KANDIAH HYDROPOWER (PRIVATE) LIMITED

SCHEDULE I
(Regulation 3(1))

The Registrar
National Electric Power Regulatory Authority

SUBJECT: **APPLICATION FOR A GENERATION LICENSE TO NEPRA**

I, Mobashir A. Malik, Chief Executive Officer being the duly authorized representative Kandiah Hydropower (Private) Limited, by virtue of Board Resolution dated 27th June 2015 hereby apply to the National Electric Power Regulatory Authority for the grant of a Generation License to the Karot Power Company (Pvt) Limited, pursuant to section (3) of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

I certify that the documents-in-support attached with this application are prepared and submitted in conformity with provisions of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulation, 1999 and undertake to abide by the terms and provisions of the above said regulations. I further undertake and confirm that the information provided in the attached documents in support is true and correct to the best of my knowledge and belief.

A bank draft # 0207250 in the sum of Rupees 697,360/- being the non-refundable license application fee calculated in accordance with Schedule-II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, is also attached herewith.

Mobashir A. Malik
Chief Executive Officer

Date: 28 July 2015

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

COMPANY REGISTRATION OFFICE

1st Floor SLIC Building No.7, Blue Area,
Islamabad

CERTIFICATE OF INCORPORATION

[Under Section 32 of the Companies Ordinance, 1984 (XLVII of 1984)

Corporate Universal Identification No. **0084370**

I hereby certify that **KANDIAH HYDRO POWER (PRIVATE) LIMITED** is this day incorporated under the Companies Ordinance, 1984 (XLVII of 1984) and that the company is **limited by shares.**

Given under my hand at Islamabad this 30th day of June, Two Thousand and Thirteen.

Fee Rs. **52,000/-**

(Muhammad Mudassar Rahim)
Joint Registrar of Companies

No. JR1 57
Dated 1/7/13

THE COMPANIES ORDINANCE, 1984

--:o:--

(PRIVATE COMPANY LIMITED BY SHARES)

--:o:--

Articles of Association

of

KANDIAH HYDRO POWER (PRIVATE) LIMITED

PRELIMINARY

1. Subject as hereinafter provided, the Regulations contained in Table 'A' of the First Schedule to the Companies Ordinance, 1984, (hereinafter referred to as Table 'A') shall apply to the Company so far as those are applicable to Private Companies, with the exception of the Regulations which are modified, altered or added hereunder.

PRIVATE LIMITED COMPANY

2. The Company is a Private Company within the meaning of Clause (28) of Section 2(1) of the Companies Ordinance, 1984 and accordingly :-

(a) No invitation shall be issued to the public to subscribe for any shares, debentures or debenture-stocks of the Company.

(b) The number of members of the Company (exclusive of persons in the employment of the Company) shall be limited to fifty provided that for the purpose of this provision when two or more persons hold one or more shares in the Company jointly they shall for the purposes of this clause be treated as a single member ; and

(c) The right to transfer shares in the Company is restricted in the manner and to the extent hereinafter appearing.

BUSINESS

3. The Company is entitled to commence business from the date of its incorporation.

4. The business of the Company shall include all or any of the objects enumerated in the Memorandum of Association.

5. The business of the Company shall be carried out at such place or places in the whole of Pakistan or elsewhere as the Directors may deem proper or advisable from time to time.

CAPITAL

6. The Authorised Capital of the Company is Rs. 10,000,000/- (Rupees Ten Million only) divided into 100,000 ordinary shares of Rs. 100/- (Rupees One Hundred only) each with powers to the company from time to time to increase and reduce its capital subject to any permission required under the law.

7. The shares shall be under the control of the Board of Directors who may allot or otherwise dispose of the same to such persons, firms, corporation or corporations on such terms and conditions and at any such time as may be thought fit.

8. The shares in the capital of the Company may be allotted or issued in payment of any property, land, machinery or goods supplied or any services rendered to the Company or promotion or formation of the Company or conduct of its business and any shares so allotted may be issued as fully paid shares.

SHARES, TRANSFER AND TRANSMISSION

9. Every person whose name is entered as a member in the Register of Members shall without payment, be entitled to a certificate under the Common Seal of the Company specifying the shares held by several persons. The Company shall not be bound to issue more than one certificate and delivery of a share certificate to any one of several joint holders shall be sufficient delivery to all.

10. The Directors may decline to register any transfer of share to transferee of whom they do not approve and shall be bound to show any reasons for exercising their discretion subject to the provisions of Sections 77 and 78 of the Companies Ordinance, 1984.

11. No share can be mortgaged, pledged, sold, hypothecated, transferred or disposed off by any member to a non-member without the previous sanction of the Board of Directors.

12. The legal heirs, executors or administrators of a deceased holder shall be the only persons to be recognised by the Directors as having title to the shares. In case of shares registered in the name of two or more holders the survivors and the executors of the deceased shall be the only persons to be recognised by the Company as having any title to the shares.

GENERAL MEETING

13. The First Annual General Meeting shall be held within 18 months from the date of incorporation of the Company in accordance with the provisions of Section 158 and thereafter once at least in every year and within a period of four months following the close of its financial year and not more than fifteen months after the holding of its last preceding Annual General Meeting as may be determined by Directors. The Directors may, whenever they think fit, call an Extraordinary General Meeting of the shareholders in terms of Section 159 of the Companies Ordinance, 1984.

PROCEEDINGS AT GENERAL MEETING

14. Twenty one days' notice atleast specifying the place, day and hour of the General Meeting and in case of special business the general nature of such business, shall be given to the members in the manner provided in Table "A" but accidental omission to give such notice to or non-receipt of such notice by the member shall not invalidate the proceedings of the General Meeting.

15. The Chief Executive, with the consent of a meeting at which quorum is present and shall if so directed by the meeting may adjourn the meeting 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.

QUORUM

16. No business shall be transacted at any General Meeting unless a Quorum of members is present at the time when the meeting proceeds to business. Two members, present in person, representing not less than 25% of the total voting power either on their own account or as proxies, shall form a Quorum for a General Meeting.

VOTES OF MEMBERS

17. At any General Meeting a resolution put to the vote of the General Meeting shall be decided on a show of hands, unless a poll is demanded in accordance with the provisions of Section 167 of the Companies Ordinance, 1984.

18. On a show of hands every member present shall have one vote and on a poll, every member present in person or by proxy shall have one vote in respect of each share held by him.

19. The instrument appointing a proxy and the power of attorney or other authority under which it is signed or notarially certified copy of that power of attorney or authority shall be deposited at the Registered Office of the Company not less than forty eight hours before the time for holding the meeting at which the person named in the instrument proposes to vote and in default, the instrument of proxy will not be treated as valid.

CHAIRMAN

20. The Directors may from time to time appoint one of their members to be the Chairman of the Company for a period not exceeding three years on such terms and conditions as they deem fit. The Chairman shall preside over the meetings of the Board of Directors and members of the Company. In his absence, the Directors may elect one of them to preside over Board's / General Meetings. The questions arising at the meeting of the Directors shall be decided by a majority of votes. In the case of equality of votes, the Chairman or the Director presiding over the meeting, as the case may be, shall have a casting vote.

CHIEF EXECUTIVE

21. The first Chief Executive of the Company will be appointed by the Board of Directors within fifteen days from the date of incorporation of the Company who shall hold office till the first Annual General Meeting.

DIRECTORS

22. Unless otherwise determined, the number of Directors shall not be less than two. The following are the first Directors of the Company.

1. **MOBASHIR AHMED MALIK**
2. **SADIA MALIK**

23. The election of the Directors shall be held in accordance with the provisions of Section 178 of the Companies Ordinance, 1984.

24. The first Directors including the Chief Executive, shall hold office upto the First Annual General Meeting in accordance with the provisions of the Companies Ordinance, 1984, unless any one of them resigns earlier or becomes disqualified for being Director or otherwise ceases to hold office.

25. A resolution for removing a Director shall not be deemed to have been passed if the number of votes against him is less than the number of votes that would have been necessary for the election of Directors at the immediately preceding annual election of Directors in the manner aforesaid but as provided under Section 181 of the Companies Ordinance, 1984.

26. The remuneration of Directors except regularly paid Chief Executive and full time working Directors shall, from time to time, be determined by the Board of Directors but it shall not exceed Rs. 500/- per meeting at which the Directors are present.

27. The Directors may sanction the payment of such additional sums as they may think fit to any Director for any special service he may render to the Company or be thought capable of rendering either by fixed sum or in any other form as may be determined by the Directors subject to the provisions of the Companies Ordinance, 1984.

28. The Director who resides out of station shall also be entitled to be paid such travelling and other expenses for attending the meeting for the Company as may be fixed by the Directors from time to time according to the provisions of the Companies Ordinance, 1984.

29. Any casual vacancy occurring on the Board of Directors shall be filled in by a resolution of the Board of Directors and the person so appointed shall hold office for the remainder of the term of the Directors in whose place he is appointed.

30. No Director shall be disqualified from his office by contracting with the Company either as vendor, purchaser or otherwise nor shall any Director be liable to account for any profit realised from any such contract or arrangement or the fiduciary relation thereby established, but the nature of his interest must be disclosed by him at the first meeting of the Directors after acquisition of his interest.

NOMINEE DIRECTOR

31. In addition to the elected Directors, the Financial Institutions shall be entitled, during the currency of their respective loan(s) to the Company to appoint one person on the Board of Directors of the Company to be called Nominee Director and to recall and/or replace such a person from time to time. Such Nominee Director on the Board of Directors of the Company may not be holders of share(s) in the Capital of the Company and regulations and/or rules pertaining to the election, retirement, qualification and/or disqualification of Directors shall not apply to him.

NOTICES

32. Notices for every meeting of the Board of Directors will be given in writing and there must be given a reasonable time in advance. The nature of the business to be transacted at an intended Board meeting will be specified in the notice.

MANAGEMENT

33. The whole business and affairs of the Company shall, subject to the control and supervision of the Board of Directors, be managed and controlled by the Chief Executive.

34. Subject to the limit fixed by the Directors, the Chief Executive may from time to time raise or borrow any sums of money for and on behalf of the Company from other companies, banks or financial institutions on such terms as may be approved by the Board of Directors from time to time.

35. Without prejudice to the powers conferred by these Articles, the Board of Directors shall have the following powers :-

(a) To take on lease, purchase, erect or otherwise acquire for the Company any assets, stocks, lands, buildings, property, rights or privileges which the Company is authorised to acquire at such price and generally on such terms and conditions as they think fit.

(b) To let, mortgage, sell, exchange or otherwise dispose of absolutely or conditionally all or any part of the assets, stocks, raw materials, properties, privileges and undertaking of the Company upon such terms and conditions and for such consideration as they think fit.

(c) To appoint any person or persons to be attorney or attorneys of the Company for such purposes and with such powers, authorities and discretions and for such period and subject to such conditions as they may, from time to time, think fit.

(d) To enter into, carry out, rescind or vary all financial arrangements with any bank, person, company, firm or corporation or in connection with such arrangements to deposit, pledge or hypothecate property of the Company or the documents representing or relating to the same.

(e) To make and give receipts, release and discharge all moneys payable to the Company and for the claims and demands of the Company.

(f) To compound or allow time to the payment or satisfaction of any debt due to or by the Company and any claim and demands by or against the Company and to refer claims or demands by or against the Company to arbitration and observe and perform the awards.

(g) To institute, prosecute, compromise, withdraw or abandon any legal proceedings by or against the Company or its affairs or otherwise concerning the affairs of the Company.

(h) To raise and borrow money from time to time for the purposes of the Company, on the mortgage of its property or any part thereof and/or on any bond or debenture payable to bearer otherwise repayable in such a manner and generally upon such terms as they think fit.

(i) To open, operate and maintain bank/banks account(s) individually or jointly as the Board may authorise or to any other person on its behalf.

(j) To manage, control, administrator, regulate and decide all affairs of the Company, the decision of the Board of Directors in respect of any issues pertaining to the Company including all the disputes between Share Holders shall be final with no recourse.

BORROWING POWERS

36. The Directors may from time to time raise, borrow or secure the payment of any sums for the purposes of the Company in such manner and upon such terms and conditions as they think fit and in particular by the issue of debentures, debenture-stock or other securities charged upon all or any part of the property of the Company present or future.

37. Debentures, debenture-stock, or other securities may be issued with any special privileges as to redemption, surrender, allotment of shares, attending and appointment of Directors or other privileges subject to any permission required by law.

THE SEAL

38. The Company shall have a Common Seal and the Directors shall provide for the safe custody of the same. The Seal shall not be applied on any instrument except by the authority of the Board of Directors and in the presence of atleast two Directors who shall sign every instrument to which the Seal shall be affixed in their presence. Such signatures shall be conclusive evidence of the fact that the Seal has been properly affixed.

ACCOUNTS

39. The Directors shall cause to be kept proper books of account as required under Section 230 of the Companies Ordinance, 1984.

40. The books of account shall be kept at the registered office of the Company or at such other place as the Directors shall think fit subject to the provisions of Section 230 of the Companies Ordinance, 1984.

AUDIT

41. Once at least in every year the accounts of the Company shall be audited and correctness of the Balance Sheet shall be ascertained by one or

more Auditors. The Auditors shall be appointed and their duties regulated in accordance with the provisions of Section 252 to 255 of the Companies Ordinance, 1984.

INDEMNITY

42. In connection with carrying on the business of the Company, the Chief Executive, every Director, or other officers of the Company shall be indemnified by the Company for all losses and expenses occasioned by error of judgement or oversight on his part, unless the same happens through his own dishonesty or wilful act and defaults.

SECRECY

43. No member shall be entitled to visit and inspect the Books of the Company without the permission of the Chief Executive or one of the Directors or to require discovery of any information regarding any detail of the Company's business or any matter which is or may be in the nature of trade secret, or secret process which may relate to the conduct of the Company's business and which in the opinion of the Directors, will not be in the interest of the members of the Company to communicate to the public.

ARBITRATION

44. Whenever any difference arises between the Company on the one hand and the members, their executors, administrators or assignee on the other hand, touching the true intent or construction or the incident or consequence of these present or of the statutes or touching any thing thereafter done, executed, omitted or suffered in pursuance of these presents or otherwise relating to these presents or to any statutes affecting the Company, every such difference shall be referred for the decision of the arbitrator who will be qualified in Islamic law.

45. The cost incidental to any such reference and award shall be at the discretion of the arbitrator or umpire respectively who may determine the amount thereof and direct the same to be shared between the attorney and client or otherwise and may award by whom and in what manner the same shall be borne and paid.

WINDING UP

46. If the Company is wound up whether voluntarily or otherwise the liquidator may, with the sanction of a special resolution, divide amongst the contributories in specie any part of the assets and liabilities of the Company, subject to Section 421 and other provisions of the Companies Ordinance, 1984 as may be applicable.

We, the several persons whose names and addresses are subscribed below, are desirous of being formed into a Company, in pursuance of these Articles of Association, and we respectively agree to take the number of shares in the Capital of the Company as set opposite to our respective names.

Name and Surname (Present & Former) in Full (in Block Letters)	N.I.C. No. (in case of foreigner, Passport No)	Father's / Husband's Name (in Full)	Nationality with any former Nationality	Occupation	Residential Address (in Full)	Number of shares taken by each sub-scriber	Signatures
1. MOBASHIR AHMED MALIK	35202-2919231-5	S/o Malik Mehr Din	Pakistani	Construction Business	H. No. 174 - C, Model Town, Lahore.	50 Fifty	
2. SADIA MALIK	35202-2733553-4	*Wife of* Bilal Ahmed Chaudhry	Pakistani	Construction Business	H. No. 174-C, Model Town, Lahore.	50 Fifty	
3. Associated Technologies (Pvt) Limited Incorporation # L-00492	--	--	Pakistani	Company	142 - D, Model Town, Lahore.	9,900 Nine Thousand Nine Hundred	
					Total Number of Shares Taken	10,000 Ten Thousand	

Dated this 20th Day of June, 2013.

Witness:

National Institutional Facilitation Technologies (Pvt.) Ltd.
5th Floor, AWT Plaza,
I. I. Chundrigar Road,
Karachi.

THE COMPANIES ORDINANCE, 1984

--:o:--

(PRIVATE COMPANY LIMITED BY SHARES)

--:o:--

Memorandum of Association

of

KANDIAH HYDRO POWER (PRIVATE) LIMITED

I. The name of the Company is **"KANDIAH HYDRO POWER (PRIVATE) LIMITED"**.

II. The Registered Office of the Company will be situated in the Islamabad Capital Territory.

III. The objects for which the Company established, are all or any of the following : -

1. To design, construct, acquire, own, operate and maintain power generation complexes and to carry on the business of electricity generation, power transmission and distribution services, over hauling and re-powering of power plants and to deal in electrical and other appliances cables, dry cells accumulators, lamps and to work, generate, accumulate, distribute and supply electricity for the purpose of light, heat, motive power and for all other purposes for which electrical energy can be employed and to manufacture and deal in all apparatuses and things 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 incidently hereafter discovered in dealing with electricity.

2. To carry out the business of manufacturers and suppliers of power generation plants and distribution systems of power, steam, gas, diesel, hydro thermal power, solar, transfer of technology, manufacturing of solar cell / biogas / windmills and any other new technology, gas-generators, farmers, carriers and merchants, and to buy, sell, manufacturer, repair, convent, alter, let on hire, and deal in machinery including workshops and field services.

3. To manufacture and deal in all apparatuses and things 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 incidentally hereafter discovered in dealing with electricity and also to deal in sale of spares and equipments required for the above purposes whether as manufacturers, importer and / or as indentor / trader.

4. To provide consultancy services and to enter into and perform any plant / power plant operation and maintenance (O&M) agreement as contractor or subcontractor or any other engineering, construction erection, and supervision contract with regard to the plants / power plants and to enter negotiation and agreements with governments authorities / agencies semi government bodies or any other private associations, persons, corporations and companies for the sale of fuel supply or other inputs, sale of electricity in any mode.

5. To carry on the business of hydro electric sides, operation and maintenance, services of power generation plants and distribution systems of power, steam, gas, diesel, solar, gas-generators, farmers, carriers and merchants, and to buy, sell, manufacturer, repair, convent, alter, let on hire, and deal in machinery including workshops and field services.

6. To register the company with National and International bodies for availing carbon credit against emission reduction and to market carbon credit in local and international market for the benefit of the company.

7. To carry on business of agricultural farming, dairy farming, poultry farming, sheep farming and fish farming in all perspectives and to sell, process, store or deal in any manner with the products and by-products derived from all such farms and for that purpose to undertake do all such acts, deeds, and things which would be required to carry on the above said functions effectively and efficiently.

8. To make use of the by-products derived from the agricultural farming, dairy farming, fish farming, poultry farming, animal keeping, slaughter house and other operations mentioned in these presents in any profitable manner including preparation of manure, fertilizer, bio-fuels and any other feasible use thereof and to do all such acts, deeds and things as would be required to derive maximum benefit of the products and by-products.

9. To carry on and undertake trading business and to act as indentors, importers, exporters, traders, suppliers, manufacturers and commission agents of general item products and materials in any form or shape manufactured or supplied by any company, firm, association of persons, body, whether incorporated or not, individuals, Government, Semi-Government or any local authority.

10. To acquire, own, construct, establish, install, maintain, work, manage, operate, control or aid in or contribute or subscriber to the construction, erection and maintenance of recreational water games park, equipment and machines of amusement, swimming pools, fountains, pleasure grounds and parks.

11. To apply for tender, offer, accept, purchase or otherwise acquire any contracts and concessions for or in relation to the projection, execution, carrying out, improvements, management, administrations or control of works and conveniences and undertake, execute, carry out, dispose of or otherwise turn to account the same.

12. To carry on in or outside Pakistan the business of manufacturers, importers, exporters, indentors, transporters, dealers in all articles and commodities akin to or connected with any of the business of the Company capable of being conveniently carried on or necessary for the promotion of the objects herein contained, as permissible under law.

13. To carry on business and obtain licences for shipping agents, clearing and forwarding agents, purchasing and indenting agents, selling agents, (except managing agent) on such terms and conditions as the Company may think proper, subject to any permission as required under the law.

14. To carry on agency business (except managing agency) and to acquire and hold selling agencies and to act as selling agents, commission agents, manufacturers' representatives and distributing agents of and for the distribution of all kinds of legally permissible merchandise, goods, commodities, products, materials, substances, articles and things whether finished, semi-finished, raw, under process, refined, treated or otherwise pertaining to trade and commerce and for that purpose to remunerate them and to open and maintain depots and branches.

15. To purchase, take on lease or in exchange, hire, apply for or otherwise acquire and hold for any interest, any rights, privileges, lands, building, easements, trade marks, patents, patent rights, copyrights, licences, machinery, plants, stock-in-trade and any movable and immovable property of any kind necessary or convenient for the purposes of or in connection with the Company's business or any branch or department thereof and to use, exercise, in respect of or otherwise turn to account any property, rights and information so acquired, subject to any permission required under the law.

16. To acquire by concession, grant, purchase, barter, licence either absolutely or conditionally and either solely or jointly with others any lands, buildings, machinery, plants, equipments, privileges, rights, licences, trade marks, patents, and other movable and immovable property of any description which the Company may deem necessary or which may seem to the Company capable of being turned to account, subject to any permission as required under the law.

17. To act as representatives, for any person, firm or company and to undertake and perform sub-contracts, and also act in the business of the Company through or by means of agents, sub-contractors and to do all or any of the things mentioned herein in any part of the world and either alone or in collaboration with others and by or through agents, sub-contractors or otherwise.

18. To go in for, buy or otherwise acquire and use any patent design, copyright, licence, concession, convenience, innovation, invention, trade marks, rights, privileges, plants, tools or machinery and the like in Pakistan or elsewhere, which may for the time being appear to be useful or valuable for adding to the efficiency or productivity of the Company's work or business, as permissible under the law.

19. To acquire and carry on all or any part of the business or property of any person, firm, association suitable for any of the purposes of the Company or carrying on any business legally permissible which this Company is authorised to carry on and in consideration for the same, to pay cash or to issue shares of the Company, and to undertake the liabilities of associated undertakings.

20. To enter into arrangements with the government or authority (supreme, municipal, local or otherwise) or any corporation, company or persons that may seem conducive to the Company's objects or any of them and to obtain from any such government, authority, corporation, company or person any charters, contracts, rights, privileges and commission which the Company may think desirable and to carry on exercise and comply with any such charters, contracts, decrees, rights, privileges and concessions.

21. To enter into partnership, to amalgamate and / or to buy on all interests, assets, liabilities, stocks or to make any arrangement for sharing profits, union of interests, co-operation, joint-venture, reciprocal concession or otherwise with any person, firm or company carrying on or proposing to carry on any business which this Company is authorised to carry on or which is capable of being conducted so as directly or indirectly to benefit this Company and to have foreign collaborations and to pay royalties / technical fees to collaborators, subject to the provisions of the Companies Ordinance, 1984.

22. To establish, promote or assist in establishing or promoting and subscribe to or become a member of any other company, association or club whose objects are similar or in part similar to the objects of this Company or the establishment or promotion of which may be beneficial to the Company, as permissible under the law.

23. To open accounts with any Bank or Banks and to draw, make, accept, endorse, execute, issue, negotiate and discount cheques, promissory notes, bills of exchange, bills of lading, warrants, deposit notes, debentures, letter of credit and other negotiable instruments and securities legally permissible.

24. To arrange local and foreign currency loans from scheduled banks, industrial banks and financial institutions for the purpose of purchase, manufacture, market, supply, export and import of machinery, construction of factory, building and for the purpose of working capital or for any other purpose.

25. To sell or otherwise dispose of the whole or any part of the undertaking of the Company, either together or in portions for such consideration as the Company may think fit and in particular, for shares, debenture-stock or securities of any Company purchasing the same.

26. To borrow or raise money by means of loans or other legal arrangements from banks, or other financial institutions, or Directors in such manner as the Company may think fit and in particular by issue of debentures, debenture stock, perpetual or otherwise convertible into shares and to mortgage, or charge the whole or any part of the property or assets of the Company, present or future, by special assignment or to transfer or convey the same absolutely or in trust as may seem expedient and to purchase, redeem or pay off any such securities.

27. To pay all costs, charges, and expenses preliminary or incidental incurred in formation or about the promotion and establishment of the Company and to remunerate any person, firm or company for services rendered or to be rendered in or about the formation or promotion of the Company or the conduct of its business.

