1342

Application for the Generation License

for

10.49 MW Hydro Power Generation Facility

on behalf of

Mehar Hydro Power (Private) Limited

At

Mauza Kanda kharan, Tehsil Chunian, District Kasur, Province of Punjab, Pakistan

Before

The National Electric Power Regulatory Authority (NEPRA)

Dated: February 9, 2017

Mehar Hydro Power (Private) Limited
Address : 142 D, Model Town Lahore, Punjab, Pakistan
Phone : 042 -35854210

MEHAR HYDROPOWER (PRIVATE) LIMITED

MHPL/GL-01 February 9 , 2017

The Registrar,
National Electric Power Regulatory Authority,
NEPRA Tower, Attaturk Avenue (East),
Sector G-5/I
Islamabad, Pakistan.

Subject: **Application for Generation License for 10.49 MW HPP - Mehar Hydropower (Private) Limited**

Dear Sir,

I, Mobashir Ahmed Malik, being the authorized representative of Mehar Hydropower (Private) Limited, duly authorized by virtue of Board resolution dated 6th February 2017, hereby apply for grant of generation license to the project company pursuant to section 3 of the Regulation of Generation, Transmission and Distribution of Electric Power Act 1997.

I certify that documents enclosed in support of this application are prepared and submitted in conformity with the provisions of the National Electric Power Regulatory Authority Licensing (Generation) Rules, 2000 read with the National Electric Power Regulatory Authority Licensing (Application and Modification Procedures) Regulations 1999 and undertake to abide by the said rules and 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 No.BBB12478847 in the sum of Rupees PKR 219,672 (Two Lac Nineteen Thousand Six Hundred and Seventy Two), being the non-refundable license application fee calculated in accordance with the schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations 1999 is also attached herewith.

We have attached below documents, in this regard, along with the application:

a) Letter of intent
b) Three copies of Generation License Application;
c) Board Resolution dated 6 February 2017;
d) Affidavit of Chief Executive Officer dated 9th February 2017;
e) Bank Draft;
f) Certificate of Incorporation;
g) Memorandum and Articles of Association;
h) Returns filed with the Companies Registration Office;
i) Profile of key employees and advisors;
j) Project Feasibility Study;
k) Grid Interconnection Study;
l) Initial Environment Examination Report;

We request that Project Feasibility Study and Grid Interconnection Study shall be held in confidence.

We shall be pleased to provide any further information you may require. We request an early action in this matter.

For and On Behalf of Mehar Hydropower (Private) Limited
Thanking You,

Mobashir Ahmed Malik
CEO

MEHAR HYDROPOWER (PRIVATE) LIMITED

EXTRACT OF THE RESOLUTION PASSED IN THE MEETING OF BOARD OF DIRECTORS HELD ON DATE, 06 February 2017 AT 10 am AT ITS REGISTERED OFFICE.

"**RESOLVED THAT**" the Mehar Hydropower (Pvt) Ltd ("MHPPL") intends to install Hydro Power Project having capacity of 10.49 MW at Mauza Kanda Kharan, Tehsil Chunian, District Kasur, Punjab Province.

"**FURTHER RESOLVED THAT**" Mr. Mobashir Ahmed Malik (Chief Executive Officer), be and is hereby authorized and empowered, on behalf of the MHPPL, to apply to the National Electric Power Regulatory Authority **(NEPRA)** in connection with the issuance of generation license, tariff and other related matters and to sign and execute all the documents, appoint consultants and present evidence and do and take all necessary acts, which may be required by NEPRA from time to time and to do all other incidental and ancillary acts, things, and deeds.

"**FURTHER RESOLVED THAT**" a copy of this board resolution be provided to NEPRA with the seal/stamp duly affixed thereon for their information and record.

Certified to be true copy

Chief Executive/Director

Mehar Hydropower (Private)

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

A026280

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

SECP

COMPANY REGISTRATION OFFICE, LAHORE

CERTIFICATE OF INCORPORATION

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

Corporate Universal Identification No. **0105145**

I hereby certify that **MEHAR HYDROPOWER (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 **Lahore** this **Twenty Third** day of **January**, Two **Thousand and Seventeen**.

Fee Rs.410,500/-

(SABOOHI ISRAR)
Deputy Registrar

No.ARL/ 17490 DATED: 23-01-2017

THE COMPANIES ORDINANCE, 1984

--:o:--

(PRIVATE COMPANY LIMITED BY SHARES)

--:o:--

Memorandum of Association

of

MEHAR HYDROPOWER (PRIVATE) LIMITED

I. The name of the Company is "**MEHAR HYDROPOWER (PRIVATE) LIMITED**".

II. The Registered Office of the Company shall be situated in the Province of the Punjab.

III. The objects for which the Company is 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 incidentally hereafter discovered in dealing with electricity, subject to permission from NEPRA/relevant authority.

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, subject to permission from

NEPRA/relevant authority.

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 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.

10. To act as dealers, traders, commission agents, mercantile construe agents, distributors, stockists, importers, exporters, shipping, clearing and business forwarding agents, selling agents, indenting agents, advertising agents, representatives of commercial, industrial, agricultural and manufacturing concerns.

11. To carry on and undertake trading business of all sorts and to act as indentors, importers, exporters, traders, suppliers and commission agents of products, commodities 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, as permissible under law.

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

13. 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.

14. 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.

15. 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 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.

16. 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, trademarks, patents, patent right, 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, develop, grant licences in respect of or

otherwise turn to account any property, rights, and information so acquired, subject to any permission required under the law.

17. 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, trademarks, 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.

18. To apply for, purchases or otherwise acquire and protect, prolong and renew whether in Pakistan or elsewhere any patents, patent rights, trade marks, designs, licenses, protections, concession and the like conferring any exclusive or non-exclusive or limited rights to use any secret or other information as to any invention, process or privilege which may seem capable of being used for any of the purpose calculated directly or indirectly to benefit the Company and to use, exercise, develop, manufacture under or grant licenses or privilege in respect of, or otherwise turn to account the property, rights and information so acquired.

19. To expend money in experimenting on and in improving or seeking to improve any patents, rights, inventions, discoveries, process or information of the Company or which the Company may acquire or propose to acquire.

20. 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, subcontractors, or otherwise.

21. To go in for, buy or otherwise acquire and use any patent design, copyright, licence, concession, convenience, innovation, invention, trade marks, or process, rights, or 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.

22. To appoint any person or company as agent of this Company and to grant power of attorney to any person or company (except managing agent).

23. To acquire and carry on all or any part of the business or property and to undertake any liabilities of any person, firm, association or company's possession of property suitable for any of the purposes of the Company or carrying on any business which this Company is authorised to carry

on and in consideration for the same, to pay cash or to issue shares of the Company.

24. 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.

25. To enter into partnership, to amalgamate, or merge movable with immovable and/or to buy on all interests, assets, liabilities, stocks, or to make any arrangement for sharing profits, union of interests, cooperation, 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.

Company Registration Office Lahore * Securities and Exchange Commission of Pakistan * SECP

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

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

28. To amalgamate with any other company whose objects are or include objects similar to those of this Company whether by sale or purchase.

29. To invest the surplus money of the Company not immediately required in any manner permitted under the law.

30. To adopt such means of making known and giving publicity to the business and products of the company by means the company may think fit and particularly by advertising in the press by circulars, by exhibition of works and of art or interest, by publication of books and periodicals and by granting prizes, rewards and donations.

31. To conduct, encourage, promote, support, arrange and organize seminars, symposiums, exhibitions, fairs, conferences, lectures, demonstrations and other similar activities for promotion of sales or other business interests of any person, companies, firms, individuals, associations, local or government bodies, foreign governments, and international agencies, in Pakistan and any part of world for and on behalf of customers and for that purpose to carry out market surveys, researches, training programs and other activities.

32. 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.

33. 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.

34. 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.

35. 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, 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.

36. 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.

37. 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.

38. To give any servant or employee of the Company commission on the sale of the products or 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.

39. To establish and support or aid in the establishment and support of associations, institutions, funds, trust, 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, predecessors or associate of the

Company or the dependents or connection of such persons and to grant pensions, gratuities, allowances, reliefs, payments towards insurance and to subscribe or contribute money to employees provident funds, or for charitable or benevolent objects and payments in any other manner calculated to benefit the persons described herein.

40. To undertake and execute any trust, the undertaking of which may seem desirable to the Company.

41. To subscribe or contribute or otherwise assist or to grant money to charitable, benevolent, religious, scientific, national, public, institutions, objects or purposes or for any exhibition.

42. To dispose of and deal with any shares and securities of other companies which may be required by this Company in such manner as may be from time to time determined. But not to act as an investment company, a brokerage house or a finance company.

To create any reserve fund, sinking fund, insurance fund or any other special fund, whether for depreciation or for repairing, insuring, improving, extending or maintaining any of the property of the Company or for any other purpose conducive to the interests of the Company.

44. To sell, exchange, mortgage, grant licenses, easements and other rights over and in any other manner deal with or dispose of the undertaking, property, assets, rights, and effects of the Company or any part thereof for such consideration as may be thought fit and in particular for stocks, shares or securities of any other Company.

45. 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 or having objects altogether or in part similar to those of this Company.

46. 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.

47. To carry on the business of general order suppliers including Government, Semi-Government Agencies, Armed Forces, Army, Military or Defence and to act as commission agents, indenters, traders, general merchants, wholesalers, retailers, dealers, distributors, stockists in any goods or products or within the scope of the object of the Company and subject to any permission required under the law.

48. 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.

49. To do all or any of the above things as principal, agents, contractors, trustees, or otherwise and by or through trustees, agents, or otherwise and either alone or in conjunction with others.

50. Notwithstanding anything stated in any object clause, the Company shall apply for and obtain necessary consents, permissions and licences from any Government, State, Local and other Authorities as and when required by law to undertake a particular business.

51. 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 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. 100,000,000/- (Rupees One Hundred Million only) divided into 1,000,000 ordinary shares of Rs. 100/- (Rupees One Hundred only) each with powers to increase and reduce the Capital of the Company and to divide the shares in the Capital for the time being into several classes in accordance with the provisions of the Companies Ordinance, 1984.

Company Registration Office Lahore
Securities and Exchange Commission of Pakistan
SECP

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) and C.N.I.C #	Father's / Husband's Name (in Full)	Nationality with any former Nationality	Occupation	Residential Address (in Full)	Number of shares taken by each subscriber	Signature
1. ASSOCIATED TECHNOLOGIES (PRIVATE) LIMITED CUIN: 0016969 Represented by: Mobashir Ahmed Malik				House No. 80-L, Model Town Ext., Lahore.	100,000 One Hundred Thousand	
2. MOBASHIR AHMED MALIK CNIC No: 35202-2919231-5	S/o Malik Mehr Din	Pakistani	Construction Business	House No. 174-C, Model Town, Lahore.	350,000 Three Hundred and Fifty Thousand	
3. SADIA MALIK CNIC No: 35202-2733553-4	W/o Bilal Ahmed Chaudhry	Pakistani	Construction Business	House No. 174-C, Model Town, Lahore.	50,000 Fifty Thousand	
				Total Number of Shares Taken	500,000 Five Hundred Thousand	

Dated this..... 6th .... Day..... of .... January, 2017.

Witness:

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

CERTIFIED TO BE TRUE COPY
23/01/2017
DEPUTY REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

Company Registration Office Lahore
Securities & Exchange Commission of Pakistan

THE COMPANIES ORDINANCE, 1984

--:o:--

(PRIVATE COMPANY LIMITED BY SHARES)

--:o:--

Articles of Association

of

MEHAR HYDROPOWER (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. 100,000,000/- (Rupees One Hundred Million only) divided into 1,000,000 ordinary shares of Rs. 100/- (Rupees One Hundred only) each with powers to increase, consolidate, sub-divide or otherwise re-organize the share Capital of the Company and to divide the shares in the Capital for the time being into several classes in accordance with the provisions of the Companies Ordinance, 1984.

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.

Company Registration Office Lahore
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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 at least 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 will be 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 up to 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 equal to, or 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 claims 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.

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 at least 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 judgment or oversight on his part, unless the same happens through his own dishonesty or willful 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. In the event that a dispute, claim or controversy arises between the company, its management and its shareholders, or between the shareholders inter-se , or the directors inter-se, all steps may be taken to settle the dispute and resolve the issue through mediation by an accredited mediator before taking recourse to formal dispute resolution such as arbitration or litigation.

45. 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 anything 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.

46. 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

47. 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.

LETTER OF INTENT

No. PPDB/ 354 /2016
PUNJAB POWER DEVELOPMENT BOARD
ENERGY DEPARTMENT
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 042-99213879 Fax: 042-99213885)

Date: 15 / 03 /2016

M/s Associated Technologies (Pvt.) Limited
142-D, Model Town,
Lahore

Subject: **LETTER OF INTEREST (LOI) FOR DEVELOPMENT OF 11 MW HYDROPOWER PROJECT (HPP) ON BALLOKI-SULEMANKI (BS) LINK-I CANAL, RD. 106+250, DISTRICT KASUR**

The Evaluation of Statement of Qualification (SOQ) submitted by M/s Associated Technologies (Pvt.) Limited, for 11 MW Raw Site HPP on Balloki-Sulemanki (BS) Link-I Canal at RD. 106+250, District Kasur (the "Project") has been considered by PPDB Board during its 33rd meeting held on 18th November 2015 as per eligibility criteria laid down in the Punjab Power Generation Policy-2006 (Revised-2009) (the "Policy") and Pre-Qualification Documents (PQD) issued to your company.

2. After due diligence, the Board has unanimously decided to issue Letter of Interest (the "LOI"), with four (4) months compressed timeline for completion of the Feasibility Study, to the Consortium comprising of following members:

(i)	**Associated Technologies (Pvt.) Limited**	**Main Sponsor**
(ii)	Xinjiang Beixin Construction Engineering Group Co. Ltd.	Member

3. In response to this Office letter No. PPDB/125/2016 dated 27.01.2016, your Company has submitted the Bank Guarantee # 003/16/093/LG/TC amounting to Rs. 1,166,000/- (Rupees One Million One Hundred & Sixty Six Thousand only), issued on February 02, 2016 with the expiry date of December 01, 2016, by SILK Bank Limited, Trade Processing Centre, 14-Egerton Road, Lahore in the name of M/s Associated Technologies Limited.

4. Now, this LOI is being issued on behalf of Government of the Punjab (the "GoPb"), in terms of the provisions of the Policy. GoPb hereby confirms its interest in your proposal to conduct the feasibility study for the development of the Project subject to the following:

a. You are required to complete the Feasibility Study of the Project, at no risk and cost to, and without any obligation on the part of, the GoPb / PPDB and its agencies, within four (4) months from the date of issuance of this LOI.

b. You will not disturb the irrigation regime.

c. You will be provided with the available data / information regarding feasibility study of the Project. You are required to conduct the Feasibility Study; complete, at internationally acceptable standards and in accordance with the terms and conditions stipulated in the Policy. The updated Feasibility Study must include an Environmental Impact Assessment Study, detailed design of power house, load flow and stability studies, design of interconnection / transmission lines, details pertaining to infrastructure, project cost, financing and, financing terms, tariff calculations and assumptions of financial calculations including economic / financial analysis. You are advised to liaise with the power purchaser while determining your plant size and site, project layout, transmission line and interconnection arrangements, etc.

d. You will carry out the Feasibility Study according to the specific milestones appended herewith at **Annex-A**, and submit monthly progress reports showing progress against these milestones.

e. You will establish a Special Purpose Vehicle (SPV) company and shall maintain the shares in this company in accordance with Para 39 & 40 of the Policy and will submit copy of Memorandum & Articles of Association as well as the Form 29 duly attested by the Securities & Exchange Commission of Pakistan (SECP). The shareholding in the said SPV must be reflected in accordance with the submitted SOQ.

f. PPDB will appoint a Panel of Experts (POE) to monitor the progress of Feasibility Study, verify attainment of the aforesaid milestones and to ensure implementation of the Project consistent with national and provincial needs.

g. The Main Sponsor will be liable for all obligations and liabilities of and on behalf of other Sponsors. Further processing of the Feasibility Study is subject to acceptance of GoPb in accordance with the Policy.

h. The validity of this LOI is four (4) months from the date of its issuance, where after, it will automatically be lapse with immediate effect. Issuance of this LOI or the lapsing of its validity, or your conducting a Feasibility Study there under, cannot form the basis of any claim for compensation or damages by the Sponsors or the project company or any party claiming through them against the GoPb / PPDB or any of its agencies, employees or consultants on any grounds whatsoever, during or after the expiration of its validity.

i. You are, therefore, required to complete the Feasibility Study for the said Project within the validity of this LOI. In case there is delay in completion of the Feasibility Study within the validity of this LOI, a one-time extension by PPDB Committee may be granted up to a maximum period of thirty (30) days, provided the Panel of Experts is satisfied that the Feasibility Study is being conducted in a satisfactory manner and is likely to be completed shortly. Furthermore, extension in validity of the LOI will only be provided upon submission of a bank guarantee in **double the original amount and valid beyond 180-days of the extended LOI period**.

j. **In case, you fail to meet the relevant milestones and standards, PPDB will terminate this LOI and encash the Bank Guarantee due to non-performance.**

k. This LOI has been issued in duplicate on the date hereof, and it shall come into effect when one copy hereof is received by PPDB after having been duly countersigned by you. Nevertheless, this LOI shall lapse if the countersigned copy is not received at PPDB within five (05) days of its issuance.

Regards,

SANIYA AWAIS
Managing Director

Accepted and agreed for & on behalf of:

Signature:

Date: 18-03-16

ENCL: *As stated above*

CC:

1. The Chairman, NEPRA, Islamabad
2. The Secretary to Chief Minister Punjab, Lahore
3. The Chairman WAPDA, WAPDA House Lahore
4. The Secretary, Ministry of Water & Power, Islamabad
5. The Chief Executive Officer, Central Power Purchasing Agency (CPPA), Islamabad
6. The Chairman PPDB Board / Additional Chief Secretary, Government of the Punjab, Energy Department, Lahore
7. The Managing Director, Private Power & Infrastructure Board (PPIB), Islamabad
8. The Chairman, Government of the Punjab, Planning & Development Department, Lahore
9. The Secretary, Government of the Punjab, Energy Department, Lahore
10. The Secretary, Government of the Punjab, Irrigation Department, Lahore
11. The Secretary, Government of the Punjab, Environement Protection Department, Lahore
12. The Chief Executive Officer, Lahore Electric Supply Company (LESCO), Lahore
13. The Chief Engineer (Power), Government of the Punjab, Energy Department, Lahore
14. The Chief Engineer, Irrigation Zone, Lahore
15. The Chief Executive Officer, Punjab Power Development Company (PPDCL), Lahore

Annex-A

TIME LINE (COMPRESSED 4 MONTHS) FOR FEASIBILITY REVIEW AND UPDATE

Sr. No.	Activities	Dates (2016)	Time (Days)	Duration (Weeks) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Issuance of LOI	15-Mar																		
2	Acceptance/Return of LOI	20-Mar	5																	
3	Procurement of Consultants	25-Mar	10																	
4	Mobilization of Consultants	30-Mar	5																	
5	Update Hydrological Data, Geology, Geo-technical, Seismicity, Topographic Survey & Power Potential study	29-Apr	30																	
4	Update Interconnection & IEE Study	19-May	50																	
6	POE Meeting	26-Apr	1																	
8	Issuance of Minutes of meeting	27-Apr	1																	
9	Selection of Final Layout, Sizing of HPP, Optimization of Selected Layout & Finalization of Feasibility Level Design	29-May	30																	
10	POE Meeting	5-Jun	1																	
11	Issuance of Minutes of meeting	6-Jun	1																	
12	Construction Planning & Project Cost Estimate	13-Jun	15																	
13	Economic & Financial Analysis	13-Jun	15																	
14	Draft Feasibility Report & Review of POE	23-Jun	10																	
15	Final Feasibility Report Submission	8-Jul	15																	
16	Meeting/Approval by POE	8-Jul	1																	
17	Issuance of Minutes of meeting	13-Jul	1																	
	Progress Reports																			
	Monthly Reports																			
	Total Days		120																	

15.9.16

1. BACKGROUND TO GENERATION LICENSE APPLICATION

1.1. PROCESS OF ISSUANCE OF LETTER OF INTENT LEADING TO GENERATION LICENSE APPLICATION

1.1.1. Issuance of "Letter of Intent"

MEHAR HYDRO POWER (PRIVATE) LIMITED (a company duly organized and existing under the laws of Pakistan, with its office located at 142 D, Model Town, Lahore, Punjab, Pakistan) (the **Project Company**),a special purpose company, to develop BS Link-1 11 MW hydropower project (the **Project**), for which Letter of Intent (the **LOI**) has been issued to Associated Technologies (Private) Limited as Main Sponsor by the Punjab Power Development Board (the **PPDB**) on March 15, 2016.

1.1.2. Approval of Project Feasibility Study

Pursuant to the relevant provisions of the Punjab Government's Power Generation Policy 2006 (the **Policy**) and the LOI, a leading technical consulting firm, **Integral Consulting Inc**, was engaged to undertake the Project Feasibility Study and for supervising the Hydro measurements and preparing conceptual design of the Facility. The detailed feasibility study was submitted the same to PPDB for its approval (the **Project Feasibility Study**). On January 25^{th}, 2017 PPDB accorded its approval to the Project Feasibility Study through its letter No PPDB/149/2017. A copy of the Project Feasibility Study and its Approval Letter are annexed as **ANNEX A**.

1.1.3. Approval of Initial Environmental Examination Report

In accordance with the requirements of the LOI and Punjab Environmental Protection Act 1997, Project's Initial Environmental Examination Report (IEEE) was undertaken and submitted to Environment Protection Agency (EPA), Punjab. EPA accorded its approval to the IEE Report for the Project through its letter dated December 23^{rd}, 2016 vide letter No. DD (EIA)/EPA/F-400(IEE)1412/2016/695. A copy of the Project Initial Environmental Examination Report (IEE)and its Approval Letter are annexed as **ANNEX B**.

1.1.4. Approval of Grid Inter-Connection Study

ARCO Energy was engaged for conducting Grid Inter-connection Study. The Grid Interconnection Study covered all aspects of the Project interconnection including Load Flow Analysis, Short circuit analysis; and Dynamic Stability Analysis. The Grid Inter-connection Study was submitted to Lahore Electric Supply Company (LESCO) for its approval.

Chief Engineer LSECO through his letter dated 21/12/2016 with Ref No *6927-31/CE (DEV)/P&S/PMU/393* accorded the approval of the Grid Interconnection Study. The Grid Interconnection Study and its approval are annexed as **Annex C**.

1.2. SUBMISSION

1.2.1. Under Regulation of Generation, Transmission and Distribution of Electric Power Act (XL of) 1997 (the **NEPRA Act**) and the National Electric Power Regulatory Authority Licensing (Generation) Rules 2000, the National Electric Power Regulatory Authority (**NEPRA**) has the authority to, *inter alia*, grant licenses for the generation of electric power and to determine other terms and conditions for the supply of electricity through generation.

1.2.2. **PURSUANT TO** the Sections 7 (2) (a) and 15 of the NEPRA Act read with the other enabling provisions of the NEPRA Act, the National Electric Power Regulatory Authority Licensing (Application & Modification Procedure) Regulations 1999, National Electric Power Regulatory Authority Licensing (Generation) Rules 2000, **AND** in accordance with the Policy: **MEHAR HYDRO POWER (PRIVATE) LIMITED SUBMITS HEREWITH** for NEPRA's kind and gracious consideration, the application for the grant of a generation license along with supporting documents (the **Generation License Application**) for and on behalf of **MEHAR HYDRO POWER (PRIVATE) LIMITED** for its 10.49 MW power generation facility to be located at Mauza Kanda Kharan, Tehsil Chunian, District Kasur, Punjab, Pakistan.

1.2.3. Given the advance stage of the Project, NEPRA is kindly requested to process the Generation License at the earliest, thereby enabling the Project Company to proceed further with the development process.

1.2.4. This Generation License Application is submitted in triplicate.

1.2.5. A bank draft amounting PKR 219,672(Pakistani Rupees) dated 07th February 2017 in favor of NEPRA is attached as Generation License fee.

2. APPLICANT'S PROFILE – MEHAR HYDRO POWER (PRIVATE) LIMITED

2.1. The Project Company, being the applicant under this Generation License Application, is a private limited company that was incorporated under the laws of Pakistan and has been specifically established to undertake power generation business and activities in Pakistan.

2.2. The Project Company (following grant of a generation license and approval of the Project Company's reference generation tariff by NEPRA) proposes to finance, design, engineer, procure, construct, install, test, complete, commission, insure, operate and maintain a project (the **Project**) constituting a 10.49 MW power generation facility (the **Facility**) to be located at Mauza Kanda Kharan, Tehsil Chunian, District Kasur, Province of Punjab, Pakistan (the **Site**).

