamla River with portal of the tunnel located above HFL at El 320m just upstream of the confluence of Puru Kro nallah and main Kamla River. The area exposes bedrocks comprising moderately strong biotite gneiss with intercalated thin bands of biotite schist. The slope on the left bank is initially moderately steep but progressively it becomes gentler uphill. The rock mass is traversed by four prominent sets of joints including those parallel to foliation.

From the surrounding geological environment, it is observed that the ground cover over the MAT would vary between 25m in the initial reaches near the portal and about 400m near to powerhouse. The initial part of the tunnel from portal is traversed by thin shear/ fracture zones in addition to joints. Based on the trend of the tunnel it is divided into three sectors. Sector-1 is aligned in 032^0 – 212^0 direction and is oriented sub-parallel to foliation joint. So, the initial part of the tunnel in sector 1, careful tunneling through controlled blasting and immediate provision of supports would be required. If required, fore poling may have to be resorted. In sector 2 tunnels are oriented in $N163^0$-$N343^0$ direction and is askew with all the joint sets by considerable angles and is considered fair situation of tunneling. In sector 3, the tunnel is aligned in $N073^0$-$N253^0$ direction and oriented favourably with respect to the discontinuities.

Based on surface and sub-surface geological data, a tentative assessment of rock quality to be encountered along MAT is attempted and it is apprehended that 30% of length will be encountered good quality rock, 50.96% will be of fair quality and 13.98% will be of poor quality and 5.06% will be very poor category rock.

Tailrace Tunnels

Four numbers 10.0 diameter tailrace tunnels (TRTs) with lengths varying between 415m and 555m are aligned on the left bank of the Kamla River with a view to discharge the tail water back into the river. Geological map shows that the slope on the left bank of Kamla River in the area of TRT is moderately steep and exposes bedrock comprising biotite gneiss above

road level. The rock mass is traversed by four prominent sets of joints in addition to some randomly oriented ones. It is also traversed by thin shear/fractures in certain reaches. The geological section along TRT indicates that ground cover over the tailrace tunnels varies between 25m near the outlet portal and about 400m near the collection gallery. The TRT alignment has been divided into two sectors based on its trend. TRT in Sector 1 is aligned in $N163^0$-$N343^0$ direction from collection gallery downstream and the orientation is fair with respect to all joint sets. However, TRT in sector 2 is aligned in $N208^0$ direction and is oriented nearly parallel to foliation but fairly askew with other joints. As the rock mass is jointed the intersection of joints result in formation of unstable wedges in crown and wall and adequate design measures have to be adopted concurrently with excavation.

Based on preliminary assessment it is apprehended that TRT will encounter 31.42 % of good rock, 44.93% of fair rock, 13.79% of poor rock and 9.86% very poor rock class category.

6.5 Seismicity and Seismotectonics

The project area lies in the seismic Zone V as per Seismic Zoning Map of India [IS1893: part-1(2002)]. The seismic Zone V is broadly associated with seismic intensity IX and above on MMI scale. The ground acceleration and, hence, seismic intensity of an earthquake at a place depends on the magnitude of earthquake, distance from the focus, duration of earthquake, type of underlying soil and its damping characteristics.

Keeping in view the high seismicity of the area, the site specific seismic studies for the project have been carried out by Department of Earthquake engineering, IIT Roorkee. A detail report is appended under **Volume-IX**. Based on parameters like regional geology, seismotectonic setup, characteristics of various seismogenic sources present in the region and seismic history of the area (IMD data), the following recommendations have been made.

The study was undertaken by considering M = 8.0 magnitude earthquake occurring along MCT (65km), Lohit Thrust (144km) and MIshmi Thrust (117km) and magnitude 7 event occurring along TI thrust (5km) that has been interpreted to be located about 5km downstream of dam site by Jain et al.. Based on the study, the Peak Ground Acceleration (PGA) values for Maximum Credible Earthquake (MCE) and Design Base Earthquake (DBE) conditions are estimated to 0.4g and 0.2g respectively, which has been recommended for designing. The detail study report prepared by IITR is appended in **Volume-IX**.

6.6 Geothermics

It is well known fact that a large number of thermal springs are located in Himalayas. Many of these emerge on the surface of boiling point temperatures. The proposed Kamala (Middle Subansiri) Hydroelectric Project is envisaged in area located between MCT and MBT in Arunachal Himalayas. As per Heat flow map of Himalaya and its adjoining regions of Ravi Shanker (1989), the area falls on the margin of Heat Flow Zone II and III in the eastern part of Arunachal Himalaya. The average temperature gradient in Zone II was measured to be of the order of 61±200C/km and heat flow values of the order of 130+30 mW/m^2.

It is observed that the thermal springs existing in the region are located at quite a distance from the site of the proposed project. In addition, none of the drill holes and drifts executed at the site encountered geothermic conditions. Since the underground structures proposed in the project are short and have shallow cover, therefore possibility of encountering hot water during underground excavations can be considered very remote or almost nil.

6.7 Conclusions

The proposed 1800MW installed capacity Kamala Hydroelectric Project is envisaged on the river Kamla, a major tributary of Subansiri about 4km upstream of Tamen village in Lower Subansiri District of Arunachal Pradesh. In the Kamla valley, the project area around Tamen located in Lesser Himalaya exposes the gneisses belonging to Daporijo/Ziro Gneiss of Bomdila Group. The rocks of Ziro Gneisses consist of mainly biotite gneiss, augen gneiss, garnetiferous sillimanite hornblende gneiss, mica schist, leucogranite and amphibolite. The gneisses are intruded by tourmaline granite, smoky quartz bearing pegmatite and silica veins at certain places.

The project was first conceptualized by Brahmaputra Board and accordingly study was being started in consultation with CWC and GSI. However, at very early stage of investigation the project was transferred to NHPC by Ministry of Power in the year 2000. Further, in the year 2010 the project was awarded to KHEPCL by Govt of Arunachal Pradesh. As the project was transferred to many agencies at different point of times, it was investigated by various agencies according to their conception and project layout. Thus, the entire project area was surveyed at various scales of 1:500, 1:1000, 1:2000 and 1:10000 and geologically mapped, which covers all alternative project components, reservoir and quarry areas. Geological mapping of the project area is followed by geophysical exploration involving 1300m length of seismic profiling and 360m length of resistivity profiling. Further, the project appurtenant

areas were probed by 63 numbers of drillhole aggregating to 4293.45m drilled length. At dam site area, 11 drifts at both abutments have been done with aggregating length of 744.60m and the powerhouse drift has so far been excavated 260m.

During this long span of investigations, different alternative dam axes with different layouts and different types of dams were conceived and pursued for Kamala Hydroelectric Project. All these alternative axes are located in a stretch of 0.75km extending between 3.5km and 4.25km upstream of Tamen Bridge in Lower Subansiri district of Arunachal Pradesh. Principally the three dam site locations were studied namely Brahmaputra Board axis, A-5/A-6 axis, A-11 axis. However, due to very adverse geological situation in conjunction with some limitations in structure accommodation and/or hydraulic aspects, Brahmaputra Board axis and A-11 axis were not adopted. Instead, the selected axis is nearby A-5/A-6 axis location but oriented in N41ºE- S41ºW direction. After selecting dam axis alternative dam structures were studied such as CFRD, Concrete Gravity Dam etc which have been discussed in civil chapter. Based on the overall assessment, a concrete gravity dam has been adopted with powerhouse located in an underground cavern on the left bank, nearly 500m downstream of the dam axis.

Based on the result of surface and sub-surface investigation, it is observed that bedrock of strong, foliated and jointed biotite gneiss and its variants would be available at shallow depth. Drilling data shows that bedrock at river channel will be available at depth ranging 11 to 24m, at left abutment 22.50m depth and about 11m depth on right abutment. Drifting results on dam abutments indicates that stripping on the left abutment is required between 5m and 19m and that for right abutment it would be between 22m and 34m. Compiling all data it could be inferred that deepest foundation for dam seating would be at El 259m considering riverbed rock stripping in the tune of 18 to 20m. While constructing dam structure, it is obvious that excavation will be taken up from higher elevation through overburden as well as bedrock. As bedrock is traversed by thin shears and jointed, hence proper care needs to be taken up for valley facing joints because these will be slip surfaces for the wedges formed by intersecting joints. Further treatment measures for dam foundation in the form of rock bolting, anchoring, shotcreting are to be adopted as per prevailing geological condition.

Seven lower levels sluices with radial gates (Crest El 370m) are envisaged as principal spillway arrangement to pass design flood. Besides, an auxiliary spillway with crest at El 446m has also been provided. Surface geology indicates moderate stable slopes of the

abutments covered by slopewash deposits with channel width of 80m. Subsurface data indicates availability of bedrock comprising biotite gneiss at El 261.83m in riverbed and the foundation could be placed at El 260m. However to accommodate the structure of 120m wide abutment cutting in bedrock will be involved. As rock mass is traversed by joints, during excavation of abutments due care is to be taken for valley facing joints, which could be the slip plane.

A preformed plunge pool about 460m downstream of dam axis is envisaged as a part of energy dissipation arrangement, which will be placed by stripping the rockmass in abutments. As major part of excavation on the abutments shall be carried out in bedrock and due to adverse orientation of dips of joints, the resultant slope cuts will be designed accordingly and stabilised through shotcreting and rock bolting wherever required.

As part of river diversion arrangement during construction, both upstream and downstream cofferdams along with three diversion tunnels on left bank have been envisaged. The upstream cofferdam is 64m high with top at El 340m and located about 250m upstream of dam. The area was probed by few Drillholes that indicate that on right bank bedrock is available at 14.5m (El. 260.63m) and 20m (El 303.88m) depths and on left abutment bedrock at 10m depth i.e. El 274.28m. This indicates that in order to make the area completely dry downstream of the cofferdam, the cut off will have to be extended to 14m and 11m depths on the right bank and left bank, respectively and 24.5m depth in the riverbed. Drifting on the right bank indicates presence of slumping, shearing and fractured rock mass. So, the impervious core will have to be extended on both the abutments to abut it against bedrock and to make the abutment water tight. About 26 m high, downstream cofferdam is proposed about 350m downstream of dam axis. The riverbed in this area is investigated through drilling and indicates 16.5m depth below riverbed (El 257.41m). Based on that, cut off in riverbed will have to be taken to about 17m depth below the riverbed to make the structure water tight.

Three diversion tunnels each of 13.5m finished diameter circular have been envisaged on the left abutment to divert monsoon flood during construction. Both inlet and outlet portals of diversion tunnels are located on bedrock of gneisses except DT-3 inlet portal where the area is occupied by slopewash depsoits. The ground cover along the tunnels varies between 40m and 248m, which is considered adequate. Drilling result indicates bedrock availability at 6.0m depth (El 430.36m) in the inlet portal of DT-3. All the three tunnels have been provided two bends thus dividing the tunnels into three parts or sectors. From surface and

sub-surface geology, it is seen that the tunnels will be excavated through bedrock of varieties of gneisses that are jointed and foliated. The orientation of discontinuities in all sectors with respect to tunnel will not be favourable. Few joints will be disposed unfavourably and hence unstable wedges could be formed on the crown and upper walls. Support system is to be developed keeping in view the wedges. Further, it is interpreted from site geology that first half of the sector 2, tunneling media is supposed to be intercepted by shears and closely fractured rock mass. Finally based on surface and subsurface geology the rockmass quality is interpreted to be encountered along DT would be 31.53% class II, 40.90% class III, 14.14% class IV and 13.42% class V rock including all the DTs. An adit to access the diversion tunnels has been provided near the inlet of the tunnels to facilitate the construction from both ends. The rock quality assessment along this adit shows 67.35% of the tunnel would encounter rock class III and the rest of about 32.65% would encounter class II type in this adit.

The 216m high concrete gravity dam (above deepest foundation) on river Kamala with Full Reservoir Level (FRL) at El 455m and Maximum water level (MWL) at El 470m. The entire reservoir area is very sparsely populated with small hamlets. Geomorphologically, the reservoir area is characterized by high ridges with moderate to steep slopes and deep valleys dissected by many perennial and seasonal streams. The area as such representing rugged topography is greatly influenced by the lithology of the area. Most of the slopes are under dense vegetation cover and so, probability of soil erosion and landslide is low. However, there are a few degraded slopes under jhoom cultivation and landslide affected areas, which could contribute debris material and silt to the river. A general assessment of reservoir area indicates that overburden supporting the dense vegetation in the area includes slope wash deposits, debris fans and cones. In general, rocks belonging to Tenga Formation. Chilliepam formation and Ziro/ Daporijo Gneisses are exposed in the reservoir area. The nature of contact between Ziro Group and Chilliepam Formation could not be established in field due to lack of direct evidences. Lineaments of varying extent & nature have been identified based on remote sensing studies done by SRSA, Itanagar and NRSA, Hyderabad. Out of several NW-SE lineaments, two are classified as faults. They are identified on the basis of the offset in the rock boundary and straight course of river Kamla. The rock of Ziro Group has undergone more than one phase of deformations. Entire reservoir area lies in competent rock and no adverse feature, which may lead to leakage of reservoir, has been observed in vicinity of dam, therefore, possibility of any leakage from the reservoir is not apprehended. As per studies carried so far and information

from the State Geology & Mining Department and Geological survey of India, no minerals of economic importance at present are likely to be submerged in the proposed reservoir area.

The proposed water conductor system includes an intake structure, four 10m diameter circular headrace tunnels 8 numbers 5.7m diameter circular steel lined pressure shafts and four 10m diameter circular tailrace tunnels. All are located on left bank of Kamala river. Power Intake structure is located nearly 50 to 160m upstream of the dam axis with invert at around El 406m. Due to paucity of rock exposures, the area of intake was investigated through seismic profiling, drilling and drifting. Compiling results from all, it can be interpreted that rock below intake structures at that particular location would be available at about 25m depth corresponding to El 404.6m. Besides, removal of overburden is also required in the tune of 40m laterally.

Four HRTs to convey 308.5 cumecs of design discharge by each tunnel with inverts at El 403m will be excavated through foliated, jointed gneissic rock traversed by shearing and thin mica schists. HRTs have been sub-divided into three sectors by providing two bend in their alignment depending on topography and hydraulic requirements. The ground cover over the tunnels in general varies between 45 and 179m except the beginning 25m part of HRT 1, wher it varies between 19 and 35m. As the rockmass encountering through tunneling is traversed by four different joint systems, the alignment of tunnels with respect to the discontinuities will not be always favourable. Hence, the possibility of forming small wedges in the crown and wall cannot be ruled out and due care to be taken during construction planning. A tentative assessment of rockmass quality along the tunnels has been made based on surface and sub-surface geological data, which indicates that 26.97% of tunnel will pass through class II, 46.32% through class III, 17.69% through class IV and 9.02% through class V.

Each of the HRTs at their respective ends has been proposed to join with two underground pressure shafts of 5.7m diameter thus resulting 8 pressure shafts of 270m length each. The area of structures is apparently under overburden cover and hence the area is investigated through drill holes, which indicates bedrock at 10.8m and 15m depths, respectively that correspond to Els 479.76m and 545.26m. Weathering effect in bedrock is found deep-seated down to about 51m. The pressure shaft is the combination of two horizontal and one vertical limbs and is located below those elevations and will not face any major problem. To facilitate construction of pressure shafts two adits have been envisaged on the left bank of Kamala river. One adit will be accessing the top of pressure shaft at higher elevation and the other will access the bottom of pressure shaft. Pressure shafts and

adits are supposed to pass through closely to moderately jointed garnetiferous biotite gneiss. A tentative assessment of rock mass quality along the adit has been attempted, which shows that 45.26% of the adit will pass through good rock, 50.62% through fair rock and 4.12% in poor rock class.

The proposed powerhouse complex including 302m (L) x 23m (W) x 56.5m (H) underground powerhouse cavern, 297m (L) x 16.5m (W) x 25.5m (H) transformer hall cavern and 212m (L) x15m (W) x 65 (H) collection gallery is located about 500m downstream of dam on the left bank of Kamala river. The area at lower elevation along river and road section exposes biotite gneiss intercalated with thin schist bands and the higher slopes are covered by slopewash deposits. The higher slope area was investigated through drilling that shows depth of overburden in the tune of 10.8m. One drift to access powerhouse area is in progress and so far been excavated towards old location by 260m. However, the drift alignment is reoriented towards new powerhouse location and drifting is in progress. So far drifting data indicates that rockmass is traversed by four joint sets and numerous thin shears along joint planes are present. It is expected that rock mass data will improve at powerhouse and transformer cavern location, which are still nearly 250m inside the hill. Presently based on discontinuity data the powerhouse and other cavern orientation have been kept in $N073^0$-$N253^0$ direction. As the cavern is of large size, wedge analysis has been carried out which indicates that the roof wedges weighing 16.421 tons and having nil factor of safety, is unstable falling wedge. Other wedges are more or less stable.

To facilitate construction of powerhouse two adits one accessing top and the other Main Access Tunnel have been proposed on the left bank. The portals are located above HFL at El 320m and on rock. The ground cover over the adit to top of powerhouse varies between 20m and 225m. At the beginning part of adit where vertical cover is less, heavy support may be required for 25m stretch. Further, as the rock mass is traversed by four sets of joints, formation of unstable wedges are expected at crown and walls due to intersection of joints, which are to be supported by providing proper design.

Further, the tentative rock mass assessment reveals that the adit will encounter class II rock for 50.10% of its length, class III rock for 35.96%, class IV rock for 8.93% and class V rock for 5.01% of its length.

MAT of size 8m x 8m is supposed to be excavated through biotite gneiss with thin biotite schist interactions. As the rock mass is traversed by four major joint sets, while excavation of MAT portal unstable wedges in slope cuts above portal is expected to roll down along valley

facing joints and is to be treated properly. The tunnel alignment with respect to the discontinuity is fair to favourable, however, wedges may be formed at crown and upper side walls due to intersection of joints and support system are to be evolved accordingly. The tentative assessment of rock quality along MAT reveals 30% of good quality rock, 50.96% fair quality and 13.98% of poor quality and 5.06% very poor category rock.

Four numbers 10m diameter tailrace tunnels (TRT.s) with lengths varying between 415m to 555m are aligned on the left bank of the Kamla River. The area around TRT portal is covered by slopewash deposits and hence investigated by drilling, which indicates presence of bedrock at varying depth range of 4m to 13.5m. So, the TRT portals are to be established in rock by removing the overburden. The ground cover over the tailrace tunnels varies between 25m near the outlet portal and about 400m near the collection gallery and the tunnels are likely to encounter biotite gneiss with intercalations of mica schist. As the rock mass is traversed by four major joint sets, it may result in formation of unstable wedges in crown and wall and adequate design measures have to be adopted concurrently with excavation. A tentative assessment of rock mass quality along TRT is assessed as 31.42% good, 44.93% fair, 13.79% poor and 9.86% very poor rock to be encountered.

Based on distribution of epicenters, fault plane solutions and geological/ tectonic setting, whole of northeastern region has been divided into five tectonic zones by Kayal (1997) and Tiwari (2000) and the project area is located in Zone- A, i.e. Himalayan Collision Zone. Further, analysing the data obtained from India Meteorological Department (IMD), it is evident that the area falls under high seismic zone. Keeping this in view, the area has been assigned to Zone-V as per Map of India showing Seismic Zones (IS-1893 (Part-I): 2002). Hence, the site specific study was undertaken by IIT, Roorkee by considering M = 8.0 magnitude earthquake occurring along MCT (65km), Lohit Thrust (144km) and MIshmi Thrust (117km) and magnitude 6 to 7.5 event occurring along Tamen thrust. Based on the study, the Peak Ground Acceleration (PGA) values for Maximum Credible Earthquake (MCE) and Design Base Earthquake (DBE) conditions are estimated to 0.4g and 0.2g, respectively, for horizontal and vertical ground motions that have been recommended for designing.

Geothermal study indicates that thermal springs existing in the region are located at quite a distance from the site of the proposed project. In addition, none of the drill holes and drifts encountered geothermic conditions. Since the underground structures proposed in the project are short and have shallow cover, therefore possibility of encountering hot water during underground excavations can be considered very remote or negligible.

CHAPTER 7
PROJECT HYDROLOGY

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7 PROJECT HYDROLOGY

7.1 Introduction

The state of Arunachal Pradesh is endowed with a vast hydropower potential. The power potential of major rivers and their tributaries are being judiciously developed by various state and private agencies. Brahmaputra river forms the principal river basin in the state and, along with its tributaries, offers significant irrigation and power benefits.

Kamala Hydroelectric Project envisages harnessing waters of river Kamla, a tributary of Subansiri river, and is located upstream of village Tamen in Lower Subansiri District of Arunachal Pradesh. The project is proposed to be developed with twin objectives of power generation and flood moderation.

Hydrological inputs play a vital role in planning, execution and operation of any hydropower development project. Hydrological studies are carried out at all stages of project development starting from the pre-feasibility stage and are continued even during the operation of the project. Hydrological assessment of a river valley project is carried out with a view to:

- Assess quantity of water available in the river for power generation and its variation with time.
- Estimate design flood and diversion flood required for hydraulic design of spillway and temporary diversion structure as well as for safety of the structure.
- Assess impact of sedimentation on the live storage with reference to the life of reservoir.

7.1.1 Adopted Conventions

The following conventions have been adopted for the hydrological calculations carried out in this study:

- The hydrological year runs from June to May (of the following calendar year);
- The monsoon season is defined from June to September;
- The non-monsoon season is defined from October to May (of the following calendar year) .

7.2 Basin Characteristics

7.2.1 River System and Basin Characteristics

River Kamla originates beyond the Great Himalayan Range (Central Himalaya) at an altitude of around 6488m and joins the Subansiri river as its right bank tributary at a distance of about 98km upstream of the outfall of the river Subansiri into Brahmaputra. The total length of river Kamla is 175km up to the confluence with Subansiri. The entire course of Kamla is characterized by narrow gorges with the river never experiencing the freedom of the plains to overflow even in its swollen spates.

Upstream of Tamen, river Kamla follows more or less a straight course up to its confluence with Kurung river. The river is drained by a large number of lateral tributaries. Kurung river and Pein river are among major tributaries of Kamla. Some other tributaries of Kamla are: Pania, Pepik Kro, Parsen, Keynia, Wsai Bung, Rapo Bung, Panyo-Pabang, Wacha, Para, Parlo, Sela nallah, Pal nallah, Phura, Phopam, Keleng, Hopar, Ked, Pabin and Pau nallah.

7.2.2 The Catchment

The catchment area of the project has been estimated by GIS processing of SRTM digital elevation model (DEM) as well as from SOI toposheets. DEM are generally available in 5 degree x 5 degree tiles in WGS-84 co-ordinate system. For the present project SRTM digital elevation model namely srtm_55_07 with latitude 25ºN to 30ºN and longitude 95ºE to 100ºE has been used to delineate the catchment area of the project and locations relevant to the project. The catchment area of the project lies between longitudes 92º39'E and 94º05'E and latitudes 27º35'N and 28º22'N. The dam site lies at longitude 93º 59'15"E and latitude 27º46'30"N.

The catchment area of project up to the proposed dam site as estimated from SRTM data is 7213km^2, whereas that estimated from toposheets is 7240km^2. Although the catchment areas delineated from both the sources are different, the margin of difference is very less. It is generally believed that the delineated boundary of the catchment from DEM would be more accurate compared to toposheets. Hence, catchment area of **7213**km^2 (obtained through GIS processing of SRTM data) has been retained and used subsequently for the Kamala HEP.

A plan of the catchment area map of the Project is shown in **Plate 7-1.** The catchment area map of the project as obtained from Survey of India toposheets has also been given in

Plate 7-2. Catchment area details at relevant locations to the project has also been delineated through GIS processing of SRTM data and shown in **Plate 7-3**.

7.2.3 Assessment of Snowfed and Rainfed Catchment Areas

The permanent snowline has been taken at an elevation of 4500m, as generally adopted in these regions (discussed with IMD before delineation of rain-fed catchment for the present study). Using this assumption, the catchment area permanently under snow at Kamala HEP has been worked out to 349km^2 and the rest 6864km^2 is defined as rain-fed catchment where seasonal snowfall might occur. It may therefore be concluded that only 5% of the total area is covered with permanent snow.

Break up of Catchment area details at different locations to the project has also been worked out and are given in **Table 7-1**.

Table 7-1: Detail Breakup of Catchment Areas

S. No	Location	Catchment Area (km^2)		
		Rain-fed	Snow-fed	Total
1	Chouldhowaghat	18840	7524	26364
2	Gerukamukh	18533	7522	26055
3	Menga	7481	7161	14642
4	Tamen (Bridge)	7233	349	7582
5	Project Site (Dam Site)	6864	349	7213

7.2.4 Hypsometric Details

A hypsometric curve is an empirical cumulative distribution function of elevations in a catchment. It is shown as a continuous function and graphically displayed as an X-Y plot, with elevation on the vertical or Y-axis and area above the corresponding elevation on the horizontal or X-axis. The hypsometric curve for the project catchment has been given below in **Figure 7-1**.

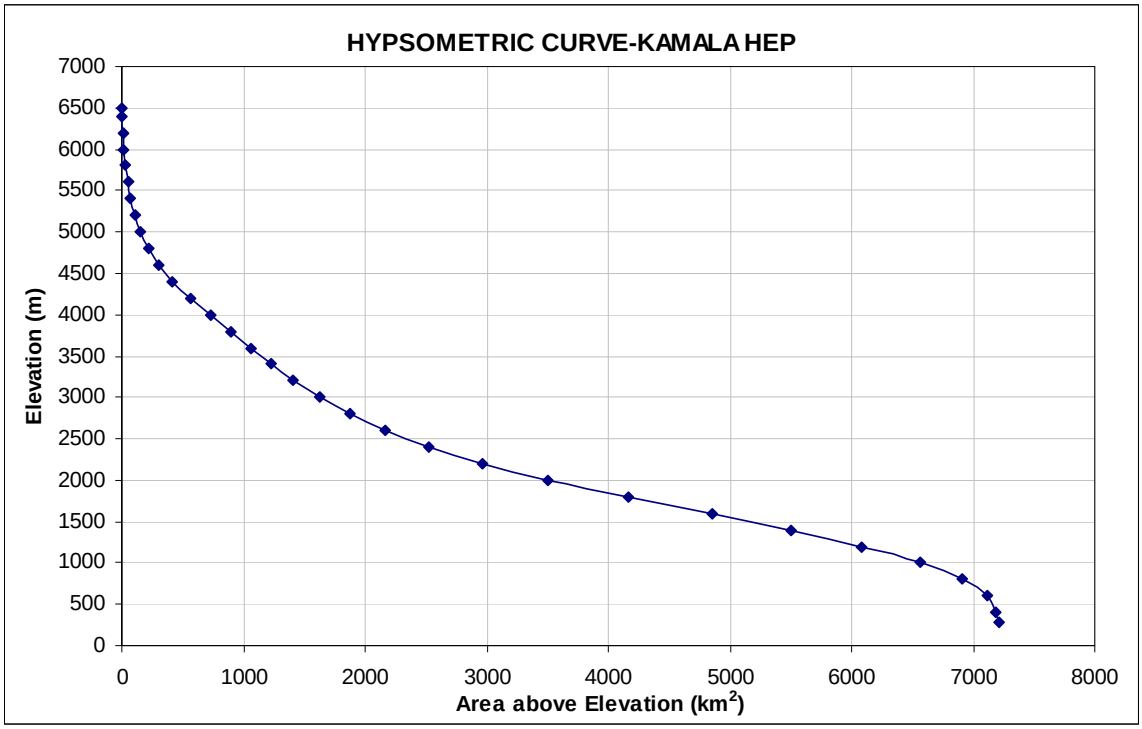


Figure 7-1: Hypsometric Curve of the Project Catchment

7.2.5 Climatology

The climate of Arunachal Pradesh is generally humid or perhumid subtropical, characterized by high rainfall and high humidity of the sub-Himalayan belt. However, a temperate climate prevails in the Lower Himalayan region and the Greater Himalayan region is perpetually covered with snow. Maximum and minimum temperatures as observed at Tamen are 43ºC and 8ºC, respectively. Relative humidity ranges from a maximum of 100% to a minimum of 35%.

Over the year, four different seasons can be defined:

- Pre-monsoon
- Monsoon
- Post-monsoon
- Winter Season

Details of different seasons and evaporation are provided in Volume-II of DPR.

7.3 Water Availability Studies

7.3.1 Data Availability

Data relevant to hydrological assessment of the project is shown in Figure 7-2. The catchment area map of Subansiri river showing location of hydro-meteorological stations has been given in **Plate 7-4.**

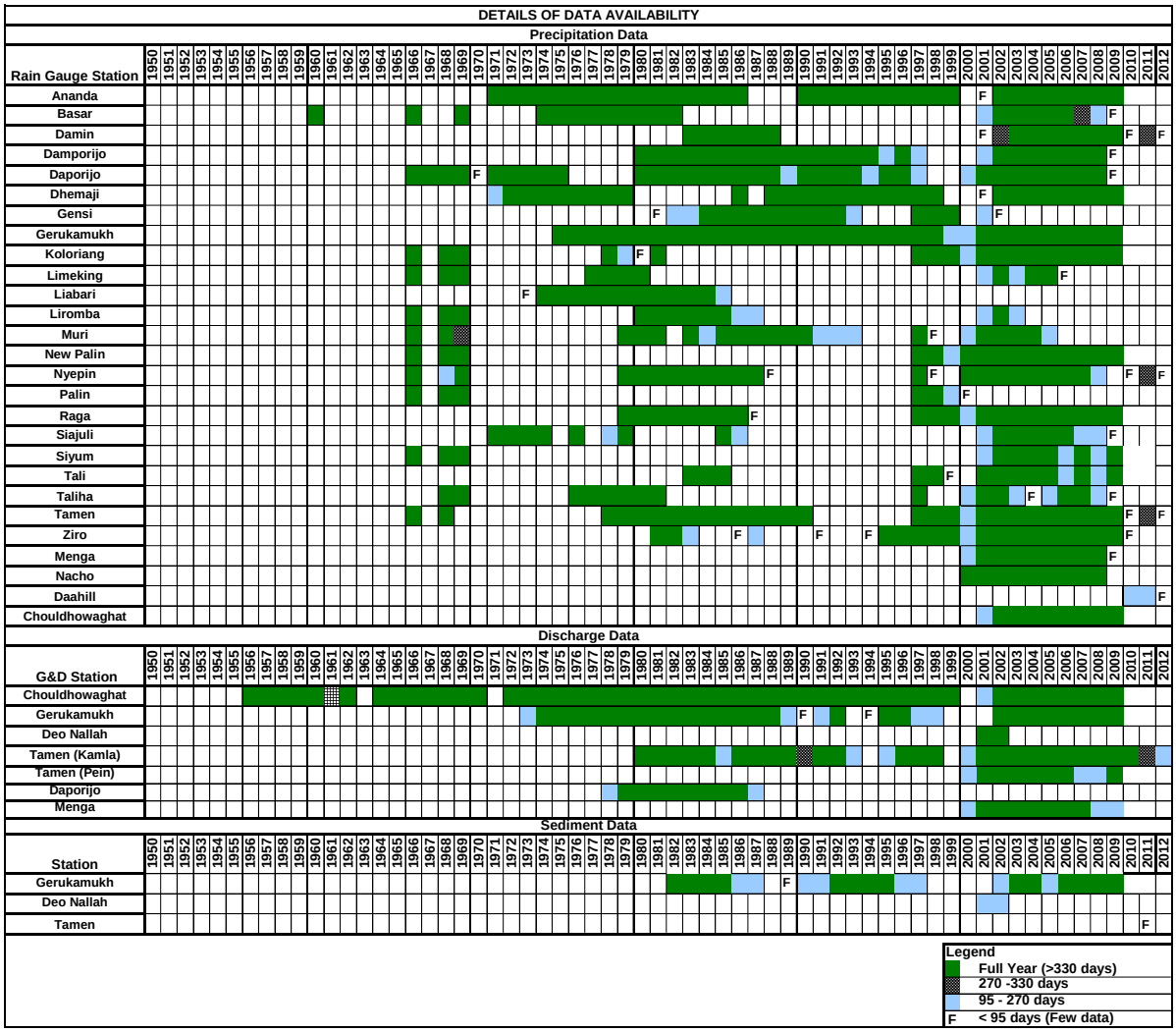


Figure 7-2: Details of Data Availability

7.3.2 Rainfall Data

There are considerable numbers of raingauge stations in the Subansiri catchment for which rainfall data is available for varying periods (see Figure 7-2). These stations are operated and maintained by agencies namely Brahmaputra Board, CWC and NHPC. Although considerable raingauge stations exist in the Subansiri catchment, only the data of raingauge stations relevant to the project are used for the study.

7.3.3 Discharge Data

Discharge data as available, for the water availability study of the present project, has been shown in **Figure 7-2** and are summarized in the below.

Table 7-2: Details of Discharge Data Availability

S.No	G&D Station	Period of Availability
1	Chouldhowaghat	1956-1962, 1972-1999, July 2001-2009
2	Gerukamukh	July 1973-May 1989, Nov 1990-May 1991, July 1991-Dec 1992, Jan 1995-Nov 1995, Mar 1996 –Dec 1996, Sep 1997-Oct 1998, Jan 2002- Dec 2009
3	Menga	June 2000-July 2008, Nov 2008-Dec 2008, May 2009-July 2009
4	Tamen (Bridge)	Jan 1980 –Dec 1984, July 1985-Mar 1990, Jun 1990-Dec 1992, Apr 1993-Oct 1993, June and July 1995, Sep 1995- Dec 1998, Jun 2000 – Jan 2011
5	Daporijo	Mar 1978 – Aug 1987
6	Deo Nallah	2001-2002

The discharge data at Tamen (bridge) G&D site for the period 2002 to 2009 has been observed by both Brahmaputra board and NHPC.

7.3.4 Consistency Checks of Rainfall and Discharge Data

Detailed calculations on water availability and flood magnitude will lead to selecting the design features of the project (installed capacity, turbine flow, spillway capacity, etc.). These features will directly reflect on the project cost and on the quantity and value of energy produced. It is therefore necessary to confirm the validity of the basic data used in the calculations. The consistency checks of the rainfall data has been carried out in the following ways. The details of consistency checks of rainfall data have been provided in Volume II of DPR.

7.3.5 Flow Series Computation

Discharge data of Tamen forms the basis of estimation of flow series at the Kamala HEP because of its proximity i.e., about 3km downstream of the project site. The methodology and philosophy of computation of flow series of the project has been finalized based on the observations of CWC (for details refer Volume-II of DPR)**.** The procedure so involved for the flow series development at the project site is as follows:

(i) Gaps in the observed series at Gerukamukh have been filled by using separate correlations for monsoon (Jun-Sep) and non-monsoon (Oct-May) with Chouldhowaghat. The correlations so developed are given below in **Figure 7-3** and **Figure 7-4** respectively.

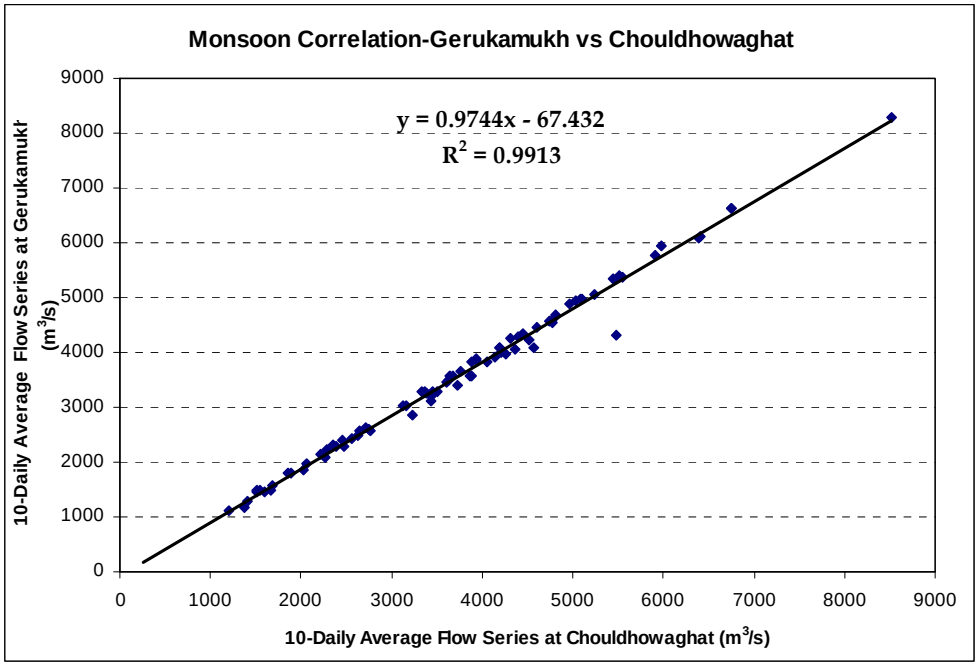


Figure 7-3: Monsoon Correlation Plot between Discharge data at Gerukamukh and Chouldhowaghat

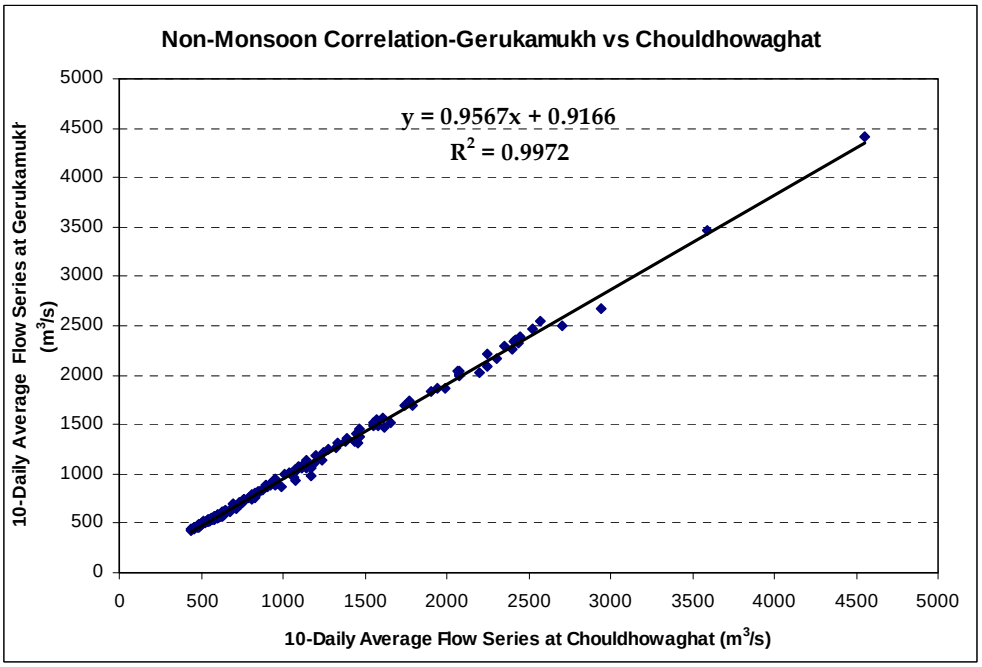


Figure 7-4: Non-Monsoon Correlation Plot between Discharge data at Gerukamukh and Chouldhowaghat

(ii) Gaps in the observed series at Tamen have been filled by using separate correlations for monsoon (Jun-Sep) and non-monsoon (Oct-May) with Gerukamukh. The correlations so developed are given in **Figure 7-5** and **Figure 7-6,** respectively.

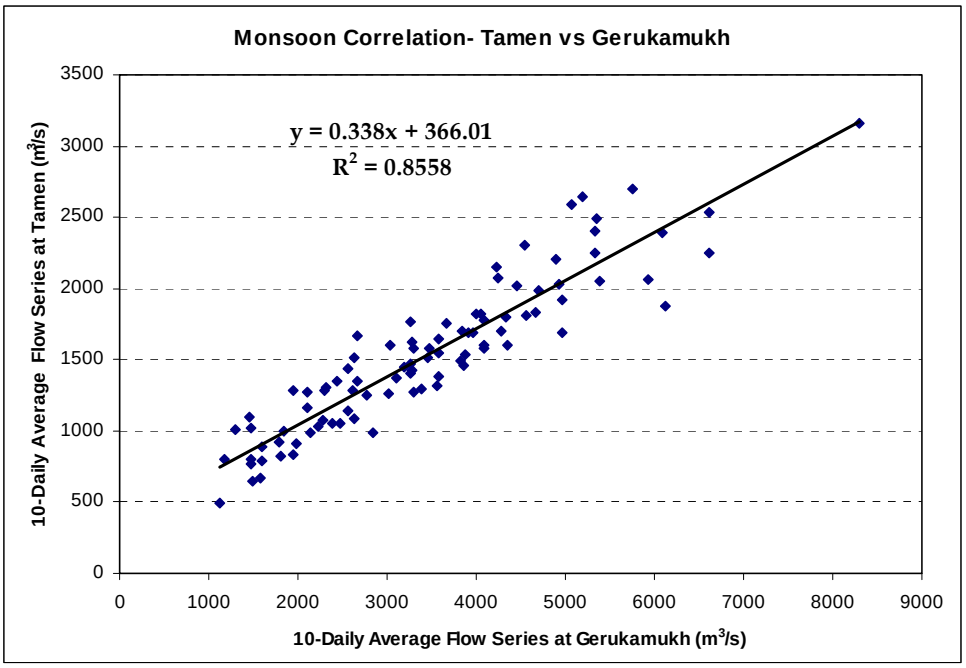


Figure 7-5: Monsoon Correlation Plot between Discharge data at Tamen and Gerukamukh

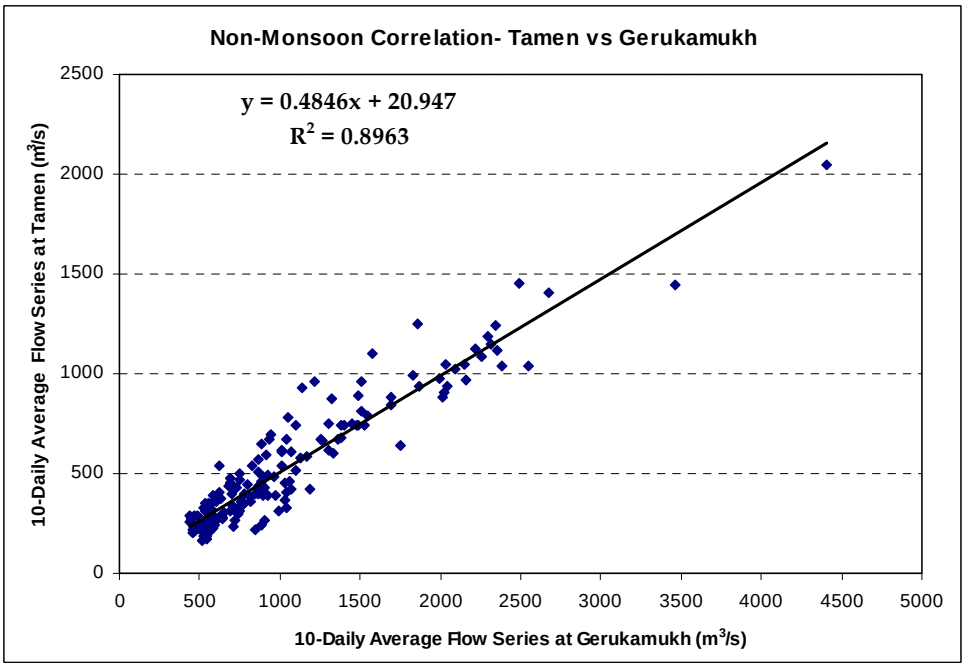


Figure 7-6: Non-Monsoon Correlation Plot between Discharge data at Tamen and Gerukamukh

(iii) If the data is not available at Tamen, Gerukamukh and Chouldhowaghat, the gaps in the Tamen flow series has been filled by long term average correcting for the yearly vs average characteristics.

(iv) Snowmelt at the rate of 5 mm/day has been deducted from the Tamen flow series for the snowmelt period of May to October to obtain the rainfed contribution of the catchment.

(v) The rainfed component of flow series at Tamen has been transferred to the proposed dam site based on rainfed catchment area ratio. The rainfed catchment area ratio for the transposition is 0.949 (=6864/7233).

(vi) The snowmelt contribution (for the period May to October) at the rate of 5 mm/day has been added to the transferred rainfed component of flow series of Kamala Hydroelectric Project (from Tamen) to obtain the water availability series at the
project site.

(vii) Finally, the flow series as obtained above has been reduced by 10% to account for observational errors etc. The final flow series thus developed at the project site is given in **Table 7-3**.

CEA/CWC has already given the concurrence for the water availability of the project.

Table 7-3: Final 10-Daily Average Flow Series (m3/s) at Kamala Project Site

Catchment Area of Kamala Project = 7213 km^2

Period		1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Jun	I	1,504.23	953.56	734.77	1,234.59	944.65	1,437.82	628.62	830.93	763.93	1,149.91	723.77	1,062.09	681.47	872.86	1,665.08	822.55	1,290.72	1,460.10	832.91	1,514.57	856.10	1,095.68	761.93	877.17	1,152.55	1,095.50	1,237.47	1,371.00	1,290.01	861.00
	II	1,569.78	735.04	1,501.05	1,396.13	1,759.00	1,312.76	910.71	1,146.36	1,103.78	1,340.67	912.77	1,256.91	675.19	855.23	1,411.73	1,141.24	963.27	1,857.90	972.25	1,569.39	1,106.82	837.48	1,098.26	1,313.02	1,444.99	923.25	1,559.30	1,724.97	1,833.68	938.26
	III	1,545.82	1,110.88	1,802.92	1,832.30	1,119.46	1,365.64	1,526.11	1,035.09	897.03	952.15	1,520.65	1,019.09	700.29	877.42	1,489.08	1,332.18	1,026.89	1,697.53	1,847.03	2,674.61	1,387.77	1,219.79	1,427.01	2,305.58	2,040.09	1,272.96	1,173.38	1,967.98	1,257.62	1,092.24
Jul	I	1,714.45	1,612.94	1,561.63	1,591.70	1,528.88	1,739.73	1,013.26	1,480.20	1,463.05	1,221.81	1,230.15	1,126.30	695.84	849.86	1,901.08	1,091.05	1,605.87	1,559.66	1,793.25	2,290.59	1,624.61	629.77	2,296.55	1,925.56	2,053.20	1,125.62	1,107.79	1,232.21	1,289.59	1,553.53
	II	2,065.67	1,484.47	1,484.92	1,263.02	1,359.66	1,999.19	1,107.11	1,412.73	1,176.82	1,042.80	1,424.42	1,195.85	664.76	885.39	1,254.35	772.30	2,138.24	1,650.95	1,548.54	2,052.59	1,848.14	1,390.76	1,543.27	1,764.82	2,164.91	1,446.67	1,178.58	1,454.13	1,371.95	994.90
	III	1,512.98	1,251.74	1,991.81	1,352.05	1,465.71	1,718.36	916.42	1,620.76	1,338.21	1,044.34	1,352.73	1,374.15	706.14	884.84	1,723.58	636.28	1,700.65	1,743.20	1,519.64	1,862.81	1,176.85	1,139.08	2,577.26	1,247.51	1,636.47	1,349.52	841.18	2,702.45	1,731.46	1,352.68
Aug	I	1,832.72	891.98	724.93	896.71	1,024.20	1,015.79	816.31	1,541.20	1,020.00	1,006.12	1,429.33	1,102.09	688.28	883.57	1,895.82	695.53	1,588.72	1,679.53	1,569.57	1,173.11	1,442.93	990.80	1,506.50	1,090.54	1,535.81	1,692.55	553.29	1,196.46	896.07	1,384.19
	II	1,412.14	1,270.23	666.57	1,156.83	713.42	907.84	638.32	1,510.26	1,452.48	1,170.28	918.78	870.57	718.55	884.53	2,248.09	771.92	1,878.77	1,861.99	1,397.31	2,237.40	1,512.47	1,036.78	2,257.49	1,919.14	926.56	1,440.04	424.92	1,769.19	1,748.89	1,516.49
	III	1,528.80	1,462.01	1,141.60	1,262.91	1,110.53	1,370.73	1,046.13	1,251.92	1,466.58	1,423.05	1,061.56	723.17	714.60	894.88	2,111.93	743.60	1,455.45	1,947.15	1,385.25	2,256.18	1,576.75	1,856.25	1,064.69	1,566.79	1,214.90	1,601.71	1,094.91	1,117.36	1,452.29	1,323.65
Sep	I	1,044.92	1,267.52	688.42	1,144.88	1,228.63	1,800.69	717.95	1,875.22	1,297.96	1,205.27	1,065.15	762.96	759.76	824.19	1,307.51	528.22	993.48	1,529.21	1,179.75	2,251.13	1,754.27	1,333.08	676.02	2,127.49	1,547.37	1,076.90	841.68	2,209.81	1,371.15	689.13
	II	1,432.14	1,217.45	1,362.23	1,504.06	1,554.57	1,183.91	1,062.11	1,676.05	1,100.29	1,330.84	1,131.63	731.66	776.87	838.03	1,336.48	535.62	904.46	1,559.16	1,091.06	1,838.98	1,758.79	1,096.29	711.99	1,883.01	780.92	572.11	1,405.25	1,499.67	789.74	870.74
	III	1,876.07	775.24	1,099.60	1,510.93	1,110.68	1,422.19	607.27	1,576.83	607.93	938.82	841.46	788.84	801.91	821.47	1,583.53	500.47	844.10	1,199.29	992.29	1,171.14	1,375.41	880.15	1,157.78	1,348.35	971.36	900.39	700.78	682.48	660.70	854.49
Oct	I	1,263.92	850.70	603.54	636.03	749.10	925.88	689.83	1,035.40	805.53	1,112.89	751.99	756.97	749.72	785.25	1,052.92	447.46	835.52	969.62	987.46	1,538.89	638.70	1,049.03	897.49	1,747.01	1,235.67	777.44	752.20	938.90	692.11	751.49
	II	689.78	468.53	393.60	890.87	862.28	506.59	503.24	788.22	595.08	896.14	721.43	789.42	701.17	792.89	916.28	487.94	824.35	705.13	1,205.68	1,646.20	584.57	756.49	503.86	890.72	955.80	514.21	673.17	897.60	528.56	518.25
	III	497.59	320.41	536.66	519.16	697.05	403.64	385.29	653.43	516.39	634.22	527.06	702.05	683.73	777.67	937.35	454.77	836.62	584.81	815.16	1,170.90	414.17	384.29	460.83	802.33	584.10	635.03	417.03	574.03	549.13	397.38
Nov	I	317.02	597.40	322.01	332.97	407.85	359.31	374.16	137.20	333.00	623.48	402.28	233.06	763.30	466.26	762.21	338.00	816.77	497.92	543.53	672.13	342.93	552.84	342.40	641.63	395.27	439.01	330.91	359.63	357.94	306.48
	II	369.42	245.39	284.59	295.39	308.06	277.95	282.17	142.62	228.60	398.31	318.15	233.54	800.36	272.23	434.42	325.58	810.74	405.17	449.56	540.63	342.71	363.36	339.65	492.10	333.53	367.99	293.99	344.07	312.04	363.23
	III	285.52	199.78	253.48	232.27	245.38	220.22	215.80	128.19	196.51	351.49	252.74	233.56	747.46	271.50	314.59	333.34	768.69	330.21	376.77	453.52	279.33	350.68	290.38	418.70	295.70	325.60	305.44	335.02	269.66	297.31
Dec	I	256.98	182.94	229.19	210.39	217.31	186.74	179.53	222.65	180.55	248.30	214.36	236.61	476.88	257.76	316.61	398.12	666.09	299.78	325.02	359.34	275.72	286.12	254.21	382.98	268.88	273.17	270.92	269.02	228.16	274.23
	II	215.38	224.97	253.66	189.08	257.24	157.59	166.38	210.26	174.43	217.62	195.20	206.55	433.71	256.79	269.63	426.02	619.18	275.64	275.27	309.18	221.78	260.66	233.21	322.71	250.19	240.92	252.92	230.90	205.53	224.06
	III	168.29	152.03	223.18	183.25	184.99	150.17	161.43	171.60	126.75	191.31	195.99	210.17	350.20	243.73	192.37	462.88	586.64	260.98	278.76	270.30	182.51	213.20	216.68	282.54	259.37	225.04	200.32	209.77	186.74	200.66
Jan	I	177.95	143.02	199.86	163.13	153.69	139.81	143.43	170.41	119.36	178.66	188.63	368.60	254.25	240.08	278.19	360.60	445.72	245.89	224.98	225.92	170.23	192.50	195.80	245.86	238.75	215.31	190.62	188.44	173.99	201.45
	II	155.50	140.21	172.71	170.02	147.75	128.82	125.28	160.49	125.96	166.62	181.91	356.84	250.15	242.94	258.94	373.28	370.71	229.81	196.14	212.22	159.76	179.56	187.96	239.41	226.72	199.59	187.62	179.20	159.38	171.82
	III	179.78	126.76	159.37	179.05	139.77	123.46	113.28	139.73	113.15	162.95	171.21	381.63	225.37	232.92	263.56	295.87	410.43	225.02	181.14	207.79	154.29	221.83	173.26	231.50	219.59	195.04	179.53	192.99	160.74	147.63
Feb	I	367.48	136.41	172.16	160.04	148.18	139.35	111.43	138.83	145.99	190.88	188.58	379.80	233.89	247.73	266.03	362.58	355.63	239.95	190.59	219.30	159.83	164.43	201.57	217.50	232.15	188.23	209.52	190.61	149.94	139.67
	II	179.95	138.68	203.13	155.98	149.71	138.26	112.29	232.16	211.48	179.48	192.26	376.35	263.76	263.80	327.30	418.57	321.44	223.96	178.40	229.97	155.01	171.63	268.95	218.61	335.85	191.52	214.07	202.03	138.71	142.12
	III	308.10	157.77	339.31	146.03	163.13	142.88	157.01	210.20	226.65	201.16	177.31	378.85	270.57	243.63	302.93	376.42	325.90	246.53	199.97	253.71	193.63	180.95	214.11	245.22	280.43	459.49	222.96	203.92	239.81	151.41
Mar	I	247.10	178.97	297.65	212.68	200.24	154.51	198.83	264.33	236.24	225.32	237.02	413.04	288.68	235.28	299.16	329.66	389.10	284.15	188.99	275.10	203.48	212.32	233.94	300.25	340.75	307.13	308.00	275.62	202.89	192.72
	II	331.66	288.86	331.66	340.81	253.65	269.64	196.33	342.13	265.39	260.16	411.55	451.84	318.18	257.91	346.92	404.57	426.98	359.58	231.13	328.86	219.46	267.17	405.35	249.43	387.92	373.97	332.54	342.11	183.14	219.05
	III	292.92	298.73	462.52	262.45	256.88	185.15	209.04	312.24	278.32	367.73	332.26	451.82	335.28	678.78	392.30	431.90	474.16	353.10	210.85	396.30	347.61	450.75	389.59	574.08	637.02	299.29	344.92	410.50	195.59	506.80
Apr	I	303.25	522.09	202.82	560.83	380.75	204.42	220.42	333.11	255.16	400.01	517.92	489.01	446.79	651.39	366.18	455.97	438.16	431.33	330.91	465.21	503.08	514.08	595.74	399.88	760.19	368.01	518.27	484.09	424.74	768.01
	II	396.67	484.05	301.31	366.20	433.95	407.92	250.00	459.14	339.38	475.58	459.61	481.65	553.89	576.96	342.84	443.17	524.07	526.26	328.55	533.55	778.86	798.59	553.14	641.93	631.86	635.00	507.65	820.64	433.35	629.26
	III	570.79	619.79	231.10	647.21	476.34	546.44	491.20	639.31	388.27	626.47	630.93	532.43	681.97	645.95	705.96	1,470.43	550.92	544.75	462.23	700.11	657.25	756.05	848.51	632.58	800.75	375.83	872.04	750.92	574.39	1,127.72
May	I	563.06	569.04	375.31	597.78	546.30	602.68	547.23	543.13	528.26	390.71	530.81	603.11	659.46	667.05	695.30	1,466.95	715.71	616.39	818.98	692.59	519.76	637.35	1,059.59	525.34	721.20	632.03	461.09	819.91	795.79	769.32
	II	785.99	1,220.14	963.17	813.92	556.44	547.68	743.90	724.54	419.17	610.26	419.95	586.57	707.35	1,076.90	644.40	1,990.07	890.42	668.00	828.09	855.79	545.89	667.70	959.28	1,204.78	979.43	833.73	574.90	570.43	668.48	1,458.25
	III	1,175.34	432.93	1,128.85	1,198.03	693.62	365.50	770.81	1,111.10	1,147.06	651.31	1,090.37	615.79	690.66	1,461.96	674.46	2,281.76	1,190.08	813.17	1,566.94	1,035.97	810.32	819.95	1,011.86	1,243.23	926.89	827.72	886.87	1,040.59	1,068.00	986.02
Inflow (MCM) =		25585.7	19963.2	20647.7	22529.8	20711.2	21567.5	16128.7	23079.2	19092.7	20731.1	20182.7	19745.0	17959.9	19602.8	27525.4	21740.2	27289.3	26461.1	24260.9	32102.1	23076.8	21107.3	24591.8	28568.2	26143.7	21443.6	18988.9	26216.0	21667.7	21459.0
Average flow (m^3/s) =		809.42	631.46	650.04	711.38	654.14	682.20	509.41	728.55	601.24	655.20	636.72	624.53	568.62	617.21	869.14	686.30	860.68	835.63	764.55	1013.50	730.05	665.48	775.45	903.31	826.87	677.71	600.72	826.63	683.11	677.10
Runoff Depth (mm) =		3547	2768	2863	3124	2871	2990	2236	3200	2647	2874	2798	2737	2490	2718	3816	3014	3783	3669	3363	4451	3199	2926	3409	3961	3625	2973	2633	3635	3004	2975

Average Runoff Depth (Including Snowmelt) = **3143** mm

7.3.6 Flow Duration Curves and Annual Dependabilities

Having prepared the long term 10-daily series at the dam site of Kamala hydroelectric project, the annual flow duration curve has been prepared and is given in the figure below:

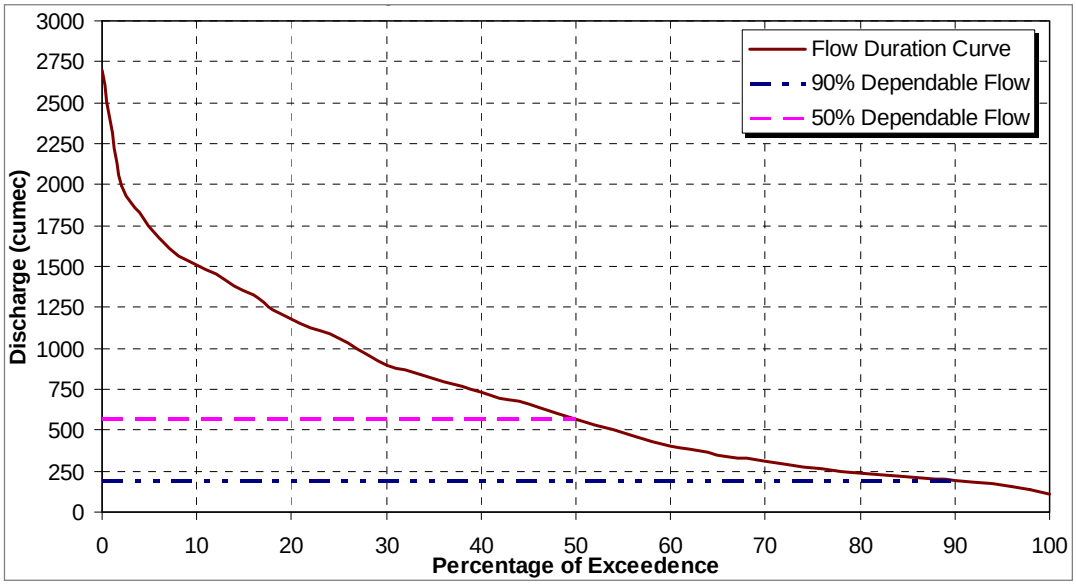


Figure 7-7: 10-Daily Flow Duration Curve

Based on the flow duration curve of the flow series of the project, the corresponding 90% and 50% dependable flows are 190.44 m^3/s and 569.73 m^3/s, respectively.

7.4 Design Flood

7.4.1 General

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood value is important as an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value will place the structure safety and downstream population at risk.

7.4.2 Criteria for Estimation of Design Flood

As per the recommendations of IS: 11223-1985, “Guidelines for Fixing Spillway Capacity”, the inflow design flood for safety of a dam is decided on the basis of gross storage and static head. The following criteria are recommended.

Table 7-4: Classification Criteria of Hydraulic Structures

Classification	Gross Storage ($x10^6$ m^3)	Static Head (m)	Inflow Design Flood
Small	0.5 - 10	7.5 - 12	100 year
Intermediate	10 - 60	12 - 30	SPF
Large	> 60	> 30	PMF

The proposed dam is having a static head of more than 200m and the reservoir has a gross storage of 1927.62 MCM upto FRL 455m. Therefore, from both the classification criteria, the inflow design flood for spillway shall be Probable Maximum Flood (PMF).

7.4.3 Computation of Design Flood - PMF

In the present case, the design floods at the project are estimated using the Hydro-meteorological approach. Since site specific short interval rainfall-runoff records are not available, the procedure for estimating unit hydrograph given in "Flood Estimation Report for North Brahmaputra, subzone 2(a), Central Water Commission, 1991" has been adopted.

The methodology comprises of the following steps:

- First, the Probable Maximum Precipitation (PMP) is estimated.
- A typical unit hydrograph is then defined for the basin, and the flood hydrograph is computed by convolution of this hydrograph.

7.4.4 Physiographic Parameters of the Catchment

a) Catchment Area (A):

The project is located on the Kamla river downstream of the confluence with the Kurung river. The project catchment area is derived by GIS processing of SRTM data. In the present case the total catchment area upto the proposed diversion site is 7213km^2. Keeping in view the limitation and basic assumptions of the unit hydrograph theory, the total catchment area of 7213km^2 has been divided into two sub-catchments as given in **Table 7-5.** The snowline elevation of 4500m (as described previously) has been taken to delineate the rain-fed area of the project catchment. The break-up of catchment areas has been given in **Table 7-5**. The sub-catchment map of Kamala hydroelectric project has been given in **Figure 7-8**.

Table 7-5: Breakup of Catchment Area

S. No.	Name of Sub-Catchment	Rain-fed Area (km^2)	Snow-fed Area (km^2)	Total Area (km^2)
1	SC1 : Kamla river catchment upto the confluence of Kurung and Kamla river	3682	131	3813
2	SC2 : Kurung river catchment including the intermediate catchment upto Dam Site	3182	218	3400

b) Parameters of the Main Stream (L & L_c):

River length (L) implies the longest length of the main river from the farthest watershed boundary of rain-fed catchment to the downstream boundary point, whereas L_c is defined as the length of the longest main stream from a point opposite to centroid of the catchment area to the gauging site (i.e., the outlet point) along the main stream. The stream may or may not pass through the centre of gravity but the point of the river nearest to the centre of gravity is considered to find the length of the main river from the centre of gravity to the point of study (Lc). In the present case, the details of these parameters as extracted from the available information are given below.