28. To give any servant or employee of the Company commission in the profits of the Company's business or any branch thereof and for the purpose to enter into any agreement or scheme of arrangement as the Company may deem fit and to procure any servants or employees of the Company to be insured against risk of accident in the course of their employment by the Company.

29. To establish and support or aid in the establishment and support of associations, institutions, funds and conveniences calculated to benefit persons who are or have been Directors of or who have been employed by or who are serving or have served the Company or any other Company which is a subsidiary or associate of the Company or the dependents or connection of such persons and to grant pensions, gratuities, allowances, reliefs and payments in any other manner calculated to benefit the persons described herein.

30. To distribute any of the Company's property and assets among the members in specie or in any manner whatsoever in case of winding up of the Company.

31. To guarantee the performance of contract and obligations of the Company in relation to the payment of any loan, debenture-stock, bonds, obligations or securities issued by or in favour of the Company and to guarantee the payment or return on such investments.

32. To carry out joint venture agreements with other companies or countries within the scope of the objects of the Company.

33. To cause the Company to be registered or recognised in any foreign country.

34. To do and perform all other acts and things as are incidental or conducive to the attainment of the above objects or any of them.

35. To apply for and obtain necessary consents, permissions and licences from any Government, State, Local and other Authorities for enabling the Company to carry on any of its objects into effect as and when required by law.

36. Notwithstanding anything stated in any object clause, the Company shall obtain such other approval or licence from the competent authority, as may be required under any law for the time being in force, to undertake a particular business.

37. It is declared that notwithstanding anything contained in the foregoing object clauses of this Memorandum of Association nothing contained therein shall be construed as empowering the Company to undertake or to indulge in business of payment systems, Electronic funds transfers in and outside Pakistan, deposit taking from general public, banking company, leasing, investment, managing agency, insurance business, any of the NBFC business, multi-level marketing (MLM), Pyramid and Ponzi Scheme, commodity, future contract or share trading business locally or internationally, directly or indirectly as restricted under the law or any unlawful operation.

IV. The liability of the members is limited.

V. The Authorised Capital of the Company is Rs. 10,000,000/- (Rupees Ten Million only) divided into 100,000 ordinary shares of Rs. 100/- (Rupees One Hundred only) each with powers to the company from time to time to increase and reduce its capital subject to any permission required under the law.

We, the several persons whose names and addresses are subscribed below, are desirous of 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 as set opposite to our respective names.

Name and Surname (Present & Former) in Full (in Block Letters)	N.I.C. No. (in case of foreigner, Passport No)	Father's / Husband's Name (in Full)	Nationality with any former Nationality	Occupation	Residential Address (in Full)	Number of shares taken by each sub-scriber	Signatures
1. MOBASHIR AHMED MALIK	35202-2919231-5	S/o Malik Mehr Din	Pakistani	Construction Business	H. No. 174 - C, Model Town, Lahore.	50 Fifty	
2. SADIA MALIK	35202-2733553-4	*Wife of* Bilal Ahmed Chaudhry	Pakistani	Construction Business	H. No. 174-C, Model Town, Lahore.	50 Fifty	
3. Associated Technologies (Pvt) Limited Incorporation # L-00492	--	--	Pakistani	Company	142 - D, Model Town, Lahore.	9,900 Nine Thousand Nine Hundred	
					Total Number of Shares Taken	10,000 Ten Thousand	

Dated this 20th Day of June, 2013.

Witness:

National Institutional Facilitation Technologies (Pvt.) Ltd.
5th Floor, AWT Plaza,
I. I. Chundrigar Road,
Karachi.

TECHNOLOGY, SIZE OF PLANT, NUMBER OF UNITS

- **Technologies**
  Run of River Type Hydropower Project

- **Size of Palnt**
  545MW

- **Number of Units**
  3 Pelton vertical units

INFRASTRUCTURE

- 548 MW Kaigah Hydropower Project is proposed in a difficult terrain in terms of accessibility and transportation. Existing road network does not have capability of improvement or up-gradation and almost the whole length of approximately 25 km is to be attended within Kandiah valley.

- The existing bridge at Kandiah-Indus confluence is the sole connection of the valley with KKH which will be submerged in the reservoir of proposed Dasu Hydropower Project. The Consultants of proposed Dasu Hydropower Project have proposed the construction of bridge near Seo village to provide access to the inhabitants of Kandiah valley to KKH. The reservoir of proposed Dasu Hydropower Project will infringe approximately 4 km stretch within Kandiah valley. The Consultants of Dasu Hydropower Project have proposed a road along the right bank of River Indus which will enter the Kandiah valley upto the Komaila, Dasu.

- 2 small bridges will be needed within the Kandiah valley to cater for the movement of local population.

- The road within Kandiah valley will be constructed according to two pronged approach i.e.

i. Road upto Powerhouse site
ii. Road upto Dam site

Road upto Powerhouse site is proposed with better strength and wider dimensions as the electromechanical equipment will have to be transported through it. However, for Dam site, Project road capable of transportation of construction material only will be enough to serve the purpose.

- As the landslides in Kandiah valley is a frequent phenomenon after the floods of 2010, retaining walls will be constructed to safeguard the road against any severe damage. The location of retaining structures will be marked during the detail engineering studies.

- Staff colonies will be established at two points i.e. near dam site and near powerhouse area. The area required for the same is proposed in the feasibility report. Moreover, temporary installations by the contractor during construction period are also taken into account.

- Provisions for improvement of educational and health facilities in the project area are provided. Better amenities will improve the life standards of the local population

System studies, load flow, short circuit, stability, reliability

Load-flow Analysis

Carried out to asses' impact on all Indus River plants, particularly, Kaigah hydro power plant during normal and single line contingency scenarios under steady state system condition.

Transient Stability Analysis

Carried-out to study/asses behavior of a particular plant and its impact on other plants in system during large system disturbance i.e. fault/single line outage contingency scenarios.

Short Circuit Analysis

It is carried out to compute fault levels at grid stations after finalization of inter connection schemes for determination of rating of switch gear and other equipment to be installed in the power plants and sub-station. It also helps to find-out impact on equipment installed in other NTDC system and to mitigate bad effects on system and to suggest ways and means to correct.

Max. Net head	523.9 m
Min. Net head	480.0 m

vi. **Information regarding size of Units as required pursuant to Regulation 3(6)(A)(c) (4) of the Regulations.**

Installed plant capacity	545 MW
Plant Factor	44.24 %
Turbine Type	Pelton vertical
No. of units	3 (@185 MW)
Turbine centerline level	972.65 m.a.s.l
Generator	3
Annual mean energy	2112 GWh

vii. **Tunnel (if proposed): length, diameter as required pursuant to Regulation 3(6)(A)(c)(5) of the Regulations.**

Headrace Tunnel	
Diameter	7.7 m
Length	17058 m
Tailrace Tunnel	
Size of tunnel	8 m
Length	3383.4 m
Diversion Tunnel	
Size of tunnel	8
Length	730 m

viii. **ESSA (Environmental and social soundness) study as required pursuant to regulation (3)(6)(A)(C)(8) of the Regulations.**

ESSA has already been conducted and has been approved by EPA/KPK vide their letter # EPA/EIA/DAM/KAIGAH/204 dated 04 May 2015.

ix. About 900 persons of four villages will have to be relocated/resettled. The resettlement plan has been proposed in Environmental and Social Impact Assessment study which has been duly approved by the concerned authority EPA Khyber Pakhtunkhwa vide their Letter # EPA/EIA/DAM/KAIGAH/204 dated 04 May 2015

x. **Environmental protection agency has granted No Objection Certificate, which is enclosed with this letter**

xi. **Interconnection with National GRID Co. distance and name of nearest grid, voltage level (single line diagram) as required pursuant to Regulation 3(6)(a)(c)(11) of the Regulations.**

The Route of the proposed corridor of 500KV transmission line from Basha-1 to Kaigah is as follows:

It is proposed that a 500 KV transmission line emanating from Basha-1 be connected to Kaigah via In-Out Basha-1 to Mardan S/C at Kaigah.

Kaigah-Mardan New 500 kV D/C (operated as an interim arrangement until the commissioning of 2nd stage of Basha).

xii. **Peaking / base load operation as required pursuant to Regulation 3(6)(A)(c)(14) of the Regulations.**

Layout	Left Bank Layout (Including Thauti Nullah)
Dam Height (m)	90.0
High Water Level (m.a.s.l)	1,500
Low Water Level (masl)	
Turbine shaft axis (m.a.s.l)	971.1
Gross Head (m)	528.9
Head losses Hf(m)	29.03
Net Head (m)	499.9
Annual Mean Flow[12] (m^3/s)	71.1
Design discharge (m^3/s)	**125**
Active Storage capacity (hm^3)	20.7
Global efficiency	90.0%
Number of units/ Type / Number of jets	3/Pelton/6
Installed Capacity (MW)	**545**
Annual mean energy (GWh)	**2,026**
Annual peak energy (GWh)	629
Annual off-peak energy (GWh)	1,397
Capacity Factor	0.42
Average Peaking Capacity [MW]	**513**
Firm Peaking Capacity [MW]	**518**

xiii. **System studies load flow, short circuit, stability as required pursuant to Regulation 3(6)(A)(c)(16) of the Regulation.**

500KV HVAC is by far the most economical system for the Hydropower stations on the Indus River and its tributaries. All proposed 500 KV lines are fully justified on the basis of maximum load flows encountered throughout the year and good receiving end voltage and reduced losses.

The system has been designed to provide transmission lines at 500 KV voltage level to all parts of network so that the entire grid system is integrated at 500 KV and 220 KV levels.

xiv. **Interconnection Study from The Concerned Agency**

Concerned agency NTDC has been contacted vide letter No.ATL-015/1240 dated 24 August 2015 for the same.

With best regards,

For Kandiah Hydropower Pvt. Ltd.,

(Mobashir A. Malik)
CEO

House No.25-B, Street No.38, Sector F-8/1, Islamabad
Phone: +92-51-2850522 Fax: +92-51-2851448

ASSOCIATED TECHNOLOGIES PRIVATE LTD.

545 MW KAIGAH HYDROPOWER PROJECT

FEASIBILITY STUDY

[redacted]

[redacted]

JANUARY 2015

SUPPLEMENTARY REPORT ON UPDATED FLOWS AND ENERGY KAIGAH HYDROPOWER PROJECT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF DRAWINGS

LIST OF FIGURES

LIST OF ANNEXURES

UPDATED FLOWS AND ENERGY KAIGAH HYDROPOWER PROJECT

1.0 Introduction

Feasibility Study for 545 MW Kaigah was prepared and submitted to Private Power Infra structure Board in year 2013. The Panel of Experts approved the Feasibility Study after review of draft report and incorporation of observations. The project layout presented in the Feasibility report utilize the flows of Kandian River as well as Thauti nullah. The hydrological studies carried out during Feasibility studies have now been reviewed with due consideration of recent flow measurements on Kandian River and the regional observed flows. Flows estimated at dam site and for Thauti nullah have been revised and energy with and without Thauti nullah contribution has been updated for Kaigah Hydropower Project.

During Feasibility, a gauging station was installed on Kandian River by the sponsoring agency "Associated Technology Limited" (ATL). The station was installed on April 01, 2012 is in operation to strengthen the previously observed flows data on Kandian river. The hydrological data observed during 2006-2009 by SWHP WAPDA were found relatively high in low flows as compared with that of 1993-2001. The extended flows series for Kandian River were prepared based on flows during 1993-2001 during Feasibility Study.

The flows observed during 2012-2014 are found relatively higher than that of 1993-2001. The present study updated the extended flows based on all observed flows for Kandian River. The improvement in flows of Kandian river have positive impact on annual energy which is estimated for Kaigah Hydropower Project with and without contribution from Thauti Nullah.

1.1 Project Location

The project has been planned on the left bank of Kandian River, a right bank tributary of Indus River with its confluence near Kaigah village, 20 km upstream of Dasu town in District Upper Kohistan of Khyber Pakhtun Khwa. Kiagah Hydropower Project has been planned on the lower 24 km stretch of Kandian River upstream of Thauti village.

The access to project area is through Karakuram Highways (KKH) upto Kandian River confluence and then for inside valley on the right bank of Kandian River. The dam site has been proposed on Kandian river near Karrang village, about 30 km from its confluence with Indus River.

The proposed Kaigah Hydropower Project was identified along Kandiah River with dam near Karrang village and powerhouse site is on right bank of Indus River. Kandiah River

has its confluence with the Indus River near Kandiah Bridge, about 20 kilometers upstream of Dasu town.

The dam site identified near Karrang village has reservoir spread over 4 km upstream valley. The dam axis was proposed downstream of confluence of Bangroan Khwar on the right bank and of Dadli Khwar on the left bank. The River bed elevation at dam site has been observed as 1420 m a.s.l and reservoir level was proposed as 1500 m.a.s.l. The headrace tunnel crosses the mountains on the right River bank and follows a nearly straight line to the powerhouse cavern, which is situated on the right Indus bank just opposite to the village Kaigah. The location of the Kaigah Hydropower Project is shown in drawing **KAGF-01.**

The horizontal coordinates of the weir and powerhouse sites are given as follows in **Table – 1**.

Table – 1: Coordinates for Dam and Powerhouse

Site	Latitude	Longitude
Dam site	35°-28'-00"	72°-58'-00"
Powerhouse site	35°-24'-35"	73°-16'-30"

2.0 Hydrological Studies

2.1 Description of the Catchment

Kandian River descends from the mountains peak at 4917.9 masl and 4999 masl. The average gradient of Kandian River in the project area is about 1.8%. The elevation at its confluence with Indus River is 826 m asl. Along the river, the valley supports clustered and scattered population centers on both the banks.

Kandian River is a medium size river with steep river gradient and abundant flows. The main river is formed by a a number of tributaries that joins the main stream to form Kandian river. These streams include: Sami Khwar (584 km^2), Maidain Khwar (419 km^2), Bangroan Khwar (284 km^2), Soyal Khwar (98 km^2) and Seri dara (327 km^2). Kandian River is joined by a few tributaries from either bank. The catchment area of the nullah at its confluence with Indus River is about 2408 km^2 and up to dam site, it is 1800 km^2. The catchment area upto gauging station at Thauti bridge located upstream of Thauti nullah confluence is 2047 km^2. The catchment area of Kandian River is illustrated as **Figure-01.**

The neighboring catchments of Kandian river are : Ushu river and Gabral river on the west, Keyal and Duber nullahs on the south, Spat Gah and Chor nullah on the south east, Summer Gah on the north east, and Ghizar River on the north west. As the climatic data in the region is scarce, therefore flows of all neighboring catchments have been considered to update the flow series for Kandian River.

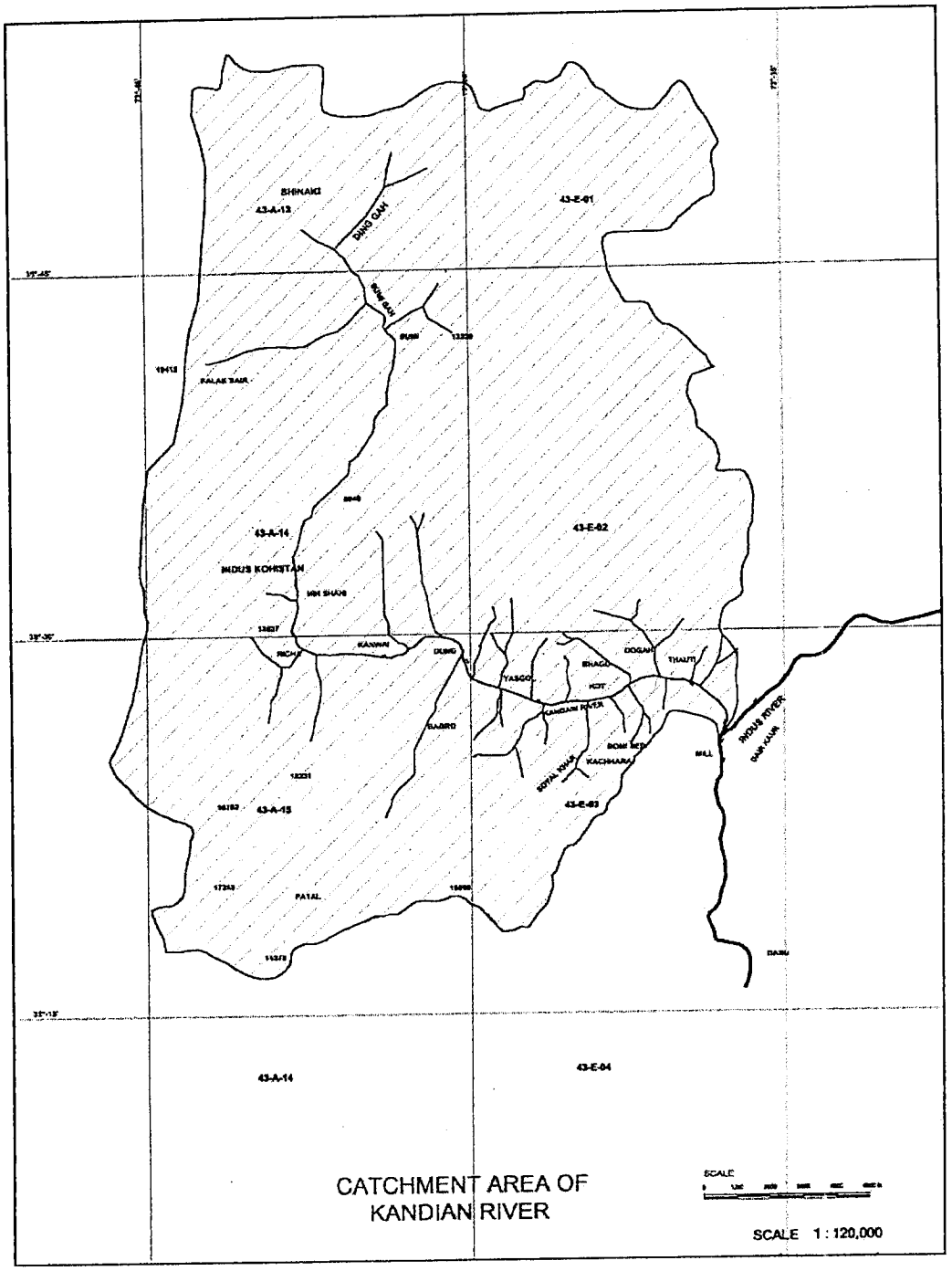

Figure - 1: Catchment Map of Kandian River

2.2 Data Collection

Climatologic and hydrologic data was collected, from the offices of the Pakistan Meteorological Service (PMS) and Surface Water Hydrology Project (SWHP) of WAPDA respectively to update the all the related studies. The data/information includes precipitation, temperature, evaporation and flows on daily basis, instantaneous peak flows and data related to suspended sediment and bed load.

2.3 Climate

The climate of the catchment is characterized by very cold snowy winter and relatively pleasant summer. The high areas of the catchment are permanently clad with snow and glaciers. The climate data in Indus Kohistan and Kandian valley is very scarce. One station in Indus valley with limited climatologically record is located at Chilas. The nearest station to project area with long term climatic data record is located at Besham.

The project area is generally affected by two large-scale meteorological phenomena. The influence of the westerlies is mainly during the winter period causes maximum precipitation in March and monsoon effects, leads to a second precipitation maximum in July/August. Annual isohytal maps of Pakistan is shown as **Figure – 2.**

It indicates that mean annual rainfall in and around project area ranges from 400 mm to 600 mm. The flow data of recording station indicates that the run off generated with precipitation is about 1100 mm. The isohyets indicate that the precipitation with rainfall where as more than 50% is generated with snowfall. As the monsoon influence is declining northwards, summer precipitation on the leeward side of the Karakorum and Himalaya foothills is less pronounced. In the upper Indus valley, north of the project area, no monsoon rainfalls occur and run off is mainly due to snow melt.

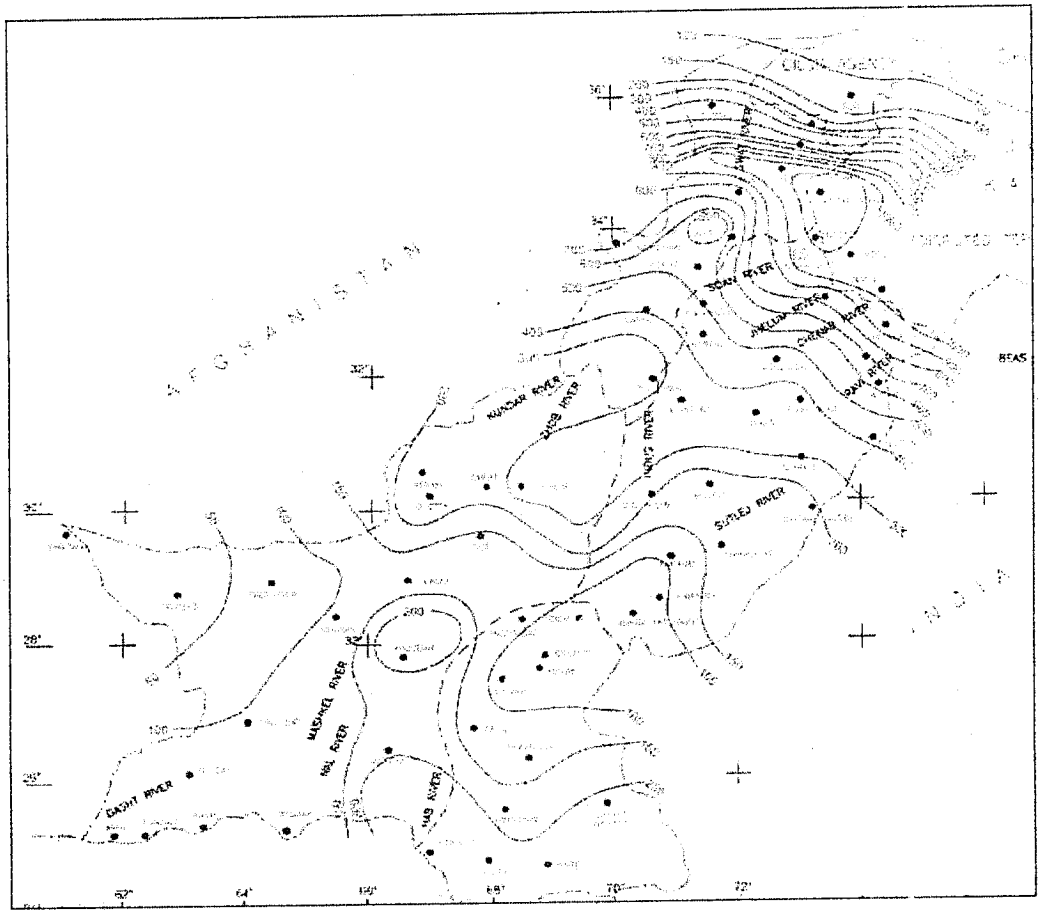

Figure - 2: Annual Isohyets Map of Pakistan

The two types of precipitation climate are illustrated by the long-term average of monthly precipitation observed at Shinkiari and Naran. Besham Qila located south of Kandian valley influences of both climate types. The project area receive major portion of precipitation during winter.

Air temperature and snow conditions depend very much on the elevation of the considered sub area. In the lowest part of the catchments, mean monthly temperatures vary between approximately 5°C in February and 25°C in June, with daily maxima up to 40°C. In the highest parts above 5000 m average temperature is always below zero. Due to the high elevation most of the catchment is snow covered from December to May. Snowmelt is also the governing factor for runoff, which reaches a maximum in May and June. Flood peaks due to monsoon rainfalls typically occur in July and August but the run off volume is due to snow melt.

There are a few climatological stations where long term precipitation data is available. Pakistan Metrological Department operate and maintain stations at Chilas, Bunji and Astore, where Surface Water Hydrology WAPDA observe data at stations: Besham, Shahpur and Kalam. The list of climatological stations in the region is presented in **Table - 2.**

Table - 2: Long Term Climatic Stations in the Region

Station	Period of Record (Years)	Elevation (m.a.s.l)	Latitude	Longitude	Mean Annual Rainfall (mm)
Besham	1971 - 2003	610	34 55 30	72 52 55	1059
Kalam	1966 - 2003	2744	35 28 10	72 35 40	734
Shahpur	1964 - 2004	2012	34 55 00	72 40 00	1132
Chilas	1954 - 2006	1070	34 54 15	73 38 40	195
Astore	1954 - 2004	2363	34 54 15	73 38 40	511
Bunji	1954 - 2004	1340	34 54 15	73 38 40	144

The above table provides the mean annual rainfall data at various stations in Indus Kohistan region. Chilas, Besham, and Kalam stations are located around Kandian river catchment. The western areas towards Besham and Shangla is strongly influenced by monsoon rainfall, while in Chilas area, rainfall is limited. In the north, rainfall influence Swat catchment but snowfall is dominant.