2.3. For the purposes of designing, engineering, procuring, constructing, installing, testing, completing, commissioning, operating and maintaining of the Facility, the Project Company is in process of finalizing key contracts with the with internationally reputable contractors.

2.4. Associated Technologies (Private) Limited (**ATL**) is the **main sponsor** of the Project. ATL is, an infrastructure development Company, was incorporated in 1987 under the Companies Ordinance 1984. ATL has successfully undertaken various power sector, construction, real estate and telecommunication projects.

ATL in association with its partners has been involved in the development of the projects like

- 720 MW Karot Hydro Power Project
- 545 MW Kaigah Hydro Power Project
- 81 MW Malakand III Hydro Power Project

2.5. The Project Company has engaged a team of qualified and experienced personnel (together with a team of reputable technical, legal and financial advisors) for the development of the Project. Following is the brief profile of the key management personnel

Mobashir Ahmed Malik

Mr.Malik is CEO of the Mehar Hydro Power (Pvt) Ltd. He is a successful entrepreneur with business interests in many sectors. He completed his Master's degree in Mechanical Engineering from Texas A & M University of USA and B.Sc. Engineering from University of Engineering & Technology Lahore Pakistan in 1976. He started his professional career as engineer with NESPAK in 1977. Mr. Malik established Associated Technologies (Pvt) Ltd in 1988 and worked as Director and became CEO in 2003. He has been involved in many construction, telecom and power sector projects . He has been involved in the development of 720 MW Karot Hydropower Project , 545 MW Kaigha Hydropower Project. He also led the ATL team in the construction of 81 MW Malakand 3 Hydropower project.

Ms.Sadia Malik

Ms.Sadia Malik is Director of the Mehar Hydro Power (Pvt) Ltd. She completed her Masters of Management from Monash University, Melbourne, Australia and Bachelors of Computer Science from National University of Computer &amp Emerging Sciences (FAST). She joined Associated Technologies (Pvt) Ltd in 2008 as Business Development Manager . She has been involved in various power projects including 720 MW Karot Hydropower Project , 545 MW Kaigha Hydropower Project, feasibility study of 20 MW solar power project and 2.2 MW Machai Hydropower Project .

Ali Nawaz Khan

Mr.Ali Nawaz Khan is working Project Manager in Mehar Hydro Power (Pvt) Ltd . He is seasoned Civil Engineer with a diversified domain experience of design and implementation. His areas of expertise include Project Management, Hydraulic and hydropower engineering, Structural Design, Construction management and Environmental Impact assessment. Mr.Ali graduated from UET Lahore in Civil Engineering and Master Degree in Hydro Power Engineering. He has thorough experience of Hydro power projects development from conception till their final execution. Currently he is working as a Project Manager with the company. He, along with the foreign consultants, has the privilege of successfully undertaking the geo-tech investigations, dam modeling and design, study of the hydrological parameters and active participation in the detailed engineering design for the following hydropower projects including 545 MW Kaigah HPP, 24 MW Kaigah-II HPP and 11 MW BS-Link HPP.

Athar Shah Khan

MrAthar Shah is working as commercial manager in Mehar Hydro Power (Pvt), He completed his Master's degree in Business Administration(MBA) from COMSATS Institute of Information Technologies Islamabad Pakistan in 2003. He started his professional career as an Assistant Manager Sales from Global Link Communication, Dubai UAE, then he Join NORVIDA, Denmark as Manger Marketing. He joined Associated Technologies Pvt. Ltd. In 2006 as Manager Business Development and since been rendering useful services to the company. Mainly he is involved in Telecommunication and renewable energy projects. He has been involved in the development of 720 MW Karot Hydro power Project , 545 MW Kaigha Hydro power Project, 24MW Kaigah-II Hydropower Project, 2.2 MW Machi Hydropower Project, 100MW Wind project and 20MW Solar project. He was a part of team in the execution of 81 MW Malakand-III Hydro power project which ATL completed in a Joint Venture with a Chinese company.

Mahmood Siddiqui

Mr.Mahmood Siddiqui is working as Generral Manager Finance.He is a professional accountant with strong educational background in accounting. He started his professional career Manager Finance in Associated Technologies Pvt. Mr.Mahmood has experience of working for telecommunication and renewable energy projects. He has been involved in the development of 720 MW Karot Hydro power Project , 545 MW Kaigha Hydro power Project, 24MW Kaigah-II Hydropower Project, 2.2 MW Machi Hydropower Project, 100MW Wind project and 20MW Solar project. He was a part of team in the execution of 81 MW Malakand-III Hydro power project which ATL completed in a Joint Venture with a Chinese company.

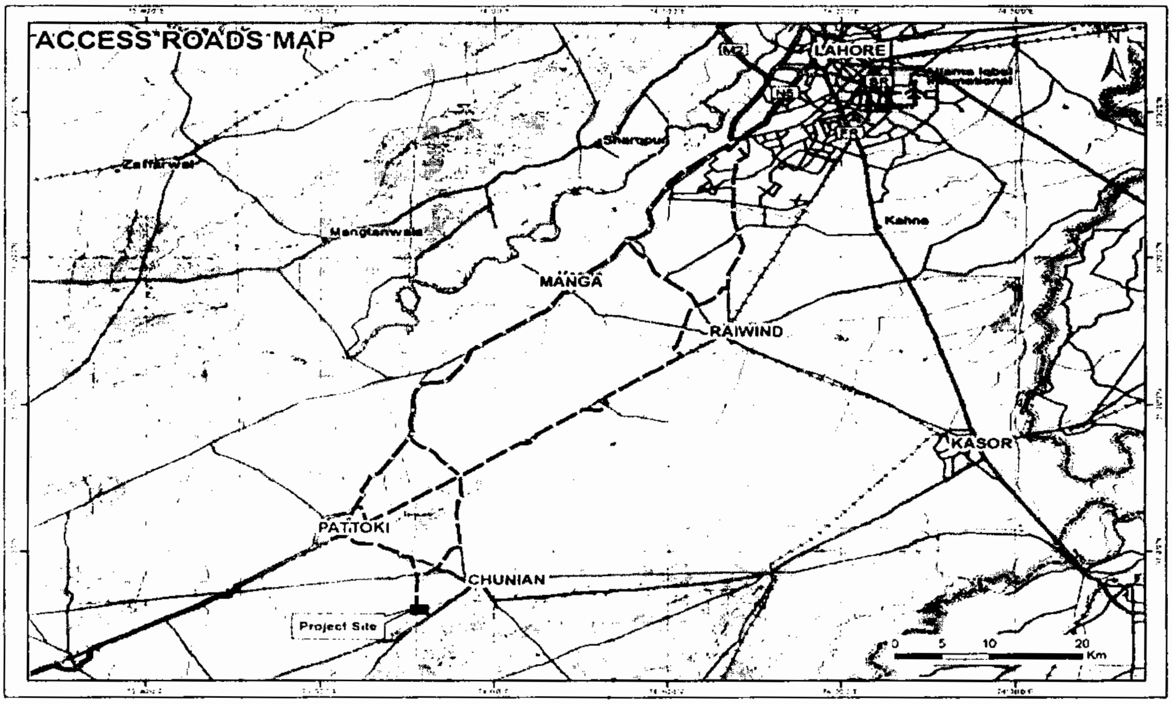
3. The Project -10.5 MW BS Link -1 Hydro Power Project

3.1. BRIEF INTRODUCTION

BS Link-I 10.49 MW Hydropower Project is located on BS Link Canal in Kasur. A Letter of Intent (LOI) for the Project has been issued by the Punjab Power Development Board (PPDB) to the consortium led by Associated Technologies (Private) Ltd (the "**Sponsors**") under Punjab Power Generation Policy 2006 for developing the Project on 30 years Built Operate and Transfer Basis (BOT).

The Sponsors shall be responsible for arranging the finances for the development and construction of the Project. Furthermore, they shall be responsible for the operation of the Project for 30 years.

The proposed BS Link-I HPP has a generation capacity of about 10.5 MW. Balloki- Sulemanki Link canal off-takes from left bank side of Balloki Barrage on river Ravi and connects Sutlej River upstream of Sulemanki Barrage. The proposed powerhouse of the Project will be constructed on the right-bank of the canal at RD 106+250 utilizing the existing available head of 3.242 m (10.64 ft.). It is located near the town of Chunian District Kasur of Punjab Province. The upstream limit of the Project is constrained by the Fall at RD 73+250 while downstream limits are controlled by the Chunian Distributary which is off-taking from right bank of BS-I link at RD 110+667. From Balloki Headwork to RD 73+250, the canal bed is unlined. However, at RD 73+250 the canal is bifurcated in two segments known as BS Link- I & BS Link-II canals and the canal bed of BS Link-I is brick-lined from that RD so on .



3.2. SALIENT FEATURES OF THE PROJECT

Following are the salient features of the Project

Project Name	BS Link -1 Hydro Power Project
Project/Facility Type	Low head – Hydro Power Project
Location	Kandu Khara, Tehsil Chunian, District Kasur
Design Discharge	350 m^3/s
Rated Head	3.55 m
Installed Capacity	10.49 MW (4x 2.6225MW)
Net Annual Plant Energy	66.61 GWh
Plant Factor	73%
Turbine Type	Horizontal Pit Type Kaplan (4 units)
Power Channel Top Width	41.124 m
Power Channel Bottom Width	34.138 m
Headrace Channel Length	464.8 m
Tailrace Channel Length	496.2 m
Design discharge for spillway	425 m^3/s
Powerhouse Dimensions	48.6 m x 88.66 m x 29.637 m
Length of Transmission Line	7km (to Chunian Grid Station)
Expected Life of the Project	50 years

Further details with respect to technology , model, design, operations, maintenance, planning, development of the Project and information related to the available and required infrastructure (roads, rail, staff colony, amenities) are discussed in the annexed Project Feasibility Report.

3.3. INVESTMENT PLAN

Total project cost is estimated at USD 45.44 Million which is equivalent to PKR 4.772 billion and is proposed to be financed through 80:20 debt and equity mix. The proposed financing plan shall be finalized and agreed with the project lenders in accordance with tariff approval by the NEPRA. Details are discussed in the annexed Project Feasibility Report.

3.4. SOCIAL AND ENVIRONMENTAL PLAN

Based on the survey of the study area and the initial environmental examination of the project site area, it is concluded that the proposed project at RD 106+250 will not have any adverse impacts on the physical, ecological, socioeconomic and the environment of the study area and small impacts should be mitigated at the end. Besides, the Project is an environmentally green project as there is no fuel usage is required and no pollution would be generated thereafter.

The IEE suggests that no further EIA is needed because no significant adverse physical, ecological and social environmental impact is identified. No dislocation is required for the people and no resettlement is needed in this area. The Project is beneficial not only for the residents living there, but it also will add electricity to the national grid of the country that will help to shortage the energy crisis of the country. Transmission lines route will not affect any settlement and the natural resources of the area rather this Project will work for the aesthetics of the area and in future there will be recreational points and parks for the people. Local residents are very much in favor of this Project and are well aware of the Project construction and activities.

Punjab EPA has accorded its approval to the IEE Report for the Project through its letter dated December 23rd, 2016 Vide letter No. DD (EIA)/EPA/F-400(IEE)1412/2016/695.

3.5. GRID INTERCONNECTION

The Project Company engaged ARCO Energy for conducting Grid Inter-connection Study and submitted the studies to LESCO for its approval. The Grid Interconnection Study covered all aspects of the Project including:

(i) Load Flow Analysis;
(ii) Short circuit analysis; and
(iii) Dynamic Stability Analysis;

The said study discusses plant characteristics: generation voltage, frequency, power factor, automatic generation control, ramping rate, auxiliary consumption, time(s) required to synchronize the grid, control, metering, instrumentation and protection.

Chief Engineer LSECO through his letter dated 21/12/2016 with Ref No *6927-31/CE (DEV)/P&S/PMU/393* conveyed the approval of the Grid Interconnection Study.

3.6. PROJECT SAFETY , TRAINING AND DEVELOPMENT PLAN

The Project shall be implemented in accordance with internationally accepted health and safety standards and in-line with the acclaimed practices and procedures of the industry. In line with the management's vision Project Company is committed to introduce and implement safety standards and procedures in the business operations of the Project both during construction as well as in the operation phase.

The Project Company aims to prepare the Project Company's staff in operating and maintaining the Facility in accordance with international standards. The training will be conducted with an aim to teach the Project Company's staff of the functions of each Facility system so that the same are informed of the Facility's (or any part thereof) functions in question and have the sufficient capacity to monitor the plant operation.

3.7. PROJECT IMPLEMENTATION SCHEDULE

The following tables provides the key upcoming milestones and expected time frame for their completion

ACTIVITIES	COMPLETION DATE
Grant of Generation License	Upon NEPRA's approval
Tariff Determination	Upon NEPRA's approval
Submission of Performance Guarantee by Project Company for issuance of LOS	15 days after Tariff determination by NEPRA
Issuance of LOS to Project Company by Government of Pakistan	7 days after submission of Performance Guarantee
Finalization of EPC Contract	April 2017
Land Acquisition	Within the time period allowed under the LOS
EPA Signing	Within the time period allowed under the LOS
IA Signing	Within the time period allowed under the LOS
Project Financial Close & ordering of equipment	Within the time period allowed under the LOS
Commercial Operation Date	36 months following Financial Close
Adjustment of reference tariff by NEPRA	Following Commercial Operations Date

In light of the above submissions and information contained in this Generation License Application, along with the Annexes annexed hereto, this Generation License Application is submitted for NEPRA's approval and for grant of the Generation License to the Project Company.

Mobashir Ahmed Malik

submitted for and on behalf of
MEHAR HYDRO POWER (PRIVATE) LIMITED

ANNEXURE-A: PROJECT FEASIBILITY STUDY

ANNEXURE-B: INITIAL ENVIRONMENT EXAMINATION REPORT

ANNEXURE-C: GRID INTERCONNECTION STUDY

ANNEXURE-C: GRID INTERCONNECTION STUDY

GRID INTERCONNECTION ASSESSMENT OF 11 MW BS LINK-1 HYDRO POWER PLANT

ARCO Energy

Final Report

November, 2016

ARCO Energy

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LAHORE ELECTRIC SUPPLY COMPANY
Office of Chief Engineer (Development) LESCO
Qartaba Grid Station Bahawalpur Road Lahore.
Ph:042-99214410 FAX 042-99214412

No. 6927-31 /CE(DEV)/P&S/PMU/393 Dated: 2/12/2016

To

Customer Services Director,
LESCO.

Sub: **Grid Interconnection Study of 11 MW BS Link-I Hydro Power Project RD 106+250, District Kasur**

Ref: Your office letter no. 52116-18 dated: 21-11-2016.

Please refer to your letter above vide which the final grid interconnection study report of the subject cited power plant was submitted to this office after addressing the discrepancies pointed out by this office.

This office has reviewed final grid interconnection study report. In this regard it has been found that the consultant has incorporated all the comments. therefore the final report is being vetted.

However, it is clarified that the report has been vetted only for interconnectivity aspect of the subject cited power plant. It should not be considered as a go-ahead signal to execute the project. Any commitment regarding project execution or consent of power purchase, tariff etc. has to be discussed with the concerned quarters.

It is further intimated that as the report has been prepared based on assumed parameters therefore if there will be any change in the parameters then the study should be revised accordingly.

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CONTENTS

EXECUTIVE SUMMARY

This Grid Interconnection Assessment (GIA) report provides the documentation of an assessment that has been performed for the connection of a 11 MW BS Link-I hydro power generation project by Associated Technologies Pvt. Limited (ATL) to the Lahore Electric Supply Company (LESCO) transmission system at 132kV. The '11 MW BS Link-I Hydro Power Project (RD. 106+250)' located in Kasur, Punjab, Pakistan and has a commercial operation date of September, 2020.

Two options are considered for interconnection arrangement of 11 MW BS Link-I Hydro Power Project. Steady state analysis has been performed on both options and evaluated as discussed below:

- **Option-I:** The hydro power plant will connect to 132/11kV Chunian grid station at 132kV by lying double 132kV circuit of 7km length on Lynx conductor.
- **Option-II:** The hydro power plant will connect to existing 132kV double circuit Pattoki-Chunian transmission line by making In/Out connection at BS Link-I HPP 132kV switchyard with feed length of 6.5km.

The steady state results of both options found no capacity constraint in terms of power flow and voltage ranges. Both options are further analysed and investigated under the influence of power & energy losses, cost of equipment installed, cost of augmentation required at substation.

After analysing, the option-II is adopted. The following conclusions emphasize the selection of option-II.

- No need of making line bays for new transmission lines that will connect Chunian 132/11kV substation to BS link-I hydro power plant in option-II.
- Less equipment would be required to install by LESCO for evacuation of power from subject power plant in option-II.
- No Right of Way (ROW) issues for option-II around the 132/11 kV Chunian grid station which is situated in a populated area.

Therefore, option-II is adopted for interconnection of the subject hydro power plant and option-II is analysed in the further analyses.

Dynamic stability analysis has been performed to access the dynamic impact of the hydro power plant on national grid system due to disturbances at the power plant and vice versa. The results of dynamic stability analysis indicate that the power system is stable for the interconnection proposal and it also fulfils all the criteria for generation connection with the power system.

Short circuit analysis has been performed to evaluate the contribution of the proposed project in fault current levels of substations in its electrical locality. Fault currents have been computed based on simulation of three-phase and single-line-to-ground faults by applying the criteria as mentioned in the IEC-909 standard. Result of the analysis shows that the calculated fault currents are below the circuit-breaker interrupting ratings of existing grid stations located in locality of the project; also it will help the EPC to select the switch-gear ratings in switchyard of BS Link-I HPP 132 kV.

Based on the study results, it is concluded that proposed generation interconnection assessment for 11 MW BS Link-I hydro power project meets the NEPRA grid code planning criteria.

1 INTRODUCTION

1.1 Project Description

This Grid Interconnection Assessment (GIA) report provides the documentation of an assessment that has been performed by ARCO Energy in response to a request made by Associated Technologies Pvt. Limited (ATL) (the "Project Owner" or "PO") for the connection of a 11 MW BS Link-I hydro power Generation Project ("Project") to the Lahore Electric Supply Company (LESCO) Transmission System at 132kV. The PO has proposed a commercial operation date of September, 2020 for the Project.

The project is located at Kasur, Punjab. Figure 1.1 shows Google site map of the project. The two interconnection arrangements are selected and analysed, Figure 1.2 and Figure 1.3 shows geographical representation of power plant for both options.

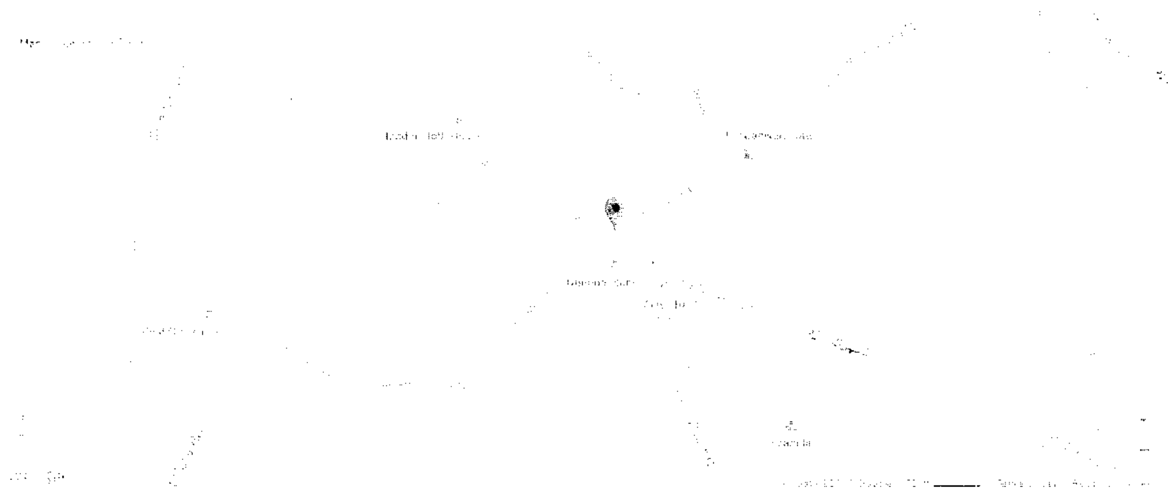

Figure 1.1: Google Site Map of the BS Link-I Hydro Power Generation Project.

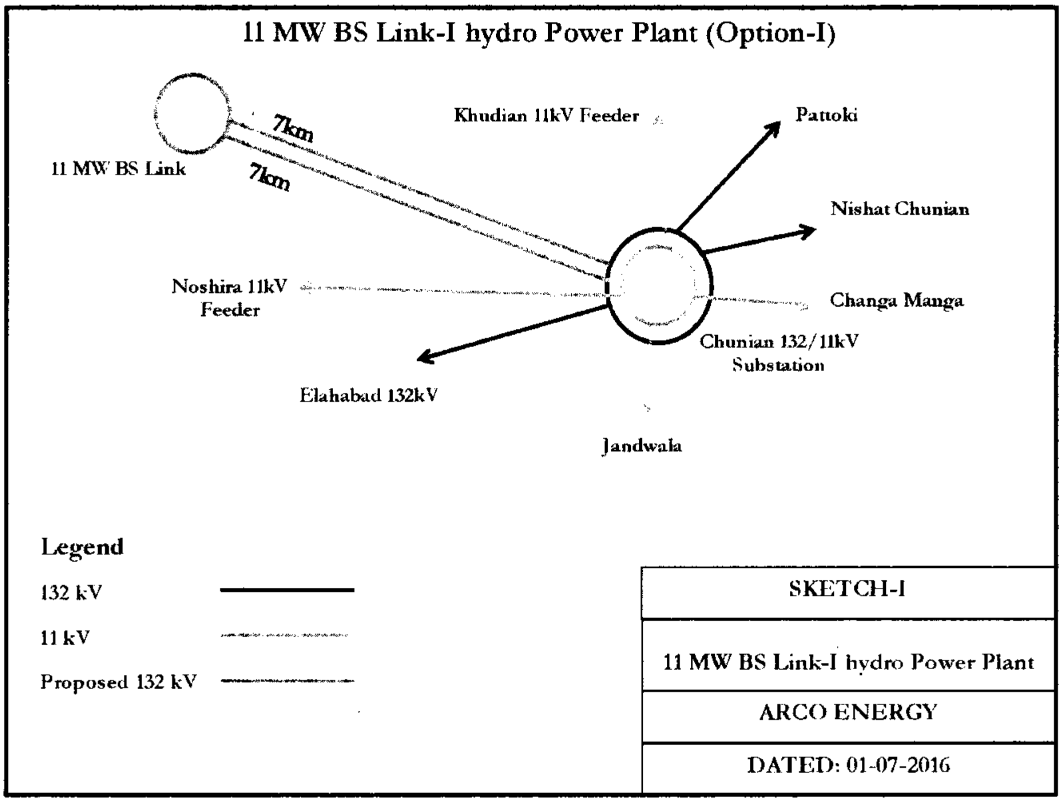

Figure 1.2: Option-I Interconnection Proposal.

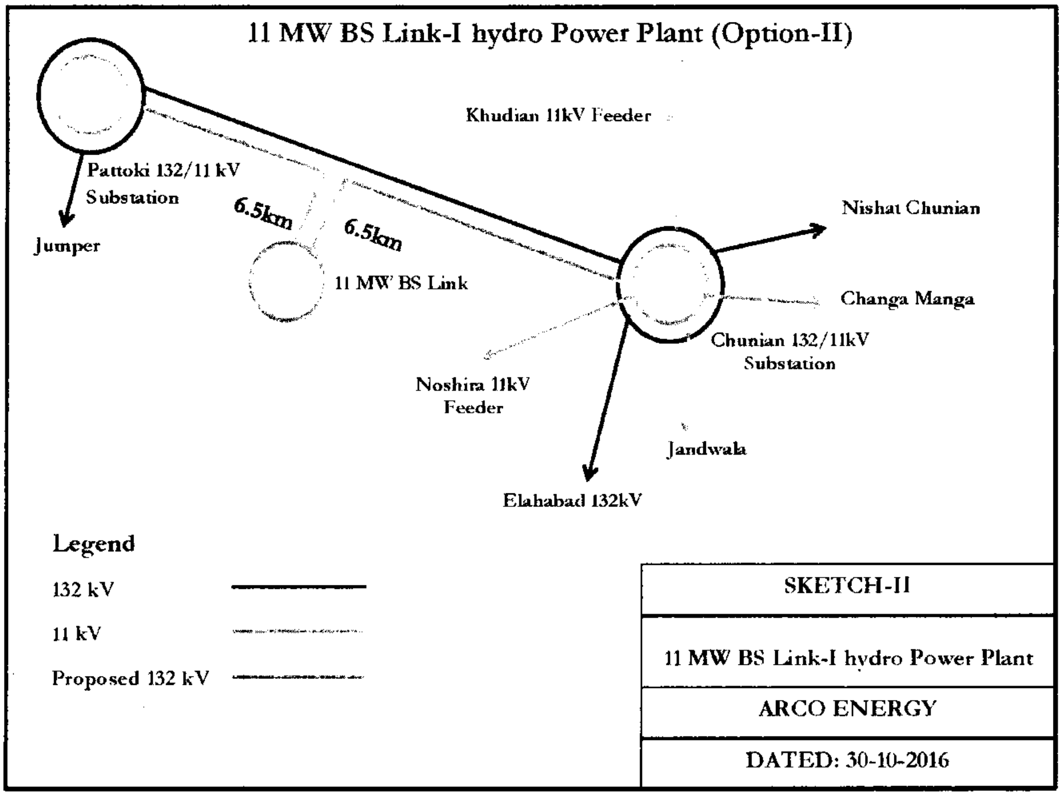

Figure 1.3: Option-II Interconnection Proposal.