Table 7-6: River Length Parameters

Name of Sub-catchment	L (km)	L_c (km)
SC1	139.53	74.88
SC2	165.31	84.01

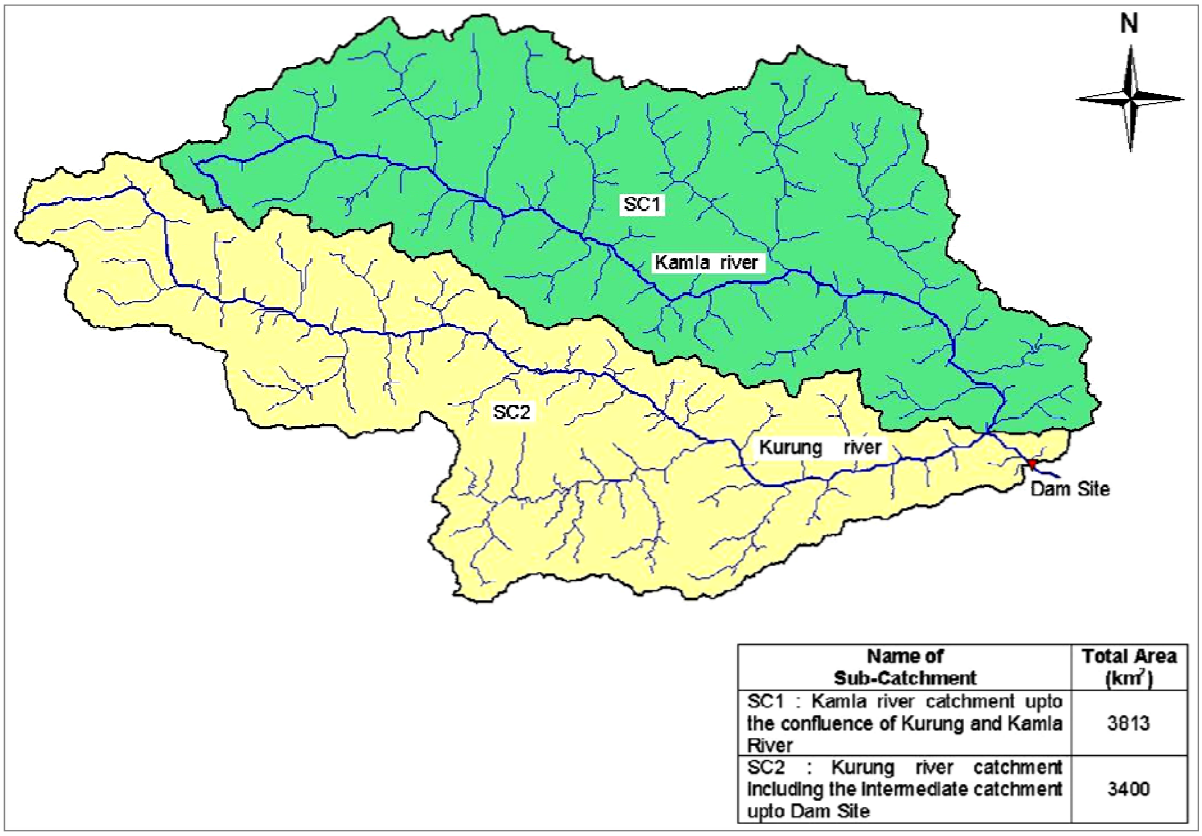
c) Equivalent Stream Slope (S):

This is one of the physiographic parameters used in the derivation of Synthetic Unit Hydrograph. The L-section of the river is derived from relevant toposheets. It is broadly divided into segments representing broad ranges of slopes. The following formula is used to compute equivalent slope (S).

$$S = \frac{\sum L_i (D_{(i-1)} + D_i)}{L^2}$$

Elevations of riverbed at intersection points of contours reckoned from the bed elevation at the diversion site are considered as datum. $D_{(i-1)}$ and D_i are the heights of successive bed locations at contour intersections.

The equivalent slope thus computed for SC1 (Kamla river catchment) is 13.62m/km and that for SC2 (Kurung river upto the dam site) is 12.97m/km.



Name of Sub-Catchment	Total Area (km^2)
SC1 : Kamla river catchment upto the confluence of Kurung and Kamla River	3813
SC2 : Kurung river catchment including the intermediate catchment upto Dam Site	3400

Figure 7-8: Sub-Catchment Map of Kamala HEP

7.4.5 Derivation of Unit Hydrograph

The Central Water Commission (CWC), in association with the India Meteorological Department (IMD), Ministry of Railways and Ministry of Surface Transport, has prepared flood estimation reports for small and medium rain-fed catchments for efficient hydro-meteorological homogenous sub-zones. These reports illustrate the procedure for derivation of synthetic unit hydrograph based on physiographic parameters. The unit hydrograph for the rain-fed catchment area of the project has been derived as per procedures and guidelines given in the regional flood report of sub zone 2a.

SUH parameters for the present project are derived using project specific information and are included in **Table 7-7.**

Table 7-7: Sub-Zone 2a Unit Hydrograph Parameters

Parameter	Definition	Formula	Unit	SC-1	SC-2
L	Length of longest main stream along the river course	Measured from Topographical Map	km	139.53	165.31
Lc	Length of longest main stream from a point opposite to centroid of the catchment area to intake site	Measured from Topographical Map	km	74.88	84.01
A	Rain fed Area	Measured from Topographical Map	km²	3682	3182
S	Equivalent Stream Slope	$S = \frac{\sum L_i (D_{i-1} + D_i)}{L^2}$	m/km	13.60	12.97
q_p	Peak Discharge of unit hydrograph per km²	$q_p = 2.272\left(\frac{LL_c}{S}\right)^{-0.409}$	m³/s/km²	0.15	0.13
Q_p	Peak Discharge of unit hydrograph	$Q_p = A \cdot q_p$	m³/s	552	417
t_p	Time from the centre of effective rain fall duration to the unit hydrograph Peak	$t_p = 2.164(q_p)^{-0.940}$	hrs	12.87	14.62
t_r	Unit period	Should be 0.25 times or smaller than t_p	Hrs	1	1
t_m	Time from start of rise to the peak of unit hydrograph	$t_m = t_p + 0.5\ t_r$	hrs	13.37	15.12
T_B	Base width of unit hydrograph	$T_B = 5.428(t_p)^{0.852}$	hrs	47.86	53.37
W_{50}	Width of unit hydrograph measured at 50% of Peak Discharge Ordinate	$W_{50} = 2.084(q_p)^{-1.065}$	hrs	15.71	18.16
W_{75}	Width of unit hydrograph measured at 75% of peak discharge ordinate	$W_{75} = 1.028(q_p)^{-1.071}$	hrs	7.84	9.07
W_{R50}	(Width of the rising limb of unit hydrograph measured at 50% of Peak Discharge Ordinate	$W_{R50} = 0.856(q_p)^{-0.865}$	hrs	4.42	4.97
W_{R75}	Width of the rising limb of unit hydrograph measured at 75% of Peak Discharge Ordinate	$W_{R75} = 0.44(q_p)^{-0.918}$	hrs	2.51	2.84

The 1-hour Synthetic Unit Hydrograph (SUH) representing effective rainfall depth of 1cm has been obtained for both the sub-catchments using the above parameters. The SUH for the sub-catchments are shown in figures below:

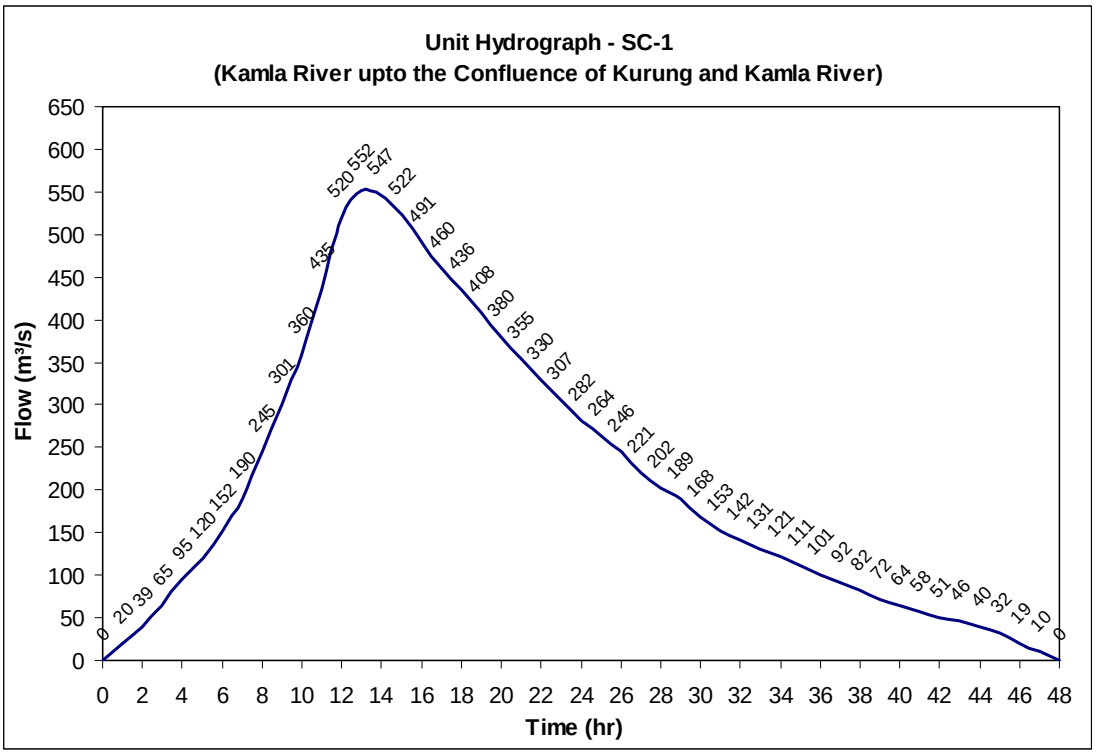


Figure 7-9: Synthetic Unit Hydrograph of SC-1

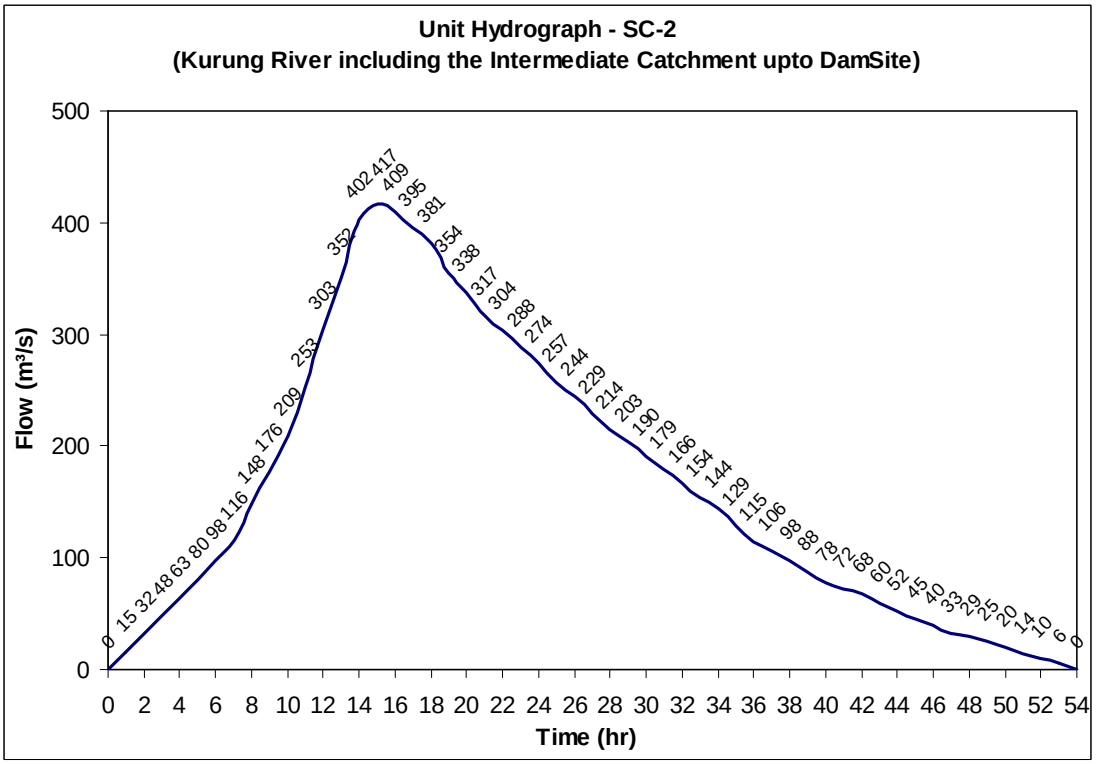


Figure 7-10: Synthetic Unit Hydrograph of SC-2

The important parameters for deciding critical storm duration are size and shape of the catchment, travel time/base period of unit hydrograph and the direction of the storm movement with reference to the direction of river flow. For all practical purposes, the UG base governs the duration of the storm. As can be seen from the above figures, the base period of unit hydrograph is 48 hours for SC-1 and 54 hours for SC-2. Therefore, design storm of 2 day has been proposed to be used for the flood estimation of both the sub-catchments.

7.4.6 Design Storm

Design storm studies for the project have been carried out by the India Meteorological Department (IMD), New Delhi on the basis of the available rainfall data in the area. The Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) values along with time distribution for 1-day and 2-day storm, provided by IMD, are given in **Table 7-8** and **Table 7-9**, respectively.

Table 7-8: Standard Project Strom (SPS) and Probable Maximum Precipitation (PMP) Values

Sub-Catchment	Duration	Design SPS (cm)	PMP (cm)
SC1 (Kamla river Catchment)	1 day	21.70	24.90
	2 day/48 hour	37.0	42.5
SC2 (Kurung river Catchment)	1 day	21.90	25.20
	2 day/48 hour	37.4	43.3

Note: As recommended by IMD, 1-day precipitation values may increased by 15% to arrive at any 24 hour values

Table 7-9: Temporal Distribution of the SPS and PMP

Duration (hrs)	24-hour (%)	48-hour (%)
3	35	25
6	53	38
9	65	46
12	74	52
15	82	58
18	89	63

Duration (hrs)	24-hour (%)	48-hour (%)
21	95	68
24	100	73
27		77
30		81
33		85
36		88
39		91
42		94
45		97
48		100

The autographic records for storms in India are indicative of a pattern of two bells per day of the storm with high intensity spells lasting for 9 to 12 hours. Therefore, the design storm of 1-day and 2-day values is distributed into 12-hour bells as given in the following tables.

Table 7-10: PMP Distribution for SC1 (Kamla river catchment)

	Design Storm, cm	Ratio of 12/24 hr rainfall		Storm Distribution (cm)	
	PMP	I-Bell	II-Bell	I-Bell	II-Bell
1st 24-hr	**24.90**	0.74	0.26	**18.43 (1A)**	**6.47 (1B)**
2nd 24-hr	**17.60 (=42.5-24.90)**	0.74	0.26	**13.02 (2A)**	**4.58 (2B)**

Table 7-11: PMP Distribution for SC2 (Kurung river catchment)

	Design Storm, cm	Ratio of 12/24 hr rainfall		Storm Distribution (cm)	
	PMP	I-Bell	II-Bell	I-Bell	II-Bell
1st 24-hr	**25.20**	0.74	0.26	**18.65 (1A)**	**6.55 (1B)**
2nd 24-hr	**18.1 (=43.3-22.20)**	0.74	0.26	**13.40 (2A)**	**4.70 (2B)**

For obtaining the largest practicable value of the PMF, the bell arrangement (sequencing) has been considered to follow the sequence: 2A-1B-1A-2B. It has also been ensured during bell sequencing that the summation of storm value of any two consecutive bells doesn't

exceed the 24-hour value of 1-day PMP (which has been obtained by adding the clock hour correction factor of 15% on 1-day PMP storm). In other words the critical sequencing of bells are done in such a way that no two consecutive bells exceeds the value of 28.635cm (=24.9*1.15) for SC1 and 28.98 cm (=25.20*1.15) for SC2, respectively.

7.4.7 Design Loss Rate

The flood estimation report for sub zone-2(a) recommends a loss rate of 0.24 cm/hr. In the present study, the same loss rate has been adopted.

7.4.8 Critical Sequence of Rainfall Excess

To obtain the critical sequence of rainfall excess, the highest rainfall depth has been placed against the maximum UG ordinate and the next ranking rainfall depth has been placed against the next ranking ordinate of hydrograph. This critical arrangement is then reversed to obtain the maximum flood peak.

7.4.9 Base flow and Snow melt

The total base-flow, including snowmelt, has been estimated as 219m^3/s for SC1 and 218.5m^3/s for SC2.

7.4.10 Surface Flow Hydrograph

The Surface Flow Hydrograph has been computed by convoluting 1-hour rainfall excess increments with the ordinates of the 1-hr Unit Hydrograph. Each of the individual incremental hydrographs has been lagged 1-hour from the previous one in the critical sequence of rainfall excess and added to obtain the surface flow hydrograph.

7.4.11 Flood Hydrograph

The Flood Hydrograph has been obtained by adding a uniform base flow, including snowmelt, to the ordinates of the surface flow hydrograph. The Probable Maximum Flood (PMF) hydrographs for SC1 and SC2 thus computed are added together to estimate the PMF hydrograph at Kamala dam site. The PMF hydrograph as obtained has been given in **Figure 7-11** and the ordinates of the hydrograph is given **Table 7-12**.

The detail calculation and analysis of design flood can be referred in Volume II of DPR.

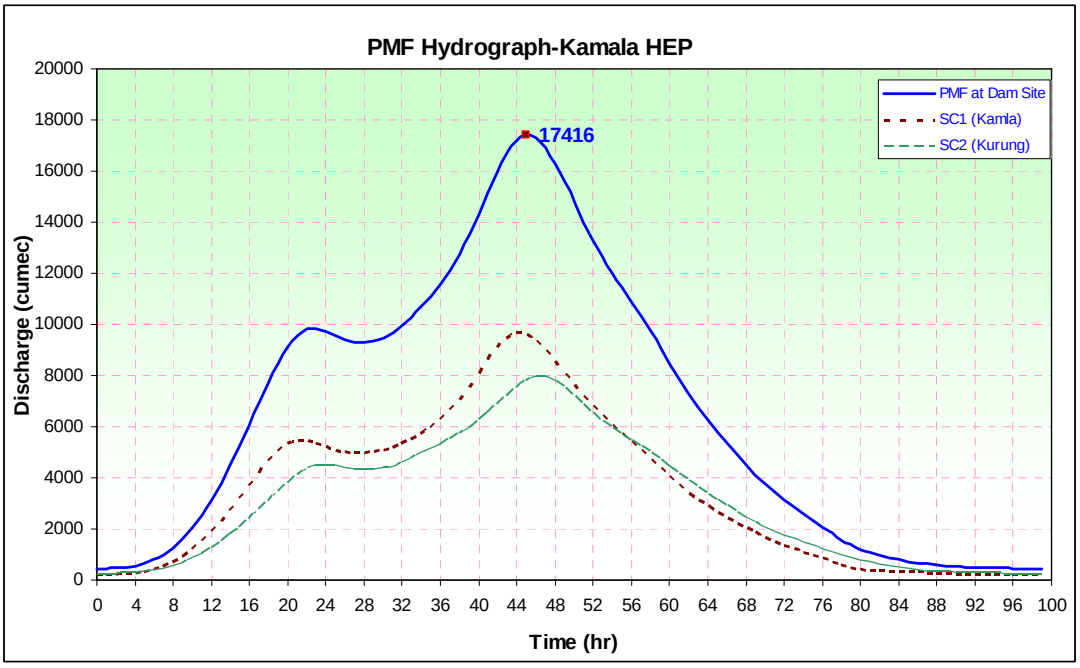


Figure 7-11: PMF Hydrograph

Table 7-12: Values of Design Flood (PMF) Hydrograph

Time (hr)	Flood Value (m^3/s)		
	SC-1 (Kamla)	SC2 (Kurung)	Total
0	219	218	438
1	225	223	448
2	236	233	469
3	258	250	508
4	292	275	567
5	345	313	658
6	419	366	785
7	533	433	966
8	698	534	1232
9	923	673	1597
10	1195	849	2044
11	1514	1043	2557
12	1882	1261	3142
13	2279	1501	3780
14	2718	1768	4486
15	3188	2067	5255
16	3680	2392	6072
17	4167	2734	6901
18	4639	3087	7726
19	5053	3443	8495

Time (hr)	Flood Value (m^3/s)		
	SC-1 (Kamla)	SC2 (Kurung)	Total
20	5347	3789	9136
21	5471	4109	9579
22	5460	4358	9818
23	5364	4486	9850
24	5231	4502	9733
25	5108	4462	9570
26	5020	4395	9416
27	4974	4339	9313
28	4973	4306	9278
29	5015	4318	9333
30	5093	4365	9458
31	5215	4451	9666
32	5368	4580	9948
33	5538	4759	10297
34	5721	4957	10679
35	5949	5136	11085
36	6259	5306	11564
37	6622	5490	12113
38	7053	5705	12758
39	7537	5959	13496
40	8061	6245	14306
41	8576	6559	15136
42	9067	6888	15956
43	9467	7215	16681
44	**9680**	7518	17198
45	9632	7784	**17416**
46	9373	**7947**	17320
47	8977	7934	16911
48	8515	7762	16277
49	8045	7501	15546
50	7597	7183	14780
51	7177	6847	14024
52	6785	6515	13300
53	6423	6218	12640
54	6075	5940	12015
55	5749	5692	11441
56	5424	5449	10874
57	5085	5222	10306
58	4725	4980	9705
59	4368	4713	9081

Time (hr)	Flood Value (m^3/s)		
	SC-1 (Kamla)	SC2 (Kurung)	Total
60	4035	4428	8464
61	3725	4146	7871
62	3428	3875	7303
63	3159	3611	6770
64	2907	3358	6265
65	2669	3121	5790
66	2443	2894	5337
67	2235	2670	4905
68	2042	2454	4496
69	1865	2261	4126
70	1693	2081	3774
71	1530	1907	3438
72	1378	1746	3124
73	1239	1602	2841
74	1103	1471	2574
75	977	1341	2318
76	849	1216	2064
77	722	1099	1821
78	600	985	1586
79	503	879	1383
80	430	782	1213
81	387	698	1085
82	358	616	974
83	338	540	878
84	325	473	798
85	313	415	728
86	301	369	670
87	288	336	624
88	272	316	588
89	256	300	556
90	239	289	528
91	228	278	506
92	221	269	489
93	219	260	479
94	219	250	470
95	219	241	461
96	219	233	453
97	219	226	446
98	219	221	440
99	219	219	438

7.4.12 Design Flood for River Diversion Works

In general, it is not economical to design the diversion works for the greatest flood which is likely to occur. As per IS 14815:2000, the diversion design flood for concrete dams and barrages must be the higher of the following two values:

- Maximum non-monsoon (Oct – May) flow observed at the dam site
- 25 years non-monsoon flow, calculated on the basis of non-monsoon yearly peaks.

The design flood selected is usually a compromise between the cost of diversion works and the risk involved. In case of earth dams, overtopping of embankment during construction may result in extensive damage, whereas in concrete dams, overtopping may be tolerated to some extent if it results in minimal damages. As per IS 14815 – 2000, titled “Design flood for River Diversion Works – Guidelines”, the following factors should be considered interalia.

- The period of stoppage of work during flood season and number of flood seasons which are to be managed during the work.
- The cost of delay in completion of the work.

In addition to the above, the time required for all the activities to be completed in the riverbed (such as excavation, foundation treatment and concreting up to about the original riverbed level) plays an important role in selecting the diversion flood. If the aforesaid activities cannot be completed in one lean season, then higher flood must be considered for diversion.

The diversion flood studies for the project have been carried out for both non-monsoon and monsoon periods.

7.4.13 Data

At present, no observed flood peak data are available at the diversion site. However, flood peaks are available at Tamen G&D site which is about 3km downstream from the proposed diversion site. Therefore, it has been proposed to carry out the diversion flood studies at Tamen and transposed to the project site by Dicken’s formula

The extreme discharge data at Tamen is available for the period from 1980-81 to 2009-10 (with some gap years). However, the observed peak discharges possibly do not take into consideration discharge occurrences during the daily non-recorded hourly gauge observation. In view of this and to allow for possibility of floods due to uncertain hydro-meteorological conditions, the observed flood peaks have been increased by 20% to

obtain instantaneous peaks. Observed and instantaneous peaks at the Tamen G&D site are given in the following table.

Table 7-13: Observed and Instantaneous Peak Flows at Tamen

Period	Monsoon Peak Flows (m^3/s)	Instantaneous Monsoon Peak(m^3/s)	Non-Monsoon Peak Flows (m^3/s)	Instantaneous Non-Monsoon Peak(m^3/s)
1980-81	5376.16	6451.39	2649.78	3179.74
1981-82	2662.32	3194.78	1925.6	2310.72
1982-83	4988.05	5985.66	1933.19	2319.83
1983-84	3201.49	3841.79	2504.16	3004.99
1985-86	3179.65	3815.58	2431.31	2917.57
1986-87	2534.29	3041.15	1468.97	1762.76
1987-88	2811.39	3373.67	1633.97	1960.76
1988-89	2575.92	3091.10	2150.85	2581.02
1989-90	3962.58	4755.10	1650.51	1980.61
1990-91	2587.79	3105.35	2150.85	2581.02
1991-92	3894.58	4673.50	1007.64	1209.17
1992-93	1028.84	1234.61	979.05	1174.86
1995-96	3002.46	3602.95	3002.46	3602.95
1996-97	3927.41	4712.89	998.04	1197.65
1997-98	3072.48	3686.98	1623.86	1948.63
2000-01	5276.66	6331.99	2266.18	2719.42
2001-02	4774.58	5729.50	1909.14	2290.97
2002-03	4424.87	5309.84	2530.01	3036.01
2003-04	4968.12	5961.74	3505.34	4206.41
2004-05	4105.51	4926.61	2012.24	2414.69
2005-06	4533.44	5440.13	2342.34	2810.81
2006-07	3076.82	3692.18	1742.46	2090.95
2007-08	4598.32	5517.98	1867.1	2240.52
2008-09	5621.79	6746.15	2292.95	2751.54
2009-10	2960.14	3552.17	2349.87	2819.85

7.4.14 Statistical Parameters

Details of important statistical parameters for the flood peaks for the two different periods i.e., monsoon and non-monsoon (Oct-May) are given in the following table.

Table 7-14: Statistical Parameters of Peak Flows at Tamen

Parameters	Monsoon Period	Non-Monsoon Period (Oct-May)
Mean(X_m)	4470.99	2444.54
SD (Sx)	1362.50	719.78
Variance	1856413	518081
Skewness	-0.19	0.18
Kurtosis	-0.36	0.53
No. of Data	25	25

7.4.15 Flood Frequency Analysis

For estimating the 25-year return period flood, Extreme Value Type-I i.e., Gumbel, Log-Normal and Log Pearson Type-III distributions have been used to model the annual maximum monsoon and non-monsoon flows in the present study. The results of the analysis are shown in the table below and are also depicted in subsequent figures:

Table 7-15: Detail of 25 year Return Period Flood (m3/s)

Period	Log-Normal	Log-Pearson	Gumbel	Observed Maximum
Monsoon	8016	6453	7801	6746.15
Non-Monsoon	4101	3740	4206	4206.41

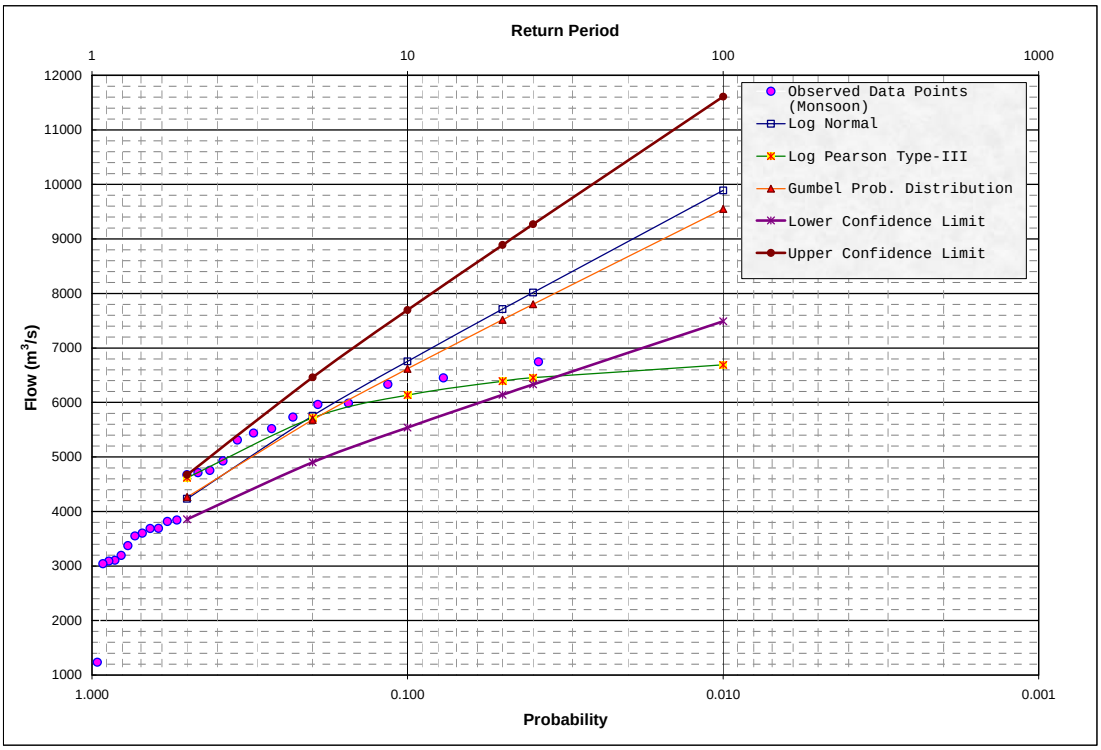


Figure 7-12: Plot of Monsoon Flood Frequency Analysis at Tamen

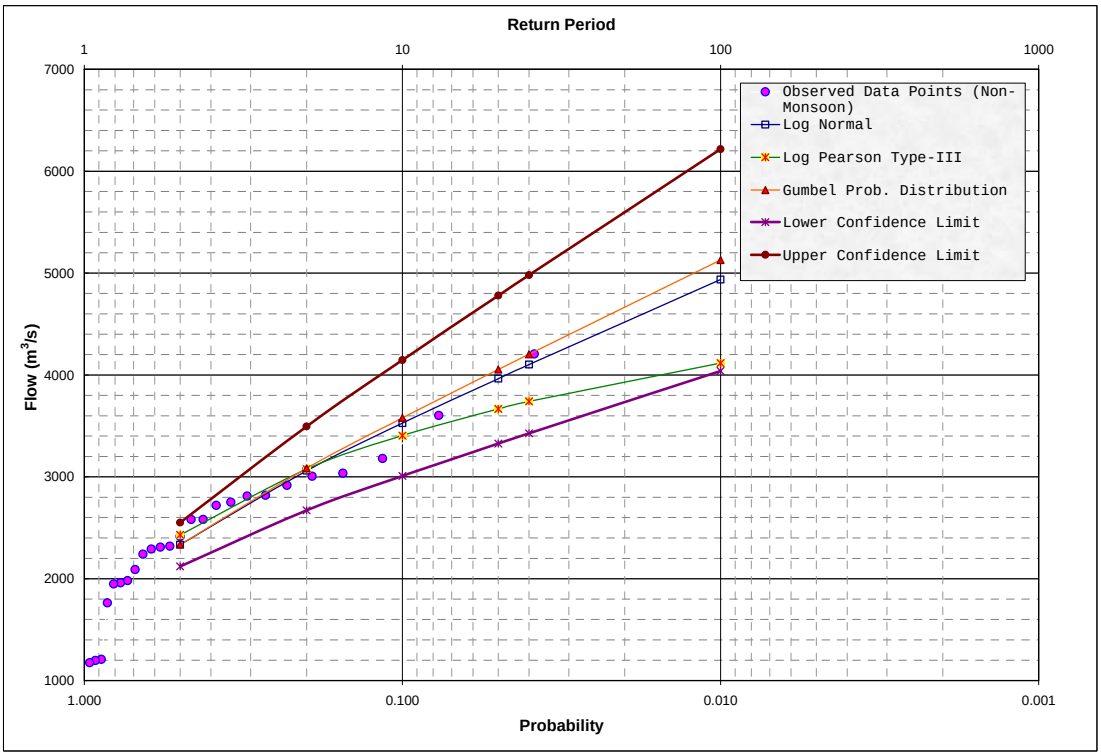


Figure 7-13: Plot of Non-monsoon Flood Frequency Analysis at Tamen

Based on the skewed nature and kurtosis of the data series, Gumbel distribution has been adopted for selecting the return period floods at Tamen G&D site.

7.4.16 Selection of Diversion Flood

The diversion flood values as computed are given in **Table 7-15.** Based on the criteria given by BIS, the diversion flood of 7801 m^3/s for monsoon period and 4206 m^3/s for non-monsoon period have been computed at Tamen.

Kamala HEP diversion site is about 3km upstream of the Tamen G&D site and there is very little variation in the catchment area of these two locations (about 5%). Therefore, it has been proposed to transpose the return period flood values by Dicken's formula as follows:

$$Q_S = Q_T * \left(\frac{A_T}{A_s} \right)^{0.75}$$

Where,

Q_s = Design flood at Kamala HEP

Q_T = Design flood at Tamen

A_S = Catchment Area at Kamala Project Site = 7213km^2

A_T = Catchment Area at Tamen = 7582km^2

Hence,

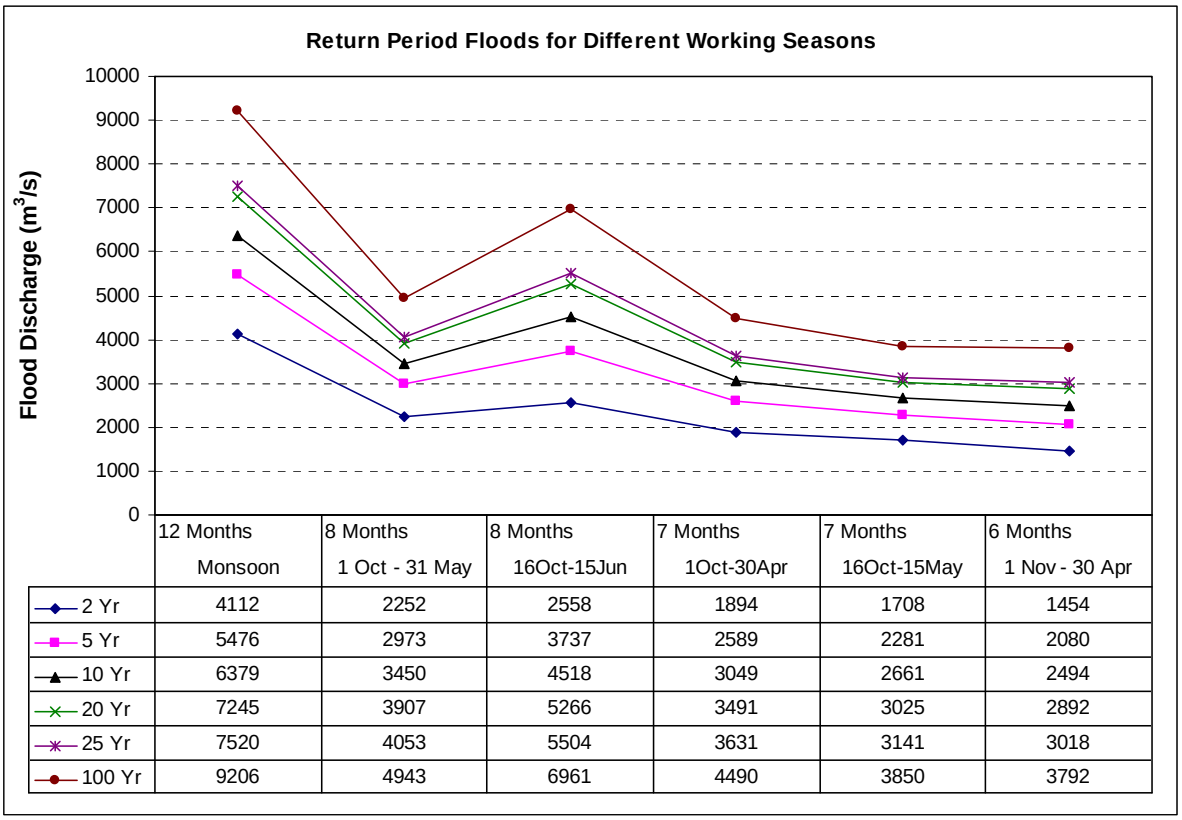
$Q_S = 0.964\ Q_T$

The 25-year return period flood values for dam site has been computed based on the above formula and are tabulated below:

Table 7-16: 25-Year Return Period Flood (m3/s) at Kamala HEP

Period	Tamen	Kamala HEP
Monsoon	7801	7520
Non-Monsoon	4206	4053

In addition to the above mentioned two working periods, frequency analysis for different working seasons have also been carried out and presented in **Figure 7-14**. The diversion floods can be finalized depending on the period of construction.



	12 Months Monsoon	8 Months 1 Oct - 31 May	8 Months 16Oct-15Jun	7 Months 1Oct-30Apr	7 Months 16Oct-15May	6 Months 1 Nov - 30 Apr
2 Yr	4112	2252	2558	1894	1708	1454
5 Yr	5476	2973	3737	2589	2281	2080
10 Yr	6379	3450	4518	3049	2661	2494
20 Yr	7245	3907	5266	3491	3025	2892
25 Yr	7520	4053	5504	3631	3141	3018
100 Yr	9206	4943	6961	4490	3850	3792

Figure 7-14: Return Period Flood for Different Working Seasons at Kamala HEP

7.5 Sedimentation

7.5.1 Need for Sediment Evaluation

Reservoir sedimentation studies are essential to assess the feasible/economic life of a reservoir. Himalayan rivers generally carry lot of suspended sediment load and when a dam is constructed across the river, it creates a reservoir which causes accumulation of sediment, as the suspended silt load settles down due to retardation effect produced by impoundment of water. This is a continuous phenomenon which is likely to have a negative impact on the intended purpose of the project. The sediment load does not settle down only in the dead storage area, it also encroaches the live storage area thus depleting the design capacity of the reservoir. Hence, it is essential to determine the volume of sediment accumulating along with its distribution at various levels so as to assess the adverse effect on the economic life of the reservoir.

As per BIS 12182:1987, the planning of Hydro-electric projects is done in such a way that full service life of the project should not be less than 25 years and feasible life shall not be less than 70 years.

7.5.2 Sediment Data

Due to non-availability of site specific long term data, total sediment rate of 1 mm/year (including bed load) as advised by CWC, has been adopted for Kamala hydroelectric project. The sediment rate of 1mm/year has also been considered by various in North-East region.

7.5.3 Reservoir Elevation-Area-Capacity

The reservoir elevation-area-capacity curves have been prepared from the area enclosed within the contours of 5m elevations. The volume between any two elevations is calculated using the cone formula:

$$V = H/3 * \left(A_1 + A_2 + \sqrt{A_1 A_2}\right)$$

Where,

V =Volume between two contours

H =Contour interval

A_1 =Area at level of first contour

A_2 =Area at level of second contour

The Elevation Area Capacity curve (before sedimentation) is given in **Figure 7-15.**

7.5.4 Trap Efficiency

With the sediment rate of 1mm/year, the total sediment inflow for the project is **7.213 MCM/year** (Catchment Area=7213 km^2). The trap efficiency of the reservoir, which is a function of capacity-inflow ratio, has been evaluated to determine the volume of sediment deposited in the reservoir. Brune's curve gives a good estimate of the trap efficiency of a reservoir and has been used in the present study. With Reservoir Capacity of 1927.62 MCM at FRL El 455.00m and Average Annual Inflow of 22672.3 MCM, the capacity-inflow ratio for Kamala hydroelectric project Reservoir is **0.085**. The trap efficiency, as per Brune's Normally Ponded curve, is nearly **82%**. Thus, the total volume of trapped sediment in the reservoir is **5.91MCM/yr** during the initial years. The trap efficiency of reservoir shall decrease with time with progressive sedimentation. The details of trap efficiency of the reservoir after different periods of sedimentation are presented in **Table 7-17.**

7.5.5 Classification of Sedimentation Problem

The sedimentation problem is usually said to be serious if the ratio of expected average annual sediment volume to the gross capacity of the reservoir is more than 0.5%. For Kamala hydroelectric project, the ratio is **0.37%**. Hence the sedimentation problem is said to be **"significant" but "not serious"**. The sedimentation studies have been carried out with **"Empirical Area Reduction"** method with progressive reduction of capacity for blocks of maximum 10 years.

7.5.6 Type and Shape of Reservoir

The reservoir operation for Kamala hydroelectric project shall be of Class-II, Moderate drawdown. The reservoir shape is determined with the depth-capacity curve and considering the sediment particle size. The weighted class of reservoir has been considered as **Type-II** (without sedimentation). The detail analysis of shape of reservoir has been given in Volume II of DPR.

Elevation	Area (Ha)	Capacity (MCM)
273.5	0.00	0.00
275	0.09	0.0005
280	2.13	0.04
285	11.15	0.35
290	28.73	1.31
295	67.49	3.65
300	101.21	7.84
305	133.33	13.68
310	183.58	21.57
315	232.66	31.95
320	275.78	44.65
325	336.47	59.93
330	393.28	78.16
335	463.53	99.55
340	543.64	124.70
345	619.23	153.76
350	685.96	186.37
355	777.32	222.93
360	859.83	263.84
365	926.00	308.48
370	1006.23	356.77
375	1100.86	409.43
380	1190.99	466.71
385	1285.44	528.60
390	1348.51	594.45
395	1428.45	663.86
400	1547.07	738.23
405	1652.21	818.20
410	1771.36	903.77
415	1900.47	995.55
420	1999.06	1093.02
425	2107.35	1195.67
430	2227.79	1304.04
435	2336.69	1418.14
440	2434.83	1537.42
445	2545.46	1661.91
450	2654.62	1791.91
455	2774.35	1927.62

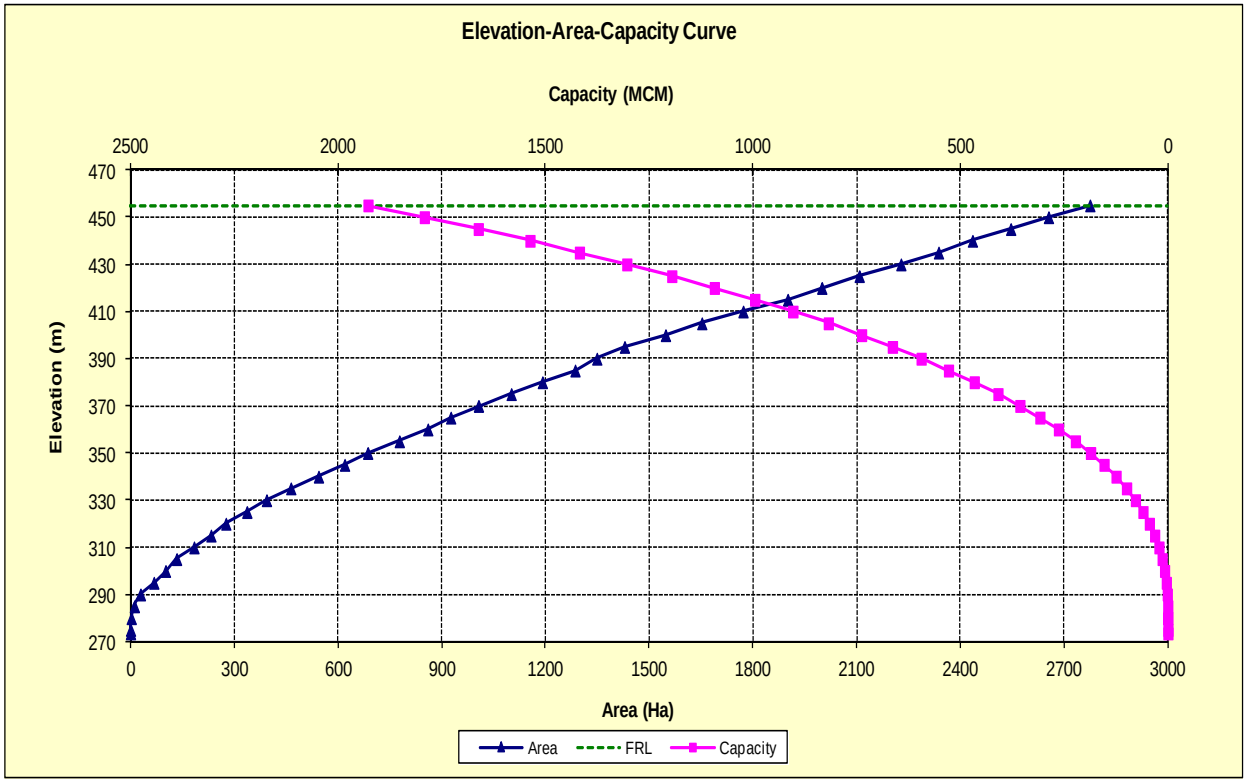


Figure 7-15: Elevation-Area-Capacity Curve of the Reservoir

7.5.7 Post Sedimentation Reservoir Capacity

The sediment accumulation, through different periods of time, has been calculated and distributed by applying the Empirical Area Reduction method. For each period, the new zero elevation is determined and the revised area and capacity after each block is considered as the initial reservoir area-capacity for the next block. Accordingly, the change in trap efficiency, initial capacity of reservoir and total accumulation of sediment volume after each block year has been considered. The details are given in **Table 7-17**.

Table 7-17: Reservoir Sediment Parameters after Different Periods of Simulation

Simulation Period (Yrs)	Capacity (MCM)	Capacity-Inflow Ratio	Reservoir Trap Efficiency (%)	Yearly Sediment Trapped (MCM)	Total Sediment Accumulation (MCM)
0-10	1927.62	0.085	82.0%	5.915	59.15
10-20	1868.47	0.082	81.1%	5.850	58.50
20-25	1809.98	0.080	80.5%	5.806	29.03
25-30	1780.94	0.079	80.2%	5.785	28.92
30-40	1752.02	0.077	80.0%	5.770	57.70
40-50	1694.32	0.075	79.5%	5.734	57.34
50-60	1636.97	0.072	79.0%	5.698	56.98
60-70	1579.99	0.070	78.8%	5.680	56.80
70-75	1523.19	0.067	78.5%	5.662	28.31
75-80	1494.88	0.066	78.0%	5.626	28.13
80-90	1466.75	0.065	77.5%	5.590	55.90
90-100	1410.84	0.062	77.4%	5.583	55.83

The summary of Area-Capacity after different periods of reservoir simulation is given in Table 7-18.

Table 7-18: Summary of Post Sedimentation Area-Capacity

Area-Capacity after 10 yrs			Area-Capacity after 20 yrs			Area-Capacity after 25 yrs		
Elevation	**Area**	**Capacity**	**Elevation**	**Area**	**Capacity**	**Elevation**	**Area**	**Capacity**
m	**km^2**	**MCM**	**m**	**km^2**	**MCM**	**m**	**km^2**	**MCM**
455.00	**27.74**	**1868.458**	**455.00**	**27.74**	**1809.91**	**455.00**	**27.74**	**1780.86**
450.00	26.36	1733.215	450.00	26.16	1675.18	450.00	26.05	1646.38
445.00	25.21	1604.298	445.00	24.95	1547.43	445.00	24.81	1519.23
440.00	24.07	1481.117	440.00	23.76	1425.68	440.00	23.60	1398.20
435.00	23.05	1363.327	435.00	22.72	1309.50	435.00	22.54	1282.85
430.00	21.94	1250.850	430.00	21.58	1198.77	430.00	21.39	1173.02
425.00	20.72	1144.217	425.00	20.33	1094.01	425.00	20.14	1069.21
420.00	19.62	1043.389	420.00	19.22	995.14	420.00	19.01	971.34
415.00	18.62	947.805	415.00	18.21	901.59	415.00	18.00	878.83
410.00	17.32	857.983	410.00	16.89	813.86	410.00	16.68	792.17
405.00	16.12	774.414	405.00	15.68	732.44	405.00	15.46	711.83
400.00	15.06	696.489	400.00	14.62	656.69	400.00	14.40	637.19
395.00	13.87	624.194	395.00	13.42	586.60	395.00	13.20	568.23
390.00	13.06	556.875	390.00	12.62	521.51	390.00	12.39	504.26
385.00	12.43	493.143	385.00	11.98	460.01	385.00	11.76	443.89
380.00	11.49	433.365	380.00	11.04	402.46	380.00	10.81	387.48
375.00	10.58	378.203	375.00	10.14	349.52	375.00	9.92	335.67
370.00	9.64	327.658	370.00	9.20	301.19	370.00	8.98	288.45
365.00	8.84	281.469	365.00	8.41	257.19	365.00	8.19	245.55
360.00	8.18	238.919	360.00	7.76	216.80	360.00	7.54	206.25
355.00	7.36	200.070	355.00	6.94	180.07	355.00	6.73	170.59
350.00	6.46	165.544	350.00	6.05	147.62	350.00	5.84	139.18
345.00	5.80	134.925	345.00	5.40	119.02	345.00	5.20	111.60
340.00	5.05	107.829	340.00	4.66	93.89	340.00	4.47	87.45
335.00	4.26	84.583	335.00	3.89	72.53	335.00	3.70	67.04
330.00	3.57	65.039	330.00	3.21	54.80	330.00	3.04	50.21
325.00	3.01	48.603	325.00	2.68	40.09	325.00	2.51	36.35
320.00	2.42	35.043	320.00	2.11	28.16	320.00	1.95	25.21
315.00	2.01	23.989	315.00	1.72	18.62	315.00	1.58	16.41
310.00	1.53	15.164	310.00	1.27	11.18	310.00	1.14	9.64
305.00	1.05	8.737	305.00	0.82	6.00	305.00	0.71	5.04
300.00	0.75	4.243	300.00	0.56	2.57	300.00	0.47	2.10
295.00	0.44	1.287	295.00	0.29	0.48	295.00	0.23	0.38
290.00	0.08	0.085	**290.04**	**0.00**	**0.00**	**290.16**	**0.00**	**0.00**
287.00	**0.00**	**0.000**						

Area-Capacity after 30 yrs		
Elevation	**Area**	**Capacity**
m	**km^2**	**MCM**
455.00	**27.74**	**1751.93**
450.00	25.95	1617.72
445.00	24.68	1491.16
440.00	23.45	1370.86
435.00	22.37	1256.32
430.00	21.21	1147.39
425.00	19.94	1044.52
420.00	18.81	947.65
415.00	17.79	856.17
410.00	16.46	770.57
405.00	15.25	691.32
400.00	14.17	617.79
395.00	12.97	549.94
390.00	12.17	487.10
385.00	11.53	427.86
380.00	10.59	372.57
375.00	9.69	321.88
370.00	8.76	275.78
365.00	7.97	233.98
360.00	7.32	195.76
355.00	6.52	161.16
350.00	5.64	130.80
345.00	5.00	104.22
340.00	4.28	81.05
335.00	3.52	61.58
330.00	2.86	45.64
325.00	2.35	32.63
320.00	1.80	22.29
315.00	1.44	14.22
310.00	1.02	8.11
305.00	0.60	4.09
300.00	0.39	1.64
295.00	0.18	0.27
290.36	**0.00**	**0.00**

Area-Capacity after 40 yrs		
Elevation	**Area**	**Capacity**
m	**km^2**	**MCM**
455.00	**27.74**	**1694.23**
450.00	25.75	1560.54
445.00	24.41	1435.16
440.00	23.14	1316.31
435.00	22.03	1203.41
430.00	20.84	1096.26
425.00	19.55	995.29
420.00	18.41	900.40
415.00	17.37	810.98
410.00	16.03	727.51
405.00	14.81	650.43
400.00	13.73	579.10
395.00	12.53	513.48
390.00	11.72	452.88
385.00	11.08	395.89
380.00	10.14	342.85
375.00	9.25	294.41
370.00	8.31	250.52
365.00	7.53	210.92
360.00	6.90	174.87
355.00	6.10	142.39
350.00	5.23	114.09
345.00	4.60	89.53
340.00	3.90	68.30
335.00	3.15	50.71
330.00	2.52	36.56
325.00	2.02	25.24
320.00	1.50	16.48
315.00	1.16	9.86
310.00	0.77	5.07
305.00	0.39	2.21
300.00	0.22	0.71
295.00	0.06	0.06
292.08	**0.00**	**0.00**

Area-Capacity after 50 yrs		
Elevation	**Area**	**Capacity**
m	**km^2**	**MCM**
455.00	**27.74**	**1636.88**
450.00	25.54	1503.72
445.00	24.14	1379.54
440.00	22.82	1262.15
435.00	21.68	1150.90
430.00	20.47	1045.54
425.00	19.16	946.48
420.00	18.00	853.59
415.00	16.94	766.25
410.00	15.60	684.91
405.00	14.37	610.01
400.00	13.28	540.90
395.00	12.08	477.52
390.00	11.26	419.18
385.00	10.63	364.45
380.00	9.69	313.67
375.00	8.80	267.47
370.00	7.87	225.81
365.00	7.10	188.41
360.00	6.47	154.52
355.00	5.68	124.16
350.00	4.82	97.93
345.00	4.21	75.38
340.00	3.52	56.09
335.00	2.79	40.35
330.00	2.17	27.98
325.00	1.70	18.32
320.00	1.20	11.12
315.00	0.89	5.93
310.00	0.53	2.41
305.00	0.19	0.67
300.00	0.06	0.07
296.71	**0.00**	**0.00**

Area-Capacity after 60 yrs		
Elevation	**Area**	**Capacity**
m	**km^2**	**MCM**
455.00	**27.74**	**1579.85**
450.00	25.32	1447.23
445.00	23.86	1324.30
440.00	22.50	1208.42
435.00	21.33	1098.87
430.00	20.08	995.36
425.00	18.76	898.28
420.00	17.58	807.46
415.00	16.51	722.26
410.00	15.16	643.12
405.00	13.91	570.47
400.00	12.83	503.63
395.00	11.62	442.55
390.00	10.80	386.53
385.00	10.17	334.11
380.00	9.23	285.64
375.00	8.34	241.74
370.00	7.42	202.35
365.00	6.65	167.19
360.00	6.03	135.48
355.00	5.26	107.27
350.00	4.41	83.13
345.00	3.81	62.59
340.00	3.14	45.23
335.00	2.43	31.34
330.00	1.84	20.70
325.00	1.39	12.67
320.00	0.91	6.96
315.00	0.64	3.11
310.00	0.32	0.75
305.00	0.03	0.02
303.13	**0.00**	**0.00**

Area-Capacity after 70 yrs		
Elevation	**Area**	**Capacity**
m	**km^2**	**MCM**
455.00	**27.74**	**1523.07**
450.00	25.10	1391.02
445.00	23.56	1269.39
440.00	22.16	1155.11
435.00	20.95	1047.36
430.00	19.68	945.80
425.00	18.33	850.78
420.00	17.13	762.13
415.00	16.05	679.17
410.00	14.69	602.34
405.00	13.44	532.03
400.00	12.35	467.58
395.00	11.13	408.89
390.00	10.32	355.27
385.00	9.69	305.26
380.00	8.75	259.18
375.00	7.87	217.63
370.00	6.96	180.58
365.00	6.20	147.70
360.00	5.59	118.24
355.00	4.83	92.20
350.00	4.00	70.16
345.00	3.42	51.63
340.00	2.77	36.19
335.00	2.08	24.11
330.00	1.51	15.15
325.00	1.10	8.66
320.00	0.66	4.32
315.00	0.42	1.63
310.00	0.16	0.20
306.27	**0.00**	**0.00**

Area-Capacity after 75 yrs		
Elevation	**Area**	**Capacity**
m	**km^2**	**MCM**
455.00	**27.74**	**1494.73**
450.00	24.98	1362.99
445.00	23.41	1242.03
440.00	21.98	1128.56
435.00	20.76	1021.73
430.00	19.47	921.17
425.00	18.12	827.22
420.00	16.91	739.68
415.00	15.82	657.87
410.00	14.45	582.21
405.00	13.20	513.10
400.00	12.10	449.86
395.00	10.89	392.40
390.00	10.08	340.00
385.00	9.44	291.21
380.00	8.51	246.34
375.00	7.63	205.99
370.00	6.72	170.12
365.00	5.97	138.40
360.00	5.37	110.06
355.00	4.62	85.12
350.00	3.79	64.12
345.00	3.22	46.60
340.00	2.58	32.12
335.00	1.91	20.92
330.00	1.36	12.79
325.00	0.96	7.03
320.00	0.54	3.33
315.00	0.33	1.17
310.00	0.11	0.12
306.60	**0.00**	**0.00**

Area-Capacity after 80 yrs			Area-Capacity after 90 yrs			Area-Capacity after 100 yrs		
Elevation	**Area**	**Capacity**	**Elevation**	**Area**	**Capacity**	**Elevation**	**Area**	**Capacity**
m	**km^2**	**MCM**	**m**	**km^2**	**MCM**	**m**	**km^2**	**MCM**
455.00	**27.74**	**1466.60**	**455.00**	**27.74**	**1410.75**	**455.00**	**27.74**	**1354.90**
450.00	24.86	1335.14	450.00	24.63	1279.88	450.00	24.39	1224.66
445.00	23.26	1214.85	445.00	22.96	1160.93	445.00	22.64	1107.10
440.00	21.81	1102.20	440.00	21.46	1049.91	440.00	21.09	997.78
435.00	20.56	996.29	435.00	20.18	945.83	435.00	19.78	895.62
430.00	19.27	896.72	430.00	18.86	848.25	430.00	18.43	800.12
425.00	17.90	803.83	425.00	17.47	757.47	425.00	17.01	711.54
420.00	16.68	717.39	420.00	16.23	673.24	420.00	15.76	629.61
415.00	15.59	636.72	415.00	15.13	594.86	415.00	14.65	553.60
410.00	14.22	562.23	410.00	13.74	522.71	410.00	13.25	483.89
405.00	12.96	494.32	405.00	12.48	457.18	405.00	11.98	420.84
400.00	11.86	432.28	400.00	11.38	397.56	400.00	10.88	363.71
395.00	10.65	376.04	395.00	10.16	343.75	395.00	9.66	312.41
390.00	9.83	324.86	390.00	9.35	295.00	390.00	8.84	266.18
385.00	9.20	277.28	385.00	8.72	249.85	385.00	8.22	223.52
380.00	8.27	233.62	380.00	7.79	208.59	380.00	7.30	184.74
375.00	7.40	194.47	375.00	6.92	171.82	375.00	6.44	150.41
370.00	6.49	159.77	370.00	6.03	139.47	370.00	5.56	120.45
365.00	5.74	129.20	365.00	5.29	111.19	365.00	4.83	94.50
360.00	5.15	101.98	360.00	4.71	86.20	360.00	4.27	71.77
355.00	4.41	78.12	355.00	3.98	64.49	355.00	3.56	52.24
350.00	3.59	58.17	350.00	3.18	46.62	350.00	2.78	36.45
345.00	3.03	41.65	345.00	2.64	32.08	345.00	2.26	23.87
340.00	2.40	28.10	340.00	2.04	20.41	340.00	1.69	14.04
335.00	1.74	17.79	335.00	1.41	11.84	335.00	1.09	7.16
330.00	1.20	10.46	330.00	0.90	6.12	330.00	0.62	2.96
325.00	0.82	5.43	325.00	0.55	2.53	325.00	0.31	0.68
320.00	0.43	2.37	320.00	0.20	0.72	320.00	0.02	0.01
315.00	0.24	0.72	315.00	0.07	0.07	**318.67**	**0.00**	**0.00**
310.00	0.05	0.05	**312.11**	**0.00**	**0.00**			
307.33	**0.00**	**0.00**						

Expected changes in zero elevation and reservoir capacity with time after different periods of reservoir simulation are given in **Figure 7-16** and **Figure 7-17**, respectively.

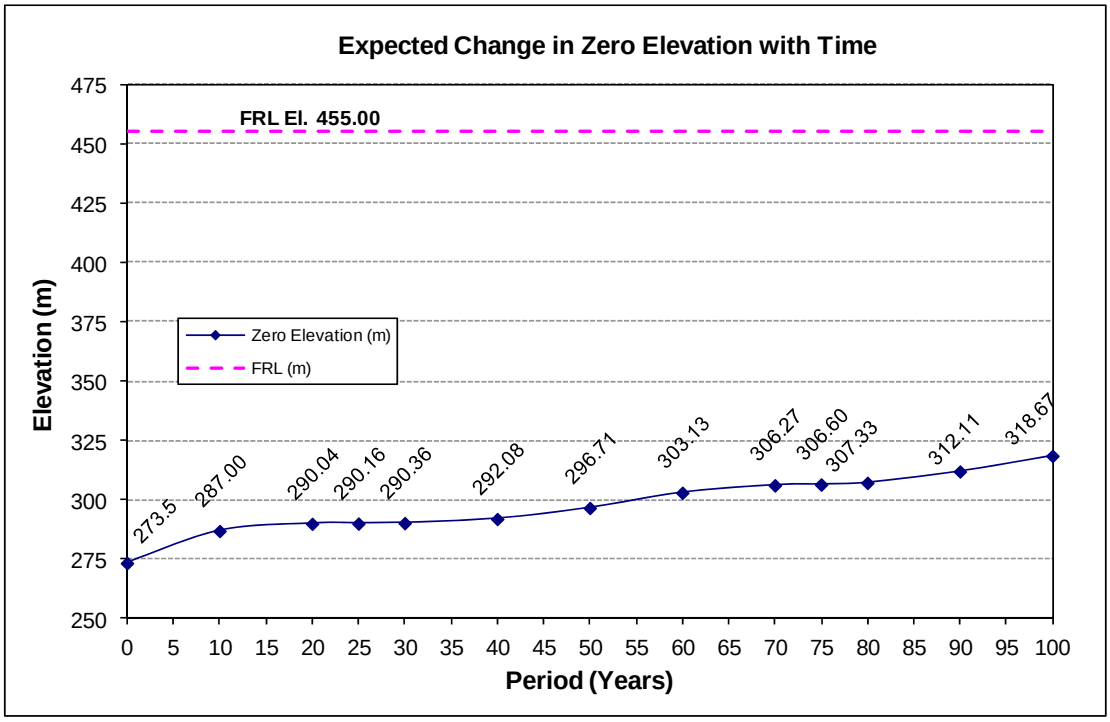


Figure 7-16: Expected Change in Zero Elevation with Time

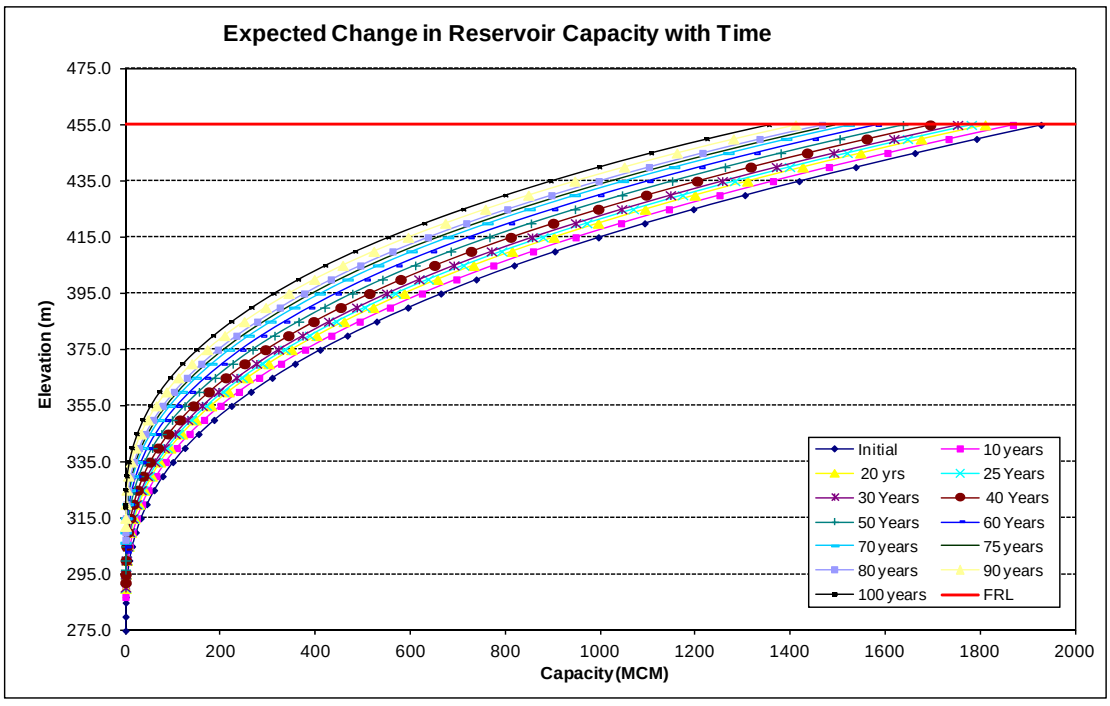


Figure 7-17: Expected Change in Reservoir Capacity with Time

A comparison of Pre-Sedimentation and Post-Sedimentation Area-Capacity profiles of the reservoir has been given in **Figure 7-18**.