Kandian river catchment is between dry zone of Northern Pakistan and monsoon influenced Indus Kohistan. Due to non availability of climatic data near Kandian valley, data of regional stations have been relied on to estimate the flow variation and the floods for various return periods. The variation in temperature over the catchment in different months affects the snow melt and consequently flows in Kandian River.

2.3.1 Temperature

One meteorological station with long record of temperature is located at Besham at a distance of about 100 km from the project area. The data has been collected from the SWHP WAPDA for the period 1971 to 2003 in order to get the maximum and minimum temperatures on monthly and yearly basis.

The elevation at Besham is about 530 m.a.s.l and upto Dam site in Kandian valley, where the elevation is 1500 m.a.s.l. The Kandian valley near Karrang village would have cooler temperature than Besham by 6 to 8 °C. Mean maximum and minimum temperatures are graphically indicated in **Figure - 2.**

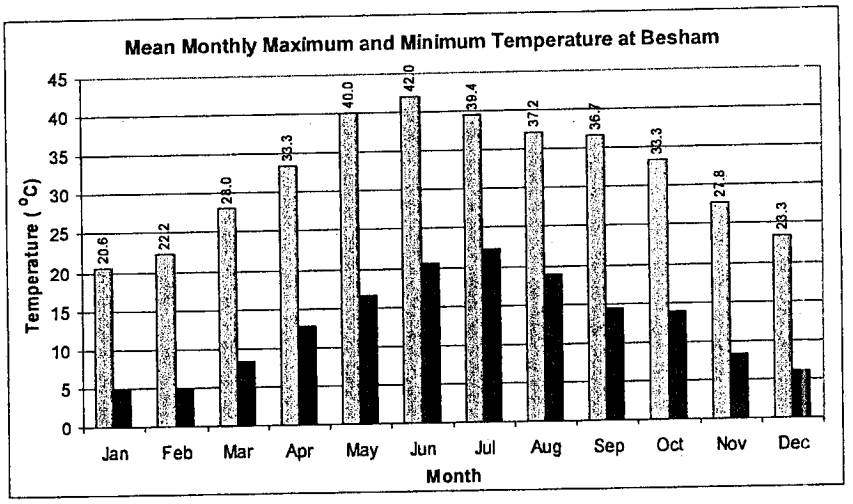

Figure - 3: Mean Monthly Maximum and Minimum Temperature at Besham

The minimum monthly temperature at Besham varies from 5° C in January to 22.5° C in July and maximum monthly temperature varies from 20° C to 42°C from winter to summer months.

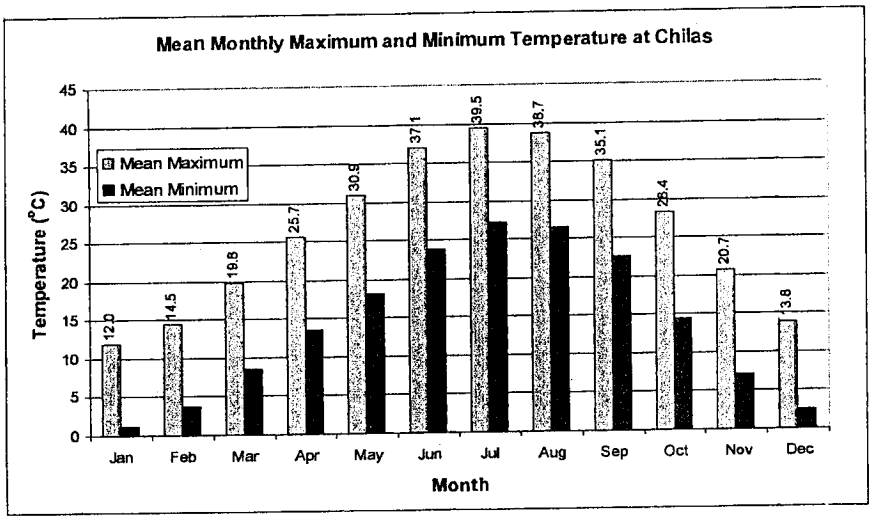

Figure - 4: Mean Monthly Maximum and Minimum Temperature at Chilas

For Chilas town, the climate data was collected from of Pakistan Meteorological Services for the period from 1953 to 2004. The mean monthly maximum and minimum temperature at Chilas are presented in **Figure - 3.**

The variation in temperature pattern is similar to Besham except that Chilas is cooler place than that of Besham due to higher elevation. Chilas is at El. 1050 m.a.s.l which is more closer to project area elevation. January is the coldest month at the project site, when the temperature drops to several degrees below zero. The highest temperatures are experienced in the month of June.

2.3.2 Precipitation

Precipitation data of Besham station was collected from Surface Water Hydrology WAPDA in order to get maximum, minimum and average rainfall on monthly and yearly basis. Annual rainfall at Besham (1970-2004) is shown in the following **Figure - 4.** Mean Annual rainfall varies from 666 mm in 2001 to 1503 mm in 1992. The average of mean annual rainfall is 1000 mm over a period from 1970 to 2004. The monthly rainfall varies from 39.6 mm in November to 327.5 mm in July. The mean monthly rainfall is presented in **Figure - 5.**

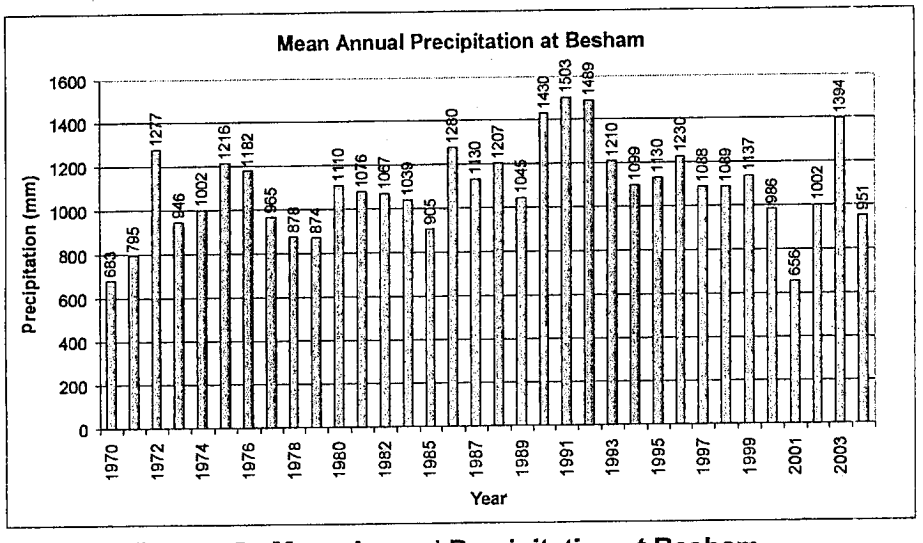

Figure - 5: Mean Annual Precipitation at Besham

From November to May, during the winter period the precipitation is mainly brought by the western disturbances. The precipitation during this part of the year is approximately 690 mm. During summer period, i.e., from June to October, the precipitation in the catchment is induced by the monsoon rainfall and averages to about 844 mm.

Kandian River catchment is located between Besham and Chilas, at about 100 m distance from both towns. The catchment is influenced by winter snowfall and receives less rainfall.

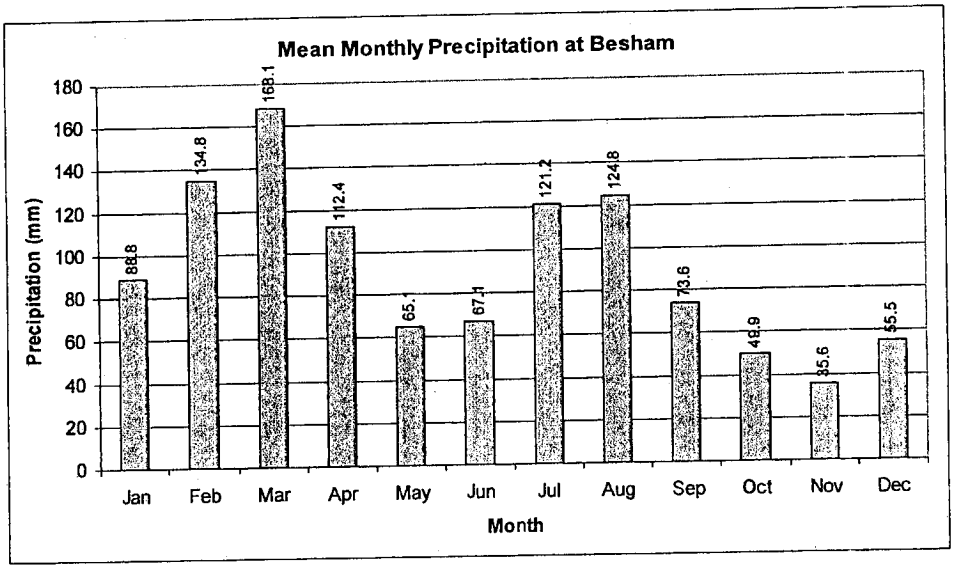

Figure - 6: Mean Monthly Precipitation at Besham

The mean annual precipitation at Chilas is presented in **Figure-6**. The annual precipitation varies from varies from 36 mm in 1977 to 569 mm in 1996. The average annual precipitation at Chilas is 195 mm. The mean monthly rainfall at Chilas is presented in **Figure - 7**.

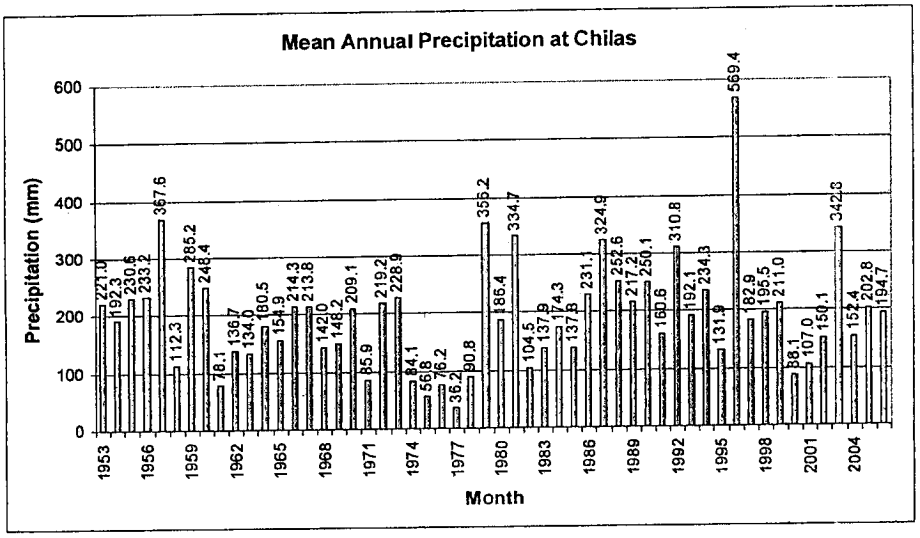

Figure - 7: Mean Annual Precipitation at Chilas

The annual variation of rainfall at Chilas is more as compared with that of Besham. Although the flows in streams of Chilas region mainly depend on snowfall however, the erratic rainfall pattern also influence the annual run off in Chilas area. Similar to Besham, during the winter period the precipitation is mainly brought by the western disturbances. The precipitation during first five months is 130 mm and there is no impact of monsoon during summer months as average rainfall each summer months is less than 20 mm.

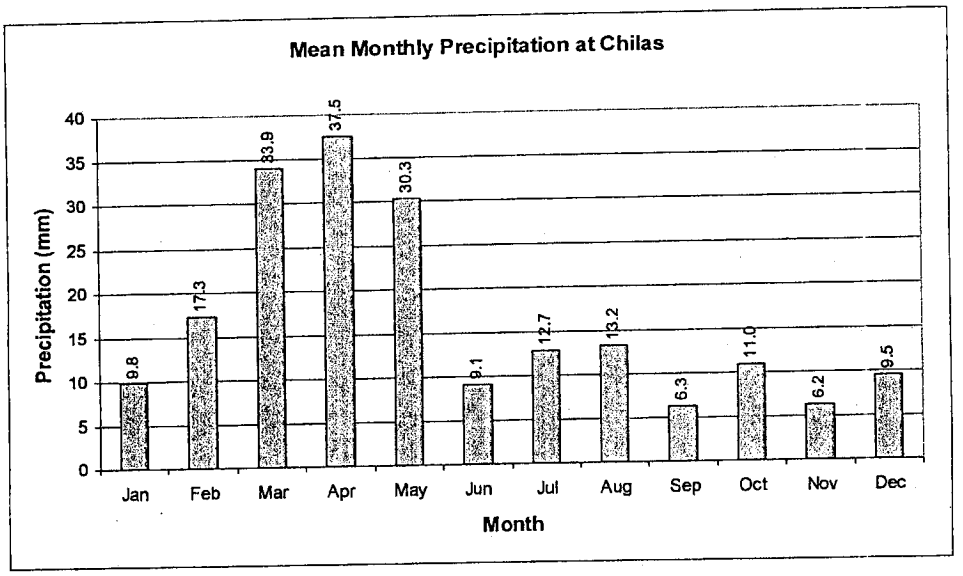

Figure - 8: Mean Monthly Precipitation at Chilas

The climate data of Kalam station was collected from SWHP, WAPDA from the period 1963 to 2006. The mean annual precipitation at Chilas varies from 45 mm in 1964 to 1515 mm in 1992 as indicated in **Figure - 8**. The average of annual precipitation over a period of 44 years is 917 mm. The mean monthly rainfall at Kalam is presented in **Figure - 9**.

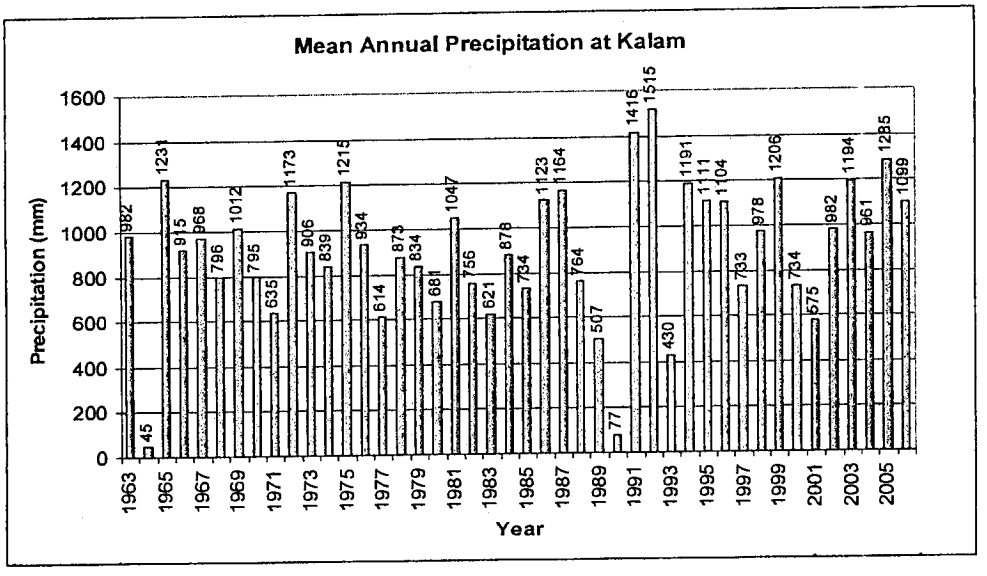

Figure - 9: Mean Annual Precipitation at Kalam

The precipitation during first five months is similar and is comparatively low during remaining seven months as compared to that of Besham. This indicates that Kalam has no effect of monsoon.

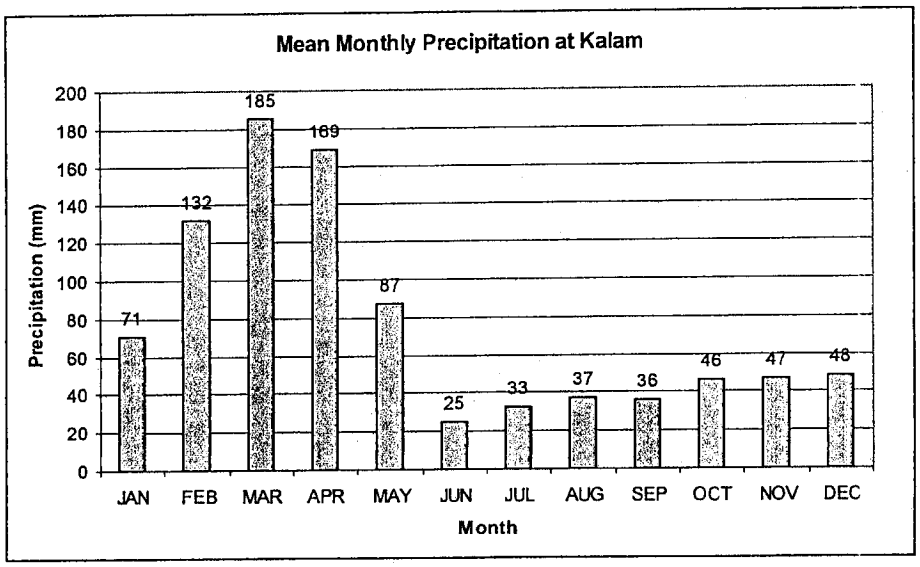

Figure - 10: Mean Monthly Precipitation at Kalam

After analyzing the precipitation of three climatic stations in the region, it is concluded that for Kandian catchment, the impact of monsoon is minor. The precipitations in form of snow fall during winter months mainly provide the run off to Kandian river during summer months.

3.0 Flows Observations

3.1 Hydrological Stations

There are a number of hydrological stations installed on main rivers and potential tributaries around project area for which flow data of 10 or more years is available. Flow measurements have generally been recorded by the Surface Water Hydrology Project (SWHP) WAPDA.

On main Indus River, there are two stations: Basham and Shatial that have long term hydrological data which is considered useful for verification of flow data on tributaries in Indus Kohistan. Besham and Shatial on Indus River and Kalam on Swat River are long term stations where daily flow data is available from SWHP WAPDA. Flows observed on tributaries of Indus River indicate the intensity of precipitation over the region.

Flow record of Kandian River at Thauti bridge, Swat River at Kalam, Spat Gah at Goshali, Duber Khwar at Duber Bala, Keyal Khwar at Shenshal, Summar Gah at Gosak, Thauti nullah at Kapar Banda, Ushu river at Jildat and Gabral river at Gulshanabad stations have been collected for the available period of record. The list of gauging stations with location, elevation, catchment area, and period of record is mentioned in **Table - 3**.

Table - 3: Hydrological Stations with Long Term Records

Sr. No.	Station / River	Location		Elevation (m asl)	Area (km^2)	Period of Record
		Latitude	Longitude			
1	Besham (Indus)	34°55'-27"	72°52'55"	530	163185	1969-2008
2	Shatial (Indus)	35°31'-56"	73° 33'52"	900	154670	1984-2008
3	Kalam (Swat)	35°28'10"	72°35'40"	1921	2020	1961-2011
4	Thuati (Kandian)	34°28'-15"	73°09'05"	980	2370	1993-2001 & 2006-09
5	Kapar Banda (Thuati)	35°28'20"	73°09'15"	946	232	1933-1996
6	Jildat (Ushu)	35°29'15"	72°35'45"	1951	7830	1993-2011
7	Gulshanabad (Gabral)	35°29'45"	72°28'40"	2195	715	1993-2011
8	Gosak (Summer Gah)	35°29'-30"	73°23'55"	1320	147	1991-2001
9	Goshali (Spat Gah)	35°13'-45"	73°12'10"	800	1624	1993-2008
10	Sarchoy (Chor Nullah)	35°04'-47"	73°05'57"	960	1095	1993-2001
11	Shenshal (Keyal)	35°08'-50"	73°02'35"	920	154	1993-2008
12	Duber Bala (Duber)	35°04'25"	72°54'10	823	408	1993-2001
13	Phandar (Ghizar)	36°11'02"	72°49'45"	2652	1450	1995-2006
14	Gilgit (Gilgit)	35°55'35"	74°18'25"	1440	12095	1962-2008

3.2 Regional Flows

The contribution of Flows data of 14 stations in the regions have been analyzed compared by first the annual specific flows. The specific flows of small to medium size streams are compared to check the range of flows in Kandian river catchment. There are two stations on main rivers like Indus river at Besham and Gilgit River at Gilgit. One station on Swat river at Kalam where more than 40 years data is available. There are 8 gauging stations on small to medium size streams where 4 to 20 years record is available. The specific flows of these stations around the project area are presented in **Table - 5**.

Kandian river is the right side tributary of Indus River. Two long term stations on Indus river are at Shatial and Besham with catchment area as 154,670 km^2 and 163,185 km^2 respectively. The long term annual flows indicates that the difference of average annual flow at two stations is 375 m^3/s which is contribution of streams between two stations. The average specific flows of intermediate catchment of 8515 km^2 is 44.0 $l/s/km^2$.

The flow contribution from Summar Gah and Kandian river is between 35 to 40 $l/s/km^2$. The specific flows of Spat Gah, Chor Nullah, Keyal and Duber Khwar has been found as 30, 49.7, 59.1 and 66.6 $l/s/km^2$ respectively. The specific of catchment between Shatial and Dasu is relatively less as compared with that of between Dasu and Besham.

Table - 4: Specific Flows of Various Gauging Stations

No.	Station	Period of Record	Mean Annual Flows (m^3/s)	Specific Flows ($l/sec/km^2$)
1	Besham (Indus)	1969-2008	2403	14.8
2	Gilgit (Indus)	1963-2008	296.7	24.5
3	Kalam (Swat)	1961-2009	88.45	43.8
4	Thuati (Kandian)	1993-2001,06-09	73.4	39.6
5	Kapar Banda (Thauti)	1993-1996	12.41	37.8
6	Gosak (Summer Gah)	1991-2001	5.07	34.4
7	Jildat (Ushu)	1993-2011	35.3	44.1
8	Gulshanabad (Gabral)	1993-2011	30.5	42.6
9	Goshali (Spat Gah)	1993-2008	48.5	30.0
10	Sarchoy (Chor Nullah)	1993-2001	58.6	49.7
11	Shenshal (Keyal)	1993-2011	9.2	59.1
12	Duber Bala (Duber)	1993-2001	25.63	66.6
13	Phandar (Ghizar)	1995-2001	31.4	19.3

On the south, Duber catchment indicates higher specific flows more than 60 $l/s/km^2$ due to monsoon effect. Kalam station located on the east have specific flows more than 40 $l/s/km^2$. Similarly Ushu River at Jildat and Gabral River at Gulshanabad have specific flows range 40 to 45 $l/s/km^2$. Gosak located on the west side have specific flows of about 35 $l/s/km^2$. The specific flows of Kandian River at Thauti and Kapar Banda on Thauti nullah are 35.9 $l/s/km^2$ and 37.8 $l/s/km^2$ respectively. Kalam station on Swat River has longer record of flows and has the specific flow value of 43.8 $l/sec/km^2$.

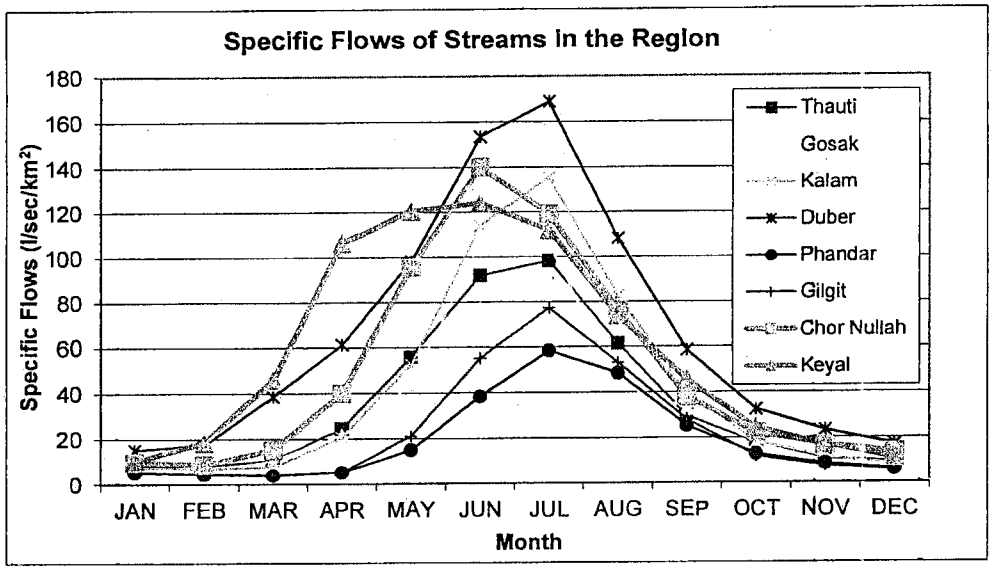

Figure - 11: Comparison of Specific Flows for streams in the Region

Phandar and Gilgit located on the north have much lower specific flow values. The long term stations at Besham and Gilgit have specific flows in the range from 15 to 25 l/sec/km^2. Phandar station have lower specific flows, whereas Summar gah at Gosak and Spat gah at Goshali being located in similar region have closer specific flows with that of Kandian river catchment. As flow record at Gosak and Goshali is short, therefore, these are useful for comparative analysis rather to be used for extension of flows.