1.2 Grid Interconnection Arrangement

The proposed project will be connected with the grid system of LESCO with the following interconnection proposals i.e. given below.

- **Option-I:** The hydro power plant will connect to 132/11kV Chunian grid station at 132kV by lying double 132kV circuit of 7km length on Lynx conductor.
- **Option-II:** The hydro power plant will connect to existing 132kV double circuit Pattoki-Chunian transmission line by making In/Out connection at BS Link-I HPP 132kV switchyard with feed length of 6.5km.

The objective of the GIA is to evaluate the impact of the proposed hydro power plant on the LESCO transmission system.

1.3 Study Components

GIA includes the following three types of analyses to evaluate the impact of interconnecting the proposed project:

i) Steady state analysis.

ii) Dynamic stability analysis.

iii) Short circuit analysis.

This report documents the results of the steady state, dynamic stability and the short circuit analyses. The steady state analysis includes pre project and post project power flow assessment. Dynamic stability analysis includes the post project dynamic stability assessment. Short circuit analysis includes pre project and post project short circuit current levels assessment at different buses in the vicinity of the project.

2 STUDY METHODOLOGY

2.1 Study Criteria

GIA has been carried out based on the National Electric Power Regulatory Authority (NEPRA) Grid Code planning criteria. Key parameters and their corresponding limits have been summarized in table below.

Parameter		Range
Voltage	System Intact	±5 % p.u at load grids +8%,-5% p.u at generation switchyards
	Contingency	±10 % p.u
Thermal loading	System Intact	100%
	Contingency	100%
Frequency	Nominal	50 Hz
	Steady State Variation	49.8 Hz - 50.2 Hz
	Contingency Band	49.4 Hz - 50.5 Hz
Power Factor	Lagging	0.8
	Leading	0.9
Breaker Short Circuit Rating	132 kV	40kA
	11 kV	25kA

2.2 Steady State Analysis

The purpose of steady-state analysis is to analyse the impact of the proposed hydro power plant on transmission system facilities under steady-state conditions. It involves two distinct analyses: thermal loading analysis and voltage analysis. Power flow solutions using the PSS/E® program (Version 33.4) has been performed.

A "study area" was defined to represent the areas of interest which includes the following areas within LESCO:

- Chunian
- Elahabad
- Pattoki
- Nishat Chunian
- Nishat Power line
- Hujra

2.2.1 System Intact Analysis

The incremental impact of the project on thermal loading of transmission facilities under system intact conditions was evaluated by comparing transmission system power flows without and with the proposed project. Loadings of the transmission facilities without and with the project were tabulated and compared. The criteria to flag thermal overloads is 100% of continuous facility rating (Rate A in the power flow model).

2.2.2 Contingency Analysis

The contingency analysis for this study consists of single branch (N-1) outage in the study area.

2.2.3 Thermal Loading Analysis

132kV rated transmission facilities in the study area have been monitored for thermal loadings.

2.2.4 Voltage Analysis

Voltages at buses inside the study area have been monitored for possible pre and post project voltage violations in accordance with NEPRA Grid Code guidelines. In accordance with these guidelines, those buses that have a voltage change of more than ±5 % p.u (System Intact condition) and ±10 % p.u (contingency condition) are considered affected.

2.3 Dynamic Stability Analysis

The purpose of dynamic stability analysis is to analyse the impact of the proposed hydro power plant on transmission system facilities under dynamic conditions. The system is considered to be stable if the system recovers with good damping after the transients die out and the synchronism is retained.

Fault clearing time for different voltage levels in accordance with NEPRA Grid Code guidelines is presented in table below.

Voltage Level	Fault Type	Fault Clearing Time
132 kV	3-Phase	5 Cycles (100 msec)
132 kV (Stuck Breaker)	3-Phase	9 Cycles (180 msec)

2.4 Short Circuit Analysis

The purpose of short-circuit analysis is to investigate the fault current levels at nearby substations without and with the proposed project online. And to check whether the calculated pre-project and post-project fault currents are within circuit breaker interrupting ratings. Short circuit analysis has been carried by applying the criteria as mentioned in the IEC-909 standard. Key assumptions in IEC-909 are given below.

- Tap ratios to unity
- Line charging to zero
- shunts are set to zero in positive sequence

- Desired voltage magnitude at bus bars is set to 1.1 p.u in Maximum and 0.9 p.u in Minimum fault levels.

3 STEADY STATE ANALYSIS

3.1 Model Development

Project specific data was provided by the plant owner and it has been compiled and presented in Annexure-A. The steady state model of the power plant and the switch-yard is presented in table below;

Generator	
No. of Units	4
Generator size (MVA)	3.24
Active Power Pgen. (MW)	2.75
Power Factor	0.85 lagging, 0.9 leading
Qmin, Qmax (MVAR)	-1.33, 1.77
Rated Frequency	50 Hz
Generation Voltage	6.3kV
Xsource	0.2 p.u
Generation Step Up (GSU) Transformer	
MVA Capacity	3.3 MVA
Rating	6.3/11kV
No. of Transformer units	4
% Reactance (X)	7%
Zero sequence Reactance (X_{01})	1.414
Step Up Transformer	
MVA Capacity	13 MVA
Rating	11/132kV
No. of Transformer units	2
% Reactance (X)	12%
Zero sequence Reactance (X_{01})	0.6154

Steady state power flow assessment has been performed using the already available network data of LESCO.

3.2 Pre Project Power Flow Assessment

A pre project power flow study was conducted to analyze the magnitude and phase angles of bus voltages, line loadings and power flows under steady-state conditions. The results of the pre project power flow analysis are in **Annexure-C**.

3.2.1 Base Year 2020: Peak Loading Summer

Power flow analysis has been performed on the peak loading summer base year 2020 case of LESCO network. This base case included a detailed representation of the LESCO transmission system in the study area.

The power flow results for the system intact conditions show that the power flows on all the transmission line branches are within their normal thermal loading limit. There is no capacity constraint in terms of power flow or voltage ratings within the study area. The results of the pre project power flow analysis are plotted in **Figure-C**.

3.3 Post Project Power Flow Assessment

Post project power flow study was conducted to determine the reliability impact of the proposed 11 MW ATL project on the LESCO transmission system. This includes the performance of a contingency analysis to identify any facility overload or voltage condition that violates the NEPRA planning criteria. Any such violation that is either directly attributable to this project or for which it will have a shared responsibility is included in this report with a least cost plan identified to mitigate them.

The results of the post project power flow analysis are plotted in **Annexure-D.**

3.3.1 Base Year 2020: Peak Loading Summer

A base case has been developed for summer (September) 2020 that allow us to judge the maximum impact of ATL power project on the LESCO network, using the network data supplied by LESCO.

3.3.1.1 Option-I:

In option-I, the hydro power plant will connect to 132/11kV Chunian grid station at 132kV by lying double 132kV circuit of 7km length on Lynx conductor.

Post project power flow analysis has been performed after the interconnection of the proposed project with the LESCO transmission system. This includes the detailed representation of the power plant and its switchyard. A simulation of all possible contingencies within the NEPRA Grid Code planning criteria has also been carried out.

The steady state results for the system intact and contingency conditions depicts that the power flows on all the transmission line branches are within their normal thermal loading limits. There is no capacity constraint in terms of load flow or voltage ratings around the study area.

Results from the power flow analysis are presented in table below.

Condition	Contingent Branch	Figure No.	Steady State Result
System Intact	-N.A-	Figure D-1	No overloading
Contingency	BS Link-1 to Chunian line out	Figure D-1.1	No overloading
	Chunian to Elahabad line out	Figure D-1.2	No overloading
	Chunian to Pattoki line out	Figure D-1.3	No overloading

	Chunian to Nishat Chunian line out	Figure D-1.4	No overloading
	Chunian to Nishat Power line out	Figure D-1.5	No overloading
	Pattoki to Nishat Chunian line out	Figure D-1.6	No overloading
	Pattoki to Nishat Power line out	Figure D-1.7	No overloading
	Elahabad to Hujra line out	Figure D-1.8	No overloading

3.3.1.2 Option-II:

In option-II, The hydro power plant will connect to existing 132kV double circuit Pattoki-Chunian transmission line by making In/Out connection at BS Link-I HPP 132kV switchyard with feed length of 6.5km.

Post project power flow analysis has been performed after the interconnection of the proposed project with the LESCO transmission system. This includes the detailed representation of the power plant and its switchyard. A simulation of all possible contingencies within the NEPRA Grid Code planning criteria has also been carried out.

The power flow results for the system intact and for the contingency conditions show that the power flows on all the transmission line branches are within their normal loading limit. There is no capacity constraint in terms of power flow or voltage ratings within the study area. Results from the power flow analysis are presented in table below.

Condition	Contingent Branch	Figure No.	Steady State Result
System Intact	-N.A-	Figure D-2	No overloading
Contingency	BS Link-I to Chunian line out	Figure D-2.1	No overloading
	BS Link-I to Pattoki line out	Figure D-2.2	
	Chunian to Elahabad line out	Figure D-2.3	No overloading
	Chunian to Pattoki line out	Figure D-2.4	No overloading
	Chunian to Nishat Chunian line out	Figure D-2.5	No overloading
	Chunian to Nishat Power line out	Figure D-2.6	No overloading
	Pattoki to Nishat Chunian line out	Figure D-2.7	No overloading
	Pattoki to Nishat Power line out	Figure D-2.8	No overloading
	Elahabad to Hujra line out	Figure D-2.9	No overloading

3.3.2 Selection of Interconnection Option:

Steady state analysis for both options is performed on the scenario of peak loading summer base year 2020 and the options are evaluated as discussed below:

Option-I: The option-I interconnection proposal for BS Link-I hydro power plant to evacuate maximum of 11 MW is analysed and investigated under the influence of power & energy losses, cost of equipment installed, cost of augmentation required at substation. This option requires following equipment to be installed at BS Link-I HPP 132kV switchyard and 132/11kV Chunian grid station.

- 2 No. 132kV line bays along-with the switch-gear control and protection panels are required at BS Link-I HPP 132kV switchyard.
- 2 No. 132kV line bays along-with the switch-gear control and protection panels are required at 132/11kV Chunian grid station.
- Energy losses and Power losses in this option are 0.082% (refer to section 3.4.1)

Option-II: The hydro power plant will connect to existing 132kV double circuit Pattoki-Chunian transmission line by making In/Out connection at BS Link-I HPP 132kV switchyard with feed length of 6.5km.

The option-II interconnection proposal is also analysed on the measures of power & energy losses, cost of equipment installed etc. This option requires following equipment to be installed at BS Link-I HPP 132 kV switchyard.

- 2 No. 132kV line bays along-with the switch-gear control and protection panels are required at BS Link-I HPP 132 kV switchyard.
- Energy losses and Power losses are in this option are 0.027% (refer to section 3.4.2)

The steady state results of both options found no capacity constraint in terms of power flow and voltage ranges, but the option-II requires less cost for the interconnection of the subject power plant as compared to the option-I. The cost for the 2 No. 132kV line bays required at 132/11 kV Chunian grid station is additional in option-I which can be saved by adopting option-II. In option-I, Right of Way (ROW) issues especially around the 132/11 kV Chunian grid station may also be experienced for constructing the double circuit 132kV lines. Moreover, rest of the key parameters indices like power and energy losses are comparable in both options.

After analysing all the possibilities of interconnection arrangement of 11 MW BS link-I hydro power plant to LESCO network, the option-II is considered. The following conclusions emphasize the selection of option-II.

- No need of making line bays for new transmission lines that will connect Chunian 132/11kV substation to BS link-I hydro power plant in option-II.
- Less equipment would be required to install by LESCO for evacuation of power from subject power plant in option-II.
- No Right of Way (ROW) issues for option-II around the 132/11 kV Chunian grid station which is situated in a populated area.

Therefore, **"OPTION-II Is Adopted for Interconnection of the 11 MW BS Link-I Hydro Power Project"**, and only option-II is analysed in the further analyses of remaining scenarios of steady state, dynamic stability and short circuit analysis.

3.3.3 Base Year: Winter 2021

Post project power flow analysis for winter (January) 2021 has been performed after the interconnection of the proposed project with the LESCO transmission system. This includes the detailed representation of the power plant and its switchyard. A simulation of all possible contingencies within the NEPRA Grid Code planning criteria has also been carried out.

By considering option-II, interconnection of hydro power plant to existing 132kV double circuit Pattoki-Chunian transmission line by making IN/OUT interconnection arrangement is considered.

Condition	Contingent Branch	Figure No.	Steady State Result
System Intact	N.A	Figure D-3	No overloading
Contingency	BS Link-I to Chunian line out	Figure D-3.1	No overloading
	BS Link-I to Pattoki line out	Figure D-3.2	
	Chunian to Elahabad line out	Figure D-3.3	No overloading
	Chunian to Pattoki line out	Figure D-3.4	No overloading
	Chunian to Nishat Chunian line out	Figure D-3.5	No overloading
	Chunian to Nishat Power line out	Figure D-3.6	No overloading
	Pattoki to Nishat Chunian line out	Figure D-3.7	No overloading
	Pattoki to Nishat Power line out	Figure D-3.8	No overloading
	Elahabad to Hujra line out	Figure D-3.9	No overloading

The power flow results for the system intact and for the contingency conditions show that the power flows on all the transmission line branches are within their normal loading limit. There is no capacity constraint in terms of power flow or voltage ratings within the study area. Results from the power flow analysis are presented in table below.

3.4 Power and Energy Loss Calculations

Power and energy loss calculations are analysed on both connection arrangements. Each one is discussed in detail below.

3.4.1 Option-I:

3.4.1.1 System Intact Conditions

Refer to Figure D-1 for system intact conditions, the power loss and energy loss is calculated as under;

Power Loss = $\frac{Power\ sent(MW) - Power\ received(MW)}{Power\ sent(MW)}$

% Power Loss = $\frac{11 - 10.996}{11}$ x 100

% Power Loss = 0.036%

Energy Loss = $\frac{Energy\ sent(MWh) - Energy\ received(MWh)}{Energy\ sent(MWh)}$

% Energy Loss = $\frac{96360 - 96324.96}{96360}$ x 100

% Energy Loss = 0.036%

3.4.1.2 N-1 Contingency Conditions

Refer to Figure D-1.1 for N-1 contingency conditions, the power loss and energy loss is calculated as under;

Power Loss = $\frac{Power\ sent(MW) - Power\ received(MW)}{Power\ sent(MW)}$

% Power Loss = $\frac{11 - 10.991}{11}$ x 100

% Power Loss = 0.082%

Energy Loss = $\frac{Energy\ sent(MWh) - Energy\ received(MWh)}{Energy\ sent(MWh)}$

% Energy Loss = $\frac{96360 - 96281.16}{96360}$ x 100

% Energy Loss = 0.082%

3.4.2 Option-II:

3.4.2.1 System Intact Conditions

Refer to Figure D-2 for system intact conditions, the power loss and energy loss is calculated as under;

Power Loss = $\frac{Power\ sent(MW) - Power\ received(MW)}{Power\ sent(MW)}$

% Power Loss = $\frac{11 - 10.956}{11}$ x 100

% Power Loss = 0.4%

$$\text{Energy Loss} = \frac{Energy\ sent(MWh) - Energy\ received(MWh)}{Energy\ sent(MWh)}$$

$$\%\ \text{Energy Loss} = \frac{96360 - 95974.56}{96360} \text{ x } 100$$

% Energy Loss = 0.4%

3.4.2.2 N-1 Contingency Conditions

Refer to Figure D-2.1 for N-1 contingency conditions, the power loss and energy loss is calculated as under;

$$\text{Power Loss} = \frac{Power\ sent(MW) - Power\ received(MW)}{Power\ sent(MW)}$$

$$\%\ \text{Power Loss} = \frac{11 - 10.997}{11} \text{ x } 100$$

% Power Loss = 0.027%

$$\text{Energy Loss} = \frac{Energy\ sent(MWh) - Energy\ received(MWh)}{Energy\ sent(MWh)}$$

$$\%\ \text{Energy Loss} = \frac{96360 - 96333.7}{96360} \text{ x } 100$$

% Energy Loss = 0.027%

4 DYNAMIC STABILITY ANALYSIS

Dynamic stability analysis has been performed to access the dynamic impact of the hydro power plant on national grid system due to disturbances at the power plant and vice versa.

4.1 Dynamic Model Development

Generic dynamic models, available in the PSSE model library, for the hydro power plant have been used to develop the dynamic model of the power plant. Dynamic model of the power plant is presented in table below;

Component	Model
Generator	GENSAL
Excitation System	EXST1
Speed Governing System	HYGOV

4.2 Post Project Dynamic Stability Assessment

4.2.1 Base Year 2020: Peak Loading Summer

Dynamic stability analysis has been carried out for the base year 2020 peak loading summer conditions. To access the dynamic behavior of power plant and system towards the disturbances, simulations have been carried out for the following faults:

i. 3 Phase fault at BS Link-I hydro power plant cleared in 5 cycles.
ii. 3 Phase fault at Chunian cleared in 5 cycles.
iii. 3 Phase fault at Pattoki cleared in 5 cycles.
iv. 3 Phase fault at BS Link-I hydro power plant cleared in 9 cycles.
v. 3 Phase fault at Chunian cleared in 9 cycles.
vi. 3 Phase fault at Pattoki cleared in 9 cycles.

Each simulation has been performed for one second to depict steady state condition. Then fault is applied and system has been simulated for the fault clearance time. Post-fault condition has been simulated, from clearance of fault followed by a certain contingency, till ten seconds.

4.2.2 3 Phase fault at BS Link-I hydro power plant cleared in 5 cycles

Three phase fault has been applied at BS Link-I hydro power plant, fault has been cleared in 100 msec (5 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

Fault E-1: 3 Phase fault at BS Link-I cleared in 5 cycles (Standard Opening in 100 msec)

No.	Contingency	Monitored Element	Figure No.	System Response
E-1.1	132kV line from BS Link-I to Chunian	Bus Voltages of 11kV BS Link-I, 132kV BS Link-I PP, Chunian, and Pattoki	E-1.1A	Stable
		Frequency at 132kV BS Link-I PP	E-1.1B	Stable
		MW and MVAR of BS Link-I PP	E-1.1C	Stable
		Rotor Angles of BS Link-I PP, Nishat Chunian, Nishat Power, Saif power plants w.r.t. Muzaffargarh Swing Bus	E-1.1D	Stable
		MW and MVAR flows at 132kV line from BS Link-I PP to Pattoki	E-1.1E	Stable
E-1.2	132kV line from BS Link-I PP to Pattoki	Bus Voltages of 11kV BS Link-I, 132kV BS Link-I PP, Chunian, and Pattoki	E-1.2A	Stable
		Frequency at 132kV BS Link-I PP	E-1.2B	Stable
		MW and MVAR of BS Link-I PP	E-1.2C	Stable
		Rotor Angles of BS Link-I PP, Nishat Chunian, Nishat Power, Saif power plants w.r.t. Muzaffargarh Swing Bus	E-1.2D	Stable
		MW and MVAR flows at 132kV line from BS Link-I to Chunian	E-1.2E	Stable

4.2.3 3 Phase fault at Chunian cleared in 5 cycles

Three phase fault has been applied at Chunian 132kV bus, fault has been cleared in 100 msec (5 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

Fault E-2: 3 Phase fault at Chunian cleared in 5 cycles (Standard Opening in 100 msec)

No.	Contingency	Monitored Element	Figure No.	System Response
E-2.1	132kV line from BS Link-I to Chunian	Bus Voltages of 11kV BS Link-I, 132kV BS Link-I PP, Chunian, and Pattoki	E-2.1A	Stable
		Frequency at 132kV BS Link-I PP	E-2.1B	Stable
		MW and MVAR of BS Link-I PP	E-2.1C	Stable

No.	Contingency	Monitored Element	Figure No.	System Response
		Rotor Angles of BS Link-I PP, Nishat Chunian, Nishat Power, Saif power plants w.r.t. Muzaffargarh Swing Bus	E-2.1D	Stable
		MW and MVAR flows at 132kV line from BS Link-I PP to Pattoki	E-2.1E	Stable

4.2.4 3 Phase fault at Pattoki cleared in 5 cycles

Three phase fault has been applied at Pattoki bus, fault has been cleared in 100 msec (5 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

Fault E-3: 3 Phase faults at Pattoki cleared in 5 cycles (Standard Opening in 100 msec)

No.	Contingency	Monitored Element	Figure No.	System Response
E-3.1	132kV line from BS Link-I PP to Pattoki	Bus Voltages of 11kV BS Link-I, 132kV BS Link-I PP, Chunian, and Pattoki	E-3.1A	Stable
		Frequency at 132kV BS Link-I PP	E-3.1B	Stable
		MW and MVAR of BS Link-I PP	E-3.1C	Stable
		Rotor Angles of BS Link-I PP, Nishat Chunian, Nishat Power, Saif power plants w.r.t. Muzaffargarh Swing Bus	E-3.1D	Stable
		MW and MVAR flows at 132kV line from BS Link-I to Chunian	E-3.1E	Stable

4.2.5 3 Phase fault at BS Link-I cleared in 9 cycles

Three phase fault has been applied at BS Link-I hydro power plant, fault has been cleared in 180 msec (9 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

Fault E-4: 3 Phase faults at BS Link-I cleared in 9 cycles (Stuck Breaker Opening in 180 msec)

No.	Contingency	Monitored Element	Figure No.	System Response
E-4.1	132kV line from BS Link-I to Chunian	Bus Voltages of 11kV BS Link-I, 132kV BS Link-I PP, Chunian, and Pattoki	E-4.1A	Stable
		Frequency at 132kV BS Link-I PP	E-4.1B	Stable
		MW and MVAR of BS Link-I PP	E-4.1C	Stable

No.	Contingency	Monitored Element	Figure No.	System Response
		Rotor Angles of BS Link-I PP, Nishat Chunian, Nishat Power, Saif power plants w.r.t. Muzaffargarh Swing Bus	E-4.1D	Stable
		MW and MVAR flows at 132kV line from BS Link-I PP to Pattoki	E-4.1E	Stable
E-4.2	132kV line from BS Link-I PP to Pattoki	Bus Voltages of 11kV BS Link-I, 132kV BS Link-I PP, Chunian, and Pattoki	E-4.2A	Stable
		Frequency at 132kV BS Link-I PP	E-4.2B	Stable
		MW and MVAR of BS Link-I PP	E-4.2C	Stable
		Rotor Angles of BS Link-I PP, Nishat Chunian, Nishat Power, Saif power plants w.r.t. Muzaffargarh Swing Bus	E-4.2D	Stable
		MW and MVAR flows at 132kV line from BS Link-I to Chunian	E-4.2E	Stable

4.2.6 3 Phase fault at Chunian cleared in 9 cycles

Three phase fault has been applied at Chunian 132 kV bus, fault has been cleared in 180 msec (9 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

Fault E-5: 3 Phase fault at Chunian cleared in 9 cycles (Stuck Breaker Opening in 180 msec)

No.	Contingency	Monitored Element	Figure No.	System Response
E-5.1	132kV line from BS Link-I to Chunian	Bus Voltages of 11kV BS Link-I, 132kV BS Link-I PP, Chunian, and Pattoki	E-5.1A	Stable
		Frequency at 132kV BS Link-I PP	E-5.1B	Stable
		MW and MVAR of BS Link-I PP	E-5.1C	Stable
		Rotor Angles of BS Link-I PP, Nishat Chunian, Nishat Power, Saif power plants w.r.t. Muzaffargarh Swing Bus	E-5.1D	Stable
		MW and MVAR flows at 132kV line from BS Link-I PP to Pattoki	E-5.1E	Stable

4.2.7 3 Phase fault at Pattoki cleared in 9 cycles

Three phase fault has been applied at Pattoki, fault has been cleared in 180 msec (9 cycles) with a particular N-1 contingency and dynamic stability response of the system is monitored, the same has been summarized in the table below.