CEA/CWC has already given the concurrence for the Sedimentation studies.

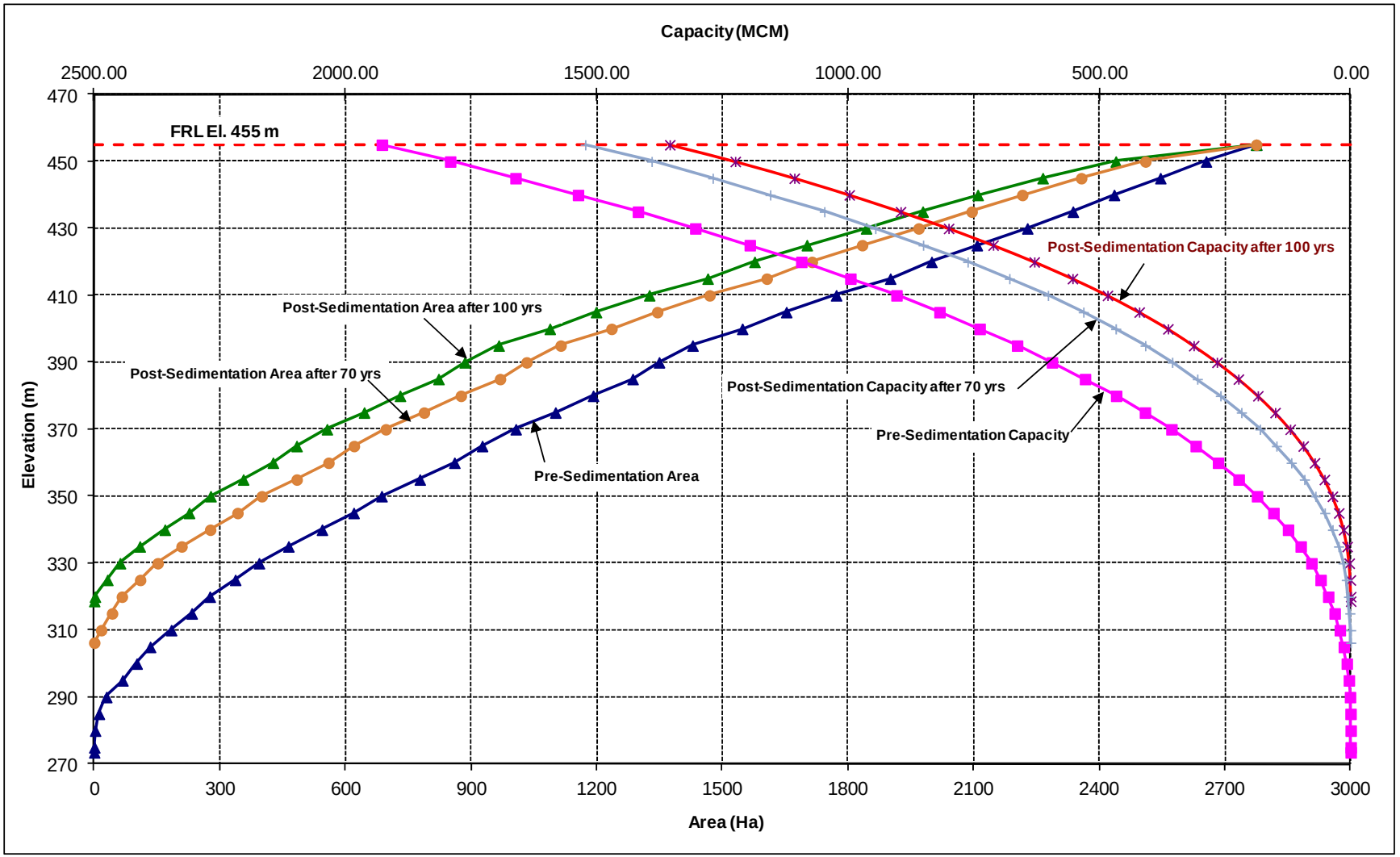
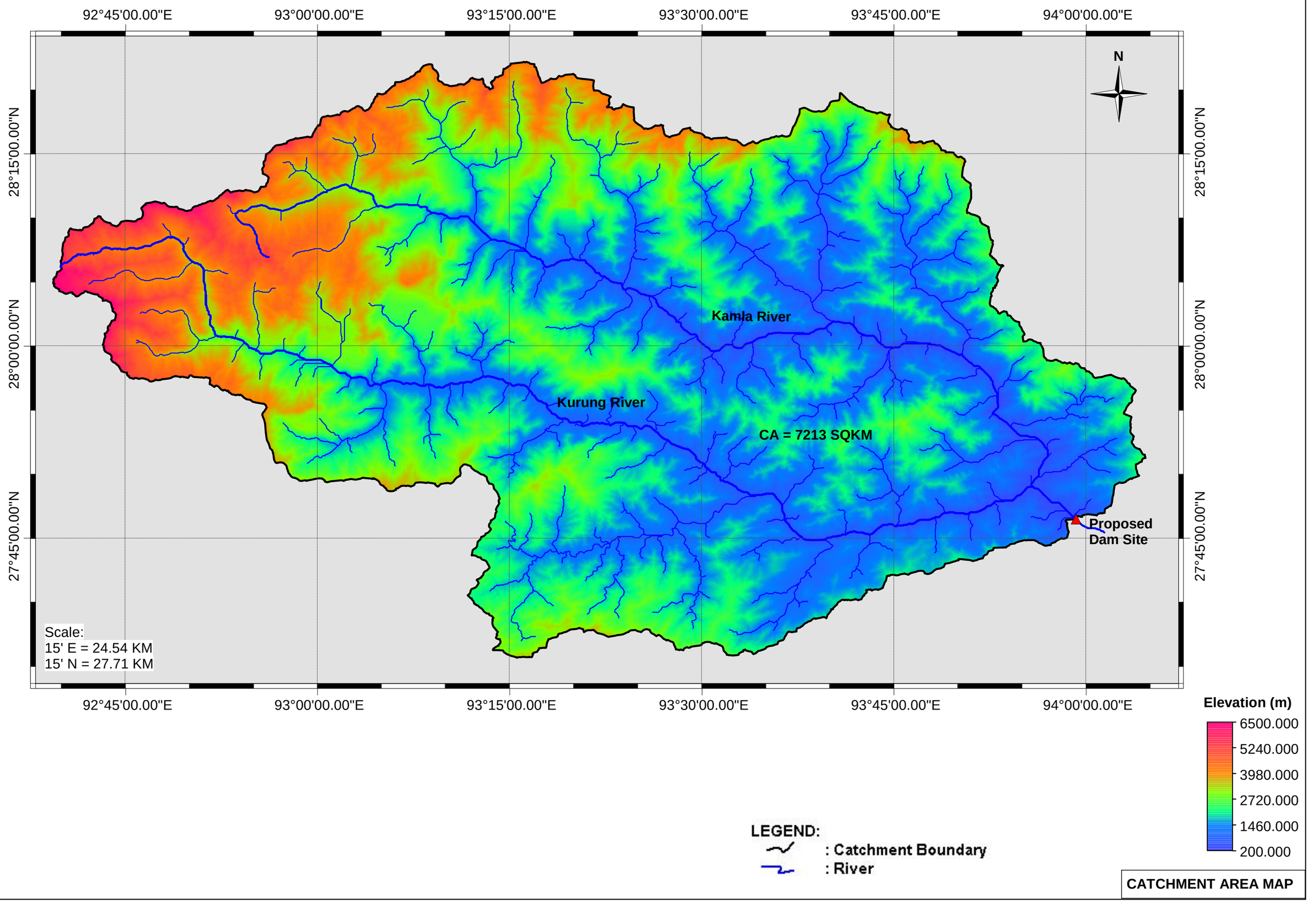


Figure 7-18: Reservoir Area-Capacity - Pre-Sedimentation and Post-Sedimentation Profiles

PLATES

PLATE 7-1



CATCHMENT AREA MAP

PLATE 7-2

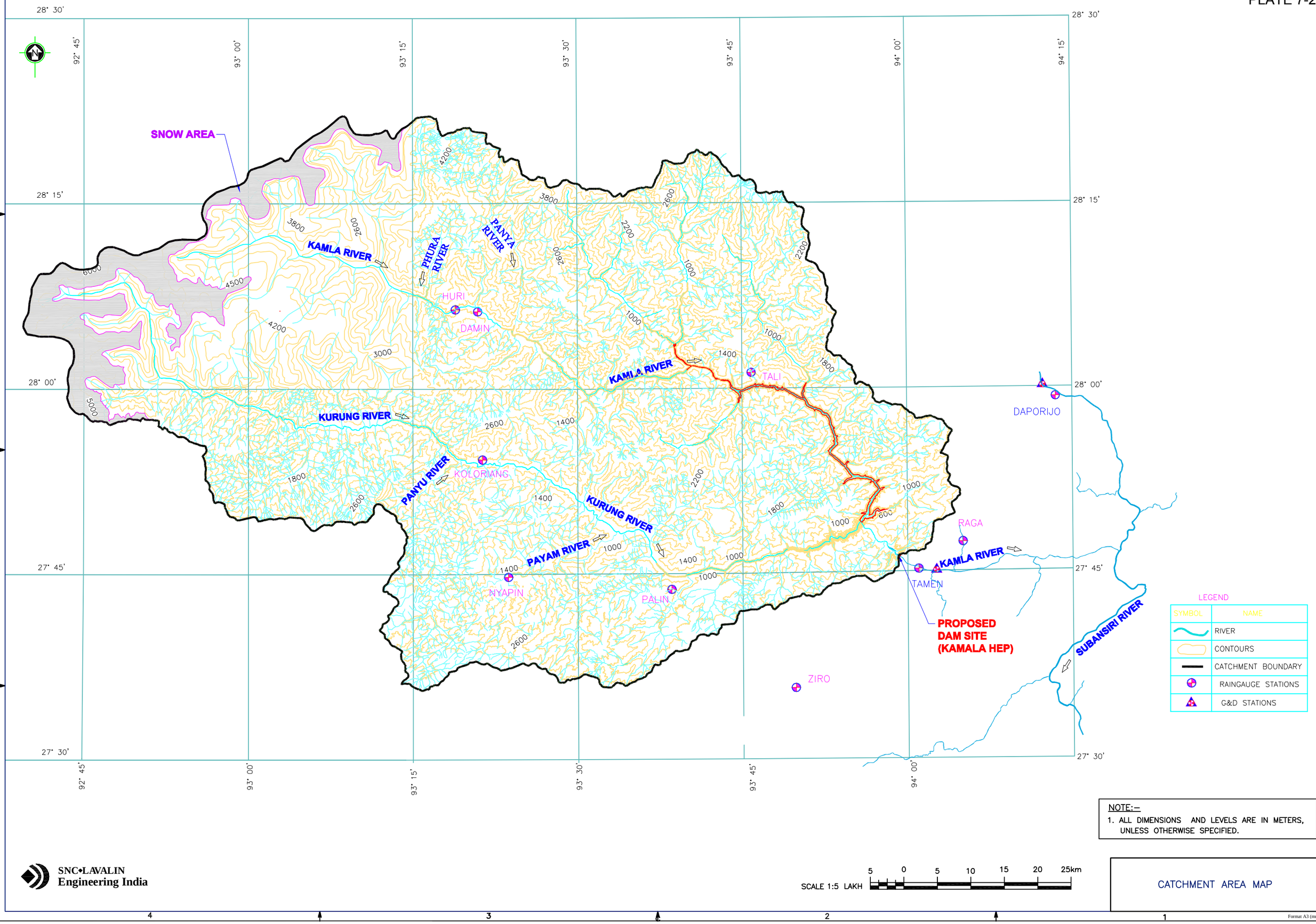
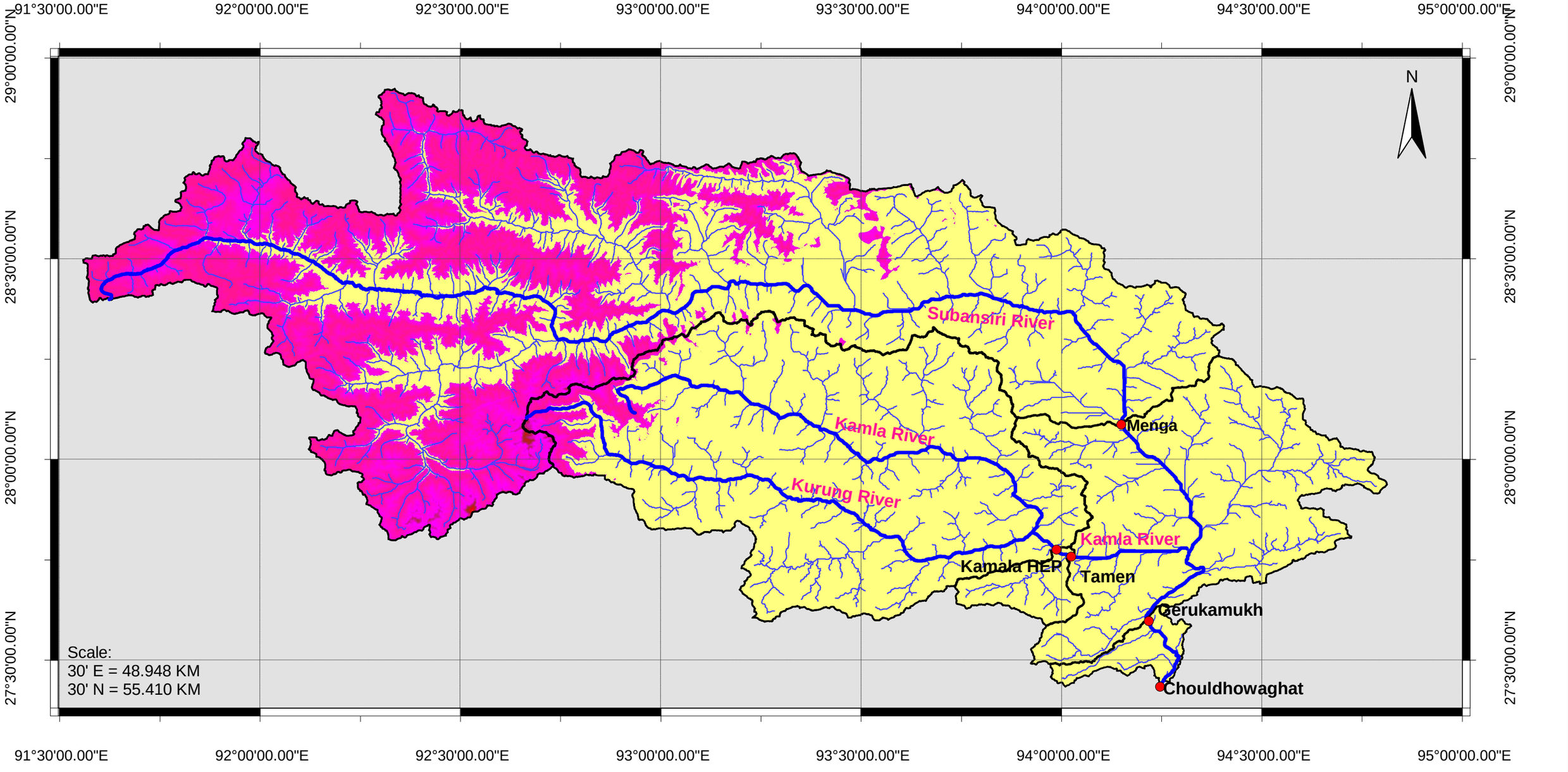

28° 30'
92° 45'
93° 00'
93° 15'
93° 30'
93° 45'
94° 00'
94° 15'
28° 15'
28° 00'
27° 45'
27° 30'
SNOW AREA
KAMLA RIVER
PHURA RIVER
PANYA RIVER
KURUNG RIVER
PANYU RIVER
PAYAM RIVER
KAMLA RIVER
SUBANSIRI RIVER
HURI
DAMIN
TALI
DAPORIJO
KOLORIANG
NYAPIN
PALIN
ZIRO
RAGA
TAMEN
PROPOSED DAM SITE (KAMALA HEP)
6000
5000
4500
4200
3800
3000
2600
2200
1800
1400
1000
800
LEGEND
SYMBOL
NAME
RIVER
CONTOURS
CATCHMENT BOUNDARY
RAINGAUGE STATIONS
G&D STATIONS
NOTE:–
1. ALL DIMENSIONS AND LEVELS ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
SNC•LAVALIN
Engineering India
SCALE 1:5 LAKH
5 0 5 10 15 20 25km
CATCHMENT AREA MAP
Format A3 (mm)

PLATE 7-3

CATCHMENT AREA MAP



Catchment Area Details

Chouldhowaghat = 26364 sqkm

Gerukamukh = 26055 sqkm

Menga = 14642 sqkm

Tamen = 7582 sqkm

Kamala HEP = 7213 sqkm

LEGEND:

: Catchment Boundary

: River

: Catchment Area Below EL. 4500m

: Catchment Area Above EL. 4500m

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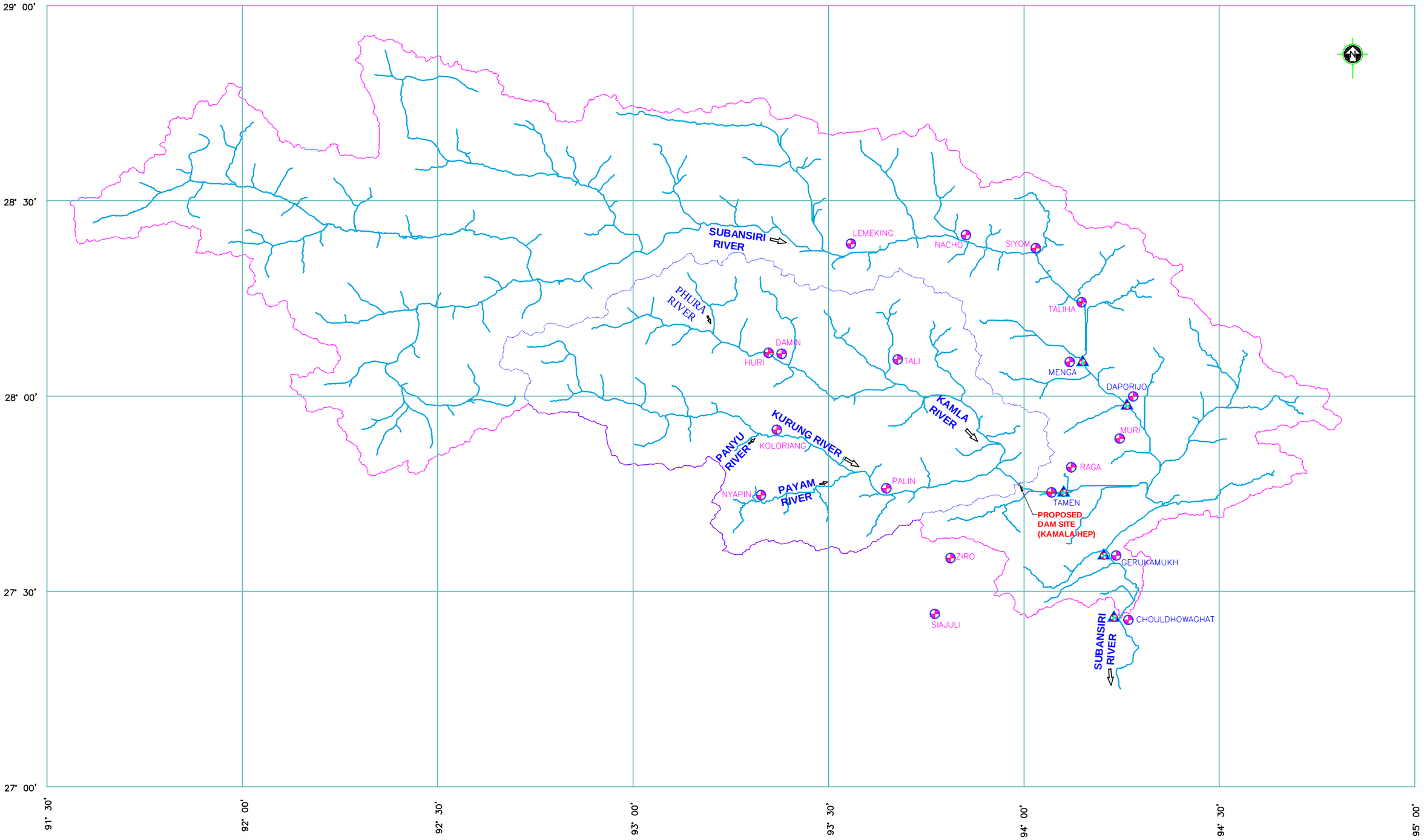
PLATE 7-4



LEGEND

SYMBOL	NAME
	RIVER
	CATCHMENT BOUNDARY
	RAINGAUGE STATIONS
	G&D STATIONS

SCALE
30' E = 48.948 KM
30' N = 55.410 KM

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LOCATION OF HYDRO–METEOROLOGICAL AND G & D STATIONS OF SUBANSIRI BASIN

Kandarij

Format A3 (mm)

CHAPTER 8
RESERVOIR

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8 RESERVOIR

8.1 General

Kamala (formerly Subansiri Middle) hydroelectric project is one the three large hydroelectric projects that are being developed in the Subansiri sub-basin of the Brahmaputra river. The project is located on Kamla river, a major tributary of Subansiri; the other two projects in the Subansiri basin, namely the Subansiri Lower and Subansiri Upper projects, are located on the Subansiri river. In addition to power generation, Subansiri Upper and Kamala HEP's are envisaged to provide flood relief in the Brahmaputra valley through integrated operation of their reservoirs.

8.2 Reservoir Characteristics

Kamala HEP envisages construction of a 216m high conventional concrete gravity dam across river Kamla. The reservoir thus created shall be spread over length of around 65 km at FRL (El. 455m) and 67km at MWL (El. 470m) along river Kamla.

The reservoir elevation-area-capacity curve has been prepared from the area enclosed within the contours of 5m elevations. The volume between any two elevations is calculated using the cone formula:

$$V = {}^{H}\!/_{3} * \left(A_1 + A_2 + \sqrt{A_1 A_2}\right)$$

Where,

V =Volume between two elevations

H =Contour interval

A_1 =Area at level of first contour

A_2 =Area at level of second contour

The salient features of the reservoir are listed below.

Dam Site Coordinates	:	27º46'18"N, 93º59'19"E
Reservoir Length	:	
- at MWL	:	67km along river Kamla
		18.8km along river Kurung

- at FRL	:	65km along river Kamla 17km along river Kurung
Submergence Area		
- at MWL	:	3075 Ha
- at FRL	:	2775 Ha
Gross Storage		
- at MWL	:	2365.70 MCM
- at FRL	:	1927.62 MCM
- at MDDL	:	1304.04 MCM
Live Storage	:	623.58 MCM

8.3 Reservoir Routing Studies

In order to finalize the various project parameters, like reservoir operation rule curve, releases from the Kamala reservoir etc., CWC vide its letter no. 2/18/2011/CMDD(E&NE)/35 requested to carry out reservoir routing studies for Kamala hydroelectric project. Along with its letter, CWC also forwarded the Integrated Flood Moderation Study Report prepared by NHPC in October 2005. A copy of letter is enclosed as Annexure 2-2 in Volume-IV of DPR.

8.3.1 Flood Moderation Criteria

Perusal of the available documents revealed that the requirement of flood moderation in the Subansiri basin as contemplated by various government agencies entailed the following two basic criteria:

1) That same flood moderation should be available throughout the monsoon period: This is indicated in the Minutes of Fourth (last) meeting of "Technical Group on Flood Moderation Aspects in Brahmaputra Basin" held on 30th Dec 2005 and states that the reservoirs should be operated in such a manner that flood moderation achieved in the months of June-July will also be available in September-October.

2) That the release downstream of Lower Subansiri dam should not exceed 7000 cumec: This requirement is spelt out in Brahmaputra Board's letter no. BB/CE(P&D)PR-04/01(Pt-1)/117 dated March 6th, 2006 addressed to the Chairman of the Technical Group on Flood Moderation Aspects in Brahmaputra Basin. The letter

states that “With improvement of the existing embankment system making it capable of providing assured flood protection, the safe release from the lower dam may be increased to some extent. For optimization of both the benefits from the system, i.e. power generation and flood moderation, it is the considered opinion of the Board that safe release may be increased, but in no case, it should be allowed to exceed 7000 cumec.” Considering that Lower Subansiri reservoir has minimal storage for flood moderation, it is clear that the flows reaching Lower Subansiri dam should be limited to 7000 cumec.

The first criterion dictates that the upstream reservoirs (Kamala and Upper Subansiri) should be operated at a constant level throughout the monsoon months to achieve same flood moderation.

The second criterion puts a restriction on the release from the upper two projects (Kamala and Upper Subansiri) so as the combined discharge (including the intermediate catchment) does not exceed maximum permissible release downstream of Lower Subansiri. This release from the two projects depends upon the physiographic characteristics of the upper, middle and intermediate catchments as well as flood cushions provided at the two projects.

8.3.2 Parametric Reservoir Routing Studies

As spelt in CWC’s letter referred earlier, the parameters to be considered for reservoir routing studies viz. flood cushion, flood impingement levels and release were to be taken as per NHPC report. The parameters that were required to be considered while performing the studies are given as under:

- Flood cushion of 15m above FRL for Kamala dam
- Flood Impingement levels according to reservoir regulation with reservoir level varying from El 431m to El 460m during the period June to October.
- 100 year and 25 year flood hydrographs.
- Constant release of 1000, 1250, 1500, 2000, 2500 and 3000 cumec during the occurrence of 100 year and 25 year floods at Kamala project site.

Summary of results of reservoir routing studies for 100 yrs and 25 yrs flood is given in **Table 8-1** and **Table 8-2**, respectively.

Table 8-1: Summary of Results – 100 year Flood Routing

Period		Impingement Level (m)	Maximum Reservoir Level (m) Attained corresponding to Constant Release (cumec)					
			1000	1250	1500	2000	2500	3000
JUN	I	431.00	**466.57**	464.60	462.68	458.99	455.48	**452.10**
	II	431.00	466.57	464.60	462.68	458.99	455.48	452.10
	III	431.00	466.57	464.60	462.68	458.99	455.48	452.10
JUL	I	431.00	466.57	464.60	462.68	458.99	455.48	452.10
	II	431.00	466.57	464.60	462.68	458.99	455.48	452.10
	III	431.00	466.57	464.60	462.68	458.99	455.48	452.10
AUG	I	443.00	475.77	473.92	472.12	468.66	465.38	462.25
	II	448.00	479.71	477.91	476.16	472.80	469.61	466.57
	III	454.00	484.53	482.78	481.08	477.83	474.75	471.82
SEP	I	454.00	484.53	482.78	481.08	477.83	474.75	471.82
	II	456.00	486.16	484.42	482.74	479.53	476.49	473.58
	III	456.00	486.16	484.42	482.74	479.53	476.49	473.58
OCT	I	458.00	487.80	486.08	484.42	481.24	478.23	475.36
	II	458.00	487.80	486.08	484.42	481.24	478.23	475.36
	III	460.00	**489.44**	487.73	486.08	482.93	479.96	**477.12**

Table 8-2: Summary of Results – 25 year Flood Routing

Period		Impingement Level (m)	Maximum Reservoir Level (m) Attained corresponding to Constant Release (cumec)					
			1000	1250	1500	2000	2500	3000
JUN	I	431.00	**459.25**	457.26	455.33	451.66	448.18	**444.86**
	II	431.00	459.25	457.26	455.33	451.66	448.18	444.86
	III	431.00	459.25	457.26	455.33	451.66	448.18	444.86
JUL	I	431.00	459.25	457.26	455.33	451.66	448.18	444.86
	II	431.00	459.25	457.26	455.33	451.66	448.18	444.86
	III	431.00	459.25	457.26	455.33	451.66	448.18	444.86
AUG	I	443.00	468.91	467.04	465.25	461.84	458.63	455.58
	II	448.00	473.03	471.22	469.48	466.16	463.05	460.10
	III	454.00	478.06	476.31	474.63	471.43	468.42	465.59
SEP	I	454.00	478.06	476.31	474.63	471.43	468.42	465.59
	II	456.00	479.76	478.03	476.36	473.20	470.23	467.43
	III	456.00	479.76	478.03	476.36	473.20	470.23	467.43
OCT	I	458.00	481.46	479.75	478.11	474.98	472.05	469.28
	II	458.00	481.46	479.75	478.11	474.98	472.05	469.28
	III	460.00	**483.15**	481.46	479.84	476.75	473.85	**471.11**

Following are the key results:

- During occurrence of 100 yrs return period flood, the maximum water level achieved varies from El 489.44m to El 477.12m corresponding to constant downstream releases of 1000 cumec and 3000 cumec, respectively. For keeping the maximum water level at El 475m i.e. within flood cushion of 15m above El 460m, it was seen that constant release of about 3400 cumec would be required when the reservoir impingement level is El 460m.
- During occurrence of 25 yrs return period flood, the maximum water level achieved varies from El 483.15m to El 471.11m corresponding to constant downstream releases of 1000 cumec and 3000 cumec, respectively. For keeping the maximum water level at El 475m i.e. within flood cushion of 15m above El 460m, it was seen that constant release of about 2300 cumec would be required.

From the above, it is clear that the reservoir rule curve adopted for the studies do not respect the flood moderation criteria. According to this rule curve, the reservoir level is to be raised starting from August and brought to El 460m (FRL) in October. Same flood moderation benefits would thus not be available in June-July and September-October if this rule curve is followed. Moreover, raising the water level close to FRL in September-October defies logic as probability of 100-year flood occurring in these months is certainly there.

Also, as demonstrated in **Table 8-1** above, the proposed flood cushion above the FRL (El. 460m) would not be able to contain the 100-year flood with any of the constant releases (1000 to 3000 cumec) considered in previous studies. Even with a release of 3000 cumec the flood cushion would exceed in October when the reservoir level is brought to El 460m as per the rule curve.

Clearly, a new reservoir operation philosophy is to be developed catering to the requirements set out by the flood moderation criteria.

8.3.3 Reservoir Routing Studies with Revised FRL

The studies discussed in previous section were done with project FRL at El 460m in conformity with requirement indicated in CWC's letter. Post transfer of development rights of Kamala HEP to KHEPCL, MoEF (in ToR) had revised the FRL from El 460m to El 455m. Since new reservoir rule curve is to be evolved, further studies have been carried out with the revised FRL.

To determine the reservoir operation/ impingement level during monsoon, parametric studies with downstream releases of 1000, 1250, 1500, 2000, 2500 and 3000 cumec have been carried out so as to contain the maximum attained reservoir level during flood moderation (of 100yr flood) within El 470m (15m flood cushion above FRL). The summary of results of reservoir routing studies is given in **Table 8-3**.

Table 8-3: Impingement Levels for FRL El 455 m (100 yr Flood)

Constant Release (cumec)	Maximum Impingement Level (m)
1000	435.50
1250	438.00
1500	440.00
2000	444.50
2500	448.00
3000	451.50

8.3.4 Discussions with CWC

During various meetings and discussions with CWC, it was informed that studies should also include flow contributions from intermediate catchment in order to assess the flow at Subansiri Lower project. CWC shared the 100 yr flood hydrograph of intermediate catchment and also suggested that the travel time from Kamala dam site to the Subansiri Lower dam site would be 9 to10 hrs. The flood peak of intermediate catchment hydrograph is 6200 cumec at 19 hrs.

Considering this travel time, the flow released from upper reservoirs (Kamala & Upper Subansiri) would add to the flood hydrograph of intermediate catchment and thus flow at Lower Subansiri may exceed 7000 cumec. To avoid this, inflow in excess of power discharge of the projects is allowed to hold in the upstream reservoirs and released in such a manner that the outflows from these projects join with intermediate catchment hydrograph on its recession limb, thus restricting the flows at Lower Subansiri to 7000 cumec. The excess flow shall only be released when the reservoir reaches an elevation called “Index Level”.

For establishing reservoir level during monsoon, parametric studies were carried out considering constant release of 1500, 2000, 2500 & 3000 cumec, power discharge of 1250 cumec[1] and travel time of 9 hrs. The summary of results is presented in **Table 8-4**.

Table 8-4: Reservoir Levels during Monsoon

Constant Release (cumec)	Reservoir Level during Monsoon considering Intermediate catchment contribution (m)
1500	440.00
2000	443.00
2500	445.50
3000	447.00

On further discussions with CWC, it was decided that during monsoon reservoir level of Kamala project, from flood moderation angle shall be kept at El 447m from 1st June to 10th October and thereafter will be raised to FRL i.e. 455m. The maximum release shall be 3000 cumec once the Index Level is reached. As the power discharge of Kamala project was not finalized by that time the studies were carried, further studies for establishing the index level, incorporating different power discharges (1250 to 1500 cumec) from Kamala project were carried out. The summary of results is presented in Table 8-5.

Table 8-5: Reservoir Index Levels for Various Power Releases

Power Discharge (cumec)	Reservoir Index Level (m)
1250	456.27
1300	456.69
1400	456.98
1500	457.93

It is seen from above Table that the index level vary from El 456.27m to El 457.93m for power discharge of 1250 cumec to 1500 cumec, respectively. A meeting was held on 3rd May 2012, chaired by Member (D&R), CWC and Member (Hydro), CEA for optimization of Reservoir level for Flood Moderation of Kamala HEP wherein CWC approved the release criteria from Kamala reservoir. The index levels and release criteria are recorded in the Minutes of Meeting vide CWC Letter No.20/30/2012/CMDD(E&NE)/300 that is enclosed as Annexure 2-11 in Volume-IV of DPR.

[1] Preliminary Power Potential studies carried during that time indicated power discharge of the order of 1250 cumec

8.3.5 Index Level and Release Criteria

The installed capacity of Kamala project has been finalized as 1800 MW with design discharge of 1282.56 cumec. For constant maximum downstream release of 3000 cumec and above power discharge, the reservoir index level works out to ~**El. 456.5m**.

Hence, reservoir level of Kamala Project, from flood moderation aspect, will be kept at El 447m from 1st June to 10th October and thereafter will be raised to FRL i.e. El 455m. During 100 year flood, the release from Kamala reservoir shall be as per following criteria:

i) The outflow from Kamala reservoir shall be restricted to power discharge of the project i.e. 1282.56 cumec till the reservoir reaches 'Index Level' i.e. El 456.5m

ii) Maximum outflow of 3000 cumec after reservoir level reaches the above Index Level.

All the studies discussed in the chapter are enclosed in Volume-IV of DPR.

CHAPTER 9
POWER POTENTIAL & INSTALLED CAPACITY

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9 POWER POTENTIAL AND INSTALLED CAPACITY

9.1 General

Kamala Hydroelectric Project features a high dam which is designed to provide storage that would ensure generation of daily peaking power for minimum 3 hours. Full Reservoir Level (FRL) for the project has been fixed at El 455m. The reservoir operation rule curve has been approved by CWC and mandates that the reservoir should be kept at a constant level of El. 447m during the monsoon season (1st June to 10th October) and thereafter it will be gradually filled to the full reservoir level. Such reservoir operation is aimed to achieve same level of moderation of high frequency floods (1 in 100 year) during monsoon period.

9.2 Water Availability

Long term flow series at the selected dam site has been derived on the basis of observed river discharges at Tamen. The 10-daily discharge series for **30 years** (Period 1980-81 to 2009-10) at the dam site has been approved by CWC and is presented in **Annexure 9-1**.

It is evident that the river exhibits temporal variation similar to other Himalayan rivers with high flows during months of June to September and low flows during winter months. The hydrological year is considered from the month of June each year to the month of May of the succeeding year.

9.3 Selection of 90% Dependable Year

As per CEA guidelines, power potential of a hydroelectric project should be assessed on the basis of 90% dependable year which is defined as the year in which the annual energy or the annual inflow has the probability of being equal to or higher than 90%. Annual inflows are arranged in descending order and the 90% dependable year is taken as (N+1) x 0.9th year, where N is the number of years in the hydrological series.

For Kamala HEP, N = 30.

Thus, 90% Dependable Year : (30+1)x0.9 = 28th Year

Accordingly, year **2006-07** comes out as 90% dependable year (Refer Table 9-1).

Table 9-1: Derivation of 90% Dependable Year

S.No.	Year	Annual Inflows (MCM)	Percentage Dependability	Remarks
1	1999-00	32102.15	3.23%	
2	2003-04	28568.21	6.45%	
3	1994-95	27525.38	9.68%	
4	1996-97	27289.33	12.90%	
5	1997-98	26366.05	16.13%	
6	2007-08	26239.36	19.35%	
7	2004-05	26143.68	22.58%	
8	1980-81	25585.73	25.81%	
9	2002-03	24591.78	29.03%	
10	1998-99	24260.89	32.26%	
11	1987-88	23079.17	35.48%	
12	2000-01	23076.85	38.71%	
13	1983-84	22529.81	41.94%	
14	1995-96	21740.22	45.16%	
15	2008-09	21667.73	48.39%	
16	1985-86	21567.5	51.61%	**50% Dependable Year**
17	2009-10	21459.03	54.84%	
18	2005-06	21443.58	58.06%	
19	2001-02	21107.33	61.29%	
20	1989-90	20731.14	64.52%	
21	1984-85	20711.19	67.74%	
22	1982-83	20647.72	70.97%	
23	1990-91	20182.68	74.19%	
24	1981-82	19963.21	77.42%	
25	1991-92	19745.03	80.65%	
26	1993-94	19602.76	83.87%	
27	1988-89	19092.72	87.10%	
28	2006-07	18988.92	90.32%	**90% Dependable Year**
29	1992-93	17959.9	93.55%	
30	1986-87	16128.69	96.77%	

9.4 Power Potential Study

The following data and assumptions are used in the power potential study.

Full Reservoir Level : Full reservoir level for the project is kept at El. 455m.

Reservoir Operation Rule Curve: The rule curve finalized by CWC is presented in Table 9-2.

Table 9-2: Reservoir Regulation Rule Curve

Month	10-daily period	Reservoir Level (El. in m)
June	I	447.00
	II	
	III	
July	I	
	II	
	III	
August	I	
	II	
	III	
September	I	
	II	
	III	
October	I	
	II	To be brought to FRL (455.00)
	III	455.00
November	I	
	II	
	III	
December	I	
	II	
	III	
January	I	
	II	
	III	
February	I	
	II	
	III	
March	I	
	II	
	III	
April	I	
	II	
	III	
May	I	452.33[1]
	II	449.67[1]
	III	To be brought to 447.00

[1] The rule curve approved by CWC mandates to achieve reservoir level of El. 447m during start of monsoon (i.e. by end of May) which has been done in three 10-dailies of May.

Tail Water Level: The river hydraulics in the project area has been studied using HEC-RAS software and discharge rating curves have been established at various locations. Manning's roughness coefficient of 0.05, applicable for bouldery rivers, has been considered in the analysis. Tail water rating curve at the tailrace outfall location is presented in **Annexure 9-2**. The tail water level has been considered corresponding to the total release from the reservoir.

Head Losses: Head losses in the water conductor system have been calculated for the variations in the gross head & discharge. The head loss varies from 6.2m to 8.6m with reservoir level varying from 455m to 430m, respectively. The variation in head loss with respect to gross head is given below in Figure 9-1.

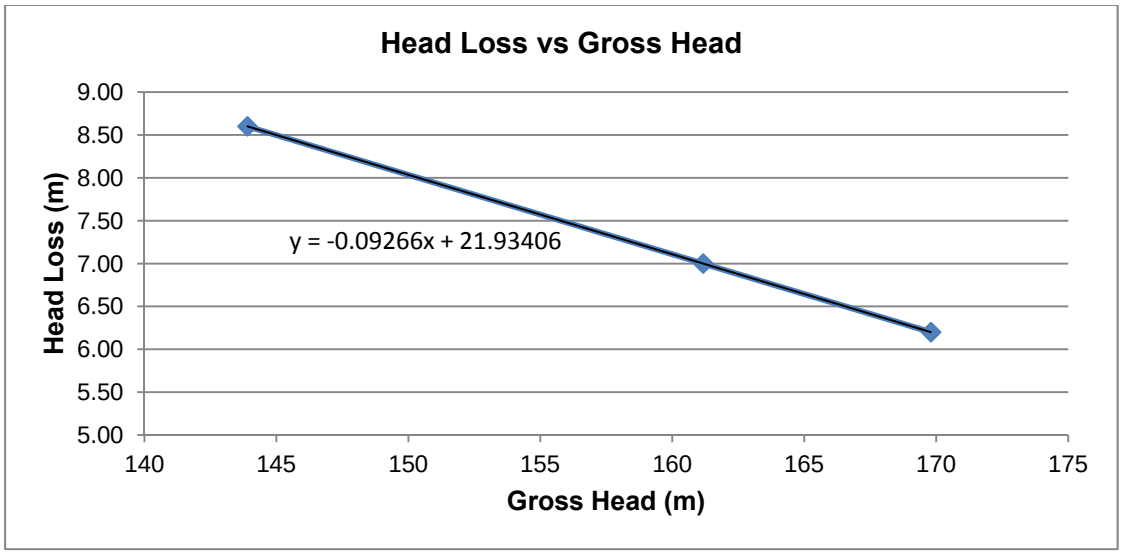


Figure 9-1: Variation in Head Loss

Gross Head: Gross head at the project varies with the reservoir operation rule curve (which defines the maximum reservoir level in different periods of the year).

Net Head: Net head has been taken as gross head minus head loss in the water conductor system.

Overall plant efficiency: Considering the head available for power generation, Francis turbines shall be the appropriate choice. The following efficiencies applicable for Francis turbine driven generating units have been considered:

Efficiency of turbine	:	94.0%
Efficiency of generator	:	98.5%
Overall plant efficiency	:	92.59%

Ecological Flow: Environmental considerations require a minimum ecological flow to be released into the river at all times. A flow of **48.56 cumec** equivalent to 20% of the average lean period flows (December to March) of the 90% dependable year has been considered as the ecological flow.

Reservoir Capacity: Elevation-Area-Capacity curve of the reservoir is enclosed in Chapter-7 of this volume.

9.5 Optimization of Installed Capacity

For optimization of the installed capacity, energy simulation studies for the 90% dependable year have been carried out for capacities varying from 1200 MW to 2100 MW in steps of 75MW ensuring generation of daily peaking power for minimum 3 hours. It is assumed that the head losses will be same for all the capacities, waterway dimensions being adjusted to give the same head loss. The energy studies are appended as **Annexure 9-3.** The Incremental Energy benefits are presented in Table 9-3 and incremental energy curve is given in Figure 9-2.

Table 9-3: Incremental Energy Benefits in 90% Dependable Year

Installed Capacity (MW)	Gross Energy (MU)	Incremental Energy (MU)	Annual Load Factor (%)	Incremental Energy / Incremental MW	Continuous Power (MW)	Min. Reservoir Level Attained (m)
1200	6105.31		58.08%		196.14	455.00
1275	6255.19	149.88	56.00%	2.00	195.84	455.00
1350	6383.91	128.72	53.98%	1.72	195.55	455.00
1425	6505.56	121.65	52.12%	1.62	195.27	455.00
1500	6618.88	113.32	50.37%	1.51	194.99	455.00
1575	6701.93	83.05	48.58%	1.11	196.88	454.95
1650	6753.48	51.55	46.72%	0.69	206.25	454.72
1725	6785.68	32.20	44.91%	0.43	215.63	454.16
1800	6812.27	26.59	43.20%	0.35	225.00	453.48
1875	6837.74	25.47	41.63%	0.34	234.38	452.52
1950	6849.88	12.15	40.10%	0.16	243.75	451.19
2025	6855.67	5.79	38.65%	0.08	253.13	449.58
2100	6860.27	4.59	37.29%	0.06	262.50	447.76

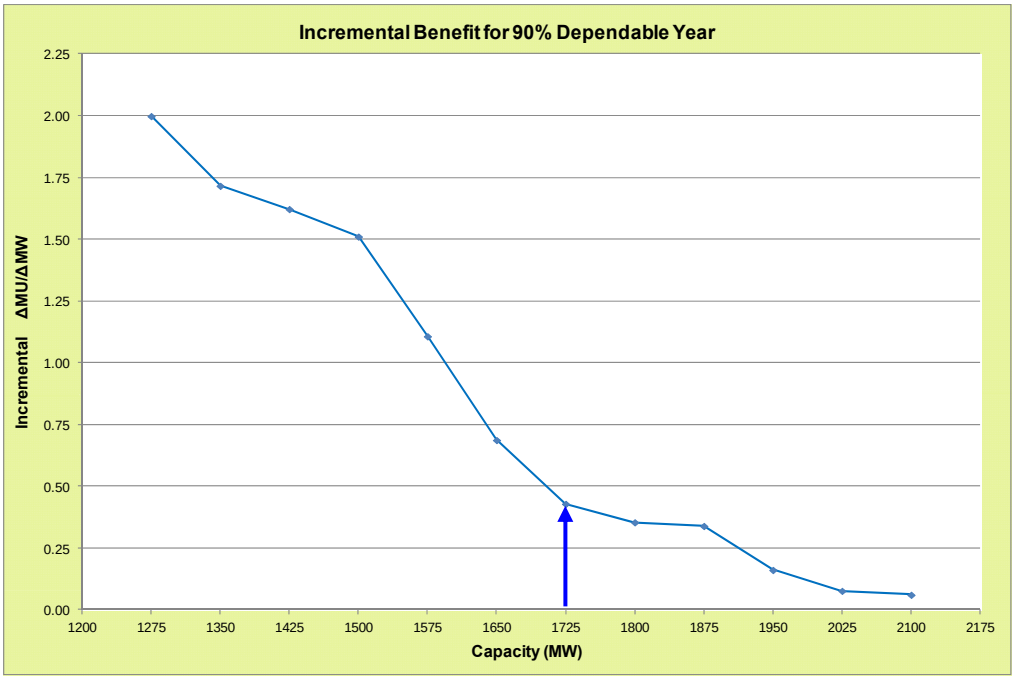


Figure 9-2: Incremental Energy Benefits

It is observed that there is almost uniform incremental energy from 1725 MW to 1875 MW. As the installed capacity is increased beyond 1875 MW, incremental energy benefits (ΔMU/ΔMW) reduce significantly and are quite low. Thus, the optimal installed capacity would likely fall between 1725 MW and 1875 MW. In order to optimize the capacity, techno-economic analysis was carried out and discussed during examination of power potential study by CEA. From the study, it was inferred that 1725 MW is the optimal installed capacity for the main powerhouse[2]. Capacity of **1728 MW** has been proposed (8 units of 216 MW each, considering whole number of each generating unit) and accepted by CEA.

9.5.1 Reservoir Operation

Reservoir operation studies for each hydrological year for capacity of 1728 MW have been done to meet the following:

- Minimum peaking requirement of 3 hrs throughout for all the hydrological years
- Regulate the reservoir level to minimize spillage during high inflow periods
- Operate the reservoir at full reservoir level during lean season drawing the water from storage only to meet peaking requirement
- Operate reservoir at El. 447 (as per rule curve) during monsoon for flood moderation.

[2] An auxiliary powerhouse to utilize ecological release from the reservoir is also proposed at the dam-toe

Reservoir operation studies meeting the above requirements for all the years of water availability series are presented in **Annexure 9-4**. Summary of results are presented in Table 9-4.

Table 9-4: Results of Reservoir Operation Studies

Year	Energy (MU)		Peak Power (MW)	Min. Continuous Power (MW)	Spillage (MCM)	Min. Reservoir Level Attained (m)	Energy[3] with ecological flow (MU)	Total Design Energy (MU)
	Gross	95% M/c Availability						
1980-81	8152.2	7889.2	1728.0	216.0	3324.2	451.6	599.2	8488.3
1981-82	6984.8	6853.5	1728.0	216.0	666.7	440.1	599.2	7452.7
1982-83	6841.0	6714.6	1728.0	216.0	1758.0	452.3	599.2	7313.7
1983-84	7773.4	7587.2	1728.0	216.0	1272.1	447.8	599.2	8186.4
1984-85	7123.4	7014.2	1728.0	216.0	1078.2	444.9	599.2	7613.4
1985-86	6918.7	6728.0	1728.0	216.0	2264.8	435.7	598.6	7326.6
1986-87	5610.5	5589.8	1728.0	216.0	206.2	434.5	597.6	6187.4
1987-88	7624.1	7443.8	1728.0	216.0	2085.3	442.0	599.2	8043.0
1988-89	6669.4	6556.8	1728.0	216.0	538.1	440.7	599.2	7156.0
1989-90	7506.4	7441.0	1728.0	216.0	225.0	451.5	599.2	8040.2
1990-91	7173.1	7084.2	1728.0	216.0	514.5	452.7	599.2	7683.4
1991-92	7205.8	7170.1	1728.0	234.4	86.7	455.0	599.2	7769.3
1992-93	6570.7	6570.7	1728.0	262.3	0.0	455.0	599.2	7169.9
1993-94	7094.1	7071.3	1728.0	273.6	246.1	455.0	599.2	7670.5
1994-95	8693.9	8449.6	1728.0	216.0	3963.4	454.9	599.2	9048.8
1995-96	7156.9	7051.1	1728.0	276.2	2238.2	455.0	599.2	7650.3
1996-97	9322.5	9152.3	1728.0	404.7	2314.4	455.0	599.2	9751.5
1997-98	8268.3	8036.0	1728.0	259.8	3841.4	455.0	599.2	8635.2
1998-99	8133.7	7961.5	1728.0	216.0	2133.3	453.7	599.2	8560.7
1999-00	9285.9	9026.3	1728.0	236.2	6989.6	455.0	599.2	9625.5
2000-01	7554.7	7366.0	1728.0	216.0	2340.1	448.1	599.2	7965.2
2001-02	7490.8	7426.1	1728.0	216.0	669.1	452.9	599.2	8025.3
2002-03	7758.6	7632.2	1728.0	216.0	3411.1	454.0	599.2	8231.3
2003-04	8938.5	8674.8	1728.0	250.2	4387.4	455.0	599.2	9273.9
2004-05	8574.0	8420.9	1728.0	253.7	2937.1	455.0	599.2	9020.1
2005-06	7493.1	7367.0	1728.0	216.0	980.2	454.7	599.2	7966.2
2006-07	**6786.8**	**6738.9**	**1728.0**	**216.0**	**338.9**	**454.1**	**599.2**	**7338.1**
2007-08	8208.2	8035.7	1728.0	216.0	3889.2	454.1	599.2	8634.8
2008-09	7294.1	7110.9	1728.0	216.0	1602.8	448.0	599.2	7710.1
2009-10	7539.5	7410.9	1728.0	216.0	870.1	447.2	599.2	8010.1
Average	**7591.6**	**7452.5**	**1728.0**	**232.9**	**1905.7**		**599.1**	**8051.6**
Minimum			**1728.0**	**216.0**		**434.5**		

[3] For details of energy generation with ecological flow refer subsequent section

Energy generation during 90% dependable year with 95% machine availability by the main powerhouse is **6738.9 MU**.

The duration of peaking hours available from the inflow in each 10-daily period for all years of the hydrological water availability series have also been calculated and presented in the results. It can be seen from the studies that during the lean period a minimum of 3 hours of peaking is available for installed capacity of a 1728 MW during all the years of hydrological series. It is also observed that the minimum reservoir level achieved by regulating the reservoir for meeting the minimum 3 hours peaking requirement throughout the year is **434.5m** in the year 1986-87.

In view of above, it is proposed to keep Minimum Drawdown Level (MDDL) of the project as **El. 430.00m**. The level of Power Intake shall be kept below MDDL considering the minimum submergence criteria.

The rated net head of the power plant is calculated as below:

H_r = MDDL + 2/3 x (FRL-MDDL) -TWL - head loss

The design discharge of the power plant has been worked out as **1234 cumec** and corresponding head loss as **7m**. Normal TWL for all units in operation is El. 285.5m. The rated head is thus worked as **154.17m.**

9.5.2 Utilization of Ecological Flow for Power Generation

A continuous flow of about 48.56 cumec is required to be released downstream of the dam to meet the environmental requirements. It is proposed to route this flow through an auxiliary powerhouse that has been located at the toe of the dam. The tail water level at the dam-toe shall be El. 286.6m during operation of main and auxiliary powerhouses (i.e. Q of 1282.56 cumec) and minimum tail water of El. 279m during operation of only auxiliary powerhouse (i.e. Q = 48.56 cumec). The tail water rating curve at the dam-toe is enclosed in **Annexure 9-5.** The head loss in the water conductor system of auxiliary powerhouse shall be 3m. This plant shall be capable of producing power varying from 69 MW to 76 MW with reservoir operated as per the rule curve. It is proposed to install two units of 36 MW each with total capacity of **72 MW**. Energy generation studies for the auxiliary powerhouse are enclosed as **Annexure 9-6**. Energy generation for 90% dependable year with 95% machine availability by the auxiliary powerhouse is **599.2 MU**.

9.5.3 Design Energy Generation

As per CERC guidelines, design energy is the energy produced in 90% dependable year with 95% machine availability. Accordingly, the design energy generation for the 1728 MW installed capacity of the Main powerhouse and 72 MW installed capacity of the Auxiliary powerhouse are as under:

Table 9-5: Design Energy Generation

Description	Main Powerhouse	Auxiliary Powerhouse	Total
Installed Capacity - MW	1728	72	1800
Design Energy - MU	**6738.9**	**599.2**	**7338.1**
PLF (for Design Energy) - %	44.52	95.00	46.54

Annexure 9-1

10-Daily Flow Series at Dam site

Annexure 9-1

10-DAILY FLOW SERIES AT DAM SITE

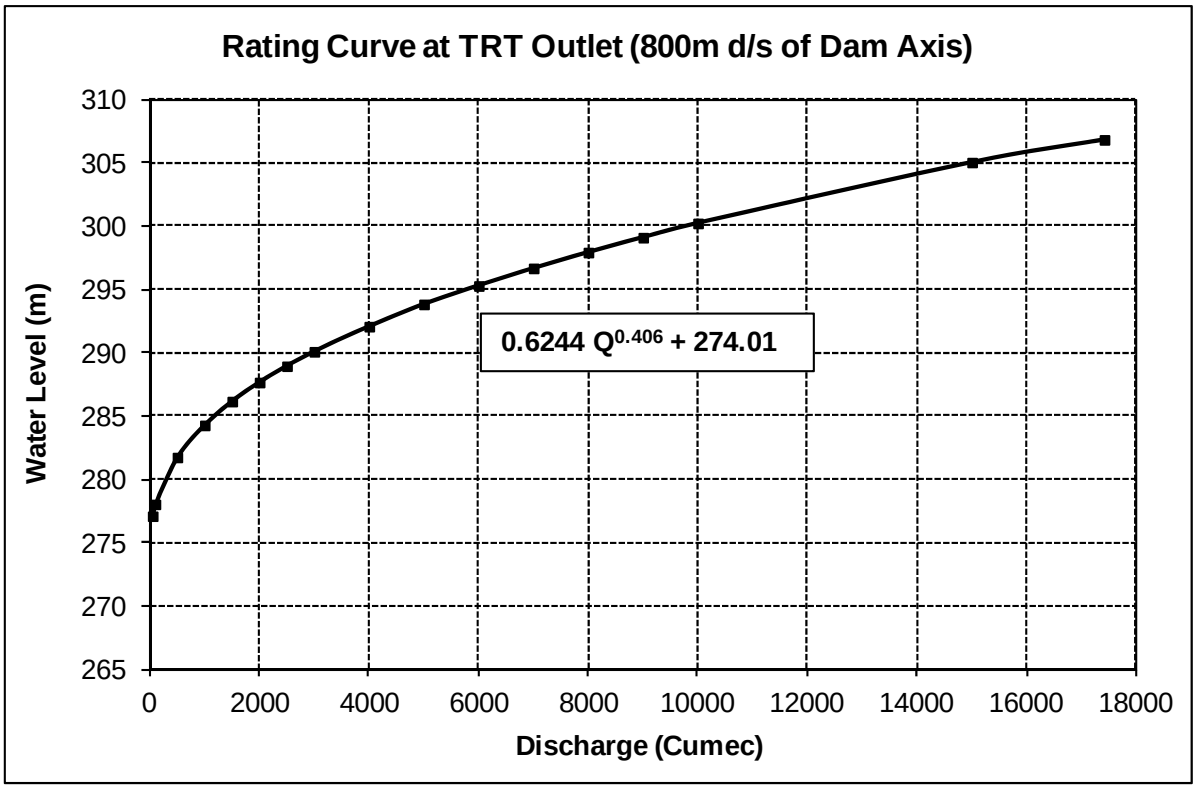
Month	Period	Days	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Jun	I	10	1,504.23	953.56	734.77	1,234.59	944.65	1,437.82	628.62	830.93	763.93	1,149.91	723.77	1,062.09	681.47	872.86	1,665.08	822.55	1,290.72	1,460.10	832.91	1,514.57	856.10	1,095.68	761.93	877.17	1,152.55	1,095.50	1,237.47	1,371.00	1,290.01	861.00
	II	10	1,569.78	735.04	1,501.05	1,396.13	1,759.00	1,312.76	910.71	1,146.36	1,103.78	1,340.67	912.77	1,256.91	675.19	855.23	1,411.73	1,141.24	963.27	1,857.90	972.25	1,569.39	1,106.82	837.48	1,098.26	1,313.02	1,444.99	923.25	1,559.30	1,724.97	1,833.68	938.26
	III	10	1,545.82	1,110.88	1,802.92	1,832.30	1,119.46	1,365.64	1,526.11	1,035.09	897.03	952.15	1,520.65	1,019.09	700.29	877.42	1,489.08	1,332.18	1,026.89	1,697.53	1,847.03	2,674.61	1,387.77	1,219.79	1,427.01	2,305.58	2,040.09	1,272.96	1,173.38	1,967.98	1,257.62	1,092.24
Jul	I	10	1,714.45	1,612.94	1,561.63	1,591.70	1,528.88	1,739.73	1,013.26	1,480.20	1,463.05	1,221.81	1,230.15	1,126.30	695.84	849.86	1,901.08	1,091.05	1,605.87	1,559.66	1,793.25	2,290.59	1,624.61	629.77	2,296.55	1,925.56	2,053.20	1,125.62	1,107.79	1,232.21	1,289.59	1,553.53
	II	10	2,065.67	1,484.47	1,484.92	1,263.02	1,359.66	1,999.19	1,107.11	1,412.73	1,176.82	1,042.80	1,424.42	1,195.85	664.76	885.39	1,254.35	772.30	2,138.24	1,650.95	1,548.54	2,052.59	1,848.14	1,390.76	1,543.27	1,764.82	2,164.91	1,446.67	1,178.58	1,454.13	1,371.95	994.90
	III	11	1,512.98	1,251.74	1,991.81	1,352.05	1,465.71	1,718.36	916.42	1,620.76	1,338.21	1,044.34	1,352.73	1,374.15	706.14	884.84	1,723.58	636.28	1,700.65	1,743.20	1,519.64	1,862.81	1,176.85	1,139.08	2,577.26	1,247.51	1,636.47	1,349.52	841.18	2,702.45	1,731.46	1,352.68
Aug	I	10	1,832.72	891.98	724.93	896.71	1,024.20	1,015.79	816.31	1,541.20	1,020.00	1,006.12	1,429.33	1,102.09	688.28	883.57	1,895.82	695.53	1,588.72	1,679.53	1,569.57	1,173.11	1,442.93	990.80	1,506.50	1,090.54	1,535.81	1,692.55	553.29	1,196.46	896.07	1,384.19
	II	10	1,412.14	1,270.23	666.57	1,156.83	713.42	907.84	638.32	1,510.26	1,452.48	1,170.28	918.78	870.57	718.55	884.53	2,248.09	771.92	1,878.77	1,861.99	1,397.31	2,237.40	1,512.47	1,036.78	2,257.49	1,919.14	926.56	1,440.04	424.92	1,796.19	1,748.89	1,516.49
	III	11	1,528.80	1,462.01	1,141.60	1,262.91	1,110.53	1,370.73	1,046.13	1,251.92	1,466.58	1,423.05	1,061.56	723.17	714.60	894.88	2,111.93	743.60	1,455.45	1,947.15	1,385.25	2,256.18	1,576.75	1,856.25	1,064.69	1,566.79	1,214.90	1,601.71	1,094.91	1,117.36	1,452.29	1,323.65
Sep	I	10	1,044.92	1,267.52	688.42	1,144.88	1,228.63	1,800.69	717.95	1,875.22	1,297.96	1,205.27	1,065.15	762.96	759.76	824.19	1,307.51	528.22	993.48	1,529.21	1,179.75	2,251.13	1,754.27	1,333.08	676.02	2,127.49	1,547.37	1,076.90	841.68	2,209.81	1,371.15	689.13
	II	10	1,432.14	1,217.45	1,362.23	1,504.06	1,554.57	1,183.91	1,062.11	1,676.05	1,100.29	1,330.84	1,131.63	731.66	776.87	838.03	1,336.48	535.62	904.46	1,559.16	1,091.06	1,838.98	1,758.79	1,096.29	711.99	1,883.01	780.92	572.11	1,405.25	1,499.67	789.74	870.74
	III	10	1,876.07	775.24	1,099.60	1,510.93	1,110.68	1,422.19	607.27	1,576.83	607.93	938.82	841.46	788.84	801.91	821.47	1,583.53	500.47	844.10	1,199.29	992.29	1,171.14	1,375.41	880.15	1,157.78	1,348.35	971.36	900.39	700.78	682.48	660.70	854.49
Oct	I	10	1,263.92	850.70	603.54	636.03	749.10	925.88	689.83	1,035.40	805.53	1,112.89	751.99	756.97	749.72	785.25	1,052.92	447.46	835.52	969.62	987.46	1,538.89	638.70	1,049.03	897.49	1,747.01	1,235.67	777.44	752.20	938.90	692.11	751.49
	II	10	689.78	468.53	393.60	890.87	862.28	506.59	503.24	788.22	595.08	896.14	721.43	789.42	701.17	792.89	916.28	487.94	824.35	705.13	1,205.68	1,646.20	584.57	756.49	503.86	890.72	955.80	514.21	673.17	897.60	528.56	518.25
	III	11	497.59	320.41	536.66	519.16	697.05	403.64	385.29	653.43	516.39	634.22	527.06	702.05	683.73	777.67	937.35	454.77	836.62	584.81	815.16	1,170.90	414.17	384.29	460.83	802.33	584.10	635.03	417.03	574.03	549.13	397.38
Nov	I	10	317.02	597.40	322.01	332.97	407.85	359.31	374.16	137.20	333.00	623.48	402.28	233.06	763.30	466.26	762.21	338.00	816.77	497.92	543.53	672.13	342.93	552.84	342.40	641.63	395.27	439.01	330.91	359.63	357.94	306.48
	II	10	369.42	245.39	284.59	295.39	308.06	277.95	282.17	142.62	228.60	398.31	318.15	233.54	800.36	272.23	434.42	325.58	810.74	405.17	449.56	540.63	342.71	363.36	339.65	492.10	333.53	367.99	293.99	344.07	312.04	363.23
	III	10	285.52	199.78	253.48	232.27	245.38	220.22	215.80	128.19	196.51	351.49	252.74	233.56	747.46	271.50	314.59	333.34	768.69	330.21	376.77	453.52	279.33	350.68	290.38	418.70	295.70	325.60	305.44	335.02	269.66	297.31
Dec	I	10	256.98	182.94	229.19	210.39	217.31	186.74	179.53	222.65	180.55	248.30	214.36	236.61	476.88	257.76	316.61	398.12	666.09	299.78	325.02	359.34	275.72	286.12	254.21	382.98	268.88	273.17	270.92	269.02	228.16	274.23
	II	10	215.38	224.97	253.66	189.08	257.24	157.59	166.38	210.26	174.43	217.62	195.20	206.55	433.71	256.79	269.63	426.02	619.18	275.64	275.27	309.18	221.78	260.66	233.21	322.71	250.19	240.92	252.92	230.90	205.53	224.06
	III	11	168.29	152.03	223.18	183.25	184.99	150.17	161.43	171.60	126.75	191.31	195.99	210.17	350.20	243.73	192.37	462.88	586.64	260.98	278.76	270.30	182.51	213.20	216.68	282.54	259.37	225.04	200.32	209.77	186.74	200.66
Jan	I	10	177.95	143.02	199.86	163.13	153.69	139.81	143.43	170.41	119.36	178.66	188.63	368.60	254.25	240.08	278.19	360.60	445.72	245.89	224.98	225.92	170.23	192.50	195.80	245.86	238.75	215.31	190.62	188.44	173.99	201.45
	II	10	155.50	140.21	172.71	170.02	147.75	128.82	125.28	160.49	125.96	166.62	181.91	356.84	250.15	242.94	258.94	373.28	370.71	229.81	196.14	212.22	159.76	179.56	187.96	239.41	226.72	199.59	187.62	179.20	159.38	171.82
	III	11	179.78	126.76	159.37	179.05	139.77	123.46	113.28	139.73	113.15	162.95	171.21	381.63	225.37	232.92	263.56	295.87	410.43	225.02	181.14	207.79	154.29	221.83	173.26	231.50	219.59	195.04	179.53	192.99	160.74	147.63
Feb	I	10	367.48	136.41	172.16	160.04	148.18	139.35	111.43	138.83	145.99	190.88	188.58	379.80	233.89	247.73	266.03	362.58	355.63	239.95	190.59	219.30	159.83	164.43	201.57	217.50	232.15	188.23	209.52	190.61	149.94	139.67
	II	10	179.95	138.68	203.13	155.98	149.71	138.26	112.29	232.16	211.48	179.48	192.26	376.35	263.76	263.80	327.30	418.57	321.44	223.96	178.40	229.97	155.01	171.63	268.95	218.61	335.85	191.52	214.07	202.03	138.71	142.12
	III	8	308.10	157.77	339.31	146.03	163.13	142.88	157.01	210.20	226.65	201.16	177.31	378.85	270.57	243.63	302.93	376.42	325.90	246.53	199.97	253.71	193.63	180.95	214.11	245.22	280.43	459.49	222.96	203.92	239.81	151.41
Mar	I	10	247.10	178.97	297.65	212.68	200.24	154.51	198.83	264.33	236.24	225.32	237.02	413.04	288.68	235.28	299.16	329.66	389.10	284.15	188.99	275.10	203.48	212.32	233.94	300.25	340.75	307.13	308.00	275.62	202.89	192.72
	II	10	331.66	288.86	331.66	340.81	253.65	269.64	196.33	342.13	265.39	260.16	411.55	451.84	318.18	257.91	346.92	404.57	426.98	359.58	231.13	328.86	219.46	267.17	405.35	249.43	387.92	373.97	332.54	342.11	183.14	219.05
	III	11	292.92	298.73	462.52	262.45	256.88	185.15	209.04	312.24	278.32	367.73	332.26	451.82	335.28	678.78	392.30	431.90	474.16	253.10	210.85	396.30	347.61	450.75	389.59	574.08	637.02	299.29	344.92	410.50	195.59	506.80
Apr	I	10	303.25	522.09	202.82	560.83	380.75	204.42	220.42	333.11	255.16	400.01	517.92	489.01	446.79	651.39	366.18	455.97	438.16	431.33	330.91	465.21	503.08	514.08	595.74	399.88	760.19	368.01	518.27	484.09	424.74	768.01
	II	10	396.67	484.05	301.31	366.20	433.95	407.92	250.00	459.14	339.38	475.58	459.61	481.65	553.89	576.96	342.84	443.17	524.07	526.26	328.55	533.55	778.86	798.59	553.14	641.93	631.86	635.00	507.65	820.64	433.35	629.26
	III	10	570.79	619.79	231.10	647.21	476.34	546.44	491.20	639.31	388.27	626.47	630.93	532.43	681.97	645.95	705.96	1,470.43	550.92	544.75	462.23	700.11	657.25	756.05	848.51	632.58	800.75	375.83	872.04	750.92	574.39	1,127.72
May	I	10	563.06	569.04	375.31	597.78	546.30	602.68	547.23	543.13	528.26	390.71	530.81	603.11	659.46	667.05	695.30	1,466.95	715.71	616.39	818.98	692.59	519.76	637.35	1,059.59	525.34	721.20	632.03	461.09	819.91	795.79	769.32
	II	10	785.99	1,220.14	963.17	813.92	556.44	547.68	743.90	724.54	419.17	610.26	419.95	586.57	707.35	1,076.90	644.40	1,990.07	890.42	668.00	828.09	855.79	545.89	667.70	959.28	1,204.78	979.43	833.73	574.90	570.43	668.48	1,458.25
	III	11	1,175.34	432.93	1,128.85	1,198.03	693.62	365.50	770.81	1,111.10	1,147.06	651.31	1,090.37	615.79	690.66	1,461.96	674.46	2,281.76	1,190.08	813.17	1,566.94	1,035.97	810.32	819.95	1,011.86	1,243.23	926.89	827.72	886.87	1,040.59	1,068.00	986.02
Inflow (MCM)			25,586	19,963	20,648	22,530	20,711	21,568	16,129	23,079	19,093	20,731	20,183	19,745	17,960	19,603	27,525	21,740	27,289	26,366	24,261	32,102	23,077	21,107	24,592	28,568	26,144	21,444	18,989	26,239	21,668	21,459
Average flow (m^3/s)			811.32	633.03	654.73	714.42	656.75	683.90	511.44	731.84	605.43	657.38	639.99	626.11	569.50	621.60	872.82	689.38	865.34	836.06	769.31	1,017.95	731.76	669.31	779.80	905.89	829.01	679.97	602.13	832.04	687.08	680.46