Swat River at Kalam, Ushu River at Jildat and Gabral River have similar flow pattern and specific flow range. Gilgit and Phandar station located in the north and receive less precipitation as compared with Thauti, correlation with long term gauging stations at Gilgit and Besham cannot be established. Only Kalam station on Swat River is appropriate to be for extension of flows. The flow record of Thauti nullah at Kapar banda provide additional flow pattern of smaller catchment within Kandian catchment. The comparison of specific flows of various streams in the neighboring region stations is presented in **Figure – 11**.

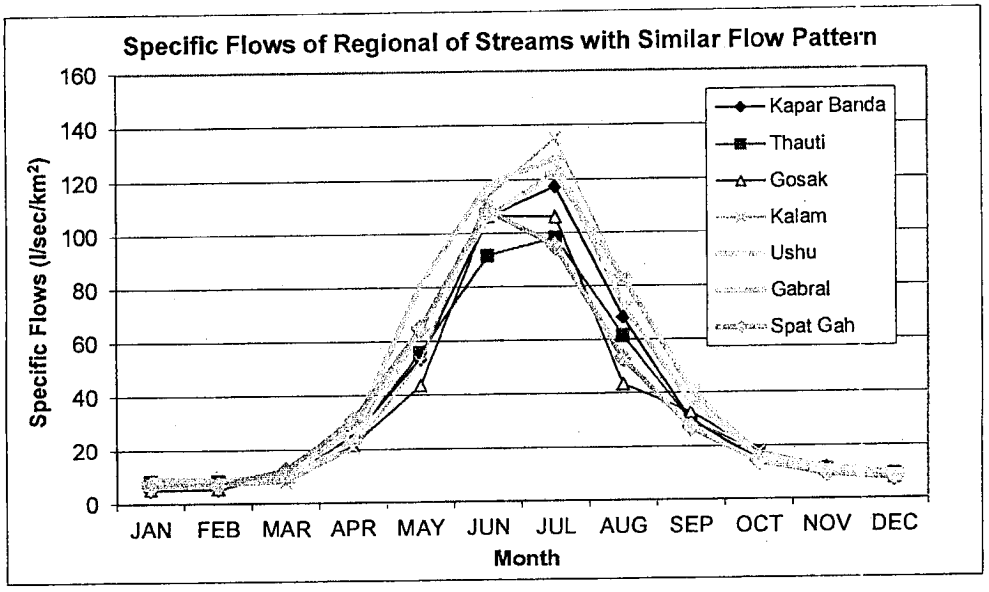

Figure - 12: Comparison of Specific Flows of Streams with Similar Flow Pattern

Kalam station with closer specific flow values to that of Kandian river, is considered the most suitable station for establishing a correlation with Kandian river at Thauti.

3.3 Flow Observations on Kandian River

Kandian River at Thuati bridge is the most relevant station for Kaigah Hydropower Project, where 13 years daily flows record is available. The discharge measurements at this location of Kandian River provide the basis for the estimation of flows.

A gauging station was initially installed by GTZ-WAPDA near Thauti bridge on Kandian River in 1992. On Kandian River, discharge observations were performed from 1992 to 2001, 2006-2010 and 2012-2014. The estimated flows during 1993-2001 by GTZ remalned in a specific range. The flows measured by Surface Water Hydrology WAPDA

during 2006-2010 has been found relatively high as compared with that of 1993-2001. Due to higher values, the flows observed during 2006-209 were not considered to establish a correlation with long gauging station and to be used for extension of flows.

Table – 5 Mean Monthly Observed Flows – Kandian River at Thauti bridge

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Flows (m^3/s)													
93-2001	16.9	16.8	20.6	47.8	112.0	178.8	193.0	122.2	60.4	35.4	22.3	18.8	70.4
2006-09	41.6	41.5	47.0	75.9	118.2	143.8	148.8	125.5	80.0	52.6	44.4	40.5	80.0
2012-14	19.7	17.5	24.5	43.9	88.4	219.7	257.0	189.3	115.2	49.1	35.2	26.3	90.5
Specific Flows ($l/s/km^2$)													
93-2001	8.3	8.2	10.0	23.4	54.7	87.4	94.3	59.7	29.5	17.3	10.9	9.2	34.4
2006-09	20.3	20.3	23.0	37.1	57.8	70.2	72.7	61.3	39.1	25.7	21.7	19.8	39.1
2012-14	9.6	8.6	12.0	21.5	43.2	107.3	125.6	92.5	56.3	24.0	17.2	12.8	44.2

The mean monthly flows of Kandian river at Thauti bridge presented in **Table -4** indicate that mean monthly as well as annual flows for the period 1993-2001 remained low as compared with that flows observed during 2006-2009 and 2012-14. With the recently flow observations 2012-14 at Thauti bridge necessitate to review the flow estimations established based on flows 1993-2001. The specific flows for the period 1993-2001 are also is considered conservative as compared with that of stations in neighboring catchments. The average specific flow for 16 years observation is 36.8 $l/s/km^2$ which is considered more realistic as compared with 34.4 $l/s/km^2$ during 1993-2001.

The flows observed in recent years 2012-14 are relatively higher than observed during 1993-2001 but slightly on lower side than that of 2006-2010. The flows of more than two years are available which is considered useful for extension of flows of Kandian River.

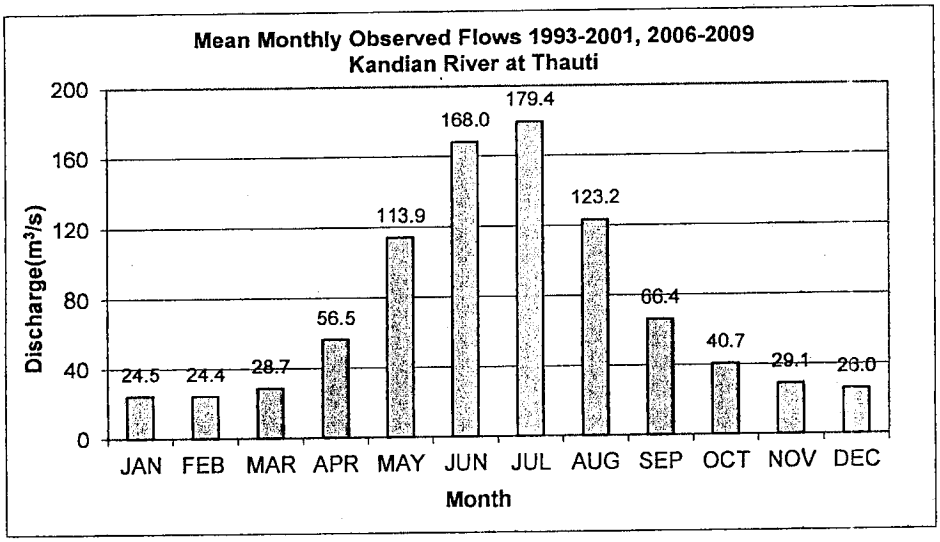

Figure - 13: Mean Monthly Flows - Kandian River at Thauti bridge

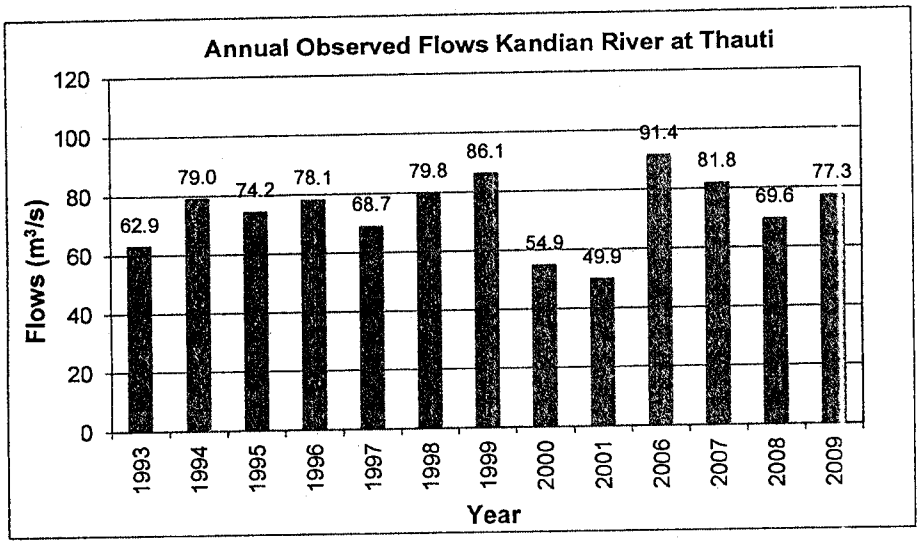

Figure - 14: Mean Annual Observed Flows- Kandian River at Thauti bridge

Thauti bridge is located 22 km downstream of proposed dam site for Kaigah Hydropower Project. The catchment area of Kandian river at dam and Thuati bridge is 1800 km^2 and 2047 km^2 respectively.

The mean monthly flows of Kandian River at Thauti bridge varies from 24.4 to 179.4 m^3/s for the period from 1993 to 2001, 2006-09. The mean annual flows vary from 49.9 to 91.4 m^3/s with mean value as 73.4 m^3/s. The mean monthly and mean annual flows of Kandian River at Thauti bridge are present in **Figures - 12** and **13** respectively.

3.4 Discharge Measurements on Kandian River

The discharge observations were started again in 2012 by ATL, the sponsor of Kaigah Hydropower Project for the Feasibility study. The new gauging station on Kandian river near Thauti river was installed in April 2012 and flow measurements are carried out at regular interval and water levels are observed twice a day. In April 2012, the field investigations were restarted by installing the staff gauges near Thauti bridge. The gauge is installed upstream of Thauti nullah confluence where previous gauge by WAPDA-GTZ was installed.

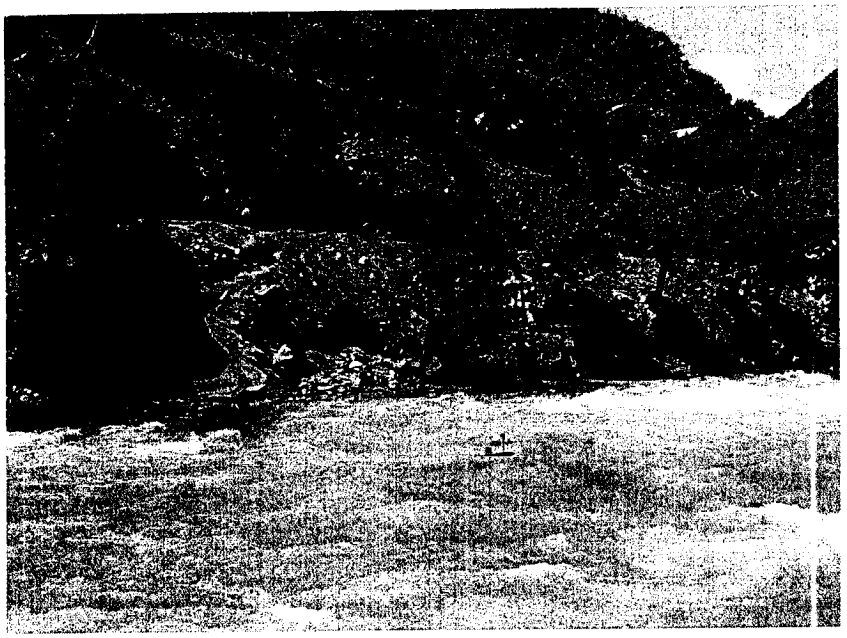

Figure - 15: Flow measurements at Thauti – Kandian river

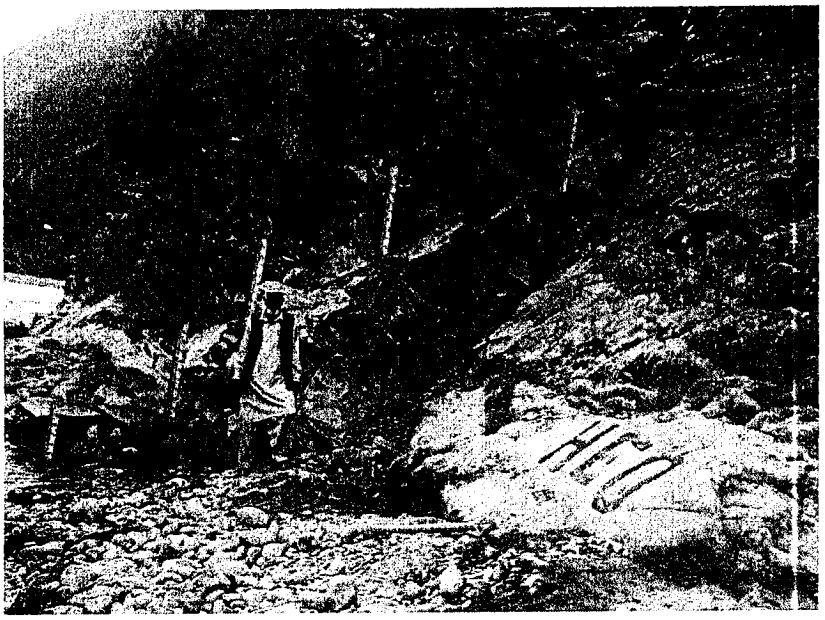

Figure - 16: Installed gauges on the left bank Kandian River at Thauti

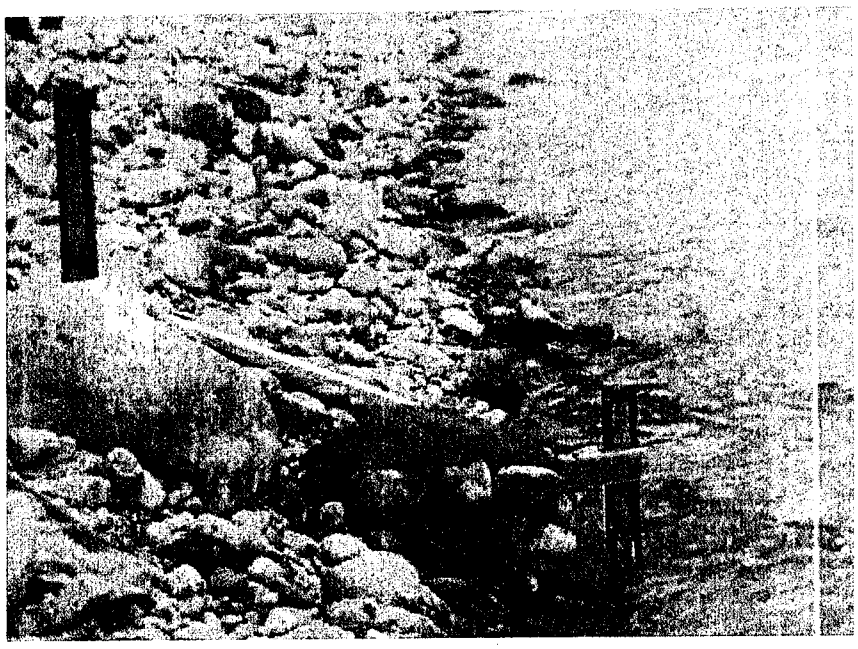

Figure - 17: Installed gauges at Lower Elevations - Kandian River at Thauti

For this study, 31 months field data from April 2012 to October 2014 have been included in the hydrological analysis. For each of observed years; 2012, 2013 and 2014, separate rating curves are developed.

For year 2013, rating curves for low and high flows are indicated in **Figure – 17** and **18**. From the observed data flows have been computed using these rating curves for year 2013.

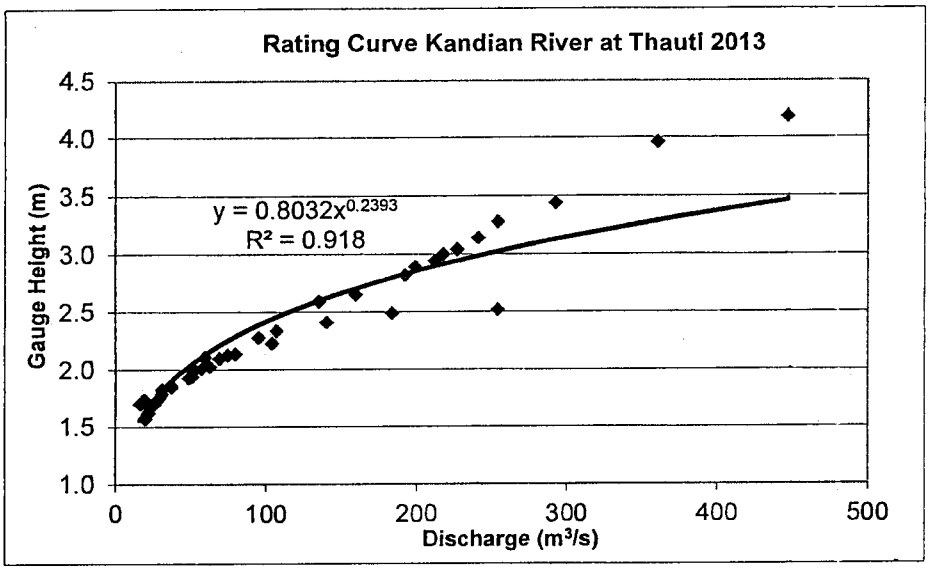

Figure - 18: Rating Curve H < 2.7 m, Kandian River at Thauti bridge

Based on flow measurements and water levels readings, discharge measurements and water level observations, the following equations for rating curve for year 2013;

$Q = 166.66*(H - 1.6238)$ $H > 2.7$ m

$Q = 2.4987*H^{4.7188}$ $H < 2.7$ m

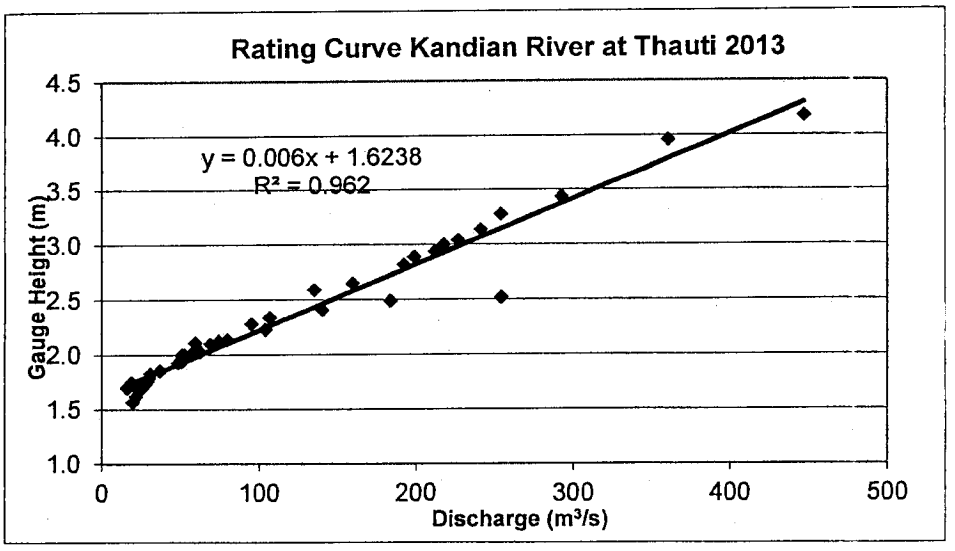

Figure - 19: Rating Curve H > 2.7 m, Kandian River at Thauti bridge

For Year 2012, rating curve equations are :

$Q = 277.7*(H - 1.6492)$ $H > 2.5$ m

$Q = 1.422*H^{5.9211}$ $H < 2.5$ m

For Year 2014, rating curve equations are :

$Q = 161.29*(H - 1.5985)$ $H > 2.9$ m

$Q = 4.2263*H^{3.58166}$ $H < 2.9$ m

The observed discharges during these months is presented in **Table 5** to **7**.With the daily gauge readings and rating curve developed, the daily flows have been estimated for the months of April 2012 to October 2013.