Fault E-6: 3 Phase faults at Pattoki cleared in 9 cycles (Stuck Breaker Opening in 180 msec)

No.	Contingency	Monitored Element	Figure No.	System Response
E-6.1	132kV line from BS Link-I PP to Pattoki	Bus Voltages of 11kV BS Link-I, 132kV BS Link-I PP, Chunian, and Pattoki	E-6.1A	Stable
		Frequency at 132kV BS Link-I PP	E-6.1B	Stable
		MW and MVAR of BS Link-I PP	E-6.1C	Stable
		Rotor Angles of BS Link-I PP, Nishat Chunian, Nishat Power, Saif power plants w.r.t. Muzaffargarh Swing Bus	E-6.1D	Stable
		MW and MVAR flows at 132kV line from BS Link-I to Chunian	E-6.1E	Stable

Dynamic Stability Analysis Results are attached in **Annexure-E**.

5 SHORT CIRCUIT ANALYSIS

Short circuit analysis has been performed to determine the need for any breaker replacements due to impacts of the hydro power plant project. Single-line-to-ground and three-phase fault current values have been calculated for buses in the vicinity of the hydro power plant project. The calculated fault currents observed at these buses were compared with the interrupting current capabilities of corresponding circuit breakers to determine need for upgrading existing circuit breakers.

5.1 Short Circuit Model Development

Short circuit database provided by LESCO has been used as a base case to perform short circuit assessment. The study project has been added to the base case to develop the post-project case. The short circuit model of the power plant and the switch yard is presented in table below.

Generator Data	
X (+ve)	0.2 p.u
X (-ve)	0.22 p.u
X (zero)	0.1 p.u

5.2 Post Project Short Circuit Assessment

With the addition of power plant, short circuit current at each bur bar is increased, so the circuit breaker capacity has analysed. Post project short circuit assessment has been performed to evaluate the contribution of the proposed project in fault current levels of substations in its electrical locality and to compute the fault levels at BS Link-I HPP.

5.2.1 Maximum Short Circuit: Year 2020

The maximum short circuit levels have been computed according to IEC-909 standard. Pre and Post project maximum short circuit levels at the buses within the study area in the year 2020 have been presented in table below.

Bus Name	Bus kV	Pre-Project		Post Project	
		1-Φ Fault Level (kA)	3-Φ Fault Level (kA)	1-Φ Fault Level (kA)	3-Φ Fault Level (kA)
BS Link-I PP HV Bus	132	-N.A-	-N.A-	10.6	15.2
BS Link-I PP MV Bus	11	-N.A-	-N.A-	15	14.5

Bus Name	Bus kV	Pre-Project		Post Project	
		1-Φ Fault Level (kA)	3-Φ Fault Level (kA)	1-Φ Fault Level (kA)	3-Φ Fault Level (kA)
Chunian	132	18.5	23.5	17.8	22.9
Pattoki	132	24.2	28.6	24	28.6
Elahabad	132	13.5	19	13.3	18.8
Renala Khurd	132	9.3	13.8	9.3	13.8

Pre and Post project maximum short circuit analysis summary for the future year 2020 are attached in **Appendix F-1 and F-2** respectively.

5.2.2 Minimum Short Circuit: Year 2020

The minimum short circuit levels have been computed according to IEC-909 standard. Pre and Post project minimum short circuit levels at the buses within the study area in the year 2020 have been presented in table below.

Bus Name	Bus kV	1-Φ Fault Level (kA)	3-Φ Fault Level (kA)
BS Link-I PP HV Bus	132	8.6	12.5
BS Link-I PP MV Bus	11	13.6	13.1
Chunian	132	13.5	17.9
Pattoki	132	17.2	21.6
Elahabad	132	10.5	15.2
Renala Khurd	132	7.5	11.5

Post project minimum short circuit analysis report of future year 2020 is attached in **Appendix F-3.**

Note:

In the attached short circuit study reports, both three phase and single phase fault currents with polar coordinates and detailed output showing contribution from adjoining sources (i.e. lines and transformers connected to the bus bar) to the fault currents are included.

6 CONCLUSIONS

6.1 Steady State Assessment

Steady state power flow assessment has been performed using the already available network data of LESCO. Pre project power flow study was conducted to analyze the magnitude and phase angles of bus voltages, line loadings, and power flows under steady-state conditions. Post project power flow analysis has also been performed after the interconnection of the proposed project with the LESCO transmission system. The power flow results for the system intact and for the contingency conditions showed that the power flows on all the transmission line branches are within their normal thermal loading limit. There is no capacity constraint in terms of power flow or voltage ratings within the study area.

Two options are considered for interconnection arrangement of 11 MW BS Link-I Hydro Power Project. Steady state analysis has been performed on both options and evaluated as discussed below:

- **Option-I:** The hydro power plant will connect to 132/11kV Chunian grid station at 132kV by lying double 132kV circuit of 7km length on Lynx conductor.
- **Option-II:** The hydro power plant will connect to existing 132kV double circuit Pattoki-Chunian transmission line by making In/Out connection at BS Link-I HPP 132kV switchyard with feed length of 6.5km.

The steady state results of both options found no capacity constraint in terms of power flow and voltage ranges. Both options are further analysed and investigated under the influence of power & energy losses, cost of equipment installed, cost of augmentation required at substation.

After analysing, the option-II is adopted. The following conclusions emphasize the selection of option-II.

- No need of making line bays for new transmission lines that will connect Chunian 132/11kV substation to BS link-I hydro power plant in option-II.
- Less equipment would be required to install by LESCO for evacuation of power from subject power plant in option-II.
- No Right of Way (ROW) issues for option-II around the 132/11 kV Chunian grid station which is situated in a populated area.

Therefore, option-II is adopted for interconnection of the subject hydro power plant and option-II is analysed in the further analyses.

6.2 Dynamic Stability Assessment

Dynamic stability analysis has been performed to access the dynamic impact of the hydro power plant on national grid system due to disturbances at the power plant and vice versa. The results of dynamic stability analysis indicate that the power system is stable for the interconnection proposal and it also fulfils all the criteria for generation connection with the power system.

6.3 Short Circuit Assessment

Short circuit analysis has been performed to evaluate the contribution of the proposed project in fault current levels of substations in its electrical locality. Fault currents have been computed based on simulation of three-phase and single-line-to-ground faults by applying the criteria as mentioned in the IEC-909 standard. Result of the analysis shows that the calculated fault currents are below the circuit-breaker interrupting ratings of existing grid stations located in locality of the project; also it will help the EPC to select the switch-gear ratings in switchyard of BS Link-I HPP 132 kV.

Hence, it is concluded that based on the study results the proposed generation interconnection assessment for 11 MW BS Link-I hydro power plant meets the NEPRA grid code planning criteria.

2017

11 MW BS LINK-I HYDROPOWER PROJECT AT RD 106+250

Feasibility Study

VOLUME-1 MAIN REPORT

Integral
INGENIEROS CONSULTORES

ASSOCIATED TECHNOLOGIES (PVT) LIMITED
142-D Model Town, Lahore, Pakistan

No. PPDB/ 149 /2017
PUNJAB POWER DEVELOPMENT BOARD
ENERGY DEPARTMENT
Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 042-99213879 Fax: 99213875)
Date: 25/01/2017

M/s Associated Technologies (Pvt.) Limited
142-D, Model Town
Lahore

Subject: <u>APPROVAL OF FEASIBILITY STUDY REPORT OF 10.49 MW HYDROPOWER PROJECT (HPP) ON BALLOKI-SULEMANKI (BS) LINK-I CANAL AT RD. 106+250, DISTRICT KASUR</u>

A letter of Interest (LOI) was issued to M/s Associated Technologies (Pvt.) Limited (the "Sponsor") for development of 11 MW Hydropower Project on BS Link-I Canal at RD. 106+250, District Kasur (the "Project") in accordance with the Punjab Power Generation Policy-2009 (the "Policy") with the compressed timelines of four (4) months for completion of Feasibility Study Report (the "FSR"). During the conduct of FSR, the Sponsor proposed to reduce the Project capacity from 11 MW to 10.49 MW. The Panel of Experts (POEs), comprising of following members, was appointed by PPDB to monitor, review and approve the FSR of the Project being developed by the Sponsor:

1) The Managing Director, Punjab Power Development Board (PPDB), Lahore
2) The Managing Director, Private Power & Infrastructure Board (PPIB), Islamabad
3) Dr. Engineer Javed Yunas Uppal, Chairman EPDC, Lahore
4) The Chief Executive Officer, Lahore Electric Supply Company (LESCO), Lahore
5) The Project Director, Punjab Power Management Unit (PPMU), Lahore
6) The Superintending Engineer, Link Circle Canal, Irrigation Department, Lahore

2. After thorough review of the FSR, the POEs, during their meeting held on 23rd August 2016, accepted the stance of the Sponsor to reduce the capacity of the Project. POE approved the said FSR subject to approval of Initial Environmental Examination Report (IEE) from Environment Protection Agency (EPA) and approval of Interconnection Study from Lahore Electric Supply Company (LESCO). During the meeting, the Sponsor submitted the undertaking to opt for upfront tariff. POE members shall certify the duly filled Performa (Annex-II) regarding net annual plant factor to apply for NEPRA's Upfront Tariff for Small Hydropower Generation Projects, notified by GoP, Ministry of Water & Power on March 28, 2016 (hereinafter refer to as "Upfront Tariff"). The POEs resolved that:

a. *The Feasibility Study Report of 10.49 MW Hydropower Project on BS Link-I Canal at RD. 106+250, District Kasur has been approved unanimously by POE subject to submission of approvals of IEE and Interconnection Study from the relevant Authorities.*

b. *In the final version of feasibility study report, the Sponsor shall include the undertaking that they unconditionally accept NEPRA's Upfront Tariff.*

c. *Prior to implementation of the Project, the sponsor is required to confirm the detailed design of the Project through Model Study at Irrigation Research Institute (IRI), Nandipur. The Sponsor shall also obtain NOC from Irrigation Department.*

3. The Sponsor has submitted the approval of IEE from EPA and approval of Interconnection Study from LESCO vide their letter No. ATL-017/1598 dated 04th January 2017. Since the above conditions have been met with, the FSR of the Project stands approved.

4. In view of the above and relevant stipulations of the Policy, the Sponsor is required to approach National Electric Power Regulatory Authority (NEPRA) for grant of Generation License and acceptance of NEPRA's Upfront Tariff. The Upfront Tariff application must be in accordance with the terms & conditions of NEPRA's notified Upfront Tariff for Small Hydropower Generation Projects. A copy of duly signed & stamped complete set of final FSR is being enclosed herewith.

5. PPDB appreciates the Sponsor's efforts towards completion of FSR and hopes that the same pace and spirit would be kept by the Sponsor for timely completion of the Project to meet the energy needs of the country.

Regards,

SANIYA AWAIS
Managing Director

ENCL: *Complete set of stamped & signed Final Feasibility Study Report*

CC:

1. The Chairman PPDB Board / Additional Chief Secretary, Government of the Punjab, Energy Department, Lahore
2. The Managing Director, Private Power & Infrastructure Board (PPIB), Islamabad
3. The Chief Executive Officer, Lahore Electric Supply Company (LESCO), Lahore
4. The Project Director, Punjab Power Management Unit (PPMU), Lahore
5. Dr. Engr. Javed Yunas Uppal, Chairman EPDC, 1-A, Aibak Block, Garden Town Lahore
6. The Superintending Engineer, Link Circle Canal, Irrigation Department, Cana Bank Road, Mustafabad (Dharampura), Lahore

BS Link-I HPP

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Sr. No. Description

LIST OF ABBREVIATIONS

AASHTO Officials	:	American Association of State Highway & Transportation
A.C	:	Alternating Current
ACI	:	American Concrete Institute
Amsl	:	above mean sea level
ARP	:	Abbreviated Resettlement Plan
ASTM	:	American Society of Testing & Materials
ATL	:	Associated Technologies (Pvt) Limited
AVR	:	Automatic Voltage Regulator
B/C	:	Benefit/Cost
BH	:	Bore Hole
BL	:	Bed Level
BLT	:	Build-Lease-Transfer
BOD	:	Biochemical Oxygen Demand
BOOT	:	Build, Own Operate & Transfer
BOQ	:	Bill of Quantities
BS	:	Balloki-Suiemanki
CDM	:	Clean Development Mechanism
CO2	:	Carbon Dioxide
CPE	:	Chlorinated Polyethylene
CPP	:	Capacity Purchase Price
Cumecs	:	Cubic meter per second (m3/s)
Cusecs	:	Cubic feet per second (ft3/s)
D.C	:	Direct Current
D/S	:	Downstream
DBFO	:	Design-Built-Finance-Operate
ECNEC	:	Executive Committee of National Economic Council
EDM	:	Electronic Distance Meter
EIRR	:	Economic Internal Rate of Return
El	:	Elevation
EMP	:	Environment Management Plan
EPA	:	Environmental Protection Agency
EPC	:	Engineering, Procurement & Construction
EPP	:	Energy Purchase Price
FEWS	:	Flood Early Warning Systems
FOS	:	Factor of Safety
FIRR	:	Financial Internal Rate of Return
FPS	:	Foot Pound Second
FSD	:	Full Supply Depth
FSL	:	Full Supply Level
GOP	:	Government of Pakistan
GPS	:	Global Positioning System
GTZ	:	Gesellschaft FÜr Technische Zusammenarbeit
GWh	:	Giga Watt Hour
GWT	:	Ground Water Table
HPP	:	Hydel Power Plant/ Hydropower Project
HPS	:	Hydel Power Station
HR	:	Head Regulator

Hz	:	Hertz
IDC	:	Interest During Construction
IEC	:	International Electro-Technical Commission
IEE	:	Initial Environmental Examination
IMF	:	International Monitory Fund
IPD	:	Irrigation & Power Department, Government of the Punjab
IRSA	:	Indus River System Authority
KESC	:	Karachi Electric Supply Corporation
kV	:	Kilo Volt
kVA	:	Kilo Volt Ampere
kWh	:	Kilo Watt-Hours
LCU	:	Local Control Unit
LESCO	:	Lahore Electric Supply Company Ltd.
LGB	:	Left Guide Bund
LMB	:	Left Marginal Bund
LOI	:	Letter of Interest
LOS	:	Letter of Support
LV	:	Low Voltage
MMI	:	Man-Machine Interface
MPa	:	Mega Pascal
MRS	:	Market Rate Schedule
MV	:	Medium Voltage
MW	:	Mega Watt
MWe	:	Maximum Electrical Output at Transformer Terminals
NEPRA	:	National Electric Power Regulatory Authority
NPV	:	Net Present Value
NSL	:	Natural Surface Level
O & M	:	Operation & Maintenance
OCC	:	Opportunity Cost of Capital
ONAF	:	Oil Natural Air Forced
ONAN	:	Oil Natural Air Natural
PAPs	:	Project Affected Persons
PCC	:	Plain Cement Concrete
PEPA	:	Pakistan Environmental Protection Act
PEPCO	:	Pakistan Electric Power Company
PGA	:	Peak Ground Acceleration
PH	:	Power House
PID	:	Punjab Irrigation Department
PMD	:	Pakistan Meteorological Department
PPA	:	Power Purchase Agreement
PPDB	:	Punjab Power Development Board
PPMU	:	Punjab Power Management Unit
PPP	:	Public-Private-Partnership
PPRA	:	Public Procurement Regulatory Authority
Qty	:	Quantity/Quantities
RAP	:	Resettlement Action Plan
RC	:	Reinforced Concrete
RD	:	Reduced Distance
RE	:	Renewable Energy
RFR	:	Risk Free Rate
RPF	:	Resettlement Policy Framework
RGB	:	Right Guide Bund
RMB	:	Right Marginal Bund

RoW	:	Right of Way
rpm	:	revolutions per minute
SCF	:	Standard Conversion Factor
SCS	:	Station Control System
SI	:	System International
SOP	:	Survey of Pakistan
SPT	:	Standard Penetration Test
SRP	:	Short Resettlement Plan
Temp.	:	Temperature
ToR	:	Terms of Reference
TP	:	Test Pit
UPS	:	Uninterruptible Power Supply
U/S	:	Upstream
USBR	:	United States of Bureau & Reclamation
USCS	:	Unified Soil Classification System
V	:	Volts
W	:	Width/Watt
WAA	:	Water Apportionment Accord
WAPDA	:	Water & Power Development Authority
WL	:	Water Level
WPCPHB	:	West Pakistan Code of Practice for Highway Bridges
WPI	:	Wholesale Price Index
XLPE	:	Cross-Linked Polyethylene

EXECUTIVE SUMMARY

The energy crisis of Pakistan is increasing day by day and producing a huge gap between the demand and supply of the electricity for the country. According to the survey report of National Transmission & Dispatch Company (NTDC) for the month of May, the total demand of the country is 18000 MW whereas the power generation capacity of the various power plants is 15764 MW. This difference between the demand and the supply of electricity is creating a gap of 2236 MW. According to the survey, the total installed capacity of the various working power plants in Pakistan is 23,526 MW.

Renewable energy is energy that is generated from natural processes that are continually replenished. This includes sunlight, geothermal heat, wind, tides, water, and various forms of biomass. This energy cannot be exhausted and is constantly renewed. Various renewable energy sources that are commonly used are Solar, Wind Power, Hydroelectric Energy, Biomass, Geothermal and other forms. The GOP has launched various renewable energy projects on priority to overcome the energy shortage in country.

In order to facilitate the private investors in setting up the hydropower schemes in accordance with Government policy, Punjab Power Development Board (PPDB), Energy Department (ED), Punjab advertised eleven (11) hydropower projects in the year 2015. Consequently, through the proper selection procedure, M/s Associated Technologies (Pvt.) Ltd (ATL) was entrusted with the task of development of a hydropower scheme proposed on Balloki-Sulemanki (BS) Link-I Canal at RD 106+250 in Kandu Khara, Tehsil Chunian, District Kasur.

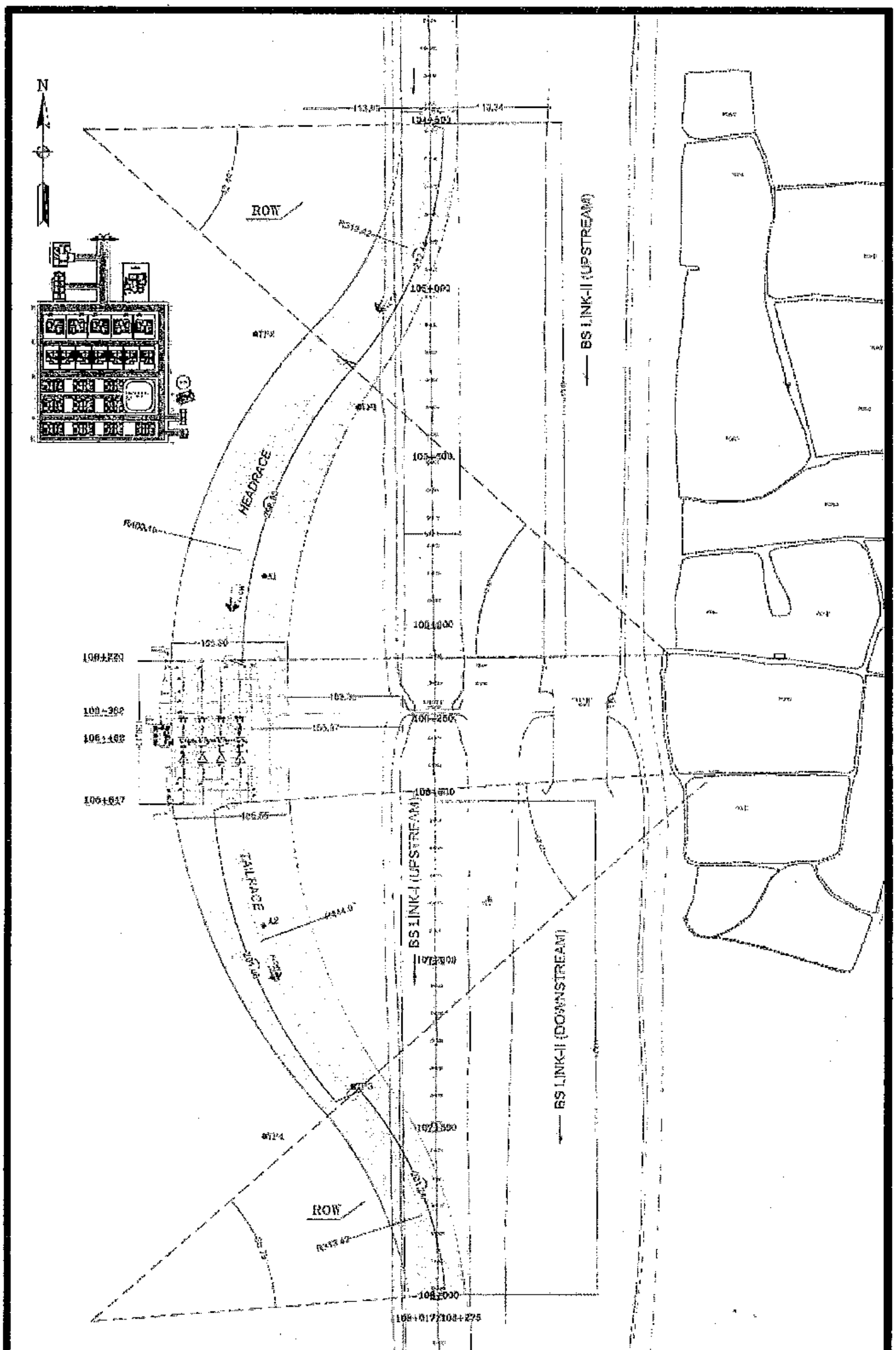
This Project has been studied previously in various time periods but ATL decided to conduct its own study to understand the technical and financial viability of the Project in depth. For this purpose, a renowned consultancy firm M/s Integral S.A of Colombian origin were entrusted with the task to undertake the feasibility study of the Project.

After collection, review and analysis of all available data from various relevant Government departments and private organizations, detailed field investigations encompassing topographic survey, geotechnical explorations and environmental surveys were carried out. Based on these investigations, Project design and technical parameters were defined, cost was estimated and financial and economic analysis was performed.

The proposed layout of the hydropower scheme and the relevant parameters are provided in the following section.

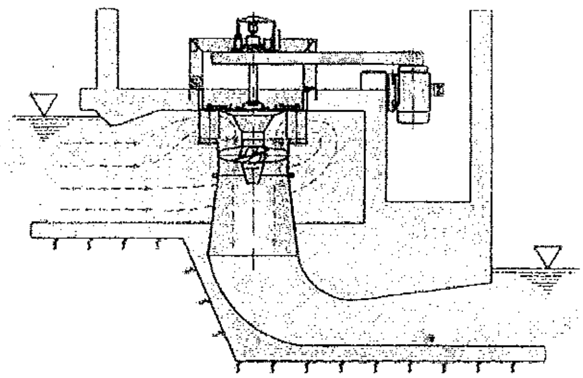
Canal Design Discharge		m^3/s (ft^3/s)	425 (15008.73)
PH Design Discharge		m^3/s (ft^3/s)	350 (12360.13)
Probability of Occurrence		(%age)	31%
Net Head at PH Design Discharge		m (ft)	3.55 (11.65)
Installed Units Capacity		(No. x MW)	4x2.6225=10.49MW
Turbine Configuration	Runner Dia.	m (ft)	4.766 (15.64)
	Speed	(RPM)	69.8
Average Annual Energy Generated		(GWh)	67.29
Auxiliary Consumption		(GWh)	0:67
Net Average Annual Energy		(GWh)	66.61
Plant Factor		(%age)	73 %
Head Race Canal	Top Width	m (ft)	41.124(134.92)
	Bottom Width	m (ft)	34.138(112.00)
	Side Slope	-	1V : 2H
Tail Race Canal	Top Width	m (ft)	41.124(134.92)
	Bottom Width	m (ft)	34.138(112.00)
	Side Slope	-	1V : 2H
Powerhouse	Length	m (ft)	48.60(159.44)
	Width	m (ft)	88.66(290.88)
	Total Height	m (ft)	29.637(97.23)

Selected Projct layout is presented in the following section



PROJECT LAYOUT PLAN, BS LINK-I
(4 UNITS)

Each turbine has a rated discharge of 87.5 cumec and is a horizontal pit Kaplan turbine, which is an outward flow reaction turbine



The total project cost is estimated to be 45.44 Million USD

1. INTRODUCTION

1.1. General

In order to facilitate the private investors in setting up the hydropower schemes in accordance with Government policy, Punjab Power Development Board (PPDB), Energy Department (ED), Punjab advertised eleven (11) hydropower projects in the year 2015. Consequently, through the proper selection procedure, M/s Associated Technologies (Pvt.) Ltd (ATL) was entrusted with the task of development of a hydropower scheme proposed on Balloki-Sulemanki (BS) Link-I Canal at RD 106+250 in Kandu Khara, Tehsil Chunian, District Kasur. A Letter of Interest (LOI) was issued in favor of ATL in March, 2016.