Riparian Flow (20% Dec to Mar of 90% DY) **48.56 cumec**

Annexure 9-2
Tailwater Rating Curve

Annexure 9-2

TAILWATER RATING CURVE



Annexure 9-3

Energy Studies for 90% Dependable Year 2006-07

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1200 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2006-07

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	737.4	737.4	1713.9	447.00	285.25	6.95	154.80	24.00	24.00	853.4	1200.0	288.00	273.60	1200.00	470.01	334.27	288.81	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	743.2	743.2	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	860.2	1200.0	288.00	273.60	1200.00	905.93	649.38	561.06	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	736.1	736.1	1713.9	447.00	285.01	6.92	155.06	24.00	24.00	852.0	1200.0	288.00	273.60	1200.00	382.57	271.62	234.68	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	734.8	734.8	1713.9	447.00	284.76	6.90	155.34	24.00	24.00	850.5	1200.0	288.00	273.60	1200.00	292.86	207.56	179.33	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	736.2	736.2	1713.9	447.00	285.03	6.93	155.04	24.00	24.00	852.1	1200.0	288.00	273.60	1200.00	389.67	276.71	239.07	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	283.86	6.82	156.32	22.47	22.47	845.2	1200.0	296.65	296.65	1123.69	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	283.86	6.82	156.32	14.30	14.30	845.2	1200.0	171.58	171.58	714.93	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	283.86	6.82	156.32	10.65	10.65	845.2	1200.0	127.84	127.84	532.67	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	808.0	808.0	1713.9	447.00	284.71	6.90	155.40	24.00	24.00	850.2	1200.0	316.80	300.96	1200.00	275.21	194.98	185.31	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	283.86	6.82	156.32	22.49	22.49	845.2	1200.0	269.86	269.86	1124.40	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	740.5	740.5	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	857.0	1200.0	288.00	273.60	1200.00	697.90	498.44	430.65	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	283.86	6.82	156.32	18.49	18.49	845.2	1200.0	221.84	221.84	924.35	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	283.86	6.82	156.32	19.96	19.96	845.2	1200.0	239.47	239.47	997.78	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	283.76	6.44	160.80	10.99	10.99	821.6	1200.0	131.92	131.92	549.67	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	283.66	6.06	165.29	11.03	11.03	799.3	1200.0	145.66	145.66	551.74	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	283.66	6.06	165.29	8.45	8.45	799.3	1200.0	101.39	101.39	422.45	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	283.66	6.06	165.29	7.34	7.34	799.3	1200.0	88.08	88.08	367.02	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	283.66	6.06	165.29	7.68	7.68	799.3	1200.0	92.21	92.21	384.21	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	283.66	6.06	165.29	6.67	6.67	799.3	1200.0	80.00	80.00	333.35	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	283.66	6.06	165.29	6.13	6.13	799.3	1200.0	73.52	73.52	306.33	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	143.9	143.9	1927.6	455.00	283.66	6.06	165.29	4.55	4.55	799.3	1200.0	60.02	60.02	227.36	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	190.6	48.56	0.28	122.5	2050.1	122.5	122.5	1927.6	455.00	283.66	6.06	165.29	4.26	4.26	799.3	1200.0	51.07	51.07	212.79	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	187.6	48.56	0.28	119.9	2047.5	119.9	119.9	1927.6	455.00	283.66	6.06	165.29	4.17	4.17	799.3	1200.0	49.99	49.99	208.29	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	179.5	48.56	0.31	124.2	2051.8	124.2	124.2	1927.6	455.00	283.66	6.06	165.29	3.92	3.92	799.3	1200.0	51.78	51.78	196.14	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	209.5	48.56	0.55	138.5	2066.1	138.5	138.5	1927.6	455.00	283.66	6.06	165.29	4.81	4.81	799.3	1200.0	57.76	57.76	240.69	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	214.1	48.56	0.55	142.4	2070.1	142.4	142.4	1927.6	455.00	283.66	6.06	165.29	4.95	4.95	799.3	1200.0	59.40	59.40	247.52	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	223.0	48.56	0.44	120.1	2047.7	120.1	120.1	1927.6	455.00	283.66	6.06	165.29	5.22	5.22	799.3	1200.0	50.09	50.09	260.86	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	308.0	48.56	1.11	223.0	2150.7	223.0	223.0	1927.6	455.00	283.66	6.06	165.29	7.75	7.75	799.3	1200.0	93.02	93.02	387.57	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	283.66	6.06	165.29	8.49	8.49	799.3	1200.0	101.86	101.86	424.41	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	283.66	6.06	165.29	8.86	8.86	799.3	1200.0	116.95	116.95	443.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	283.66	6.06	165.29	14.07	14.07	799.3	1200.0	168.78	168.78	703.25	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	283.66	6.06	165.29	13.75	13.75	799.3	1200.0	164.95	164.95	687.31	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	691.1	691.1	1927.6	455.00	283.76	6.07	165.17	24.00	24.00	799.9	1200.0	288.00	273.60	1200.00	33.51	22.34	19.30	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	283.69	6.18	163.79	14.73	14.73	806.6	1200.0	176.79	176.79	736.63	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	283.76	6.44	160.80	17.77	17.77	821.6	1200.0	213.21	213.21	888.37	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	797.4	797.4	1713.9	447.00	284.15	6.72	157.46	24.00	24.00	839.0	1200.0	316.80	300.96	1200.00	101.74	71.13	67.60	447.0	1713.91
																					6105.31	**5972.83**				**2205.82**		

Min. Res. Level 455.0 m Average Power 1200.0 MW Continuous Power 196.14 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR

KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **1275 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	783.5	783.5	1713.9	447.00	285.25	6.95	154.80	24.00	24.00	906.8	1275.0	306.00	290.70	1275.00	395.01	280.93	242.72	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	789.6	789.6	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	913.9	1275.0	306.00	290.70	1275.00	830.93	595.62	514.61	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	782.1	782.1	1713.9	447.00	285.01	6.92	155.06	24.00	24.00	905.2	1275.0	306.00	290.70	1275.00	307.57	218.37	188.68	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	780.7	780.7	1713.9	447.00	284.76	6.90	155.34	24.00	24.00	903.6	1275.0	306.00	290.70	1275.00	217.86	154.40	133.40	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	782.2	782.2	1713.9	447.00	285.03	6.93	155.04	24.00	24.00	905.4	1275.0	306.00	290.70	1275.00	314.67	223.45	193.06	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	284.10	6.84	156.06	21.12	21.12	899.5	1275.0	296.16	296.16	1121.82	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	284.10	6.84	156.06	13.44	13.44	899.5	1275.0	171.30	171.30	713.74	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	284.10	6.84	156.06	10.01	10.01	899.5	1275.0	127.63	127.63	531.78	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	858.5	858.5	1713.9	447.00	284.71	6.90	155.40	24.00	24.00	903.3	1275.0	336.60	319.77	1275.00	200.21	141.85	134.81	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	284.10	6.84	156.06	21.13	21.13	899.5	1275.0	269.41	269.41	1122.52	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	786.8	786.8	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	910.6	1275.0	306.00	290.70	1275.00	622.90	444.88	384.37	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	284.10	6.84	156.06	17.37	17.37	899.5	1275.0	221.47	221.47	922.80	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	284.10	6.84	156.06	18.75	18.75	899.5	1275.0	239.07	239.07	996.11	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	283.99	6.46	160.55	10.33	10.33	874.3	1275.0	131.71	131.71	548.79	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	283.89	6.08	165.03	10.37	10.37	850.6	1275.0	145.44	145.44	550.89	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	283.89	6.08	165.03	7.94	7.94	850.6	1275.0	101.23	101.23	421.80	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	283.89	6.08	165.03	6.90	6.90	850.6	1275.0	87.95	87.95	366.46	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	283.89	6.08	165.03	7.22	7.22	850.6	1275.0	92.07	92.07	383.62	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	283.89	6.08	165.03	6.27	6.27	850.6	1275.0	79.88	79.88	332.84	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	283.89	6.08	165.03	5.76	5.76	850.6	1275.0	73.40	73.40	305.85	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	143.9	143.9	1927.6	455.00	283.89	6.08	165.03	4.27	4.27	850.6	1275.0	59.93	59.93	227.01	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	190.6	48.56	0.28	122.5	2050.1	122.5	122.5	1927.6	455.00	283.89	6.08	165.03	4.00	4.00	850.6	1275.0	50.99	50.99	212.47	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	187.6	48.56	0.28	119.9	2047.5	119.9	119.9	1927.6	455.00	283.89	6.08	165.03	3.91	3.91	850.6	1275.0	49.91	49.91	207.97	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	179.5	48.56	0.31	124.2	2051.8	124.2	124.2	1927.6	455.00	283.89	6.08	165.03	3.69	3.69	850.6	1275.0	51.70	51.70	195.84	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	209.5	48.56	0.55	138.5	2066.1	138.5	138.5	1927.6	455.00	283.89	6.08	165.03	4.52	4.52	850.6	1275.0	57.68	57.68	240.32	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	214.1	48.56	0.55	142.4	2070.1	142.4	142.4	1927.6	455.00	283.89	6.08	165.03	4.65	4.65	850.6	1275.0	59.31	59.31	247.14	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	223.0	48.56	0.44	120.1	2047.7	120.1	120.1	1927.6	455.00	283.89	6.08	165.03	4.90	4.90	850.6	1275.0	50.01	50.01	260.46	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	308.0	48.56	1.11	223.0	2150.7	223.0	223.0	1927.6	455.00	283.89	6.08	165.03	7.28	7.28	850.6	1275.0	92.87	92.87	386.97	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	283.89	6.08	165.03	7.98	7.98	850.6	1275.0	101.70	101.70	423.76	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	283.89	6.08	165.03	8.33	8.33	850.6	1275.0	116.77	116.77	442.32	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	283.89	6.08	165.03	13.22	13.22	850.6	1275.0	168.52	168.52	702.17	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	283.89	6.08	165.03	12.92	12.92	850.6	1275.0	164.70	164.70	686.25	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	283.89	6.08	165.03	23.20	23.20	850.6	1275.0	295.79	290.70	1232.47	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	283.92	6.21	163.54	13.84	13.84	858.4	1275.0	176.52	176.52	735.48	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	283.99	6.46	160.55	16.70	16.70	874.3	1275.0	212.87	212.87	886.95	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	847.2	847.2	1713.9	447.00	284.15	6.72	157.46	24.00	24.00	891.4	1275.0	336.60	319.77	1275.00	26.74	18.69	17.77	447.0	1713.91
																					6255.19	**6124.64**				**1809.42**		

Min. Res. Level 455.0 m Average Power 1275.0 MW Continuous Power 195.84 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR

KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **1350 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	829.5	829.5	1713.9	447.00	285.25	6.95	154.80	24.00	24.00	960.1	1350.0	324.00	307.80	1350.00	320.01	227.59	196.64	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	836.1	836.1	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	967.7	1350.0	324.00	307.80	1350.00	755.93	541.86	468.16	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	828.1	828.1	1713.9	447.00	285.01	6.92	155.06	24.00	24.00	958.5	1350.0	324.00	307.80	1350.00	232.57	165.12	142.67	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	826.7	826.7	1713.9	447.00	284.76	6.90	155.34	24.00	24.00	956.8	1350.0	324.00	307.80	1350.00	142.86	101.25	87.48	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	828.3	828.3	1713.9	447.00	285.03	6.93	155.04	24.00	24.00	958.6	1350.0	324.00	307.80	1350.00	239.67	170.19	147.04	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	284.34	6.86	155.80	19.91	19.91	953.9	1350.0	295.68	295.68	1120.00	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	284.34	6.86	155.80	12.67	12.67	953.9	1350.0	171.02	171.02	712.58	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	284.34	6.86	155.80	9.44	9.44	953.9	1350.0	127.42	127.42	530.92	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	909.0	909.0	1713.9	447.00	284.71	6.90	155.40	24.00	24.00	956.4	1350.0	356.40	338.58	1350.00	125.21	88.71	84.31	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	284.34	6.86	155.80	19.92	19.92	953.9	1350.0	268.97	268.97	1120.70	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	833.1	833.1	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	964.2	1350.0	324.00	307.80	1350.00	547.90	391.31	338.09	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	284.34	6.86	155.80	16.38	16.38	953.9	1350.0	221.11	221.11	921.31	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	284.34	6.86	155.80	17.68	17.68	953.9	1350.0	238.68	238.68	994.50	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	284.22	6.48	160.30	9.74	9.74	927.2	1350.0	131.50	131.50	547.94	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	284.11	6.10	164.79	9.78	9.78	901.9	1350.0	145.22	145.22	550.07	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	284.11	6.10	164.79	7.49	7.49	901.9	1350.0	101.08	101.08	421.17	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	284.11	6.10	164.79	6.51	6.51	901.9	1350.0	87.82	87.82	365.91	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	284.11	6.10	164.79	6.81	6.81	901.9	1350.0	91.93	91.93	383.05	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	284.11	6.10	164.79	5.91	5.91	901.9	1350.0	79.76	79.76	332.34	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	284.11	6.10	164.79	5.43	5.43	901.9	1350.0	73.30	73.30	305.40	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	143.9	143.9	1927.6	455.00	284.11	6.10	164.79	4.03	4.03	901.9	1350.0	59.84	59.84	226.67	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	190.6	48.56	0.28	122.5	2050.1	122.5	122.5	1927.6	455.00	284.11	6.10	164.79	3.77	3.77	901.9	1350.0	50.92	50.92	212.15	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	187.6	48.56	0.28	119.9	2047.5	119.9	119.9	1927.6	455.00	284.11	6.10	164.79	3.69	3.69	901.9	1350.0	49.84	49.84	207.66	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	179.5	48.56	0.31	124.2	2051.8	124.2	124.2	1927.6	455.00	284.11	6.10	164.79	3.48	3.48	901.9	1350.0	51.63	51.63	195.55	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	209.5	48.56	0.55	138.5	2066.1	138.5	138.5	1927.6	455.00	284.11	6.10	164.79	4.27	4.27	901.9	1350.0	57.59	57.59	239.96	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	214.1	48.56	0.55	142.4	2070.1	142.4	142.4	1927.6	455.00	284.11	6.10	164.79	4.39	4.39	901.9	1350.0	59.22	59.22	246.77	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	223.0	48.56	0.44	120.1	2047.7	120.1	120.1	1927.6	455.00	284.11	6.10	164.79	4.62	4.62	901.9	1350.0	49.93	49.93	260.07	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	308.0	48.56	1.11	223.0	2150.7	223.0	223.0	1927.6	455.00	284.11	6.10	164.79	6.87	6.87	901.9	1350.0	92.74	92.74	386.40	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	284.11	6.10	164.79	7.52	7.52	901.9	1350.0	101.55	101.55	423.13	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	284.11	6.10	164.79	7.85	7.85	901.9	1350.0	116.60	116.60	441.66	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	284.11	6.10	164.79	12.46	12.46	901.9	1350.0	168.27	168.27	701.12	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	284.11	6.10	164.79	12.18	12.18	901.9	1350.0	164.45	164.45	685.23	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	284.11	6.10	164.79	21.88	21.88	901.9	1350.0	295.35	295.35	1230.63	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	284.15	6.23	163.29	13.06	13.06	910.2	1350.0	176.25	176.25	734.37	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	284.22	6.48	160.30	15.74	15.74	927.2	1350.0	212.54	212.54	885.57	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	284.30	6.73	157.30	23.12	23.12	944.8	1350.0	343.31	338.58	1300.40	0.00	0.00	0.00	447.0	1713.91
																					6383.91	**6264.16**				**1464.39**		

Min. Res. Level 455.0 m Average Power 1350.0 MW Continuous Power 195.55 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR
KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **1425 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	875.6	875.6	1713.9	447.00	285.25	6.95	154.80	24.00	24.00	1013.5	1425.0	342.00	324.90	1425.00	245.01	174.25	150.55	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	882.5	882.5	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1021.4	1425.0	342.00	324.90	1425.00	680.93	488.09	421.71	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	874.1	874.1	1713.9	447.00	285.01	6.92	155.06	24.00	24.00	1011.7	1425.0	342.00	324.90	1425.00	157.57	111.87	96.66	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	872.6	872.6	1713.9	447.00	284.76	6.90	155.34	24.00	24.00	1009.9	1425.0	342.00	324.90	1425.00	67.86	48.09	41.55	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	874.3	874.3	1713.9	447.00	285.03	6.93	155.04	24.00	24.00	1011.9	1425.0	342.00	324.90	1425.00	164.67	116.93	101.03	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	284.56	6.88	155.56	18.83	18.83	1008.5	1425.0	295.21	295.21	1118.23	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	284.56	6.88	155.56	11.98	11.98	1008.5	1425.0	170.75	170.75	711.46	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	284.56	6.88	155.56	8.93	8.93	1008.5	1425.0	127.22	127.22	530.08	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	959.5	959.5	1713.9	447.00	284.71	6.90	155.40	24.00	24.00	1009.6	1425.0	376.20	357.39	1425.00	50.21	35.58	33.81	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	284.56	6.88	155.56	18.85	18.85	1008.5	1425.0	268.55	268.55	1118.94	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	879.3	879.3	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	1017.7	1425.0	342.00	324.90	1425.00	472.90	337.75	291.81	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	284.56	6.88	155.56	15.49	15.49	1008.5	1425.0	220.77	220.77	919.86	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	284.56	6.88	155.56	16.72	16.72	1008.5	1425.0	238.30	238.30	992.93	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	284.44	6.50	160.05	9.21	9.21	980.2	1425.0	131.31	131.31	547.11	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	284.33	6.12	164.55	9.25	9.25	953.4	1425.0	145.01	145.01	549.27	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	284.33	6.12	164.55	7.08	7.08	953.4	1425.0	100.93	100.93	420.56	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	284.33	6.12	164.55	6.15	6.15	953.4	1425.0	87.69	87.69	365.38	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	284.33	6.12	164.55	6.44	6.44	953.4	1425.0	91.80	91.80	382.49	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	284.33	6.12	164.55	5.59	5.59	953.4	1425.0	79.65	79.65	331.86	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	284.33	6.12	164.55	5.14	5.14	953.4	1425.0	73.19	73.19	304.95	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	143.9	143.9	1927.6	455.00	284.33	6.12	164.55	3.81	3.81	953.4	1425.0	59.75	59.75	226.34	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	190.6	48.56	0.28	122.5	2050.1	122.5	122.5	1927.6	455.00	284.33	6.12	164.55	3.57	3.57	953.4	1425.0	50.84	50.84	211.84	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	187.6	48.56	0.28	119.9	2047.5	119.9	119.9	1927.6	455.00	284.33	6.12	164.55	3.49	3.49	953.4	1425.0	49.77	49.77	207.36	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	179.5	48.56	0.31	124.2	2051.8	124.2	124.2	1927.6	455.00	284.33	6.12	164.55	3.29	3.29	953.4	1425.0	51.55	51.55	195.27	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	209.5	48.56	0.55	138.5	2066.1	138.5	138.5	1927.6	455.00	284.33	6.12	164.55	4.04	4.04	953.4	1425.0	57.51	57.51	239.61	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	214.1	48.56	0.55	142.4	2070.1	142.4	142.4	1927.6	455.00	284.33	6.12	164.55	4.15	4.15	953.4	1425.0	59.14	59.14	246.41	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	223.0	48.56	0.44	120.1	2047.7	120.1	120.1	1927.6	455.00	284.33	6.12	164.55	4.37	4.37	953.4	1425.0	49.86	49.86	259.70	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	308.0	48.56	1.11	223.0	2150.7	223.0	223.0	1927.6	455.00	284.33	6.12	164.55	6.50	6.50	953.4	1425.0	92.60	92.60	385.84	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	284.33	6.12	164.55	7.12	7.12	953.4	1425.0	101.40	101.40	422.51	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	284.33	6.12	164.55	7.43	7.43	953.4	1425.0	116.43	116.43	441.02	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	284.33	6.12	164.55	11.79	11.79	953.4	1425.0	168.03	168.03	700.10	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	284.33	6.12	164.55	11.52	11.52	953.4	1425.0	164.22	164.22	684.23	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	284.33	6.12	164.55	20.70	20.70	953.4	1425.0	294.92	294.92	1228.85	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	284.37	6.25	163.05	12.35	12.35	962.2	1425.0	175.99	175.99	733.29	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	284.44	6.50	160.05	14.89	14.89	980.2	1425.0	212.22	212.22	884.23	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	284.52	6.76	157.06	21.87	21.87	998.9	1425.0	342.77	342.77	1298.38	0.00	0.00	0.00	447.0	1713.91
																					6505.56	**6384.15**				**1137.13**		

Min. Res. Level 455.0 m Average Power 1425.0 MW Continuous Power 195.27 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR

KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **1500 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	921.7	921.7	1713.9	447.00	285.25	6.95	154.80	24.00	24.00	1066.8	1500.0	360.00	342.00	1500.00	170.01	120.91	104.46	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	929.0	929.0	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1075.2	1500.0	360.00	342.00	1500.00	605.93	434.33	375.27	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	920.2	920.2	1713.9	447.00	285.01	6.92	155.06	24.00	24.00	1065.0	1500.0	360.00	342.00	1500.00	82.57	58.62	50.65	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	284.78	6.90	155.32	23.88	23.88	1063.3	1500.0	358.23	342.00	1492.64	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	920.3	920.3	1713.9	447.00	285.03	6.93	155.04	24.00	24.00	1065.1	1500.0	360.00	342.00	1500.00	89.67	63.68	55.02	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	284.78	6.90	155.32	17.86	17.86	1063.2	1500.0	294.76	294.76	1116.52	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	284.78	6.90	155.32	11.37	11.37	1063.2	1500.0	170.49	170.49	710.37	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	284.78	6.90	155.32	8.47	8.47	1063.2	1500.0	127.02	127.02	529.27	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	284.78	6.90	155.32	23.59	23.59	1063.2	1500.0	389.26	376.20	1474.47	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	284.78	6.90	155.32	17.88	17.88	1063.2	1500.0	268.13	268.13	1117.22	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	925.6	925.6	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	1071.3	1500.0	360.00	342.00	1500.00	397.90	284.18	245.53	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	284.78	6.90	155.32	14.70	14.70	1063.2	1500.0	220.43	220.43	918.44	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	284.78	6.90	155.32	15.86	15.86	1063.2	1500.0	237.94	237.94	991.41	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	284.66	6.52	159.82	8.74	8.74	1033.3	1500.0	131.11	131.11	546.30	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	284.55	6.14	164.31	8.78	8.78	1005.0	1500.0	144.80	144.80	548.50	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	284.55	6.14	164.31	6.72	6.72	1005.0	1500.0	100.79	100.79	419.96	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	284.55	6.14	164.31	5.84	5.84	1005.0	1500.0	87.57	87.57	364.86	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	284.55	6.14	164.31	6.11	6.11	1005.0	1500.0	91.67	91.67	381.95	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	284.55	6.14	164.31	5.30	5.30	1005.0	1500.0	79.53	79.53	331.39	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	284.55	6.14	164.31	4.87	4.87	1005.0	1500.0	73.09	73.09	304.52	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	143.9	143.9	1927.6	455.00	284.55	6.14	164.31	3.62	3.62	1005.0	1500.0	59.67	59.67	226.02	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	190.6	48.56	0.28	122.5	2050.1	122.5	122.5	1927.6	455.00	284.55	6.14	164.31	3.38	3.38	1005.0	1500.0	50.77	50.77	211.54	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	187.6	48.56	0.28	119.9	2047.5	119.9	119.9	1927.6	455.00	284.55	6.14	164.31	3.31	3.31	1005.0	1500.0	49.70	49.70	207.07	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	179.5	48.56	0.31	124.2	2051.8	124.2	124.2	1927.6	455.00	284.55	6.14	164.31	3.12	3.12	1005.0	1500.0	51.48	51.48	194.99	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	209.5	48.56	0.55	138.5	2066.1	138.5	138.5	1927.6	455.00	284.55	6.14	164.31	3.83	3.83	1005.0	1500.0	57.43	57.43	239.27	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	214.1	48.56	0.55	142.4	2070.1	142.4	142.4	1927.6	455.00	284.55	6.14	164.31	3.94	3.94	1005.0	1500.0	59.05	59.05	246.06	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	223.0	48.56	0.44	120.1	2047.7	120.1	120.1	1927.6	455.00	284.55	6.14	164.31	4.15	4.15	1005.0	1500.0	49.79	49.79	259.33	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	308.0	48.56	1.11	223.0	2150.7	223.0	223.0	1927.6	455.00	284.55	6.14	164.31	6.16	6.16	1005.0	1500.0	92.47	92.47	385.29	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	284.55	6.14	164.31	6.75	6.75	1005.0	1500.0	101.26	101.26	421.92	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	284.55	6.14	164.31	7.05	7.05	1005.0	1500.0	116.26	116.26	440.39	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	284.55	6.14	164.31	11.19	11.19	1005.0	1500.0	167.79	167.79	699.12	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	284.55	6.14	164.31	10.93	10.93	1005.0	1500.0	163.98	163.98	683.27	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	284.55	6.14	164.31	19.63	19.63	1005.0	1500.0	294.51	294.51	1227.11	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	284.58	6.27	162.81	11.72	11.72	1014.3	1500.0	175.74	175.74	732.24	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	284.66	6.52	159.82	14.13	14.13	1033.3	1500.0	211.90	211.90	882.93	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	284.74	6.78	156.82	20.74	20.74	1053.1	1500.0	342.25	342.25	1296.42	0.00	0.00	0.00	447.0	1713.91
																					6618.88	**6499.59**				**830.93**		

Min. Res. Level 455.0 m Average Power 1500.0 MW Continuous Power 194.99 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR
KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **1575 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	967.8	967.8	1713.9	447.00	285.25	6.95	154.80	24.00	24.00	1120.1	1575.0	378.00	359.10	1575.00	95.01	67.57	58.38	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	975.4	975.4	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1129.0	1575.0	378.00	359.10	1575.00	530.93	380.57	328.82	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	966.2	966.2	1713.9	447.00	285.01	6.92	155.06	24.00	24.00	1118.2	1575.0	378.00	359.10	1575.00	7.57	5.38	4.64	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	284.99	6.92	155.09	22.71	22.71	1118.1	1575.0	357.70	357.70	1490.41	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	966.3	966.3	1713.9	447.00	285.03	6.93	155.04	24.00	24.00	1118.4	1575.0	378.00	359.10	1575.00	14.67	10.42	9.00	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	284.99	6.92	155.09	16.99	16.99	1118.1	1575.0	294.32	294.32	1114.85	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	284.99	6.92	155.09	10.81	10.81	1118.1	1575.0	170.23	170.23	709.31	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	284.99	6.92	155.09	8.05	8.05	1118.1	1575.0	126.83	126.83	528.48	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	284.99	6.92	155.09	22.43	22.43	1118.1	1575.0	388.68	388.68	1472.27	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	284.99	6.92	155.09	17.00	17.00	1118.1	1575.0	267.73	267.73	1115.55	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	971.9	971.9	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	1124.9	1575.0	378.00	359.10	1575.00	322.90	230.61	199.25	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	284.99	6.92	155.09	13.97	13.97	1118.1	1575.0	220.10	220.10	917.07	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	284.99	6.92	155.09	15.08	15.08	1118.1	1575.0	237.58	237.58	989.93	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	284.87	6.54	159.59	8.31	8.31	1086.5	1575.0	130.92	130.92	545.52	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	284.75	6.16	164.09	8.35	8.35	1056.7	1575.0	144.60	144.60	547.74	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	284.75	6.16	164.09	6.39	6.39	1056.7	1575.0	100.65	100.65	419.39	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	284.75	6.16	164.09	5.55	5.55	1056.7	1575.0	87.45	87.45	364.36	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	284.75	6.16	164.09	5.81	5.81	1056.7	1575.0	91.54	91.54	381.43	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	284.75	6.16	164.09	5.04	5.04	1056.7	1575.0	79.42	79.42	330.93	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	284.75	6.16	164.09	4.63	4.63	1056.7	1575.0	72.99	72.99	304.11	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	143.9	143.9	1927.6	455.00	284.75	6.16	164.09	3.44	3.44	1056.7	1575.0	59.59	59.59	225.71	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	190.6	48.56	0.28	122.5	2050.1	122.5	122.5	1927.6	455.00	284.75	6.16	164.09	3.22	3.22	1056.7	1575.0	50.70	50.70	211.25	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	187.6	48.56	0.28	119.9	2047.5	119.9	119.9	1927.6	455.00	284.75	6.16	164.09	3.15	3.15	1056.7	1575.0	49.63	49.63	206.78	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	179.5	48.56	0.31	124.2	2051.8	125.6	125.6	1926.2	454.95	284.75	6.16	164.06	3.00	3.00	1056.9	1575.0	51.98	51.98	196.88	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	454.95	1926.2	209.5	48.56	0.55	138.5	2064.7	137.1	137.1	1927.6	455.00	284.75	6.16	164.06	3.60	3.60	1056.9	1575.0	56.76	56.76	236.49	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	214.1	48.56	0.55	142.4	2070.1	142.4	142.4	1927.6	455.00	284.75	6.16	164.09	3.74	3.74	1056.7	1575.0	58.97	58.97	245.72	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	223.0	48.56	0.44	120.1	2047.7	120.1	120.1	1927.6	455.00	284.75	6.16	164.09	3.95	3.95	1056.7	1575.0	49.72	49.72	258.97	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	308.0	48.56	1.11	223.0	2150.7	223.0	223.0	1927.6	455.00	284.75	6.16	164.09	5.86	5.86	1056.7	1575.0	92.34	92.34	384.76	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	284.75	6.16	164.09	6.42	6.42	1056.7	1575.0	101.12	101.12	421.34	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	284.75	6.16	164.09	6.70	6.70	1056.7	1575.0	116.10	116.10	439.79	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	284.75	6.16	164.09	10.64	10.64	1056.7	1575.0	167.56	167.56	698.15	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	284.75	6.16	164.09	10.40	10.40	1056.7	1575.0	163.76	163.76	682.33	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	284.75	6.16	164.09	18.67	18.67	1056.7	1575.0	294.10	294.10	1225.42	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	284.79	6.29	162.59	11.14	11.14	1066.5	1575.0	175.49	175.49	731.22	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	284.87	6.54	159.59	13.43	13.43	1086.5	1575.0	211.60	211.60	881.67	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	284.95	6.79	156.59	19.73	19.73	1107.3	1575.0	341.75	341.75	1294.51	0.00	0.00	0.00	447.0	1713.91
																					6701.93	**6607.43**				**600.09**		

Min. Res. Level 454.9 m Average Power 1575.0 MW Continuous Power 196.88 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR

KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **1650 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	1013.9	1013.9	1713.9	447.00	285.25	6.95	154.80	24.00	24.00	1173.5	1650.0	396.00	376.20	1650.00	20.01	14.23	12.29	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	1021.9	1021.9	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1182.7	1650.0	396.00	376.20	1650.00	455.93	326.81	282.37	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	970.8	970.8	1713.9	447.00	285.20	6.94	154.86	22.99	22.99	1173.0	1650.0	379.32	376.20	1580.50	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	285.20	6.94	154.86	21.65	21.65	1173.0	1650.0	357.18	357.18	1488.24	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	975.3	975.3	1713.9	447.00	285.20	6.94	154.86	23.10	23.10	1173.0	1650.0	381.07	376.20	1587.81	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	285.20	6.94	154.86	16.19	16.19	1173.0	1650.0	293.89	293.89	1113.22	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	285.20	6.94	154.86	10.30	10.30	1173.0	1650.0	169.99	169.99	708.27	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	285.20	6.94	154.86	7.68	7.68	1173.0	1650.0	126.65	126.65	527.71	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	285.20	6.94	154.86	21.38	21.38	1173.0	1650.0	388.11	388.11	1470.12	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	285.20	6.94	154.86	16.20	16.20	1173.0	1650.0	267.34	267.34	1113.92	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	1018.2	1018.2	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	1178.4	1650.0	396.00	376.20	1650.00	247.90	177.05	152.97	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	285.20	6.94	154.86	13.32	13.32	1173.0	1650.0	219.78	219.78	915.73	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	285.20	6.94	154.86	14.38	14.38	1173.0	1650.0	237.24	237.24	988.48	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	285.07	6.56	159.37	7.92	7.92	1139.9	1650.0	130.74	130.74	544.76	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	284.95	6.18	163.87	7.96	7.96	1108.6	1650.0	144.41	144.41	547.01	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	284.95	6.18	163.87	6.09	6.09	1108.6	1650.0	100.52	100.52	418.82	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	284.95	6.18	163.87	5.29	5.29	1108.6	1650.0	87.33	87.33	363.87	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	284.95	6.18	163.87	5.54	5.54	1108.6	1650.0	91.42	91.42	380.91	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	284.95	6.18	163.87	4.81	4.81	1108.6	1650.0	79.32	79.32	330.49	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	284.95	6.18	163.87	4.42	4.42	1108.6	1650.0	72.89	72.89	303.70	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	143.9	143.9	1927.6	455.00	284.95	6.18	163.87	3.28	3.28	1108.6	1650.0	59.51	59.51	225.41	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	190.6	48.56	0.28	122.5	2050.1	122.5	122.5	1927.6	455.00	284.95	6.18	163.87	3.07	3.07	1108.6	1650.0	50.63	50.63	210.97	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	187.6	48.56	0.28	119.9	2047.5	119.9	119.9	1927.6	455.00	284.95	6.18	163.87	3.00	3.00	1108.6	1650.0	49.56	49.56	206.50	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	179.5	48.56	0.31	124.2	2051.8	131.8	131.8	1920.0	454.72	284.96	6.19	163.71	3.00	3.00	1109.6	1650.0	54.45	54.45	206.25	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	454.72	1920.0	209.5	48.56	0.55	138.5	2058.5	130.9	130.9	1927.6	455.00	284.96	6.19	163.71	3.28	3.28	1109.6	1650.0	54.05	54.05	225.22	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	214.1	48.56	0.55	142.4	2070.1	142.4	142.4	1927.6	455.00	284.95	6.18	163.87	3.57	3.57	1108.6	1650.0	58.89	58.89	245.39	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	223.0	48.56	0.44	120.1	2047.7	120.1	120.1	1927.6	455.00	284.95	6.18	163.87	3.76	3.76	1108.6	1650.0	49.66	49.66	258.63	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	308.0	48.56	1.11	223.0	2150.7	223.0	223.0	1927.6	455.00	284.95	6.18	163.87	5.59	5.59	1108.6	1650.0	92.22	92.22	384.25	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	284.95	6.18	163.87	6.12	6.12	1108.6	1650.0	100.99	100.99	420.77	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	284.95	6.18	163.87	6.39	6.39	1108.6	1650.0	115.95	115.95	439.20	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	284.95	6.18	163.87	10.14	10.14	1108.6	1650.0	167.33	167.33	697.22	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	284.95	6.18	163.87	9.91	9.91	1108.6	1650.0	163.54	163.54	681.41	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	284.95	6.18	163.87	17.80	17.80	1108.6	1650.0	293.71	293.71	1223.78	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	284.99	6.30	162.37	10.62	10.62	1118.8	1650.0	175.25	175.25	730.22	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	285.07	6.56	159.37	12.81	12.81	1139.9	1650.0	211.30	211.30	880.43	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	285.16	6.81	156.37	18.80	18.80	1161.7	1650.0	341.26	341.26	1292.65	0.00	0.00	0.00	447.0	1713.91
																					6753.48	**6686.09**				**447.63**		

Min. Res. Level 454.7 m Average Power 1650.0 MW Continuous Power 206.25 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR

KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **1725 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	1026.2	1026.2	1713.9	447.00	285.40	6.96	154.64	23.21	23.21	1228.1	1725.0	400.38	393.30	1668.26	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	1068.3	1068.3	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1236.5	1725.0	414.00	393.30	1725.00	380.93	273.05	235.92	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	970.8	970.8	1713.9	447.00	285.40	6.96	154.64	21.96	21.96	1228.1	1725.0	378.78	378.78	1578.24	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	285.40	6.96	154.64	20.68	20.68	1228.1	1725.0	356.67	356.67	1486.11	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	975.3	975.3	1713.9	447.00	285.40	6.96	154.64	22.06	22.06	1228.1	1725.0	380.53	380.53	1585.55	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	285.40	6.96	154.64	15.47	15.47	1228.1	1725.0	293.47	293.47	1111.63	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	285.40	6.96	154.64	9.84	9.84	1228.1	1725.0	169.74	169.74	707.26	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	285.40	6.96	154.64	7.33	7.33	1228.1	1725.0	126.47	126.47	526.95	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	285.40	6.96	154.64	20.42	20.42	1228.1	1725.0	387.56	387.56	1468.02	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	285.40	6.96	154.64	15.48	15.48	1228.1	1725.0	266.96	266.96	1112.34	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	1064.5	1064.5	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	1232.0	1725.0	414.00	393.30	1725.00	172.90	123.48	106.69	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	285.40	6.96	154.64	12.72	12.72	1228.1	1725.0	219.46	219.46	914.43	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	285.40	6.96	154.64	13.73	13.73	1228.1	1725.0	236.90	236.90	987.07	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	285.27	6.58	159.15	7.57	7.57	1193.3	1725.0	130.56	130.56	544.01	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	285.15	6.20	163.65	7.60	7.60	1160.5	1725.0	144.22	144.22	546.29	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	285.15	6.20	163.65	5.82	5.82	1160.5	1725.0	100.39	100.39	418.27	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	285.15	6.20	163.65	5.06	5.06	1160.5	1725.0	87.21	87.21	363.39	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	285.15	6.20	163.65	5.29	5.29	1160.5	1725.0	91.30	91.30	380.41	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	285.15	6.20	163.65	4.59	4.59	1160.5	1725.0	79.21	79.21	330.05	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	285.15	6.20	163.65	4.22	4.22	1160.5	1725.0	72.79	72.79	303.30	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	143.9	143.9	1927.6	455.00	285.15	6.20	163.65	3.13	3.13	1160.5	1725.0	59.43	59.43	225.11	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	190.6	48.56	0.28	122.5	2050.1	125.4	125.4	1924.7	454.89	285.15	6.20	163.59	3.00	3.00	1160.9	1725.0	51.75	51.75	215.63	0.00	0.00	0.00	455.0	1927.62
	II	10	454.89	1924.7	187.6	48.56	0.28	119.9	2044.6	125.5	125.5	1919.1	454.68	285.16	6.22	163.42	3.00	3.00	1162.2	1725.0	51.75	51.75	215.63	0.00	0.00	0.00	455.0	1927.62
	III	11	454.68	1919.1	179.5	48.56	0.31	124.2	2043.2	138.4	138.4	1904.8	454.16	285.17	6.25	163.00	3.00	3.00	1165.1	1725.0	56.93	56.93	215.63	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	454.16	1904.8	209.5	48.56	0.55	138.5	2043.3	125.9	125.9	1917.5	454.63	285.17	6.25	162.97	3.00	3.00	1165.3	1725.0	51.75	51.75	215.63	0.00	0.00	0.00	455.0	1927.62
	II	10	454.63	1917.5	214.1	48.56	0.55	142.4	2059.9	132.3	132.3	1927.6	455.00	285.16	6.21	163.44	3.16	3.16	1162.0	1725.0	54.56	54.56	227.33	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	223.0	48.56	0.44	120.1	2047.7	120.1	120.1	1927.6	455.00	285.15	6.20	163.65	3.59	3.59	1160.5	1725.0	49.59	49.59	258.29	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	308.0	48.56	1.11	223.0	2150.7	223.0	223.0	1927.6	455.00	285.15	6.20	163.65	5.34	5.34	1160.5	1725.0	92.10	92.10	383.74	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	285.15	6.20	163.65	5.85	5.85	1160.5	1725.0	100.85	100.85	420.22	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	285.15	6.20	163.65	6.10	6.10	1160.5	1725.0	115.80	115.80	438.62	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	285.15	6.20	163.65	9.69	9.69	1160.5	1725.0	167.11	167.11	696.30	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	285.15	6.20	163.65	9.47	9.47	1160.5	1725.0	163.32	163.32	680.52	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	285.15	6.20	163.65	17.00	17.00	1160.5	1725.0	293.32	293.32	1222.17	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	285.19	6.32	162.15	10.15	10.15	1171.2	1725.0	175.02	175.02	729.25	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	285.27	6.58	159.15	12.23	12.23	1193.3	1725.0	211.02	211.02	879.23	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	285.36	6.83	156.15	17.96	17.96	1216.3	1725.0	340.78	340.78	1290.83	0.00	0.00	0.00	447.0	1713.91
																					6785.68	**6737.20**				**342.61**		

Min. Res. Level 454.2 m Average Power 1725.0 MW Continuous Power 215.63 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR
KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **1800 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	1026.2	1026.2	1713.9	447.00	285.60	6.98	154.42	22.21	22.21	1283.3	1800.0	399.82	399.82	1665.94	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	1114.8	1114.8	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1290.2	1800.0	432.00	410.40	1800.00	305.93	219.29	189.47	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	970.8	970.8	1713.9	447.00	285.60	6.98	154.42	21.01	21.01	1283.3	1800.0	378.25	378.25	1576.04	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	285.60	6.98	154.42	19.79	19.79	1283.3	1800.0	356.17	356.17	1484.04	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	975.3	975.3	1713.9	447.00	285.60	6.98	154.42	21.11	21.11	1283.3	1800.0	380.00	380.00	1583.34	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	285.60	6.98	154.42	14.80	14.80	1283.3	1800.0	293.06	293.06	1110.08	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	285.60	6.98	154.42	9.42	9.42	1283.3	1800.0	169.51	169.51	706.28	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	285.60	6.98	154.42	7.02	7.02	1283.3	1800.0	126.29	126.29	526.22	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	285.60	6.98	154.42	19.55	19.55	1283.3	1800.0	387.02	387.02	1465.98	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	285.60	6.98	154.42	14.81	14.81	1283.3	1800.0	266.59	266.59	1110.78	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	1110.7	1110.7	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	1285.6	1800.0	432.00	410.40	1800.00	97.90	69.92	60.41	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	285.60	6.98	154.42	12.18	12.18	1283.3	1800.0	219.16	219.16	913.15	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	285.60	6.98	154.42	13.14	13.14	1283.3	1800.0	236.57	236.57	985.70	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	285.47	6.60	158.94	7.24	7.24	1246.9	1800.0	130.39	130.39	543.28	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	285.34	6.21	163.44	7.27	7.27	1212.5	1800.0	144.04	144.04	545.59	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	285.34	6.21	163.44	5.57	5.57	1212.5	1800.0	100.26	100.26	417.74	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	285.34	6.21	163.44	4.84	4.84	1212.5	1800.0	87.10	87.10	362.93	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	285.34	6.21	163.44	5.07	5.07	1212.5	1800.0	91.18	91.18	379.93	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	285.34	6.21	163.44	4.40	4.40	1212.5	1800.0	79.11	79.11	329.63	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	285.34	6.21	163.44	4.04	4.04	1212.5	1800.0	72.70	72.70	302.91	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	144.0	144.0	1927.5	455.00	285.34	6.21	163.44	3.00	3.00	1212.5	1800.0	59.40	59.40	225.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.5	190.6	48.56	0.28	122.5	2050.0	131.1	131.1	1918.9	454.68	285.35	6.23	163.26	3.00	3.00	1213.8	1800.0	54.00	54.00	225.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.68	1918.9	187.6	48.56	0.28	119.9	2038.7	131.4	131.4	1907.3	454.25	285.36	6.26	162.84	3.00	3.00	1217.0	1800.0	54.00	54.00	225.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.25	1907.3	179.5	48.56	0.31	124.2	2031.5	145.2	145.2	1886.3	453.48	285.38	6.32	162.16	3.00	3.00	1222.0	1800.0	59.40	59.40	225.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	453.48	1886.3	209.5	48.56	0.55	138.5	2024.8	132.2	132.2	1892.6	453.71	285.39	6.35	161.86	3.00	3.00	1224.3	1800.0	54.00	54.00	225.00	0.00	0.00	0.00	455.0	1927.62
	II	10	453.71	1892.6	214.1	48.56	0.55	142.4	2035.0	131.9	131.9	1903.1	454.10	285.38	6.32	162.21	3.00	3.00	1221.7	1800.0	54.00	54.00	225.00	0.00	0.00	0.00	455.0	1927.62
	III	8	454.10	1903.1	223.0	48.56	0.44	120.1	2023.2	105.2	105.2	1918.0	454.64	285.36	6.27	162.73	3.00	3.00	1217.8	1800.0	43.20	43.20	225.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	454.64	1918.0	308.0	48.56	1.11	223.0	2141.0	213.4	213.4	1927.6	455.00	285.35	6.23	163.24	4.88	4.88	1214.0	1800.0	87.89	87.89	366.22	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	285.34	6.21	163.44	5.60	5.60	1212.5	1800.0	100.72	100.72	419.68	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	285.34	6.21	163.44	5.84	5.84	1212.5	1800.0	115.65	115.65	438.06	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	285.34	6.21	163.44	9.27	9.27	1212.5	1800.0	166.90	166.90	695.41	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	285.34	6.21	163.44	9.06	9.06	1212.5	1800.0	163.11	163.11	679.64	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	285.34	6.21	163.44	16.27	16.27	1212.5	1800.0	292.94	292.94	1220.60	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	285.38	6.34	161.94	9.71	9.71	1223.7	1800.0	174.79	174.79	728.30	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	285.47	6.60	158.94	11.71	11.71	1246.9	1800.0	210.73	210.73	878.06	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	285.55	6.85	155.93	17.19	17.19	1270.9	1800.0	340.31	340.31	1289.05	0.00	0.00	0.00	447.0	1713.91
																					6812.27	**6769.07**				**249.88**		

Min. Res. Level 453.5 m Average Power 1800.0 MW Continuous Power 225.00 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR
KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3 Hours **Installed Capacity** **1875 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	1026.2	1026.2	1713.9	447.00	285.79	7.00	154.21	21.29	21.29	1338.6	1875.0	399.28	399.28	1663.66	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	1161.2	1161.2	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1344.0	1875.0	450.00	427.50	1875.00	230.93	165.53	143.02	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	970.8	970.8	1713.9	447.00	285.79	7.00	154.21	20.15	20.15	1338.6	1875.0	377.73	377.73	1573.89	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	285.79	7.00	154.21	18.97	18.97	1338.6	1875.0	355.68	355.68	1482.02	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	975.3	975.3	1713.9	447.00	285.79	7.00	154.21	20.24	20.24	1338.6	1875.0	379.48	379.48	1581.17	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	285.79	7.00	154.21	14.19	14.19	1338.6	1875.0	292.66	292.66	1108.57	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	285.79	7.00	154.21	9.03	9.03	1338.6	1875.0	169.27	169.27	705.31	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	285.79	7.00	154.21	6.73	6.73	1338.6	1875.0	126.12	126.12	525.50	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	285.79	7.00	154.21	18.74	18.74	1338.6	1875.0	386.49	386.49	1463.97	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	285.79	7.00	154.21	14.20	14.20	1338.6	1875.0	266.22	266.22	1109.27	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	1157.0	1157.0	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	1339.1	1875.0	450.00	427.50	1875.00	22.90	16.35	14.13	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	285.79	7.00	154.21	11.67	11.67	1338.6	1875.0	218.86	218.86	911.90	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	285.79	7.00	154.21	12.60	12.60	1338.6	1875.0	236.24	236.24	984.35	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	285.66	6.61	158.73	6.94	6.94	1300.5	1875.0	130.22	130.22	542.57	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	285.53	6.23	163.24	6.97	6.97	1264.6	1875.0	143.85	143.85	544.90	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	285.53	6.23	163.24	5.34	5.34	1264.6	1875.0	100.13	100.13	417.21	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	285.53	6.23	163.24	4.64	4.64	1264.6	1875.0	86.99	86.99	362.47	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	285.53	6.23	163.24	4.86	4.86	1264.6	1875.0	91.07	91.07	379.45	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	285.53	6.23	163.24	4.21	4.21	1264.6	1875.0	79.01	79.01	329.22	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	285.53	6.23	163.24	3.87	3.87	1264.6	1875.0	72.61	72.61	302.53	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	150.4	150.4	1921.2	454.76	285.53	6.24	163.10	3.00	3.00	1265.6	1875.0	61.88	61.88	234.38	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.76	1921.2	190.6	48.56	0.28	122.5	2043.7	137.1	137.1	1906.6	454.23	285.55	6.28	162.67	3.00	3.00	1269.0	1875.0	56.25	56.25	234.38	0.00	0.00	0.00	455.0	1927.62
	II	10	454.23	1906.6	187.6	48.56	0.28	119.9	2026.5	137.6	137.6	1888.9	453.57	285.57	6.34	162.00	3.00	3.00	1274.3	1875.0	56.25	56.25	234.38	0.00	0.00	0.00	455.0	1927.62
	III	11	453.57	1888.9	179.5	48.56	0.31	124.2	2013.0	152.3	152.3	1860.7	452.54	285.59	6.42	161.04	3.00	3.00	1281.8	1875.0	61.88	61.88	234.38	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	452.54	1860.7	209.5	48.56	0.55	138.5	1999.3	138.9	138.9	1860.3	452.52	285.61	6.47	160.45	3.00	3.00	1286.5	1875.0	56.25	56.25	234.38	0.00	0.00	0.00	455.0	1927.62
	II	10	452.52	1860.3	214.1	48.56	0.55	142.4	2002.8	138.9	138.9	1863.9	452.65	285.61	6.46	160.52	3.00	3.00	1286.0	1875.0	56.25	56.25	234.38	0.00	0.00	0.00	455.0	1927.62
	III	8	452.65	1863.9	223.0	48.56	0.44	120.1	1984.0	110.9	110.9	1873.0	452.99	285.60	6.44	160.78	3.00	3.00	1283.9	1875.0	45.00	45.00	234.38	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	452.99	1873.0	308.0	48.56	1.11	223.0	2096.1	168.5	168.5	1927.6	455.00	285.56	6.33	162.10	3.67	3.67	1273.4	1875.0	68.90	68.90	287.09	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	285.53	6.23	163.24	5.37	5.37	1264.6	1875.0	100.60	100.60	419.15	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	285.53	6.23	163.24	5.60	5.60	1264.6	1875.0	115.50	115.50	437.51	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	285.53	6.23	163.24	8.89	8.89	1264.6	1875.0	166.69	166.69	694.54	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	285.53	6.23	163.24	8.69	8.69	1264.6	1875.0	162.91	162.91	678.79	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	285.53	6.23	163.24	15.60	15.60	1264.6	1875.0	292.58	292.58	1219.07	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	285.57	6.36	161.73	9.31	9.31	1276.3	1875.0	174.57	174.57	727.38	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	285.66	6.61	158.73	11.22	11.22	1300.5	1875.0	210.46	210.46	876.91	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	285.75	6.87	155.72	16.48	16.48	1325.6	1875.0	339.85	339.85	1287.32	0.00	0.00	0.00	447.0	1713.91
																					6837.74	**6792.74**				**157.15**		

Min. Res. Level 452.5 m Average Power 1875.0 MW Continuous Power 234.38 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR

KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **1950 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	1026.2	1026.2	1713.9	447.00	285.98	7.01	154.01	20.45	20.45	1394.0	1950.0	398.74	398.74	1661.44	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	1207.7	1207.7	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1397.8	1950.0	468.00	444.60	1950.00	155.93	111.77	96.57	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	970.8	970.8	1713.9	447.00	285.98	7.01	154.01	19.35	19.35	1394.0	1950.0	377.23	377.23	1571.78	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	285.98	7.01	154.01	18.22	18.22	1394.0	1950.0	355.21	355.21	1480.03	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	975.3	975.3	1713.9	447.00	285.98	7.01	154.01	19.43	19.43	1394.0	1950.0	378.97	378.97	1579.06	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	285.98	7.01	154.01	13.63	13.63	1394.0	1950.0	292.27	292.27	1107.08	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	285.98	7.01	154.01	8.67	8.67	1394.0	1950.0	169.05	169.05	704.37	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	285.98	7.01	154.01	6.46	6.46	1394.0	1950.0	125.95	125.95	524.80	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	285.98	7.01	154.01	17.99	17.99	1394.0	1950.0	385.97	385.97	1462.02	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	285.98	7.01	154.01	13.63	13.63	1394.0	1950.0	265.87	265.87	1107.78	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	1171.1	1171.1	1713.9	447.00	285.98	7.01	154.01	23.34	23.34	1394.0	1950.0	455.07	444.60	1896.14	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	285.98	7.01	154.01	11.21	11.21	1394.0	1950.0	218.56	218.56	910.68	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	285.98	7.01	154.01	12.10	12.10	1394.0	1950.0	235.93	235.93	983.03	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	285.84	6.63	158.52	6.67	6.67	1354.3	1950.0	130.05	130.05	541.88	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	285.72	6.25	163.04	6.70	6.70	1316.8	1950.0	143.68	143.68	544.23	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	285.72	6.25	163.04	5.13	5.13	1316.8	1950.0	100.01	100.01	416.70	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	285.72	6.25	163.04	4.46	4.46	1316.8	1950.0	86.89	86.89	362.03	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	285.72	6.25	163.04	4.66	4.66	1316.8	1950.0	90.96	90.96	378.98	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	285.72	6.25	163.04	4.05	4.05	1316.8	1950.0	78.91	78.91	328.81	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	285.72	6.25	163.04	3.72	3.72	1316.8	1950.0	72.52	72.52	302.16	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	156.7	156.7	1914.9	454.53	285.72	6.27	162.77	3.00	3.00	1318.9	1950.0	64.35	64.35	243.75	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.53	1914.9	190.6	48.56	0.28	122.5	2037.3	143.1	143.1	1894.3	453.77	285.74	6.33	162.08	3.00	3.00	1324.6	1950.0	58.50	58.50	243.75	0.00	0.00	0.00	455.0	1927.62
	II	10	453.77	1894.3	187.6	48.56	0.28	119.9	2014.1	143.9	143.9	1870.3	452.89	285.77	6.41	161.15	3.00	3.00	1332.2	1950.0	58.50	58.50	243.75	0.00	0.00	0.00	455.0	1927.62
	III	11	452.89	1870.3	179.5	48.56	0.31	124.2	1994.4	159.5	159.5	1834.9	451.59	285.80	6.51	159.92	3.00	3.00	1342.5	1950.0	64.35	64.35	243.75	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	451.59	1834.9	209.5	48.56	0.55	138.5	1973.5	145.8	145.8	1827.7	451.32	285.83	6.59	159.03	3.00	3.00	1349.9	1950.0	58.50	58.50	243.75	0.00	0.00	0.00	455.0	1927.62
	II	10	451.32	1827.7	214.1	48.56	0.55	142.4	1970.1	146.0	146.0	1824.1	451.19	285.84	6.61	158.81	3.00	3.00	1351.8	1950.0	58.50	58.50	243.75	0.00	0.00	0.00	455.0	1927.62
	III	8	451.19	1824.1	223.0	48.56	0.44	120.1	1944.2	116.8	116.8	1827.4	451.31	285.84	6.61	158.80	3.00	3.00	1351.9	1950.0	46.80	46.80	243.75	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	451.31	1827.4	308.0	48.56	1.11	223.0	2050.5	144.5	144.5	1906.0	454.20	285.79	6.46	160.51	3.00	3.00	1337.5	1950.0	58.50	58.50	243.75	0.00	0.00	0.00	455.0	1927.62
	II	10	454.20	1906.0	332.5	48.56	1.11	244.2	2150.3	222.6	222.6	1927.6	455.00	285.73	6.29	162.59	4.68	4.68	1320.4	1950.0	91.33	91.33	380.54	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	285.72	6.25	163.04	5.38	5.38	1316.8	1950.0	115.36	115.36	436.97	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	285.72	6.25	163.04	8.54	8.54	1316.8	1950.0	166.48	166.48	693.68	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	285.72	6.25	163.04	8.34	8.34	1316.8	1950.0	162.71	162.71	677.95	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	285.72	6.25	163.04	14.99	14.99	1316.8	1950.0	292.22	292.22	1217.57	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	285.76	6.38	161.53	8.94	8.94	1329.1	1950.0	174.35	174.35	726.47	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	285.84	6.63	158.52	10.78	10.78	1354.3	1950.0	210.19	210.19	875.78	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	285.93	6.89	155.52	15.82	15.82	1380.5	1950.0	339.40	339.40	1285.62	0.00	0.00	0.00	447.0	1713.91
																					6849.88	**6816.01**				**96.57**		