Regulation #	Information	Compliance		Remarks	
		Yes	No		
3(5)(h)	Feasibility Report **(Approved by Government of Pakistan, PPIB Islamabad dated 18 July 2014 copy attached)**	Yes		Annex-T	
3(5)(i)	Prospectus	Yes		Annex-U	
1	Location maps, site maps, land	Yes		Annex-V	
2	Technology, size of plant, number of units	Yes		Annex-W	
3	Fuel: type, imported/indigenous, supplier, logistics, pipelines etc.	Yes		Annex-X	
4	Emission values (Since this is a hydropower project, hence no omissions)	Yes		Annex-Y	
5	Cooling water source: tube wells, sea/river/canal, distance from source, etc.	Yes		Annex-Z	(N/A)
6	Interconnection with Grid Co. distance and name of nearest grid, voltage level (single line diagram)	Yes		Annex-AA	
7	Infrastructure: roads, rail, staff colony, amenities	Yes		Annex-AB	
8	Project cost, information regarding sources and amounts of equity, debt.	Yes		Annex- AC	
9	Project commencement and completion schedule with milestones	Yes		Annex- AD	
10	ESSA (Environmental and Social Soundness Assessment) (Approved from EPA/KPK dated 04-05-2015 copy attached)	Yes		Annex- AE	
11	Safety plans, emergency plans	Yes		Annex-AF	
12	System studies, load flow, short circuit, stability, reliability	Yes		Annex-AG	
13	Plant characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control metering and instrumentation	Yes		Annex-AH	
14	Control, metering, instrumentation and protection	Yes		Annex-AI	
15	Training and development	Yes		Annex-AJ	

Regulation #	Information	Compliance		Remarks	
		Yes	No		
3(5)(h)	Feasibility Report **(Approved by Government of Pakistan, PPIB Islamabad dated 18 July 2014 copy attached)**	Yes		Annex-T	
3(5)(i)	Prospectus	Yes		Annex-U	
1	Location maps, site maps, land	Yes		Annex-V	
2	Technology, size of plant, number of units	Yes		Annex-W	
3	Fuel: type, imported/indigenous, supplier, logistics, pipelines etc.	Yes		Annex-X	
4	Emission values (Since this is a hydropower project, hence no omissions)	Yes		Annex-Y	
5	Cooling water source: tube wells, sea/river/canal, distance from source, etc.	Yes		Annex-Z	(N/A)
6	Interconnection with Grid Co. distance and name of nearest grid, voltage level (single line diagram)	Yes		Annex-AA	
7	Infrastructure: roads, rail, staff colony, amenities	Yes		Annex-AB	
8	Project cost, information regarding sources and amounts of equity, debt.	Yes		Annex- AC	
9	Project commencement and completion schedule with milestones	Yes		Annex- AD	
10	ESSA (Environmental and Social Soundness Assessment) (Approved from EPA/KPK dated 04-05-2015 copy attached)	Yes		Annex- AE	
11	Safety plans, emergency plans	Yes		Annex-AF	
12	System studies, load flow, short circuit, stability, reliability	Yes		Annex-AG	
13	Plant characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control metering and instrumentation	Yes		Annex-AH	
14	Control, metering, instrumentation and protection	Yes		Annex-AI	
15	Training and development	Yes		Annex-AJ	

Table - 6 Kandian River at Thauti bridge

Estimated Flows (m^3/s)

Year 2012

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
1				14.5	36.5	197.1	315.4	258.5	202.2	81.2	52.6	40.4
2				13.9	31.8	147.5	244.7	261.3	187.2	81.2	52.6	39.1
3				15.1	34.1	121.7	272.4	255.8	192.1	78.8	52.6	39.1
4				22.2	37.8	128.6	316.9	255.8	202.2	78.8	50.9	39.1
5				28.6	44.7	151.5	372.4	253.0	207.5	78.8	50.9	39.1
6				27.6	46.2	164.2	383.5	244.7	223.9	76.4	50.9	37.8
7				25.7	49.3	168.6	355.8	241.9	235.4	76.4	49.3	37.8
8				27.6	54.3	173.1	330.8	247.4	241.4	74.2	49.3	37.8
9				28.6	69.8	182.4	300.2	244.7	259.9	74.2	49.3	37.8
10				31.8	83.6	173.1	286.3	308.0	241.4	71.9	49.3	37.8
11				30.7	78.8	168.6	311.3	286.5	223.9	69.8	47.7	36.5
12				29.6	69.8	182.4	300.2	253.6	207.5	69.8	47.7	36.5
13				29.6	59.7	173.1	272.4	241.4	192.1	71.9	47.7	36.5
14				25.7	63.6	177.7	264.1	235.4	177.7	74.2	46.2	36.5
15				24.7	61.6	187.2	308.5	229.6	168.6	69.8	46.2	35.3
16				24.7	67.7	212.8	300.2	223.9	177.7	69.8	46.2	35.3
17				24.7	81.2	192.1	305.8	218.3	173.1	65.6	44.7	34.1
18				28.6	71.9	192.1	308.5	235.4	159.8	63.6	44.7	32.9
19				35.3	63.6	197.1	294.7	247.4	159.8	63.6	44.7	32.9
20				41.8	59.7	187.2	286.3	266.4	143.5	61.6	43.2	32.9
21				47.7	57.9	197.1	289.1	286.5	121.7	65.6	43.2	31.8
22				52.6	57.9	212.8	291.9	300.7	111.8	61.6	43.2	31.8
23				50.9	52.6	223.9	294.7	308.0	102.6	59.7	41.8	31.8
24				44.7	50.9	229.6	300.2	279.7	94.1	59.7	41.8	30.7
25				41.8	57.9	253.6	297.4	259.9	91.4	57.9	41.8	30.7
26				43.2	63.6	266.4	303.0	247.4	94.1	57.9	41.8	28.6
27				40.4	57.9	293.5	300.2	241.4	91.4	57.9	41.8	28.6
28				44.7	71.9	315.4	291.9	229.6	88.7	56.1	40.4	28.6
29				41.8	96.9	293.5	272.4	223.9	86.2	54.3	40.4	27.6
30				36.5	155.6	300.7	272.4	207.5	86.2	54.3	40.4	27.6
31					192.1		266.9	202.2		54.3		27.6

Table - 7 Kandian River at Thauti bridge

Estimated Flows (m^3/s)

Year 2013

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
1	25.8	21.6	21.0	46.7	84.7	152.5	262.7	196.0	168.2	67.4	36.0	26.5
2	25.8	21.6	21.6	49.1	90.6	158.6	252.7	201.0	138.0	67.4	36.0	26.5
3	25.8	21.0	21.6	51.7	88.6	171.4	244.4	207.7	119.6	65.8	36.0	26.5
4	25.8	21.0	22.3	54.3	88.6	195.8	251.0	211.0	110.0	65.8	35.0	26.5
5	25.8	21.0	22.3	55.6	88.6	122.1	254.4	216.0	107.7	64.3	35.0	26.5
6	25.8	20.4	23.0	58.4	88.6	114.7	256.0	214.4	110.0	64.3	35.0	25.8
7	25.1	20.4	23.6	59.8	90.6	110.0	252.7	211.0	107.7	64.3	35.0	25.8
8	25.1	20.4	24.3	62.8	92.6	146.6	244.4	212.7	107.7	62.8	35.0	25.8
9	25.1	20.4	25.1	58.4	94.6	178.2	241.0	211.0	105.4	62.8	34.1	25.1
10	25.1	19.8	25.1	59.8	98.8	235.3	236.0	214.4	103.2	61.3	34.1	25.1
11	25.1	19.8	25.8	65.8	105.4	222.7	227.7	219.4	103.2	59.8	33.2	25.1
12	25.1	19.8	26.5	72.2	105.4	257.7	231.0	216.0	101.0	57.0	33.2	25.1
13	25.1	19.8	26.5	73.9	110.0	426.0	232.7	216.0	101.0	55.6	33.2	24.3
14	24.3	19.8	27.3	81.0	117.1	312.7	236.0	247.7	101.0	55.6	33.2	24.3
15	24.3	19.8	28.9	88.6	124.7	286.0	237.7	224.4	101.0	53.0	33.2	24.3
16	24.3	19.8	29.7	88.6	129.9	281.0	236.0	192.7	94.6	51.7	31.9	24.3
17	24.3	19.8	30.6	84.7	140.8	287.7	232.7	266.5	90.6	50.4	31.5	23.6
18	24.3	19.8	31.4	84.7	152.5	292.7	231.0	248.3	86.6	47.9	31.2	23.6
19	24.3	19.2	32.3	82.8	158.6	296.0	227.7	239.6	81.0	46.7	31.0	23.6
20	23.6	19.2	33.2	82.8	146.6	301.0	229.4	235.3	73.9	46.7	30.6	23.0
21	23.6	19.2	34.1	82.8	161.8	299.4	227.7	226.9	72.2	44.4	30.3	23.0
22	23.6	19.2	35.0	79.2	181.6	302.7	224.4	222.9	72.2	43.3	30.2	22.3
23	23.6	19.8	36.0	77.4	203.3	307.7	221.0	210.9	69.0	43.3	29.9	22.3
24	23.6	19.8	37.0	79.2	199.5	304.4	219.4	203.3	69.0	42.2	28.9	22.3
25	23.0	20.4	38.0	82.8	185.1	296.0	214.4	207.1	70.6	41.1	29.4	21.6
26	23.0	20.4	40.0	86.6	174.8	302.7	207.7	207.1	70.6	40.0	29.3	21.6
27	23.0	20.4	41.1	86.6	164.9	316.0	202.7	214.8	70.6	39.0	28.6	21.0
28	22.3	21.0	42.2	84.7	149.5	299.4	199.4	222.9	70.6	38.0	28.5	21.0
29	22.3		43.3	86.6	140.8	287.7	197.7	218.8	70.6	37.0	27.9	21.0
30	22.3		44.4	88.6	146.6	276.0	194.4	210.9	69.0	37.0	27.7	20.4
31	22.3		45.5		155.6		192.7	207.1		36.0		20.4

Table - 8 Kandian River at Thauti bridge

Estimated Flows (m^3/s)

Year 2014

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
1	20.3	18.9	18.8	26.5	73.5	177.7	355.1	184.5	146.3	53.4		
2	20.3	19.4	18.7	27.7	78.4	209.9	353.5	177.7	146.3	51.5		
3	19.8	19.6	18.5	28.9	79.6	218.0	356.7	173.2	148.2	49.7		
4	19.8	20.1	18.4	30.1	80.9	227.7	348.6	168.9	152.2	47.9		
5	19.8	20.1	18.3	31.4	83.5	235.7	345.4	166.7	152.2	47.1		
6	19.8	20.1	18.2	33.3	86.1	250.2	337.3	166.7	154.2	45.4		
7	19.4	20.0	18.1	34.7	88.8	266.4	342.2	166.7	154.2	45.4		
8	19.8	19.8	18.5	34.0	92.9	250.2	348.6	164.6	152.2	44.5		
9	19.8	19.4	18.5	35.4	98.7	230.9	347.0	164.6	150.2	43.7		
10	19.4	19.0	18.7	35.4	103.1	211.5	353.5	164.6	150.2	43.7		
11	19.4	18.7	18.9	36.8	101.6	173.2	363.1	164.6	148.2	42.9		
12	19.4	18.3	19.8	37.5	100.2	158.3	368.0	162.5	148.2	42.1		
13	19.4	18.3	20.8	38.3	98.7	168.9	376.0	160.4	146.3	41.3		
14	19.4	18.1	22.1	39.0	95.8	213.1	385.7	160.4	146.3	42.1		
15	19.4	17.9	24.3	40.5	94.3	243.8	377.7	160.4	144.3	42.9		
16	19.4	18.0	26.0	39.0	92.9	266.4	369.6	158.3	142.4	42.1		
17	19.4	18.1	29.5	39.8	91.5	282.5	353.5	158.3	138.6	42.1		
18	19.4	18.2	30.7	39.0	90.2	316.4	340.6	154.2	131.3	42.1		
19	19.4	18.3	31.7	38.3	88.8	327.7	326.0	154.2	127.7	42.1		
20	18.9	18.3	29.8	39.0	90.2	348.6	329.3	150.2	120.8	42.1		
21	18.9	18.3	29.1	39.8	94.3	371.2	319.6	152.2	119.1	41.3		
22	18.9	18.3	27.9	41.3	91.5	363.1	306.7	152.2	112.5	41.3		
23	18.9	18.3	29.3	42.9	88.8	358.3	297.0	152.2	106.2	41.3		
24	19.4	18.3	29.1	44.5	95.8	351.9	285.7	150.2	94.3	40.5		
25	18.9	18.4	28.5	47.9	107.8	364.8	268.0	150.2	84.8	40.5		
26	18.9	18.4	28.5	52.4	119.1	359.9	256.7	150.2	80.9	40.5		
27	18.9	18.5	29.1	57.2	138.6	350.2	245.4	152.2	73.5	40.5		
28	18.9	18.5	28.2	60.3	150.2	353.5	234.1	150.2	68.9	39.8		
29	18.9		26.5	63.4	166.7	356.7	226.0	150.2	63.4	39.8		
30	18.9		26.5	66.7	179.9	359.9	216.4	150.2	57.2	39.0		
31	18.9		26.0		173.2		211.5	148.2		39.0		

The mean monthly observed flows as presented in **Figure - 20** and it shows that the maximum flows in the Kandian nullah are in the months of July. The peak flow is due to melting of snow in summer and partly due to the monsoon rainfall. The monthly flow observed on Kandian river varies from 17.5 m^3/s to 257.0 m^3/s. The maximum flows have been observed in the month of June 2013, i.e., 426 m^3/s. The flows have the increasing trend upto June and then start decreasing.

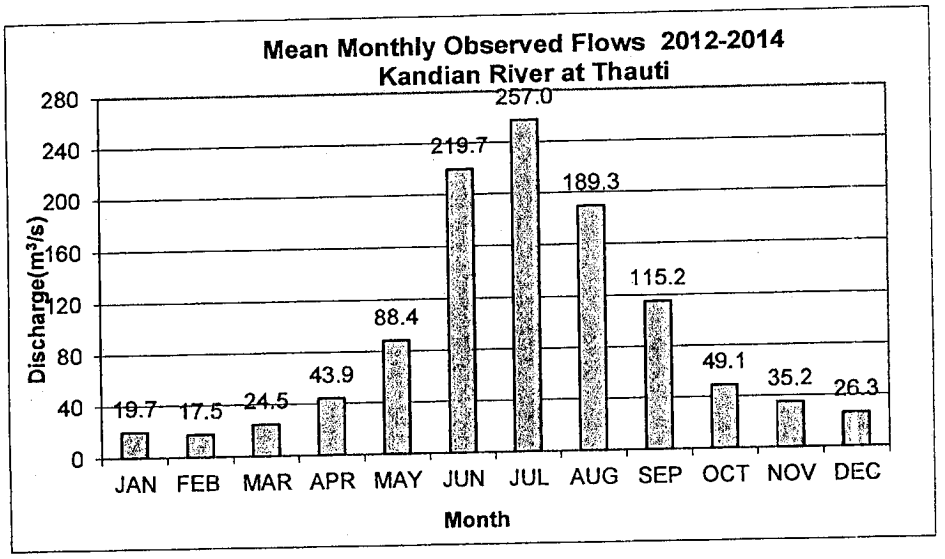

Figure - 20: Observed Flows - Kandian River at Thauti bridge

4.0 Extension of Flows

Long term flows are required at a site to design the proposed project. The methodology for estimation of flows at Kandian River is first to have an extended series of the flows at a station where some years of flow record is available. On Kandian River, daily flow record for few years is available at Thauti bridge on Kandian River.

With the 15 years daily flows record, it would be useful to develop a correlation with a gauging station having similar catchment characteristics and with flow data at least thirty years data. Flow data of streams in the region have been checked to determine the trend of flows over various months as well as over the recorded period.

4.1 Flows of Indus River at Besham

Historic data of daily flows for Indus River at Besham is available from 1969 to 2009. The catchment area of Indus River at Besham is 162,393 km^2. For the recorded period, the average annual flow of Indus River at Besham is 2403 m^3/s. A comparison has been made between the flows at Besham with the flows at Thauti bridge by using the daily flow data for the year 1993 as presented in **Figure 20**.

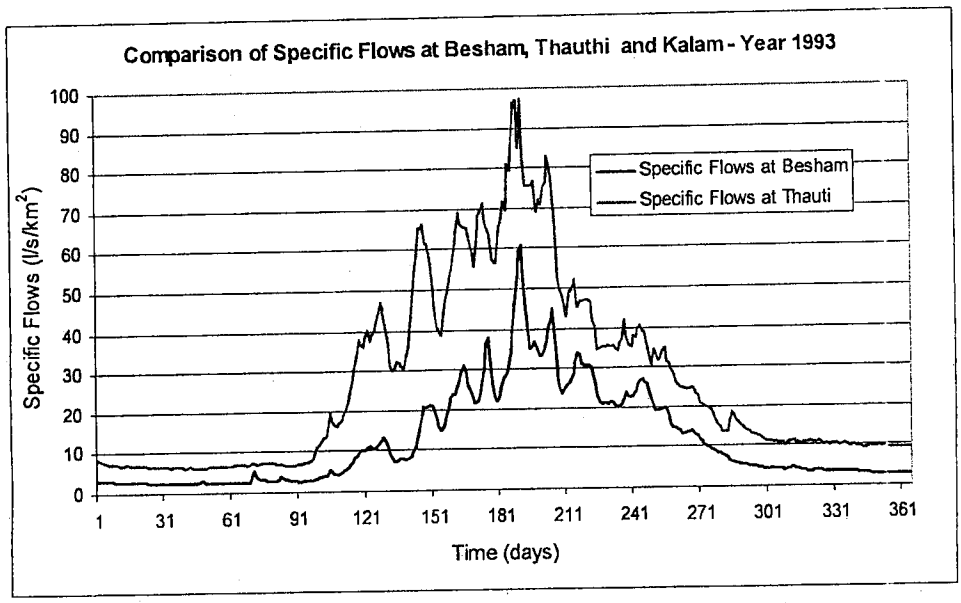

Figure - 21: Comparison of Specific Flows Besham and Thauti.

The above comparison indicates that Kandian River has higher specific flows than of Indus River in summer months. The difference in specific flows rivers during winter period is relatively small. The specific flows of at Besham have similar trend with that of at Thauti bridge. As the catchment of Indus river at Besham is very large as compared with Kandian at Thauti, therefore long term station at Besham is not suitable for developing at correlation with Thauti.

4.2 Kalam - Thauti Correlation

For extension of flows of Kandian river at Thauti, flow data of long term gauging station, Kalam station has been selected to be used as a reference station. Flows of Swat River at Kalam have been analyzed to be used to develop a correlation with Thauti bridge. Swat River at Kalam have longer period of recorded data and similar catchment characteristics is the most suitable station for extension of flow data of Kandian River at Thauti bridge and subsequently to estimate the flows at the proposed dam site.

Historic data of daily flows for Swat River at Kalam is available from 1961 to 2009. The catchment area of Swat River at Kalam is 2020 km^2. For the recorded period, the average annual flow of Swat River at Kalam is 88.0 m^3/s.

Kandian river at Thuati bridge where catchment area is 2047 km^2 have flow record from 1993 to 2001, 2006-09 and 2012-14. For the recorded period, the average annual flow of Swat River at Kalam is 72.89 m^3/s. For the same period 1993-2001, the specific flows of both stations are compared by using daily flow data. The comparison of specific flows of Kalam and Thauti stations is presented in **Figure - 22.**

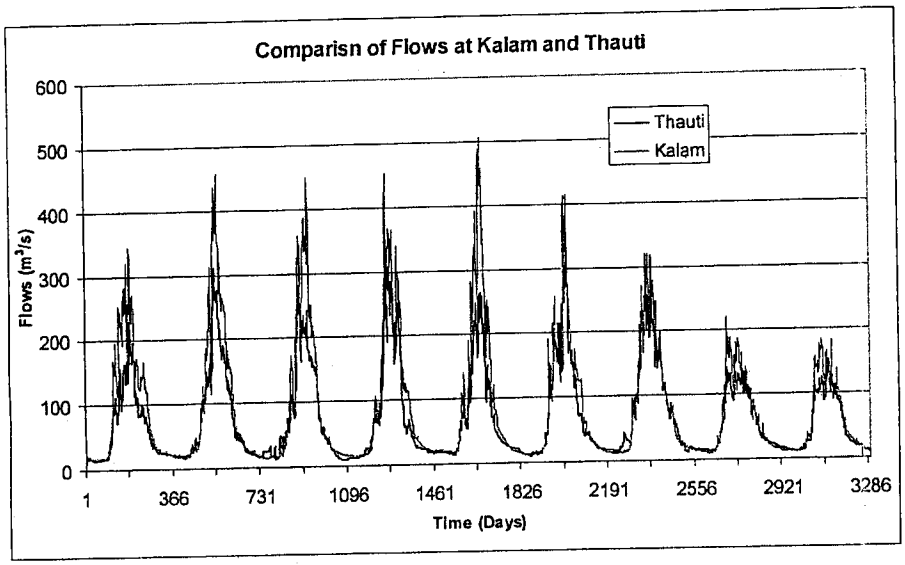

Figure - 22: Comparison of Flows at Kalam and Thauti

The comparison indicates that Kalam River during summer months has higher specific flows than Kandian river at Thauti. Kandian river has some equal or higher specific flows during the winter months than that of Swat River. The regression analysis is carried out and data is correlated as depicted in **Figure - 22,** which shows R^2 value of 0.889. The data in the summer months are closely oriented along the trendline. The equation from the rating curve thus obtained is:

$$y = 0.6457X+19.05$$

Putting the specific flows of Swat River at Kalam (x) in the above equation will give the specific flow of the Kandian River at Thauti (y) for the same period.

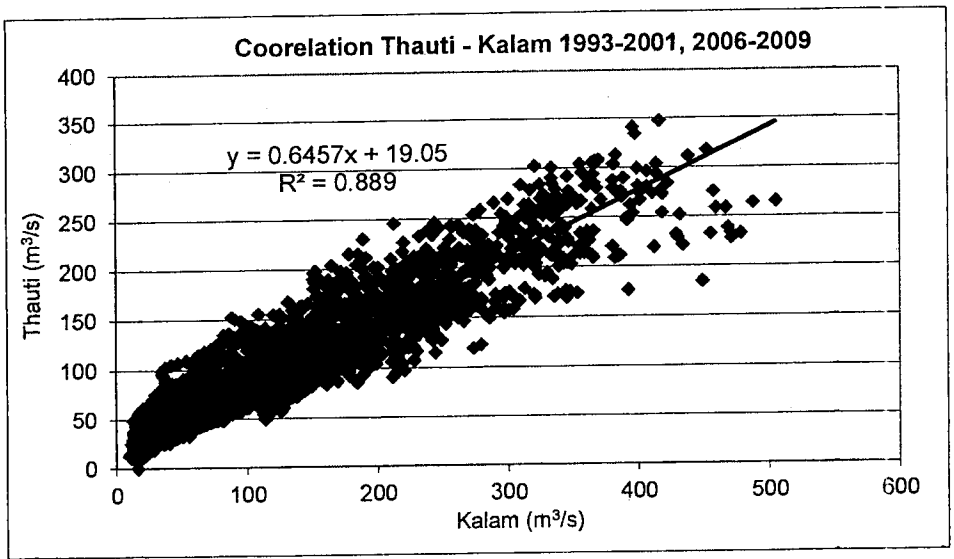

Figure - 23: Relationship between Flows at Thauti and Kalam

The above relation has been applied to Kalam flow data and it has been found that the estimated flow values are found more realistic with the observed values.

4.3 Extended Flow Series - Kandian River

The daily flows have been estimated with the consideration of above established relation. The comparison of monthly measured and estimated flows for the years 1993-2001, 2006-09 and 2012 is shown in **Figure - 22**. The estimated flows in the summer months are comparatively less than the actual flows. The estimated mean annual flow during 14 year period is 78.24 m^3/s against the observed flows of 79.73 m^3/s.

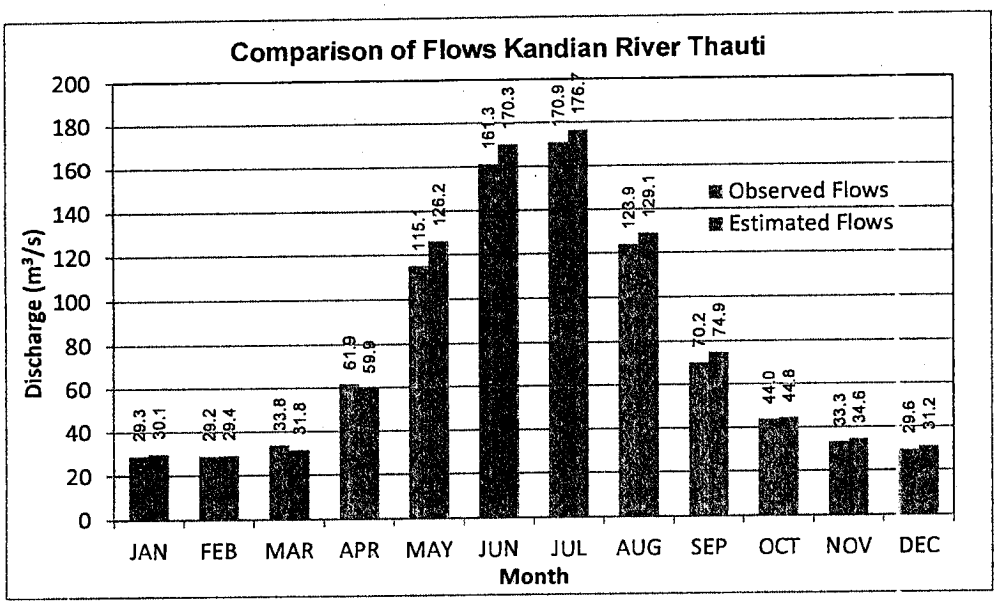

Figure - 24: Estimated and Observed Flows at Thauti bridge

By comparing the observed and the estimated flows of Kandian river, it is clear that the observed flows are in close proximity during April, August, October to May and for the rest of months, the is minor and overall mean annual flows are very close with a difference of 1%.