ATL further engaged M/s Integral S.A, a renowned Colombian consultancy firm as Project Consultants to conduct Feasibility Study of the Project.

BS Link-I Hydropower Project will possess a power capacity of about 11 MW which will be added to the national grid through 132 KV transmission line to Chunian grid station under LESCO. Feasibility Study evaluates the Project proposition in terms of technical viability considering the parameters like hydrology, geology, best suitable layout, power potential, selection of hydro-mechanical turbines and electrical equipment including generators, power generation and power evacuation. Also the potential environmental impacts of the Project have been studied in detail and reported. The financial and economic analysis has been prepared in the light of the estimated cost of the Project.

This section elaborates the background, nature and location of the project as well as the scope, extent, methodology, limitations and approach to conduct the Feasibility Study of the Project

1.2. Background

Today the energy crisis in Pakistan is more than the demand of the electricity. The gap between the demand and supply of the electricity is widening. Also the portion of generated electricity through non-renewable sources is quite high which needs to be reduced by injecting energy into the system produced through clean and renewable sources. Government of Punjab through its attached departments is working to overcome the energy crisis in Pakistan and meet the energy demand by utilizing the available hydel power potential at barrages and canal Falls to generate clean and cheap electricity.

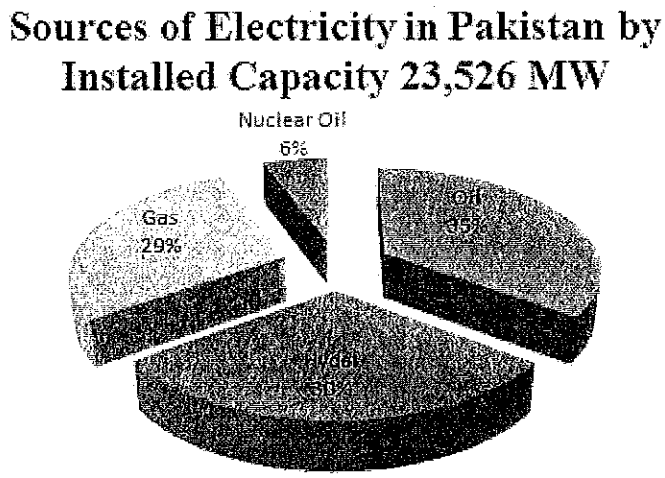


Figure 1: Energy Generation Mix of Various Sources

BS Link-I HPP was first identified during a comprehensive study conducted by WAPDA/GTZ in 1985. A number of hydropower project sites were identified along existing canal Falls and barrages in the existing irrigation system of Pakistan (WAPDA\GTZ Ranking 1985 and Inventory 1992). Since then, a few studies relating to the project have been performed which have been reviewed thoroughly and discussed in subsequent sections.

1.3. Objective of the Project

The broader and the main objective of the project is to shorten the energy crisis of the country by utilizing the available energy resources of the country. The idea is to install small hydel projects on the canal Falls and barrages to generate cheap and environment friendly electricity to add power into the national grid of the country.

1.4. Nature, Size and Location of the Project

The proposed BS Link-I HPP has a generation capacity of about 11 MW. Balloki-Sulemanki Link canal off-takes from the left bank side of Balloki Barrage on river Ravi and connects Sutlej River upstream of Sulemanki Barrage. The proposed powerhouse of the project will be constructed on the right-bank of the canal at RD 106+250 utilizing the existing available head of 3.242 m (10.64 ft). It is located near the town of Chunian District Kasur in Punjab Province. The upstream limit of the project is constrained by the Fall at RD 73+250 while downstream limits are controlled by the Chunian Distributary which is off-taking from the right bank of BS-I link at RD 110+667. From Balloki Headwork to RD 73+250, the canal bed is unlined. However, at RD 73+250 the canal is bifurcated in two segments known as BS Link-I & BS Link-II canals and the canal bed of BS Link-I is brick-lined from that RD so on.

A detailed location map of the proposed project area is shown in the figure below.

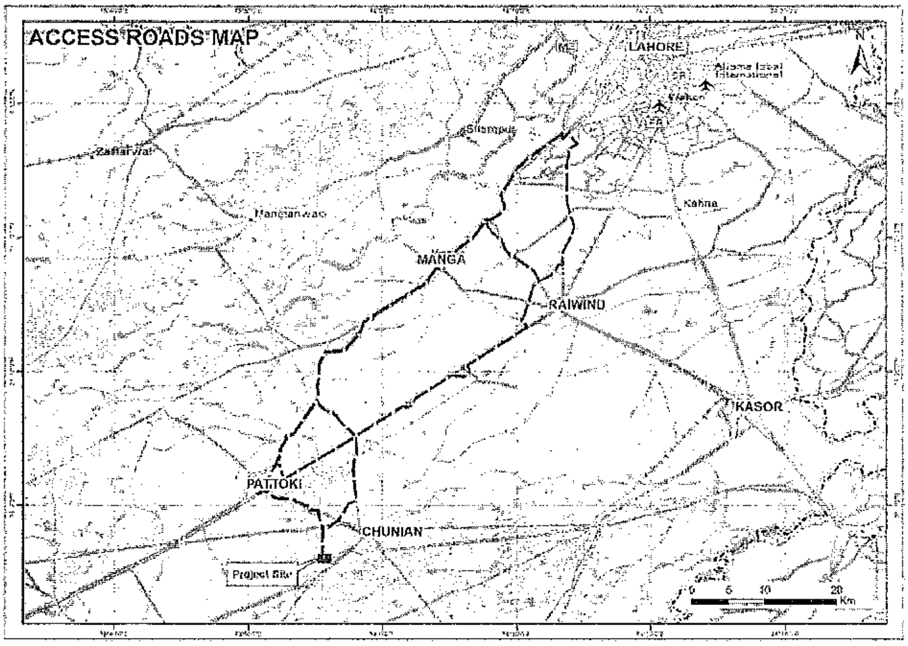


Figure 2: Location Map of the BS Link-I Hydropower Project

1.5. Description of Project Area

I. BS Link-I HPP area is located in Tehsil Chunian, District Kasur, Punjab. The Project area is located at about 90 Km from Lahore. The general climatic condition of the area is five season semi-arid. Monsoons and western disturbances are the two main factors that affect the weather of the region; otherwise, continental air prevails for the rest of the seasons.

Following table depicts the monthly temperature variation in the Project area:

Table - 1: Climate of Project Area

Month	Average Daily Temp. (oC)			Relative Humidity (%)			Wind	RainFall
	Min	Max	Mean	Min	Max	Mean	(knots)	(mm)
January	6.7	19.6	13.2	48.3	86	67.2	1.3	22.9
February	9.4	22.1	15.8	42	79.7	60.9	2.5	30.3
March	14.2	26.9	20.6	38.6	75.3	57	3.1	38.4
April	20	34	27	27.6	62.9	45.3	3.2	22.3
May	24.5	38.9	31.7	23.7	53.3	38.5	2.8	20.8
June	27.2	39.9	33.6	31.8	61.7	46.8	2.8	51.3
July	26.8	35.7	31.3	57	81.7	69.4	2.6	212.1
August	26.5	34.9	30.7	61.8	85.5	73.7	2.2	194.5
September	24.6	35	29.8	50.8	82.5	66.7	1.8	65.1
October	18.5	32.8	25.7	41.1	80.1	60.6	0.9	14.8
November	12.4	27.7	20.1	47.6	84.6	66.1	0.4	6.5
December	7.8	21.9	14.9	52.8	86.9	69.9	0.5	9.9

II. Chunian is known for the Changa Manga forest, the largest single plantation of trees in Pakistan, and the Chunian Industrial Estate, one of the largest concentrations of manufacturing in the country. The area is a busy regional market for agricultural produce.

III. The land is generally fertile and irrigated. The project site is located within the Punjab plain which is the upper part of the Indus Basin with thick alluvial deposits. The sediments comprise soil materials Falling in the range of sand,. silt and clay. These are generally devoid of grain sizes bigger than sand, i.e. pebbles, cobbles, gravels and stones etc. No rock outcrop is located in the near vicinity of the project site.

1.6. Previous Studies

On the project, in different periods, different studies remained under progress and the conclusions / recommendations of these studies have been described for reference as follows:

1.6.1. HEPO/WAPDA-GTZ Study (1984-85)

In 1984-85, HEPO-GTZ conducted a Ranking Study and a hydropower project was considered at RD 106+250 of BS Link-I Canal, ranked second in the canal Falls category. The said project was proposed at downstream of the existing Fall as a submersible type of the powerhouse with spillway at its top in the bed of the canal. It was further proposed that the diversion canal would be constructed on the right side of the existing canal through which operation of the canal would be kept in progress. The combined powerhouse & spillway was also studied, but not recommended due to different foundations levels of both the structures which were considered susceptible to different settlements. After completion of the powerhouse & spillway, existing Fall along with diversion channel was recommended to be dismantled.

1.6.2. Army Welfare Trust Study (1987)

In 1987, Army Welfare Trust Pakistan, a private developer, conducted a Feasibility Study through Associated Consulting Engineer (ACE) Pakistan in association with HARZA Engineering International USA. The study recommended the powerhouse in the bypass arrangement with double regulated bulb type turbines and a sluice structure (spillway) was proposed near the powerhouse. The sluice structure was proposed with the capacity of 64% of the flows and balance flows were considered to pass through turbines.

1.6.3. MK Power Study (1994)

MK Power Consortium, a joint venture of M/S Macro Services Pakistan and M/S Kvaerner Boving UK conducted a Feasibility Study through a M/S Royds Consulting Limited, New Zealand and M/S Pakistan Engineering Services Lahore. In the study, the powerhouse was proposed to be in bypass arrangement while the existing Fall at RD 106+250 was considered to be remodeled to act as a spillway. The powerhouse was proposed to be equipped with three single regulated pit type turbines.

1.6.4. Olympia Feasibility Study Report (2009)

In 2009, Olympia Chemicals, conducted a Feasibility Study through M/S Technical, Engineering and Management – TEAM Consultants, Pakistan. In the study, powerhouse & spillway were proposed in the diversion arrangement on the right side of BS Link-I Canal opposite Fall RD 106+250. Design discharge of the powerhouse is selected as 381 cumec with three (03) number of horizontal pit type turbines.

1.7. Present Study

The present study is aimed at investigating, processing and analyzing the available data in order to conclude the design parameters of the Project in the form of a bankable feasibility study. The structure and format of the study are explained in subsequent sections.

This study is constituted as follows:

Volume-1 **Main Report**

Volume-2 **Project Drawings**

Volume-3 **Initial Environmental Examination**

Volume-1 covers the following heads:

I. Topographic Survey
II. Geotechnical Investigations
III. Hydrology & Sedimentation
IV. Layout Alternatives Study
V. Hydraulic Design of Project Components
VI. Power & Energy Optimization
VII. Structural Design Criteria
VIII. Electrical & Mechanical Equipment
IX. Environmental Study
X. BOQ & Cost Estimation

XI. Economic & Financial Analysis
XII. Conclusion & Recommendations

Moreover, Following Appendices are also added as part of the Main Report, which contain detailed studies of the subject heads:

Appendix-A	Topographic Survey report
Appendix-B	Geotechnical Investigations Report
Appendix-C	Hydrological Study Report
Appendix-D	Sedimentation Study Report
Appendix-E	Power & Energy Study
Appendix-F	BOQ & Cost Estimation

1.8. Selection of Unit Systems

Considering the international practices and existing system of units in all the documents of the Punjab Irrigation Department, unit system in this report will be as follows:

- All Hydraulic structures/channel will be designed in SI units. These calculations, designs & drawings include the followings pertinent components:
  - Layout plan of BS Link-I Hydropower Project;
  - Headrace / tailrace Channels;
  - Spillway;
  - Powerhouse;
  - Energy calculations on the basis of field record of discharges;
- RD (Reduced Distance) will be mentioned in FPS in all design calculations and drawings
- Revised Longitudinal Section of Upper Chenab Canal from RD 100+000 to RD 110+000 will be made in FPS as it has to be approved and read in conjunction with the already approved longitudinal section/profile from the Punjab Irrigation Department. However, the same is also produced in SI Units for making compatibility with the hydraulic structures.

2. TOPOGRAPHIC SURVEY

2.1. Introduction

A reliable topographic survey is one of the basic requirements for feasibility study of **BS Link-I** hydropower Project. This Topographic survey was carried out using modern instruments and state-of-the-art techniques. The topographic survey of proposed BS Link-I Hydropower site located at existing structure at RD 106+250 of BS link-I canal and bathymetric survey of twin BS Link canals was awarded to **The Spatio** on 5th January 2016. The survey crew along with survey equipment was mobilized to site on 5th January 2016.

The detailed topographic survey of existing structure at RD 106+250 and bathymetric survey of twin BS Link canals 1100 meters upstream and 800 meters downstream from the existing structure was comprising of establishment of Permanent Control, cross sections of BS Link canal and detailed general topographic survey of the area. It was completed by experienced survey Experts and then digitized maps produced utilizing acquired field data.

The following are the some of the main steps/tasks considered for carrying out detailed topographic survey and mapping.

- Initial reconnaissance and collection of available data.
- Identification of existing survey control points and verification.
- Establishment of Permanent control in Project area with reference to existing control.
- Detailed topographical survey and cross sections of twin BS Link Canal.
- Acquisition of High Resolution Satellite Imagery.

2.2. Project Location and Layout

BS Link-I Hydropower Project has been proposed at RD 106+250 of BS Link-I canal. BS Link Canal off-takes from Head Balloki on Ravi River. The Project area is located in Tehsil Chunian, District Kasur at about 90 km from Lahore. At RD 73+250, the BS Link Canal is bifurcated into two canals named as BS Link-I and BS Link-II. At this location, the chainage of BS Link-II is 33+300.

The location coordinates of BS Link Hydropower site are given in following Table.

Table - 2: Location Coordinates of Project Site

Site	Latitude	Longitude
BS Link-I at RD 106+250	30°56'23.29"N	73°55'26.46"E

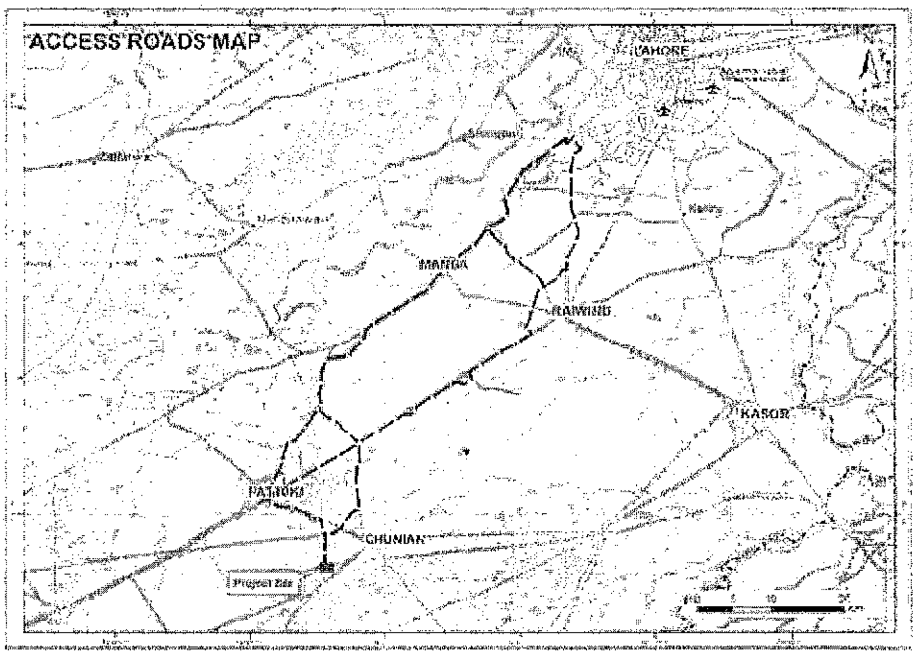


Figure 3: Location Map Of Project

2.3. Scope of Work

The following work has been carried out regarding the survey:

- Reconnaissance of proposed hydropower site and finalization of required survey corridor.
- Fixing / Installation of primary control points, monuments in the Project area. Four concrete monuments were installed in the project area and their description sheets are provided in **Appendix-A**
- Shifting of the reference benchmark in Project area. The SOP benchmark installed at Head Balloki was taken as reference benchmarks and the control points installed in the project area were connected to it by using dual frequency GPS.
- Establishment of primary and secondary horizontal and vertical control in the project area using high accuracy dual frequency GPS. The list of the control points is provided in the Table-6.
- Detailed topographic survey of 500m wide and 1500m long strip from edge of canal on both sides. Total area surveyed is 390 Acres.
- Bathymetric cross sectional survey of twin canals 1km upstream and 0.5 km downstream from existing head at every 25 m interval (60 cross sections). Cross-sections are presented in **Annexure-E**.
- Picking up of field details / features (natural / man–made) with electronic total station and dual frequency GPS in RTK mode and spot elevation for generation of contours at 20cm interval.

- Picking up of boundary demarcations of agriculture and built-up area for land acquisition purpose.
- Production of topographic survey maps on 1:1000 scale with 20 cm contour interval. The topographic sheets are attached as **Annexture-C**
- Preparation of vertical cross sections in digital format of whole strip at every 25m interval.
- Preparation of Vertical profile of canal.
- Acquisition of High Resolution Google Satellite Image of Project Area. The DVD enclosed with this report contain the soft copy of the image in the format of ECW at the resolution of 0.5 m (See Annexure-G folder on DVD). The image is shown in Fig-5.
- High resolution site photographs on enclosed DVD (See Annexure-G folder on DVD).
- The Rinex files, satellite availability reports, calibration certificate, site photographs and Raw topo data files are in Annexture-G folder on DVD.
- Preparation of Topographic survey Report along with all required deliverables in Soft and Hard Copies.

2.4. Datum and coordinate system

The Universal Transverse Mercator projection was adopted as reference coordinate system based on WGS84 ellipsoid. The WGS 84 ellipsoid has following parameters.

- Semi major Axis (a): **6378137.000 m**
- Semi Minor Axis (b): **6356752.314 m**
- Inverse flattening (1/f): **298.257224**

The coordinate system is based on Universal Transverse Mercator projection which is a cylindrical projection. UTM projection is suitable for the projects having north-south orientated area. BS Link Hydropower Project area falls in UTM zone 43. The parameters of UTM Zone 43 are as follows:

- Latitude of Origin: **0°**
- Central meridian: **75° E**
- False easting: **500,000 m**
- False northing: **0 m**
- Scale factor: **0.9996**

2.5. Installation of Permanent Survey Monuments

Four control point monuments were installed in project area as permanent control point. A ditch, about 30cm x 30cm in size and 30cm deep was dug into ground (depth varied according to hardness of strata) for each control point, two steel rods 15mm in diameter and 100cm long driven into the bottom of ditch such that about 70cm length is in virgin land, below the ditch bottom. The ditch was filled with good quality concrete (cement sand aggregate ratio 1:2:4) and truncated concrete monument cast over it with dowels extended from the foundation. The truncated pyramid shape concrete monuments are with dimensions 15cm x 15cm at top, 30cm x 30cm at bottom and 30cm high.

A steel nail at its top represents the control point location. These have been located in safe and stable places, so that these can survive in fairly good number even after construction phase. Position of each control point has been shown on the relevant drawing, while its coordinates and elevation have been tabulated in Table-3. Detailed description sheets of all control points, including coordinates; digital photographs have been prepared. Refer Annexure- A for description sheets of survey control points. A photograph of Bench mark is shown below:

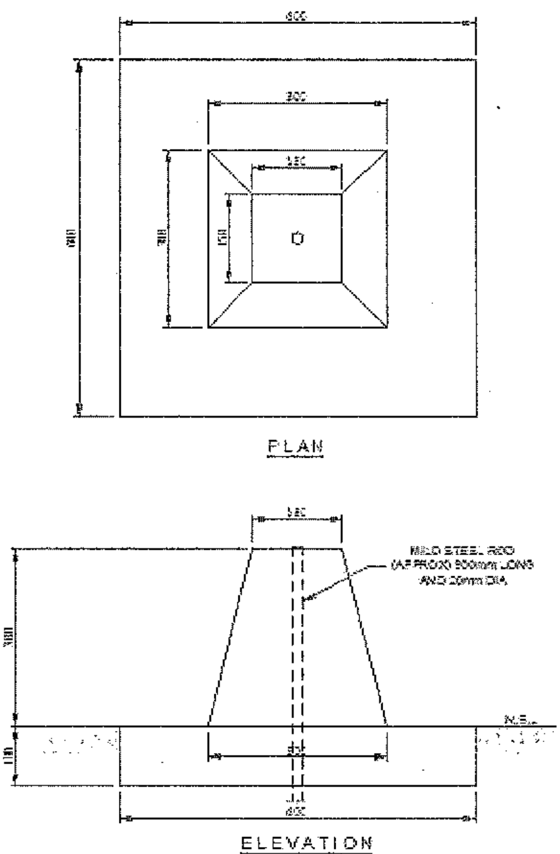


Figure 4: Sketch of Permanent Monument

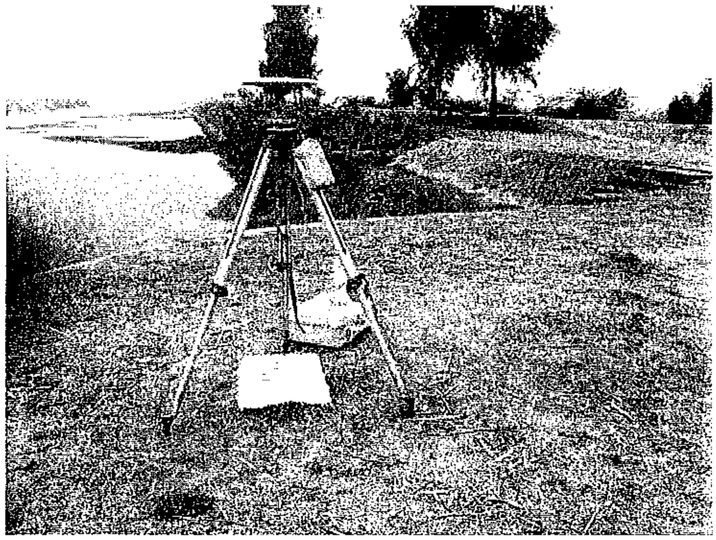


Figure 5: **Installed Permanent Monument at Site**

2.6. Establishment of Permanent Survey Control Network

The installed monuments were established as permanent control points for the project. These control points were used for detailed topographic survey of the project area. The coordinates of these control points were derived from dual frequency GPS observations. The elevations of the control point were derived from GPS using geoid model EGM 2008. The official Earth Gravitational Model EGM2008 is released by the National Geospatial-Intelligence Agency (NGA) EGM Development Team.

EGM2008 is used to compute Geoid undulation values with respect to WGS 84. The resolution of this gravitational model is 1 minute. Using EGM2008, the orthometric heights (elevations) were derived by Trimble Business Center post processing GPS software.

2.6.1. Survey Equipment

Two units of Dual Frequency GPS, model 5700 Trimble made were used for establishing horizontal control network. The data acquired was processed by using the software Trimble Business Center. Specifications of used Dual Frequency GPS are provided below:

Table - 3: Positioning Specification of GPS

Positioning	Mode	Horizontal Accuracy (RMS)	Vertical Accuracy (RMS)
RTK (OTF)	Synchronized	1 cm + 1 ppm (× baseline length)	2 cm + 1 ppm (× baseline length)
	Low Latency	2 cm + 2 ppm (× baseline length)[a]	3 cm + 2 ppm (× baseline length)[a]
L1 C/A Code Phase	Synchronized/ Low Latency	.25 m + 1 ppm RMS	.50 m + 1 ppm RMS
Static/ FastStatic	N/A	5 mm + 0.5 ppm (× baseline length)	5 mm + 1 ppm (× baseline length)
WAAS	N/A	Less than 5 m[b]	Less than 5 m[b]

Table - 4: Technical Specification of GPS

Feature	Specification
Tracking	24 channels L1 C/A code, L1/L2 full cycle carrier Fully operational during P-code encryption WAAS satellite tracking
Signal processing	Maxwell architecture Very low-noise C/A code processing Multipath suppression
Start-up	Cold start: < 60 seconds from power on Warm start: < 30 seconds with recent ephemeris
Initialization	Automatic while moving or static
Minimum initialization time	10 sec + 0.5 × baseline length (km)
Communications	Three RS-232 serial ports (Port 1, Port 2, and Port 3) Baud rates up to 115,200 bps RTS/CTS flow control negotiation supported on Port 3 only One USB port (download only)
Configuration	Via user-definable application files or GPS Configurator
Output formats	NMEA-0183: AVR; GGA; GST; GSV; PTNL,GGK; PTNL,GGK_SYNC; HDT; PTNL,PJK; PTNL,PJT; ROT PTNL,VGK; VHD; VTG; ZDA GSOF (Trimble Binary Streamed Output) 1PPS RT17

2.7. Methodology

The measuring gauge installed at the upstream of right bank of BS Link-I was adopted as vertical reference. The level was shifted to TS-1 using auto level. The coordinates of TS-1 in UTM system were fixed by taking a long GPS session. The coordinates of TS-1 are listed in Table-4. TS-2, TS-3 and TS-4 were tied with reference to TS-1 using GPS in static mode as depicted in Fig-6.