Min. Res. Level 451.2 m Average Power 1950.0 MW Continuous Power 243.75 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR
KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **2025 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	1026.2	1026.2	1713.9	447.00	286.16	7.03	153.80	19.67	19.67	1449.5	2025.0	398.22	398.22	1659.26	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	1254.1	1254.1	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1451.5	2025.0	486.00	461.70	2025.00	80.93	58.01	50.12	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	970.8	970.8	1713.9	447.00	286.16	7.03	153.80	18.60	18.60	1449.5	2025.0	376.73	376.73	1569.72	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	286.16	7.03	153.80	17.52	17.52	1449.5	2025.0	354.74	354.74	1478.09	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	975.3	975.3	1713.9	447.00	286.16	7.03	153.80	18.69	18.69	1449.5	2025.0	378.48	378.48	1576.99	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	286.16	7.03	153.80	13.10	13.10	1449.5	2025.0	291.89	291.89	1105.63	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	286.16	7.03	153.80	8.34	8.34	1449.5	2025.0	168.83	168.83	703.44	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	286.16	7.03	153.80	6.21	6.21	1449.5	2025.0	125.79	125.79	524.11	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	286.16	7.03	153.80	17.30	17.30	1449.5	2025.0	385.47	385.47	1460.10	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	286.16	7.03	153.80	13.11	13.11	1449.5	2025.0	265.52	265.52	1106.33	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	1171.1	1171.1	1713.9	447.00	286.16	7.03	153.80	22.44	22.44	1449.5	2025.0	454.48	454.48	1893.65	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	286.16	7.03	153.80	10.78	10.78	1449.5	2025.0	218.28	218.28	909.49	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	286.16	7.03	153.80	11.64	11.64	1449.5	2025.0	235.62	235.62	981.74	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	286.03	6.65	158.33	6.41	6.41	1408.1	2025.0	129.89	129.89	541.20	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	285.90	6.26	162.84	6.44	6.44	1369.1	2025.0	143.50	143.50	543.58	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	285.90	6.26	162.84	4.93	4.93	1369.1	2025.0	99.89	99.89	416.20	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	285.90	6.26	162.84	4.29	4.29	1369.1	2025.0	86.78	86.78	361.59	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	285.90	6.26	162.84	4.49	4.49	1369.1	2025.0	90.85	90.85	378.52	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	285.90	6.26	162.84	3.89	3.89	1369.1	2025.0	78.82	78.82	328.42	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	285.90	6.26	162.84	3.58	3.58	1369.1	2025.0	72.43	72.43	301.79	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	163.0	163.0	1908.5	454.30	285.91	6.30	162.44	3.00	3.00	1372.4	2025.0	66.83	66.83	253.13	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.30	1908.5	190.6	48.56	0.28	122.5	2031.0	149.1	149.1	1881.9	453.31	285.93	6.38	161.49	3.00	3.00	1380.5	2025.0	60.75	60.75	253.13	0.00	0.00	0.00	455.0	1927.62
	II	10	453.31	1881.9	187.6	48.56	0.28	119.9	2001.7	150.2	150.2	1851.5	452.20	285.97	6.48	160.31	3.00	3.00	1390.7	2025.0	60.75	60.75	253.13	0.00	0.00	0.00	455.0	1927.62
	III	11	452.20	1851.5	179.5	48.56	0.31	124.2	1975.7	166.8	166.8	1808.9	450.63	286.01	6.61	158.79	3.00	3.00	1404.0	2025.0	66.83	66.83	253.13	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	450.63	1808.9	209.5	48.56	0.55	138.5	1947.4	152.8	152.8	1794.7	450.10	286.05	6.71	157.61	3.00	3.00	1414.5	2025.0	60.75	60.75	253.13	0.00	0.00	0.00	455.0	1927.62
	II	10	450.10	1794.7	214.1	48.56	0.55	142.4	1937.1	153.3	153.3	1783.8	449.69	286.06	6.75	157.08	3.00	3.00	1419.3	2025.0	60.75	60.75	253.13	0.00	0.00	0.00	455.0	1927.62
	III	8	449.69	1783.8	223.0	48.56	0.44	120.1	1903.9	122.9	122.9	1781.1	449.58	286.07	6.78	156.78	3.00	3.00	1422.0	2025.0	48.60	48.60	253.13	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	449.58	1781.1	308.0	48.56	1.11	223.0	2004.1	152.2	152.2	1851.9	452.21	286.03	6.66	158.21	3.00	3.00	1409.2	2025.0	60.75	60.75	253.13	0.00	0.00	0.00	455.0	1927.62
	II	10	452.21	1851.9	332.5	48.56	1.11	244.2	2096.2	168.6	168.6	1927.6	455.00	285.94	6.40	161.27	3.39	3.39	1382.4	2025.0	68.58	68.58	285.76	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	285.90	6.26	162.84	5.17	5.17	1369.1	2025.0	115.22	115.22	436.44	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	285.90	6.26	162.84	8.21	8.21	1369.1	2025.0	166.28	166.28	692.84	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	285.90	6.26	162.84	8.03	8.03	1369.1	2025.0	162.51	162.51	677.14	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	285.90	6.26	162.84	14.41	14.41	1369.1	2025.0	291.86	291.86	1216.10	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	285.94	6.39	161.33	8.60	8.60	1381.9	2025.0	174.14	174.14	725.58	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	286.03	6.65	158.33	10.37	10.37	1408.1	2025.0	209.92	209.92	874.68	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	286.12	6.90	155.31	15.22	15.22	1435.4	2025.0	338.96	338.96	1283.96	0.00	0.00	0.00	447.0	1713.91
																					6855.67	**6831.37**				**50.12**		

Min. Res. Level 449.6 m Average Power 2025.0 MW Continuous Power 253.13 MW

Annexure 9-3

ENERGY STUDY FOR 90% DEPENDABLE YEAR

KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec Min. Peaking hrs 3.00 Hours **Installed Capacity** **2100 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2006-07**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	1026.2	1026.2	1713.9	447.00	286.35	7.05	153.61	18.94	18.94	1505.1	2100.0	397.71	397.71	1657.12	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	1300.6	1300.6	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1505.3	2100.0	504.00	478.80	2100.00	5.93	4.25	3.67	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	970.8	970.8	1713.9	447.00	286.35	7.05	153.61	17.92	17.92	1505.1	2100.0	376.25	376.25	1567.70	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	286.35	7.05	153.61	16.87	16.87	1505.1	2100.0	354.29	354.29	1476.19	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	975.3	975.3	1713.9	447.00	286.35	7.05	153.61	18.00	18.00	1505.1	2100.0	377.99	377.99	1574.96	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	286.35	7.05	153.61	12.62	12.62	1505.1	2100.0	291.51	291.51	1104.21	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	286.35	7.05	153.61	8.03	8.03	1505.1	2100.0	168.61	168.61	702.54	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	286.35	7.05	153.61	5.98	5.98	1505.1	2100.0	125.62	125.62	523.43	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	286.35	7.05	153.61	16.67	16.67	1505.1	2100.0	384.97	384.97	1458.22	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	286.35	7.05	153.61	12.63	12.63	1505.1	2100.0	265.18	265.18	1104.91	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	1171.1	1171.1	1713.9	447.00	286.35	7.05	153.61	21.61	21.61	1505.1	2100.0	453.89	453.89	1891.21	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	286.35	7.05	153.61	10.38	10.38	1505.1	2100.0	218.00	218.00	908.32	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	286.35	7.05	153.61	11.21	11.21	1505.1	2100.0	235.31	235.31	980.48	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.80	538.9	2252.8	325.2	325.2	1927.6	455.00	286.21	6.66	158.13	6.18	6.18	1462.1	2100.0	129.73	129.73	540.53	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	286.07	6.28	162.65	6.20	6.20	1421.5	2100.0	143.33	143.33	542.93	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	286.07	6.28	162.65	4.75	4.75	1421.5	2100.0	99.77	99.77	415.70	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	286.07	6.28	162.65	4.13	4.13	1421.5	2100.0	86.68	86.68	361.16	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	286.07	6.28	162.65	4.32	4.32	1421.5	2100.0	90.74	90.74	378.08	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	286.07	6.28	162.65	3.75	3.75	1421.5	2100.0	78.73	78.73	328.03	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	286.07	6.28	162.65	3.44	3.44	1421.5	2100.0	72.34	72.34	301.43	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	169.4	169.4	1902.1	454.06	286.09	6.33	162.12	3.00	3.00	1426.1	2100.0	69.30	69.30	262.50	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.06	1902.1	190.6	48.56	0.28	122.5	2024.6	155.2	155.2	1869.4	452.86	286.12	6.43	160.91	3.00	3.00	1436.9	2100.0	63.00	63.00	262.50	0.00	0.00	0.00	455.0	1927.62
	II	10	452.86	1869.4	187.6	48.56	0.28	119.9	1989.3	156.6	156.6	1832.7	451.50	286.17	6.55	159.46	3.00	3.00	1449.9	2100.0	63.00	63.00	262.50	0.00	0.00	0.00	455.0	1927.62
	III	11	451.50	1832.7	179.5	48.56	0.31	124.2	1956.9	174.2	174.2	1782.6	449.64	286.22	6.71	157.65	3.00	3.00	1466.6	2100.0	69.30	69.30	262.50	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	449.64	1782.6	209.5	48.56	0.55	138.5	1921.1	159.9	159.9	1761.2	448.82	286.27	6.83	156.13	3.00	3.00	1480.8	2100.0	63.00	63.00	262.50	0.00	0.00	0.00	455.0	1927.62
	II	10	448.82	1761.2	214.1	48.56	0.55	142.4	1903.7	160.8	160.8	1742.8	448.11	286.29	6.91	155.27	3.00	3.00	1489.1	2100.0	63.00	63.00	262.50	0.00	0.00	0.00	455.0	1927.62
	III	8	448.11	1742.8	223.0	48.56	0.44	120.1	1863.0	129.2	129.2	1733.8	447.76	286.31	6.96	154.67	3.00	3.00	1494.8	2100.0	50.40	50.40	262.50	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	447.76	1733.8	308.0	48.56	1.11	223.0	1956.8	160.2	160.2	1796.6	450.17	286.28	6.86	155.83	3.00	3.00	1483.6	2100.0	63.00	63.00	262.50	0.00	0.00	0.00	455.0	1927.62
	II	10	450.17	1796.6	332.5	48.56	1.11	244.2	2040.9	157.0	157.0	1883.8	453.39	286.18	6.59	159.01	3.00	3.00	1454.0	2100.0	63.00	63.00	262.50	0.00	0.00	0.00	455.0	1927.62
	III	11	453.39	1883.8	344.9	48.56	1.22	280.4	2164.3	236.7	236.7	1927.6	455.00	286.10	6.36	161.74	4.18	4.18	1429.5	2100.0	96.57	96.57	365.81	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	286.07	6.28	162.65	7.91	7.91	1421.5	2100.0	166.09	166.09	692.02	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	286.07	6.28	162.65	7.73	7.73	1421.5	2100.0	162.32	162.32	676.33	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	286.07	6.28	162.65	13.88	13.88	1421.5	2100.0	291.52	291.52	1214.66	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.10	355.3	2282.9	427.8	427.8	1855.1	452.33	286.12	6.41	161.14	8.28	8.28	1434.8	2100.0	173.93	173.93	724.71	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.07	453.7	2308.8	525.5	525.5	1783.3	449.67	286.21	6.66	158.13	9.98	9.98	1462.1	2100.0	209.66	209.66	873.60	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.15	795.6	2578.9	865.0	865.0	1713.9	447.00	286.30	6.92	155.12	14.66	14.66	1490.5	2100.0	338.53	338.53	1282.33	0.00	0.00	0.00	447.0	1713.91
																					6860.27	**6835.07**				**3.67**		

Min. Res. Level 447.8 m Average Power 2100.0 MW Continuous Power 262.50 MW

Annexure 9-4
Reservoir Operation Studies

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1980-81

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1504.2	48.56	1.04	1256.7	2970.6	1068.8	1068.8	1713.9	447.00	286.18	7.03	153.79	24.00	24.00	1237.1	1728.0	414.72	393.98	1728.00	303.69	217.41	187.84	447.0	1713.91
	II	10	447.00	1713.9	1569.8	48.56	1.04	1313.3	3027.2	1070.4	1070.4	1713.9	447.00	286.39	7.05	153.55	24.00	24.00	1238.9	1728.0	414.72	393.98	1728.00	392.04	281.09	242.86	447.0	1713.91
	III	10	447.00	1713.9	1545.8	48.56	1.04	1292.6	3006.5	1069.9	1069.9	1713.9	447.00	286.32	7.05	153.64	24.00	24.00	1238.3	1728.0	414.72	393.98	1728.00	359.77	257.81	222.74	447.0	1713.91
Jul	I	10	447.00	1713.9	1714.5	48.56	1.04	1438.3	3152.2	1073.9	1073.9	1713.9	447.00	286.84	7.09	153.06	24.00	24.00	1242.9	1728.0	414.72	393.98	1728.00	586.36	421.76	364.40	447.0	1713.91
	II	10	447.00	1713.9	2065.7	48.56	1.04	1741.7	3455.7	1081.7	1081.7	1713.9	447.00	287.85	7.19	151.96	24.00	24.00	1252.0	1728.0	414.72	393.98	1728.00	1054.45	763.96	660.06	447.0	1713.91
	III	11	447.00	1713.9	1513.0	48.56	1.14	1390.6	3104.6	1175.9	1175.9	1713.9	447.00	286.21	7.04	153.76	24.00	24.00	1237.3	1728.0	456.19	433.38	1728.00	315.50	225.91	214.70	447.0	1713.91
Aug	I	10	447.00	1713.9	1832.7	48.56	1.04	1540.5	3254.4	1076.6	1076.6	1713.9	447.00	287.20	7.13	152.68	24.00	24.00	1246.1	1728.0	414.72	393.98	1728.00	744.55	536.90	463.88	447.0	1713.91
	II	10	447.00	1713.9	1412.1	48.56	1.04	1177.1	2891.0	1066.5	1066.5	1713.9	447.00	285.87	7.00	154.12	24.00	24.00	1234.4	1728.0	414.72	393.98	1728.00	179.22	128.02	110.61	447.0	1713.91
	III	11	447.00	1713.9	1528.8	48.56	1.14	1405.7	3119.6	1176.4	1176.4	1713.9	447.00	286.26	7.04	153.70	24.00	24.00	1237.8	1728.0	456.19	433.38	1728.00	336.83	241.27	229.31	447.0	1713.91
Sep	I	10	447.00	1713.9	1044.9	48.56	1.04	859.8	2573.7	859.8	859.8	1713.9	447.00	285.41	6.96	154.63	19.41	19.41	1230.3	1728.0	335.45	335.45	1397.73	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1432.1	48.56	1.04	1194.4	2908.3	1067.0	1067.0	1713.9	447.00	285.94	7.01	154.05	24.00	24.00	1235.0	1728.0	414.72	393.98	1728.00	206.29	147.43	127.38	447.0	1713.91
	III	10	447.00	1713.9	1876.1	48.56	1.04	1577.9	3291.8	1077.6	1077.6	1713.9	447.00	287.32	7.14	152.54	24.00	24.00	1247.2	1728.0	414.72	393.98	1728.00	802.38	579.12	500.36	447.0	1713.91
Oct	I	10	447.00	1713.9	1263.9	48.56	0.78	1049.3	2763.2	1049.3	1049.3	1713.9	447.00	285.41	6.96	154.63	23.69	23.69	1230.3	1728.0	409.38	393.98	1705.74	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	689.8	48.56	0.83	553.2	2267.1	339.5	339.5	1927.6	455.00	285.28	6.58	159.14	7.89	7.89	1195.4	1728.0	136.31	136.31	567.94	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	497.6	48.56	0.92	425.8	2353.5	425.8	425.8	1927.6	455.00	285.16	6.20	163.64	9.25	9.25	1162.5	1728.0	175.83	175.83	666.00	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	317.0	48.56	0.83	231.1	2158.7	231.1	231.1	1927.6	455.00	285.16	6.20	163.64	5.52	5.52	1162.5	1728.0	95.43	95.43	397.61	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	369.4	48.56	0.83	276.4	2204.0	276.4	276.4	1927.6	455.00	285.16	6.20	163.64	6.60	6.60	1162.5	1728.0	114.12	114.12	475.49	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	285.5	48.56	0.83	203.9	2131.5	203.9	203.9	1927.6	455.00	285.16	6.20	163.64	4.87	4.87	1162.5	1728.0	84.19	84.19	350.78	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	257.0	48.56	0.28	179.8	2107.4	179.8	179.8	1927.6	455.00	285.16	6.20	163.64	4.30	4.30	1162.5	1728.0	74.24	74.24	309.32	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	215.4	48.56	0.28	143.9	2071.5	143.9	143.9	1927.6	455.00	285.16	6.20	163.64	3.44	3.44	1162.5	1728.0	59.40	59.40	247.48	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	168.3	48.56	0.31	113.5	2041.1	138.6	138.6	1902.6	454.08	285.17	6.24	163.12	3.00	3.00	1166.2	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.08	1902.6	178.0	48.56	0.28	111.5	2014.1	126.6	126.6	1887.5	453.52	285.20	6.31	162.29	3.00	3.00	1172.2	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	453.52	1887.5	155.5	48.56	0.28	92.1	1979.6	127.4	127.4	1852.2	452.22	285.22	6.40	161.25	3.00	3.00	1179.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	452.22	1852.2	179.8	48.56	0.31	124.4	1976.6	141.1	141.1	1835.5	451.60	285.25	6.49	160.17	3.00	3.00	1187.8	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	451.60	1835.5	367.5	48.56	0.55	275.0	2110.5	182.8	182.8	1927.6	455.00	285.21	6.36	161.73	4.32	4.32	1176.3	1728.0	74.61	74.61	310.88	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	180.0	48.56	0.55	113.0	2040.6	125.8	125.8	1914.8	454.53	285.17	6.22	163.38	3.00	3.00	1164.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	454.53	1914.8	308.1	48.56	0.44	179.0	2093.8	166.2	166.2	1927.6	455.00	285.17	6.22	163.38	4.95	4.95	1164.4	1728.0	68.49	68.49	356.74	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	247.1	48.56	1.11	170.4	2098.0	170.4	170.4	1927.6	455.00	285.16	6.20	163.64	4.07	4.07	1162.5	1728.0	70.37	70.37	293.20	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	331.7	48.56	1.11	243.5	2171.1	243.5	243.5	1927.6	455.00	285.16	6.20	163.64	5.82	5.82	1162.5	1728.0	100.53	100.53	418.89	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	292.9	48.56	1.22	231.0	2158.6	231.0	231.0	1927.6	455.00	285.16	6.20	163.64	5.02	5.02	1162.5	1728.0	95.38	95.38	361.31	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	303.3	48.56	1.11	218.9	2146.6	218.9	218.9	1927.6	455.00	285.16	6.20	163.64	5.23	5.23	1162.5	1728.0	90.40	90.40	376.66	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	396.7	48.56	1.11	299.7	2227.3	299.7	299.7	1927.6	455.00	285.16	6.20	163.64	7.16	7.16	1162.5	1728.0	123.72	123.72	515.52	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	570.8	48.56	1.11	450.1	2377.7	450.1	450.1	1927.6	455.00	285.16	6.20	163.64	10.75	10.75	1162.5	1728.0	185.84	185.84	774.33	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	563.1	48.56	1.08	443.4	2371.1	515.9	515.9	1855.1	452.33	285.20	6.32	162.14	12.21	12.21	1173.3	1728.0	211.06	211.06	879.41	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	786.0	48.56	1.06	636.1	2491.2	707.9	707.9	1783.3	449.67	285.28	6.58	159.14	16.45	16.45	1195.4	1728.0	284.24	284.24	1184.33	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1175.3	48.56	1.14	1069.8	2853.1	1139.2	1139.2	1713.9	447.00	285.37	6.83	156.14	23.61	23.61	1218.4	1728.0	448.77	433.38	1699.88	0.00	0.00	0.00	447.0	1713.91
																159.21		**3.00**			**8152.18**	**7889.16**				**3324.15**		

Min. Res. Level 451.6 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1981-82

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	953.6	48.56	1.04	780.9	2494.8	780.9	780.9	1713.9	447.00	285.41	6.96	154.63	17.63	17.63	1230.3	1728.0	304.66	304.66	1269.41	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	735.0	48.56	1.04	592.1	2306.0	592.1	592.1	1713.9	447.00	285.41	6.96	154.63	13.37	13.37	1230.3	1728.0	231.00	231.00	962.49	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1110.9	48.56	1.04	916.8	2630.7	916.8	916.8	1713.9	447.00	285.41	6.96	154.63	20.70	20.70	1230.3	1728.0	357.69	357.69	1490.37	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1612.9	48.56	1.04	1350.6	3064.5	1071.5	1071.5	1713.9	447.00	286.53	7.06	153.40	24.00	24.00	1240.1	1728.0	414.72	393.98	1728.00	450.11	323.04	279.10	447.0	1713.91
	II	10	447.00	1713.9	1484.5	48.56	1.04	1239.6	2953.5	1068.3	1068.3	1713.9	447.00	286.12	7.03	153.86	24.00	24.00	1236.5	1728.0	414.72	393.98	1728.00	277.02	198.22	171.26	447.0	1713.91
	III	11	447.00	1713.9	1251.7	48.56	1.14	1142.4	2856.3	1142.4	1142.4	1713.9	447.00	285.41	6.96	154.63	23.45	23.45	1230.3	1728.0	445.69	433.38	1688.21	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	892.0	48.56	1.04	727.7	2441.6	727.7	727.7	1713.9	447.00	285.41	6.96	154.63	16.43	16.43	1230.3	1728.0	283.90	283.90	1182.92	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1270.2	48.56	1.04	1054.5	2768.4	1054.5	1054.5	1713.9	447.00	285.41	6.96	154.63	23.81	23.81	1230.3	1728.0	411.40	393.98	1714.18	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1462.0	48.56	1.14	1342.2	3056.1	1174.5	1174.5	1713.9	447.00	286.04	7.02	153.94	24.00	24.00	1235.8	1728.0	456.19	433.38	1728.00	246.68	176.42	167.67	447.0	1713.91
Sep	I	10	447.00	1713.9	1267.5	48.56	1.04	1052.1	2766.1	1052.1	1052.1	1713.9	447.00	285.41	6.96	154.63	23.76	23.76	1230.3	1728.0	410.49	393.98	1710.38	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1217.5	48.56	1.04	1008.9	2722.8	1008.9	1008.9	1713.9	447.00	285.41	6.96	154.63	22.78	22.78	1230.3	1728.0	393.61	393.61	1640.05	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	775.2	48.56	1.04	626.8	2340.7	626.8	626.8	1713.9	447.00	285.41	6.96	154.63	14.15	14.15	1230.3	1728.0	244.55	244.55	1018.96	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	850.7	48.56	0.78	692.3	2406.2	692.3	692.3	1713.9	447.00	285.41	6.96	154.63	15.63	15.63	1230.3	1728.0	270.09	270.09	1125.36	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	468.5	48.56	0.83	362.0	2075.9	148.3	148.3	1927.6	455.00	285.28	6.58	159.14	3.45	3.45	1195.4	1728.0	59.55	59.55	248.13	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	320.4	48.56	0.92	257.5	2185.1	257.5	257.5	1927.6	455.00	285.16	6.20	163.64	5.59	5.59	1162.5	1728.0	106.30	106.30	402.64	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	597.4	48.56	0.83	473.4	2401.0	473.4	473.4	1927.6	455.00	285.16	6.20	163.64	11.31	11.31	1162.5	1728.0	195.45	195.45	814.36	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	245.4	48.56	0.83	169.2	2096.8	169.2	169.2	1927.6	455.00	285.16	6.20	163.64	4.04	4.04	1162.5	1728.0	69.87	69.87	291.14	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	199.8	48.56	0.83	129.8	2057.4	129.8	129.8	1927.6	455.00	285.16	6.20	163.64	3.10	3.10	1162.5	1728.0	53.60	53.60	223.34	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	182.9	48.56	0.28	115.8	2043.4	125.7	125.7	1917.7	454.64	285.16	6.21	163.44	3.00	3.00	1164.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.64	1917.7	225.0	48.56	0.28	152.1	2069.9	142.3	142.3	1927.6	455.00	285.16	6.21	163.44	3.39	3.39	1164.0	1728.0	58.66	58.66	244.42	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	152.0	48.56	0.31	98.0	2025.7	138.8	138.8	1886.8	453.50	285.18	6.27	162.80	3.00	3.00	1168.6	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	453.50	1886.8	143.0	48.56	0.28	81.3	1968.2	127.6	127.6	1840.5	451.79	285.23	6.42	160.99	3.00	3.00	1181.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	451.79	1840.5	140.2	48.56	0.28	78.9	1919.4	129.2	129.2	1790.2	449.93	285.29	6.59	158.99	3.00	3.00	1196.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	449.93	1790.2	126.8	48.56	0.31	74.0	1864.2	144.5	144.5	1719.7	447.22	285.36	6.81	156.41	3.00	3.00	1216.3	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	447.22	1719.7	136.4	48.56	0.55	75.3	1795.1	133.8	133.8	1661.3	444.98	285.44	7.05	153.62	3.00	3.00	1238.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	444.98	1661.3	138.7	48.56	0.55	77.3	1738.6	136.1	136.1	1602.6	442.62	285.51	7.27	151.02	3.00	3.00	1259.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	442.62	1602.6	157.8	48.56	0.44	75.0	1677.6	110.4	110.4	1567.2	441.20	285.58	7.45	148.88	3.00	3.00	1277.8	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	441.20	1567.2	179.0	48.56	1.11	111.6	1678.8	139.3	139.3	1539.4	440.08	285.62	7.57	147.45	3.00	3.00	1290.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	440.08	1539.4	288.9	48.56	1.11	206.5	1745.9	138.5	138.5	1607.5	442.81	285.59	7.49	148.36	3.00	3.00	1282.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	442.81	1607.5	298.7	48.56	1.22	236.5	1844.0	148.8	148.8	1695.2	446.28	285.49	7.20	151.86	3.00	3.00	1252.7	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	446.28	1695.2	522.1	48.56	1.11	408.0	2103.2	175.6	175.6	1927.6	455.00	285.29	6.61	158.73	4.07	4.07	1198.5	1728.0	70.32	70.32	292.98	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	484.1	48.56	1.11	375.2	2302.8	375.2	375.2	1927.6	455.00	285.16	6.20	163.64	8.96	8.96	1162.5	1728.0	154.90	154.90	645.40	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	619.8	48.56	1.11	492.4	2420.1	492.4	492.4	1927.6	455.00	285.16	6.20	163.64	11.77	11.77	1162.5	1728.0	203.32	203.32	847.16	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	569.0	48.56	1.08	448.6	2376.2	521.1	521.1	1855.1	452.33	285.20	6.32	162.14	12.34	12.34	1173.3	1728.0	213.17	213.17	888.22	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	1220.1	48.56	1.06	1011.2	2866.3	1034.4	1034.4	1783.3	449.67	285.49	6.60	158.91	24.00	24.00	1197.2	1728.0	414.72	393.98	1728.00	81.27	56.30	48.65	449.7	1783.33
	III	11	449.67	1783.3	432.9	48.56	1.14	364.2	2147.5	433.6	433.6	1713.9	447.00	285.37	6.83	156.14	8.99	8.99	1218.4	1728.0	170.81	170.81	647.00	0.00	0.00	0.00	447.0	1713.91
																156.99		**3.00**			**6984.80**	**6853.55**				**666.68**		

Min. Res. Level 440.1 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1982-83

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	734.8	48.56	1.04	591.8	2305.8	591.8	591.8	1713.9	447.00	285.41	6.96	154.63	13.36	13.36	1230.3	1728.0	230.91	230.91	962.12	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1501.1	48.56	1.04	1253.9	2967.8	1068.7	1068.7	1713.9	447.00	286.17	7.03	153.80	24.00	24.00	1237.0	1728.0	414.72	393.98	1728.00	299.40	214.32	185.17	447.0	1713.91
	III	10	447.00	1713.9	1802.9	48.56	1.04	1514.7	3228.6	1075.9	1075.9	1713.9	447.00	287.11	7.12	152.77	24.00	24.00	1245.3	1728.0	414.72	393.98	1728.00	704.75	507.88	438.81	447.0	1713.91
Jul	I	10	447.00	1713.9	1561.6	48.56	1.04	1306.3	3020.2	1070.2	1070.2	1713.9	447.00	286.37	7.05	153.58	24.00	24.00	1238.7	1728.0	414.72	393.98	1728.00	381.07	273.17	236.02	447.0	1713.91
	II	10	447.00	1713.9	1484.9	48.56	1.04	1240.0	2953.9	1068.3	1068.3	1713.9	447.00	286.12	7.03	153.86	24.00	24.00	1236.5	1728.0	414.72	393.98	1728.00	277.62	198.66	171.64	447.0	1713.91
	III	11	447.00	1713.9	1991.8	48.56	1.14	1845.7	3559.6	1188.1	1188.1	1713.9	447.00	287.65	7.17	152.18	24.00	24.00	1250.1	1728.0	456.19	433.38	1728.00	956.43	691.93	657.61	447.0	1713.91
Aug	I	10	447.00	1713.9	724.9	48.56	1.04	583.3	2297.3	583.3	583.3	1713.9	447.00	285.41	6.96	154.63	13.17	13.17	1230.3	1728.0	227.59	227.59	948.29	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	666.6	48.56	1.04	532.9	2246.8	532.9	532.9	1713.9	447.00	285.41	6.96	154.63	12.03	12.03	1230.3	1728.0	207.92	207.92	866.33	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1141.6	48.56	1.14	1037.7	2751.6	1037.7	1037.7	1713.9	447.00	285.41	6.96	154.63	21.30	21.30	1230.3	1728.0	404.85	404.85	1533.52	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	688.4	48.56	1.04	551.8	2265.7	551.8	551.8	1713.9	447.00	285.41	6.96	154.63	12.46	12.46	1230.3	1728.0	215.28	215.28	897.02	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1362.2	48.56	1.04	1134.0	2847.9	1065.2	1065.2	1713.9	447.00	285.70	6.99	154.31	24.00	24.00	1232.9	1728.0	414.72	393.98	1728.00	111.60	79.62	68.79	447.0	1713.91
	III	10	447.00	1713.9	1099.6	48.56	1.04	907.1	2621.0	907.1	907.1	1713.9	447.00	285.41	6.96	154.63	20.48	20.48	1230.3	1728.0	353.89	353.89	1474.53	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	603.5	48.56	0.78	478.7	2192.6	478.7	478.7	1713.9	447.00	285.41	6.96	154.63	10.81	10.81	1230.3	1728.0	186.77	186.77	778.22	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	393.6	48.56	0.83	297.3	2011.2	129.9	129.9	1881.3	453.29	285.31	6.66	158.18	3.00	3.00	1202.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	453.29	1881.3	536.7	48.56	0.92	463.0	2344.3	416.7	416.7	1927.6	455.00	285.18	6.28	162.68	9.00	9.00	1169.4	1728.0	171.02	171.02	647.81	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	322.0	48.56	0.83	235.4	2163.0	235.4	235.4	1927.6	455.00	285.16	6.20	163.64	5.63	5.63	1162.5	1728.0	97.21	97.21	405.02	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	284.6	48.56	0.83	203.1	2130.7	203.1	203.1	1927.6	455.00	285.16	6.20	163.64	4.85	4.85	1162.5	1728.0	83.86	83.86	349.40	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	253.5	48.56	0.83	176.2	2103.8	176.2	176.2	1927.6	455.00	285.16	6.20	163.64	4.21	4.21	1162.5	1728.0	72.76	72.76	303.16	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	229.2	48.56	0.28	155.8	2083.4	155.8	155.8	1927.6	455.00	285.16	6.20	163.64	3.72	3.72	1162.5	1728.0	64.32	64.32	268.01	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	253.7	48.56	0.28	176.9	2104.5	176.9	176.9	1927.6	455.00	285.16	6.20	163.64	4.23	4.23	1162.5	1728.0	73.05	73.05	304.38	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	223.2	48.56	0.31	165.7	2093.3	165.7	165.7	1927.6	455.00	285.16	6.20	163.64	3.60	3.60	1162.5	1728.0	68.40	68.40	259.08	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	199.9	48.56	0.28	130.4	2058.1	130.4	130.4	1927.6	455.00	285.16	6.20	163.64	3.12	3.12	1162.5	1728.0	53.86	53.86	224.41	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	172.7	48.56	0.28	107.0	2034.6	125.9	125.9	1908.8	454.30	285.17	6.23	163.25	3.00	3.00	1165.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.30	1908.8	159.4	48.56	0.31	105.0	2013.8	139.4	139.4	1874.4	453.04	285.20	6.32	162.15	3.00	3.00	1173.3	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	453.04	1874.4	172.2	48.56	0.55	106.2	1980.6	127.6	127.6	1853.0	452.25	285.23	6.42	160.99	3.00	3.00	1181.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	452.25	1853.0	203.1	48.56	0.55	133.0	1986.0	127.9	127.9	1858.1	452.44	285.24	6.45	160.65	3.00	3.00	1184.2	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	452.44	1858.1	339.3	48.56	0.44	200.5	2058.6	131.0	131.0	1927.6	455.00	285.20	6.32	162.20	3.88	3.88	1172.9	1728.0	53.61	53.61	279.22	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	297.7	48.56	1.11	214.1	2141.7	214.1	214.1	1927.6	455.00	285.16	6.20	163.64	5.12	5.12	1162.5	1728.0	88.40	88.40	368.34	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	331.7	48.56	1.11	243.5	2171.1	243.5	243.5	1927.6	455.00	285.16	6.20	163.64	5.82	5.82	1162.5	1728.0	100.53	100.53	418.89	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	462.5	48.56	1.22	392.2	2319.8	392.2	392.2	1927.6	455.00	285.16	6.20	163.64	8.52	8.52	1162.5	1728.0	161.94	161.94	613.40	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	202.8	48.56	1.11	132.2	2059.8	132.2	132.2	1927.6	455.00	285.16	6.20	163.64	3.16	3.16	1162.5	1728.0	54.57	54.57	227.38	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	301.3	48.56	1.11	217.3	2144.9	217.3	217.3	1927.6	455.00	285.16	6.20	163.64	5.19	5.19	1162.5	1728.0	89.71	89.71	373.78	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	231.1	48.56	1.11	156.6	2084.2	156.6	156.6	1927.6	455.00	285.16	6.20	163.64	3.74	3.74	1162.5	1728.0	64.66	64.66	269.42	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	375.3	48.56	1.08	281.2	2208.8	353.7	353.7	1855.1	452.33	285.20	6.32	162.14	8.37	8.37	1173.3	1728.0	144.70	144.70	602.90	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	963.2	48.56	1.06	789.2	2644.3	861.0	861.0	1783.3	449.67	285.28	6.58	159.14	20.01	20.01	1195.4	1728.0	345.71	345.71	1440.44	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1128.9	48.56	1.14	1025.6	2808.9	1095.0	1095.0	1713.9	447.00	285.37	6.83	156.14	22.69	22.69	1218.4	1728.0	431.36	431.36	1633.95	0.00	0.00	0.00	447.0	1713.91
																159.38		**3.00**			**6841.04**	**6714.55**				**1758.04**		

Min. Res. Level 452.3 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1983-84

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1234.6	48.56	1.04	1023.7	2737.6	1023.7	1023.7	1713.9	447.00	285.41	6.96	154.63	23.11	23.11	1230.3	1728.0	399.39	393.98	1664.12	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1396.1	48.56	1.04	1163.3	2877.2	1066.1	1066.1	1713.9	447.00	285.82	7.00	154.18	24.00	24.00	1233.9	1728.0	414.72	393.98	1728.00	157.54	112.49	97.20	447.0	1713.91
	III	10	447.00	1713.9	1832.3	48.56	1.04	1540.1	3254.0	1076.6	1076.6	1713.9	447.00	287.20	7.13	152.68	24.00	24.00	1246.1	1728.0	414.72	393.98	1728.00	743.99	536.49	463.52	447.0	1713.91
Jul	I	10	447.00	1713.9	1591.7	48.56	1.04	1332.2	3046.1	1071.0	1071.0	1713.9	447.00	286.46	7.06	153.48	24.00	24.00	1239.6	1728.0	414.72	393.98	1728.00	421.55	302.39	261.26	447.0	1713.91
	II	10	447.00	1713.9	1263.0	48.56	1.04	1048.3	2762.2	1048.3	1048.3	1713.9	447.00	285.41	6.96	154.63	23.67	23.67	1230.3	1728.0	408.97	393.98	1704.06	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1352.1	48.56	1.14	1237.7	2951.6	1171.4	1171.4	1713.9	447.00	285.66	6.98	154.35	24.00	24.00	1232.5	1728.0	456.19	433.38	1728.00	97.79	69.75	66.29	447.0	1713.91
Aug	I	10	447.00	1713.9	896.7	48.56	1.04	731.8	2445.7	731.8	731.8	1713.9	447.00	285.41	6.96	154.63	16.52	16.52	1230.3	1728.0	285.50	285.50	1189.56	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1156.8	48.56	1.04	956.5	2670.4	956.5	956.5	1713.9	447.00	285.41	6.96	154.63	21.60	21.60	1230.3	1728.0	373.18	373.18	1554.91	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1262.9	48.56	1.14	1153.0	2866.9	1153.0	1153.0	1713.9	447.00	285.41	6.96	154.63	23.67	23.67	1230.3	1728.0	449.83	433.38	1703.90	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	1144.9	48.56	1.04	946.2	2660.1	946.2	946.2	1713.9	447.00	285.41	6.96	154.63	21.36	21.36	1230.3	1728.0	369.15	369.15	1538.12	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1504.1	48.56	1.04	1256.5	2970.4	1068.8	1068.8	1713.9	447.00	286.18	7.03	153.79	24.00	24.00	1237.1	1728.0	414.72	393.98	1728.00	303.46	217.24	187.70	447.0	1713.91
	III	10	447.00	1713.9	1510.9	48.56	1.04	1262.5	2976.4	1069.0	1069.0	1713.9	447.00	286.20	7.03	153.76	24.00	24.00	1237.3	1728.0	414.72	393.98	1728.00	312.73	223.92	193.46	447.0	1713.91
Oct	I	10	447.00	1713.9	636.0	48.56	0.78	506.8	2220.7	506.8	506.8	1713.9	447.00	285.41	6.96	154.63	11.44	11.44	1230.3	1728.0	197.72	197.72	823.85	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	890.9	48.56	0.83	726.9	2440.8	513.2	513.2	1927.6	455.00	285.28	6.58	159.14	11.93	11.93	1195.4	1728.0	206.07	206.07	858.62	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	519.2	48.56	0.92	446.3	2374.0	446.3	446.3	1927.6	455.00	285.16	6.20	163.64	9.70	9.70	1162.5	1728.0	184.29	184.29	698.07	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	333.0	48.56	0.83	244.9	2172.5	244.9	244.9	1927.6	455.00	285.16	6.20	163.64	5.85	5.85	1162.5	1728.0	101.12	101.12	421.31	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	295.4	48.56	0.83	212.4	2140.0	212.4	212.4	1927.6	455.00	285.16	6.20	163.64	5.08	5.08	1162.5	1728.0	87.71	87.71	365.45	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	232.3	48.56	0.83	157.9	2085.5	157.9	157.9	1927.6	455.00	285.16	6.20	163.64	3.77	3.77	1162.5	1728.0	65.19	65.19	271.63	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	210.4	48.56	0.28	139.5	2067.2	139.5	139.5	1927.6	455.00	285.16	6.20	163.64	3.33	3.33	1162.5	1728.0	57.62	57.62	240.07	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	189.1	48.56	0.28	121.1	2048.8	125.6	125.6	1923.1	454.83	285.16	6.20	163.55	3.00	3.00	1163.2	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.83	1923.1	183.3	48.56	0.31	127.7	2050.8	138.5	138.5	1912.4	454.44	285.17	6.23	163.24	3.00	3.00	1165.5	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.44	1912.4	163.1	48.56	0.28	98.7	2011.1	126.5	126.5	1884.6	453.41	285.19	6.30	162.44	3.00	3.00	1171.2	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	453.41	1884.6	170.0	48.56	0.28	104.7	1989.3	127.3	127.3	1862.0	452.58	285.22	6.39	161.39	3.00	3.00	1178.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	452.58	1862.0	179.1	48.56	0.31	123.7	1985.7	140.8	140.8	1844.9	451.95	285.24	6.46	160.57	3.00	3.00	1184.8	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	451.95	1844.9	160.0	48.56	0.55	95.8	1940.7	128.8	128.8	1811.9	450.74	285.27	6.55	159.53	3.00	3.00	1192.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	450.74	1811.9	156.0	48.56	0.55	92.3	1904.1	130.0	130.0	1774.1	449.32	285.31	6.67	158.04	3.00	3.00	1203.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	449.32	1774.1	146.0	48.56	0.44	66.9	1841.1	105.1	105.1	1736.0	447.85	285.36	6.81	156.42	3.00	3.00	1216.3	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	447.85	1736.0	212.7	48.56	1.11	140.7	1876.7	131.9	131.9	1744.8	448.19	285.38	6.86	155.78	3.00	3.00	1221.2	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	448.19	1744.8	340.8	48.56	1.11	251.4	1996.2	129.6	129.6	1866.6	452.75	285.30	6.63	158.54	3.00	3.00	1200.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	452.75	1866.6	262.5	48.56	1.22	202.1	2068.6	141.0	141.0	1927.6	455.00	285.19	6.30	162.38	3.04	3.04	1171.6	1728.0	57.77	57.77	218.82	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	560.8	48.56	1.11	441.5	2369.1	441.5	441.5	1927.6	455.00	285.16	6.20	163.64	10.55	10.55	1162.5	1728.0	182.29	182.29	759.53	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	366.2	48.56	1.11	273.3	2201.0	273.3	273.3	1927.6	455.00	285.16	6.20	163.64	6.53	6.53	1162.5	1728.0	112.86	112.86	470.23	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	647.2	48.56	1.11	516.1	2443.7	516.1	516.1	1927.6	455.00	285.16	6.20	163.64	12.33	12.33	1162.5	1728.0	213.10	213.10	887.92	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	597.8	48.56	1.08	473.4	2401.1	545.9	545.9	1855.1	452.33	285.20	6.32	162.14	12.92	12.92	1173.3	1728.0	223.33	223.33	930.55	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	813.9	48.56	1.06	660.2	2515.4	732.0	732.0	1783.3	449.67	285.28	6.58	159.14	17.01	17.01	1195.4	1728.0	293.93	293.93	1224.70	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1198.0	48.56	1.14	1091.3	2874.6	1158.1	1158.1	1713.9	447.00	285.38	6.83	156.13	24.00	24.00	1218.5	1728.0	456.19	433.38	1728.00	3.94	2.78	2.64	447.0	1713.91
																158.67		**3.00**			**7773.39**	**7587.24**				**1272.08**		

Min. Res. Level 447.8 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1984-85

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	944.7	48.56	1.04	773.2	2487.1	773.2	773.2	1713.9	447.00	285.41	6.96	154.63	17.46	17.46	1230.3	1728.0	301.66	301.66	1256.90	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1759.0	48.56	1.04	1476.8	3190.7	1074.9	1074.9	1713.9	447.00	286.98	7.11	152.91	24.00	24.00	1244.1	1728.0	414.72	393.98	1728.00	646.02	465.12	401.86	447.0	1713.91
	III	10	447.00	1713.9	1119.5	48.56	1.04	924.2	2638.1	924.2	924.2	1713.9	447.00	285.41	6.96	154.63	20.87	20.87	1230.3	1728.0	360.58	360.58	1502.42	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1528.9	48.56	1.04	1278.0	2991.9	1069.4	1069.4	1713.9	447.00	286.26	7.04	153.70	24.00	24.00	1237.8	1728.0	414.72	393.98	1728.00	336.94	241.35	208.53	447.0	1713.91
	II	10	447.00	1713.9	1359.7	48.56	1.04	1131.8	2845.7	1065.1	1065.1	1713.9	447.00	285.69	6.99	154.32	24.00	24.00	1232.8	1728.0	414.72	393.98	1728.00	108.11	77.13	66.64	447.0	1713.91
	III	11	447.00	1713.9	1465.7	48.56	1.14	1345.7	3059.6	1174.6	1174.6	1713.9	447.00	286.05	7.02	153.93	24.00	24.00	1235.9	1728.0	456.19	433.38	1728.00	251.68	180.01	171.08	447.0	1713.91
Aug	I	10	447.00	1713.9	1024.2	48.56	1.04	841.9	2555.8	841.9	841.9	1713.9	447.00	285.41	6.96	154.63	19.01	19.01	1230.3	1728.0	328.47	328.47	1368.63	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	713.4	48.56	1.04	573.4	2287.3	573.4	573.4	1713.9	447.00	285.41	6.96	154.63	12.95	12.95	1230.3	1728.0	223.71	223.71	932.13	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1110.5	48.56	1.14	1008.2	2722.1	1008.2	1008.2	1713.9	447.00	285.41	6.96	154.63	20.69	20.69	1230.3	1728.0	393.33	393.33	1489.88	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	1228.6	48.56	1.04	1018.5	2732.5	1018.5	1018.5	1713.9	447.00	285.41	6.96	154.63	23.00	23.00	1230.3	1728.0	397.38	393.98	1655.75	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1554.6	48.56	1.04	1300.2	3014.1	1070.1	1070.1	1713.9	447.00	286.34	7.05	153.61	24.00	24.00	1238.5	1728.0	414.72	393.98	1728.00	371.56	266.31	230.09	447.0	1713.91
	III	10	447.00	1713.9	1110.7	48.56	1.04	916.6	2630.5	916.6	916.6	1713.9	447.00	285.41	6.96	154.63	20.70	20.70	1230.3	1728.0	357.62	357.62	1490.09	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	749.1	48.56	0.78	604.5	2318.4	604.5	604.5	1713.9	447.00	285.41	6.96	154.63	13.65	13.65	1230.3	1728.0	235.84	235.84	982.66	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	862.3	48.56	0.83	702.2	2416.1	488.5	488.5	1927.6	455.00	285.28	6.58	159.14	11.35	11.35	1195.4	1728.0	196.15	196.15	817.29	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	697.1	48.56	0.92	615.4	2543.0	615.4	615.4	1927.6	455.00	285.16	6.20	163.64	13.37	13.37	1162.5	1728.0	254.09	254.09	962.48	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	407.9	48.56	0.83	309.6	2237.2	309.6	309.6	1927.6	455.00	285.16	6.20	163.64	7.40	7.40	1162.5	1728.0	127.83	127.83	532.61	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	308.1	48.56	0.83	223.4	2151.0	223.4	223.4	1927.6	455.00	285.16	6.20	163.64	5.34	5.34	1162.5	1728.0	92.23	92.23	384.29	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	245.4	48.56	0.83	169.2	2096.8	169.2	169.2	1927.6	455.00	285.16	6.20	163.64	4.04	4.04	1162.5	1728.0	69.87	69.87	291.12	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	217.3	48.56	0.28	145.5	2073.1	145.5	145.5	1927.6	455.00	285.16	6.20	163.64	3.48	3.48	1162.5	1728.0	60.08	60.08	250.35	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	257.2	48.56	0.28	180.0	2107.6	180.0	180.0	1927.6	455.00	285.16	6.20	163.64	4.30	4.30	1162.5	1728.0	74.33	74.33	309.70	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	185.0	48.56	0.31	129.4	2057.0	138.3	138.3	1918.7	454.67	285.16	6.21	163.46	3.00	3.00	1163.9	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.67	1918.7	153.7	48.56	0.28	90.6	2009.3	126.4	126.4	1882.9	453.35	285.19	6.29	162.53	3.00	3.00	1170.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	453.35	1882.9	147.8	48.56	0.28	85.4	1968.3	127.7	127.7	1840.6	451.79	285.23	6.43	160.91	3.00	3.00	1182.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	451.79	1840.6	139.8	48.56	0.31	86.4	1927.0	142.3	142.3	1784.7	449.72	285.29	6.60	158.87	3.00	3.00	1197.5	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	449.72	1784.7	148.2	48.56	0.55	85.5	1870.2	131.1	131.1	1739.1	447.97	285.35	6.78	156.71	3.00	3.00	1214.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	447.97	1739.1	149.7	48.56	0.55	86.8	1826.0	132.8	132.8	1693.2	446.20	285.41	6.95	154.73	3.00	3.00	1229.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	446.20	1693.2	163.1	48.56	0.44	78.7	1771.9	107.4	107.4	1664.6	445.10	285.45	7.09	153.11	3.00	3.00	1242.5	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	445.10	1664.6	200.2	48.56	1.11	129.9	1794.5	134.8	134.8	1659.7	444.91	285.47	7.15	152.38	3.00	3.00	1248.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	444.91	1659.7	253.7	48.56	1.11	176.1	1835.7	134.1	134.1	1701.6	446.53	285.45	7.08	153.18	3.00	3.00	1241.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	446.53	1701.6	256.9	48.56	1.22	196.8	1898.4	145.6	145.6	1752.8	448.49	285.39	6.91	155.21	3.00	3.00	1225.7	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	448.49	1752.8	380.8	48.56	1.11	285.9	2038.7	128.7	128.7	1909.9	454.35	285.27	6.54	159.62	3.00	3.00	1191.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.35	1909.9	434.0	48.56	1.11	331.9	2241.8	314.2	314.2	1927.6	455.00	285.17	6.23	163.28	7.49	7.49	1165.2	1728.0	129.44	129.44	539.32	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	476.3	48.56	1.11	368.5	2296.1	368.5	368.5	1927.6	455.00	285.16	6.20	163.64	8.80	8.80	1162.5	1728.0	152.15	152.15	633.94	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	546.3	48.56	1.08	429.0	2356.6	501.4	501.4	1855.1	452.33	285.20	6.32	162.14	11.87	11.87	1173.3	1728.0	205.13	205.13	854.73	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	556.4	48.56	1.06	437.7	2292.9	509.6	509.6	1783.3	449.67	285.28	6.58	159.14	11.84	11.84	1195.4	1728.0	204.60	204.60	852.52	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	693.6	48.56	1.14	611.9	2395.3	681.3	681.3	1713.9	447.00	285.37	6.83	156.14	14.12	14.12	1218.4	1728.0	268.41	268.41	1016.71	0.00	0.00	0.00	447.0	1713.91
																157.82		**3.00**			**7123.40**	**7014.25**				**1078.20**		

Min. Res. Level 444.9 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1985-86

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1437.8	48.56	1.04	1199.3	2913.2	1067.1	1067.1	1713.9	447.00	285.96	7.01	154.03	24.00	24.00	1235.1	1728.0	414.72	393.98	1728.00	213.97	152.94	132.14	447.0	1713.91
	II	10	447.00	1713.9	1312.8	48.56	1.04	1091.2	2805.1	1063.9	1063.9	1713.9	447.00	285.53	6.97	154.50	24.00	24.00	1231.3	1728.0	414.72	393.98	1728.00	44.44	31.67	27.36	447.0	1713.91
	III	10	447.00	1713.9	1365.6	48.56	1.04	1136.9	2850.8	1065.3	1065.3	1713.9	447.00	285.71	6.99	154.30	24.00	24.00	1233.0	1728.0	414.72	393.98	1728.00	116.22	82.93	71.65	447.0	1713.91
Jul	I	10	447.00	1713.9	1739.7	48.56	1.04	1460.1	3174.0	1074.5	1074.5	1713.9	447.00	286.92	7.10	152.98	24.00	24.00	1243.6	1728.0	414.72	393.98	1728.00	620.22	446.36	385.66	447.0	1713.91
	II	10	447.00	1713.9	1999.2	48.56	1.04	1684.3	3398.2	1080.3	1080.3	1713.9	447.00	287.67	7.17	152.16	24.00	24.00	1250.3	1728.0	414.72	393.98	1728.00	966.23	699.12	604.04	447.0	1713.91
	III	11	447.00	1713.9	1718.4	48.56	1.14	1585.8	3299.8	1181.4	1181.4	1713.9	447.00	286.86	7.10	153.05	24.00	24.00	1243.0	1728.0	456.19	433.38	1728.00	591.60	425.57	404.46	447.0	1713.91
Aug	I	10	447.00	1713.9	1015.8	48.56	1.04	834.7	2548.6	834.7	834.7	1713.9	447.00	285.41	6.96	154.63	18.84	18.84	1230.3	1728.0	325.64	325.64	1356.81	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	907.8	48.56	1.04	741.4	2455.3	741.4	741.4	1713.9	447.00	285.41	6.96	154.63	16.74	16.74	1230.3	1728.0	289.25	289.25	1205.20	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1370.7	48.56	1.14	1255.5	2969.4	1171.9	1171.9	1713.9	447.00	285.73	6.99	154.28	24.00	24.00	1233.1	1728.0	456.19	433.38	1728.00	123.12	87.86	83.50	447.0	1713.91
Sep	I	10	447.00	1713.9	1800.7	48.56	1.04	1512.8	3226.7	1075.9	1075.9	1713.9	447.00	287.10	7.12	152.78	24.00	24.00	1245.2	1728.0	414.72	393.98	1728.00	701.77	505.70	436.93	447.0	1713.91
	II	10	447.00	1713.9	1183.9	48.56	1.04	979.9	2693.8	979.9	979.9	1713.9	447.00	285.41	6.96	154.63	22.12	22.12	1230.3	1728.0	382.31	382.31	1592.94	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1422.2	48.56	1.04	1185.8	2899.7	1066.7	1066.7	1713.9	447.00	285.91	7.01	154.09	24.00	24.00	1234.7	1728.0	414.72	393.98	1728.00	192.83	137.78	119.04	447.0	1713.91
Oct	I	10	447.00	1713.9	925.9	48.56	0.78	757.2	2471.1	757.2	757.2	1713.9	447.00	285.41	6.96	154.63	17.10	17.10	1230.3	1728.0	295.43	295.43	1230.95	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	506.6	48.56	0.83	394.9	2108.8	181.2	181.2	1927.6	455.00	285.28	6.58	159.14	4.21	4.21	1195.4	1728.0	72.75	72.75	303.15	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	403.6	48.56	0.92	336.6	2264.2	336.6	336.6	1927.6	455.00	285.16	6.20	163.64	7.31	7.31	1162.5	1728.0	138.96	138.96	526.36	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	359.3	48.56	0.83	267.7	2195.3	267.7	267.7	1927.6	455.00	285.16	6.20	163.64	6.40	6.40	1162.5	1728.0	110.51	110.51	460.47	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	278.0	48.56	0.83	197.4	2125.0	197.4	197.4	1927.6	455.00	285.16	6.20	163.64	4.72	4.72	1162.5	1728.0	81.49	81.49	339.53	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	220.2	48.56	0.83	147.5	2075.1	147.5	147.5	1927.6	455.00	285.16	6.20	163.64	3.52	3.52	1162.5	1728.0	60.89	60.89	253.72	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	186.7	48.56	0.28	119.1	2046.7	125.7	125.7	1921.1	454.76	285.16	6.21	163.51	3.00	3.00	1163.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.76	1921.1	157.6	48.56	0.28	93.9	2015.0	126.3	126.3	1888.7	453.57	285.18	6.28	162.70	3.00	3.00	1169.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	453.57	1888.7	150.2	48.56	0.31	96.3	1985.0	140.3	140.3	1844.7	451.95	285.23	6.41	161.12	3.00	3.00	1180.8	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	451.95	1844.7	139.8	48.56	0.28	78.6	1923.3	129.1	129.1	1794.2	450.08	285.28	6.58	159.16	3.00	3.00	1195.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	450.08	1794.2	128.8	48.56	0.28	69.1	1863.2	131.1	131.1	1732.2	447.70	285.35	6.78	156.77	3.00	3.00	1213.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	447.70	1732.2	123.5	48.56	0.31	70.9	1803.1	147.0	147.0	1656.1	444.77	285.43	7.03	153.77	3.00	3.00	1237.2	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	444.77	1656.1	139.4	48.56	0.55	77.9	1734.0	136.3	136.3	1597.7	442.42	285.52	7.29	150.79	3.00	3.00	1261.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	442.42	1597.7	138.3	48.56	0.55	76.9	1674.6	138.8	138.8	1535.9	439.94	285.60	7.52	148.06	3.00	3.00	1284.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	439.94	1535.9	142.9	48.56	0.44	64.8	1600.6	113.0	113.0	1487.7	437.91	285.68	7.73	145.51	3.00	3.00	1307.5	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	437.91	1487.7	154.5	48.56	1.11	90.4	1578.1	143.6	143.6	1434.5	435.69	285.76	7.94	143.10	3.00	3.00	1329.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	435.69	1434.5	269.6	48.56	1.11	189.9	1624.4	143.7	143.7	1480.7	437.62	285.76	7.95	142.94	3.00	3.00	1331.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	437.62	1480.7	185.2	48.56	1.22	128.6	1609.3	157.7	157.7	1451.6	436.40	285.75	7.92	143.34	3.00	3.00	1327.2	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	436.40	1451.6	204.4	48.56	1.11	133.6	1585.1	144.3	144.3	1440.9	435.95	285.78	8.00	142.40	3.00	3.00	1336.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	435.95	1440.9	407.9	48.56	1.11	309.4	1750.2	140.7	140.7	1609.6	442.90	285.66	7.69	146.07	3.00	3.00	1302.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	10	442.90	1609.6	546.4	48.56	1.11	429.1	2038.6	131.4	131.4	1907.3	454.25	285.36	6.81	156.41	3.00	3.00	1216.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
May	I	10	454.25	1907.3	602.7	48.56	1.08	477.7	2384.9	529.8	529.8	1855.1	452.33	285.21	6.36	161.72	12.51	12.51	1176.4	1728.0	216.17	216.17	900.72	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	547.7	48.56	1.06	430.2	2285.3	502.0	502.0	1783.3	449.67	285.28	6.58	159.14	11.66	11.66	1195.4	1728.0	201.57	201.57	839.86	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	365.5	48.56	1.14	300.1	2083.4	369.5	369.5	1713.9	447.00	285.37	6.83	156.14	7.66	7.66	1218.4	1728.0	145.56	145.56	551.37	0.00	0.00	0.00	447.0	1713.91
																154.64		**3.00**			**6918.73**	**6727.96**				**2264.78**		

Min. Res. Level 435.7 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1986-87

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	628.6	48.56	1.04	500.1	2214.0	500.1	500.1	1713.9	447.00	285.41	6.96	154.63	11.29	11.29	1230.3	1728.0	195.13	195.13	813.02	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	910.7	48.56	1.04	743.9	2457.8	743.9	743.9	1713.9	447.00	285.41	6.96	154.63	16.79	16.79	1230.3	1728.0	290.21	290.21	1209.23	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1526.1	48.56	1.04	1275.6	2989.5	1069.4	1069.4	1713.9	447.00	286.25	7.04	153.71	24.00	24.00	1237.7	1728.0	414.72	393.98	1728.00	333.20	238.66	206.20	447.0	1713.91
Jul	I	10	447.00	1713.9	1013.3	48.56	1.04	832.5	2546.4	832.5	832.5	1713.9	447.00	285.41	6.96	154.63	18.80	18.80	1230.3	1728.0	324.78	324.78	1353.26	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1107.1	48.56	1.04	913.6	2627.5	913.6	913.6	1713.9	447.00	285.41	6.96	154.63	20.63	20.63	1230.3	1728.0	356.42	356.42	1485.08	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	916.4	48.56	1.14	823.7	2537.6	823.7	823.7	1713.9	447.00	285.41	6.96	154.63	16.91	16.91	1230.3	1728.0	321.35	321.35	1217.25	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	816.3	48.56	1.04	662.3	2376.2	662.3	662.3	1713.9	447.00	285.41	6.96	154.63	14.95	14.95	1230.3	1728.0	258.39	258.39	1076.64	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	638.3	48.56	1.04	508.5	2222.4	508.5	508.5	1713.9	447.00	285.41	6.96	154.63	11.48	11.48	1230.3	1728.0	198.40	198.40	826.65	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1046.1	48.56	1.14	947.0	2660.9	947.0	947.0	1713.9	447.00	285.41	6.96	154.63	19.44	19.44	1230.3	1728.0	369.45	369.45	1399.43	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	718.0	48.56	1.04	577.3	2291.2	577.3	577.3	1713.9	447.00	285.41	6.96	154.63	13.03	13.03	1230.3	1728.0	225.24	225.24	938.49	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1062.1	48.56	1.04	874.7	2588.6	874.7	874.7	1713.9	447.00	285.41	6.96	154.63	19.75	19.75	1230.3	1728.0	341.25	341.25	1421.87	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	607.3	48.56	1.04	481.7	2195.6	481.7	481.7	1713.9	447.00	285.41	6.96	154.63	10.88	10.88	1230.3	1728.0	187.93	187.93	783.04	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	689.8	48.56	0.78	553.3	2267.2	553.3	553.3	1713.9	447.00	285.41	6.96	154.63	12.49	12.49	1230.3	1728.0	215.86	215.86	899.42	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	503.2	48.56	0.83	392.0	2105.9	178.3	178.3	1927.6	455.00	285.28	6.58	159.14	4.14	4.14	1195.4	1728.0	71.59	71.59	298.30	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	385.3	48.56	0.92	319.1	2246.7	319.1	319.1	1927.6	455.00	285.16	6.20	163.64	6.93	6.93	1162.5	1728.0	131.76	131.76	499.08	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	374.2	48.56	0.83	280.5	2208.1	280.5	280.5	1927.6	455.00	285.16	6.20	163.64	6.70	6.70	1162.5	1728.0	115.81	115.81	482.54	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	282.2	48.56	0.83	201.0	2128.6	201.0	201.0	1927.6	455.00	285.16	6.20	163.64	4.80	4.80	1162.5	1728.0	82.99	82.99	345.80	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	215.8	48.56	0.83	143.7	2071.3	143.7	143.7	1927.6	455.00	285.16	6.20	163.64	3.43	3.43	1162.5	1728.0	59.32	59.32	247.15	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	179.5	48.56	0.28	112.9	2040.5	125.8	125.8	1914.7	454.53	285.17	6.22	163.38	3.00	3.00	1164.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.53	1914.7	166.4	48.56	0.28	101.5	2016.3	126.4	126.4	1889.9	453.61	285.19	6.29	162.60	3.00	3.00	1170.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	453.61	1889.9	161.4	48.56	0.31	107.0	1996.9	140.0	140.0	1856.8	452.39	285.22	6.39	161.39	3.00	3.00	1178.8	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	452.39	1856.8	143.4	48.56	0.28	81.7	1938.5	128.6	128.6	1809.9	450.66	285.26	6.53	159.73	3.00	3.00	1191.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	450.66	1809.9	125.3	48.56	0.28	66.0	1875.9	130.6	130.6	1745.3	448.21	285.33	6.73	157.38	3.00	3.00	1208.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	448.21	1745.3	113.3	48.56	0.31	61.2	1806.5	146.6	146.6	1659.9	444.92	285.42	7.00	154.14	3.00	3.00	1234.2	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	444.92	1659.9	111.4	48.56	0.55	53.8	1713.7	136.6	136.6	1577.1	441.59	285.53	7.32	150.40	3.00	3.00	1264.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	441.59	1577.1	112.3	48.56	0.55	54.5	1631.6	140.2	140.2	1491.4	438.07	285.65	7.65	146.53	3.00	3.00	1298.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	438.07	1491.4	157.0	48.56	0.44	74.5	1565.9	114.5	114.5	1451.4	436.39	285.74	7.90	143.59	3.00	3.00	1324.9	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	436.39	1451.4	198.8	48.56	1.11	128.7	1580.1	144.4	144.4	1435.7	435.74	285.79	8.01	142.27	3.00	3.00	1337.2	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	435.74	1435.7	196.3	48.56	1.11	126.6	1562.3	145.3	145.3	1417.0	434.95	285.81	8.08	141.45	3.00	3.00	1344.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	434.95	1417.0	209.0	48.56	1.22	151.3	1568.3	160.5	160.5	1407.8	434.55	285.83	8.14	140.78	3.00	3.00	1351.4	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	434.55	1407.8	220.4	48.56	1.11	147.4	1555.2	146.2	146.2	1409.0	434.60	285.84	8.15	140.58	3.00	3.00	1353.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	434.60	1409.0	250.0	48.56	1.11	172.9	1581.9	145.4	145.4	1436.5	435.77	285.82	8.09	141.27	3.00	3.00	1346.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	10	435.77	1436.5	491.2	48.56	1.11	381.3	1817.8	139.3	139.3	1678.6	445.64	285.62	7.56	147.52	3.00	3.00	1289.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
May	I	10	445.64	1678.6	547.2	48.56	1.08	429.8	2108.3	253.2	253.2	1855.1	452.33	285.34	6.77	156.87	5.80	5.80	1212.8	1728.0	100.21	100.21	417.54	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	743.9	48.56	1.06	599.7	2454.9	671.5	671.5	1783.3	449.67	285.28	6.58	159.14	15.60	15.60	1195.4	1728.0	269.64	269.64	1123.49	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	770.8	48.56	1.14	685.3	2468.6	754.7	754.7	1713.9	447.00	285.37	6.83	156.14	15.64	15.64	1218.4	1728.0	297.31	297.31	1126.18	0.00	0.00	0.00	447.0	1713.91
																154.12		**3.00**			**5610.54**	**5589.80**			**206.20**		