The extended mean monthly flows of Kandian River estimated from a series of flows at Kalam are given in **Table - 8.** The estimated mean monthly flows are presented in **Figure-25**. The mean monthly flows vary from 29.01 to 179.65 m^3/s. The mean annual flow of Kandian river at Thauti is estimated as 74.8 m^3/s. The annual flows of Kandian River vary from 57.3 to 84.8 m^3/s as presented in the **Figure - 22.**

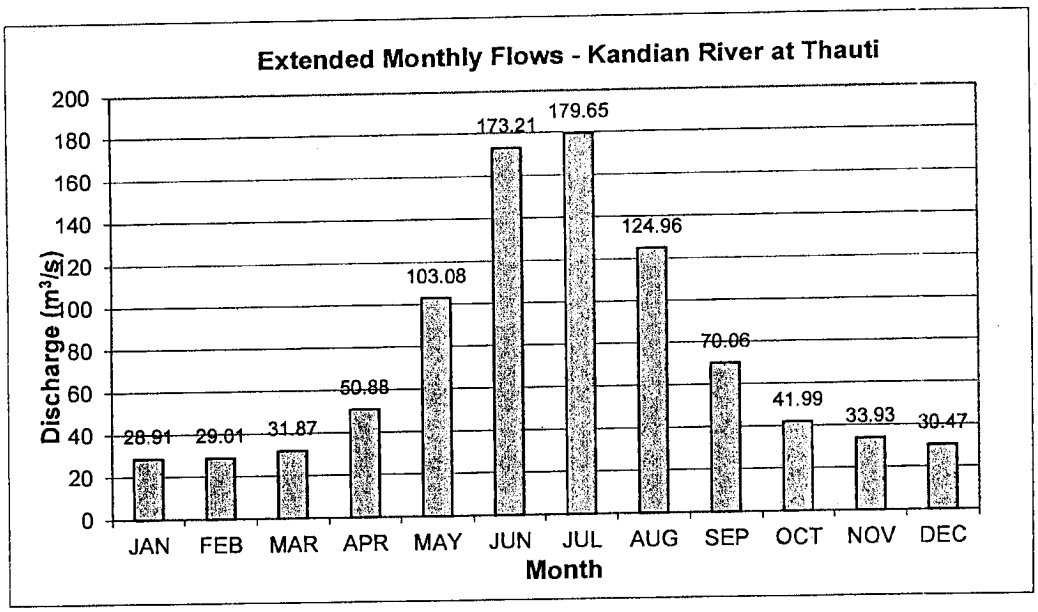

Figure - 25: Extended Mean Monthly Flows - Kandian River at Thauti bridge

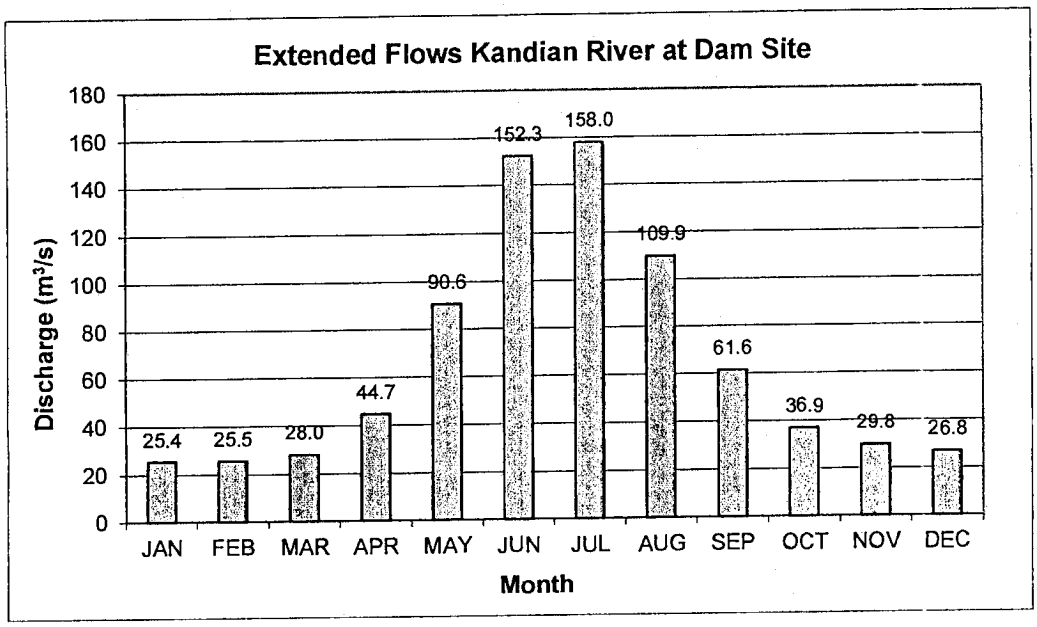

Figure - 26: Extended Mean Monthly Flows - Kandian River at Dam Site

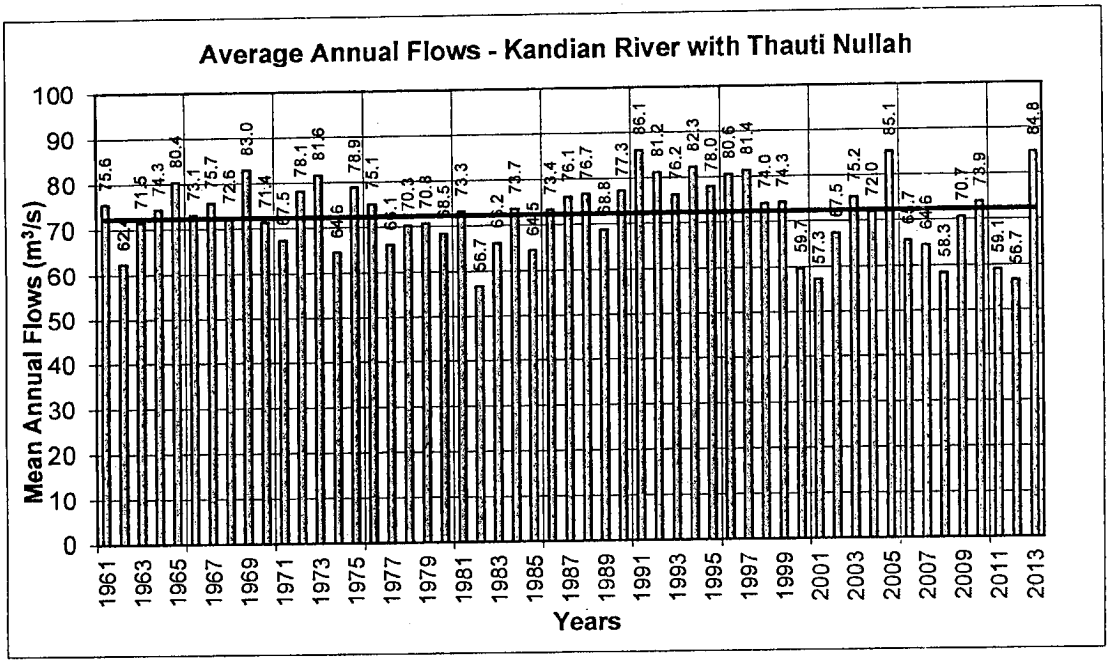

Figure - 27 Annual Flows - Kandian River With Thauti Nullah

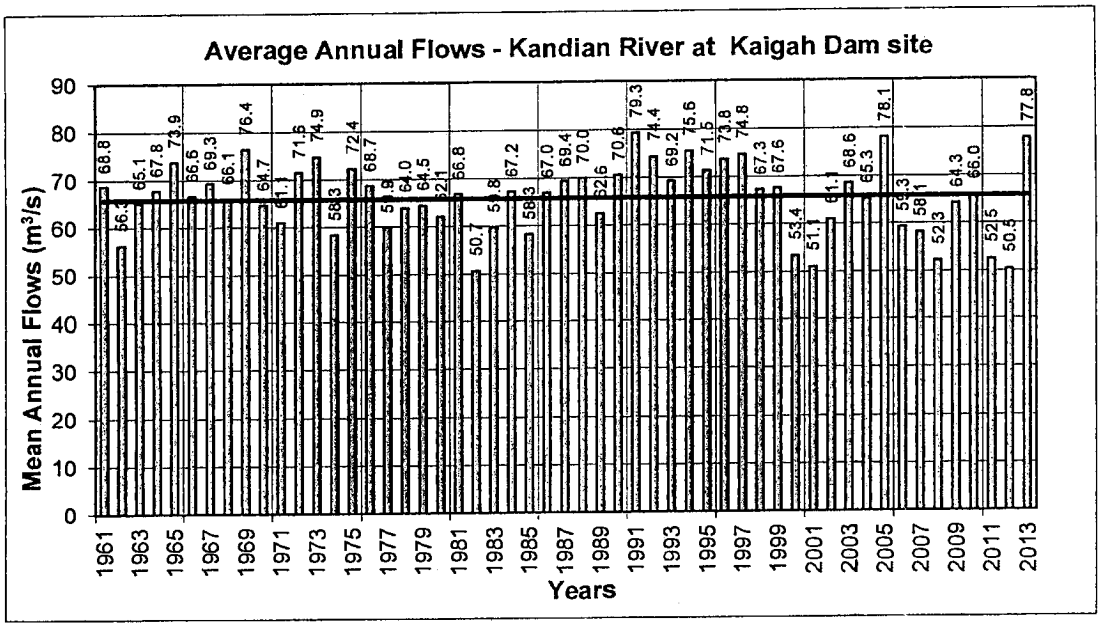

Figure - 28 Annual Flows - Kandian River at Kaigah Dam Site

The estimated daily flows for Kandian river at Dam and with Thauti are appended as **Annex – 2 and 3**.

Table - 9: Extended Mean Monthly Flows - Kandian River at Dam site

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1961	24.7	23.2	24.3	36.0	85.3	150.4	166.1	123.5	87.7	45.1	31.2	28.0
1962	25.9	24.9	25.5	34.9	57.4	122.4	136.3	100.5	56.9	35.0	29.1	26.1

1963	24.3	23.4	25.8	40.6	71.3	167.3	160.1	111.7	64.7	36.9	29.1	26.2
1964	24.8	24.1	25.7	39.5	83.5	147.8	184.3	124.3	69.5	36.0	27.5	25.7
1965	24.1	23.1	24.6	37.5	89.3	207.4	197.0	121.7	67.4	38.7	29.8	26.0
1966	24.5	24.5	27.7	39.5	73.5	176.0	147.5	123.3	70.0	37.1	29.2	26.1
1967	24.6	23.5	24.0	34.3	70.3	158.7	208.9	125.6	70.9	35.2	28.8	26.2
1968	25.0	24.1	25.4	41.9	74.2	152.8	177.2	119.5	60.1	36.5	28.8	26.6
1969	24.7	24.4	29.5	46.6	75.9	169.7	225.7	162.0	60.4	38.6	31.5	27.7
1970	25.6	24.5	25.0	42.9	86.2	147.3	129.3	119.9	79.0	39.5	30.4	27.1
1971	25.2	24.4	26.7	47.2	96.4	154.3	116.2	104.8	53.0	32.7	27.5	25.0
1972	24.1	23.2	25.3	41.9	87.1	195.7	178.0	120.4	71.6	36.6	28.8	25.9
1973	24.1	23.1	24.4	49.0	103.9	193.0	170.1	137.1	78.2	40.0	28.8	25.9
1974	24.1	23.5	27.5	47.4	70.9	127.8	140.7	99.5	50.8	34.2	28.0	25.6
1975	24.0	23.6	23.9	41.0	119.3	169.8	159.2	144.3	67.1	37.6	31.7	27.5
1976	25.0	24.2	24.9	32.1	97.8	158.2	190.7	115.0	63.2	38.5	29.7	26.1
1977	24.6	24.3	26.8	43.9	76.4	137.0	141.8	100.2	53.4	34.7	28.4	26.0
1978	24.8	24.1	24.3	40.3	93.5	163.4	164.4	95.1	46.5	34.5	29.1	27.2
1979	24.7	23.9	24.1	47.1	70.5	156.4	185.1	99.9	53.0	33.0	28.6	25.4
1980	26.2	24.2	24.3	41.0	91.9	161.4	139.6	90.6	53.1	35.2	30.0	26.9
1981	26.2	25.6	27.0	51.4	121.2	147.9	164.3	97.7	49.6	33.9	28.4	26.4
1982	25.0	24.4	24.4	36.9	70.2	95.8	101.7	98.8	42.8	32.0	29.0	27.4
1983	25.9	25.1	25.5	33.6	76.2	125.6	135.4	112.8	61.0	36.4	31.3	28.1
1984	26.0	24.2	26.3	39.8	86.9	198.8	134.7	119.6	62.8	33.7	28.2	26.0
1985	25.1	24.1	25.3	36.2	70.1	126.8	138.4	107.7	53.5	36.1	29.1	26.5
1986	25.2	24.0	25.7	42.9	81.1	150.0	189.5	116.9	53.8	37.0	29.2	26.1
1987	25.6	25.5	27.1	46.1	88.4	150.4	170.8	128.5	72.2	39.2	31.7	27.7
1988	27.3	26.3	27.1	56.8	120.4	162.6	168.7	103.7	55.0	35.2	28.5	26.5
1989	25.1	24.1	25.5	32.1	72.1	165.7	145.6	106.6	61.0	35.9	29.8	27.0
1990	25.5	24.9	27.8	38.1	137.5	158.3	159.1	109.4	71.8	37.3	29.6	26.0
1991	25.2	25.7	27.9	43.3	81.0	187.7	226.9	150.9	83.2	40.9	31.4	28.6
1992	26.5	26.2	26.6	40.1	75.1	154.4	208.2	141.1	82.8	45.8	36.0	29.6
1993	27.9	25.9	26.0	49.5	111.2	151.6	154.5	99.7	80.4	41.7	32.3	30.0
1994	27.6	26.7	29.5	40.0	93.4	174.2	208.8	131.4	72.5	39.5	32.4	29.4
1995	25.5	25.9	26.2	40.1	84.1	165.8	208.0	129.7	57.3	38.5	29.9	27.0
1996	25.5	25.1	26.8	46.3	79.8	197.2	175.5	136.7	72.2	41.6	31.7	27.2
1997	28.9	27.3	26.8	46.6	75.6	168.0	236.4	130.1	61.1	39.2	30.1	26.5
1998	24.6	24.3	24.8	52.3	106.1	123.2	189.0	99.5	68.2	37.3	30.6	25.8
1999	24.4	24.1	25.8	53.1	115.4	171.9	142.7	99.0	62.2	36.6	29.9	26.5
2000	24.7	23.4	24.8	46.6	108.9	103.1	95.7	71.7	51.7	36.0	28.3	25.2
2001	23.6	23.8	25.6	36.2	88.4	104.5	97.6	77.4	49.6	34.0	28.4	24.8
2002	23.8	23.3	27.9	50.8	107.0	160.3	112.9	89.1	49.8	34.3	27.9	25.5
2003	23.3	23.1	25.5	48.4	94.9	190.2	167.5	91.8	60.5	38.3	31.9	27.3
2004	25.8	24.2	32.1	57.0	118.0	159.6	117.5	92.3	54.8	36.8	34.6	31.0
2005	30.0	29.6	32.1	55.4	92.0	187.8	225.2	120.3	64.9	39.0	30.2	28.6
2006	26.8	26.8	27.8	43.9	114.6	109.4	128.7	94.4	49.6	33.0	27.7	27.4
2007	25.9	26.0	27.2	55.9	103.2	133.7	112.1	76.1	51.7	31.1	27.5	26.0
2008	25.6	24.9	28.5	40.6	85.3	137.2	88.1	70.3	44.2	31.2	26.2	25.7
2009	25.1	24.7	26.9	41.5	88.6	122.1	176.6	123.6	52.9	35.8	27.2	25.7
2010	26.5	48.4	75.6	82.2	103.0	93.1	103.4	89.7	67.8	43.6	30.2	27.2
2011	27.6	45.0	63.2	74.3	98.1	74.3	54.5	48.9	44.9	36.8	36.2	26.5
2012	30.2	28.8	30.4	42.5	54.4	92.6	101.8	77.6	54.7	33.5	29.5	29.8
Mean	**25.4**	**25.5**	**28.0**	**44.7**	**90.6**	**152.3**	**158.0**	**109.9**	**61.6**	**36.9**	**29.8**	**26.8**

4.4 Extended Flow Series – Thauti Nullah

For Thauti nullah, daily flows were observed for 1991 to 1996. The flows have been correlated with estimated flows of Kandian river and monthly flows are developed for Thauti nullah. The mean monthly flows for Thauti nullah are presented in **Figure-29**. The mean annual flows for six recorded year is 12.34 m^3/s and for extended period 1961 to 2012, it is 10.6 m^3/s. The estimated mean monthly flows of Thauti nullah varies from 1.64 m^3/s to 30.33 m^3/s.

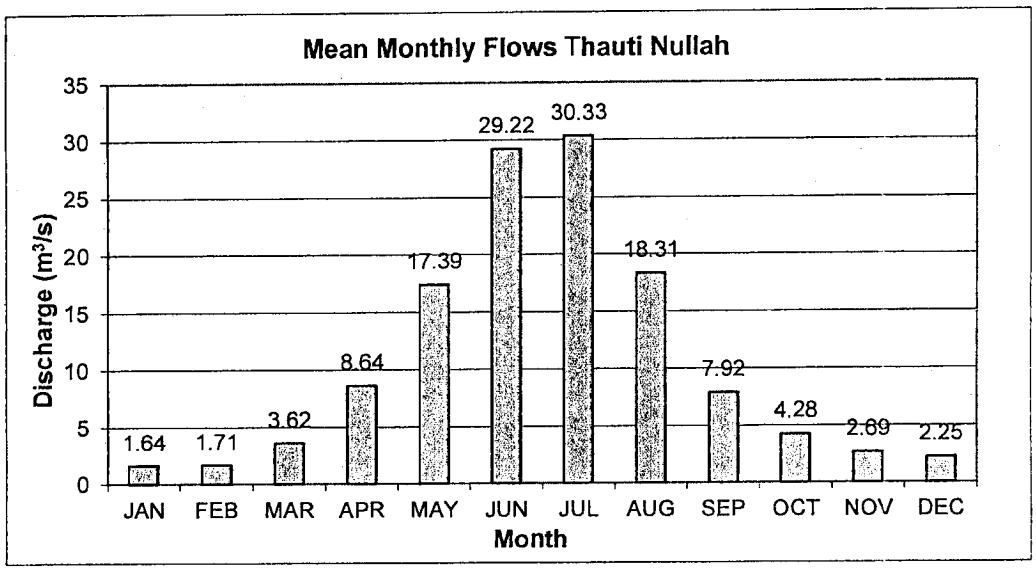

Figure - 29: Mean Monthly Flows – Thauti Nullah

The mean annual flows for Thauti nullah are shown in **Figure - 22**. The annual flow varies from 8.0 to 13.2 m^3/s.

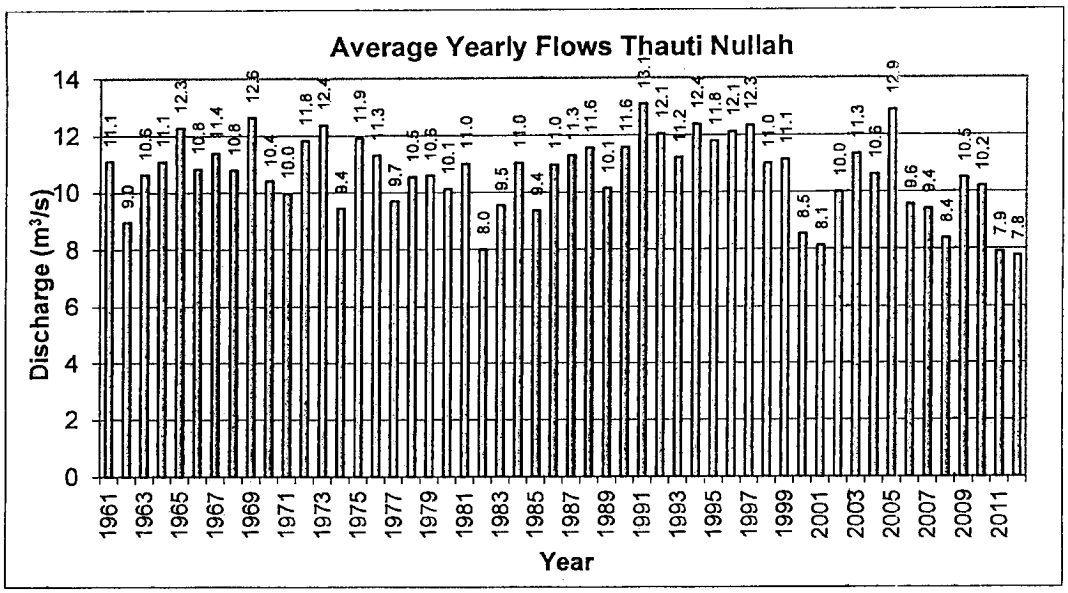

Figure - 30: Annual Flows Thauti Nullah

Table - 10: Estimated Mean Monthly Flows – Kandian River with Thauti Nullah

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1961	1.59	1.56	3.14	6.95	16.50	29.09	32.12	20.69	11.30	5.23	2.81	2.35
1962	1.67	1.67	3.28	6.75	11.11	23.65	26.36	16.85	7.33	4.05	2.63	2.19
1963	1.56	1.57	3.33	7.86	13.79	32.34	30.96	18.71	8.34	4.28	2.63	2.19
1964	1.60	1.62	3.32	7.64	16.15	28.58	35.64	20.83	8.96	4.17	2.49	2.15
1965	1.55	1.55	3.17	7.24	17.26	40.10	38.09	20.40	8.68	4.49	2.69	2.18
1966	1.58	1.64	3.58	7.63	14.22	34.03	28.52	20.66	9.02	4.30	2.63	2.19
1967	1.59	1.57	3.09	6.62	13.59	30.69	40.40	21.05	9.14	4.08	2.60	2.19
1968	1.61	1.62	3.28	8.09	14.34	29.55	34.27	20.02	7.74	4.23	2.60	2.23
1969	1.59	1.64	3.81	9.01	14.68	32.81	43.63	27.14	7.79	4.47	2.84	2.32
1970	1.65	1.64	3.23	8.29	16.66	28.48	25.00	20.08	10.18	4.59	2.75	2.27
1971	1.63	1.63	3.45	9.12	18.64	29.82	22.46	17.56	6.83	3.80	2.48	2.10
1972	1.55	1.56	3.26	8.10	16.84	37.83	34.41	20.18	9.22	4.24	2.60	2.17
1973	1.55	1.55	3.15	9.47	20.09	37.32	32.88	22.97	10.08	4.64	2.60	2.17
1974	1.55	1.57	3.54	9.16	13.70	24.70	27.19	16.66	6.55	3.97	2.52	2.15
1975	1.54	1.59	3.07	7.92	23.07	32.82	30.78	24.18	8.64	4.36	2.86	2.30
1976	1.61	1.62	3.21	6.20	18.90	30.58	36.87	19.26	8.15	4.47	2.68	2.19
1977	1.58	1.63	3.45	8.49	14.78	26.48	27.41	16.80	6.88	4.03	2.57	2.18
1978	1.60	1.61	3.14	7.79	18.07	31.59	31.79	15.93	5.99	4.00	2.63	2.28
1979	1.59	1.60	3.11	9.11	13.63	30.24	35.80	16.74	6.83	3.83	2.58	2.13
1980	1.69	1.62	3.14	7.94	17.78	31.20	26.99	15.18	6.84	4.08	2.71	2.25
1981	1.69	1.72	3.48	9.93	23.42	28.59	31.77	16.38	6.39	3.93	2.57	2.21
1982	1.61	1.63	3.14	7.14	13.58	18.52	19.65	16.56	5.51	3.71	2.62	2.30
1983	1.67	1.68	3.28	6.49	14.73	24.28	26.19	18.91	7.86	4.22	2.82	2.35
1984	1.67	1.62	3.38	7.70	16.81	38.44	26.03	20.03	8.09	3.91	2.54	2.18
1985	1.61	1.62	3.26	7.00	13.56	24.51	26.76	18.05	6.90	4.19	2.63	2.22
1986	1.62	1.61	3.31	8.29	15.68	29.00	36.64	19.58	6.94	4.29	2.64	2.19
1987	1.65	1.71	3.49	8.91	17.09	29.07	33.02	21.53	9.30	4.55	2.86	2.32
1988	1.76	1.76	3.49	10.98	23.27	31.44	32.62	17.38	7.09	4.08	2.57	2.22
1989	1.62	1.62	3.28	6.21	13.94	32.03	28.15	17.85	7.86	4.16	2.68	2.26
1990	1.64	1.67	3.58	7.37	26.58	30.60	30.76	18.33	9.25	4.33	2.67	2.18
1991	1.62	1.72	3.60	8.38	15.67	36.29	43.87	25.28	10.73	4.75	2.83	2.39
1992	1.71	1.76	3.43	7.75	14.51	29.85	40.26	23.65	10.68	5.32	3.25	2.48
1993	1.80	1.74	3.35	9.56	21.50	29.30	29.88	16.71	10.36	4.84	2.91	2.51
1994	1.78	1.79	3.80	7.74	18.06	33.67	40.36	22.01	9.34	4.58	2.92	2.46
1995	1.64	1.73	3.38	7.75	16.26	32.06	40.21	21.74	7.39	4.46	2.70	2.26
1996	1.64	1.68	3.46	8.94	15.43	38.12	33.94	22.91	9.30	4.83	2.86	2.28
1997	1.86	1.83	3.46	9.02	14.62	32.47	45.71	21.79	7.87	4.55	2.72	2.22
1998	1.59	1.63	3.19	10.12	20.51	23.82	36.54	16.67	8.79	4.33	2.76	2.16
1999	1.57	1.61	3.32	10.26	22.30	33.23	27.58	16.59	8.01	4.25	2.69	2.22
2000	1.59	1.57	3.20	9.01	21.05	19.93	18.50	12.01	6.66	4.17	2.55	2.11
2001	1.52	1.60	3.30	7.00	17.08	20.21	18.86	12.96	6.40	3.94	2.56	2.08
2002	1.53	1.56	3.60	9.81	20.69	30.99	21.82	14.93	6.42	3.98	2.52	2.13
2003	1.50	1.55	3.28	9.35	18.35	36.76	32.39	15.38	7.80	4.45	2.88	2.29
2004	1.66	1.62	4.14	11.02	22.81	30.86	22.71	15.47	7.07	4.27	3.12	2.60
2005	1.93	1.99	4.13	10.70	17.80	36.30	43.55	20.15	8.36	4.53	2.72	2.39
2006	1.73	1.79	3.59	8.49	22.15	21.16	24.88	15.81	6.39	3.83	2.50	2.29

2007	1.67	1.74	3.51	10.80	19.95	25.86	21.66	12.75	6.66	3.61	2.49	2.18
2008	1.65	1.67	3.67	7.84	16.49	26.53	17.03	11.78	5.69	3.61	2.36	2.15
2009	1.62	1.66	3.47	8.03	17.13	23.60	34.15	20.71	6.82	4.16	2.46	2.15
2010	1.71	3.24	9.75	15.89	19.92	18.00	20.00	15.02	8.74	5.06	2.73	2.28
2011	1.78	3.02	8.14	14.36	18.97	14.36	10.53	8.20	5.79	4.26	3.26	2.22
2012	1.95	1.93	3.92	8.22	10.51	17.90	19.69	13.01	7.05	3.89	2.66	2.49
Mean	**1.64**	**1.71**	**3.62**	**8.64**	**17.39**	**29.22**	**30.33**	**18.31**	**7.92**	**4.28**	**2.69**	**2.25**

4.5 FLOW DURATION CURVE

The estimated flows in Kandian River have been estimated from Kalam daily flows from 1961 to 2012. The estimated flows are very close to the observed flows for the observed period. With the estimated series of flows, flow duration curves for average year at downstream of Thauti bridge and is presented in **Figure - 30**.