The average observing session length was 15 to 30 minutes with 5 sec epoch rate. The typical session length for static survey using Dual Frequency GPS is 10 min + 1 min/ Km. The baselines are shown in the following diagram.

The raw GPS data was downloaded into PC computer. The data files were processed using Spectra Precision Survey Office software. The acceptance criteria for baselines used in Spectra Precision Survey Office software are illustrated in following figure.

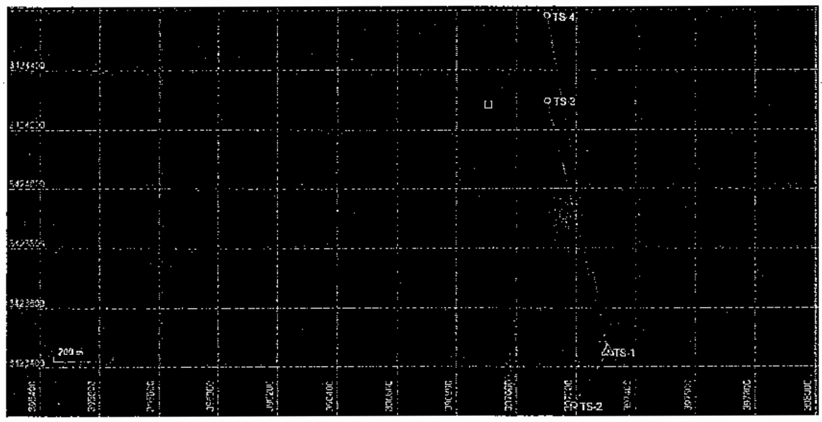


Figure 6: Installed Permanent Monument at Site

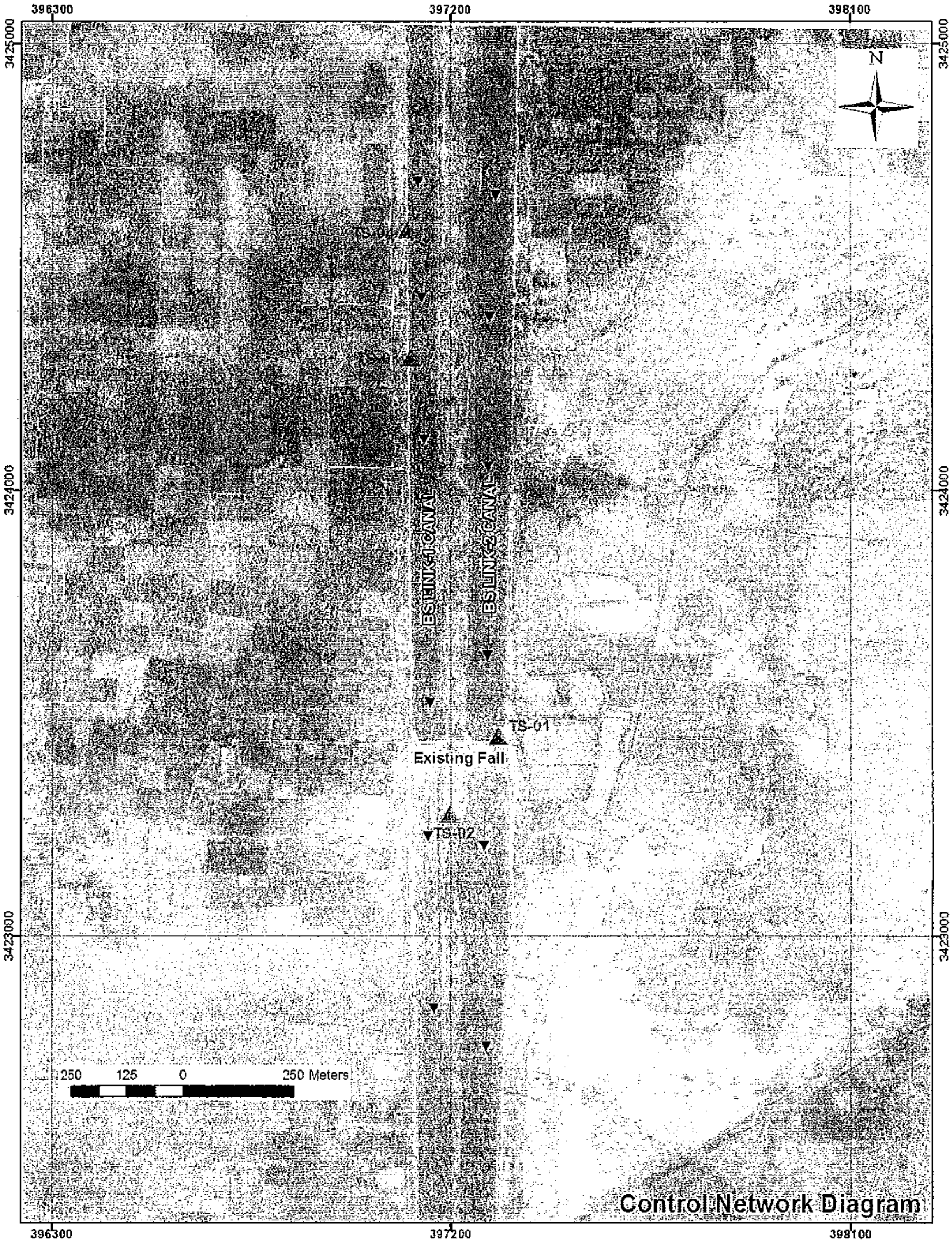


Figure 7: Permanent Control Network Diagram

Fortunately, no any baseline was failed, hence no baseline was resurveyed. The processing parameters, quality indicators, residual errors and accuracy achieved are mentioned in baseline processing reports included as Annexure-B.

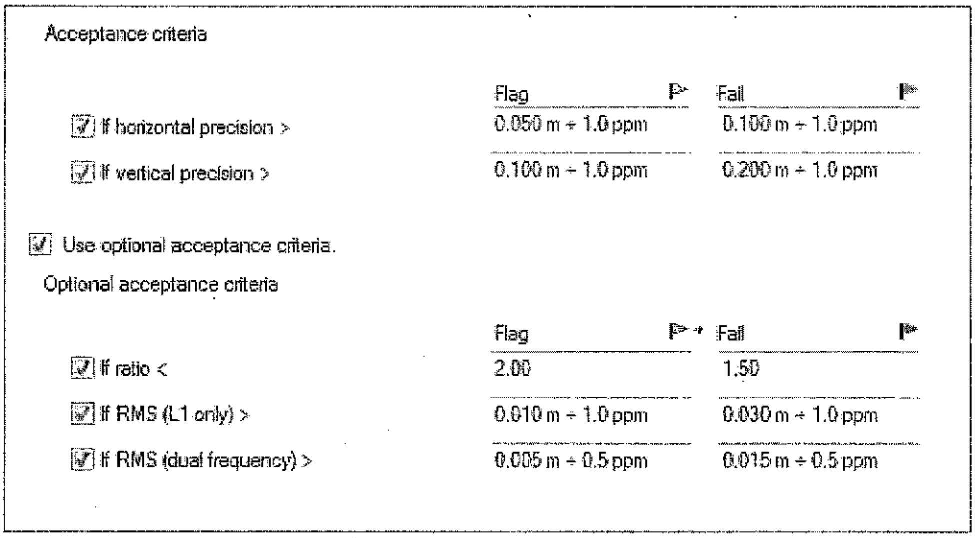


Figure 8: Accuracy Acceptance Criteria

Table - 5: UTM Coordinates of Permanent Control Points

Sr.No	Easting (m)	Northing (m)	Elevation (m)
TS-1	397306.239	3423453.159	189.132
TS-2	397193.686	3423272.253	189.205
TS-3	397104.937	3424296.392	190.939
TS-4	397102.621	3424582.537	191.223

Table - 6: WGS Coordinates of Permanent Control Points

Sr.No	LATITUDE	LONGITUDE	ELL. HEIGHT (m)
TS-1	30°56'24.17367"N	73°55'29.97228" E	144.601
TS-2	30°56'18.26288"N	73°55'25.79717" E	144.674
TS-3	30°56'51.49715"N	73°55'22.08013"E	146.426
TS-4	30°57'00.78987"N	73°55'21.88857"E	146.714

2.8. Detailed Topographic Survey

2.8.1. Equipment

For topographic survey, Sokkia make models CX105, electronic total stations were used. These total stations have distance measuring accuracy of 3mm + 2ppm and angular accuracy of 5" of arc. These have fairly large size built-in memory, enough for a week's work. Heavy duty wooden tripods were used with these instruments.

Sokkia reflector prisms, mounted on telescopic rods fitted with level bubbles were used.

Figure 9: Survey in Progress

2.8.2. Field Work Methodology

The survey control points already established at site were used for topographic survey. Additional temporary control points were also installed where required. A temporary control point was installed directly from a permanent control point via traversing and closed back or on another similar control point to ensure accuracy.

With each electronic total station at least four reflectors were used, all having the same target height. All man-made physical features and natural topography has been surveyed by EDM (Electronic Distance Measurement) tacheometry method. Spot heights have been measured at random interval and at abrupt changes in ground. The boundary of houses and commercial buildings has been surveyed from outside; the permanent and temporary features have been shown by different symbols in the drawings. The tracks foot paths and the forests have been mapped.

Different details are in different layers. Spot heights were taken at close interval randomly and in no case more than 25m apart.

The topographic survey commenced from one control point and was always closed on another to ensure reliability. Both the raw data and coordinates data were saved in electronic total stations. Unique codes, internationally accepted, were used for different features.

Two different survey teams were appointed for detailed topographic survey on both sides of BS Link-I. The survey teams first surveyed the right side of BS link-I and Left side of BS Link-II channels. Later, the median area between both channels was surveyed consequently.

The survey data was directly saved in total stations and downloaded and reviewed on daily basis on the laptops provided to survey parties. The closure error, if out of the tolerance limit, was identified and if required the survey was repeated. The data after initial check was combined in one laptop computer date-wise and party-wise. So that it can be referred back if required.

2.8.3. Bathymetric Survey

The bathymetric survey of twin canals (both BS Link-I and BS Link-II) was carried out with total station. Since, it has been a closure period of the canal, but there was still a low flow in both channels. The maximum depth at that time was not more than 3 meters. The cross sections were taken at the interval of 25 m in both channels with prism rod. The red men were equipped with rubber tire tube to navigate on water surface. The pictures given below illustrate the bathymetric survey.

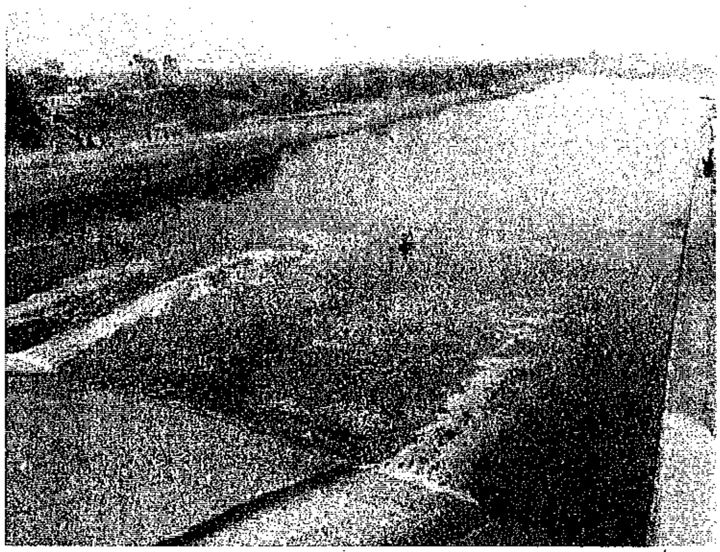


Figure 10: Bathymetric Survey in Progress

Figure 11: Bathymetric Survey in Progress

Cross Sections of both canals are presented in Appendix-A

2.9. General Topographic Features of Survey

The survey work was carried out to produce digital Topographic mapping for BS Link-I Hydropower Project.

- The horizontal survey grid and vertical control has been established.
- For the entire survey all features, both natural and man-made are recorded; including but not limited to the following:
    - Top edges of both channels
    - Inspection paths on both channels
    - Agriculture fields
    - Forestation, Plantation and Trees Areas
    - Road, Tracks and Paths
    - Fences, Boundaries, etc.
    - Houses, Buildings and other Monuments
    - Cultural Areas, Mosques, Cemeteries / Graveyards, etc. if found
    - The components of structure (slab, piers, wing walls etc.)
    - Property Boundaries

2.10. Data Processing and Production of Drawings

The electronic total stations surveyed data, already checked for quality, combined as one file was processed to generate digital elevation model (DEM). In order to avoid flat triangles in TIN model, soft break lines were introduced. These break lines include the agriculture field separators, the extents of water ponds (on left side of BS Link-II), inspection paths and tracks. Break lines were inserted at break points before generation of DEM. The processed and approved (after quality assurance) results were converted into ESRI point shape files to import in ESRI ArcGIS software. The digital elevation model was further reviewed thoroughly in ArcGIS software for quality. Any gaps still there were filled with additional survey data, and the doubtful data, if any, was replaced with fresh survey data at this stage also. Once data were found acceptable the DEM was again generated.

ESRI 3D analyst, spatial analyst extensions was used to model the topography, water channels and structure. The 3D Analyst extension has a very good algorithm for building TIN. It has plenty of functions to analyze and visualize a TIN surface. It stores the TIN structure using the points and their neighbors. Different features were saved in different layers.

The contours were generated at 1m interval; with 5th contour identified as index contours. The index contours have been identified with different color and heavy lines. The survey control points of permanent nature have been shown in sheets with suitable codes; the serial number and elevation of each control point is shown with each control point.

The drawings have been generated at 1:2,000 scales for design purpose. Grid lines have been shown 200 m apart; each sheet contains general notes, list of symbols, the scale bar, sheet index of the surrounding sheets, the coordinates at each grid at the sheet margins, the North symbol etc.

A separate index sheet showing the arrangement of all sheets has also been attached at the beginning. Also each sheet shows an index of the sheet with reference to the adjacent sheets. The topographic survey sheets have been plotted on A3 size standard paper in color and attached as Annexure-C with this report.

2.11. Plan & Profile Drawings:

The plan and profile sheets for main channel (BS Link-I) were extracted from the survey data at the interval of 25 m and were plotted in AutoCAD format. The plan and profile drawing shows the Plan of the BS Link-I at top portion of drawing with chainage, the profile at middle portion of the drawing and the corresponding elevation with chainage at the bottom portion.

2.12. Cross Section drawings:

The cross sections of the BS Link-I were extracted from survey data at 25 m interval and were plotted and are presented as Annexure-E.

3. GEOTECHNICAL INVESTIGATIONS

Executive Summary

Associated Technologies (Pvt) Ltd has planned BS Link Canal-I HydroPower Project. The project site is located adjacent to existing head work on Balloki Sulemanki Link Canal. The location of the site can be seen in the Site Location Map attached as Annexure A.1. Keeping in view the layout of the proposed structures, Associated Technologies (Pvt) Ltd provided the requirement of the Geotechnical Investigation to be implemented for the design and evaluation of the proposed structure.

For evaluation of sub-surface soil parameters and safe design of foundations, it was essential to carry out Geotechnical Investigations. The Driller was entrusted by Associated Technologies (Pvt) Ltd to carry out Geotechnical Investigations at the project site.

The proposed project involves development of 11 MW hydropower project on Balloki Sulemanki Link Canal

The Scope of Work (SOW) was defined considering the current project requirements provided by the client. A total of 11 boreholes, 2 of 10m, 7 of 20m & 2 of 30m depth and 4 Test pits of 3m each were planned to assess the ground conditions.

Probabilistic Seismic Hazard Assessment (PSHA) recently carried out for revision of seismic provisions of the Building Code of Pakistan, shows that the site area falls in Zone 2A. It is therefore, recommended that the project structures should be designed to cater for the requirements of Zone 2A of Building Code of Pakistan (2007).

The sub-soil lithology comprises of Silty Clay (CL-ML) encountered at top generally varying in depth from 2m to 3m in firm to stiff state. The Silty Clay was underlain by a layer of Silty Sand (SM) from 3m to about 16 m in depth in medium dense to dense state with occasional thin lenses of Silty Clay (CL-ML) encountered at variable depths. This layer was followed by a thick layer of Fine Sand (SW) from 16 m up to maximum investigated depth of 32 m below NSL.

Groundwater was encountered in the borehole at a variable depth of 5m to 6m and at 1.5 m in TP-4. Therefore, to simulate the worst case scenario, GWT has been taken as 1.5m for the foundation design.

The evaluation of the net allowable bearing capacity of the Square Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 1 m below NSL. The bearing capacity curves are presented in Annexure B.3.1.

The evaluation of the net allowable bearing capacity of the Strip Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 1 m below NSL. The bearing capacity curves are presented as Annexure B.3.2.

Similarly the evaluation of net allowable bearing capacity of the Mat Foundation has been done for a depth of foundation 20m below NSL which will be reviewed at detail design stage. The bearing capacity curves are presented as Annexure B.3.3.

3.1. Introduction

3.1.1. Scope of Report

Associated Technologies (Pvt) Ltd has planned BS Link Canal-I HydroPower Project. The project site is located adjacent to existing head work on Balloki Sulemanki Link Canal. Keeping in view the layout of the proposed structures the Associated Technologies (Pvt) Ltd provided the requirement of the Geotechnical Investigation to be implemented for the design and evaluation of the proposed structure.

For evaluation of sub-surface soil parameters and safe design of foundations, it was essential to carry out Geotechnical Investigations. The Driller was entrusted by Associated Technologies (Pvt) Ltd to carry out Geotechnical Investigations at the project site.

This Geotechnical Investigation report provides detail of current site conditions and interpretation of the investigation works carried out for the design and evaluation of proposed foundations. In addition, the report also delineates the guidelines and recommendations on geotechnical aspects to be used for structural design as well as considerations for construction activity.

The project site is located adjacent to existing Fall at RD 106+250 on Balloki-Sulemanki Link-I Canal. Keeping in view the layout of the proposed structures ATL decided to thoroughly conduct geotechnical investigations in order to investigate the subsurface condition and design parameters required for the design of the Project.

This Geotechnical Investigation report provides detail of current site conditions and interpretation of the investigation works carried out for the design and evaluation of proposed foundations. In addition, the report also delineates the guidelines and recommendations on geotechnical aspects to be used for structural design as well as considerations for construction activity.

3.1.2. Objectives of Investigations

The geotechnical investigations were undertaken to meet the following objectives:

- To delineate the subsoil conditions of the site area.
- To evaluate the geotechnical design parameters for various structures

3.1.3. Proposed Development

The proposed project involves development of 11 MW hydropower project on Balloki-Sulemanki Link Canal.

3.1.4. Scope of Work

The Scope of Work (SOW) was defined considering the current project requirements. The Geotechnical Investigation was accordingly planned to assess the ground condition for supporting the proposed structure.

3.1.5. Field Investigations

The Scope of Work (SOW) was defined considering the current project requirements provided by the client. A total of 11 boreholes, 2 of 10m, 7 of 20m & 2 of 30m depth and 4 Test pits of 3m each were planned to assess the ground conditions. The field investigations were performed as per the latest ASTM standards listed in Table 1-1

Table - 7: List of Field Tests

No.	Field Test	ASTM / BS Standard
1.	*Sand Cone Replacement Field Density*	*ASTM D1556-07*
2.	*Standard Penetration Tests (SPT)*	*ASTM D1586-11*

In addition to above field permeability tests were also performed at the project site in the boreholes

3.1.6. Laboratory Tests

Samples collected from the boreholes were subjected to the following tests, as per latest ASTM, AASHTO, BS or equivalent Standards, as listed in Table as under:

Table - 8: List of Laboratory Tests

No.	Laboratory Test	ASTM / BS Standard
1.	*Grain Size Analysis (GSD)*	*ASTM D421-85(07), ASTM D422-63(07)*
2.	*Atterberg Limits (ATL)*	*ASTM D4318-00*
3.	*Natural Moisture Content (NMC)*	*ASTM D2216-10*
4.	*Direct Shear Test (DST)*	*ASTM D3080-11*
5.	*Consolidated Undrained Triaxial Test (CU)*	*ASTM D4767-11*
6.	*Modified Proctor Compaction Test (MPT)*	*ASTM D1557-12, AASHTO T180*
7.	*California Bearing Ratio Test (CBR)*	*ASTM D1883-05, AASHTO T193-92*
8.	*Chemical Tests (CHM)*	*BS 1377-3:1990*

3.2. Site Description

3.2.1. Location of the Project Site

The project site is located adjacent to the Fall structure at RD 106+250 of Balloki-Sulemanki Link Canal.

3.2.2. Geology and Seismicity of the Area

3.2.2.1. Geology

The project site is located in Punjab, which is a plain of alluvial material and scattered rocks at deeper depth. A Geological Map showing the Geological distribution of the area is provided in Appendix A.3 Geological Map of the Project Area.

3.2.2.2. Seismicity

Probabilistic Seismic Hazard Assessment (PSHA) carried out for revision of seismic provisions of the Building Code of Pakistan, shows that the site area Falls in Zone 2A. It is therefore, recommended that the project structures should be designed to cater for the requirements of Zone 2A of Building Code of Pakistan (2007).

A plan showing various zones of Pakistan as per Latest Seismic Micro zonation as given in the Building code of Pakistan is attached with this report as Appendix A4.

3.2.3. Current Use of Project Area

The site area is currently open land.

3.2.4. Topography of Project Area

Topographically project area is plain land. However, some of the adjacent area is of variable topography mainly due to spoil banks.

3.3. Subsurface Exploration

3.3.1. General

The field investigation was performed under full time supervision by our experienced geotechnical engineer who supervised drilling operation, sampling and logging and top supervised the laboratory testing. The field tests that were performed are listed in Table-7.

3.3.2. Test Pits

A total of four (4) test pits were excavated at the project site up to a maximum depth of 3 m below NSL. In these test pits, seven (7) field density tests were performed using the sand cone replacement method as per ASTM D1556-07, at selected horizons. The density and moisture content values are shown on the individual test pit logs Annexure C.2.

The test pits were carefully logged during excavation by a geotechnical engineer and field logs were developed, which were later confirmed by laboratory test results. The test pit logs have also been appended to this report in Annexure C.2.

3.3.3. Drilling

A total of eleven (11) boreholes of maximum borehole depth of thirty-two meters (32 m) were planned at the project site. The field investigation was supported by relevant laboratory testing. The drilling and sampling work has been performed using the standards, procedures and equipment's recommended for engineering site investigation. The exact location of boreholes has been marked on the ground in the presence of the client's representative.

3.3.4. Standard Penetration Tests (SPT)

Standard penetration test is by far the most popular and economical method of obtaining subsurface information. It is carried out to assess the in-situ compactness of various soil layers. Significant numbers of foundation design procedures make use of SPT results.

Testing method essentially consists of driving split spoon sampler of specified dimensions up to a distance of 46 cm into the soil at bottom of borehole. A 63.5 kg hammer failing free from a height of 76 cm is used to drive the sampler. Number of blows required to drive the sampler were carried out in accordance with the specification of ASTM D1586-11. Continuous standard penetration test is performed wherever possible.

The SPT's were carried out at an interval of 1m in boreholes. A total of two hundred six (206) SPT's were performed. Annexure B.1 shows the variation of SPT blows with depth and the detail of SPT Results are given in the individual borehole log in Annexure C.1

3.3.5. Field Permeability Test

Field permeability is a field test used to determine the permeability of soils. The soil permeability is a very important factor to study the behaviour of soil in its natural condition with respect to water flow. The constant head method is particularly suitable for relatively coarse grained soil such as sands and gravel. For fine grained soils such as clay-like or silty soils see Falling head permeability apparatus.