Min. Res. Level 434.5 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1987-88

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	830.9	48.56	1.04	674.9	2388.8	674.9	674.9	1713.9	447.00	285.41	6.96	154.63	15.24	15.24	1230.3	1728.0	263.32	263.32	1097.17	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1146.4	48.56	1.04	947.5	2661.4	947.5	947.5	1713.9	447.00	285.41	6.96	154.63	21.39	21.39	1230.3	1728.0	369.65	369.65	1540.20	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1035.1	48.56	1.04	851.3	2565.2	851.3	851.3	1713.9	447.00	285.41	6.96	154.63	19.22	19.22	1230.3	1728.0	332.14	332.14	1383.92	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1480.2	48.56	1.04	1235.9	2949.8	1068.2	1068.2	1713.9	447.00	286.10	7.03	153.87	24.00	24.00	1236.4	1728.0	414.72	393.98	1728.00	271.25	194.08	167.68	447.0	1713.91
	II	10	447.00	1713.9	1412.7	48.56	1.04	1177.6	2891.5	1066.5	1066.5	1713.9	447.00	285.87	7.00	154.12	24.00	24.00	1234.4	1728.0	414.72	393.98	1728.00	180.02	128.60	111.11	447.0	1713.91
	III	11	447.00	1713.9	1620.8	48.56	1.14	1493.1	3207.0	1178.8	1178.8	1713.9	447.00	286.56	7.07	153.38	24.00	24.00	1240.4	1728.0	456.19	433.38	1728.00	460.63	330.64	314.24	447.0	1713.91
Aug	I	10	447.00	1713.9	1541.2	48.56	1.04	1288.6	3002.5	1069.7	1069.7	1713.9	447.00	286.30	7.04	153.66	24.00	24.00	1238.1	1728.0	414.72	393.98	1728.00	353.55	253.32	218.87	447.0	1713.91
	II	10	447.00	1713.9	1510.3	48.56	1.04	1261.9	2975.8	1069.0	1069.0	1713.9	447.00	286.20	7.03	153.77	24.00	24.00	1237.2	1728.0	414.72	393.98	1728.00	311.83	223.27	192.90	447.0	1713.91
	III	11	447.00	1713.9	1251.9	48.56	1.14	1142.5	2856.4	1142.5	1142.5	1713.9	447.00	285.41	6.96	154.63	23.45	23.45	1230.3	1728.0	445.75	433.38	1688.46	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	1875.2	48.56	1.04	1577.2	3291.1	1077.6	1077.6	1713.9	447.00	287.32	7.14	152.54	24.00	24.00	1247.2	1728.0	414.72	393.98	1728.00	801.25	578.29	499.65	447.0	1713.91
	II	10	447.00	1713.9	1676.1	48.56	1.04	1405.1	3119.0	1073.0	1073.0	1713.9	447.00	286.73	7.08	153.19	24.00	24.00	1241.9	1728.0	414.72	393.98	1728.00	534.87	384.41	332.13	447.0	1713.91
	III	10	447.00	1713.9	1576.8	48.56	1.04	1319.4	3033.3	1070.6	1070.6	1713.9	447.00	286.42	7.05	153.53	24.00	24.00	1239.1	1728.0	414.72	393.98	1728.00	401.54	287.94	248.78	447.0	1713.91
Oct	I	10	447.00	1713.9	1035.4	48.56	0.78	851.9	2565.8	851.9	851.9	1713.9	447.00	285.41	6.96	154.63	19.23	19.23	1230.3	1728.0	332.35	332.35	1384.78	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	788.2	48.56	0.83	638.2	2352.1	424.5	424.5	1927.6	455.00	285.28	6.58	159.14	9.86	9.86	1195.4	1728.0	170.46	170.46	710.24	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	653.4	48.56	0.92	574.0	2501.6	574.0	574.0	1927.6	455.00	285.16	6.20	163.64	12.47	12.47	1162.5	1728.0	236.98	236.98	897.64	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	137.2	48.56	0.83	75.8	2003.4	126.4	126.4	1877.0	453.14	285.19	6.29	162.60	3.00	3.00	1170.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	453.14	1877.0	142.6	48.56	0.83	80.4	1957.4	128.0	128.0	1829.5	451.38	285.24	6.46	160.56	3.00	3.00	1184.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	10	451.38	1829.5	128.2	48.56	0.83	68.0	1897.4	129.8	129.8	1767.6	449.07	285.31	6.65	158.27	3.00	3.00	1202.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	449.07	1767.6	222.7	48.56	0.28	150.1	1917.8	130.5	130.5	1787.2	449.82	285.33	6.73	157.39	3.00	3.00	1208.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	449.82	1787.2	210.3	48.56	0.28	139.4	1926.6	130.0	130.0	1796.6	450.17	285.31	6.67	158.01	3.00	3.00	1204.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	450.17	1796.6	171.6	48.56	0.31	116.6	1913.2	143.4	143.4	1769.9	449.15	285.32	6.71	157.63	3.00	3.00	1206.9	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	449.15	1769.9	170.4	48.56	0.28	105.0	1874.9	131.3	131.3	1743.6	448.14	285.36	6.80	156.49	3.00	3.00	1215.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	448.14	1743.6	160.5	48.56	0.28	96.4	1840.0	132.4	132.4	1707.6	446.76	285.39	6.92	155.14	3.00	3.00	1226.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	446.76	1707.6	139.7	48.56	0.31	86.3	1793.9	147.7	147.7	1646.2	444.37	285.46	7.10	153.01	3.00	3.00	1243.4	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	444.37	1646.2	138.8	48.56	0.55	77.4	1723.6	136.7	136.7	1586.9	441.99	285.53	7.33	150.32	3.00	3.00	1265.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	441.99	1586.9	232.2	48.56	0.55	158.1	1745.0	137.5	137.5	1607.5	442.82	285.56	7.40	149.44	3.00	3.00	1273.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	442.82	1607.5	210.2	48.56	0.44	111.3	1718.8	109.6	109.6	1609.2	442.88	285.55	7.36	149.94	3.00	3.00	1268.8	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	442.88	1609.2	264.3	48.56	1.11	185.3	1794.5	136.0	136.0	1658.5	444.86	285.51	7.26	151.10	3.00	3.00	1259.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	444.86	1658.5	342.1	48.56	1.11	252.5	1911.1	132.7	132.7	1778.4	449.48	285.40	6.94	154.82	3.00	3.00	1228.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	449.48	1778.4	312.2	48.56	1.22	249.4	2027.7	141.5	141.5	1886.2	453.47	285.27	6.53	159.68	3.00	3.00	1191.4	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	453.47	1886.2	333.1	48.56	1.11	244.7	2130.9	203.3	203.3	1927.6	455.00	285.18	6.27	162.79	4.83	4.83	1168.7	1728.0	83.51	83.51	347.95	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	459.1	48.56	1.11	353.6	2281.3	353.6	353.6	1927.6	455.00	285.16	6.20	163.64	8.45	8.45	1162.5	1728.0	146.01	146.01	608.37	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	639.3	48.56	1.11	509.3	2436.9	509.3	509.3	1927.6	455.00	285.16	6.20	163.64	12.17	12.17	1162.5	1728.0	210.28	210.28	876.18	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	543.1	48.56	1.08	426.2	2353.8	498.7	498.7	1855.1	452.33	285.20	6.32	162.14	11.81	11.81	1173.3	1728.0	204.01	204.01	850.06	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	724.5	48.56	1.06	583.0	2438.1	654.8	654.8	1783.3	449.67	285.28	6.58	159.14	15.22	15.22	1195.4	1728.0	262.92	262.92	1095.51	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1111.1	48.56	1.14	1008.7	2792.0	1078.1	1078.1	1713.9	447.00	285.37	6.83	156.14	22.34	22.34	1218.4	1728.0	424.72	424.72	1608.78	0.00	0.00	0.00	447.0	1713.91
																156.27		**3.00**			**7624.12**	**7443.78**				**2085.35**		

Min. Res. Level 442.0 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1988-89

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	763.9	48.56	1.04	617.0	2331.0	617.0	617.0	1713.9	447.00	285.41	6.96	154.63	13.93	13.93	1230.3	1728.0	240.74	240.74	1003.07	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1103.8	48.56	1.04	910.7	2624.6	910.7	910.7	1713.9	447.00	285.41	6.96	154.63	20.56	20.56	1230.3	1728.0	355.30	355.30	1480.40	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	897.0	48.56	1.04	732.0	2446.0	732.0	732.0	1713.9	447.00	285.41	6.96	154.63	16.53	16.53	1230.3	1728.0	285.60	285.60	1190.01	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1463.1	48.56	1.04	1221.1	2935.0	1067.8	1067.8	1713.9	447.00	286.04	7.02	153.94	24.00	24.00	1235.9	1728.0	414.72	393.98	1728.00	248.08	177.43	153.30	447.0	1713.91
	II	10	447.00	1713.9	1176.8	48.56	1.04	973.8	2687.7	973.8	973.8	1713.9	447.00	285.41	6.96	154.63	21.99	21.99	1230.3	1728.0	379.92	379.92	1582.99	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1338.2	48.56	1.14	1224.5	2938.5	1171.0	1171.0	1713.9	447.00	285.62	6.98	154.40	24.00	24.00	1232.1	1728.0	456.19	433.38	1728.00	79.01	56.33	53.54	447.0	1713.91
Aug	I	10	447.00	1713.9	1020.0	48.56	1.04	838.3	2552.2	838.3	838.3	1713.9	447.00	285.41	6.96	154.63	18.93	18.93	1230.3	1728.0	327.05	327.05	1362.73	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1452.5	48.56	1.04	1212.0	2925.9	1067.5	1067.5	1713.9	447.00	286.01	7.02	153.97	24.00	24.00	1235.6	1728.0	414.72	393.98	1728.00	233.80	167.17	144.43	447.0	1713.91
	III	11	447.00	1713.9	1466.6	48.56	1.14	1346.5	3060.5	1174.7	1174.7	1713.9	447.00	286.06	7.02	153.92	24.00	24.00	1236.0	1728.0	456.19	433.38	1728.00	252.85	180.85	171.88	447.0	1713.91
Sep	I	10	447.00	1713.9	1298.0	48.56	1.04	1078.4	2792.4	1063.5	1063.5	1713.9	447.00	285.47	6.97	154.56	24.00	24.00	1230.9	1728.0	414.72	393.98	1728.00	24.33	17.33	14.97	447.0	1713.91
	II	10	447.00	1713.9	1100.3	48.56	1.04	907.7	2621.6	907.7	907.7	1713.9	447.00	285.41	6.96	154.63	20.49	20.49	1230.3	1728.0	354.12	354.12	1475.50	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	607.9	48.56	1.04	482.3	2196.2	482.3	482.3	1713.9	447.00	285.41	6.96	154.63	10.89	10.89	1230.3	1728.0	188.15	188.15	783.97	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	805.5	48.56	0.78	653.2	2367.2	653.2	653.2	1713.9	447.00	285.41	6.96	154.63	14.75	14.75	1230.3	1728.0	254.86	254.86	1061.92	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	595.1	48.56	0.83	471.4	2185.3	257.7	257.7	1927.6	455.00	285.28	6.58	159.14	5.99	5.99	1195.4	1728.0	103.45	103.45	431.06	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	516.4	48.56	0.92	443.7	2371.3	443.7	443.7	1927.6	455.00	285.16	6.20	163.64	9.64	9.64	1162.5	1728.0	183.20	183.20	693.95	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	333.0	48.56	0.83	244.9	2172.5	244.9	244.9	1927.6	455.00	285.16	6.20	163.64	5.85	5.85	1162.5	1728.0	101.13	101.13	421.36	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	228.6	48.56	0.83	154.7	2082.3	154.7	154.7	1927.6	455.00	285.16	6.20	163.64	3.70	3.70	1162.5	1728.0	63.88	63.88	266.18	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	196.5	48.56	0.83	127.0	2054.6	127.0	127.0	1927.6	455.00	285.16	6.20	163.64	3.03	3.03	1162.5	1728.0	52.44	52.44	218.48	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	180.6	48.56	0.28	113.8	2041.4	125.7	125.7	1915.6	454.56	285.17	6.22	163.40	3.00	3.00	1164.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.56	1915.6	174.4	48.56	0.28	108.5	2024.1	126.2	126.2	1897.9	453.90	285.18	6.27	162.78	3.00	3.00	1168.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	453.90	1897.9	126.8	48.56	0.31	74.0	1971.9	140.3	140.3	1831.5	451.46	285.23	6.42	161.04	3.00	3.00	1181.4	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	451.46	1831.5	119.4	48.56	0.28	60.9	1892.4	129.9	129.9	1762.6	448.87	285.31	6.66	158.20	3.00	3.00	1202.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	448.87	1762.6	126.0	48.56	0.28	66.6	1829.2	132.3	132.3	1696.9	446.34	285.39	6.90	155.32	3.00	3.00	1224.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	446.34	1696.9	113.2	48.56	0.31	61.1	1758.0	148.8	148.8	1609.2	442.88	285.49	7.19	151.94	3.00	3.00	1252.1	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	442.88	1609.2	146.0	48.56	0.55	83.6	1692.8	138.1	138.1	1554.7	440.69	285.58	7.46	148.75	3.00	3.00	1279.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	440.69	1554.7	211.5	48.56	0.55	140.2	1694.9	139.3	139.3	1555.6	440.73	285.62	7.56	147.53	3.00	3.00	1289.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	440.73	1555.6	226.7	48.56	0.44	122.7	1678.3	111.2	111.2	1567.1	441.19	285.61	7.54	147.81	3.00	3.00	1287.1	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	441.19	1567.1	236.2	48.56	1.11	161.0	1728.1	138.3	138.3	1589.9	442.11	285.59	7.47	148.59	3.00	3.00	1280.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	442.11	1589.9	265.4	48.56	1.11	186.2	1776.1	136.8	136.8	1639.3	444.09	285.54	7.33	150.23	3.00	3.00	1266.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	444.09	1639.3	278.3	48.56	1.22	217.1	1856.5	147.8	147.8	1708.6	446.80	285.46	7.11	152.88	3.00	3.00	1244.4	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	446.80	1708.6	255.2	48.56	1.11	177.4	1886.0	132.2	132.2	1753.8	448.53	285.39	6.90	155.38	3.00	3.00	1224.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	448.53	1753.8	339.4	48.56	1.11	250.2	2003.9	129.3	129.3	1874.6	453.05	285.29	6.60	158.90	3.00	3.00	1197.2	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	10	453.05	1874.6	388.3	48.56	1.11	292.4	2167.0	239.4	239.4	1927.6	455.00	285.19	6.29	162.55	5.68	5.68	1170.4	1728.0	98.19	98.19	409.13	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	528.3	48.56	1.08	413.4	2341.0	485.8	485.8	1855.1	452.33	285.20	6.32	162.14	11.50	11.50	1173.3	1728.0	198.76	198.76	828.16	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	419.2	48.56	1.06	319.1	2174.3	391.0	391.0	1783.3	449.67	285.28	6.58	159.14	9.08	9.08	1195.4	1728.0	156.98	156.98	654.10	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1147.1	48.56	1.14	1042.9	2826.2	1112.3	1112.3	1713.9	447.00	285.37	6.83	156.14	23.05	23.05	1218.4	1728.0	438.18	433.38	1659.78	0.00	0.00	0.00	447.0	1713.91
																156.23		**3.00**			**6669.44**	**6556.82**				**538.13**		

Min. Res. Level 440.7 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1989-90

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1149.9	48.56	1.04	950.5	2664.4	950.5	950.5	1713.9	447.00	285.41	6.96	154.63	21.46	21.46	1230.3	1728.0	370.85	370.85	1545.19	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1340.7	48.56	1.04	1115.3	2829.3	1064.6	1064.6	1713.9	447.00	285.62	6.98	154.39	24.00	24.00	1232.2	1728.0	414.72	393.98	1728.00	82.35	58.72	50.73	447.0	1713.91
	III	10	447.00	1713.9	952.2	48.56	1.04	779.7	2493.6	779.7	779.7	1713.9	447.00	285.41	6.96	154.63	17.60	17.60	1230.3	1728.0	304.18	304.18	1267.43	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1221.8	48.56	1.04	1012.7	2726.6	1012.7	1012.7	1713.9	447.00	285.41	6.96	154.63	22.86	22.86	1230.3	1728.0	395.08	393.98	1646.17	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1042.8	48.56	1.04	858.0	2571.9	858.0	858.0	1713.9	447.00	285.41	6.96	154.63	19.37	19.37	1230.3	1728.0	334.74	334.74	1394.75	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1044.3	48.56	1.14	945.3	2659.2	945.3	945.3	1713.9	447.00	285.41	6.96	154.63	19.40	19.40	1230.3	1728.0	368.79	368.79	1396.91	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	1006.1	48.56	1.04	826.3	2540.2	826.3	826.3	1713.9	447.00	285.41	6.96	154.63	18.66	18.66	1230.3	1728.0	322.38	322.38	1343.23	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1170.3	48.56	1.04	968.1	2682.0	968.1	968.1	1713.9	447.00	285.41	6.96	154.63	21.86	21.86	1230.3	1728.0	377.71	377.71	1573.80	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1423.1	48.56	1.14	1305.2	3019.1	1173.4	1173.4	1713.9	447.00	285.91	7.01	154.08	24.00	24.00	1234.7	1728.0	456.19	433.38	1728.00	193.99	138.61	131.73	447.0	1713.91
Sep	I	10	447.00	1713.9	1205.3	48.56	1.04	998.4	2712.3	998.4	998.4	1713.9	447.00	285.41	6.96	154.63	22.54	22.54	1230.3	1728.0	389.51	389.51	1622.94	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1330.8	48.56	1.04	1106.9	2820.8	1064.4	1064.4	1713.9	447.00	285.59	6.98	154.43	24.00	24.00	1231.9	1728.0	414.72	393.98	1728.00	69.00	49.19	42.50	447.0	1713.91
	III	10	447.00	1713.9	938.8	48.56	1.04	768.1	2482.1	768.1	768.1	1713.9	447.00	285.41	6.96	154.63	17.34	17.34	1230.3	1728.0	299.69	299.69	1248.71	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	1112.9	48.56	0.78	918.8	2632.7	918.8	918.8	1713.9	447.00	285.41	6.96	154.63	20.74	20.74	1230.3	1728.0	358.47	358.47	1493.61	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	896.1	48.56	0.83	731.5	2445.4	517.8	517.8	1927.6	455.00	285.28	6.58	159.14	12.03	12.03	1195.4	1728.0	207.90	207.90	866.23	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	634.2	48.56	0.92	555.7	2483.3	555.7	555.7	1927.6	455.00	285.16	6.20	163.64	12.07	12.07	1162.5	1728.0	229.44	229.44	869.09	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	623.5	48.56	0.83	495.9	2423.5	495.9	495.9	1927.6	455.00	285.16	6.20	163.64	11.85	11.85	1162.5	1728.0	204.75	204.75	853.13	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	398.3	48.56	0.83	301.4	2229.0	301.4	301.4	1927.6	455.00	285.16	6.20	163.64	7.20	7.20	1162.5	1728.0	124.42	124.42	518.43	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	351.5	48.56	0.83	260.9	2188.5	260.9	260.9	1927.6	455.00	285.16	6.20	163.64	6.23	6.23	1162.5	1728.0	107.72	107.72	448.84	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	248.3	48.56	0.28	172.3	2099.9	172.3	172.3	1927.6	455.00	285.16	6.20	163.64	4.12	4.12	1162.5	1728.0	71.14	71.14	296.42	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	217.6	48.56	0.28	145.8	2073.4	145.8	145.8	1927.6	455.00	285.16	6.20	163.64	3.48	3.48	1162.5	1728.0	60.20	60.20	250.81	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	191.3	48.56	0.31	135.4	2063.0	138.2	138.2	1924.8	454.90	285.16	6.20	163.59	3.00	3.00	1163.0	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.90	1924.8	178.7	48.56	0.28	112.1	2037.0	125.9	125.9	1911.1	454.39	285.17	6.23	163.24	3.00	3.00	1165.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.39	1911.1	166.6	48.56	0.28	101.7	2012.8	126.5	126.5	1886.3	453.48	285.19	6.30	162.45	3.00	3.00	1171.1	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	453.48	1886.3	163.0	48.56	0.31	108.4	1994.7	140.1	140.1	1854.6	452.31	285.22	6.40	161.27	3.00	3.00	1179.6	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	452.31	1854.6	190.9	48.56	0.55	122.4	1977.0	128.0	128.0	1849.0	452.10	285.24	6.46	160.50	3.00	3.00	1185.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	452.10	1849.0	179.5	48.56	0.55	112.6	1961.6	128.4	128.4	1833.2	451.52	285.26	6.50	160.06	3.00	3.00	1188.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	451.52	1833.2	201.2	48.56	0.44	105.0	1938.2	102.9	102.9	1835.3	451.60	285.26	6.52	159.77	3.00	3.00	1190.7	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	451.60	1835.3	225.3	48.56	1.11	151.6	1987.0	128.2	128.2	1858.8	452.46	285.25	6.48	160.30	3.00	3.00	1186.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	452.46	1858.8	260.2	48.56	1.11	181.7	2040.5	126.9	126.9	1913.6	454.48	285.20	6.34	161.93	3.00	3.00	1174.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.48	1913.6	367.7	48.56	1.22	302.1	2215.7	288.1	288.1	1927.6	455.00	285.17	6.22	163.35	6.25	6.25	1164.6	1728.0	118.75	118.75	449.80	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	400.0	48.56	1.11	302.5	2230.2	302.5	302.5	1927.6	455.00	285.16	6.20	163.64	7.23	7.23	1162.5	1728.0	124.92	124.92	520.48	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	475.6	48.56	1.11	367.8	2295.5	367.8	367.8	1927.6	455.00	285.16	6.20	163.64	8.79	8.79	1162.5	1728.0	151.87	151.87	632.81	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	626.5	48.56	1.11	498.2	2425.8	498.2	498.2	1927.6	455.00	285.16	6.20	163.64	11.90	11.90	1162.5	1728.0	205.70	205.70	857.09	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	390.7	48.56	1.08	294.5	2222.2	367.0	367.0	1855.1	452.33	285.20	6.32	162.14	8.69	8.69	1173.3	1728.0	150.14	150.14	625.58	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	610.3	48.56	1.06	484.2	2339.4	556.1	556.1	1783.3	449.67	285.28	6.58	159.14	12.92	12.92	1195.4	1728.0	223.28	223.28	930.32	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	651.3	48.56	1.14	571.7	2355.0	641.1	641.1	1713.9	447.00	285.37	6.83	156.14	13.29	13.29	1218.4	1728.0	252.57	252.57	956.70	0.00	0.00	0.00	447.0	1713.91
																159.31		**3.00**			**7506.37**	**7440.99**				**224.97**		

Min. Res. Level 451.5 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1990-91

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	723.8	48.56	1.04	582.3	2296.3	582.3	582.3	1713.9	447.00	285.41	6.96	154.63	13.15	13.15	1230.3	1728.0	227.20	227.20	946.67	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	912.8	48.56	1.04	745.6	2459.6	745.6	745.6	1713.9	447.00	285.41	6.96	154.63	16.84	16.84	1230.3	1728.0	290.91	290.91	1212.12	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1520.7	48.56	1.04	1270.9	2984.8	1069.2	1069.2	1713.9	447.00	286.23	7.04	153.73	24.00	24.00	1237.5	1728.0	414.72	393.98	1728.00	325.84	233.36	201.62	447.0	1713.91
Jul	I	10	447.00	1713.9	1230.2	48.56	1.04	1019.9	2733.8	1019.9	1019.9	1713.9	447.00	285.41	6.96	154.63	23.03	23.03	1230.3	1728.0	397.89	393.98	1657.89	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1424.4	48.56	1.04	1187.7	2901.6	1066.8	1066.8	1713.9	447.00	285.91	7.01	154.08	24.00	24.00	1234.7	1728.0	414.72	393.98	1728.00	195.84	139.94	120.91	447.0	1713.91
	III	11	447.00	1713.9	1352.7	48.56	1.14	1238.3	2952.3	1171.4	1171.4	1713.9	447.00	285.67	6.98	154.35	24.00	24.00	1232.6	1728.0	456.19	433.38	1728.00	98.71	70.41	66.92	447.0	1713.91
Aug	I	10	447.00	1713.9	1429.3	48.56	1.04	1191.9	2905.9	1066.9	1066.9	1713.9	447.00	285.93	7.01	154.06	24.00	24.00	1234.9	1728.0	414.72	393.98	1728.00	202.49	144.70	125.02	447.0	1713.91
	II	10	447.00	1713.9	918.8	48.56	1.04	750.8	2464.7	750.8	750.8	1713.9	447.00	285.41	6.96	154.63	16.95	16.95	1230.3	1728.0	292.93	292.93	1220.56	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1061.6	48.56	1.14	961.6	2675.5	961.6	961.6	1713.9	447.00	285.41	6.96	154.63	19.74	19.74	1230.3	1728.0	375.17	375.17	1421.10	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	1065.2	48.56	1.04	877.3	2591.2	877.3	877.3	1713.9	447.00	285.41	6.96	154.63	19.81	19.81	1230.3	1728.0	342.27	342.27	1426.14	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1131.6	48.56	1.04	934.7	2648.6	934.7	934.7	1713.9	447.00	285.41	6.96	154.63	21.10	21.10	1230.3	1728.0	364.68	364.68	1519.51	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	841.5	48.56	1.04	684.0	2397.9	684.0	684.0	1713.9	447.00	285.41	6.96	154.63	15.44	15.44	1230.3	1728.0	266.87	266.87	1111.96	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.0	48.56	0.78	607.0	2320.9	607.0	607.0	1713.9	447.00	285.41	6.96	154.63	13.70	13.70	1230.3	1728.0	236.81	236.81	986.72	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	721.4	48.56	0.83	580.5	2294.4	366.8	366.8	1927.6	455.00	285.28	6.58	159.14	8.52	8.52	1195.4	1728.0	147.29	147.29	613.69	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	527.1	48.56	0.92	453.9	2381.5	453.9	453.9	1927.6	455.00	285.16	6.20	163.64	9.86	9.86	1162.5	1728.0	187.39	187.39	709.81	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	402.3	48.56	0.83	304.8	2232.4	304.8	304.8	1927.6	455.00	285.16	6.20	163.64	7.28	7.28	1162.5	1728.0	125.84	125.84	524.34	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	318.2	48.56	0.83	232.1	2159.7	232.1	232.1	1927.6	455.00	285.16	6.20	163.64	5.55	5.55	1162.5	1728.0	95.83	95.83	399.29	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	252.7	48.56	0.83	175.6	2103.2	175.6	175.6	1927.6	455.00	285.16	6.20	163.64	4.20	4.20	1162.5	1728.0	72.49	72.49	302.06	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	214.4	48.56	0.28	143.0	2070.6	143.0	143.0	1927.6	455.00	285.16	6.20	163.64	3.42	3.42	1162.5	1728.0	59.03	59.03	245.97	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	195.2	48.56	0.28	126.4	2054.0	126.4	126.4	1927.6	455.00	285.16	6.20	163.64	3.02	3.02	1162.5	1728.0	52.20	52.20	217.49	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	196.0	48.56	0.31	139.8	2067.4	139.8	139.8	1927.6	455.00	285.16	6.20	163.64	3.04	3.04	1162.5	1728.0	57.73	57.73	218.66	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	188.6	48.56	0.28	120.7	2048.4	125.6	125.6	1922.7	454.82	285.16	6.21	163.54	3.00	3.00	1163.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.82	1922.7	181.9	48.56	0.28	114.9	2037.7	125.9	125.9	1911.8	454.42	285.17	6.23	163.21	3.00	3.00	1165.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.42	1911.8	171.2	48.56	0.31	116.3	2028.0	139.1	139.1	1889.0	453.58	285.19	6.29	162.51	3.00	3.00	1170.6	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	453.58	1889.0	188.6	48.56	0.55	120.4	2009.4	126.9	126.9	1882.5	453.34	285.21	6.34	161.91	3.00	3.00	1175.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	453.34	1882.5	192.3	48.56	0.55	123.6	2006.1	127.1	127.1	1879.0	453.21	285.21	6.36	161.70	3.00	3.00	1176.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	453.21	1879.0	177.3	48.56	0.44	88.5	1967.6	101.9	101.9	1865.7	452.72	285.22	6.39	161.35	3.00	3.00	1179.1	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	452.72	1865.7	237.0	48.56	1.11	161.7	2027.4	127.0	127.0	1900.4	454.00	285.21	6.35	161.80	3.00	3.00	1175.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.00	1900.4	411.6	48.56	1.11	312.5	2213.0	285.3	285.3	1927.6	455.00	285.17	6.24	163.08	6.79	6.79	1166.6	1728.0	117.41	117.41	489.19	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	332.3	48.56	1.22	268.4	2196.0	268.4	268.4	1927.6	455.00	285.16	6.20	163.64	5.83	5.83	1162.5	1728.0	110.82	110.82	419.78	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	517.9	48.56	1.11	404.4	2332.0	404.4	404.4	1927.6	455.00	285.16	6.20	163.64	9.66	9.66	1162.5	1728.0	166.98	166.98	695.75	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	459.6	48.56	1.11	354.0	2281.7	354.0	354.0	1927.6	455.00	285.16	6.20	163.64	8.46	8.46	1162.5	1728.0	146.18	146.18	609.07	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	630.9	48.56	1.11	502.1	2429.7	502.1	502.1	1927.6	455.00	285.16	6.20	163.64	12.00	12.00	1162.5	1728.0	207.29	207.29	863.72	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	530.8	48.56	1.08	415.6	2343.2	488.1	488.1	1855.1	452.33	285.20	6.32	162.14	11.55	11.55	1173.3	1728.0	199.66	199.66	831.92	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	420.0	48.56	1.06	319.8	2175.0	391.6	391.6	1783.3	449.67	285.28	6.58	159.14	9.10	9.10	1195.4	1728.0	157.25	157.25	655.23	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1090.4	48.56	1.14	989.0	2772.3	1058.4	1058.4	1713.9	447.00	285.37	6.83	156.14	21.94	21.94	1218.4	1728.0	416.96	416.96	1579.38	0.00	0.00	0.00	447.0	1713.91
																159.55		**3.00**			**7173.14**	**7084.21**				**514.47**		

Min. Res. Level 452.7 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1991-92

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1062.1	48.56	1.04	874.7	2588.6	874.7	874.7	1713.9	447.00	285.41	6.96	154.63	19.75	19.75	1230.3	1728.0	341.24	341.24	1421.84	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1256.9	48.56	1.04	1043.0	2756.9	1043.0	1043.0	1713.9	447.00	285.41	6.96	154.63	23.55	23.55	1230.3	1728.0	406.91	393.98	1695.47	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1019.1	48.56	1.04	837.5	2551.4	837.5	837.5	1713.9	447.00	285.41	6.96	154.63	18.91	18.91	1230.3	1728.0	326.75	326.75	1361.45	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1126.3	48.56	1.04	930.1	2644.0	930.1	930.1	1713.9	447.00	285.41	6.96	154.63	21.00	21.00	1230.3	1728.0	362.89	362.89	1512.03	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1195.9	48.56	1.04	990.2	2704.1	990.2	990.2	1713.9	447.00	285.41	6.96	154.63	22.36	22.36	1230.3	1728.0	386.33	386.33	1609.71	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1374.2	48.56	1.14	1258.7	2972.6	1172.0	1172.0	1713.9	447.00	285.74	6.99	154.27	24.00	24.00	1233.2	1728.0	456.19	433.38	1728.00	127.76	91.18	86.66	447.0	1713.91
Aug	I	10	447.00	1713.9	1102.1	48.56	1.04	909.2	2623.1	909.2	909.2	1713.9	447.00	285.41	6.96	154.63	20.53	20.53	1230.3	1728.0	354.73	354.73	1478.03	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	870.6	48.56	1.04	709.2	2423.1	709.2	709.2	1713.9	447.00	285.41	6.96	154.63	16.01	16.01	1230.3	1728.0	276.68	276.68	1152.85	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	723.2	48.56	1.14	640.0	2353.9	640.0	640.0	1713.9	447.00	285.41	6.96	154.63	13.14	13.14	1230.3	1728.0	249.70	249.70	945.82	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	763.0	48.56	1.04	616.2	2330.1	616.2	616.2	1713.9	447.00	285.41	6.96	154.63	13.91	13.91	1230.3	1728.0	240.41	240.41	1001.71	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	731.7	48.56	1.04	589.2	2303.1	589.2	589.2	1713.9	447.00	285.41	6.96	154.63	13.30	13.30	1230.3	1728.0	229.86	229.86	957.75	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	788.8	48.56	1.04	638.6	2352.5	638.6	638.6	1713.9	447.00	285.41	6.96	154.63	14.42	14.42	1230.3	1728.0	249.13	249.13	1038.06	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	757.0	48.56	0.78	611.3	2325.2	611.3	611.3	1713.9	447.00	285.41	6.96	154.63	13.80	13.80	1230.3	1728.0	238.49	238.49	993.72	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	789.4	48.56	0.83	639.3	2353.2	425.6	425.6	1927.6	455.00	285.28	6.58	159.14	9.89	9.89	1195.4	1728.0	170.87	170.87	711.97	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	702.1	48.56	0.92	620.2	2547.8	620.2	620.2	1927.6	455.00	285.16	6.20	163.64	13.47	13.47	1162.5	1728.0	256.06	256.06	969.91	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	233.1	48.56	0.83	158.6	2086.2	158.6	158.6	1927.6	455.00	285.16	6.20	163.64	3.79	3.79	1162.5	1728.0	65.47	65.47	272.81	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	233.5	48.56	0.83	159.0	2086.6	159.0	159.0	1927.6	455.00	285.16	6.20	163.64	3.80	3.80	1162.5	1728.0	65.65	65.65	273.52	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	233.6	48.56	0.83	159.0	2086.6	159.0	159.0	1927.6	455.00	285.16	6.20	163.64	3.80	3.80	1162.5	1728.0	65.65	65.65	273.55	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	236.6	48.56	0.28	162.2	2089.8	162.2	162.2	1927.6	455.00	285.16	6.20	163.64	3.88	3.88	1162.5	1728.0	66.97	66.97	279.04	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	206.6	48.56	0.28	136.2	2063.8	136.2	136.2	1927.6	455.00	285.16	6.20	163.64	3.25	3.25	1162.5	1728.0	56.25	56.25	234.36	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	210.2	48.56	0.31	153.3	2080.9	153.3	153.3	1927.6	455.00	285.16	6.20	163.64	3.33	3.33	1162.5	1728.0	63.29	63.29	239.74	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	368.6	48.56	0.28	276.2	2203.9	276.2	276.2	1927.6	455.00	285.16	6.20	163.64	6.60	6.60	1162.5	1728.0	114.05	114.05	475.23	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	356.8	48.56	0.28	266.1	2193.7	266.1	266.1	1927.6	455.00	285.16	6.20	163.64	6.36	6.36	1162.5	1728.0	109.86	109.86	457.75	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	381.6	48.56	0.31	316.2	2243.9	316.2	316.2	1927.6	455.00	285.16	6.20	163.64	6.87	6.87	1162.5	1728.0	130.57	130.57	494.60	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	379.8	48.56	0.55	285.6	2213.3	285.6	285.6	1927.6	455.00	285.16	6.20	163.64	6.82	6.82	1162.5	1728.0	117.94	117.94	491.40	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	376.4	48.56	0.55	282.7	2210.3	282.7	282.7	1927.6	455.00	285.16	6.20	163.64	6.75	6.75	1162.5	1728.0	116.70	116.70	486.27	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	378.9	48.56	0.44	227.9	2155.5	227.9	227.9	1927.6	455.00	285.16	6.20	163.64	6.81	6.81	1162.5	1728.0	94.08	94.08	489.99	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	413.0	48.56	1.11	313.8	2241.4	313.8	313.8	1927.6	455.00	285.16	6.20	163.64	7.50	7.50	1162.5	1728.0	129.56	129.56	539.85	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	451.8	48.56	1.11	347.3	2274.9	347.3	347.3	1927.6	455.00	285.16	6.20	163.64	8.30	8.30	1162.5	1728.0	143.41	143.41	597.52	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	451.8	48.56	1.22	382.0	2309.7	382.0	382.0	1927.6	455.00	285.16	6.20	163.64	8.30	8.30	1162.5	1728.0	157.74	157.74	597.49	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	489.0	48.56	1.11	379.4	2307.1	379.4	379.4	1927.6	455.00	285.16	6.20	163.64	9.07	9.07	1162.5	1728.0	156.67	156.67	652.77	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	481.7	48.56	1.11	373.1	2300.7	373.1	373.1	1927.6	455.00	285.16	6.20	163.64	8.91	8.91	1162.5	1728.0	154.04	154.04	641.83	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	532.4	48.56	1.11	417.0	2344.6	417.0	417.0	1927.6	455.00	285.16	6.20	163.64	9.96	9.96	1162.5	1728.0	172.16	172.16	717.31	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	603.1	48.56	1.08	478.0	2405.7	550.5	550.5	1855.1	452.33	285.20	6.32	162.14	13.03	13.03	1173.3	1728.0	225.21	225.21	938.40	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	586.6	48.56	1.06	463.8	2318.9	535.6	535.6	1783.3	449.67	285.28	6.58	159.14	12.45	12.45	1195.4	1728.0	215.06	215.06	896.07	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	615.8	48.56	1.14	538.0	2321.3	607.4	607.4	1713.9	447.00	285.37	6.83	156.14	12.59	12.59	1218.4	1728.0	239.27	239.27	906.33	0.00	0.00	0.00	447.0	1713.91
																159.88		**3.25**			**7205.84**	**7170.10**				**86.66**		

Min. Res. Level 455.0 m Average Power 1728.0 MW Continuous Power 234.36 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1992-93

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	681.5	48.56	1.04	545.8	2259.7	545.8	545.8	1713.9	447.00	285.41	6.96	154.63	12.32	12.32	1230.3	1728.0	212.94	212.94	887.25	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	675.2	48.56	1.04	540.4	2254.3	540.4	540.4	1713.9	447.00	285.41	6.96	154.63	12.20	12.20	1230.3	1728.0	210.82	210.82	878.43	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	700.3	48.56	1.04	562.1	2276.0	562.1	562.1	1713.9	447.00	285.41	6.96	154.63	12.69	12.69	1230.3	1728.0	219.28	219.28	913.69	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	695.8	48.56	1.04	558.2	2272.1	558.2	558.2	1713.9	447.00	285.41	6.96	154.63	12.60	12.60	1230.3	1728.0	217.78	217.78	907.44	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	664.8	48.56	1.04	531.4	2245.3	531.4	531.4	1713.9	447.00	285.41	6.96	154.63	12.00	12.00	1230.3	1728.0	207.31	207.31	863.78	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	706.1	48.56	1.14	623.8	2337.7	623.8	623.8	1713.9	447.00	285.41	6.96	154.63	12.80	12.80	1230.3	1728.0	243.38	243.38	921.90	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	688.3	48.56	1.04	551.7	2265.6	551.7	551.7	1713.9	447.00	285.41	6.96	154.63	12.46	12.46	1230.3	1728.0	215.24	215.24	896.82	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	718.6	48.56	1.04	577.8	2291.7	577.8	577.8	1713.9	447.00	285.41	6.96	154.63	13.05	13.05	1230.3	1728.0	225.44	225.44	939.33	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	714.6	48.56	1.14	631.9	2345.8	631.9	631.9	1713.9	447.00	285.41	6.96	154.63	12.97	12.97	1230.3	1728.0	246.52	246.52	933.79	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	759.8	48.56	1.04	613.4	2327.4	613.4	613.4	1713.9	447.00	285.41	6.96	154.63	13.85	13.85	1230.3	1728.0	239.33	239.33	997.21	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	776.9	48.56	1.04	628.2	2342.1	628.2	628.2	1713.9	447.00	285.41	6.96	154.63	14.18	14.18	1230.3	1728.0	245.10	245.10	1021.25	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	801.9	48.56	1.04	649.9	2363.8	649.9	649.9	1713.9	447.00	285.41	6.96	154.63	14.67	14.67	1230.3	1728.0	253.54	253.54	1056.41	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	749.7	48.56	0.78	605.0	2318.9	605.0	605.0	1713.9	447.00	285.41	6.96	154.63	13.66	13.66	1230.3	1728.0	236.05	236.05	983.53	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	701.2	48.56	0.83	563.0	2276.9	349.3	349.3	1927.6	455.00	285.28	6.58	159.14	8.12	8.12	1195.4	1728.0	140.26	140.26	584.41	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	683.7	48.56	0.92	602.8	2530.4	602.8	602.8	1927.6	455.00	285.16	6.20	163.64	13.09	13.09	1162.5	1728.0	248.87	248.87	942.68	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	763.3	48.56	0.83	616.7	2544.3	616.7	616.7	1927.6	455.00	285.16	6.20	163.64	14.74	14.74	1162.5	1728.0	254.63	254.63	1060.95	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	800.4	48.56	0.83	648.7	2576.3	648.7	648.7	1927.6	455.00	285.16	6.20	163.64	15.50	15.50	1162.5	1728.0	267.85	267.85	1116.04	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	747.5	48.56	0.83	603.0	2530.6	603.0	603.0	1927.6	455.00	285.16	6.20	163.64	14.41	14.41	1162.5	1728.0	248.98	248.98	1037.41	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	476.9	48.56	0.28	369.8	2297.4	369.8	369.8	1927.6	455.00	285.16	6.20	163.64	8.84	8.84	1162.5	1728.0	152.68	152.68	636.18	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	433.7	48.56	0.28	332.5	2260.1	332.5	332.5	1927.6	455.00	285.16	6.20	163.64	7.94	7.94	1162.5	1728.0	137.28	137.28	572.01	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	350.2	48.56	0.31	286.4	2214.0	286.4	286.4	1927.6	455.00	285.16	6.20	163.64	6.22	6.22	1162.5	1728.0	118.24	118.24	447.88	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	254.3	48.56	0.28	177.4	2105.1	177.4	177.4	1927.6	455.00	285.16	6.20	163.64	4.24	4.24	1162.5	1728.0	73.26	73.26	305.26	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	250.2	48.56	0.28	173.9	2101.5	173.9	173.9	1927.6	455.00	285.16	6.20	163.64	4.16	4.16	1162.5	1728.0	71.80	71.80	299.17	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	225.4	48.56	0.31	167.7	2095.4	167.7	167.7	1927.6	455.00	285.16	6.20	163.64	3.64	3.64	1162.5	1728.0	69.26	69.26	262.33	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	233.9	48.56	0.55	159.6	2087.2	159.6	159.6	1927.6	455.00	285.16	6.20	163.64	3.81	3.81	1162.5	1728.0	65.88	65.88	274.52	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	263.8	48.56	0.55	185.4	2113.0	185.4	185.4	1927.6	455.00	285.16	6.20	163.64	4.43	4.43	1162.5	1728.0	76.54	76.54	318.92	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	270.6	48.56	0.44	153.0	2080.6	153.0	153.0	1927.6	455.00	285.16	6.20	163.64	4.57	4.57	1162.5	1728.0	63.18	63.18	329.04	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	288.7	48.56	1.11	206.4	2134.0	206.4	206.4	1927.6	455.00	285.16	6.20	163.64	4.93	4.93	1162.5	1728.0	85.20	85.20	355.00	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	318.2	48.56	1.11	231.8	2159.5	231.8	231.8	1927.6	455.00	285.16	6.20	163.64	5.54	5.54	1162.5	1728.0	95.72	95.72	398.85	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	335.3	48.56	1.22	271.3	2198.9	271.3	271.3	1927.6	455.00	285.16	6.20	163.64	5.89	5.89	1162.5	1728.0	112.01	112.01	424.27	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	446.8	48.56	1.11	343.0	2270.6	343.0	343.0	1927.6	455.00	285.16	6.20	163.64	8.19	8.19	1162.5	1728.0	141.60	141.60	590.02	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	553.9	48.56	1.11	435.5	2363.1	435.5	435.5	1927.6	455.00	285.16	6.20	163.64	10.41	10.41	1162.5	1728.0	179.81	179.81	749.21	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	682.0	48.56	1.11	546.2	2473.8	546.2	546.2	1927.6	455.00	285.16	6.20	163.64	13.05	13.05	1162.5	1728.0	225.50	225.50	939.59	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	659.5	48.56	1.08	526.7	2454.4	599.2	599.2	1855.1	452.33	285.20	6.32	162.14	14.19	14.19	1173.3	1728.0	245.13	245.13	1021.38	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	707.4	48.56	1.06	568.1	2423.3	640.0	640.0	1783.3	449.67	285.28	6.58	159.14	14.87	14.87	1195.4	1728.0	256.96	256.96	1070.66	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	690.7	48.56	1.14	609.1	2392.4	678.5	678.5	1713.9	447.00	285.37	6.83	156.14	14.06	14.06	1218.4	1728.0	267.30	267.30	1012.51	0.00	0.00	0.00	447.0	1713.91
																159.89		**3.64**			**6570.69**	**6570.69**				**0.00**			

Min. Res. Level 455.0 m Average Power 1728.0 MW Continuous Power 262.33 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1993-94

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	872.9	48.56	1.04	711.2	2425.1	711.2	711.2	1713.9	447.00	285.41	6.96	154.63	16.06	16.06	1230.3	1728.0	277.46	277.46	1156.07	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	855.2	48.56	1.04	695.9	2409.8	695.9	695.9	1713.9	447.00	285.41	6.96	154.63	15.71	15.71	1230.3	1728.0	271.51	271.51	1131.30	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	877.4	48.56	1.04	715.1	2429.0	715.1	715.1	1713.9	447.00	285.41	6.96	154.63	16.15	16.15	1230.3	1728.0	278.99	278.99	1162.47	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	849.9	48.56	1.04	691.3	2405.2	691.3	691.3	1713.9	447.00	285.41	6.96	154.63	15.61	15.61	1230.3	1728.0	269.70	269.70	1123.76	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	885.4	48.56	1.04	722.0	2435.9	722.0	722.0	1713.9	447.00	285.41	6.96	154.63	16.30	16.30	1230.3	1728.0	281.68	281.68	1173.66	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	884.8	48.56	1.14	793.7	2507.6	793.7	793.7	1713.9	447.00	285.41	6.96	154.63	16.29	16.29	1230.3	1728.0	309.64	309.64	1172.89	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	883.6	48.56	1.04	720.4	2434.3	720.4	720.4	1713.9	447.00	285.41	6.96	154.63	16.27	16.27	1230.3	1728.0	281.07	281.07	1171.11	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	884.5	48.56	1.04	721.2	2435.2	721.2	721.2	1713.9	447.00	285.41	6.96	154.63	16.28	16.28	1230.3	1728.0	281.39	281.39	1172.46	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	894.9	48.56	1.14	803.2	2517.1	803.2	803.2	1713.9	447.00	285.41	6.96	154.63	16.49	16.49	1230.3	1728.0	313.37	313.37	1186.99	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	824.2	48.56	1.04	669.1	2383.0	669.1	669.1	1713.9	447.00	285.41	6.96	154.63	15.11	15.11	1230.3	1728.0	261.05	261.05	1087.71	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	838.0	48.56	1.04	681.1	2395.0	681.1	681.1	1713.9	447.00	285.41	6.96	154.63	15.38	15.38	1230.3	1728.0	265.72	265.72	1107.15	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	821.5	48.56	1.04	666.8	2380.7	666.8	666.8	1713.9	447.00	285.41	6.96	154.63	15.05	15.05	1230.3	1728.0	260.13	260.13	1083.89	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	785.3	48.56	0.78	635.7	2349.6	635.7	635.7	1713.9	447.00	285.41	6.96	154.63	14.35	14.35	1230.3	1728.0	248.02	248.02	1033.44	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	792.9	48.56	0.83	642.3	2356.2	428.6	428.6	1927.6	455.00	285.28	6.58	159.14	9.96	9.96	1195.4	1728.0	172.08	172.08	716.99	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	777.7	48.56	0.92	692.0	2619.7	692.0	692.0	1927.6	455.00	285.16	6.20	163.64	15.03	15.03	1162.5	1728.0	285.73	285.73	1082.31	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	466.3	48.56	0.83	360.1	2287.7	360.1	360.1	1927.6	455.00	285.16	6.20	163.64	8.60	8.60	1162.5	1728.0	148.66	148.66	619.44	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	272.2	48.56	0.83	192.4	2120.0	192.4	192.4	1927.6	455.00	285.16	6.20	163.64	4.60	4.60	1162.5	1728.0	79.45	79.45	331.03	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	271.5	48.56	0.83	191.8	2119.4	191.8	191.8	1927.6	455.00	285.16	6.20	163.64	4.58	4.58	1162.5	1728.0	79.19	79.19	329.95	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	257.8	48.56	0.28	180.5	2108.1	180.5	180.5	1927.6	455.00	285.16	6.20	163.64	4.31	4.31	1162.5	1728.0	74.51	74.51	310.48	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	256.8	48.56	0.28	179.6	2107.3	179.6	179.6	1927.6	455.00	285.16	6.20	163.64	4.29	4.29	1162.5	1728.0	74.17	74.17	309.03	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	243.7	48.56	0.31	185.2	2112.8	185.2	185.2	1927.6	455.00	285.16	6.20	163.64	4.02	4.02	1162.5	1728.0	76.46	76.46	289.62	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	240.1	48.56	0.28	165.2	2092.8	165.2	165.2	1927.6	455.00	285.16	6.20	163.64	3.95	3.95	1162.5	1728.0	68.21	68.21	284.20	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	242.9	48.56	0.28	167.7	2095.3	167.7	167.7	1927.6	455.00	285.16	6.20	163.64	4.01	4.01	1162.5	1728.0	69.23	69.23	288.45	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	232.9	48.56	0.31	174.9	2102.5	174.9	174.9	1927.6	455.00	285.16	6.20	163.64	3.80	3.80	1162.5	1728.0	72.22	72.22	273.55	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	247.7	48.56	0.55	171.5	2099.1	171.5	171.5	1927.6	455.00	285.16	6.20	163.64	4.10	4.10	1162.5	1728.0	70.82	70.82	295.09	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	263.8	48.56	0.55	185.4	2113.0	185.4	185.4	1927.6	455.00	285.16	6.20	163.64	4.43	4.43	1162.5	1728.0	76.55	76.55	318.98	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	243.6	48.56	0.44	134.4	2062.0	134.4	134.4	1927.6	455.00	285.16	6.20	163.64	4.01	4.01	1162.5	1728.0	55.49	55.49	289.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	235.3	48.56	1.11	160.2	2087.8	160.2	160.2	1927.6	455.00	285.16	6.20	163.64	3.83	3.83	1162.5	1728.0	66.15	66.15	275.63	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	257.9	48.56	1.11	179.8	2107.4	179.8	179.8	1927.6	455.00	285.16	6.20	163.64	4.30	4.30	1162.5	1728.0	74.22	74.22	309.27	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	678.8	48.56	1.22	597.7	2525.4	597.7	597.7	1927.6	455.00	285.16	6.20	163.64	12.98	12.98	1162.5	1728.0	246.80	246.80	934.85	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	651.4	48.56	1.11	519.7	2447.4	519.7	519.7	1927.6	455.00	285.16	6.20	163.64	12.42	12.42	1162.5	1728.0	214.59	214.59	894.13	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	577.0	48.56	1.11	455.4	2383.0	455.4	455.4	1927.6	455.00	285.16	6.20	163.64	10.88	10.88	1162.5	1728.0	188.04	188.04	783.50	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	646.0	48.56	1.11	515.0	2442.7	515.0	515.0	1927.6	455.00	285.16	6.20	163.64	12.31	12.31	1162.5	1728.0	212.65	212.65	886.05	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	667.1	48.56	1.08	533.3	2460.9	605.8	605.8	1855.1	452.33	285.20	6.32	162.14	14.34	14.34	1173.3	1728.0	247.82	247.82	1032.56	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	1076.9	48.56	1.06	887.4	2742.6	959.2	959.2	1783.3	449.67	285.28	6.58	159.14	22.29	22.29	1195.4	1728.0	385.16	385.16	1604.84	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1462.0	48.56	1.14	1342.2	3125.5	1165.5	1165.5	1713.9	447.00	286.28	6.92	155.14	24.00	24.00	1226.3	1728.0	456.19	433.38	1728.00	364.87	258.93	246.09	447.0	1713.91
																159.86		**3.80**			**7094.13**	**7071.32**				**246.09**		

Min. Res. Level 455.0 m Average Power 1728.0 MW Continuous Power 273.55 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1994-95

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1665.1	48.56	1.04	1395.6	3109.5	1072.7	1072.7	1713.9	447.00	286.69	7.08	153.23	24.00	24.00	1241.6	1728.0	414.72	393.98	1728.00	520.15	373.74	322.91	447.0	1713.91
	II	10	447.00	1713.9	1411.7	48.56	1.04	1176.7	2890.7	1066.5	1066.5	1713.9	447.00	285.87	7.00	154.13	24.00	24.00	1234.3	1728.0	414.72	393.98	1728.00	178.67	127.63	110.27	447.0	1713.91
	III	10	447.00	1713.9	1489.1	48.56	1.04	1243.6	2957.5	1068.4	1068.4	1713.9	447.00	286.13	7.03	153.84	24.00	24.00	1236.6	1728.0	414.72	393.98	1728.00	283.24	202.70	175.13	447.0	1713.91
Jul	I	10	447.00	1713.9	1901.1	48.56	1.04	1599.5	3313.5	1078.1	1078.1	1713.9	447.00	287.40	7.15	152.46	24.00	24.00	1247.8	1728.0	414.72	393.98	1728.00	835.72	603.49	521.42	447.0	1713.91
	II	10	447.00	1713.9	1254.4	48.56	1.04	1040.8	2754.7	1040.8	1040.8	1713.9	447.00	285.41	6.96	154.63	23.50	23.50	1230.3	1728.0	406.05	393.98	1691.88	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1723.6	48.56	1.14	1590.8	3304.7	1181.5	1181.5	1713.9	447.00	286.87	7.10	153.03	24.00	24.00	1243.2	1728.0	456.19	433.38	1728.00	598.59	430.65	409.29	447.0	1713.91
Aug	I	10	447.00	1713.9	1895.8	48.56	1.04	1595.0	3308.9	1078.0	1078.0	1713.9	447.00	287.38	7.14	152.48	24.00	24.00	1247.7	1728.0	414.72	393.98	1728.00	828.71	598.37	516.99	447.0	1713.91
	II	10	447.00	1713.9	2248.1	48.56	1.04	1899.4	3613.3	1085.5	1085.5	1713.9	447.00	288.34	7.23	151.43	24.00	24.00	1256.3	1728.0	414.72	393.98	1728.00	1295.67	942.01	813.89	447.0	1713.91
	III	11	447.00	1713.9	2111.9	48.56	1.14	1959.9	3673.8	1190.9	1190.9	1713.9	447.00	287.98	7.20	151.82	24.00	24.00	1253.1	1728.0	456.19	433.38	1728.00	1115.74	809.09	768.96	447.0	1713.91
Sep	I	10	447.00	1713.9	1307.5	48.56	1.04	1086.7	2800.6	1063.7	1063.7	1713.9	447.00	285.51	6.97	154.52	24.00	24.00	1231.2	1728.0	414.72	393.98	1728.00	37.31	26.58	22.97	447.0	1713.91
	II	10	447.00	1713.9	1336.5	48.56	1.04	1111.7	2825.6	1064.5	1064.5	1713.9	447.00	285.61	6.98	154.41	24.00	24.00	1232.1	1728.0	414.72	393.98	1728.00	76.66	54.66	47.22	447.0	1713.91
	III	10	447.00	1713.9	1583.5	48.56	1.04	1325.2	3039.1	1070.8	1070.8	1713.9	447.00	286.44	7.06	153.51	24.00	24.00	1239.3	1728.0	414.72	393.98	1728.00	410.55	294.45	254.40	447.0	1713.91
Oct	I	10	447.00	1713.9	1052.9	48.56	0.78	867.0	2580.9	867.0	867.0	1713.9	447.00	285.41	6.96	154.63	19.57	19.57	1230.3	1728.0	338.25	338.25	1409.39	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	916.3	48.56	0.83	748.9	2462.8	535.2	535.2	1927.6	455.00	285.28	6.58	159.14	12.44	12.44	1195.4	1728.0	214.88	214.88	895.35	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	937.4	48.56	0.92	843.8	2771.4	843.8	843.8	1927.6	455.00	285.16	6.20	163.64	18.33	18.33	1162.5	1728.0	348.39	348.39	1319.66	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	762.2	48.56	0.83	615.8	2543.4	615.8	615.8	1927.6	455.00	285.16	6.20	163.64	14.71	14.71	1162.5	1728.0	254.24	254.24	1059.33	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	434.4	48.56	0.83	332.6	2260.2	332.6	332.6	1927.6	455.00	285.16	6.20	163.64	7.95	7.95	1162.5	1728.0	137.31	137.31	572.11	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	314.6	48.56	0.83	229.0	2156.6	229.0	229.0	1927.6	455.00	285.16	6.20	163.64	5.47	5.47	1162.5	1728.0	94.56	94.56	393.99	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	316.6	48.56	0.28	231.3	2158.9	231.3	231.3	1927.6	455.00	285.16	6.20	163.64	5.53	5.53	1162.5	1728.0	95.51	95.51	397.95	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	269.6	48.56	0.28	190.7	2118.3	190.7	190.7	1927.6	455.00	285.16	6.20	163.64	4.56	4.56	1162.5	1728.0	78.75	78.75	328.12	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	192.4	48.56	0.31	136.4	2064.0	138.1	138.1	1925.9	454.93	285.16	6.20	163.61	3.00	3.00	1162.8	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.93	1925.9	278.2	48.56	0.28	198.1	2124.0	196.4	196.4	1927.6	455.00	285.16	6.20	163.61	4.69	4.69	1162.8	1728.0	81.05	81.05	337.72	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	258.9	48.56	0.28	181.5	2109.1	181.5	181.5	1927.6	455.00	285.16	6.20	163.64	4.34	4.34	1162.5	1728.0	74.94	74.94	312.23	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	263.6	48.56	0.31	204.0	2131.7	204.0	204.0	1927.6	455.00	285.16	6.20	163.64	4.43	4.43	1162.5	1728.0	84.24	84.24	319.10	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	266.0	48.56	0.55	187.3	2115.0	187.3	187.3	1927.6	455.00	285.16	6.20	163.64	4.48	4.48	1162.5	1728.0	77.35	77.35	322.29	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	327.3	48.56	0.55	240.3	2167.9	240.3	240.3	1927.6	455.00	285.16	6.20	163.64	5.74	5.74	1162.5	1728.0	99.21	99.21	413.36	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	302.9	48.56	0.44	175.4	2103.0	175.4	175.4	1927.6	455.00	285.16	6.20	163.64	5.24	5.24	1162.5	1728.0	72.41	72.41	377.14	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	299.2	48.56	1.11	215.4	2143.0	215.4	215.4	1927.6	455.00	285.16	6.20	163.64	5.15	5.15	1162.5	1728.0	88.94	88.94	370.58	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	346.9	48.56	1.11	256.7	2184.3	256.7	256.7	1927.6	455.00	285.16	6.20	163.64	6.13	6.13	1162.5	1728.0	105.98	105.98	441.57	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	392.3	48.56	1.22	325.5	2253.1	325.5	325.5	1927.6	455.00	285.16	6.20	163.64	7.07	7.07	1162.5	1728.0	134.38	134.38	509.02	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	366.2	48.56	1.11	273.3	2200.9	273.3	273.3	1927.6	455.00	285.16	6.20	163.64	6.53	6.53	1162.5	1728.0	112.85	112.85	470.20	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	342.8	48.56	1.11	253.1	2180.8	253.1	253.1	1927.6	455.00	285.16	6.20	163.64	6.05	6.05	1162.5	1728.0	104.52	104.52	435.51	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	706.0	48.56	1.11	566.9	2494.5	566.9	566.9	1927.6	455.00	285.16	6.20	163.64	13.55	13.55	1162.5	1728.0	234.06	234.06	975.25	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	695.3	48.56	1.08	557.7	2485.3	630.2	630.2	1855.1	452.33	285.20	6.32	162.14	14.92	14.92	1173.3	1728.0	257.80	257.80	1074.17	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	644.4	48.56	1.06	513.7	2368.9	585.6	585.6	1783.3	449.67	285.28	6.58	159.14	13.61	13.61	1195.4	1728.0	235.12	235.12	979.67	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	674.5	48.56	1.14	593.7	2377.0	663.1	663.1	1713.9	447.00	285.37	6.83	156.14	13.74	13.74	1218.4	1728.0	261.24	261.24	989.54	0.00	0.00	0.00	447.0	1713.91
																159.44		**3.00**			**8693.91**	**8449.60**				**3963.45**		

Min. Res. Level 454.9 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1995-96