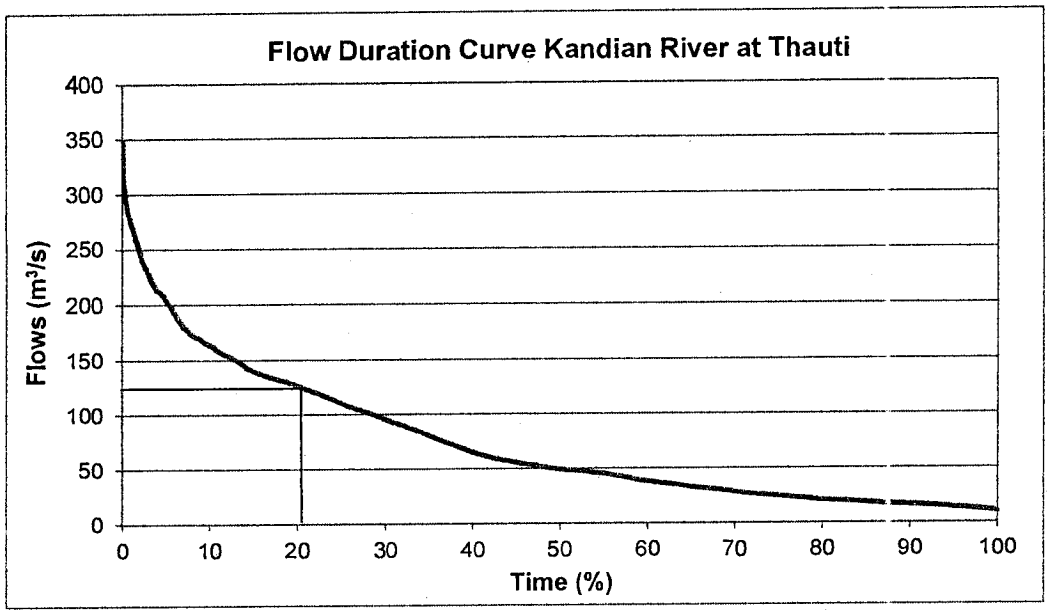

Figure - 31: Flow Duration Curve – Kandian River at Thauti bridge

The mean annual flow of Kandian river at dam site is 65.8 m3/s and downstream of Thauti nullah it is 74.8 m³/s. The design discharge of 125.0 m³/s is available for about 22.0 % time of the year. The availability of flows against the different percentages of time is listed in the **Table - 10.**

Table - 11: Flow Duration Values – Kandian River at Thauti bridge

Time (%)	Flow (m^3/sec)	Time (%)	Flow (m^3/sec)
1	483.0	55	45.3
5	204.3	60	38.3
10	163.6	65	32.8
15	140.1	70	28.2
20	126.2	75	24.3
25	110.3	80	20.5
30	95.5	85	18.5
35	80.6	90	16.3
40	65.6	95	13.9
45	55.8	100	10.2
50	49.3	**Mean**	**74.8**

5.0 Project Layout

Alternative project layout have been considered on either bank of Kandiah River to arrive a technically sound and optimum layout. The various layout options have been drawn up on the available survey of Pakistan maps scale 1:50,000 and details are elaborated on maps prepared with digital elevation models. The alternate project layouts have been compared on the basis of topographic, geologic, environment and cost per kWh to select one best technically sound and economically attractive project layout.

Four (04) alternate layouts were identified, all four layouts have same dam axis and gross head. The difference in water ways length creates some difference in net head but installed power is in the same range. Based on NPV, Alternative-II been selected. Brief description of main structures is as follows:

This report has been finalized with the salient features described as under.

TABLE – 12 Salient Features – Kaigah Hydropower Project

1	**Hydrology (Design flows)**		
	Design discharge	125	m^3/s
	Mean Annual Flow	65.8	m^3/s
	Design flood (PMF)	2113	m^3/s
2	**Reservoir**		
	Max. reservoir operating level	1500	m.a.s.l
	Min. reservoir operating level	1480	m.a.s.l
	Reservoir capacity at 1500 m.a.s.l	40.39	MCM
	Reservoir capacity at 1480 m.a.s.l	19.65	MCM
3	**Dam Structure**		
	Dam height	100	m
	Dam crest level	1510	m.a.s.l
	Spillways		
	Number of gates	Ungated	
	Discharge capacity	2150	m^3/s
	Bottom Outlet		
	No. of bays	3	
	Gate size (WxH)	3.0 x 6.0	m
	Discharge capacity	407.5	m^3/s
4	**Power Waterways**		
	Power Intake		
	No. of gates	2 No.	
	Gate size (WxH)	5.3 x 6.7	m
	Deck elevation	1511.0	m.a.s.l
	Intake sill level	1464.0	
5	***Headrace Tunnel***		
	Diameter	7.7	m
	Length	17058	m
6	***Surge Shaft***		
	Diameter	5.30	m
	Height	38.67	m
7	***Surge Tank***		
	Diameter	10.50	m
	Height	260	m
8	**Power Generation**		
	Max. Net head	523.9	m
	Min. Net head	480.0	m
	Plant Design discharge	125	m^3/s
	Installed plant capacity	545	MW
	Turbine Type	Pelton vertical	
	No. of units	3	
	Turbine centerline level	972.65	m.a.s.l
	Design Annual mean energy	2184.6	GWh
	Power house type	Cavern	.
	Size of powerhouse (LxWxH)	105.5x27.1x47.9	m.
9	**Tailrace Tunnel**		
	Size of tunnel	8	m
	Length of tailrace tunnel	3,383.4	m
	Project Cost	1564.8	MUSD

5.1 Dam Site

The dam site (D-1) is located on Kandiah River near Karrang village. At the dam site, rock is exposed on either side and the River width is about 100 m, which is enough to accommodate the flood release structure. The bed elevation at weir site is 1420 m.a.s.l. A concrete gravity dam of 90 m high and 400 m long has been proposed. The dam would consist of two bottom outlets for sediment flushing and four spillways to release 1000 year estimated flood. The size of bottom outlet would be 6 m high and 6 m wide. The crest elevation of dam would be 1510 m. The reservoir volume facilitate to consider peaking during low flow months.

- Dam: will be an asphalt faced rock fill dam across the Kandiah River, 100 m height and will develop a superficial reservoir area of approximately 1.500.000 m^2.
- Diversion tunnel: is located in the right bank of the river, 730 m length, is developed in a D-section and is complemented by a pre-cofferdam, an upstream cofferdam and a downstream cofferdam.
- Spillway: has been designed to evacuate the probable maximum flood (PMF), is in the left bank of the river and is set by three channel sections.
- Bottom outlet: its purpose is to keep a useful volume of the reservoir of 20 million of cubic meters, evacuating the sediments that can be deposit on it; is a structure under the spillway structure which is a tunnel that will have a horseshoe section and 440 m length.

5.2 Headrace Tunnel

The headrace tunnel leads from intake to surge tank. The tunnel alignment has been proposed with minimum cover and with option of adits on the way. The diameter of low pressure tunnel is 7.5 m to convey a design discharge of 125 m^3/s. The total length of headrace tunnel will be 14500 m. With the cross-sectional area of 50.24 m^2, the velocity would be 2.68 m/s. The head loss in the tunnel would be approx. 22.0 m.

No inlet from any tributary to headrace tunnel has been considered. The tunnel would be low pressure tunnel with concrete lined section proposed on the left of Kandiah River. For the excavation of headrace tunnel, adits at Four (04) locations have been foreseen with approximate length of 200 m, 180 m, 190 m and 190 m.

The rock cover over headrace tunnel in initial portion 1.8 km varies upto maximum of 400 m. In the middle 2.0 km portion, the cover is upto 350 m, then for the next 2.5 km and 2.2 km portion, maximum cover is 350 m and 650 m. Overall the tunnel alignment have to be excavated with moderate rock below 650 m. Surge tank would be located near powerhouse area. About 750 m long pressure shaft/tunnel would join the surge tank with powerhouse.

The headrace system of the Kaigah Hydropower Project is composed of the main headrace tunnel, pressure shaft and three penstock tunnels that will deliver the water to the three turbines of the project.

The headrace tunnel begins from the intake structure near the Karrang village and ends at 17 km downstream of the dam site with the connection with the pressure shaft; three adit tunnels are proposed to construction and equipment access to the tunnel during the construction stage and future inspection. The adit tunnel 1 and adit tunnel 2 are located at 5.1 km and 10.5 km respectively and will allow the access in the intermediate part of the tunnel; and the adit tunnel 3 located at 17.02 km will allow the access to the connection of the headrace and the pressure shaft. At the chainage 13360 m the Thauti Nullah headrace tunnel will deliver the water from the Thauti Nullah to the main headrace tunnel. In addition the pressure system will be protected by a surge system composed by an elevator shaft of 1.5 m radius of 67 m length and surge tank of 6 m radius of 265 m length. This system will control the hydraulic oscillation protecting the system against water hammer.

The pressure shaft begins at chainage 17.06 km. This branch is inclined and divided in the last part into three horizontal independent penstock tunnels that will deliver the water to the three turbines located in the powerhouse.

5.3 Power House

The powerhouse is proposed in the rock as Cavern type on the left bank of Indus River, at location P-1, just upstream of Thauti nullah. The access road to powerhouse would have to be constructed at higher elevation above 950 m and underground powerhouse have to be accessed with 500 m tunnel.

The powerhouse consists of a cavern where the turbine-generator set for the three units and the other auxiliary equipment are located. In a parallel cavern the power transformers and the corresponding auxiliary equipment are localized. The two caverns are interconnected by an access gallery between the main floors, and by three bar output galleries.

The access to the powerhouse is through a two-way vehicular tunnel that starts from a yard. The tunnel reaches the right sidewall of the cavern, directly to the assembly room.

A lower auxiliary tunnel, leading down to the floor of the excavation of the powerhouse cavern at the right sidewall, is connected to the access tunnel of the power house. In addition, an extension of this auxiliary tunnel is linked to the outflow tunnel. This auxiliary tunnel is employed as permanent access to the turbine area and as an emergency exit way from the powerhouse cavern during the operation stage.

The location of the caverns for the powerhouse and the transformers has been selected on the left bank of the River Kandiah considering the topographical, geological and geotechnical characteristics of the rock mass, which is formed by diorite. In addition the following requirements were taken into account:

- The layout of the final section of the conduction tunnel and the pressure well
- The layout of the access tunnel to the powerhouse and the output tunnel for the power cables.
- The location of the equilibrium chimney and the connection to the derivation of Thauti Nullah.
- The layout of the outflow tunnel.

5.4 Tailrace Tunnel

From cavern powerhouse to Indus River, tailrace tunnel have to be designed to join Kandiah river above maximum tail water level. The length of tailrace tunnel would be 250 m with cross section area for a design discharge of 125 m^3/s. The normal tail water level in Kandiah river has been assumed as 952 m.a.s.l and with Dasu reservoir, the flood level has been taken as 958 m. The tailrace outlet sill would be at 954.0 m and it join Kandiah river at El. 960 m.

5.5. Thauti Nullah Derivation and Headrace

The diversion works of the scheme will be two Tyrolean weirs (one by each stream), each one with a screen bar, a collector channel, a well to deposit gravels, a conduction channel, a lateral excess weir, a desander with three cells, a control thin wall weir and a stilling well. The Tyrolean weirs will work as spillway during the floods and at the same time will work as an intake using the screen bar that will be along the weir and over it. Under this screen bar there will be a channel to conduct the water to the headrace channel, at the beginning, it will have a tank where the gravels are going to be deposited.

Downstream of the tank, on the left lateral wall of the channel the lateral excess weir will be located. Downstream of the lateral excess weir, there will be a trifurcation in the channel that would allow to conduct the water to each one of the desander's cells where the particles in suspension will be settled. At the end of the desander's cells, there will be a thin wall weir that will work like an hydraulic control and will allow to cross the water into a stilling well, which is connected to a Morning Glory structure.

The Thauti Nullah headrace system will consist of a tank and morning glory-spillway, intake structure, a pressure shaft and headrace tunnel.

6.0 Estimation of Energy

Kaigah Hydropower Project has been planned as run of river scheme with limited reservoir volume to generate daily peaking. Various cases were analyzed for energy production (firm energy and secondary energy) to be computed under consideration of the production pattern. For the selected project layout, and structures dimensions, hydraulic losses have been used as input for energy simulation.

Energy generation in the hydropower plants is estimated with the following parameters:

a) Mean monthly flows (m^3/s)
b) Compensation release (m^3/s)
c) Target design discharge
d) Gross and net head for turbines
e) Waterways hydraulic loss coefficients.
f) E&M plant efficiencies

Power and energy have been estimated for design discharge of 125 m^3/s after preliminary design of structures and detailed calculations of the head loses of the system. While estimating the energy, the following assumptions have been made.

- Sediment flushing is assumed to be carried out every year during summer months. The maximum flow in the river occurs from June to August. The sediment flushing would be carried out when the flows in Kandiah River are more than design discharge.

- During low flow periods, when the discharge in Kandiah River is less than 125 m^3/s, the live storage is used to store water in off peak hours to improve the flows for power generation in peak hours. It has been estimated that 20.0 million m^3 would provide additional flow required to generate maximum capacity 4 peak hours in off summer days.

Peak off peak energy have been estimated on the basis of 10 daily flows at dam and intake structures for power conduits for a period of 53 years (1961-2013). For three years, 1984 as average year, 1982 dry year and 2005 as wet year, power and energy have been estimated and are presented as **Tables 16 to 18**.

6.1 Flows for Power Generation

The observed flows data of Kandian river at Thauti gauging station is available for the period 1993 to 2001, 2006 to 2009 and 2012 to 2014. The catchment area of Kandian river at dam and Thauti station is 1800 km^2 and 2047 km^2 respectively. The flows have been extended with the help of Swat river station at Kalam after establishing a corelation to have a long term series of Kandian river at Thauti and Dam site. The estimated 10-daily flows of Kandian river at Thauti are presented in **Annex – 2** and **3**.

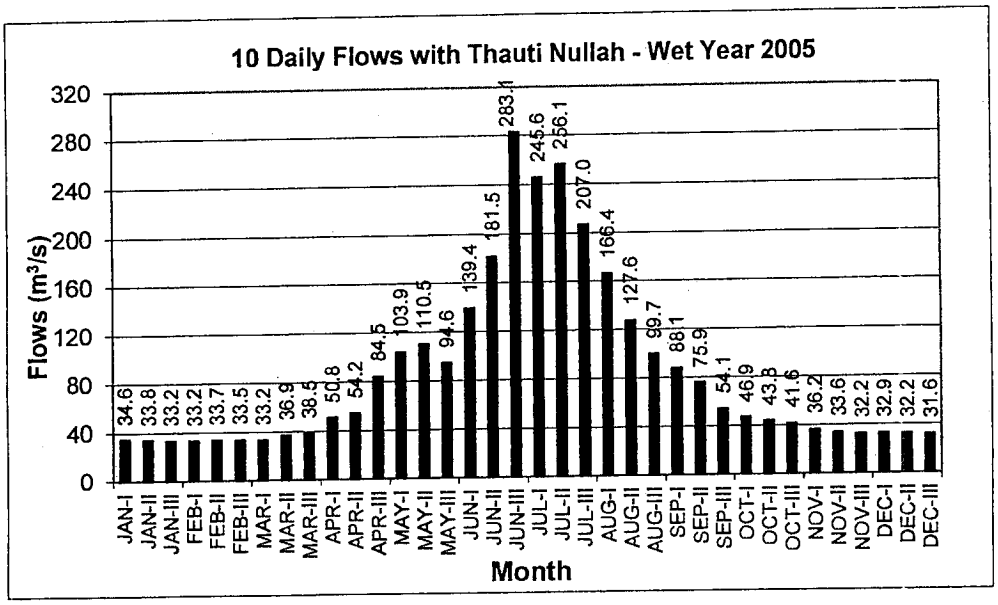

Figure - 32: Flows of Kandian River at Dam with Thauti nullah – Average Year

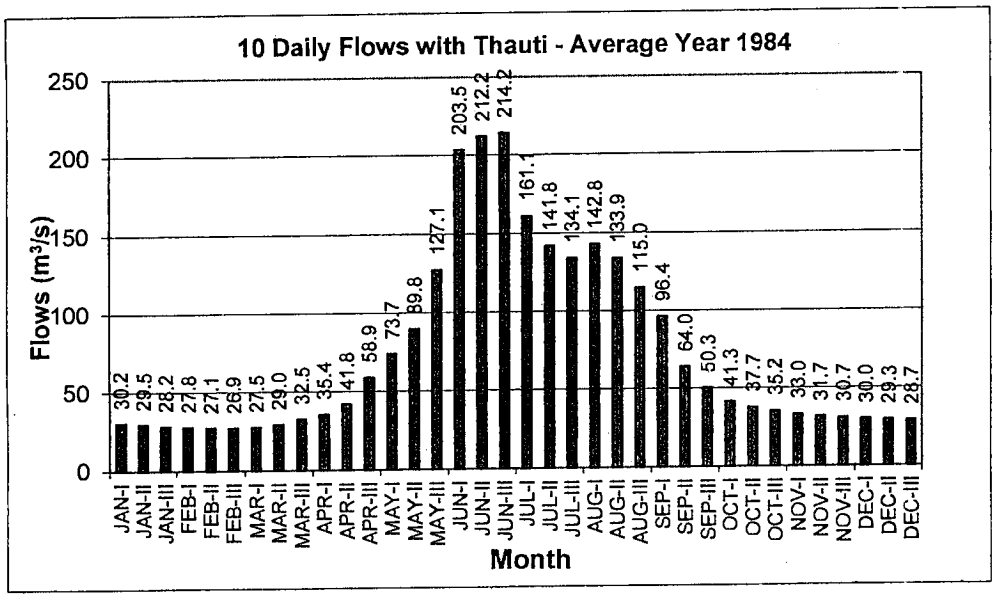

Figure - 33: Flows of Kandian River at Dam with Thauti nullah – Average Year

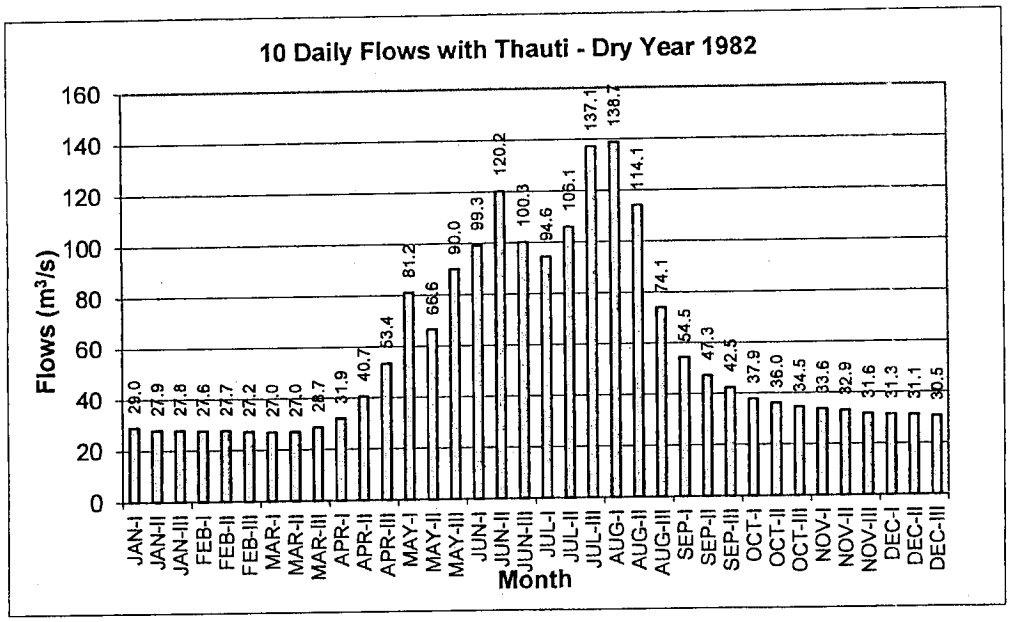

Figure - 34: Flows of Kandian River at Dam with Thauti nullah – Wet Year

6.2 Compensation Releases

For Kandian River, necessary releases have been assumed, which vary from winter months to summer months. The power and energy are estimated on the basis of mean monthly discharges for the average year. For sediment flushing, it has been assumed that the power station may have to be shut down for a few days during the summer months. A compensation flow ranging from 2.5 m^3/s in winter six months to 4.0 m^3/s in the summer months have been considered to be released from the dam as residual flows. The compensation flow have been estimated with due considering the downstream ecological and biological needs and the downstream water uses.

6.3 Head Losses

The hydraulic loss coefficients have been estimated based on the empirical values at various locations of the important structures. For intake entrance, headrace low pressure tunnel, pressure shaft and tailrace, exit losses and bend losses etc. have been computed for the design discharge through the waterways. The optimal velocity for the concrete lined headrace tunnel is assumed as 3.0 m/s, and for the steel lined pressure shaft as 6 m/s. Head losses have been estimated based on the monthly flows through the waterways. The maximum losses from the intake to the turbine axis have been estimated as 16.36 m and these are reduced to a minimum in winter months, as given in **Table - 13.**

Table - 13: Estimated Losses in Hydraulic System

No.	Structure	Losses (m)
1	Trash rack	0.06
2	Entrance at intake	0.07
3	Headrace tunnel	12.2
4	Pressure Shaft	1.10
5	Bifurcation Pipe and bend losses	0.23
6	Tailrace	2.50
7	Exit Losses	0.10
8	Other Losses	0.20
Total	From Intake to tailrace	**16.36**

6.4 Efficiencies of E&M Equipment

The variations in the efficiencies of the generating units due to change of net heads have not been considered. For the design discharge available to the powerhouse, an efficiency of 90.7%, 98.0% and 99% has been used for the turbine, generator and transformer, respectively.

The selected design discharge is 125 m^3/s, and normal maximum and minimum reservoir operating level are 1500 m and 1480 m.a.s.l respectively. The tail water elevation varies from 950.0 to 954.0 m^3/s for flows in the Kandiah River. With Pelton turbine, turbine axis has been assumed as 964.70 m.a.s.l. The gross head is 536 m and net head varies 511.3 to 523.7 m for varying discharge in the water ways.

6.5 Estimated Energy with Thauti Nullah

6.5.1 Energy with Thauti Nullah

The power and energy have been estimated on the basis of 10 day flows for all years from 1961 to 2013. For design discharge of 125 m^3/s and net head of 511.1 m, the optimum installed capacity would be **545 MW** with average mean annual energy of **2368.1 GWh** and the plant factor is 49.6%.