During the course of geotechnical investigations, Constant head permeability tests are performed in accordance with ASTM D2434 or British Standard 5930. During the test, the hole is sealed from side by lowering of the casing down to the require depth; therefore water infiltration could only take place at the open bottom of the hole. The test is then performed by pumping water into the hole & adjusting the rate of inflow such a way that the water level in the hole remains constant under these conditions. The inflow of water "Q" is the rate of outflow from the hole through its bottom.

Twenty one constant head permeability tests were performed in granular soil, depth ranging from 1.5m to 12m. The permeability values as evaluated are in the range from 1.300 E-04 cm/sec to 1.379 E-02 cm/sec. The results of permeability tests are given in Annexure C.3.

3.3.6. Sampling

Collection of representative samples forms an essential part of investigation program. The following types of samples have been collected for this Project.

3.3.6.1. Disturbed Soil Samples

Disturbed soil samples were obtained either from the Auger/bailer as the borehole was advanced or from the spilt spoon sampler after performing Standard Penetration Test (SPT). Disturbed samples were used to classify the soil type and depth of occurrence of different layers, and were preserved, for laboratory testing. All the samples obtained from the boreholes were properly preserved in polythene bags and labelled as disturbed samples. The entire sampling, preservation and transportation of the samples were carried out as per latest ASTM standards.

3.3.6.2. Undisturbed Soil Samples

A total of fifteen (15) undisturbed soil samples were recovered from the boreholes, using Shelby samplers. After determining the in-situ density, the samples were properly waxed, labelled and preserved before transportation to the laboratory.

3.3.6.3. Ground Water Samples

Groundwater was encountered in the borehole at a variable depth of 5 m to 6 m. In one of the test pits, TP-4, the ground water was encountered at 1.5 m depth. Considering that the project is located very close to the head work, the depth of ground water for foundation design has been taken as 1.5 m.

A total of five (5) water sample were collected from the boreholes.

3.4. Laboratory Test Results

In addition to field testing, a number of laboratory tests, as listed in Table-8 were also conducted on selected soil samples. Results of these tests are helpful in classification of soil, determining engineering properties such as classification, compactness and suitability for construction material; the same is given in the Appendix B.2.1 which contains laboratory test results.

Brief description of all the laboratory tests and testing standards is given in the following sections.

3.4.1. Grain Size Analysis

Soil is an uncemented aggregate of mineral grains and decayed matter with liquid and gas in the empty spaces between the solid particles, which consists of an assemblage of discrete of particles of various sizes and shapes. This analysis consists of shaking the soil sample through a set of sieves, which decrease in opening sizes from top to bottom. The object is to group these particles into separate size ranges and to determine the relative proportions by dry weight, of each size range.

Grain size analysis is been conducted in two stages. Particles size distribution of coarse-grained soils is performed by sieve analysis while hydrometer analysis is conducted to establish distribution of fine-grained soils. Grain size analysis is carried out as per ASTM D422-63(07).

Based on the results of these analyses and the Atterberg limits, the soil is classified into groups and sub-groups according to their engineering behaviour. Generally two elaborate classification systems are used which are the American Association of State Highway and Transportation Officials (AASHTO) classification system and the Unified Soil Classification System (USCS). The AASHTO classification system (AASHTO M145 or ASTM D3282-09) is used mostly by highway departments for road design, whereas the USCS system (ASTM D2487-11) is used by geotechnical engineers for foundation design etc.

A total of twenty (20) sieve analyses were conducted on the samples collected from the site.

The classification test results indicate that the subsoil mostly comprises of CL, CL-ML, ML, SM, SW- SM groups on the basis of USCS System. The soils classified as granular indicated fines (passing # 200 sieve) ranging from 7% to 39%. The fine content in the cohesive soils were indicated as 62% to 98%.

3.4.2. Atterberg Limits

Atterberg limits, as described in ASTM D4318-00, are a basic measure of the critical water contents of a fine-grained soil, such as its shrinkage limit, plastic limit, and liquid limit. As a dry, clayey soil takes on increasing amounts of water, it undergoes dramatic and distinct changes in behaviour and consistency. Depending on the water content of the soil, it may appear in four states: solid, semi- solid, plastic and liquid. In each state, the consistency and behaviour of a soil is different and consequently so are its engineering properties.

Plastic limit (PL) is the moisture content at which the soil passes from the semisolid to the plastic state, as the moisture content is increased. It is determined by rolling out a thread of the fine portion of a soil on a flat, non-porous surface.

Liquid Limit (LL) is the moisture content at which a soil passes from the plastic state to a liquid state as the water content is increased.

Plasticity Index (PI) is the difference of moisture content at liquid and plastic limits (PI=LL-PL). A plot of PI against LL provides the bases for classification of cohesive soils. It also provides insight into several soil characteristics such as compressibility and strength.

A total of fourteen (14) Atterberg limit tests performed on the soil samples indicated that the liquid limit (LL) ranged from 20 to 30 and plasticity index (PI) varied from 5 to 10, while eight (8) samples showed a non-plastic (NP) behaviour.

3.4.3. Natural Moisture Content

Moisture content of soil is the ratio of the amount of water present in a soil sample to the solid mass of the soil. The knowledge of the in situ natural moisture content will give an idea of the state of soil in the field. It is essential in in establishing a correlation between soil behavior and its index properties and determining the bearing capacity and settlement. The standard procedure is given in ASTM D2216-10.

The laboratory tests performed on three (3) relatively undisturbed soil samples extracted up to a maximum depth of 10m below NSL have yielded natural moisture content ranging from 14% to 22%.

3.4.4. Direct Shear Test

Direct shear test, according to ASTM D3080-11, is a laboratory to measure the shear strength properties of soil. It is performed on three or four specimens from a relatively undisturbed soil sample. A specimen is placed in a shear box which has two stacked rings to hold the sample; the contact between the two rings is at approximately the mid-height of the sample. A confining stress is applied vertically to the specimen, and the upper ring is pulled laterally until the sample fails, or through a specified strain. The load applied and the strain induced is recorded at frequent intervals to determine a stress-strain curve for each confining stress. This test is commonly used for dry or saturated sandy soils.

A total of two (2) direct shear tests were performed on the relatively undisturbed soil samples extracted from extracted from boreholes. The results indicated angles of internal friction (∅) varying from 36° to 37° with the corresponding cohesion intercept ranging from 0 to 0.1 kg/cm^2.

3.4.5. Triaxial Test

The triaxial shear test is one of the most reliable methods available for determining shear strength parameters. It is widely used for research and conventional testing. In this test a soil specimen about 36 mm (1.4 in.) in diameter and 76 mm (3 in.) long is used. The specimen is encased by a thin rubber membrane and placed inside a plastic cylindrical chamber that is usually filled with water or glycerine. The specimen is subjected to a confining pressure by compression of the fluid in the chamber.

To cause shear failure in the specimen, axial stress is applied through a vertical loading ram (sometimes called deviator stress). The corresponding axial deformation is measured by a proving ring or load cell attached to the ram.

Connections to measure drainage into or out the specimen, or to measure pressure in the pore water (as per the test conditions), are also provided.

The following triaxial tests have been conducted, which have been described in sections below:

- Unconsolidated Undrained Test (UU)
- Consolidated Undrained Test (CU)
- Consolidated Drained Test (CD)

3.4.5.1. Consolidated Undrained Test (CU)

The consolidated undrained test is the most common type of triaxial test. In this test, the saturated soil specimen is first consolidated by an all around chamber fluid pressure that results in drainage. After the pore water pressure generated by the application of confining pressure is dissipated, the deviator stress on the specimen is increased to cause shear failure.

During the application of the deviator stress, the drainage line from the specimen is kept closed. Simultaneous measurements of deviator stress and increase in pore water pressure is made. The detailed process is given in ASTM D4767-11.

Consolidated undrained (CU) triaxial test with pore pressure measurement was carried out on three
(3) undisturbed samples, indicates effective angle of internal friction (Phi') of 35° to 38o with cohesion (c') as 0.08kg/cm^2 to 0.15 kg/cm^2.

3.4.6. Modified Proctor Compaction Test

Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. The dry density of a soil for a given compactive effort depends on the amount of water the soil contains during soil compaction.

The tests generally consist of compacting soil at known moisture content into a cylindrical mould of standard dimensions using a compactive effort of controlled magnitude. The soil is usually compacted into the mould to a certain amount of equal layers, each receiving a number blows from a standard weighted hammer at a specified height.

This process is then repeated for various moisture contents and the dry densities are determined for each. The graphical relationship of the dry density to moisture content is then plotted to establish the compaction curve. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content, also known as the optimal moisture content.

The Standard Proctor Compaction Test is designated by ASTM D698-12 and AASHTO T99. Also, the modified Proctor compaction test is designated by ASTM D1557-12 and AASHTO T180.

Laboratory compaction tests of soil using modified effort were performed on four (4) samples collected from test pits, the results of which indicate maximum dry density ranging from 1.85g/cm^3 to 1.86g/cm^3.

3.4.7. California Bearing Ratio Test (CBR)

California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road subgrades and base-courses. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. The CBR test is described in ASTM D1883-05 (for laboratory-prepared samples) and ASTM D4429-09 (for soils in place in field), and AASHTO T193-92.

The CBR rating was developed for measuring the load-bearing capacity of soils used for building roads. The harder the surface, the higher is the CBR rating. A CBR of 3 equates to tilled farmland, a CBR of 4.75 equates to turf or moist clay, while moist sand may have a CBR of 10. High quality crushed rock has a CBR over 80. The standard material for this test is crushed California limestone which has a value of 100.

A total of four (4) soil samples were tested for 3-point soaked CBR test showing CBR values ranging from 2% to 18% at 95% maximum dry density.

3.4.8. Chemical Tests

The chemical tests are performed, as per BS 1377 Part 3, to check the acidity of the soil and the quantities of aggressive materials in the ground, such as Sulphates, Chlorides and Organic materials which may attack buried concrete or metal.

Chemical tests carried out on five (5) water samples indicated that total soluble solids varied as 1475 to 2100ppm, Sulphates contents from 197 to 512ppm, chloride contents from 102 to 401ppm and pH values from 6.9 to 7.02.

3.5. Ground Conditions and Engineering Properties

3.5.1. Lithology of Project Area

The sub-soil lithology comprises of

- Silty Clay (CL-ML) was encountered at top generally varying in depth from 2 m to 3 m in a firm to stiff state.
- A layer of Silty Sand (SM) from 3 m to about 16 m in depth in medium dense to dense state with occasional thin lenses of Silty Clay (CL-ML) encountered at variable depth.
- A thick layer of Fine Sand (SW) from 16 m up to maximum investigated depth of 32 m below NSL.

3.5.2. Ground Conditions

The ground conditions consist of the following general conditions summarized below:

Table - 9: Summary of Ground Conditions

Borehole No.	Top Depth (m)	Bottom Depth (m)	Description Title	Description
S-1	*0*	*3*	*SILTY CLAY*	*Light brown, stiff, fine grain, silty clay with low to medium plasticity.*
S-1	*3*	*9*	*SILTY SAND*	*Light grey, medium dense, fine to medium grain, silty sand.*
S-1	*9*	*10*	*SILTY CLAY*	*Light brown, stiff, fine grain, silty clay, with low to medium plasticity.*
S-1	*10*	*16*	*SILTY SAND*	*Light grey, medium dense to very dense, fine to medium grain, silty sand with trace mica.*
S-1	*16*	*20*	*FINE SAND*	*Light grey, dense, fine to medium grain, sand with trace mica.*
S-2	*0*	*3*	*SILTY CLAY*	*Light brown, stiff, silty clay with concretion and low plasticity.*
S-2	*3*	*9*	*SILTY SAND*	*Light grey, medium dense, fine grain, silty sand with trace mica, trace concretion.*
S-2	*9*	*18*	*FINE SAND*	*Light grey to dark grey, medium dense to very dense, fine grain*

Borehole No.	Top Depth (m)	Bottom Depth (m)	Description Title	Description
				sand, trace mica.
S-2	18	20	SILTY CLAY	Light brown, hard, silty clay, with low plasticity.
S-3	0	2	SILTY CLAY	Light brown, stiff, silty clay, with concretion, low to medium plasticity.
S-3	2	6	SILTY SAND	Light grey medium dense silty sand, fine to medium grain, with trace mica.
S-3	6	10	SILTY SAND	Light grey, medium dense, fine to medium grain, silty sand.
S-3	10	14	FINE SAND	Light grey, dense, fine to medium grain, sand with trace mica.
S-3	14	20	FINE SAND	Light grey, dense, fine to medium grain, sand with trace mica.
P-1	0	1	SILTY CLAY	Brown, firm, fine grain, silty clay, with low to medium plasticity.
P-1	1	2	SILTY SAND	Grey to dark grey, medium dense, fine to medium grain, silty sand with trace mica.
P-1	2	6	FINE SAND	Grey, medium dense, fine grain, sand with trace mica.
P-1	6	9	SILTY SAND	Light grey, dense to very dense, fine grain, silty sand, trace mica.
P-1	9	10	SILTY CLAY	Light brown, hard, fine grain, silty clay, with low to medium plasticity.
P-1	10	20	FINE SAND	Light grey, dense, fine to medium grain, sand with trace mica.
P-1	20	32	FINE SAND	Grey to dark grey, dense, fine to coarse grain, sand.
P-2	0	2	SILTY CLAY	Brown, stiff, fine grain, silty clay, with low to medium plasticity.
P-2	2	6	FINE SAND	Grey to dark grey, medium dense, fine grain, sand with trace mica.
P-2	6	10	SILTY SAND	Light grey, medium dense, fine grain, silty sand, trace mica.
P-2	10	32	FINE SAND	Light grey, dense to very dense, fine to coarse grain, sand with trace mica.
R-1	0	1	SILTY CLAY	Brown, firm, fine grain, silty clay, with low to medium plasticity, trace concretion.

Borehole No.	Top Depth (m)	Bottom Depth (m)	Description Title	Description
R-1	1	9	SILTY SAND	Grey, loose to dense, fine to medium grain, silty sand with trace mica.
	9	10	SILTY CLAY	Light brown, stiff, fine grain, silty clay, with low to medium plasticity, trace concretion.
R-1	10	16	SILTY SAND	Light grey, dense, fine grain, silty sand with trace mica.
R-1	16	20	FINE SAND	Light grey, very dense, fine grain, sand with trace mica.
R-2	0	1	SANDY SILT	Brown, loose, fine grain, sandy silt with trace concretion.
R-2	1	9	SILTY SAND	Light grey, medium dense, fine to medium grain, silty sand with trace mica.
R-2	9	10	SILTY CLAY	Light brown, stiff, fine grain, silty clay with low plasticity.
R-2	10	16	SILTY SAND	Light grey, dense, fine grain, silty sand with trace mica.
R-2	16	20	FINE SAND	Light grey, very dense, fine grain, sand with trace mica.
R-3	0	1	SANDY SILT	Brown, loose, fine grain, sandy silt with trace concretion.
R-3	1	10	SILTY SAND	Light grey to grey, medium dense to dense, fine grain, silty sand.
R-3	10	20	FINE SAND	Light grey to grey to dark grey, medium dense to dense, fine to medium grain, sand.
R-4	0	7	FINE SAND	Grey to dark grey, medium dense, fine grain, sand.
R-4	7	10	SILTY SAND	Grey, medium dense, fine to medium grain, silty sand.
R-4	10	20	FINE SAND	Light grey to dark grey, medium dense to dense, fine to medium grain, sand.
A-1	0	3	SILTY CLAY	Brown, stiff to very stiff, silty clay with trace concretion.
A-1	3	10	SILTY SAND	Light grey, medium dense, fine to medium grain, silty sand, trace mica.
A-2	0	2	SILTY SAND	Brown, very loose, fine grain, silty sand.
A-2	2	4	SILTY CLAY	Brown, soft, silty clay with trace

Borehole No.	Top Depth (m)	Bottom Depth (m)	Description Title	Description
				concretion.
A-2	4	10	SILTY SAND	Light grey, medium dense, fine to medium grain, silty sand trace mica.
TP-1	0	1.5	SILTY CLAY	Brown, firm, fine grain, silty clay, with low to medium plasticity.
TP-1	1.5	3	FINE SAND	Grey, medium dense, fine to medium grain, slightly micaceous sand.
TP-2	0	3	SILTY CLAY	Brown, firm to stiff, fine grain, silty clay, with low to medium plasticity.
TP-3	0	1.5	SILTY CLAY	Brown, firm, fine grain, silty clay, with low to medium plasticity.
TP-3	1.5	3	FINE SAND	Grey, medium dense, fine to medium grain, slightly micaceous sand.
TP-4	0	1.5	SILTY CLAY	Brown, firm, fine grain, silty clay, with low to medium plasticity.

3.5.3. Groundwater Table

Groundwater was encountered in the borehole at a variable depth of 5 m to 6 m and at 1.5 m in TP-4. Therefore, to simulate the worst case scenario, GWT has been taken as 1.5 m for the foundation design.

3.5.4. Geotechnical Design Parameters

3.5.4.1. Summary of Design Parameters

Following Table summarizes the recommended layer thicknesses used in parameters selection and design recommendation evaluated.

Table - 10: Summary of Generalized Design Parameters

Material Type	Depth below NSL D (m)	Bulk Density / Submerged Density (g/cm^3)	Coefficient of Volume Compressibility (m_v)	Angle of Internal Friction Phi (°)	Cohesion C (kg/cm^2)	Young's Modulus E (MPa)
Silty Clay	0-3	1.80/0.80	0.012	-	0.45	3
Silty Sand	3-16	1.65/0.65		30		5
Fine Sand	16-32	1.70/0.70		32		8

3.5.4.2. Discussion on Design Parameters

The design parameters have been evaluated considering results of field geotechnical investigation, laboratory testing, experience, and judgment of author of this report in the similar ground. The ground condition reveals mostly Cohesive at the foundation laying depth of about 1 m below NSL.

3.5.4.3. Geotechnical Design Criteria

The foundations of all the structures should meet the following design criteria:

- These should be safe against shear failure of the supporting ground. A factor of safety of 3 is adopted for this purpose

- These should not settle excessively under the service loads. A limit of 25mm has been put on the total settlement of individual foundations. Similarly, the angular distortion between the two adjacent foundations should not exceed 1/500

- If mat foundation is adopted, it should not settle beyond limits under the service loads. A limit of 50mm has been put on the total settlement of foundations (corresponds to a differential settlement of about 35mm between the centre and edge of the mat foundation)

- The bedding of pipelines should be rigid enough to remain stable. This should be attained by compacting the pipe bedding to at least 95% Modified Proctor Compaction (70% Relative density)

3.6. Engineering Considerations

3.6.1. Earthworks

3.6.1.1. Ground Preparation

The topsoil at site mostly belongs to vegetative material. Initial site preparation will require removal of such contaminated/vegetative topsoil. Such soil may be used in the landscaping.

3.6.1.2. Excavation

The excavation required for the construction of foundation up to a shallow depth of about 6 m, can be made without provision of any supporting system. The provision of dewatering must be kept in the scope of work of construction due to adjacent canal and possibility of rainy season, during construction.

3.6.2. Foundations

3.6.2.1. Proposed Structures

The proposed Powerhouse and Spillway are expected to be medium to high level loading while the other project structures are expected to be of low level of loading. Usually the low level loading structures can be supported on shallow foundation. Considering the ground conditions, it is recommended to support the smaller structure on strip / isolated foundation while and Powerhouse and Spillway on be supported either mat to be decided by the structural engineer based on actual structural configuration.

3.6.2.2. Design of Shallow Foundations

The evaluation of the net allowable bearing capacity of the Square Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 1 m below NSL. The bearing capacity curves are presented in Appendix B.3.1

The evaluation of the net allowable bearing capacity of the Strip Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 1 m below NSL. The bearing capacity curves are presented as Appendix B.3.2

Similarly, the evaluation of net allowable bearing capacity of the Mat Foundation has been done for a depth of foundation 20m below NSL which will be reviewed at detail design stage. The bearing capacity curves are presented as Appendix B.3.3

3.6.2.3. Modulus of Subgrade Reaction

Modulus of sub-grade reaction Ks can be evaluated using the evaluated allowable bearing pressure, respective structural pressure, and factor of safety (FOS). The expression for its calculation is given below:

- For Strip and Square Footings with 25.4 mm (1 inch) tolerable settlement

$$K_s = \frac{\text{Evaluated Net Allowable Bearing Pressure}}{\text{Settlement (25.4mm) under maximum structural pressure}} \times \text{Factor of Safety}$$

- For Raft / Mat Footings with 50.8 mm (2 inch) tolerable settlement

$$K_s = \frac{\text{Evaluated Net Allowable Bearing Pressure}}{\text{Settlement (50.8 mm) under maximum structural pressure}} \times \text{Factor of Safety}$$

3.6.2.4. Placement of Granular Fill

If any soft and loose material encountered, at foundation excavation level, during construction, then it should be further excavated and replaced with suitable granular material in proper compaction.

The availability of the sound ground must be confirmed before placement of the foundation pad. An experienced engineer should confirm the soundness of the excavation base.

The excavated surface must be proof compacted to at least 95% of the Modified AASHTO Dry Density before placement of foundation.

The suitable granular material, if used, should comprise granular material, free draining, well graded, non-plastic and having particle size in a range of 0.075 mm to maximum 75 mm. The maximum content of fines should be limit to 10%. The minimum compaction requirement for granular back fill or proof rolling below foundation base should be at least 95% Modified AASHTO dry density or 75 % Relative Density.

3.6.3. Lateral Earth Pressure

3.6.3.1. Static Earth Pressure Coefficients

In case of buried structures and retaining walls, use of cohesion-less backfill is recommended. The evaluation of static earth pressure on buried wall / retaining walls depends upon the movement allowed for in the design, configuration of the wall, backfill geometry and the type of soil used as backfill. For smooth vertical walls with horizontal backfill, the following simplified expressions can be used for determination of coefficients of Lateral Earth Pressure.

- Coefficient of Active Earth Pressure

$$K_a = \frac{(1 - Sin O^1)}{(1 + Sin O^1)}$$

- Coefficient of Earth Pressure at Rest

$$K_0 = (1 - Sin O')$$

- Coefficient of Passive Earth Pressure

$$K_p = \frac{(1 + Sin O^1)}{(1 - Sin O^1)}$$

Where O^1 is effective Angle of Internal Friction of backfill soil.

The effective Angle of Friction of typical granular soils available in Punjab may be used as 30 degrees.

3.6.3.2. Dynamic Earth Pressure Coefficients

For evaluation of earth pressure under earthquake conditions, the equations proposed by Mononobe-Okabe may be used.

3.6.4. Construction of Roads & Embankments

3.6.4.1. Formation of Subgrade and Embankment

Subgrade consisting of Silty Clay / Silty Sand usually belongs to A4 material is found at site as per test pit excavation.

It must be noted that the in-situ surface should be scarified and re-compacted to minimum 95% MDD AASHTO Dry density before placement of any pavement subgrade or embankment over it.

Three points soaked California Bearing Ratio (CBR) tests were performed on A-4 soil samples of subgrade material, collected along the alignment. The CBR and swell values were determined. The CBR value of A-4 material at 95% MDD is in a range of 2 to 18 at 95% MDD. The lower values are for samples having high plasticity index, and border line A4 material. Therefore, it is recommended to adopt a CBR value of 10 on safer side. The borderline material of high plasticity (approaching 10) should not be used for any subgrade or embankment construction.

3.6.4.2. Borrow Placement and Compaction

Before placement of the Earth fill/borrow fill, in-situ soil should be proof-rolled to achieve a minimum compaction level of 90% Modified AASHTO density.

The following maximum layer thickness, minimum compaction is recommended for various elements of embankment:

Table - 11: Borrow Compaction Parameters

Material Type	Material Type	Maximum Compacted Layer Thickness (cm)	Recommended Modified AASHTO Compaction (%)
(a). A-4 or better soil as Embankment & Subgrade			
Top 30cm	*A-4 or better*	*15*	*95*
30cm – 75cm	*A-4 or better*	*20*	*93*
Below 75cm	*A-4 or better*	*20*	*90*

3.6.5. Construction Materials

Availability of required construction materials in the project vicinity has direct impact on the cost of the project. Although the scope of this work was not part of the present study, nevertheless, an effort was made to identify construction materials using existing archive which shows that the following are the nearest sources of the coarse and fine aggregate for the concrete.

Margalla Hill Quarries

Lawrencepur Sand Deposits

3.6.5.1. Margalla Hill Quarries

These quarries are located in the Margalla Range which forms the northern boundary of the Pothowar plateau. The nearest location of limestone is about 25 Km north of Rawalpindi near Taxila pass. At this point the G.T. road cuts across the Margalla ridge. There are several privately owned quarries at the left side of the road, heading towards Peshawar. Aggregates from these quarries are crushed to various sizes and extensively used for various projects.