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	822.6	48.56	1.04	667.7	2381.6	667.7	667.7	1713.9	447.00	285.41	6.96	154.63	15.08	15.08	1230.3	1728.0	260.50	260.50	1085.40	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1141.2	48.56	1.04	943.0	2657.0	943.0	943.0	1713.9	447.00	285.41	6.96	154.63	21.29	21.29	1230.3	1728.0	367.92	367.92	1533.01	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1332.2	48.56	1.04	1108.0	2821.9	1064.4	1064.4	1713.9	447.00	285.59	6.98	154.43	24.00	24.00	1231.9	1728.0	414.72	393.98	1728.00	70.82	50.49	43.62	447.0	1713.91
Jul	I	10	447.00	1713.9	1091.1	48.56	1.04	899.7	2613.6	899.7	899.7	1713.9	447.00	285.41	6.96	154.63	20.31	20.31	1230.3	1728.0	351.00	351.00	1462.52	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	772.3	48.56	1.04	624.3	2338.2	624.3	624.3	1713.9	447.00	285.41	6.96	154.63	14.09	14.09	1230.3	1728.0	243.56	243.56	1014.83	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	636.3	48.56	1.14	557.4	2271.3	557.4	557.4	1713.9	447.00	285.41	6.96	154.63	11.44	11.44	1230.3	1728.0	217.48	217.48	823.78	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	695.5	48.56	1.04	557.9	2271.9	557.9	557.9	1713.9	447.00	285.41	6.96	154.63	12.60	12.60	1230.3	1728.0	217.68	217.68	907.00	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	771.9	48.56	1.04	623.9	2337.9	623.9	623.9	1713.9	447.00	285.41	6.96	154.63	14.09	14.09	1230.3	1728.0	243.43	243.43	1014.29	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	743.6	48.56	1.14	659.4	2373.3	659.4	659.4	1713.9	447.00	285.41	6.96	154.63	13.53	13.53	1230.3	1728.0	257.27	257.27	974.52	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	528.2	48.56	1.04	413.4	2127.3	413.4	413.4	1713.9	447.00	285.41	6.96	154.63	9.33	9.33	1230.3	1728.0	161.28	161.28	672.01	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	535.6	48.56	1.04	419.8	2133.7	419.8	419.8	1713.9	447.00	285.41	6.96	154.63	9.48	9.48	1230.3	1728.0	163.78	163.78	682.40	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	500.5	48.56	1.04	389.4	2103.3	389.4	389.4	1713.9	447.00	285.41	6.96	154.63	8.79	8.79	1230.3	1728.0	151.93	151.93	633.04	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	447.5	48.56	0.78	343.9	2057.8	343.9	343.9	1713.9	447.00	285.41	6.96	154.63	7.76	7.76	1230.3	1728.0	134.16	134.16	559.00	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	487.9	48.56	0.83	378.8	2092.7	165.1	165.1	1927.6	455.00	285.28	6.58	159.14	3.84	3.84	1195.4	1728.0	66.28	66.28	276.19	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	454.8	48.56	0.92	385.1	2312.8	385.1	385.1	1927.6	455.00	285.16	6.20	163.64	8.37	8.37	1162.5	1728.0	159.02	159.02	602.36	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	338.0	48.56	0.83	249.2	2176.9	249.2	249.2	1927.6	455.00	285.16	6.20	163.64	5.96	5.96	1162.5	1728.0	102.91	102.91	428.79	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	325.6	48.56	0.83	238.5	2166.1	238.5	238.5	1927.6	455.00	285.16	6.20	163.64	5.70	5.70	1162.5	1728.0	98.48	98.48	410.33	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	333.3	48.56	0.83	245.2	2172.8	245.2	245.2	1927.6	455.00	285.16	6.20	163.64	5.86	5.86	1162.5	1728.0	101.25	101.25	421.86	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	398.1	48.56	0.28	301.7	2229.4	301.7	301.7	1927.6	455.00	285.16	6.20	163.64	7.21	7.21	1162.5	1728.0	124.59	124.59	519.11	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	426.0	48.56	0.28	325.8	2253.5	325.8	325.8	1927.6	455.00	285.16	6.20	163.64	7.79	7.79	1162.5	1728.0	134.54	134.54	560.58	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	462.9	48.56	0.31	393.5	2321.1	393.5	393.5	1927.6	455.00	285.16	6.20	163.64	8.55	8.55	1162.5	1728.0	162.46	162.46	615.37	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	360.6	48.56	0.28	269.3	2196.9	269.3	269.3	1927.6	455.00	285.16	6.20	163.64	6.44	6.44	1162.5	1728.0	111.20	111.20	463.34	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	373.3	48.56	0.28	280.3	2207.9	280.3	280.3	1927.6	455.00	285.16	6.20	163.64	6.70	6.70	1162.5	1728.0	115.72	115.72	482.19	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	295.9	48.56	0.31	234.7	2162.4	234.7	234.7	1927.6	455.00	285.16	6.20	163.64	5.10	5.10	1162.5	1728.0	96.92	96.92	367.12	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	362.6	48.56	0.55	270.8	2198.4	270.8	270.8	1927.6	455.00	285.16	6.20	163.64	6.47	6.47	1162.5	1728.0	111.79	111.79	465.80	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	418.6	48.56	0.55	319.1	2246.8	319.1	319.1	1927.6	455.00	285.16	6.20	163.64	7.63	7.63	1162.5	1728.0	131.77	131.77	549.03	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	376.4	48.56	0.44	226.2	2153.8	226.2	226.2	1927.6	455.00	285.16	6.20	163.64	6.76	6.76	1162.5	1728.0	93.38	93.38	486.37	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	329.7	48.56	1.11	241.8	2169.4	241.8	241.8	1927.6	455.00	285.16	6.20	163.64	5.78	5.78	1162.5	1728.0	99.82	99.82	415.92	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	404.6	48.56	1.11	306.5	2234.1	306.5	306.5	1927.6	455.00	285.16	6.20	163.64	7.32	7.32	1162.5	1728.0	126.54	126.54	527.26	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	431.9	48.56	1.22	363.1	2290.7	363.1	363.1	1927.6	455.00	285.16	6.20	163.64	7.89	7.89	1162.5	1728.0	149.92	149.92	567.89	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	456.0	48.56	1.11	350.9	2278.5	350.9	350.9	1927.6	455.00	285.16	6.20	163.64	8.38	8.38	1162.5	1728.0	144.88	144.88	603.66	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	443.2	48.56	1.11	339.8	2267.5	339.8	339.8	1927.6	455.00	285.16	6.20	163.64	8.12	8.12	1162.5	1728.0	140.31	140.31	584.64	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	1470.4	48.56	1.11	1227.4	3155.0	1010.6	1010.6	1927.6	455.00	286.07	6.28	162.65	24.00	24.00	1169.6	1728.0	414.72	393.98	1728.00	370.73	250.94	216.81	455.0	1927.62
May	I	10	455.00	1927.6	1467.0	48.56	1.08	1224.4	3152.0	1021.5	1021.5	1855.1	452.33	286.33	6.43	160.90	24.00	24.00	1182.3	1728.0	414.72	393.98	1728.00	465.73	318.67	275.33	452.3	1855.15
	II	10	452.33	1855.1	1990.1	48.56	1.06	1676.4	3531.6	1051.6	1051.6	1783.3	449.67	287.87	6.82	156.31	24.00	24.00	1217.1	1728.0	414.72	393.98	1728.00	1144.72	806.29	696.63	449.7	1783.33
	III	11	449.67	1783.3	2281.8	48.56	1.14	2121.3	3904.6	1184.9	1184.9	1713.9	447.00	288.61	7.13	152.59	24.00	24.00	1246.8	1728.0	456.19	433.38	1728.00	1466.75	1058.27	1005.78	447.0	1713.91
																159.64		**3.84**			**7156.85**	**7051.10**				**2238.18**		

Min. Res. Level 455.0 m Average Power 1728.0 MW Continuous Power 276.19 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1996-97

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1290.7	48.56	1.04	1072.2	2786.1	1063.3	1063.3	1713.9	447.00	285.45	6.96	154.59	24.00	24.00	1230.6	1728.0	414.72	393.98	1728.00	14.49	10.32	8.91	447.0	1713.91
	II	10	447.00	1713.9	963.3	48.56	1.04	789.3	2503.2	789.3	789.3	1713.9	447.00	285.41	6.96	154.63	17.82	17.82	1230.3	1728.0	307.93	307.93	1283.05	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1026.9	48.56	1.04	844.2	2558.2	844.2	844.2	1713.9	447.00	285.41	6.96	154.63	19.06	19.06	1230.3	1728.0	329.38	329.38	1372.40	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1605.9	48.56	1.04	1344.5	3058.4	1071.3	1071.3	1713.9	447.00	286.51	7.06	153.43	24.00	24.00	1239.9	1728.0	414.72	393.98	1728.00	440.61	316.16	273.16	447.0	1713.91
	II	10	447.00	1713.9	2138.2	48.56	1.04	1804.4	3518.4	1083.2	1083.2	1713.9	447.00	288.05	7.21	151.74	24.00	24.00	1253.7	1728.0	414.72	393.98	1728.00	1150.56	834.77	721.24	447.0	1713.91
	III	11	447.00	1713.9	1700.7	48.56	1.14	1569.0	3282.9	1180.9	1180.9	1713.9	447.00	286.80	7.09	153.11	24.00	24.00	1242.6	1728.0	456.19	433.38	1728.00	567.87	408.34	388.08	447.0	1713.91
Aug	I	10	447.00	1713.9	1588.7	48.56	1.04	1329.7	3043.6	1070.9	1070.9	1713.9	447.00	286.45	7.06	153.49	24.00	24.00	1239.5	1728.0	414.72	393.98	1728.00	417.54	299.49	258.76	447.0	1713.91
	II	10	447.00	1713.9	1878.8	48.56	1.04	1580.3	3294.2	1077.6	1077.6	1713.9	447.00	287.33	7.14	152.53	24.00	24.00	1247.3	1728.0	414.72	393.98	1728.00	805.98	581.75	502.63	447.0	1713.91
	III	11	447.00	1713.9	1455.5	48.56	1.14	1336.0	3049.9	1174.4	1174.4	1713.9	447.00	286.02	7.02	153.96	24.00	24.00	1235.6	1728.0	456.19	433.38	1728.00	237.81	170.05	161.62	447.0	1713.91
Sep	I	10	447.00	1713.9	993.5	48.56	1.04	815.4	2529.3	815.4	815.4	1713.9	447.00	285.41	6.96	154.63	18.41	18.41	1230.3	1728.0	318.12	318.12	1325.48	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	904.5	48.56	1.04	738.5	2452.4	738.5	738.5	1713.9	447.00	285.41	6.96	154.63	16.67	16.67	1230.3	1728.0	288.11	288.11	1200.45	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	844.1	48.56	1.04	686.3	2400.2	686.3	686.3	1713.9	447.00	285.41	6.96	154.63	15.50	15.50	1230.3	1728.0	267.76	267.76	1115.67	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	835.5	48.56	0.78	679.2	2393.1	679.2	679.2	1713.9	447.00	285.41	6.96	154.63	15.33	15.33	1230.3	1728.0	264.97	264.97	1104.04	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	824.4	48.56	0.83	669.5	2383.4	455.7	455.7	1927.6	455.00	285.28	6.58	159.14	10.59	10.59	1195.4	1728.0	182.99	182.99	762.46	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	836.6	48.56	0.92	748.1	2675.7	748.1	748.1	1927.6	455.00	285.16	6.20	163.64	16.25	16.25	1162.5	1728.0	308.86	308.86	1169.94	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	816.8	48.56	0.83	662.9	2590.5	662.9	662.9	1927.6	455.00	285.16	6.20	163.64	15.84	15.84	1162.5	1728.0	273.70	273.70	1140.43	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	810.7	48.56	0.83	657.7	2585.3	657.7	657.7	1927.6	455.00	285.16	6.20	163.64	15.71	15.71	1162.5	1728.0	271.55	271.55	1131.47	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	768.7	48.56	0.83	621.4	2549.0	621.4	621.4	1927.6	455.00	285.16	6.20	163.64	14.85	14.85	1162.5	1728.0	256.55	256.55	1068.97	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	666.1	48.56	0.28	533.3	2460.9	533.3	533.3	1927.6	455.00	285.16	6.20	163.64	12.74	12.74	1162.5	1728.0	220.18	220.18	917.42	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	619.2	48.56	0.28	492.7	2420.4	492.7	492.7	1927.6	455.00	285.16	6.20	163.64	11.77	11.77	1162.5	1728.0	203.45	203.45	847.69	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	586.6	48.56	0.31	511.1	2438.7	511.1	511.1	1927.6	455.00	285.16	6.20	163.64	11.10	11.10	1162.5	1728.0	211.02	211.02	799.32	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	445.7	48.56	0.28	342.9	2270.5	342.9	342.9	1927.6	455.00	285.16	6.20	163.64	8.19	8.19	1162.5	1728.0	141.57	141.57	589.86	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	370.7	48.56	0.28	278.1	2205.7	278.1	278.1	1927.6	455.00	285.16	6.20	163.64	6.64	6.64	1162.5	1728.0	114.81	114.81	478.37	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	410.4	48.56	0.31	343.6	2271.2	343.6	343.6	1927.6	455.00	285.16	6.20	163.64	7.46	7.46	1162.5	1728.0	141.87	141.87	537.40	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	355.6	48.56	0.55	264.8	2192.4	264.8	264.8	1927.6	455.00	285.16	6.20	163.64	6.33	6.33	1162.5	1728.0	109.31	109.31	455.47	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	321.4	48.56	0.55	235.2	2162.8	235.2	235.2	1927.6	455.00	285.16	6.20	163.64	5.62	5.62	1162.5	1728.0	97.12	97.12	404.65	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	325.9	48.56	0.44	191.3	2118.9	191.3	191.3	1927.6	455.00	285.16	6.20	163.64	5.71	5.71	1162.5	1728.0	78.97	78.97	411.28	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	389.1	48.56	1.11	293.1	2220.7	293.1	293.1	1927.6	455.00	285.16	6.20	163.64	7.00	7.00	1162.5	1728.0	121.02	121.02	504.27	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	427.0	48.56	1.11	325.8	2253.5	325.8	325.8	1927.6	455.00	285.16	6.20	163.64	7.79	7.79	1162.5	1728.0	134.54	134.54	560.57	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	474.2	48.56	1.22	403.3	2330.9	403.3	403.3	1927.6	455.00	285.16	6.20	163.64	8.76	8.76	1162.5	1728.0	166.50	166.50	630.70	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	438.2	48.56	1.11	335.5	2263.1	335.5	335.5	1927.6	455.00	285.16	6.20	163.64	8.02	8.02	1162.5	1728.0	138.53	138.53	577.19	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	524.1	48.56	1.11	409.7	2337.4	409.7	409.7	1927.6	455.00	285.16	6.20	163.64	9.79	9.79	1162.5	1728.0	169.17	169.17	704.89	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	550.9	48.56	1.11	432.9	2360.5	432.9	432.9	1927.6	455.00	285.16	6.20	163.64	10.34	10.34	1162.5	1728.0	178.75	178.75	744.80	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	715.7	48.56	1.08	575.3	2503.0	647.8	647.8	1855.1	452.33	285.20	6.32	162.14	15.34	15.34	1173.3	1728.0	265.01	265.01	1104.23	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	890.4	48.56	1.06	726.3	2581.5	798.1	798.1	1783.3	449.67	285.28	6.58	159.14	18.55	18.55	1195.4	1728.0	320.47	320.47	1335.28	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1190.1	48.56	1.14	1083.8	2867.1	1153.2	1153.2	1713.9	447.00	285.37	6.83	156.14	23.90	23.90	1218.4	1728.0	454.29	433.38	1720.79	0.00	0.00	0.00	447.0	1713.91
																159.62		**5.62**			**9322.49**	**9152.28**				**2314.41**		

Min. Res. Level 455.0 m Average Power 1728.0 MW Continuous Power 404.65 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1997-98

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1460.1	48.56	1.04	1218.5	2932.4	1067.7	1067.7	1713.9	447.00	286.03	7.02	153.95	24.00	24.00	1235.8	1728.0	414.72	393.98	1728.00	244.10	174.56	150.82	447.0	1713.91
	II	10	447.00	1713.9	1857.9	48.56	1.04	1562.2	3276.1	1077.2	1077.2	1713.9	447.00	287.27	7.13	152.60	24.00	24.00	1246.7	1728.0	414.72	393.98	1728.00	778.15	561.42	485.07	447.0	1713.91
	III	10	447.00	1713.9	1697.5	48.56	1.04	1423.7	3137.6	1073.5	1073.5	1713.9	447.00	286.79	7.09	153.12	24.00	24.00	1242.5	1728.0	414.72	393.98	1728.00	563.68	405.30	350.18	447.0	1713.91
Jul	I	10	447.00	1713.9	1559.7	48.56	1.04	1304.6	3018.5	1070.2	1070.2	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1238.6	1728.0	414.72	393.98	1728.00	378.42	271.25	234.36	447.0	1713.91
	II	10	447.00	1713.9	1651.0	48.56	1.04	1383.4	3097.3	1072.4	1072.4	1713.9	447.00	286.65	7.08	153.27	24.00	24.00	1241.2	1728.0	414.72	393.98	1728.00	501.18	359.99	311.03	447.0	1713.91
	III	11	447.00	1713.9	1743.2	48.56	1.14	1609.4	3323.4	1182.0	1182.0	1713.9	447.00	286.93	7.10	152.97	24.00	24.00	1243.7	1728.0	456.19	433.38	1728.00	624.87	449.74	427.43	447.0	1713.91
Aug	I	10	447.00	1713.9	1679.5	48.56	1.04	1408.1	3122.0	1073.1	1073.1	1713.9	447.00	286.74	7.08	153.18	24.00	24.00	1242.0	1728.0	414.72	393.98	1728.00	539.54	387.79	335.05	447.0	1713.91
	II	10	447.00	1713.9	1862.0	48.56	1.04	1565.8	3279.7	1077.3	1077.3	1713.9	447.00	287.28	7.13	152.58	24.00	24.00	1246.8	1728.0	414.72	393.98	1728.00	783.61	565.41	488.51	447.0	1713.91
	III	11	447.00	1713.9	1947.2	48.56	1.14	1803.3	3517.2	1187.1	1187.1	1713.9	447.00	287.53	7.16	152.32	24.00	24.00	1249.0	1728.0	456.19	433.38	1728.00	897.05	648.39	616.23	447.0	1713.91
Sep	I	10	447.00	1713.9	1529.2	48.56	1.04	1278.2	2992.2	1069.4	1069.4	1713.9	447.00	286.26	7.04	153.70	24.00	24.00	1237.8	1728.0	414.72	393.98	1728.00	337.38	241.67	208.80	447.0	1713.91
	II	10	447.00	1713.9	1559.2	48.56	1.04	1304.1	3018.0	1070.2	1070.2	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1238.6	1728.0	414.72	393.98	1728.00	377.74	270.77	233.94	447.0	1713.91
	III	10	447.00	1713.9	1199.3	48.56	1.04	993.2	2707.1	993.2	993.2	1713.9	447.00	285.41	6.96	154.63	22.42	22.42	1230.3	1728.0	387.49	387.49	1614.54	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	969.6	48.56	0.78	795.0	2508.9	795.0	795.0	1713.9	447.00	285.41	6.96	154.63	17.95	17.95	1230.3	1728.0	310.17	310.17	1292.39	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	705.1	48.56	0.83	566.4	2280.4	352.7	352.7	1927.6	455.00	285.28	6.58	159.14	8.20	8.20	1195.4	1728.0	141.63	141.63	590.13	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	584.8	48.56	0.92	508.7	2436.4	508.7	508.7	1927.6	455.00	285.16	6.20	163.64	11.05	11.05	1162.5	1728.0	210.05	210.05	795.65	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	497.9	48.56	0.83	387.4	2315.0	387.4	387.4	1927.6	455.00	285.16	6.20	163.64	9.26	9.26	1162.5	1728.0	159.96	159.96	666.49	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	405.2	48.56	0.83	307.3	2234.9	307.3	307.3	1927.6	455.00	285.16	6.20	163.64	7.34	7.34	1162.5	1728.0	126.87	126.87	528.63	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	330.2	48.56	0.83	242.5	2170.1	242.5	242.5	1927.6	455.00	285.16	6.20	163.64	5.79	5.79	1162.5	1728.0	100.13	100.13	417.21	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	299.8	48.56	0.28	216.8	2144.4	216.8	216.8	1927.6	455.00	285.16	6.20	163.64	5.18	5.18	1162.5	1728.0	89.50	89.50	372.93	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	275.6	48.56	0.28	195.9	2123.5	195.9	195.9	1927.6	455.00	285.16	6.20	163.64	4.68	4.68	1162.5	1728.0	80.89	80.89	337.05	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	261.0	48.56	0.31	201.6	2129.2	201.6	201.6	1927.6	455.00	285.16	6.20	163.64	4.38	4.38	1162.5	1728.0	83.23	83.23	315.26	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	245.9	48.56	0.28	170.2	2097.8	170.2	170.2	1927.6	455.00	285.16	6.20	163.64	4.07	4.07	1162.5	1728.0	70.28	70.28	292.83	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	229.8	48.56	0.28	156.3	2083.9	156.3	156.3	1927.6	455.00	285.16	6.20	163.64	3.74	3.74	1162.5	1728.0	64.54	64.54	268.93	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	225.0	48.56	0.31	167.4	2095.0	167.4	167.4	1927.6	455.00	285.16	6.20	163.64	3.64	3.64	1162.5	1728.0	69.12	69.12	261.81	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	240.0	48.56	0.55	164.8	2092.4	164.8	164.8	1927.6	455.00	285.16	6.20	163.64	3.94	3.94	1162.5	1728.0	68.05	68.05	283.53	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	224.0	48.56	0.55	151.0	2078.6	151.0	151.0	1927.6	455.00	285.16	6.20	163.64	3.61	3.61	1162.5	1728.0	62.34	62.34	259.76	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	246.5	48.56	0.44	136.4	2064.0	136.4	136.4	1927.6	455.00	285.16	6.20	163.64	4.07	4.07	1162.5	1728.0	56.31	56.31	293.31	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	284.2	48.56	1.11	202.4	2130.1	202.4	202.4	1927.6	455.00	285.16	6.20	163.64	4.84	4.84	1162.5	1728.0	83.58	83.58	348.27	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	359.6	48.56	1.11	267.6	2195.2	267.6	267.6	1927.6	455.00	285.16	6.20	163.64	6.39	6.39	1162.5	1728.0	110.49	110.49	460.39	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	253.1	48.56	1.22	193.2	2120.8	193.2	193.2	1927.6	455.00	285.16	6.20	163.64	4.20	4.20	1162.5	1728.0	79.76	79.76	302.12	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	431.3	48.56	1.11	329.6	2257.2	329.6	329.6	1927.6	455.00	285.16	6.20	163.64	7.88	7.88	1162.5	1728.0	136.09	136.09	567.04	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	526.3	48.56	1.11	411.6	2339.2	411.6	411.6	1927.6	455.00	285.16	6.20	163.64	9.84	9.84	1162.5	1728.0	169.95	169.95	708.14	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	544.8	48.56	1.11	427.6	2355.2	427.6	427.6	1927.6	455.00	285.16	6.20	163.64	10.22	10.22	1162.5	1728.0	176.55	176.55	735.63	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	616.4	48.56	1.08	489.5	2417.1	562.0	562.0	1855.1	452.33	285.20	6.32	162.14	13.30	13.30	1173.3	1728.0	229.91	229.91	957.95	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	668.0	48.56	1.06	534.1	2389.3	606.0	606.0	1783.3	449.67	285.28	6.58	159.14	14.08	14.08	1195.4	1728.0	243.31	243.31	1013.78	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	813.2	48.56	1.14	725.5	2508.9	795.0	795.0	1713.9	447.00	285.37	6.83	156.14	16.48	16.48	1218.4	1728.0	313.17	313.17	1186.25	0.00	0.00	0.00	447.0	1713.91
																159.44		**3.61**			**8268.26**	**8036.02**				**3841.44**		

Min. Res. Level 455.0 m Average Power 1728.0 MW Continuous Power 259.76 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1998-99

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	832.9	48.56	1.04	676.6	2390.6	676.6	676.6	1713.9	447.00	285.41	6.96	154.63	15.28	15.28	1230.3	1728.0	263.99	263.99	1099.96	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	972.3	48.56	1.04	797.0	2510.9	797.0	797.0	1713.9	447.00	285.41	6.96	154.63	18.00	18.00	1230.3	1728.0	310.96	310.96	1295.66	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1847.0	48.56	1.04	1552.8	3266.8	1076.9	1076.9	1713.9	447.00	287.24	7.13	152.63	24.00	24.00	1246.4	1728.0	414.72	393.98	1728.00	763.65	550.83	475.92	447.0	1713.91
Jul	I	10	447.00	1713.9	1793.3	48.56	1.04	1506.4	3220.3	1075.7	1075.7	1713.9	447.00	287.08	7.12	152.80	24.00	24.00	1245.0	1728.0	414.72	393.98	1728.00	691.82	498.46	430.67	447.0	1713.91
	II	10	447.00	1713.9	1548.5	48.56	1.04	1294.9	3008.9	1069.9	1069.9	1713.9	447.00	286.33	7.05	153.63	24.00	24.00	1238.3	1728.0	414.72	393.98	1728.00	363.44	260.45	225.03	447.0	1713.91
	III	11	447.00	1713.9	1519.6	48.56	1.14	1397.0	3110.9	1176.1	1176.1	1713.9	447.00	286.23	7.04	153.73	24.00	24.00	1237.5	1728.0	456.19	433.38	1728.00	324.48	232.38	220.85	447.0	1713.91
Aug	I	10	447.00	1713.9	1569.6	48.56	1.04	1313.1	3027.0	1070.4	1070.4	1713.9	447.00	286.39	7.05	153.56	24.00	24.00	1238.9	1728.0	414.72	393.98	1728.00	391.76	280.88	242.68	447.0	1713.91
	II	10	447.00	1713.9	1397.3	48.56	1.04	1164.3	2878.2	1066.1	1066.1	1713.9	447.00	285.82	7.00	154.18	24.00	24.00	1233.9	1728.0	414.72	393.98	1728.00	159.14	113.64	98.18	447.0	1713.91
	III	11	447.00	1713.9	1385.3	48.56	1.14	1269.3	2983.2	1172.4	1172.4	1713.9	447.00	285.78	7.00	154.22	24.00	24.00	1233.5	1728.0	456.19	433.38	1728.00	142.80	101.94	96.89	447.0	1713.91
Sep	I	10	447.00	1713.9	1179.8	48.56	1.04	976.3	2690.2	976.3	976.3	1713.9	447.00	285.41	6.96	154.63	22.04	22.04	1230.3	1728.0	380.90	380.90	1587.10	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1091.1	48.56	1.04	899.7	2613.6	899.7	899.7	1713.9	447.00	285.41	6.96	154.63	20.31	20.31	1230.3	1728.0	351.01	351.01	1462.53	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	992.3	48.56	1.04	814.3	2528.3	814.3	814.3	1713.9	447.00	285.41	6.96	154.63	18.39	18.39	1230.3	1728.0	317.71	317.71	1323.81	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	987.5	48.56	0.78	810.4	2524.3	810.4	810.4	1713.9	447.00	285.41	6.96	154.63	18.30	18.30	1230.3	1728.0	316.19	316.19	1317.45	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1205.7	48.56	0.83	998.9	2712.8	785.2	785.2	1927.6	455.00	285.28	6.58	159.14	18.25	18.25	1195.4	1728.0	315.28	315.28	1313.67	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	815.2	48.56	0.92	727.7	2655.3	727.7	727.7	1927.6	455.00	285.16	6.20	163.64	15.81	15.81	1162.5	1728.0	300.44	300.44	1138.04	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	543.5	48.56	0.83	426.8	2354.4	426.8	426.8	1927.6	455.00	285.16	6.20	163.64	10.20	10.20	1162.5	1728.0	176.23	176.23	734.29	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	449.6	48.56	0.83	345.6	2273.3	345.6	345.6	1927.6	455.00	285.16	6.20	163.64	8.26	8.26	1162.5	1728.0	142.71	142.71	594.61	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	376.8	48.56	0.83	282.7	2210.4	282.7	282.7	1927.6	455.00	285.16	6.20	163.64	6.76	6.76	1162.5	1728.0	116.74	116.74	486.42	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	325.0	48.56	0.28	238.6	2166.2	238.6	238.6	1927.6	455.00	285.16	6.20	163.64	5.70	5.70	1162.5	1728.0	98.51	98.51	410.45	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	275.3	48.56	0.28	195.6	2123.2	195.6	195.6	1927.6	455.00	285.16	6.20	163.64	4.67	4.67	1162.5	1728.0	80.76	80.76	336.50	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	278.8	48.56	0.31	218.5	2146.1	218.5	218.5	1927.6	455.00	285.16	6.20	163.64	4.75	4.75	1162.5	1728.0	90.21	90.21	341.69	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	225.0	48.56	0.28	152.1	2079.8	152.1	152.1	1927.6	455.00	285.16	6.20	163.64	3.64	3.64	1162.5	1728.0	62.82	62.82	261.75	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	196.1	48.56	0.28	127.2	2054.9	127.2	127.2	1927.6	455.00	285.16	6.20	163.64	3.04	3.04	1162.5	1728.0	52.53	52.53	218.89	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	181.1	48.56	0.31	125.7	2053.3	138.3	138.3	1915.0	454.53	285.17	6.22	163.38	3.00	3.00	1164.4	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	454.53	1915.0	190.6	48.56	0.55	122.2	2037.1	126.0	126.0	1911.1	454.39	285.18	6.25	163.04	3.00	3.00	1166.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.39	1911.1	178.4	48.56	0.55	111.6	2022.8	126.3	126.3	1896.4	453.85	285.19	6.28	162.66	3.00	3.00	1169.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	453.85	1896.4	200.0	48.56	0.44	104.2	2000.6	101.2	101.2	1899.4	453.96	285.19	6.30	162.41	3.00	3.00	1171.4	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	453.96	1899.4	189.0	48.56	1.11	120.2	2019.7	126.6	126.6	1893.1	453.73	285.19	6.31	162.34	3.00	3.00	1171.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	453.73	1893.1	231.1	48.56	1.11	156.6	2049.7	126.2	126.2	1923.6	454.85	285.18	6.26	162.84	3.00	3.00	1168.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.85	1923.6	210.9	48.56	1.22	153.0	2076.6	149.0	149.0	1927.6	455.00	285.16	6.20	163.56	3.23	3.23	1163.1	1728.0	61.47	61.47	232.85	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	330.9	48.56	1.11	242.8	2170.5	242.8	242.8	1927.6	455.00	285.16	6.20	163.64	5.80	5.80	1162.5	1728.0	100.27	100.27	417.77	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	328.6	48.56	1.11	240.8	2168.4	240.8	240.8	1927.6	455.00	285.16	6.20	163.64	5.75	5.75	1162.5	1728.0	99.42	99.42	414.27	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	462.2	48.56	1.11	356.3	2283.9	356.3	356.3	1927.6	455.00	285.16	6.20	163.64	8.51	8.51	1162.5	1728.0	147.11	147.11	612.97	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	819.0	48.56	1.08	664.6	2592.2	737.0	737.0	1855.1	452.33	285.20	6.32	162.14	17.45	17.45	1173.3	1728.0	301.52	301.52	1256.32	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	828.1	48.56	1.06	672.5	2527.6	744.3	744.3	1783.3	449.67	285.28	6.58	159.14	17.29	17.29	1195.4	1728.0	298.84	298.84	1245.19	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1566.9	48.56	1.14	1441.9	3225.3	1168.2	1168.2	1713.9	447.00	286.62	6.95	154.77	24.00	24.00	1229.2	1728.0	456.19	433.38	1728.00	507.52	361.02	343.11	447.0	1713.91
																159.49		**3.00**			**8133.66**	**7961.55**				**2133.33**		

Min. Res. Level 453.7 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 1999-00

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1514.6	48.56	1.04	1265.6	2979.5	1069.1	1069.1	1713.9	447.00	286.21	7.04	153.75	24.00	24.00	1237.4	1728.0	414.72	393.98	1728.00	317.64	227.45	196.52	447.0	1713.91
	II	10	447.00	1713.9	1569.4	48.56	1.04	1313.0	3026.9	1070.4	1070.4	1713.9	447.00	286.39	7.05	153.56	24.00	24.00	1238.9	1728.0	414.72	393.98	1728.00	391.52	280.71	242.53	447.0	1713.91
	III	10	447.00	1713.9	2674.6	48.56	1.04	2267.9	3981.8	1093.7	1093.7	1713.9	447.00	289.39	7.33	150.28	24.00	24.00	1265.9	1728.0	414.72	393.98	1728.00	1855.03	1358.96	1174.14	447.0	1713.91
Jul	I	10	447.00	1713.9	2290.6	48.56	1.04	1936.1	3650.0	1086.3	1086.3	1713.9	447.00	288.45	7.24	151.31	24.00	24.00	1257.3	1728.0	414.72	393.98	1728.00	1351.70	983.51	849.76	447.0	1713.91
	II	10	447.00	1713.9	2052.6	48.56	1.04	1730.4	3444.4	1081.4	1081.4	1713.9	447.00	287.82	7.18	152.00	24.00	24.00	1251.6	1728.0	414.72	393.98	1728.00	1037.11	751.20	649.04	447.0	1713.91
	III	11	447.00	1713.9	1862.8	48.56	1.14	1723.1	3437.0	1185.0	1185.0	1713.9	447.00	287.29	7.13	152.58	24.00	24.00	1246.8	1728.0	456.19	433.38	1728.00	784.70	566.20	538.12	447.0	1713.91
Aug	I	10	447.00	1713.9	1173.1	48.56	1.04	970.6	2684.5	970.6	970.6	1713.9	447.00	285.41	6.96	154.63	21.91	21.91	1230.3	1728.0	378.67	378.67	1577.77	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	2237.4	48.56	1.04	1890.1	3604.0	1085.2	1085.2	1713.9	447.00	288.31	7.23	151.46	24.00	24.00	1256.1	1728.0	414.72	393.98	1728.00	1281.57	931.57	804.87	447.0	1713.91
	III	11	447.00	1713.9	2256.2	48.56	1.14	2097.0	3810.9	1194.2	1194.2	1713.9	447.00	288.36	7.23	151.41	24.00	24.00	1256.5	1728.0	456.19	433.38	1728.00	1306.34	949.91	902.79	447.0	1713.91
Sep	I	10	447.00	1713.9	2251.1	48.56	1.04	1902.0	3615.9	1085.5	1085.5	1713.9	447.00	288.35	7.23	151.42	24.00	24.00	1256.4	1728.0	414.72	393.98	1728.00	1299.68	944.97	816.46	447.0	1713.91
	II	10	447.00	1713.9	1839.0	48.56	1.04	1545.9	3259.8	1076.7	1076.7	1713.9	447.00	287.22	7.13	152.66	24.00	24.00	1246.2	1728.0	414.72	393.98	1728.00	752.91	542.99	469.15	447.0	1713.91
	III	10	447.00	1713.9	1171.1	48.56	1.04	968.9	2682.8	968.9	968.9	1713.9	447.00	285.41	6.96	154.63	21.88	21.88	1230.3	1728.0	378.00	378.00	1575.01	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	1538.9	48.56	0.78	1286.9	3000.8	1069.7	1069.7	1713.9	447.00	286.29	7.04	153.66	24.00	24.00	1238.1	1728.0	414.72	393.98	1728.00	350.84	251.37	217.18	447.0	1713.91
	II	10	447.00	1713.9	1646.2	48.56	0.83	1379.5	3093.4	1036.8	1036.8	1927.6	455.00	285.83	6.63	158.54	24.00	24.00	1199.9	1728.0	414.72	393.98	1728.00	215.12	149.38	129.06	455.0	1927.62
	III	11	455.00	1927.6	1170.9	48.56	0.92	1065.8	2993.4	1065.8	1065.8	1927.6	455.00	285.16	6.20	163.64	23.15	23.15	1162.5	1728.0	440.04	433.38	1666.81	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	672.1	48.56	0.83	537.9	2465.6	537.9	537.9	1927.6	455.00	285.16	6.20	163.64	12.85	12.85	1162.5	1728.0	222.11	222.11	925.44	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	540.6	48.56	0.83	424.3	2351.9	424.3	424.3	1927.6	455.00	285.16	6.20	163.64	10.14	10.14	1162.5	1728.0	175.19	175.19	729.98	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	453.5	48.56	0.83	349.1	2276.7	349.1	349.1	1927.6	455.00	285.16	6.20	163.64	8.34	8.34	1162.5	1728.0	144.12	144.12	600.50	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	359.3	48.56	0.28	268.2	2195.9	268.2	268.2	1927.6	455.00	285.16	6.20	163.64	6.41	6.41	1162.5	1728.0	110.75	110.75	461.46	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	309.2	48.56	0.28	224.9	2152.5	224.9	224.9	1927.6	455.00	285.16	6.20	163.64	5.37	5.37	1162.5	1728.0	92.86	92.86	386.91	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	270.3	48.56	0.31	210.4	2138.1	210.4	210.4	1927.6	455.00	285.16	6.20	163.64	4.57	4.57	1162.5	1728.0	86.89	86.89	329.12	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	225.9	48.56	0.28	153.0	2080.6	153.0	153.0	1927.6	455.00	285.16	6.20	163.64	3.65	3.65	1162.5	1728.0	63.16	63.16	263.15	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	212.2	48.56	0.28	141.1	2068.7	141.1	141.1	1927.6	455.00	285.16	6.20	163.64	3.37	3.37	1162.5	1728.0	58.27	58.27	242.79	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	207.8	48.56	0.31	151.0	2078.6	151.0	151.0	1927.6	455.00	285.16	6.20	163.64	3.28	3.28	1162.5	1728.0	62.36	62.36	236.20	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	219.3	48.56	0.55	147.0	2074.6	147.0	147.0	1927.6	455.00	285.16	6.20	163.64	3.51	3.51	1162.5	1728.0	60.68	60.68	252.83	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	230.0	48.56	0.55	156.2	2083.8	156.2	156.2	1927.6	455.00	285.16	6.20	163.64	3.73	3.73	1162.5	1728.0	64.49	64.49	268.69	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	253.7	48.56	0.44	141.4	2069.0	141.4	141.4	1927.6	455.00	285.16	6.20	163.64	4.22	4.22	1162.5	1728.0	58.36	58.36	303.98	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	275.1	48.56	1.11	194.6	2122.2	194.6	194.6	1927.6	455.00	285.16	6.20	163.64	4.65	4.65	1162.5	1728.0	80.36	80.36	334.82	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	328.9	48.56	1.11	241.1	2168.7	241.1	241.1	1927.6	455.00	285.16	6.20	163.64	5.76	5.76	1162.5	1728.0	99.53	99.53	414.73	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	396.3	48.56	1.22	329.3	2256.9	329.3	329.3	1927.6	455.00	285.16	6.20	163.64	7.15	7.15	1162.5	1728.0	135.95	135.95	514.97	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	465.2	48.56	1.11	358.9	2286.5	358.9	358.9	1927.6	455.00	285.16	6.20	163.64	8.57	8.57	1162.5	1728.0	148.18	148.18	617.40	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	533.6	48.56	1.11	417.9	2345.5	417.9	417.9	1927.6	455.00	285.16	6.20	163.64	9.99	9.99	1162.5	1728.0	172.55	172.55	718.98	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	700.1	48.56	1.11	561.8	2489.4	561.8	561.8	1927.6	455.00	285.16	6.20	163.64	13.42	13.42	1162.5	1728.0	231.97	231.97	966.55	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	692.6	48.56	1.08	555.4	2483.0	627.8	627.8	1855.1	452.33	285.20	6.32	162.14	14.86	14.86	1173.3	1728.0	256.84	256.84	1070.18	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	855.8	48.56	1.06	696.4	2551.5	768.2	768.2	1783.3	449.67	285.28	6.58	159.14	17.85	17.85	1195.4	1728.0	308.45	308.45	1285.23	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1036.0	48.56	1.14	937.3	2720.6	1006.7	1006.7	1713.9	447.00	285.37	6.83	156.14	20.86	20.86	1218.4	1728.0	396.59	396.59	1502.23	0.00	0.00	0.00	447.0	1713.91
																159.13		**3.28**			**9285.95**	**9026.31**				**6989.62**		

Min. Res. Level 455.0 m Average Power 1728.0 MW Continuous Power 236.20 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2000-01

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	856.1	48.56	1.04	696.7	2410.6	696.7	696.7	1713.9	447.00	285.41	6.96	154.63	15.73	15.73	1230.3	1728.0	271.81	271.81	1132.53	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1106.8	48.56	1.04	913.3	2627.2	913.3	913.3	1713.9	447.00	285.41	6.96	154.63	20.62	20.62	1230.3	1728.0	356.32	356.32	1484.67	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1387.8	48.56	1.04	1156.0	2870.0	1065.9	1065.9	1713.9	447.00	285.79	7.00	154.22	24.00	24.00	1233.6	1728.0	414.72	393.98	1728.00	146.22	104.39	90.19	447.0	1713.91
Jul	I	10	447.00	1713.9	1624.6	48.56	1.04	1360.7	3074.6	1071.8	1071.8	1713.9	447.00	286.57	7.07	153.36	24.00	24.00	1240.5	1728.0	414.72	393.98	1728.00	465.80	334.38	288.91	447.0	1713.91
	II	10	447.00	1713.9	1848.1	48.56	1.04	1553.8	3267.7	1076.9	1076.9	1713.9	447.00	287.24	7.13	152.63	24.00	24.00	1246.5	1728.0	414.72	393.98	1728.00	765.13	551.91	476.85	447.0	1713.91
	III	11	447.00	1713.9	1176.9	48.56	1.14	1071.2	2785.1	1071.2	1071.2	1713.9	447.00	285.41	6.96	154.63	21.99	21.99	1230.3	1728.0	417.92	417.92	1583.03	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	1442.9	48.56	1.04	1203.7	2917.6	1067.3	1067.3	1713.9	447.00	285.98	7.01	154.01	24.00	24.00	1235.3	1728.0	414.72	393.98	1728.00	220.88	157.90	136.43	447.0	1713.91
	II	10	447.00	1713.9	1512.5	48.56	1.04	1263.8	2977.7	1069.0	1069.0	1713.9	447.00	286.21	7.04	153.76	24.00	24.00	1237.3	1728.0	414.72	393.98	1728.00	314.81	225.41	194.76	447.0	1713.91
	III	11	447.00	1713.9	1576.8	48.56	1.14	1451.3	3165.2	1177.7	1177.7	1713.9	447.00	286.42	7.05	153.53	24.00	24.00	1239.1	1728.0	456.19	433.38	1728.00	401.43	287.86	273.58	447.0	1713.91
Sep	I	10	447.00	1713.9	1754.3	48.56	1.04	1472.7	3186.6	1074.8	1074.8	1713.9	447.00	286.97	7.11	152.93	24.00	24.00	1244.0	1728.0	414.72	393.98	1728.00	639.69	460.51	397.88	447.0	1713.91
	II	10	447.00	1713.9	1758.8	48.56	1.04	1476.6	3190.5	1074.9	1074.9	1713.9	447.00	286.98	7.11	152.91	24.00	24.00	1244.1	1728.0	414.72	393.98	1728.00	645.74	464.91	401.69	447.0	1713.91
	III	10	447.00	1713.9	1375.4	48.56	1.04	1145.4	2859.3	1065.5	1065.5	1713.9	447.00	285.75	6.99	154.26	24.00	24.00	1233.3	1728.0	414.72	393.98	1728.00	129.47	92.40	79.83	447.0	1713.91
Oct	I	10	447.00	1713.9	638.7	48.56	0.78	509.1	2223.0	509.1	509.1	1713.9	447.00	285.41	6.96	154.63	11.49	11.49	1230.3	1728.0	198.62	198.62	827.60	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	584.6	48.56	0.83	462.3	2176.2	248.6	248.6	1927.6	455.00	285.28	6.58	159.14	5.78	5.78	1195.4	1728.0	99.81	99.81	415.86	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	414.2	48.56	0.92	346.6	2274.2	346.6	346.6	1927.6	455.00	285.16	6.20	163.64	7.53	7.53	1162.5	1728.0	143.09	143.09	542.01	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	342.9	48.56	0.83	253.5	2181.1	253.5	253.5	1927.6	455.00	285.16	6.20	163.64	6.06	6.06	1162.5	1728.0	104.67	104.67	436.12	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	342.7	48.56	0.83	253.3	2180.9	253.3	253.3	1927.6	455.00	285.16	6.20	163.64	6.05	6.05	1162.5	1728.0	104.59	104.59	435.79	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	279.3	48.56	0.83	198.6	2126.2	198.6	198.6	1927.6	455.00	285.16	6.20	163.64	4.74	4.74	1162.5	1728.0	81.98	81.98	341.58	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	275.7	48.56	0.28	196.0	2123.6	196.0	196.0	1927.6	455.00	285.16	6.20	163.64	4.68	4.68	1162.5	1728.0	80.92	80.92	337.17	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	221.8	48.56	0.28	149.4	2077.0	149.4	149.4	1927.6	455.00	285.16	6.20	163.64	3.57	3.57	1162.5	1728.0	61.68	61.68	257.00	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	182.5	48.56	0.31	127.0	2054.6	138.3	138.3	1916.3	454.58	285.17	6.22	163.41	3.00	3.00	1164.2	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.58	1916.3	170.2	48.56	0.28	104.8	2021.2	126.3	126.3	1894.9	453.79	285.18	6.27	162.73	3.00	3.00	1169.1	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	453.79	1894.9	159.8	48.56	0.28	95.8	1990.7	127.1	127.1	1863.6	452.64	285.21	6.37	161.64	3.00	3.00	1177.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	452.64	1863.6	154.3	48.56	0.31	100.2	1963.8	141.1	141.1	1822.6	451.13	285.25	6.49	160.14	3.00	3.00	1188.0	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	451.13	1822.6	159.8	48.56	0.55	95.6	1918.2	129.6	129.6	1788.7	449.87	285.30	6.63	158.58	3.00	3.00	1199.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	449.87	1788.7	155.0	48.56	0.55	91.4	1880.1	130.9	130.9	1749.2	448.36	285.34	6.76	157.02	3.00	3.00	1211.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	448.36	1749.2	193.6	48.56	0.44	99.8	1849.0	105.3	105.3	1743.7	448.15	285.37	6.84	156.04	3.00	3.00	1219.2	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	448.15	1743.7	203.5	48.56	1.11	132.7	1876.4	131.8	131.8	1744.7	448.18	285.37	6.85	155.94	3.00	3.00	1219.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	448.18	1744.7	219.5	48.56	1.11	146.5	1891.2	131.5	131.5	1759.8	448.76	285.36	6.82	156.29	3.00	3.00	1217.2	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	448.76	1759.8	347.6	48.56	1.22	283.0	2042.8	141.6	141.6	1901.2	454.02	285.27	6.54	159.59	3.00	3.00	1192.1	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	454.02	1901.2	503.1	48.56	1.11	391.6	2292.8	365.1	365.1	1927.6	455.00	285.17	6.24	163.10	8.70	8.70	1166.5	1728.0	150.25	150.25	626.05	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	778.9	48.56	1.11	629.9	2557.5	629.9	629.9	1927.6	455.00	285.16	6.20	163.64	15.05	15.05	1162.5	1728.0	260.07	260.07	1083.61	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	657.3	48.56	1.11	524.8	2452.4	524.8	524.8	1927.6	455.00	285.16	6.20	163.64	12.54	12.54	1162.5	1728.0	216.68	216.68	902.84	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	519.8	48.56	1.08	406.0	2333.7	478.5	478.5	1855.1	452.33	285.20	6.32	162.14	11.33	11.33	1173.3	1728.0	195.75	195.75	815.64	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	545.9	48.56	1.06	428.6	2283.8	500.5	500.5	1783.3	449.67	285.28	6.58	159.14	11.63	11.63	1195.4	1728.0	200.94	200.94	837.27	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	810.3	48.56	1.14	722.8	2506.2	792.3	792.3	1713.9	447.00	285.37	6.83	156.14	16.42	16.42	1218.4	1728.0	312.10	312.10	1182.21	0.00	0.00	0.00	447.0	1713.91
																158.34		**3.00**			**7554.75**	**7366.05**				**2340.12**		

Min. Res. Level 448.1 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2001-02

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1095.7	48.56	1.04	903.7	2617.6	903.7	903.7	1713.9	447.00	285.41	6.96	154.63	20.40	20.40	1230.3	1728.0	352.57	352.57	1469.02	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	837.5	48.56	1.04	680.6	2394.5	680.6	680.6	1713.9	447.00	285.41	6.96	154.63	15.37	15.37	1230.3	1728.0	265.53	265.53	1106.37	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1219.8	48.56	1.04	1010.9	2724.8	1010.9	1010.9	1713.9	447.00	285.41	6.96	154.63	22.82	22.82	1230.3	1728.0	394.40	393.98	1643.34	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	629.8	48.56	1.04	501.1	2215.0	501.1	501.1	1713.9	447.00	285.41	6.96	154.63	11.31	11.31	1230.3	1728.0	195.51	195.51	814.64	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1390.8	48.56	1.04	1158.6	2872.5	1065.9	1065.9	1713.9	447.00	285.80	7.00	154.20	24.00	24.00	1233.7	1728.0	414.72	393.98	1728.00	150.27	107.29	92.69	447.0	1713.91
	III	11	447.00	1713.9	1139.1	48.56	1.14	1035.3	2749.2	1035.3	1035.3	1713.9	447.00	285.41	6.96	154.63	21.25	21.25	1230.3	1728.0	403.91	403.91	1529.98	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	990.8	48.56	1.04	813.1	2527.0	813.1	813.1	1713.9	447.00	285.41	6.96	154.63	18.36	18.36	1230.3	1728.0	317.21	317.21	1321.72	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1036.8	48.56	1.04	852.8	2566.7	852.8	852.8	1713.9	447.00	285.41	6.96	154.63	19.25	19.25	1230.3	1728.0	332.71	332.71	1386.30	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1856.3	48.56	1.14	1716.9	3430.8	1184.8	1184.8	1713.9	447.00	287.27	7.13	152.60	24.00	24.00	1246.7	1728.0	456.19	433.38	1728.00	775.95	559.81	532.05	447.0	1713.91
Sep	I	10	447.00	1713.9	1333.1	48.56	1.04	1108.8	2822.7	1064.4	1064.4	1713.9	447.00	285.60	6.98	154.42	24.00	24.00	1232.0	1728.0	414.72	393.98	1728.00	72.04	51.36	44.38	447.0	1713.91
	II	10	447.00	1713.9	1096.3	48.56	1.04	904.2	2618.1	904.2	904.2	1713.9	447.00	285.41	6.96	154.63	20.41	20.41	1230.3	1728.0	352.77	352.77	1469.88	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	880.2	48.56	1.04	717.5	2431.4	717.5	717.5	1713.9	447.00	285.41	6.96	154.63	16.20	16.20	1230.3	1728.0	279.91	279.91	1166.30	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	1049.0	48.56	0.78	863.6	2577.5	863.6	863.6	1713.9	447.00	285.41	6.96	154.63	19.50	19.50	1230.3	1728.0	336.94	336.94	1403.92	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	756.5	48.56	0.83	610.8	2324.7	397.1	397.1	1927.6	455.00	285.28	6.58	159.14	9.23	9.23	1195.4	1728.0	159.45	159.45	664.37	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	384.3	48.56	0.92	318.2	2245.8	318.2	318.2	1927.6	455.00	285.16	6.20	163.64	6.91	6.91	1162.5	1728.0	131.37	131.37	497.60	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	552.8	48.56	0.83	434.9	2362.5	434.9	434.9	1927.6	455.00	285.16	6.20	163.64	10.39	10.39	1162.5	1728.0	179.55	179.55	748.13	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	363.4	48.56	0.83	271.2	2198.8	271.2	271.2	1927.6	455.00	285.16	6.20	163.64	6.48	6.48	1162.5	1728.0	111.96	111.96	466.49	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	350.7	48.56	0.83	260.2	2187.8	260.2	260.2	1927.6	455.00	285.16	6.20	163.64	6.22	6.22	1162.5	1728.0	107.43	107.43	447.64	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	286.1	48.56	0.28	205.0	2132.6	205.0	205.0	1927.6	455.00	285.16	6.20	163.64	4.90	4.90	1162.5	1728.0	84.63	84.63	352.63	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	260.7	48.56	0.28	183.0	2110.6	183.0	183.0	1927.6	455.00	285.16	6.20	163.64	4.37	4.37	1162.5	1728.0	75.55	75.55	314.79	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	213.2	48.56	0.31	156.2	2083.8	156.2	156.2	1927.6	455.00	285.16	6.20	163.64	3.39	3.39	1162.5	1728.0	64.48	64.48	244.24	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	192.5	48.56	0.28	124.1	2051.7	125.6	125.6	1926.1	454.95	285.16	6.20	163.61	3.00	3.00	1162.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.95	1926.1	179.6	48.56	0.28	112.9	2039.0	125.8	125.8	1913.2	454.47	285.17	6.22	163.32	3.00	3.00	1164.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.47	1913.2	221.8	48.56	0.31	164.4	2077.6	150.0	150.0	1927.6	455.00	285.17	6.22	163.35	3.25	3.25	1164.7	1728.0	61.81	61.81	234.13	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	164.4	48.56	0.55	99.6	2027.2	126.0	126.0	1901.2	454.03	285.17	6.24	163.10	3.00	3.00	1166.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.03	1901.2	171.6	48.56	0.55	105.8	2007.0	126.7	126.7	1880.2	453.25	285.20	6.33	162.11	3.00	3.00	1173.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	453.25	1880.2	181.0	48.56	0.44	91.1	1971.3	101.8	101.8	1869.5	452.86	285.22	6.38	161.46	3.00	3.00	1178.3	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	452.86	1869.5	212.3	48.56	1.11	140.4	2009.9	127.2	127.2	1882.7	453.34	285.22	6.38	161.51	3.00	3.00	1177.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	453.34	1882.7	267.2	48.56	1.11	187.8	2070.4	142.8	142.8	1927.6	455.00	285.18	6.28	162.71	3.39	3.39	1169.2	1728.0	58.63	58.63	244.28	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	450.8	48.56	1.22	381.0	2308.6	381.0	381.0	1927.6	455.00	285.16	6.20	163.64	8.28	8.28	1162.5	1728.0	157.32	157.32	595.90	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	514.1	48.56	1.11	401.1	2328.7	401.1	401.1	1927.6	455.00	285.16	6.20	163.64	9.58	9.58	1162.5	1728.0	165.61	165.61	690.04	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	798.6	48.56	1.11	646.9	2574.5	646.9	646.9	1927.6	455.00	285.16	6.20	163.64	15.46	15.46	1162.5	1728.0	267.10	267.10	1112.93	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	756.1	48.56	1.11	610.2	2537.8	610.2	610.2	1927.6	455.00	285.16	6.20	163.64	14.58	14.58	1162.5	1728.0	251.93	251.93	1049.70	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	637.4	48.56	1.08	507.6	2435.3	580.1	580.1	1855.1	452.33	285.20	6.32	162.14	13.73	13.73	1173.3	1728.0	237.32	237.32	988.82	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	667.7	48.56	1.06	533.9	2389.0	605.7	605.7	1783.3	449.67	285.28	6.58	159.14	14.07	14.07	1195.4	1728.0	243.20	243.20	1013.35	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	820.0	48.56	1.14	732.0	2515.3	801.4	801.4	1713.9	447.00	285.37	6.83	156.14	16.61	16.61	1218.4	1728.0	315.71	315.71	1195.87	0.00	0.00	0.00	447.0	1713.91
																159.59		**3.00**			**7490.82**	**7426.12**				**669.12**		

Min. Res. Level 452.9 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2002-03

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	761.9	48.56	1.04	615.3	2329.2	615.3	615.3	1713.9	447.00	285.41	6.96	154.63	13.89	13.89	1230.3	1728.0	240.06	240.06	1000.26	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1098.3	48.56	1.04	905.9	2619.8	905.9	905.9	1713.9	447.00	285.41	6.96	154.63	20.45	20.45	1230.3	1728.0	353.43	353.43	1472.65	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1427.0	48.56	1.04	1189.9	2903.9	1066.9	1066.9	1713.9	447.00	285.92	7.01	154.07	24.00	24.00	1234.8	1728.0	414.72	393.98	1728.00	199.35	142.45	123.08	447.0	1713.91
Jul	I	10	447.00	1713.9	2296.6	48.56	1.04	1941.2	3655.1	1086.4	1086.4	1713.9	447.00	288.46	7.24	151.29	24.00	24.00	1257.5	1728.0	414.72	393.98	1728.00	1359.55	989.34	854.79	447.0	1713.91
	II	10	447.00	1713.9	1543.3	48.56	1.04	1290.4	3004.3	1069.8	1069.8	1713.9	447.00	286.31	7.04	153.65	24.00	24.00	1238.2	1728.0	414.72	393.98	1728.00	356.34	255.33	220.60	447.0	1713.91
	III	11	447.00	1713.9	2577.3	48.56	1.14	2402.1	4116.0	1201.1	1201.1	1713.9	447.00	289.16	7.31	150.54	24.00	24.00	1263.8	1728.0	456.19	433.38	1728.00	1727.91	1263.72	1201.04	447.0	1713.91
Aug	I	10	447.00	1713.9	1506.5	48.56	1.04	1258.6	2972.5	1068.9	1068.9	1713.9	447.00	286.19	7.03	153.78	24.00	24.00	1237.1	1728.0	414.72	393.98	1728.00	306.75	219.61	189.75	447.0	1713.91
	II	10	447.00	1713.9	2257.5	48.56	1.04	1907.5	3621.4	1085.7	1085.7	1713.9	447.00	288.36	7.23	151.40	24.00	24.00	1256.5	1728.0	414.72	393.98	1728.00	1308.07	951.19	821.82	447.0	1713.91
	III	11	447.00	1713.9	1064.7	48.56	1.14	964.6	2678.5	964.6	964.6	1713.9	447.00	285.41	6.96	154.63	19.80	19.80	1230.3	1728.0	376.33	376.33	1425.50	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	676.0	48.56	1.04	541.1	2255.0	541.1	541.1	1713.9	447.00	285.41	6.96	154.63	12.22	12.22	1230.3	1728.0	211.10	211.10	879.60	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	712.0	48.56	1.04	572.2	2286.1	572.2	572.2	1713.9	447.00	285.41	6.96	154.63	12.92	12.92	1230.3	1728.0	223.23	223.23	930.12	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1157.8	48.56	1.04	957.3	2671.2	957.3	957.3	1713.9	447.00	285.41	6.96	154.63	21.61	21.61	1230.3	1728.0	373.50	373.50	1556.24	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	897.5	48.56	0.78	732.7	2446.6	732.7	732.7	1713.9	447.00	285.41	6.96	154.63	16.54	16.54	1230.3	1728.0	285.86	285.86	1191.08	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	503.9	48.56	0.83	392.5	2106.5	178.8	178.8	1927.6	455.00	285.28	6.58	159.14	4.16	4.16	1195.4	1728.0	71.81	71.81	299.20	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	460.8	48.56	0.92	390.9	2318.5	390.9	390.9	1927.6	455.00	285.16	6.20	163.64	8.49	8.49	1162.5	1728.0	161.40	161.40	611.36	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	342.4	48.56	0.83	253.0	2180.7	253.0	253.0	1927.6	455.00	285.16	6.20	163.64	6.05	6.05	1162.5	1728.0	104.48	104.48	435.33	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	339.7	48.56	0.83	250.7	2178.3	250.7	250.7	1927.6	455.00	285.16	6.20	163.64	5.99	5.99	1162.5	1728.0	103.50	103.50	431.24	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	290.4	48.56	0.83	208.1	2135.7	208.1	208.1	1927.6	455.00	285.16	6.20	163.64	4.97	4.97	1162.5	1728.0	85.92	85.92	358.01	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	254.2	48.56	0.28	177.4	2105.0	177.4	177.4	1927.6	455.00	285.16	6.20	163.64	4.24	4.24	1162.5	1728.0	73.25	73.25	305.20	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	233.2	48.56	0.28	159.3	2086.9	159.3	159.3	1927.6	455.00	285.16	6.20	163.64	3.81	3.81	1162.5	1728.0	65.76	65.76	273.99	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	216.7	48.56	0.31	159.5	2087.1	159.5	159.5	1927.6	455.00	285.16	6.20	163.64	3.46	3.46	1162.5	1728.0	65.85	65.85	249.42	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	195.8	48.56	0.28	126.9	2054.6	126.9	126.9	1927.6	455.00	285.16	6.20	163.64	3.03	3.03	1162.5	1728.0	52.41	52.41	218.38	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	188.0	48.56	0.28	120.2	2047.8	125.6	125.6	1922.1	454.80	285.16	6.21	163.53	3.00	3.00	1163.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.80	1922.1	173.3	48.56	0.31	118.2	2040.4	138.7	138.7	1901.7	454.04	285.18	6.25	162.99	3.00	3.00	1167.2	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	454.04	1901.7	201.6	48.56	0.55	131.6	2033.3	126.3	126.3	1907.0	454.24	285.18	6.28	162.68	3.00	3.00	1169.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.24	1907.0	269.0	48.56	0.55	189.9	2096.9	169.3	169.3	1927.6	455.00	285.17	6.23	163.22	4.03	4.03	1165.6	1728.0	69.71	69.71	290.46	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	214.1	48.56	0.44	114.0	2041.6	114.0	114.0	1927.6	455.00	285.16	6.20	163.64	3.40	3.40	1162.5	1728.0	47.06	47.06	245.12	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	233.9	48.56	1.11	159.1	2086.7	159.1	159.1	1927.6	455.00	285.16	6.20	163.64	3.80	3.80	1162.5	1728.0	65.67	65.67	273.64	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	405.4	48.56	1.11	307.2	2234.8	307.2	307.2	1927.6	455.00	285.16	6.20	163.64	7.34	7.34	1162.5	1728.0	126.82	126.82	528.42	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	389.6	48.56	1.22	322.9	2250.5	322.9	322.9	1927.6	455.00	285.16	6.20	163.64	7.01	7.01	1162.5	1728.0	133.32	133.32	505.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	595.7	48.56	1.11	471.7	2399.3	471.7	471.7	1927.6	455.00	285.16	6.20	163.64	11.27	11.27	1162.5	1728.0	194.74	194.74	811.42	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	553.1	48.56	1.11	434.8	2362.5	434.8	434.8	1927.6	455.00	285.16	6.20	163.64	10.39	10.39	1162.5	1728.0	179.54	179.54	748.10	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	848.5	48.56	1.11	690.0	2617.7	690.0	690.0	1927.6	455.00	285.16	6.20	163.64	16.49	16.49	1162.5	1728.0	284.91	284.91	1187.13	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	1059.6	48.56	1.08	872.4	2800.1	944.9	944.9	1855.1	452.33	285.20	6.32	162.14	22.37	22.37	1173.3	1728.0	386.56	386.56	1610.67	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	959.3	48.56	1.06	785.8	2641.0	857.6	857.6	1783.3	449.67	285.28	6.58	159.14	19.93	19.93	1195.4	1728.0	344.36	344.36	1434.82	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1011.9	48.56	1.14	914.4	2697.7	983.8	983.8	1713.9	447.00	285.37	6.83	156.14	20.39	20.39	1218.4	1728.0	387.56	387.56	1468.04	0.00	0.00	0.00	447.0	1713.91
																159.47		**3.00**			**7758.65**	**7632.16**				**3411.08**		

Min. Res. Level 454.0 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2003-04