The calculated annual energy without Thauti Nullah flows, for years 1984 (average year), 1982 (dry year) and 2005 (wet year), are 2382.0, 2071.0 and 2519.0 GWh respectively. The energy calculated based on daily flows for 53 years ranges between 2071 GWh to 2735 GWh. For the purpose of this study, a conservative value of **2368.1 GWh** has been taken as mean annual energy.

The 10 daily energy for wet, average and dry years is graphically presented in Figures – 35, 36 and 37 respectively. The mean annual energy for the recorded period from 1961 to 2013 have been estimated and is graphically presented in **Figure - 38.**

The annual flows, peak, off peak and total annual energy for 53 years is summarized in **Table – 14.** 10 Daliy flows, net head, peak, off peak and total energy for the period 1961 to 2013 are presented as **Annex-2.**

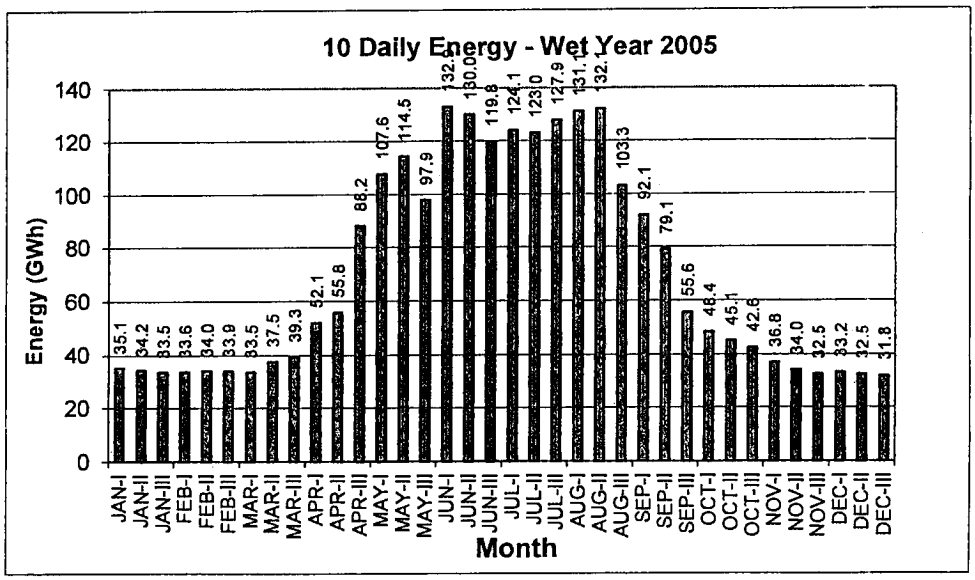

Figure - 35: 10 Daily Energy with Thauti Flows – Wet Year 2005

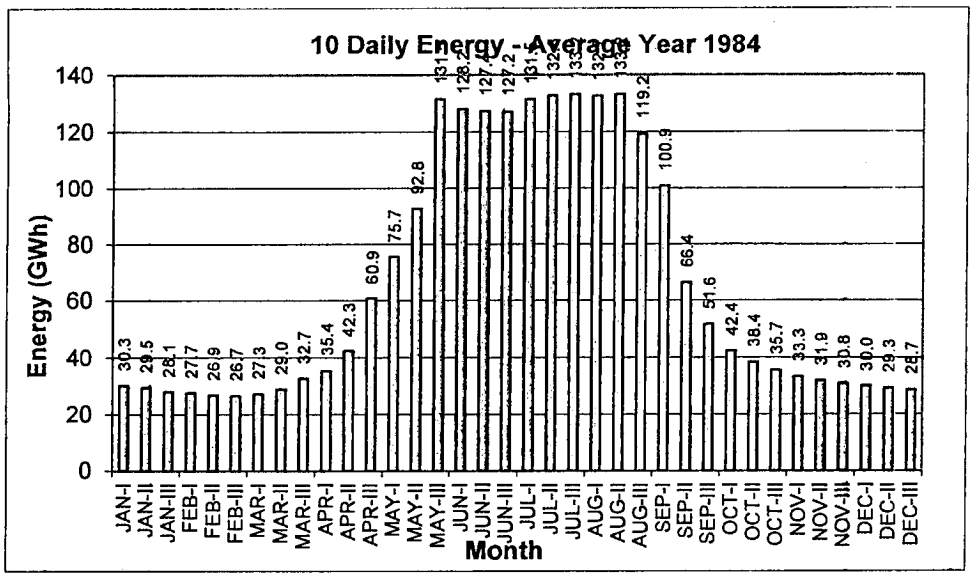

Figure - 36: 10 Daily Energy with Thauti Flows– Average Year 1984

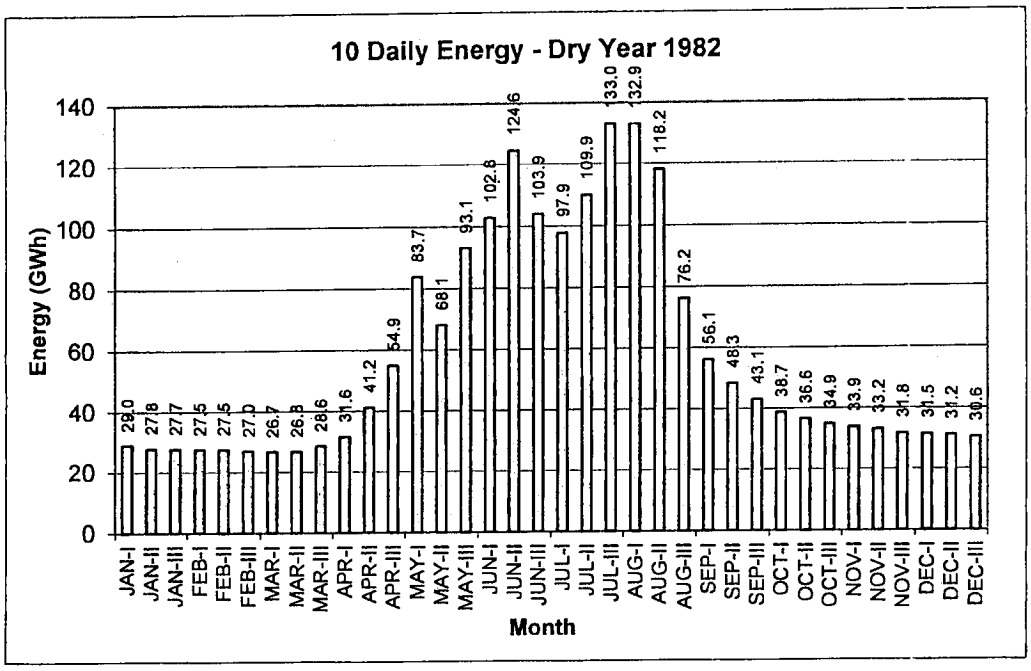

Figure - 37: **10 Daily Energy with Thauti Flows – Dry Year 1982**

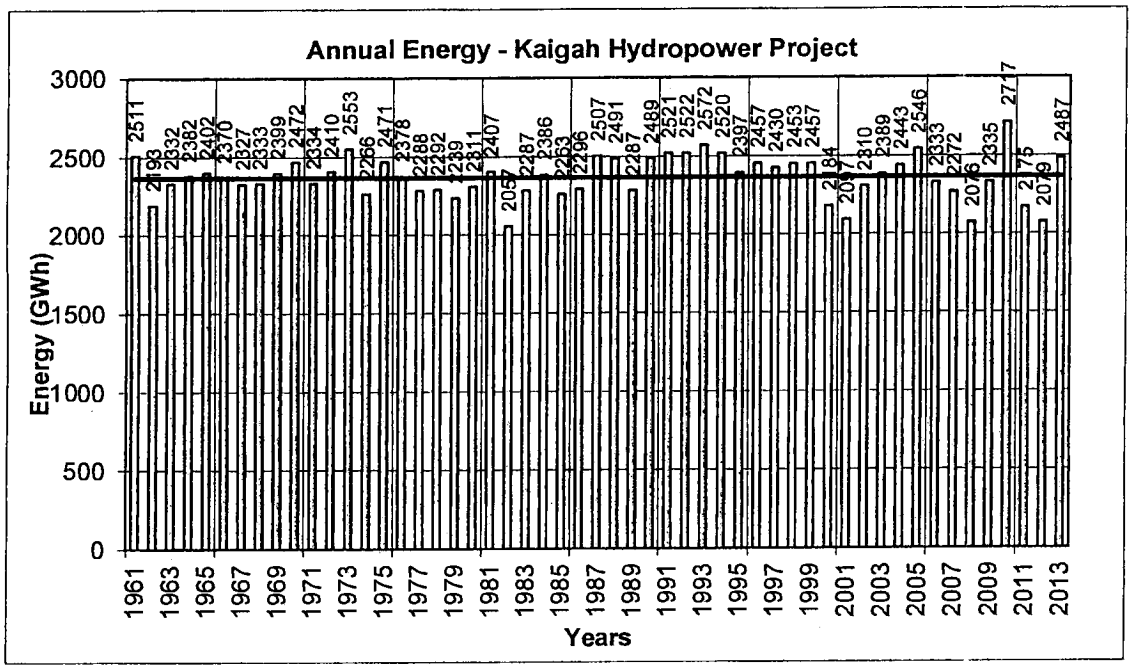

Figure - 38 **Average Yearly Energy with Thauti Nullah– Kaigah HPP**

Table – 14 Estimated Annual Flows and Energy with Thauti Nullah

Year	Mean Annual Flow			Firm Power	Annual Energy			Plant Factor
	River (m^3/s)	Power (%)	Spillage (%)	(MW)	Peak (GWh)	Off Peak (GWh)	Total (GWh)	(%)
1961	75.57	86.3	13.7	545	807.37	1703.90	2511.27	52.6
1962	62.41	91.0	9.0	545	809.09	1383.72	2192.81	45.9
1963	71.54	84.5	15.5	545	808.35	1523.79	2332.14	48.8
1964	74.34	83.1	16.9	545	808.05	1573.79	2381.84	49.9
1965	80.37	77.6	22.4	545	807.84	1594.29	2402.12	50.3
1966	73.11	84.1	15.9	545	808.15	1562.20	2370.35	49.6
1967	75.69	79.8	20.2	545	808.22	1519.06	2327.28	48.7
1968	72.57	83.4	16.6	545	808.36	1525.06	2333.42	48.9
1969	82.97	75.0	25.0	545	808.14	1590.48	2398.62	50.2
1970	71.35	89.9	10.1	545	807.54	1664.07	2471.62	51.8
1971	67.47	89.7	10.3	545	808.32	1526.02	2334.34	48.9
1972	78.15	80.0	20.0	545	807.86	1601.69	2409.55	50.5
1973	81.64	81.3	18.7	545	807.03	1746.18	2553.21	53.5
1974	64.62	90.8	9.2	545	808.76	1457.14	2265.90	47.5
1975	78.91	81.3	18.7	545	807.40	1663.15	2470.55	51.7
1976	75.12	82.2	17.8	545	807.92	1569.89	2377.82	49.8
1977	66.15	89.6	10.4	545	808.60	1478.96	2287.56	47.9
1978	70.30	84.5	15.5	545	808.49	1483.52	2292.02	48.0
1979	70.76	82.0	18.0	545	808.88	1430.34	2239.22	46.9
1980	68.50	87.5	12.5	545	808.50	1502.72	2311.22	48.4
1981	73.28	85.2	14.8	545	807.93	1599.41	2407.34	50.4
1982	56.72	93.7	6.3	545	810.00	1247.20	2057.21	43.1
1983	66.21	89.5	10.5	545	808.70	1478.45	2287.15	47.9
1984	73.67	84.1	15.9	545	807.92	1578.40	2386.32	50.0
1985	64.48	90.9	9.1	545	808.67	1453.89	2262.56	47.4
1986	73.40	81.0	19.0	545	808.63	1487.09	2295.72	48.1
1987	76.13	85.5	14.5	545	807.43	1699.38	2506.81	52.5
1988	76.71	84.3	15.7	545	807.48	1683.10	2490.58	52.2
1989	68.82	86.2	13.8	545	808.48	1478.95	2287.43	47.9
1990	77.29	83.6	16.4	545	807.46	1681.60	2489.06	52.1
1991	86.11	76.0	24.0	545	807.43	1713.58	2521.01	52.8
1992	81.25	80.6	19.4	545	807.53	1714.64	2522.16	52.8
1993	76.24	87.6	12.4	545	807.29	1764.53	2571.82	53.9
1994	82.33	79.5	20.5	545	807.45	1712.77	2520.23	52.8
1995	77.95	79.8	20.2	545	808.01	1589.01	2397.02	50.2
1996	80.56	79.1	20.9	545	807.84	1648.72	2456.56	51.5
1997	81.43	77.4	22.6	545	807.93	1622.28	2430.21	50.9
1998	74.02	86.0	14.0	545	807.80	1645.32	2453.12	51.4
1999	74.27	85.9	14.1	545	807.71	1649.68	2457.40	51.5
2000	59.70	94.6	5.4	545	809.42	1374.99	2184.41	45.8
2001	57.26	94.6	5.4	545	809.87	1287.58	2097.45	43.9
2002	67.49	88.7	11.3	545	808.54	1501.94	2310.48	48.4
2003	75.24	82.3	17.7	545	808.16	1581.29	2389.45	50.0
2004	72.04	87.9	12.1	545	808.15	1634.67	2442.82	51.2
2005	**85.13**	**77.6**	**22.4**	**545**	**807.60**	**1738.77**	**2546.36**	**53.3**
2006	65.72	92.0	8.0	545	808.46	1524.44	2332.90	48.9
2007	64.57	91.1	8.9	545	808.93	1463.22	2272.15	47.6
2008	58.31	92.0	8.0	545	809.93	1266.04	2075.96	43.5
2009	70.67	85.7	14.3	545	808.28	1526.31	2334.59	48.9
2010	73.93	95.1	4.9	545	807.61	1909.67	2717.28	56.9
2011	59.11	94.8	5.2	545	810.34	1364.74	2175.08	45.6
2012	56.70	94.6	5.4	545	810.36	1268.89	2079.26	43.6
2013	84.79	76.21	23.8	415	777.61	1709.03	2486.65	52.1
Mean	**72.32**	**85.40**	**14.60**	**542.54**	**807.69**	**1560.37**	**2368.06**	**49.60**

6.5.2 Energy without Thauti Nullah

The power and energy have been estimated on the basis of 10 day flows for all years from 1961 to 2013. For design discharge of 125 m³/s and net head of 511.1 m, the optimum installed capacity would be **545 MW** with average mean annual energy of **2184.6** without flows from Thauti nullah. The plant factor is worked out as 45.8%.

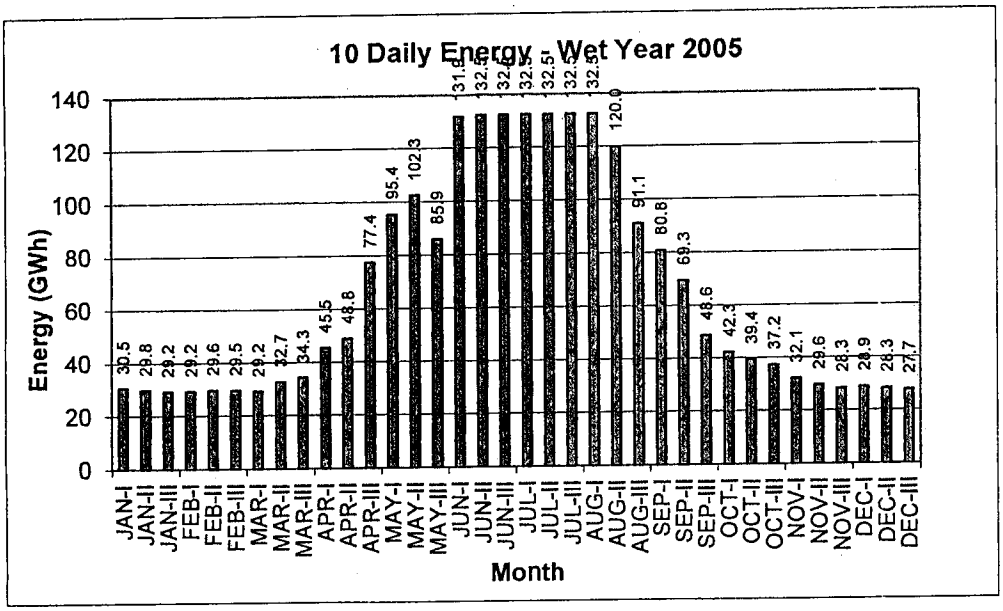

Figure - 39: 10 Daily Energy without Thauti Flows– Wet Year 2005

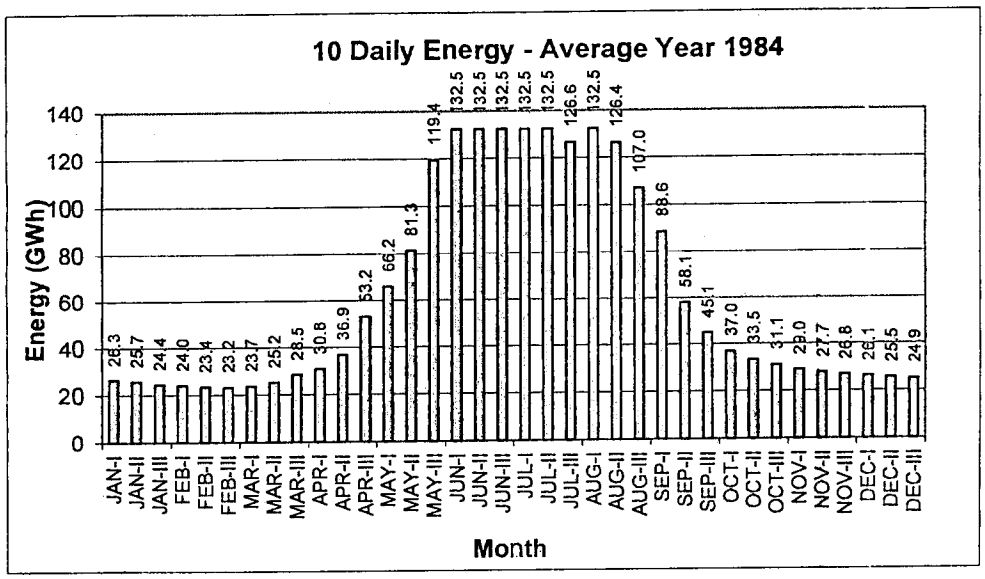

Figure - 40: 10 Daily Energy without Thauti Flows – Average Year 1984

The calculated annual energy without Thauti Nullah flows, for years 1984 (average year), 1982 (dry year) and 2005 (wet year), are 2360.1, 2220.9 and 1845.6 GWh respectively. The energy calculated based on daily flows for 53 years ranges between

1841 GWh to 2428 GWh. For the purpose of this study, a conservative value of **2184.6 GWh** has been taken as mean annual energy.

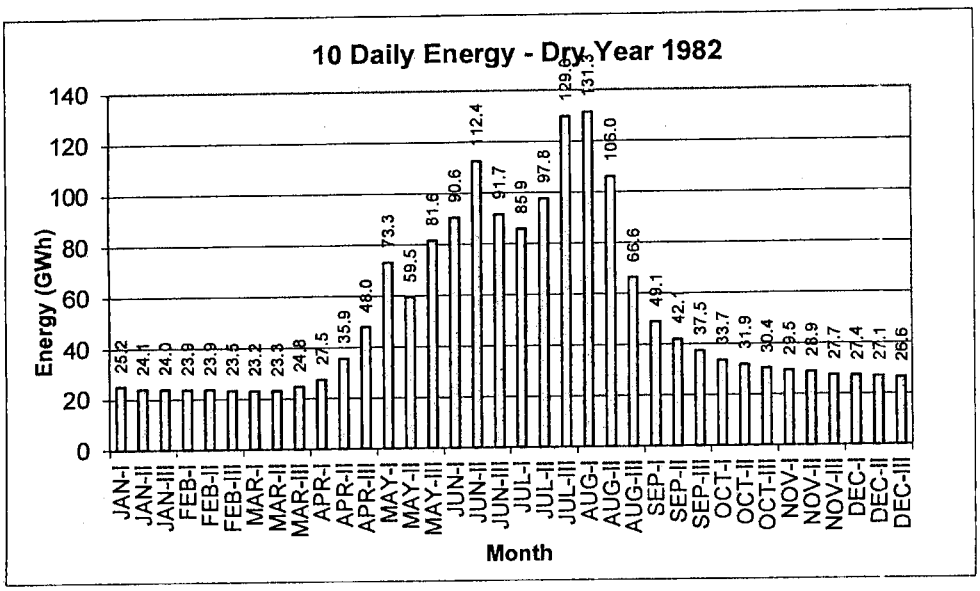

Figure - 41: 10 Daily Energy without Thauti Flows – Dry Year 1982

The 10 daily energy for wet, average and dry years is graphically presented in **Figures – 39, 40** and **41** respectively.The mean annual energy for the recorded period from 1961 to 2013 have been estimated and is graphically presented in **Figure - 42**. The annual flows, peak, off peak and total annual energy for 53 years is summarized in **Table – 15.** 10 Daliy flows, net head, peak, off peak and total energy for the period 1961 to 2013 are presented as **Annex-3**.

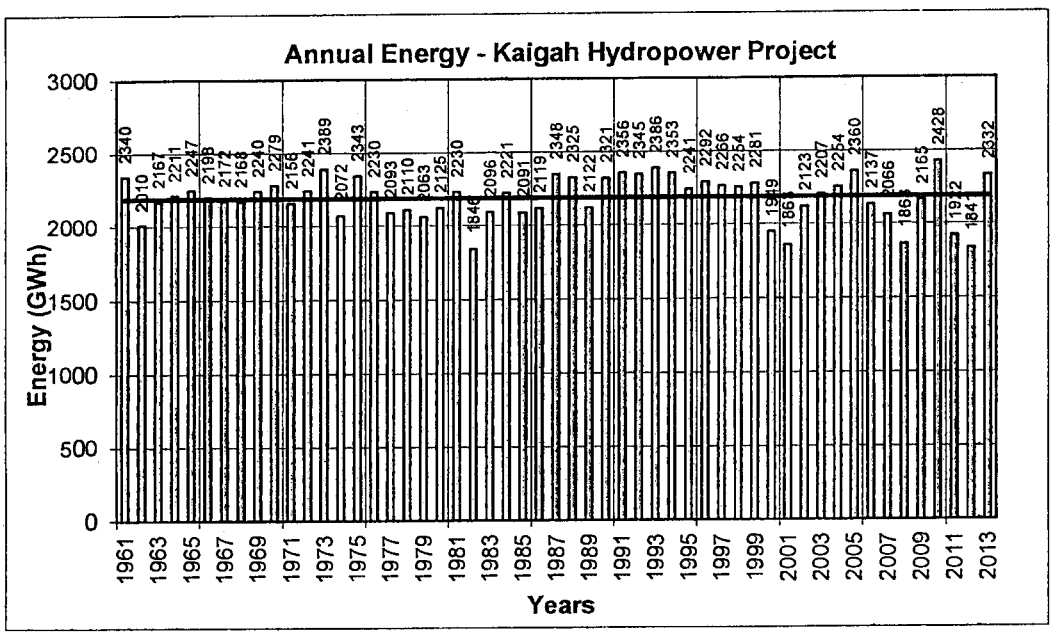

Figure - 42 Average Yearly Energy without Thauti Nullah– Kaigah HPP

7.0 Conclusions

The flow observations of Kandian River at Thauti during 2006-09, and 2012-14 improve the specific flows of Kandian catchment from 34.4 l/s/km^2 to 36.8 l/s/km^2 which is more realistic in comparison with specific flows of neighboring catchments.

The average annual flows of Kandian river at Thauti nullah was estimated as 68.4 m^3/s during Feasibility study and it has now been improved to 74.8 m^3/s. The mean annual flows of Kandian River at dam and along with Thauti nullah have been worked as 65.8 m^3/s and 72.3 m^3/s respectively.

For optimized design discharge of 125 m^3/s and a net head of 511.3 m, the installed capacity is 545 MW. The mean annual energy with Thauti nullah 2368 GWh at a plant factor of 49.6%. The mean annual energy without Thauti nullah reduced to 2184 GWh at plant factor of 45.8%.

The mean annual energy 2184 GWh without Thauti nullah is still more than 2116 GWh, estimated in the Feasibility with Thauti nullah. The utilization of flows of Thauti nullah may be reviewed to be considered along with Kaigah Hydropower Project or a separate project.