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	877.2	48.56	1.04	714.9	2428.8	714.9	714.9	1713.9	447.00	285.41	6.96	154.63	16.14	16.14	1230.3	1728.0	278.91	278.91	1162.12	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1313.0	48.56	1.04	1091.5	2805.4	1063.9	1063.9	1713.9	447.00	285.53	6.97	154.50	24.00	24.00	1231.3	1728.0	414.72	393.98	1728.00	44.80	31.92	27.58	447.0	1713.91
	III	10	447.00	1713.9	2305.6	48.56	1.04	1949.0	3662.9	1086.6	1086.6	1713.9	447.00	288.49	7.25	151.27	24.00	24.00	1257.7	1728.0	414.72	393.98	1728.00	1371.44	998.16	862.41	447.0	1713.91
Jul	I	10	447.00	1713.9	1925.6	48.56	1.04	1620.7	3334.6	1078.7	1078.7	1713.9	447.00	287.46	7.15	152.38	24.00	24.00	1248.5	1728.0	414.72	393.98	1728.00	868.32	627.35	542.03	447.0	1713.91
	II	10	447.00	1713.9	1764.8	48.56	1.04	1481.8	3195.7	1075.1	1075.1	1713.9	447.00	287.00	7.11	152.89	24.00	24.00	1244.3	1728.0	414.72	393.98	1728.00	653.80	470.78	406.76	447.0	1713.91
	III	11	447.00	1713.9	1247.5	48.56	1.14	1138.3	2852.3	1138.3	1138.3	1713.9	447.00	285.41	6.96	154.63	23.36	23.36	1230.3	1728.0	444.12	433.38	1682.27	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	1090.5	48.56	1.04	899.2	2613.1	899.2	899.2	1713.9	447.00	285.41	6.96	154.63	20.30	20.30	1230.3	1728.0	350.83	350.83	1461.80	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1919.1	48.56	1.04	1615.1	3329.1	1078.5	1078.5	1713.9	447.00	287.45	7.15	152.40	24.00	24.00	1248.3	1728.0	414.72	393.98	1728.00	859.77	621.09	536.62	447.0	1713.91
	III	11	447.00	1713.9	1566.8	48.56	1.14	1441.8	3155.7	1177.4	1177.4	1713.9	447.00	286.38	7.05	153.56	24.00	24.00	1238.9	1728.0	456.19	433.38	1728.00	388.02	278.18	264.38	447.0	1713.91
Sep	I	10	447.00	1713.9	2127.5	48.56	1.04	1795.2	3509.1	1083.0	1083.0	1713.9	447.00	288.02	7.20	151.78	24.00	24.00	1253.5	1728.0	414.72	393.98	1728.00	1136.34	824.28	712.18	447.0	1713.91
	II	10	447.00	1713.9	1883.0	48.56	1.04	1583.9	3297.8	1077.7	1077.7	1713.9	447.00	287.34	7.14	152.52	24.00	24.00	1247.4	1728.0	414.72	393.98	1728.00	811.64	585.88	506.20	447.0	1713.91
	III	10	447.00	1713.9	1348.4	48.56	1.04	1122.0	2835.9	1064.8	1064.8	1713.9	447.00	285.65	6.98	154.37	24.00	24.00	1232.4	1728.0	414.72	393.98	1728.00	92.77	66.16	57.17	447.0	1713.91
Oct	I	10	447.00	1713.9	1747.0	48.56	0.78	1466.7	3180.6	1074.7	1074.7	1713.9	447.00	286.94	7.10	152.95	24.00	24.00	1243.8	1728.0	414.72	393.98	1728.00	630.37	453.74	392.03	447.0	1713.91
	II	10	447.00	1713.9	890.7	48.56	0.83	726.8	2440.7	513.1	513.1	1927.6	455.00	285.28	6.58	159.14	11.92	11.92	1195.4	1728.0	206.02	206.02	858.40	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	802.3	48.56	0.92	715.5	2643.1	715.5	715.5	1927.6	455.00	285.16	6.20	163.64	15.54	15.54	1162.5	1728.0	295.41	295.41	1118.97	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	641.6	48.56	0.83	511.6	2439.2	511.6	511.6	1927.6	455.00	285.16	6.20	163.64	12.22	12.22	1162.5	1728.0	211.23	211.23	880.10	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	492.1	48.56	0.83	382.4	2310.0	382.4	382.4	1927.6	455.00	285.16	6.20	163.64	9.14	9.14	1162.5	1728.0	157.88	157.88	657.84	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	418.7	48.56	0.83	319.0	2246.6	319.0	319.0	1927.6	455.00	285.16	6.20	163.64	7.62	7.62	1162.5	1728.0	131.70	131.70	548.74	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	383.0	48.56	0.28	288.7	2216.3	288.7	288.7	1927.6	455.00	285.16	6.20	163.64	6.90	6.90	1162.5	1728.0	119.18	119.18	496.60	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	322.7	48.56	0.28	236.6	2164.2	236.6	236.6	1927.6	455.00	285.16	6.20	163.64	5.65	5.65	1162.5	1728.0	97.68	97.68	407.02	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	282.5	48.56	0.31	222.1	2149.7	222.1	222.1	1927.6	455.00	285.16	6.20	163.64	4.82	4.82	1162.5	1728.0	91.69	91.69	347.31	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	245.9	48.56	0.28	170.2	2097.8	170.2	170.2	1927.6	455.00	285.16	6.20	163.64	4.07	4.07	1162.5	1728.0	70.27	70.27	292.79	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	239.4	48.56	0.28	164.6	2092.2	164.6	164.6	1927.6	455.00	285.16	6.20	163.64	3.93	3.93	1162.5	1728.0	67.97	67.97	283.20	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	231.5	48.56	0.31	173.6	2101.2	173.6	173.6	1927.6	455.00	285.16	6.20	163.64	3.77	3.77	1162.5	1728.0	71.66	71.66	271.44	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	217.5	48.56	0.55	145.4	2073.0	145.4	145.4	1927.6	455.00	285.16	6.20	163.64	3.47	3.47	1162.5	1728.0	60.04	60.04	250.16	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	218.6	48.56	0.55	146.4	2074.0	146.4	146.4	1927.6	455.00	285.16	6.20	163.64	3.50	3.50	1162.5	1728.0	60.43	60.43	251.81	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	245.2	48.56	0.44	135.5	2063.1	135.5	135.5	1927.6	455.00	285.16	6.20	163.64	4.05	4.05	1162.5	1728.0	55.94	55.94	291.36	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	300.3	48.56	1.11	216.4	2144.0	216.4	216.4	1927.6	455.00	285.16	6.20	163.64	5.17	5.17	1162.5	1728.0	89.33	89.33	372.20	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	249.4	48.56	1.11	172.4	2100.1	172.4	172.4	1927.6	455.00	285.16	6.20	163.64	4.12	4.12	1162.5	1728.0	71.20	71.20	296.66	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	574.1	48.56	1.22	498.2	2425.9	498.2	498.2	1927.6	455.00	285.16	6.20	163.64	10.82	10.82	1162.5	1728.0	205.71	205.71	779.22	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	399.9	48.56	1.11	302.4	2230.1	302.4	302.4	1927.6	455.00	285.16	6.20	163.64	7.23	7.23	1162.5	1728.0	124.87	124.87	520.29	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	641.9	48.56	1.11	511.6	2439.2	511.6	511.6	1927.6	455.00	285.16	6.20	163.64	12.22	12.22	1162.5	1728.0	211.22	211.22	880.07	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	632.6	48.56	1.11	503.5	2431.1	503.5	503.5	1927.6	455.00	285.16	6.20	163.64	12.03	12.03	1162.5	1728.0	207.88	207.88	866.18	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	525.3	48.56	1.08	410.9	2338.5	483.3	483.3	1855.1	452.33	285.20	6.32	162.14	11.44	11.44	1173.3	1728.0	197.73	197.73	823.86	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	1204.8	48.56	1.06	997.9	2853.1	1034.0	1034.0	1783.3	449.67	285.44	6.59	158.97	24.00	24.00	1196.7	1728.0	414.72	393.98	1728.00	59.78	41.40	35.77	449.7	1783.33
	III	11	449.67	1783.3	1243.2	48.56	1.14	1134.3	2917.6	1159.4	1159.4	1713.9	447.00	285.54	6.85	155.95	24.00	24.00	1219.9	1728.0	456.19	433.38	1728.00	65.99	46.59	44.28	447.0	1713.91
																159.39		**3.47**			**8938.48**	**8674.77**				**4387.40**		

Min. Res. Level 455.0 m Average Power 1728.0 MW Continuous Power 250.16 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release **48.56** m^3/sec **Min. Peaking hrs** **3.00** Hours **Installed Capacity** **1728 MW**

Machine Availability **95.00%** **System efficiency** **92.59%** **Year** **2004-05**

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1152.6	48.56	1.04	952.8	2666.7	952.8	952.8	1713.9	447.00	285.41	6.96	154.63	21.51	21.51	1230.3	1728.0	371.74	371.74	1548.90	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1445.0	48.56	1.04	1205.5	2919.4	1067.3	1067.3	1713.9	447.00	285.98	7.01	154.00	24.00	24.00	1235.3	1728.0	414.72	393.98	1728.00	223.67	159.90	138.15	447.0	1713.91
	III	10	447.00	1713.9	2040.1	48.56	1.04	1719.6	3433.6	1081.1	1081.1	1713.9	447.00	287.78	7.18	152.03	24.00	24.00	1251.3	1728.0	414.72	393.98	1728.00	1020.53	739.01	638.50	447.0	1713.91
Jul	I	10	447.00	1713.9	2053.2	48.56	1.04	1731.0	3444.9	1081.4	1081.4	1713.9	447.00	287.82	7.18	152.00	24.00	24.00	1251.6	1728.0	414.72	393.98	1728.00	1037.92	751.80	649.55	447.0	1713.91
	II	10	447.00	1713.9	2164.9	48.56	1.04	1827.5	3541.4	1083.8	1083.8	1713.9	447.00	288.12	7.21	151.67	24.00	24.00	1254.4	1728.0	414.72	393.98	1728.00	1185.84	860.80	743.73	447.0	1713.91
	III	11	447.00	1713.9	1636.5	48.56	1.14	1508.0	3221.9	1179.3	1179.3	1713.9	447.00	286.60	7.07	153.32	24.00	24.00	1240.8	1728.0	456.19	433.38	1728.00	481.74	345.91	328.76	447.0	1713.91
Aug	I	10	447.00	1713.9	1535.8	48.56	1.04	1283.9	2997.9	1069.6	1069.6	1713.9	447.00	286.28	7.04	153.67	24.00	24.00	1238.0	1728.0	414.72	393.98	1728.00	346.28	248.08	214.34	447.0	1713.91
	II	10	447.00	1713.9	926.6	48.56	1.04	757.6	2471.5	757.6	757.6	1713.9	447.00	285.41	6.96	154.63	17.10	17.10	1230.3	1728.0	295.56	295.56	1231.49	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1214.9	48.56	1.14	1107.4	2821.3	1107.4	1107.4	1713.9	447.00	285.41	6.96	154.63	22.73	22.73	1230.3	1728.0	432.03	432.03	1636.47	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	1547.4	48.56	1.04	1293.9	3007.8	1069.9	1069.9	1713.9	447.00	286.32	7.05	153.63	24.00	24.00	1238.3	1728.0	414.72	393.98	1728.00	361.86	259.31	224.05	447.0	1713.91
	II	10	447.00	1713.9	780.9	48.56	1.04	631.7	2345.6	631.7	631.7	1713.9	447.00	285.41	6.96	154.63	14.26	14.26	1230.3	1728.0	246.46	246.46	1026.93	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	971.4	48.56	1.04	796.3	2510.2	796.3	796.3	1713.9	447.00	285.41	6.96	154.63	17.98	17.98	1230.3	1728.0	310.66	310.66	1294.41	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	1235.7	48.56	0.78	1024.9	2738.8	1024.9	1024.9	1713.9	447.00	285.41	6.96	154.63	23.14	23.14	1230.3	1728.0	399.85	393.98	1666.06	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	955.8	48.56	0.83	783.0	2496.9	569.3	569.3	1927.6	455.00	285.28	6.58	159.14	13.23	13.23	1195.4	1728.0	228.59	228.59	952.47	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	584.1	48.56	0.92	508.1	2435.7	508.1	508.1	1927.6	455.00	285.16	6.20	163.64	11.04	11.04	1162.5	1728.0	209.77	209.77	794.59	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	395.3	48.56	0.83	298.7	2226.3	298.7	298.7	1927.6	455.00	285.16	6.20	163.64	7.14	7.14	1162.5	1728.0	123.34	123.34	513.92	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	333.5	48.56	0.83	245.4	2173.0	245.4	245.4	1927.6	455.00	285.16	6.20	163.64	5.86	5.86	1162.5	1728.0	101.32	101.32	422.15	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	295.7	48.56	0.83	212.7	2140.3	212.7	212.7	1927.6	455.00	285.16	6.20	163.64	5.08	5.08	1162.5	1728.0	87.82	87.82	365.92	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	268.9	48.56	0.28	190.1	2117.7	190.1	190.1	1927.6	455.00	285.16	6.20	163.64	4.54	4.54	1162.5	1728.0	78.48	78.48	327.01	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	250.2	48.56	0.28	173.9	2101.6	173.9	173.9	1927.6	455.00	285.16	6.20	163.64	4.16	4.16	1162.5	1728.0	71.81	71.81	299.22	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	259.4	48.56	0.31	200.0	2127.7	200.0	200.0	1927.6	455.00	285.16	6.20	163.64	4.35	4.35	1162.5	1728.0	82.60	82.60	312.87	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	238.8	48.56	0.28	164.0	2091.7	164.0	164.0	1927.6	455.00	285.16	6.20	163.64	3.92	3.92	1162.5	1728.0	67.73	67.73	282.22	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	226.7	48.56	0.28	153.7	2081.3	153.7	153.7	1927.6	455.00	285.16	6.20	163.64	3.67	3.67	1162.5	1728.0	63.44	63.44	264.34	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	219.6	48.56	0.31	162.2	2089.9	162.2	162.2	1927.6	455.00	285.16	6.20	163.64	3.52	3.52	1162.5	1728.0	66.99	66.99	253.74	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	232.2	48.56	0.55	158.1	2085.7	158.1	158.1	1927.6	455.00	285.16	6.20	163.64	3.78	3.78	1162.5	1728.0	65.26	65.26	271.93	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	335.9	48.56	0.55	247.7	2175.3	247.7	247.7	1927.6	455.00	285.16	6.20	163.64	5.92	5.92	1162.5	1728.0	102.26	102.26	426.07	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	280.4	48.56	0.44	159.8	2087.4	159.8	159.8	1927.6	455.00	285.16	6.20	163.64	4.77	4.77	1162.5	1728.0	65.99	65.99	343.70	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	340.8	48.56	1.11	251.3	2179.0	251.3	251.3	1927.6	455.00	285.16	6.20	163.64	6.01	6.01	1162.5	1728.0	103.78	103.78	432.40	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	387.9	48.56	1.11	292.1	2219.7	292.1	292.1	1927.6	455.00	285.16	6.20	163.64	6.98	6.98	1162.5	1728.0	120.60	120.60	502.51	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	637.0	48.56	1.22	558.1	2485.7	558.1	558.1	1927.6	455.00	285.16	6.20	163.64	12.12	12.12	1162.5	1728.0	230.41	230.41	872.77	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	760.2	48.56	1.11	613.7	2541.4	613.7	613.7	1927.6	455.00	285.16	6.20	163.64	14.66	14.66	1162.5	1728.0	253.40	253.40	1055.85	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	631.9	48.56	1.11	502.9	2430.5	502.9	502.9	1927.6	455.00	285.16	6.20	163.64	12.02	12.02	1162.5	1728.0	207.63	207.63	865.10	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	800.8	48.56	1.11	648.8	2576.4	648.8	648.8	1927.6	455.00	285.16	6.20	163.64	15.50	15.50	1162.5	1728.0	267.87	267.87	1116.14	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	721.2	48.56	1.08	580.1	2507.7	652.5	652.5	1855.1	452.33	285.20	6.32	162.14	15.45	15.45	1173.3	1728.0	266.95	266.95	1112.31	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	979.4	48.56	1.06	803.2	2658.4	875.0	875.0	1783.3	449.67	285.28	6.58	159.14	20.33	20.33	1195.4	1728.0	351.35	351.35	1463.95	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	926.9	48.56	1.14	833.6	2617.0	903.0	903.0	1713.9	447.00	285.37	6.83	156.14	18.72	18.72	1218.4	1728.0	355.75	355.75	1347.53	0.00	0.00	0.00	447.0	1713.91
																159.55		**3.52**			**8573.96**	**8420.87**				**2937.08**		

Min. Res. Level 455.0 m Average Power 1728.0 MW Continuous Power 253.74 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2005-06

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1095.5	48.56	1.04	903.5	2617.4	903.5	903.5	1713.9	447.00	285.41	6.96	154.63	20.40	20.40	1230.3	1728.0	352.50	352.50	1468.77	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	923.3	48.56	1.04	754.7	2468.6	754.7	754.7	1713.9	447.00	285.41	6.96	154.63	17.04	17.04	1230.3	1728.0	294.44	294.44	1226.84	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1273.0	48.56	1.04	1056.8	2770.8	1056.8	1056.8	1713.9	447.00	285.41	6.96	154.63	23.86	23.86	1230.3	1728.0	412.32	393.98	1718.02	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1125.6	48.56	1.04	929.5	2643.5	929.5	929.5	1713.9	447.00	285.41	6.96	154.63	20.99	20.99	1230.3	1728.0	362.66	362.66	1511.07	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1446.7	48.56	1.04	1206.9	2920.8	1067.4	1067.4	1713.9	447.00	285.99	7.01	154.00	24.00	24.00	1235.4	1728.0	414.72	393.98	1728.00	225.94	161.53	139.56	447.0	1713.91
	III	11	447.00	1713.9	1349.5	48.56	1.14	1235.3	2949.2	1171.3	1171.3	1713.9	447.00	285.66	6.98	154.36	24.00	24.00	1232.5	1728.0	456.19	433.38	1728.00	94.36	67.30	63.96	447.0	1713.91
Aug	I	10	447.00	1713.9	1692.6	48.56	1.04	1419.4	3133.3	1073.4	1073.4	1713.9	447.00	286.78	7.09	153.13	24.00	24.00	1242.3	1728.0	414.72	393.98	1728.00	557.01	400.46	345.99	447.0	1713.91
	II	10	447.00	1713.9	1440.0	48.56	1.04	1201.2	2915.1	1067.2	1067.2	1713.9	447.00	285.97	7.01	154.02	24.00	24.00	1235.2	1728.0	414.72	393.98	1728.00	216.98	155.10	134.00	447.0	1713.91
	III	11	447.00	1713.9	1601.7	48.56	1.14	1475.0	3188.9	1178.3	1178.3	1713.9	447.00	286.50	7.06	153.44	24.00	24.00	1239.8	1728.0	456.19	433.38	1728.00	435.01	312.12	296.64	447.0	1713.91
Sep	I	10	447.00	1713.9	1076.9	48.56	1.04	887.5	2601.4	887.5	887.5	1713.9	447.00	285.41	6.96	154.63	20.04	20.04	1230.3	1728.0	346.23	346.23	1442.65	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	572.1	48.56	1.04	451.3	2165.2	451.3	451.3	1713.9	447.00	285.41	6.96	154.63	10.19	10.19	1230.3	1728.0	176.08	176.08	733.66	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	900.4	48.56	1.04	734.9	2448.9	734.9	734.9	1713.9	447.00	285.41	6.96	154.63	16.59	16.59	1230.3	1728.0	286.74	286.74	1194.73	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	777.4	48.56	0.78	629.0	2342.9	629.0	629.0	1713.9	447.00	285.41	6.96	154.63	14.20	14.20	1230.3	1728.0	245.39	245.39	1022.47	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	514.2	48.56	0.83	401.5	2115.4	187.8	187.8	1927.6	455.00	285.28	6.58	159.14	4.36	4.36	1195.4	1728.0	75.40	75.40	314.16	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	635.0	48.56	0.92	556.5	2484.1	556.5	556.5	1927.6	455.00	285.16	6.20	163.64	12.09	12.09	1162.5	1728.0	229.76	229.76	870.29	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	439.0	48.56	0.83	336.5	2264.1	336.5	336.5	1927.6	455.00	285.16	6.20	163.64	8.04	8.04	1162.5	1728.0	138.94	138.94	578.93	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	368.0	48.56	0.83	275.2	2202.8	275.2	275.2	1927.6	455.00	285.16	6.20	163.64	6.57	6.57	1162.5	1728.0	113.61	113.61	473.37	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	325.6	48.56	0.83	238.5	2166.2	238.5	238.5	1927.6	455.00	285.16	6.20	163.64	5.70	5.70	1162.5	1728.0	98.49	98.49	410.36	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	273.2	48.56	0.28	193.8	2121.4	193.8	193.8	1927.6	455.00	285.16	6.20	163.64	4.63	4.63	1162.5	1728.0	80.01	80.01	333.38	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	240.9	48.56	0.28	165.9	2093.5	165.9	165.9	1927.6	455.00	285.16	6.20	163.64	3.96	3.96	1162.5	1728.0	68.51	68.51	285.45	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	225.0	48.56	0.31	167.4	2095.0	167.4	167.4	1927.6	455.00	285.16	6.20	163.64	3.64	3.64	1162.5	1728.0	69.13	69.13	261.84	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	215.3	48.56	0.28	143.8	2071.4	143.8	143.8	1927.6	455.00	285.16	6.20	163.64	3.44	3.44	1162.5	1728.0	59.37	59.37	247.38	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	199.6	48.56	0.28	130.2	2057.8	130.2	130.2	1927.6	455.00	285.16	6.20	163.64	3.11	3.11	1162.5	1728.0	53.76	53.76	224.01	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	195.0	48.56	0.31	138.9	2066.5	138.9	138.9	1927.6	455.00	285.16	6.20	163.64	3.02	3.02	1162.5	1728.0	57.35	57.35	217.25	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	455.00	1927.6	188.2	48.56	0.55	120.1	2047.7	125.6	125.6	1922.1	454.80	285.16	6.21	163.53	3.00	3.00	1163.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.80	1922.1	191.5	48.56	0.55	123.0	2045.1	125.8	125.8	1919.3	454.69	285.17	6.22	163.36	3.00	3.00	1164.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	454.69	1919.3	459.5	48.56	0.44	283.6	2202.9	275.3	275.3	1927.6	455.00	285.16	6.21	163.47	8.21	8.21	1163.8	1728.0	113.53	113.53	591.30	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	307.1	48.56	1.11	222.3	2149.9	222.3	222.3	1927.6	455.00	285.16	6.20	163.64	5.31	5.31	1162.5	1728.0	91.78	91.78	382.43	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	374.0	48.56	1.11	280.0	2207.7	280.0	280.0	1927.6	455.00	285.16	6.20	163.64	6.69	6.69	1162.5	1728.0	115.63	115.63	481.78	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	299.3	48.56	1.22	237.1	2164.7	237.1	237.1	1927.6	455.00	285.16	6.20	163.64	5.15	5.15	1162.5	1728.0	97.88	97.88	370.77	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	368.0	48.56	1.11	274.9	2202.5	274.9	274.9	1927.6	455.00	285.16	6.20	163.64	6.57	6.57	1162.5	1728.0	113.50	113.50	472.92	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	635.0	48.56	1.11	505.6	2433.2	505.6	505.6	1927.6	455.00	285.16	6.20	163.64	12.08	12.08	1162.5	1728.0	208.75	208.75	869.77	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	375.8	48.56	1.11	281.7	2209.3	281.7	281.7	1927.6	455.00	285.16	6.20	163.64	6.73	6.73	1162.5	1728.0	116.29	116.29	484.54	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	632.0	48.56	1.08	503.0	2430.7	575.5	575.5	1855.1	452.33	285.20	6.32	162.14	13.62	13.62	1173.3	1728.0	235.44	235.44	980.99	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	833.7	48.56	1.06	677.3	2532.5	749.1	749.1	1783.3	449.67	285.28	6.58	159.14	17.41	17.41	1195.4	1728.0	300.80	300.80	1253.34	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	827.7	48.56	1.14	739.4	2522.7	808.8	808.8	1713.9	447.00	285.37	6.83	156.14	16.76	16.76	1218.4	1728.0	318.62	318.62	1206.89	0.00	0.00	0.00	447.0	1713.91
																159.76		**3.00**			**7493.14**	**7366.97**				**980.16**		

Min. Res. Level 454.7 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2006-07

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1237.5	48.56	1.04	1026.2	2740.1	1026.2	1026.2	1713.9	447.00	285.41	6.96	154.63	23.17	23.17	1230.3	1728.0	400.36	393.98	1668.17	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1559.3	48.56	1.04	1304.2	3018.2	1070.2	1070.2	1713.9	447.00	286.36	7.05	153.59	24.00	24.00	1238.6	1728.0	414.72	393.98	1728.00	377.93	270.90	234.06	447.0	1713.91
	III	10	447.00	1713.9	1173.4	48.56	1.04	970.8	2684.7	970.8	970.8	1713.9	447.00	285.41	6.96	154.63	21.92	21.92	1230.3	1728.0	378.76	378.76	1578.15	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1107.8	48.56	1.04	914.1	2628.1	914.1	914.1	1713.9	447.00	285.41	6.96	154.63	20.64	20.64	1230.3	1728.0	356.65	356.65	1486.03	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1178.6	48.56	1.04	975.3	2689.2	975.3	975.3	1713.9	447.00	285.41	6.96	154.63	22.02	22.02	1230.3	1728.0	380.51	380.51	1585.46	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	841.2	48.56	1.14	752.2	2466.1	752.2	752.2	1713.9	447.00	285.41	6.96	154.63	15.44	15.44	1230.3	1728.0	293.45	293.45	1111.57	0.00	0.00	0.00	447.0	1713.91
Aug	I	10	447.00	1713.9	553.3	48.56	1.04	435.1	2149.0	435.1	435.1	1713.9	447.00	285.41	6.96	154.63	9.82	9.82	1230.3	1728.0	169.73	169.73	707.22	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	424.9	48.56	1.04	324.1	2038.1	324.1	324.1	1713.9	447.00	285.41	6.96	154.63	7.32	7.32	1230.3	1728.0	126.46	126.46	526.92	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1094.9	48.56	1.14	993.3	2707.2	993.3	993.3	1713.9	447.00	285.41	6.96	154.63	20.39	20.39	1230.3	1728.0	387.54	387.54	1467.94	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	841.7	48.56	1.04	684.2	2398.1	684.2	684.2	1713.9	447.00	285.41	6.96	154.63	15.45	15.45	1230.3	1728.0	266.95	266.95	1112.27	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1405.3	48.56	1.04	1171.1	2885.1	1066.3	1066.3	1713.9	447.00	285.85	7.00	154.15	24.00	24.00	1234.2	1728.0	414.72	393.98	1728.00	169.90	121.34	104.84	447.0	1713.91
	III	10	447.00	1713.9	700.8	48.56	1.04	562.5	2276.4	562.5	562.5	1713.9	447.00	285.41	6.96	154.63	12.70	12.70	1230.3	1728.0	219.45	219.45	914.38	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	752.2	48.56	0.78	607.2	2321.1	607.2	607.2	1713.9	447.00	285.41	6.96	154.63	13.71	13.71	1230.3	1728.0	236.88	236.88	987.02	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	673.2	48.56	0.83	538.8	2252.7	325.1	325.1	1927.6	455.00	285.28	6.58	159.14	7.55	7.55	1195.4	1728.0	130.54	130.54	543.93	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	417.0	48.56	0.92	349.3	2276.9	349.3	349.3	1927.6	455.00	285.16	6.20	163.64	7.59	7.59	1162.5	1728.0	144.21	144.21	546.26	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	330.9	48.56	0.83	243.1	2170.7	243.1	243.1	1927.6	455.00	285.16	6.20	163.64	5.81	5.81	1162.5	1728.0	100.38	100.38	418.25	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	294.0	48.56	0.83	211.2	2138.8	211.2	211.2	1927.6	455.00	285.16	6.20	163.64	5.05	5.05	1162.5	1728.0	87.21	87.21	363.37	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	305.4	48.56	0.83	221.1	2148.7	221.1	221.1	1927.6	455.00	285.16	6.20	163.64	5.28	5.28	1162.5	1728.0	91.29	91.29	380.39	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	270.9	48.56	0.28	191.8	2119.5	191.8	191.8	1927.6	455.00	285.16	6.20	163.64	4.58	4.58	1162.5	1728.0	79.21	79.21	330.04	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	252.9	48.56	0.28	176.3	2103.9	176.3	176.3	1927.6	455.00	285.16	6.20	163.64	4.21	4.21	1162.5	1728.0	72.79	72.79	303.28	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.3	48.56	0.31	143.9	2071.5	143.9	143.9	1927.6	455.00	285.16	6.20	163.64	3.13	3.13	1162.5	1728.0	59.43	59.43	225.10	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	190.6	48.56	0.28	122.5	2050.1	125.6	125.6	1924.5	454.88	285.16	6.20	163.58	3.00	3.00	1163.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.88	1924.5	187.6	48.56	0.28	119.9	2044.3	125.7	125.7	1918.6	454.67	285.17	6.22	163.39	3.00	3.00	1164.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.67	1918.6	179.5	48.56	0.31	124.2	2042.8	138.7	138.7	1904.1	454.13	285.18	6.25	162.97	3.00	3.00	1167.4	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	454.13	1904.1	209.5	48.56	0.55	138.5	2042.6	126.1	126.1	1916.5	454.59	285.18	6.26	162.93	3.00	3.00	1167.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.59	1916.5	214.1	48.56	0.55	142.4	2058.9	131.3	131.3	1927.6	455.00	285.17	6.22	163.41	3.13	3.13	1164.2	1728.0	54.14	54.14	225.60	0.00	0.00	0.00	455.0	1927.62
	III	8	455.00	1927.6	223.0	48.56	0.44	120.1	2047.7	120.1	120.1	1927.6	455.00	285.16	6.20	163.64	3.59	3.59	1162.5	1728.0	49.59	49.59	258.27	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	455.00	1927.6	308.0	48.56	1.11	223.0	2150.7	223.0	223.0	1927.6	455.00	285.16	6.20	163.64	5.33	5.33	1162.5	1728.0	92.09	92.09	383.72	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	332.5	48.56	1.11	244.2	2171.9	244.2	244.2	1927.6	455.00	285.16	6.20	163.64	5.84	5.84	1162.5	1728.0	100.85	100.85	420.20	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	344.9	48.56	1.22	280.4	2208.1	280.4	280.4	1927.6	455.00	285.16	6.20	163.64	6.09	6.09	1162.5	1728.0	115.79	115.79	438.60	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	518.3	48.56	1.11	404.7	2332.3	404.7	404.7	1927.6	455.00	285.16	6.20	163.64	9.67	9.67	1162.5	1728.0	167.10	167.10	696.27	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	507.7	48.56	1.11	395.5	2323.2	395.5	395.5	1927.6	455.00	285.16	6.20	163.64	9.45	9.45	1162.5	1728.0	163.32	163.32	680.48	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	872.0	48.56	1.11	710.4	2638.0	710.4	710.4	1927.6	455.00	285.16	6.20	163.64	16.97	16.97	1162.5	1728.0	293.31	293.31	1222.11	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	461.1	48.56	1.08	355.3	2283.0	427.8	427.8	1855.1	452.33	285.20	6.32	162.14	10.13	10.13	1173.3	1728.0	175.02	175.02	729.24	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	574.9	48.56	1.06	453.7	2308.8	525.5	525.5	1783.3	449.67	285.28	6.58	159.14	12.21	12.21	1195.4	1728.0	211.01	211.01	879.20	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	886.9	48.56	1.14	795.6	2578.9	865.0	865.0	1713.9	447.00	285.37	6.83	156.14	17.93	17.93	1218.4	1728.0	340.76	340.76	1290.78	0.00	0.00	0.00	447.0	1713.91
																159.79		**3.00**			**6786.77**	**6738.92**				**338.90**		

Min. Res. Level 454.1 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2007-08

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1371.0	48.56	1.04	1141.6	2855.5	1065.4	1065.4	1713.9	447.00	285.73	6.99	154.28	24.00	24.00	1233.1	1728.0	414.72	393.98	1728.00	123.49	88.12	76.14	447.0	1713.91
	II	10	447.00	1713.9	1725.0	48.56	1.04	1447.4	3161.3	1074.1	1074.1	1713.9	447.00	286.88	7.10	153.03	24.00	24.00	1243.2	1728.0	414.72	393.98	1728.00	600.46	432.00	373.25	447.0	1713.91
	III	10	447.00	1713.9	1968.0	48.56	1.04	1657.3	3371.3	1079.6	1079.6	1713.9	447.00	287.58	7.16	152.25	24.00	24.00	1249.5	1728.0	414.72	393.98	1728.00	924.75	668.69	577.75	447.0	1713.91
Jul	I	10	447.00	1713.9	1232.2	48.56	1.04	1021.6	2735.5	1021.6	1021.6	1713.9	447.00	285.41	6.96	154.63	23.07	23.07	1230.3	1728.0	398.59	393.98	1660.78	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1454.1	48.56	1.04	1213.4	2927.3	1067.6	1067.6	1713.9	447.00	286.01	7.02	153.97	24.00	24.00	1235.6	1728.0	414.72	393.98	1728.00	236.03	168.77	145.82	447.0	1713.91
	III	11	447.00	1713.9	2702.5	48.56	1.14	2521.1	4235.0	1203.7	1203.7	1713.9	447.00	289.45	7.34	150.21	24.00	24.00	1266.5	1728.0	456.19	433.38	1728.00	1891.33	1386.20	1317.44	447.0	1713.91
Aug	I	10	447.00	1713.9	1196.5	48.56	1.04	990.7	2704.7	990.7	990.7	1713.9	447.00	285.41	6.96	154.63	22.37	22.37	1230.3	1728.0	386.54	386.54	1610.57	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1796.2	48.56	1.04	1508.9	3222.8	1075.8	1075.8	1713.9	447.00	287.09	7.12	152.79	24.00	24.00	1245.1	1728.0	414.72	393.98	1728.00	695.75	501.32	433.14	447.0	1713.91
	III	11	447.00	1713.9	1117.4	48.56	1.14	1014.6	2728.6	1014.6	1014.6	1713.9	447.00	285.41	6.96	154.63	20.83	20.83	1230.3	1728.0	395.86	395.86	1499.47	0.00	0.00	0.00	447.0	1713.91
Sep	I	10	447.00	1713.9	2209.8	48.56	1.04	1866.3	3580.2	1084.7	1084.7	1713.9	447.00	288.24	7.22	151.54	24.00	24.00	1255.4	1728.0	414.72	393.98	1728.00	1245.16	904.63	781.60	447.0	1713.91
	II	10	447.00	1713.9	1499.7	48.56	1.04	1252.7	2966.6	1068.7	1068.7	1713.9	447.00	286.17	7.03	153.80	24.00	24.00	1236.9	1728.0	414.72	393.98	1728.00	297.54	212.98	184.02	447.0	1713.91
	III	10	447.00	1713.9	682.5	48.56	1.04	546.7	2260.6	546.7	546.7	1713.9	447.00	285.41	6.96	154.63	12.34	12.34	1230.3	1728.0	213.28	213.28	888.67	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	938.9	48.56	0.78	768.5	2482.4	768.5	768.5	1713.9	447.00	285.41	6.96	154.63	17.35	17.35	1230.3	1728.0	299.82	299.82	1249.24	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	897.6	48.56	0.83	732.7	2446.7	519.0	519.0	1927.6	455.00	285.28	6.58	159.14	12.06	12.06	1195.4	1728.0	208.40	208.40	868.34	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	574.0	48.56	0.92	498.5	2426.1	498.5	498.5	1927.6	455.00	285.16	6.20	163.64	10.83	10.83	1162.5	1728.0	205.82	205.82	779.62	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	359.6	48.56	0.83	267.9	2195.6	267.9	267.9	1927.6	455.00	285.16	6.20	163.64	6.40	6.40	1162.5	1728.0	110.63	110.63	460.94	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	344.1	48.56	0.83	254.5	2182.1	254.5	254.5	1927.6	455.00	285.16	6.20	163.64	6.08	6.08	1162.5	1728.0	105.08	105.08	437.81	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	335.0	48.56	0.83	246.7	2174.3	246.7	246.7	1927.6	455.00	285.16	6.20	163.64	5.89	5.89	1162.5	1728.0	101.85	101.85	424.36	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	269.0	48.56	0.28	190.2	2117.8	190.2	190.2	1927.6	455.00	285.16	6.20	163.64	4.54	4.54	1162.5	1728.0	78.53	78.53	327.21	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	230.9	48.56	0.28	157.3	2084.9	157.3	157.3	1927.6	455.00	285.16	6.20	163.64	3.76	3.76	1162.5	1728.0	64.93	64.93	270.55	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	209.8	48.56	0.31	152.9	2080.5	152.9	152.9	1927.6	455.00	285.16	6.20	163.64	3.32	3.32	1162.5	1728.0	63.13	63.13	239.14	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	188.4	48.56	0.28	120.6	2048.2	125.6	125.6	1922.6	454.81	285.16	6.21	163.54	3.00	3.00	1163.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.81	1922.6	179.2	48.56	0.28	112.6	2035.2	125.9	125.9	1909.2	454.32	285.17	6.24	163.16	3.00	3.00	1166.0	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.32	1909.2	193.0	48.56	0.31	137.0	2046.2	138.8	138.8	1907.4	454.26	285.18	6.26	162.84	3.00	3.00	1168.3	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	454.26	1907.4	190.6	48.56	0.55	122.2	2029.6	126.3	126.3	1903.3	454.10	285.18	6.27	162.72	3.00	3.00	1169.1	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.10	1903.3	202.0	48.56	0.55	132.0	2035.4	126.2	126.2	1909.1	454.32	285.18	6.27	162.76	3.00	3.00	1168.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	454.32	1909.1	203.9	48.56	0.44	106.9	2016.1	100.8	100.8	1915.2	454.54	285.18	6.25	163.00	3.00	3.00	1167.1	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	454.54	1915.2	275.6	48.56	1.11	195.1	2110.3	182.7	182.7	1927.6	455.00	285.17	6.22	163.39	4.36	4.36	1164.4	1728.0	75.30	75.30	313.76	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	342.1	48.56	1.11	252.5	2180.1	252.5	252.5	1927.6	455.00	285.16	6.20	163.64	6.03	6.03	1162.5	1728.0	104.26	104.26	434.42	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	410.5	48.56	1.22	342.8	2270.4	342.8	342.8	1927.6	455.00	285.16	6.20	163.64	7.45	7.45	1162.5	1728.0	141.52	141.52	536.08	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	484.1	48.56	1.11	375.2	2302.8	375.2	375.2	1927.6	455.00	285.16	6.20	163.64	8.96	8.96	1162.5	1728.0	154.91	154.91	645.46	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	820.6	48.56	1.11	666.0	2593.6	666.0	666.0	1927.6	455.00	285.16	6.20	163.64	15.91	15.91	1162.5	1728.0	274.97	274.97	1145.71	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	750.9	48.56	1.11	605.7	2533.3	605.7	605.7	1927.6	455.00	285.16	6.20	163.64	14.47	14.47	1162.5	1728.0	250.10	250.10	1042.08	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	819.9	48.56	1.08	665.4	2593.0	737.8	737.8	1855.1	452.33	285.20	6.32	162.14	17.47	17.47	1173.3	1728.0	301.84	301.84	1257.69	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	570.4	48.56	1.06	449.8	2305.0	521.7	521.7	1783.3	449.67	285.28	6.58	159.14	12.12	12.12	1195.4	1728.0	209.46	209.46	872.74	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1040.6	48.56	1.14	941.7	2725.0	1011.1	1011.1	1713.9	447.00	285.37	6.83	156.14	20.96	20.96	1218.4	1728.0	398.32	398.32	1508.78	0.00	0.00	0.00	447.0	1713.91
																159.35		**3.00**			**8208.23**	**8035.66**				**3889.16**		

Min. Res. Level 454.1 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2008-09

Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	1290.0	48.56	1.04	1071.6	2785.5	1063.3	1063.3	1713.9	447.00	285.44	6.96	154.59	24.00	24.00	1230.6	1728.0	414.72	393.98	1728.00	13.52	9.63	8.32	447.0	1713.91
	II	10	447.00	1713.9	1833.7	48.56	1.04	1541.3	3255.2	1076.6	1076.6	1713.9	447.00	287.20	7.13	152.67	24.00	24.00	1246.1	1728.0	414.72	393.98	1728.00	745.83	537.83	464.69	447.0	1713.91
	III	10	447.00	1713.9	1257.6	48.56	1.04	1043.6	2757.5	1043.6	1043.6	1713.9	447.00	285.41	6.96	154.63	23.56	23.56	1230.3	1728.0	407.15	393.98	1696.47	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1289.6	48.56	1.04	1071.2	2785.1	1063.2	1063.2	1713.9	447.00	285.44	6.96	154.59	24.00	24.00	1230.6	1728.0	414.72	393.98	1728.00	12.95	9.22	7.97	447.0	1713.91
	II	10	447.00	1713.9	1372.0	48.56	1.04	1142.4	2856.3	1065.4	1065.4	1713.9	447.00	285.73	6.99	154.28	24.00	24.00	1233.1	1728.0	414.72	393.98	1728.00	124.78	89.04	76.93	447.0	1713.91
	III	11	447.00	1713.9	1731.5	48.56	1.14	1598.3	3312.2	1181.7	1181.7	1713.9	447.00	286.90	7.10	153.00	24.00	24.00	1243.4	1728.0	456.19	433.38	1728.00	609.15	438.31	416.57	447.0	1713.91
Aug	I	10	447.00	1713.9	896.1	48.56	1.04	731.2	2445.1	731.2	731.2	1713.9	447.00	285.41	6.96	154.63	16.51	16.51	1230.3	1728.0	285.28	285.28	1188.66	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	1748.9	48.56	1.04	1468.0	3182.0	1074.7	1074.7	1713.9	447.00	286.95	7.10	152.95	24.00	24.00	1243.9	1728.0	414.72	393.98	1728.00	632.49	455.28	393.36	447.0	1713.91
	III	11	447.00	1713.9	1452.3	48.56	1.14	1333.0	3046.9	1174.3	1174.3	1713.9	447.00	286.01	7.02	153.98	24.00	24.00	1235.5	1728.0	456.19	433.38	1728.00	233.54	166.98	158.70	447.0	1713.91
Sep	I	10	447.00	1713.9	1371.2	48.56	1.04	1141.7	2855.6	1065.4	1065.4	1713.9	447.00	285.73	6.99	154.28	24.00	24.00	1233.1	1728.0	414.72	393.98	1728.00	123.69	88.27	76.26	447.0	1713.91
	II	10	447.00	1713.9	789.7	48.56	1.04	639.3	2353.3	639.3	639.3	1713.9	447.00	285.41	6.96	154.63	14.44	14.44	1230.3	1728.0	249.44	249.44	1039.32	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	660.7	48.56	1.04	527.9	2241.8	527.9	527.9	1713.9	447.00	285.41	6.96	154.63	11.92	11.92	1230.3	1728.0	205.94	205.94	858.08	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	692.1	48.56	0.78	555.3	2269.2	555.3	555.3	1713.9	447.00	285.41	6.96	154.63	12.54	12.54	1230.3	1728.0	216.63	216.63	902.62	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	528.6	48.56	0.83	413.9	2127.8	200.2	200.2	1927.6	455.00	285.28	6.58	159.14	4.65	4.65	1195.4	1728.0	80.38	80.38	334.90	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	549.1	48.56	0.92	474.8	2402.4	474.8	474.8	1927.6	455.00	285.16	6.20	163.64	10.31	10.31	1162.5	1728.0	196.05	196.05	742.61	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	357.9	48.56	0.83	266.5	2194.1	266.5	266.5	1927.6	455.00	285.16	6.20	163.64	6.37	6.37	1162.5	1728.0	110.02	110.02	458.43	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	312.0	48.56	0.83	226.8	2154.4	226.8	226.8	1927.6	455.00	285.16	6.20	163.64	5.42	5.42	1162.5	1728.0	93.65	93.65	390.20	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	269.7	48.56	0.83	190.2	2117.8	190.2	190.2	1927.6	455.00	285.16	6.20	163.64	4.54	4.54	1162.5	1728.0	78.53	78.53	327.21	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	228.2	48.56	0.28	154.9	2082.5	154.9	154.9	1927.6	455.00	285.16	6.20	163.64	3.70	3.70	1162.5	1728.0	63.96	63.96	266.48	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	205.5	48.56	0.28	135.3	2063.0	135.3	135.3	1927.6	455.00	285.16	6.20	163.64	3.23	3.23	1162.5	1728.0	55.88	55.88	232.84	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	186.7	48.56	0.31	131.0	2058.6	138.2	138.2	1920.4	454.73	285.16	6.21	163.49	3.00	3.00	1163.6	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	454.73	1920.4	174.0	48.56	0.28	108.1	2028.5	126.1	126.1	1902.4	454.07	285.18	6.25	162.97	3.00	3.00	1167.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	454.07	1902.4	159.4	48.56	0.28	95.5	1997.9	126.9	126.9	1871.0	452.92	285.20	6.34	161.95	3.00	3.00	1174.7	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	452.92	1871.0	160.7	48.56	0.31	106.3	1977.3	140.7	140.7	1836.6	451.65	285.24	6.46	160.58	3.00	3.00	1184.7	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	451.65	1836.6	149.9	48.56	0.55	87.0	1923.6	129.2	129.2	1794.4	450.09	285.29	6.59	158.99	3.00	3.00	1196.6	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	450.09	1794.4	138.7	48.56	0.55	77.3	1871.7	130.9	130.9	1740.8	448.04	285.34	6.76	156.96	3.00	3.00	1212.1	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	448.04	1740.8	239.8	48.56	0.44	131.7	1872.6	105.1	105.1	1767.5	449.06	285.36	6.81	156.38	3.00	3.00	1216.6	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	449.06	1767.5	202.9	48.56	1.11	132.2	1899.7	130.9	130.9	1768.8	449.11	285.34	6.76	156.98	3.00	3.00	1211.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	449.11	1768.8	183.1	48.56	1.11	115.2	1884.0	131.1	131.1	1752.8	448.50	285.35	6.79	156.67	3.00	3.00	1214.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	448.50	1752.8	195.6	48.56	1.22	138.5	1891.4	144.7	144.7	1746.7	448.26	285.36	6.83	156.19	3.00	3.00	1218.1	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	448.26	1746.7	424.7	48.56	1.11	323.9	2070.6	142.9	142.9	1927.6	455.00	285.26	6.52	159.85	3.34	3.34	1190.1	1728.0	57.65	57.65	240.21	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	433.4	48.56	1.11	331.3	2259.0	331.3	331.3	1927.6	455.00	285.16	6.20	163.64	7.92	7.92	1162.5	1728.0	136.81	136.81	570.04	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	574.4	48.56	1.11	453.2	2380.8	453.2	453.2	1927.6	455.00	285.16	6.20	163.64	10.83	10.83	1162.5	1728.0	187.12	187.12	779.68	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	795.8	48.56	1.08	644.5	2572.1	717.0	717.0	1855.1	452.33	285.20	6.32	162.14	16.97	16.97	1173.3	1728.0	293.32	293.32	1222.16	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	668.5	48.56	1.06	534.6	2389.7	606.4	606.4	1783.3	449.67	285.28	6.58	159.14	14.09	14.09	1195.4	1728.0	243.47	243.47	1014.47	0.00	0.00	0.00	449.7	1783.33
	III	11	449.67	1783.3	1068.0	48.56	1.14	967.7	2751.1	1037.2	1037.2	1713.9	447.00	285.37	6.83	156.14	21.50	21.50	1218.4	1728.0	408.58	408.58	1547.65	0.00	0.00	0.00	447.0	1713.91
																158.34		**3.00**			**7294.15**	**7110.95**				**1602.81**		

Min. Res. Level 448.0 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-4

RESERVOIR OPERATION STUDY

KAMALA HYDROELECTRIC PROJECT

Riparian Release 48.56 m^3/sec **Min. Peaking hrs** 3.00 Hours **Installed Capacity** 1728 MW

Machine Availability 95.00% **System efficiency** 92.59% **Year** 2009-10

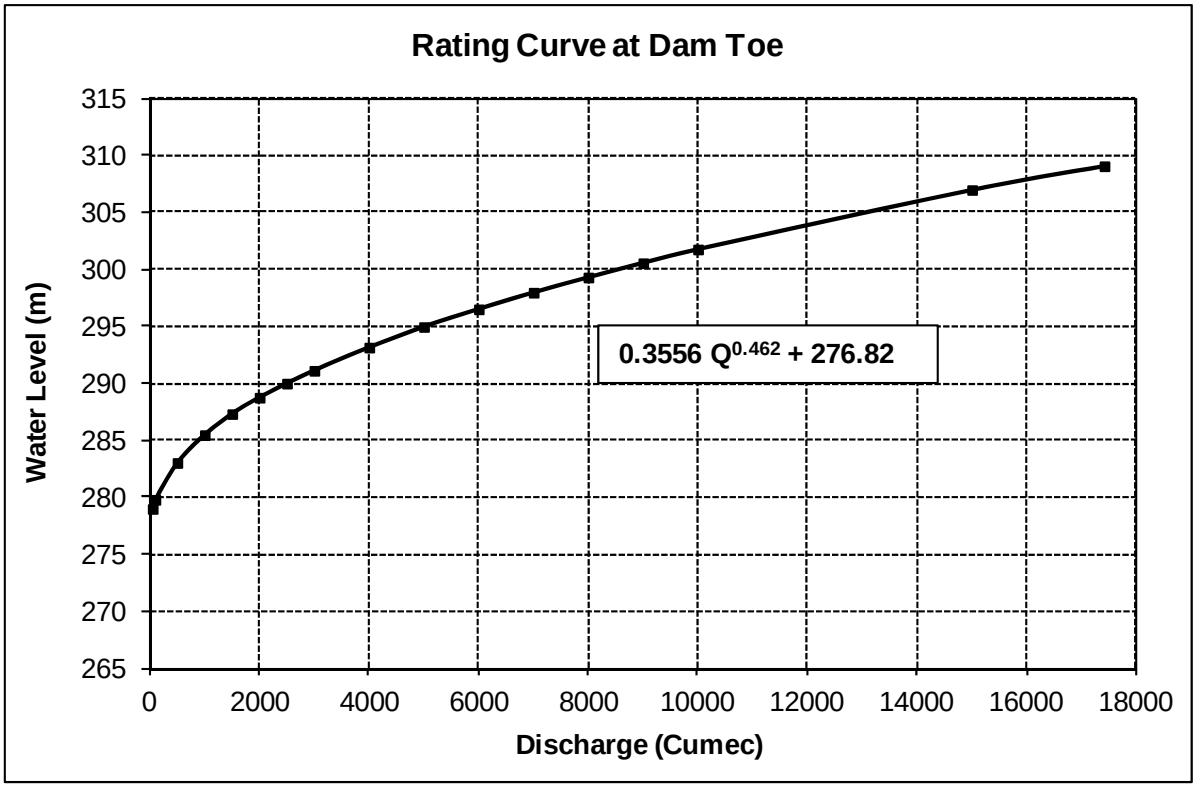
Month	Period	No. of Days	Initial		Inflow during the Period	Riparian without generation	Evaporation Loss	Inflow during the period	Total Storage	Power Draft	Total With-drawal	Final Storage	Final level of resevoir	TWL	Head Loss	Net Head	Full Genration in 24 hrs		For full generation with 100% Machine availability			Energy with 95% M/c availability	Continuous Power	Spillover Quantity			Rule Curve for Reservoir Operation	
			Level	Storage													Actual	Adjusted	Discharge	Power	Energy	Energy		Power	Discharge		Elevation	Storage
			m	MCM	m^3/sec	m^3/sec	MCM	MCM	MCM	MCM	MCM	MCM	m	m	m	m	hr	hr	m^3/sec	MW	MU	MU	MW	MW	m^3/sec	MCM	m	MCM
Jun	I	10	447.00	1713.9	861.0	48.56	1.04	700.9	2414.8	700.9	700.9	1713.9	447.00	285.41	6.96	154.63	15.83	15.83	1230.3	1728.0	273.46	273.46	1139.41	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	938.3	48.56	1.04	767.7	2481.6	767.7	767.7	1713.9	447.00	285.41	6.96	154.63	17.33	17.33	1230.3	1728.0	299.50	299.50	1247.92	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	1092.2	48.56	1.04	900.7	2614.6	900.7	900.7	1713.9	447.00	285.41	6.96	154.63	20.34	20.34	1230.3	1728.0	351.41	351.41	1464.19	0.00	0.00	0.00	447.0	1713.91
Jul	I	10	447.00	1713.9	1553.5	48.56	1.04	1299.3	3013.2	1070.0	1070.0	1713.9	447.00	286.34	7.05	153.61	24.00	24.00	1238.5	1728.0	414.72	393.98	1728.00	370.16	265.30	229.22	447.0	1713.91
	II	10	447.00	1713.9	994.9	48.56	1.04	816.6	2530.5	816.6	816.6	1713.9	447.00	285.41	6.96	154.63	18.44	18.44	1230.3	1728.0	318.59	318.59	1327.47	0.00	0.00	0.00	447.0	1713.91
	III	11	447.00	1713.9	1352.7	48.56	1.14	1238.3	2952.2	1171.4	1171.4	1713.9	447.00	285.67	6.98	154.35	24.00	24.00	1232.6	1728.0	456.19	433.38	1728.00	98.64	70.36	66.87	447.0	1713.91
Aug	I	10	447.00	1713.9	1384.2	48.56	1.04	1152.9	2866.9	1065.8	1065.8	1713.9	447.00	285.78	7.00	154.23	24.00	24.00	1233.5	1728.0	414.72	393.98	1728.00	141.37	100.91	87.19	447.0	1713.91
	II	10	447.00	1713.9	1516.5	48.56	1.04	1267.3	2981.2	1069.1	1069.1	1713.9	447.00	286.22	7.04	153.74	24.00	24.00	1237.4	1728.0	414.72	393.98	1728.00	320.23	229.32	198.13	447.0	1713.91
	III	11	447.00	1713.9	1323.7	48.56	1.14	1210.7	2924.6	1170.6	1170.6	1713.9	447.00	285.56	6.98	154.46	24.00	24.00	1231.7	1728.0	456.19	433.38	1728.00	59.24	42.22	40.13	447.0	1713.91
Sep	I	10	447.00	1713.9	689.1	48.56	1.04	552.4	2266.3	552.4	552.4	1713.9	447.00	285.41	6.96	154.63	12.47	12.47	1230.3	1728.0	215.52	215.52	898.01	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	870.7	48.56	1.04	709.3	2423.2	709.3	709.3	1713.9	447.00	285.41	6.96	154.63	16.02	16.02	1230.3	1728.0	276.74	276.74	1153.09	0.00	0.00	0.00	447.0	1713.91
	III	10	447.00	1713.9	854.5	48.56	1.04	695.3	2409.2	695.3	695.3	1713.9	447.00	285.41	6.96	154.63	15.70	15.70	1230.3	1728.0	271.26	271.26	1130.26	0.00	0.00	0.00	447.0	1713.91
Oct	I	10	447.00	1713.9	751.5	48.56	0.78	606.6	2320.5	606.6	606.6	1713.9	447.00	285.41	6.96	154.63	13.69	13.69	1230.3	1728.0	236.64	236.64	986.02	0.00	0.00	0.00	447.0	1713.91
	II	10	447.00	1713.9	518.3	48.56	0.83	405.0	2118.9	191.3	191.3	1927.6	455.00	285.28	6.58	159.14	4.44	4.44	1195.4	1728.0	76.80	76.80	320.00	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	397.4	48.56	0.92	330.6	2258.2	330.6	330.6	1927.6	455.00	285.16	6.20	163.64	7.18	7.18	1162.5	1728.0	136.50	136.50	517.05	0.00	0.00	0.00	455.0	1927.62
Nov	I	10	455.00	1927.6	306.5	48.56	0.83	222.0	2149.6	222.0	222.0	1927.6	455.00	285.16	6.20	163.64	5.30	5.30	1162.5	1728.0	91.67	91.67	381.94	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	363.2	48.56	0.83	271.0	2198.7	271.0	271.0	1927.6	455.00	285.16	6.20	163.64	6.48	6.48	1162.5	1728.0	111.91	111.91	466.29	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	297.3	48.56	0.83	214.1	2141.7	214.1	214.1	1927.6	455.00	285.16	6.20	163.64	5.12	5.12	1162.5	1728.0	88.39	88.39	368.31	0.00	0.00	0.00	455.0	1927.62
Dec	I	10	455.00	1927.6	274.2	48.56	0.28	194.7	2122.3	194.7	194.7	1927.6	455.00	285.16	6.20	163.64	4.65	4.65	1162.5	1728.0	80.39	80.39	334.96	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	224.1	48.56	0.28	151.4	2079.0	151.4	151.4	1927.6	455.00	285.16	6.20	163.64	3.62	3.62	1162.5	1728.0	62.49	62.49	260.39	0.00	0.00	0.00	455.0	1927.62
	III	11	455.00	1927.6	200.7	48.56	0.31	144.3	2071.9	144.3	144.3	1927.6	455.00	285.16	6.20	163.64	3.13	3.13	1162.5	1728.0	59.56	59.56	225.60	0.00	0.00	0.00	455.0	1927.62
Jan	I	10	455.00	1927.6	201.5	48.56	0.28	131.8	2059.4	131.8	131.8	1927.6	455.00	285.16	6.20	163.64	3.15	3.15	1162.5	1728.0	54.43	54.43	226.78	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	171.8	48.56	0.28	106.2	2033.8	125.9	125.9	1908.0	454.28	285.17	6.23	163.24	3.00	3.00	1165.4	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	454.28	1908.0	147.6	48.56	0.31	93.9	2001.8	139.6	139.6	1862.2	452.59	285.21	6.35	161.88	3.00	3.00	1175.2	1728.0	57.02	57.02	216.00	0.00	0.00	0.00	455.0	1927.62
Feb	I	10	452.59	1862.2	139.7	48.56	0.55	78.2	1940.4	128.5	128.5	1811.9	450.74	285.26	6.52	159.89	3.00	3.00	1189.9	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	450.74	1811.9	142.1	48.56	0.55	80.3	1892.1	130.2	130.2	1761.9	448.85	285.32	6.69	157.78	3.00	3.00	1205.8	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	8	448.85	1761.9	151.4	48.56	0.44	70.6	1832.6	105.4	105.4	1727.2	447.51	285.37	6.85	155.96	3.00	3.00	1219.8	1728.0	41.47	41.47	216.00	0.00	0.00	0.00	455.0	1927.62
Mar	I	10	447.51	1727.2	192.7	48.56	1.11	123.4	1850.6	132.5	132.5	1718.1	447.16	285.40	6.93	155.01	3.00	3.00	1227.3	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	II	10	447.16	1718.1	219.1	48.56	1.11	146.2	1864.3	132.5	132.5	1731.8	447.69	285.39	6.92	155.11	3.00	3.00	1226.5	1728.0	51.84	51.84	216.00	0.00	0.00	0.00	455.0	1927.62
	III	11	447.69	1731.8	506.8	48.56	1.22	434.3	2166.1	238.5	238.5	1927.6	455.00	285.27	6.55	159.53	5.05	5.05	1192.5	1728.0	95.99	95.99	363.58	0.00	0.00	0.00	455.0	1927.62
Apr	I	10	455.00	1927.6	768.0	48.56	1.11	620.5	2548.1	620.5	620.5	1927.6	455.00	285.16	6.20	163.64	14.83	14.83	1162.5	1728.0	256.19	256.19	1067.48	0.00	0.00	0.00	455.0	1927.62
	II	10	455.00	1927.6	629.3	48.56	1.11	500.6	2428.2	500.6	500.6	1927.6	455.00	285.16	6.20	163.64	11.96	11.96	1162.5	1728.0	206.70	206.70	861.24	0.00	0.00	0.00	455.0	1927.62
	III	10	455.00	1927.6	1127.7	48.56	1.11	931.3	2858.9	931.3	931.3	1927.6	455.00	285.16	6.20	163.64	22.25	22.25	1162.5	1728.0	384.52	384.52	1602.15	0.00	0.00	0.00	455.0	1927.62
May	I	10	455.00	1927.6	769.3	48.56	1.08	621.7	2549.3	694.1	694.1	1855.1	452.33	285.20	6.32	162.14	16.43	16.43	1173.3	1728.0	283.96	283.96	1183.18	0.00	0.00	0.00	452.3	1855.15
	II	10	452.33	1855.1	1458.3	48.56	1.06	1216.9	3072.1	1040.2	1040.2	1783.3	449.67	286.30	6.67	158.03	24.00	24.00	1203.9	1728.0	414.72	393.98	1728.00	412.96	287.71	248.58	449.7	1783.33
	III	11	449.67	1783.3	986.0	48.56	1.14	889.8	2673.2	959.2	959.2	1713.9	447.00	285.37	6.83	156.14	19.88	19.88	1218.4	1728.0	377.89	377.89	1431.39	0.00	0.00	0.00	447.0	1713.91
																158.65		**3.00**			**7539.47**	**7410.91**				**870.11**		

Min. Res. Level 447.2 m Average Power 1728.0 MW Continuous Power 216.00 MW

Annexure 9-5
Tailwater Rating Curve at Dam-toe

Annexure 9-5

TAILWATER RATING CURVE AT DAM-TOE



Annexure 9-6

Energy Generation for Auxiliary Powerhouse

Annexure 9-6

Energy Generation at Dam Toe Powerhouse utilising Ecological Flow - 90% Dependable Year

FRL	**455 m**				
Monsoon Operation Level	**447.00 m**	**Machine Availability**	**95%**	**System efficiency**	**92.59%**
		Installed Capacity	**72.0 MW**	**Losses in WCS**	**3 m**
Riparian through generation	**48.56 m^3/sec**	**Design Discharge**	**48.56 m^3/sec**		

Month	Period	No. of Days	Riparian without generation	Net Head	For full generation with 100% M/c availability	Power	Energy	Energy with 95% machine availability	Continuous Power	Rule Curve for Reservoir Operation	
										Elevation	Storage
			m^3/sec	m	m^3/sec	MW	MU	MU	MW	m	MCM
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*		
June	I	10	48.56	157.66	48.56	69.54	16.69	16.42	69.54	447.00	1713.91
	II	10	48.56	157.40	48.56	69.43	16.66	16.42	69.43	447.00	1713.91
	III	10	48.56	158.06	48.56	69.72	16.73	16.42	69.72	447.00	1713.91
July	I	10	48.56	158.46	48.56	69.89	16.77	16.42	69.89	447.00	1713.91
	II	10	48.56	158.03	48.56	69.70	16.73	16.42	69.70	447.00	1713.91
	III	11	48.56	160.11	48.56	70.62	18.64	18.06	70.62	447.00	1713.91
Aug	I	10	48.56	161.89	48.56	71.41	17.14	16.42	71.41	447.00	1713.91
	II	10	48.56	162.68	48.56	71.76	17.22	16.42	71.76	447.00	1713.91
	III	11	48.56	158.54	48.56	69.93	18.46	18.06	69.93	447.00	1713.91
Sep.	I	10	48.56	160.11	48.56	70.62	16.95	16.42	70.62	447.00	1713.91
	II	10	48.56	157.40	48.56	69.43	16.66	16.42	69.43	447.00	1713.91
	III	10	48.56	160.98	48.56	71.00	17.04	16.42	71.00	447.00	1713.91
Oct.	I	10	48.56	160.66	48.56	70.86	17.01	16.42	70.86	447.00	1713.91
	II	10	48.56	166.61	48.56	73.49	17.64	16.42	73.49	455.00	1927.62
	III	11	48.56	170.60	48.56	75.25	19.86	18.06	75.25	455.00	1927.62
Nov.	I	10	48.56	171.16	48.56	75.49	18.12	16.42	75.49	455.00	1927.62
	II	10	48.56	171.40	48.56	75.60	18.14	16.42	75.60	455.00	1927.62
	III	10	48.56	171.33	48.56	75.57	18.14	16.42	75.57	455.00	1927.62
Dec.	I	10	48.56	171.55	48.56	75.67	18.16	16.42	75.67	455.00	1927.62
	II	10	48.56	171.67	48.56	75.72	18.17	16.42	75.72	455.00	1927.62
	III	11	48.56	172.01	48.56	75.87	20.03	18.06	75.87	455.00	1927.62
Jan.	I	10	48.56	171.99	48.56	75.86	18.21	16.42	75.86	455.00	1927.62
	II	10	48.56	171.83	48.56	75.79	18.19	16.42	75.79	455.00	1927.62
	III	11	48.56	171.45	48.56	75.62	19.96	18.06	75.62	455.00	1927.62
Feb.	I	10	48.56	171.41	48.56	75.61	18.15	16.42	75.61	455.00	1927.62
	II	10	48.56	171.80	48.56	75.78	18.19	16.42	75.78	455.00	1927.62
	III	8	48.56	171.86	48.56	75.80	14.55	13.13	75.80	455.00	1927.62
Mar.	I	10	48.56	171.31	48.56	75.56	18.13	16.42	75.56	455.00	1927.62
	II	10	48.56	171.15	48.56	75.49	18.12	16.42	75.49	455.00	1927.62
	III	11	48.56	171.07	48.56	75.45	19.92	18.06	75.45	455.00	1927.62
Apr.	I	10	48.56	169.94	48.56	74.96	17.99	16.42	74.96	455.00	1927.62
	II	10	48.56	170.01	48.56	74.99	18.00	16.42	74.99	455.00	1927.62
	III	10	48.56	167.62	48.56	73.94	17.74	16.42	73.94	455.00	1927.62
May	I	10	48.56	168.46	48.56	74.30	17.83	16.42	74.30	452.33	1855.15
	II	10	48.56	165.13	48.56	72.84	17.48	16.42	72.84	449.67	1783.33
	III	11	48.56	160.66	48.56	70.86	18.71	18.06	70.86	447.00	1713.91
							642.14	**599.18**			