The Margalla Hill limestone, of Middle Eocene age, is grey to dark grey, thin to thick bedded and distinctly nodular. It contains subordinate shale and argillaceous limestone. Grey hard and blocky to massive limestone is suitable for manufacturing of aggregates for all uses. Other sedimentary rocks like shale, laterite and sandstone are also exposed in the area. The Margalla Quarry is recommended for concrete coarse aggregates.

Evaluation of the Quarries

a) Gradation

The insitu rock may be reduced to the desired gradation after blasting and crushing the rock.

b) Abrasion Resistance

The abrasion losses of good limestone are generally less than 30 percent in Los Angeles Abrasion tests. The limestone has a good resistance to abrasion and is suitable both for asphalt and cement concrete.

c) Specific Gravity and Water Absorption

The specific gravity of the representative sample of limestone, on SSD basis, was found to be 2.64 and water absorption was 0.35 percent.

d) Soundness

The weighted percent losses of the aggregates as determined by ASTM C-88 were observed to be

0.08 percent after five cycles of immersion in Sodium Sulphate solution. This value is well below the maximum allowable limit of 12 percent.

e) Clay lumps and friable particles

Clay lumps and friable particles were observed as 0.03 percent. This value is well below the maximum permitted limit of 3 percent.

f) Coating and Stripping of Bitumen-Aggregate Mixture

Bituminous adhesion value of the limestone was reported above 95 percent, which indicate that the aggregates are suitable for asphaltic concrete.

(g) Petrographic Studies

Petrographic studies (ASTM C 295) in terms of Alkali-Silica Reaction, Alkali Carbonate Reaction (ASR/ACR) indicate that the limestone is composed of 95 to 98 percent calcite and 2 to 5 percent iron oxide, clay and quartz. These studies also indicate that grey, hard, blocky and massive limestone from this source may safely be used with Portland cement of high alkalies as no reactive minerals are present in this limestone.

3.6.5.2. Lawrencepur Sand Deposits

Description of the Sand Deposits

Lawrencepur sand deposits are located about 70 Km northwest of Islamabad near Lawrencepur between the Haro and the Indus rivers. The sand in Lawrencepur area is deposited in an area of about 60 square kilometers and the deposits are quite thick. Sand is being excavated at several places in the Lawrencepur area for several major and minor projects in Pakistan. In Lawrencepur area, sand deposited in Qibla Bandi beside Lawrencepur Tarbela road is more suitable as it is well graded sand or gravelly sand requiring separation of gravel.

a) Evaluation of the Sand Deposits

Sand at Qibla Bandi in Lawrencepur area meets the gradation requirement after little or no processing. The fineness modulus of Qibla Bandi sand lies within 1.86 and 3.8 as against from 2.30 to 3.1 (ASTM C 33) for cement concrete. Sand equivalent values as obtained from the test (ASTM-D2419) were 82 to 87 %. The minimum specified limit for concrete aggregate is 80, which indicate its suitability.

The material passing No. 200 sieve in some of the Lawrencepur deposits is more than 11 percent as against permitted limits of 0 to 3 percent (as per NHA Specs) and therefore requires washing.

b) Organic Impurities

The organic impurities are within the range of 0.031 to 0.048 percent. These are well within ASTM C 33□93 limit of 0.5 percent.

c) Soundness

The losses in sodium sulphate soundness tests on the Lawrencepur sand in general are between 1.80 to 4.42 percent as against ASTM C 33-93 maximum allowable limit of 10 percent.

d) Clay Lumps and Friable Particles

Clay lumps and friable particles of the Qibla Bandi sand deposits are between 0.34 and 2.80 percent. The maximum allowable limit is 3 percent as per ASTM C-33.

e) Petrographic Studies

Petrographic studies indicate that the major sand forming mineral is quartz which is reported between 43 and 65 percent. Chert, a reactive mineral, is indicated from 0.2 to 0.3 percent. This source may safely be used with Portland cement of high alkalies without the risk of ASR/ACR. However material larger than 4.75 mm (fine gravel) at places in this source is found reactive.

The analysis show that the reactive constituents are mostly restricted to the larger fractions (retained on #4 sieve) which contribute to sand from layers the fine gravelly sand invariably distributed in the deposit. The earlier studies warrant preventive measure when the source is used for the production of concrete with Ordinary Portland Cement.

3.6.6. Constraints and Risks

3.6.6.1. Damp Proofing and Surface Drainage

Principle constraints include following:

- Proper paving should be provided along the periphery of the Structure
- All the backfilling of the foundation above concrete pad should be done with cohesive material to avoid seepage of water in the foundation base. Alternatively, the top 30cm of any backfilling should be carried out with non-swelling cohesive soil
- Adequate water proofing/damp proofing shall be provided for the structure. To avoid problem regarding moisture, it is recommended to adopt water-reducing admixtures in concrete
- Cementitious coatings should also be provided to avoid moisture movement through the concrete.

3.6.6.2. Contaminated Land

The spillage of fuels, oils or other contaminants on the site should be prohibited and servicing of tools, plants, and machinery during the construction period should be managed to prevent pollution, while large numbers of machines are operating on the site.

3.6.6.3. Quality Control

The following precautions must be ensured for better quality control at site for construction stage:

- The water cement ratio of the concrete should be monitored properly for better quality of concrete

- The compaction works should be supervised by experienced geotechnical engineer. The compaction of the area under foundation and other major load bearing locations should be certified by a licensed professional engineer for its laying as per specifications

- It is must be noted that the site soil and prone to strength loss on exposure to moisture, therefore, any excavation of foundation must be covered with lean, immediately to avoid such strength loss problems

- It is recommended that the geotechnical investigation agency would be provided with the finalized layout/master plan of the site before adopting any recommendations for the design of foundation or any other aspect related to the use of geotechnical design parameter.

3.7. Ground Water Dewatering & Acquifer Characterization

3.7.1. Introduction

This section of the report focuses and highlights the Ground water dewatering and aquifer characterization for Geotechnical Investigation for 11MW BS Link -I Canal HPP carried out by THE DRILLER, Lahore. The site area is located on Coordinates (E: 396970.07 N: 3423414.86) at Kandu Khara, Tehsil Chunian, District Kasur. The fieldwork started on dated: 13-05-2016 and completed on dated: 16-05-2016.

For characterization of aquifer system, dewatering of ground water and future reduction in availability of water, hydrogeological characters of power plant is important. It has been investigated that this site has greater potential of ground water due to unconfined aquifers. The recharging rate is high therefore a continues flow of water towards site is expected and dynamic equilibrium may be attained after every two days. The power house dimensions are given as

Length = 48.6m, Width = 88.66m, Total Height = 29.637 m, Area=4308.876sq m

The study comprises evaluation of ground water potential and its dewatering at the proposed power plant site. The primary focus was to access the aquifer characteristics like transmissitivity, yielding potential and its dewatering at site.

3.7.1.1. Scope of Work

For hydro geological investigation pumping test has been carried out using one running well and installation of three piezometers to draw down/recovery assessment of the existing aquifer and later desk studies and review of the previous studies of the adjacent areas. A detailed hydro geological study was carried out for the evaluation of the aquifer characteristics (transmissivity and specific yield) and design of the tube wells keeping in view production rate/mining yield of well, Installation of temporary piezometer for ground water monitoring, complete set of drilling by percussion method up to depth of 150 feet was carried out. Visual inspection and logging of insitu substrata was carried out at site by an experienced team of hydrologist and hydro geologists. As part of the services pumping test was carried out at site in pumping well for drawdown/recovery of the ground water table under the supervision of the experienced team.

3.7.1.2. Hydrological Conditions

Hydro geological studies were carried out in the project area which revealed that recent alluvium composed of light grey fine to medium grained sand and trace amount of mica are distributed in the upper part of five feet and from five feet to about 300 feet identified zones by drilling in the vicinity of the project area strata is medium to coarse grained sand with trace mica and little fine sand, age of these deposits is recent. Fine to coarse grained sand is present as unconfined aquifer, highly transmissive and this entire zone is very suitable for high capacity tube wells therefore mining of ground water is cost effective at this site.

Water table was observed in the newly installed piezometer near pumping well and ground water table was encountered at 25 feet in the piezometer. Readings of the piezometers were monitored for seventy two hours after final installation and during all of the time observation is same for ground water table.

3.7.1.3. Aquifer characterization through pump out test

Aquifer pump tests are a reliable, effective way of quantifying ground water flow and determining aquifer properties at a particular location. This consists of pumping a bore at a certain rate and recording drawdown in the pumped bore and nearby bores at specific times. When the data is analyzed, pumping tests can be used to determine the performance characteristics of a bore and the hydraulic parameters of an aquifer

Aquifer parameter estimation based on pumping tests has received much attention for years. A sensitivity analysis is used as an important approach to understand the behavior of hydraulic parameters in an aquifer with zones which have parameters significantly different from those of the background aquifer (e.g., McElwee, 1982; Butler, 1988; Butler and McElwee, 1990; Jiao, 1995). A parameter can be best estimated from drawdown time curve when the sensitivity of the parameter is not only large but also changing significantly with time characteristics of transmissivity and storativity in response to pumping. The different characteristics of transmissivity and storativity under constant rate pumping conditions have been examined and the influence of these characteristics on parameter estimation investigated using a pumping test data and drawdown curve.

At power plant site a pumping test is performed for the recommended seventy two hours and draw down is observed with different time intervals. Then the recovery test is performed to evaluate the transmissive characteristics of acquifer.

The pumping test data were used to plot drawdown curves. The drawdown curves show the fine to medium sand at the depth of 25 and coarser at further depth. The unconfined aquifer with high permeability characteristics was observed at this site.

The detailed report, findings and recommendations on Ground Water Dewatering & Aquifer Characterization is given in Annexure E.

3.8. Geophysical Well Logging

3.8.1. Introduction

This section of the report provides an account of the geophysical well logging (SPR) for evaluating the lithologic properties of the drilled strata and general quality of the formation fluid in the borehole at the project site located at Kandu Khara, Tehsil Chunian. These investigations are considered necessary to define the exact depth and thickness of aquifers for the optimal design of the tube well and placement of screen lengths.

Field Statistics:

Executed date: May 10, 2016

Drilled depth: 153 feet (46.63 m)

Logged depth: 152 feet (46.33m)

3.8.2. Interpretation

After correlating the interpreted subsurface lithology based on Geophysical logging and physical examination of the drilled samples, the final results are presented below in tabular form.

Table - 12: Interpreted sub-surface lithology based on Geophysical logging and physical examination of the collected soil samples of the boreholes

Lithology	Depth (feet)
Clay	*0-5*
Fine Sand	*5-32*
Sand with gravels and kankers	*32-52*
Sand	*52-108*
Clay / sandy clay	*108-118*

Clay	*118-125*
Sand	*125-152*

3.8.3. Conclusions

Geophysical logging results and physical examination of the lithologic samples presented at site show the:

Dominance of sand is present in the borehole

- Sand beds below water table are prospective aquifers of the area
- Occurrence of good quality of groundwater is interpreted within the defined aquifers

3.8.4. Recommendations

The borehole is recommended for conversion into tube well with placement of suitable screen lengths against the following defined aquifers:

Positions of screen lengths

- 72-98 feet
- 137-150 feet

The detailed report, findings and recommendations on Geophysical Well Logging is given in Annexure F.

3.9. Conclusions

In summary it is concluded that

- The subsoil lithology comprises of Silty Clay (CL-ML) encountered at top generally varying in depth from 2m to 3m in firm to stiff state. The Silty Clay was underlain by a layer of Silty Sand (SM) from 3m to about 16 m in depth in medium dense to dense state with occasional thin lenses of Silty Clay (CL-ML) encountered at variable depths. This layer was followed by a thick layer of Fine Sand (SW) from 16 m up to maximum investigated depth of 32 m below NSL.
- Groundwater was encountered in the borehole at a variable depth of 5m to 6m and at 1.5 m in TP-4. Therefore, to simulate the worst case scenario, GWT has been taken as 1.5m for the foundation design
- The evaluation of the net allowable bearing capacity of the Square Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 1 m below NSL. The bearing capacity curves are presented in Annexure B.3.1.

- The evaluation of the net allowable bearing capacity of the Strip Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 1 m below NSL. The bearing capacity curves are presented as Annexure B.3.2.

- Similarly the evaluation of net allowable bearing capacity of the Mat Foundation has been done for a depth of foundation 20m below NSL which will be reviewed at detail design stage.. The bearing capacity curves are presented as Annexure B.3.3.

- Proper paving should be provided along the periphery of the Structure.

- All the backfilling of the foundation above concrete pad should be done with cohesive material to avoid seepage of water in the foundation base. Alternatively, the top 30cm of any backfilling should be carried out with non-swelling cohesive soil.

- Adequate waterproofing/damp proofing shall be provided for the structure. To avoid problem regarding moisture, it is recommended to adopt water-reducing admixtures in concrete.

- If any soft and loose material encountered, at foundation excavation level, during construction, then it should be further excavated and replaced with suitable granular material in proper compaction.

- Cementitious coatings should also be provided to avoid moisture movement through the concrete.

3.10. References

Following References and specialized Software have been utilized in the development of this report:

- Foundation Analysis and Design by Joseph E. Bowles

- Winlog & Winfence (softwares for generation of graphical borehole logs and subsurface profiles)

- NovoSPT a software from Novotech (for assessment and correlation of standard penetration resistance data for analysis and design)

- Building Code of Pakistan as given on Pakistan Engineering Council Website

- ASTM Book volume 4.08 (Soils and Rocks)

- Geotechnical Earthquake Engineering by Kramer

4. HYDROLOGY & SEDIMENTATION STUDIES

4.1. HYDROLOGY

4.1.1. General

Balloki Barrage was constructed on River Ravi in 1914. The barrage was remodeled during 1964-65 under Indus replacement works for a discharge capacity of 6374 cumec (225,000 cusec). The length of main Barrage is 501.80 m. Two Canals I.e. Lower Bari Doab Canal (LBDC) and Balloki-Sulemanki (BS) Link Canal off-take from its left bank. BS Link Canal off-taking discharge at its head is 693.66 cumec (24,500 cusec). At RD 73+250 of BS Link-I Canal, BS Link-II offtakes with design head discharge of 254.8 cumec (9,000 cusec). The BS Link-II canal runs parallel to BS-I Link along its left side and ends at a tail regulator constructed adjacent to the out Fall structure of BS Link-I. The unlined BS-II Link has a capacity of 184.08 cumec (6500 cusec).

At RD 106+250 of BS Link-I Canal, an existing Fall of 3.242 m (10.64 ft) is situated. On this Fall, a hydropower project is planned with power potential of 10.49 MW. The site is located 90 km south of Lahore and 7 Km south west of Chunian town of the Kasur District in Punjab Province. The Project location longitude is 730 55' 18" and the latitude is 300 56' 15".. BS Link-I canal is unlined from head to RD 73+250 from where BS Link-II canal offtakes and is brick lined in the downstream reaches. D/s RD 73+250, the discharge of BS Link-I canal Is 424.75 cumec (15000 cusec). In the near past, the canal has been remodeled during 2003 – 2005. Before the remodeling, due to operational difficulties, it was not possible to run the canal at its design discharge. However, after the remodeling, it has been observed that canal is normally operated with high discharges.

At RD 106+250 of BS Link-I Canal, an un-gated Fall structure has 3 piers and 4 spans. The village road bridge of 3.66 m width and a length of 34.14 m rest on 3 piers. The Fall structure has been designed for discharge of 424.75 m^3/s. The full supply level of the canal at upstream and downstream of Fall structure is 188.545 masl (618.59 ft) and 185.303 masl (607.95 ft) respectively. The said Fall has an un-gated drop of 3.242 m (10.64 ft) and crest level of the Fall is at 184.593 masl.

4.1.2. Sources of Hydrological Data

Punjab Irrigation Department (PID) has a reliable system of recording observations including discharges and gauges at different points in the canal system / barrages. The historical daily discharges / gauges in BS Link-I Canal at RD 106+250 at the location of proposed powerhouse have been collected from the gauge registers of the BS Link Canal Division, Irrigation Department for the period of 1978 – 2015 (daily discharge data for 1980, 1981, 1984, 1985, 1986 is missing). Available gauge and discharge data have been digitized and processed for its accuracy and consistency. Discharge and gauges at the upstream & downstream of Fall, RD 106+250 have been scrutinized and adequacy of the rating curves for converting the water levels to flows has also been checked. The analyses showed that the observed data by the PID is generally reliable at the gauging locations and can be used for reliable estimates of water availability at the project location. The daily discharge data collected from Gauge Registers for the period 1978 – 2015 has been attached in Appendix C.

4.1.3. Selection of Time Series

After detailed review of the history of the BS Link-I Canal and the parent barrage for selection of time series, the following periods of data series have been considered important:

- **Post Tarbela Series:**

Historically, the discharges at barrages / canal systems had been significantly changed after the construction of large reservoirs, including Tarbela and Mangla dams (1976). The available data range composed of 1978 to 2015, completely lies under "Post Tarbela Period". In this data series, all the available data from 1978 to 2015 will be considered for evaluation.

- **Post WAA Series:**

Water Apportionment Accord (WAA) was agreed between the provinces in 1991 in which water share of each province had been defined. According to the WAA, the provinces within their share have the liberty of allocating water to various canal systems. As water distribution between the provinces changed after the WAA, hence a data series "Post WAA Series" has been considered from 1991 to 2015.

- **Post Remodeling Series:**

During 2003-2005, BS Link-I Canal was remodeled for the design discharge of 615 cumec for unlined parts from head to RD 73+250 and for 424.75 cumec for lined part from RD 73+250 to downstream reach. Before the remodeling, due to operational difficulties, it was not possible to run the canal at its design discharge. However, after the remodeling, it has been observed that canal is normally operated with high discharges. Data series "Post Remodeling Series" has been considered from 2006 to 2015.

All the above said series will be evaluated separately, but focus will be given to the last series, i.e. "Post Remodeling Series" being most relevant to the current circumstances.

4.1.4. Evaluation of Discharges

The collected discharges at RD 106+250 (opposite to the proposed powerhouse site) from 1978 to 2015 have been evaluated based on the following aspects:

- Flow Duration Curve;
- Average Daily Historical Discharges;
- Availability of Maximum Discharges.

As described earlier, the total period under consideration is evaluated in following data series:

- Post Tarbela Series (1978 – 2015)
- Post WAA Series (1991 – 2015)
- Post Remodeling Series (2006 – 2015)
- Comparison of Data Series

4.1.4.1. Post Tarbela Series (1978 – 2015)

The first series of data which have been considered is Post Tarbela Series, considering the available data from 1978 to 2015. The flow duration curve of BS Link-I Canal at RD 106+250 (opposite to the proposed powerhouse site) is shown in Figure below analyzes 38 years data simultaneously:

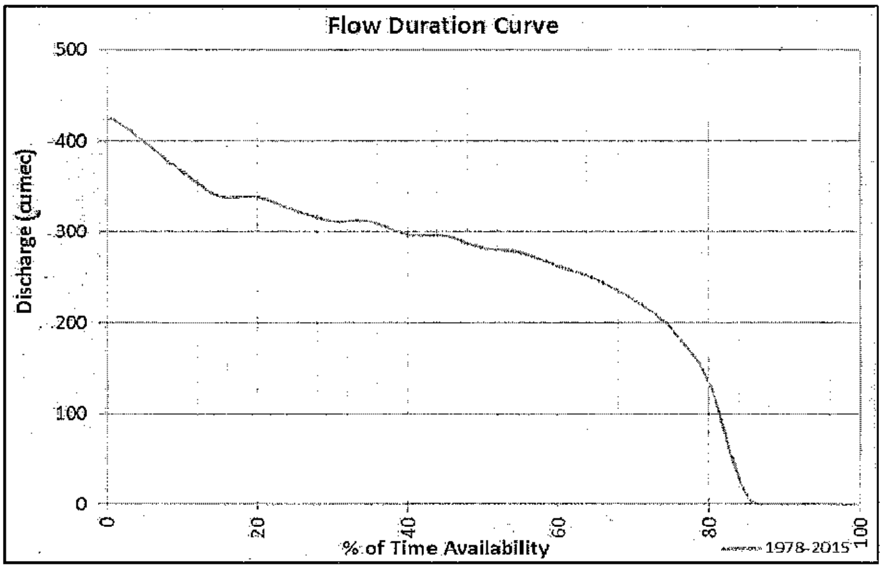


Figure 12: : Flow Duration Curve (Complete Data Series)

The flow duration curve of the data series shows 399.7 cumec remains available for 5% of the time, 338.8 cumec remains available for 20% of time, 297.3 cumec remains available for 40% of time and 263.5 cumec remains available for 60% of time.

The historical average daily flow series of BS Link-I Canal at RD 106+250 considering the Post Tarbela series from 1978 to 2015 is shown in Figure below in cusec, analyzing 38 years' data simultaneously which shows that on the average, discharges remained less than 12000 cusecs throughout the year:

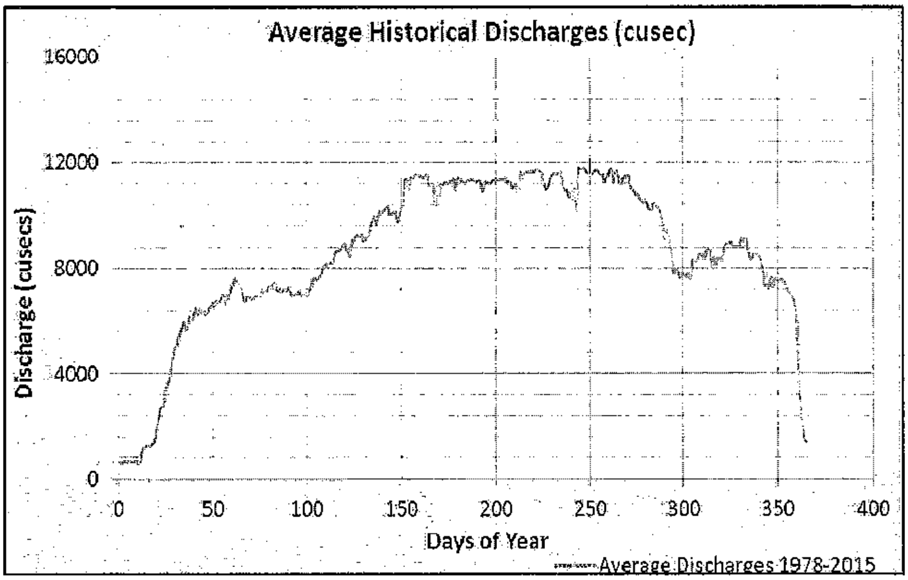


Figure 13: Average Historical Discharges in Cusec (Complete Data Series)

The historical average daily flow series of BS Link-I Canal at RD 106+250 considering the complete data series from 1978 to 2015 is shown in Figure below in cumec analyzing 38 years data simultaneously which shows that on the average, discharges remained less than 340 cumec throughout the year:

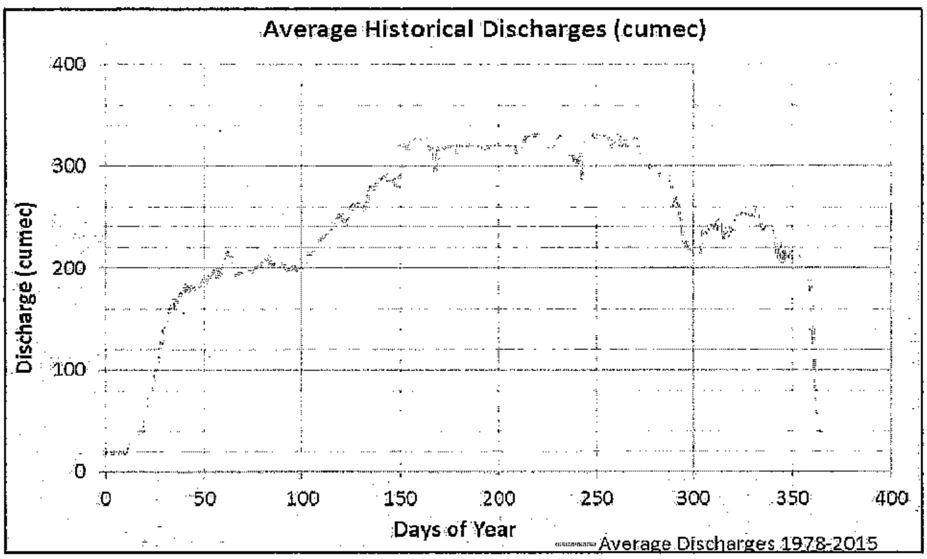


Figure 14: Average Historical Discharges in Cumec (Complete Data Series)

The year-wise maximum flow series of BS Link-I Canal at RD 106+250 considering the complete data series from 1978 to 2015 is shown in Figure below analyzes 38 years data simultaneously:

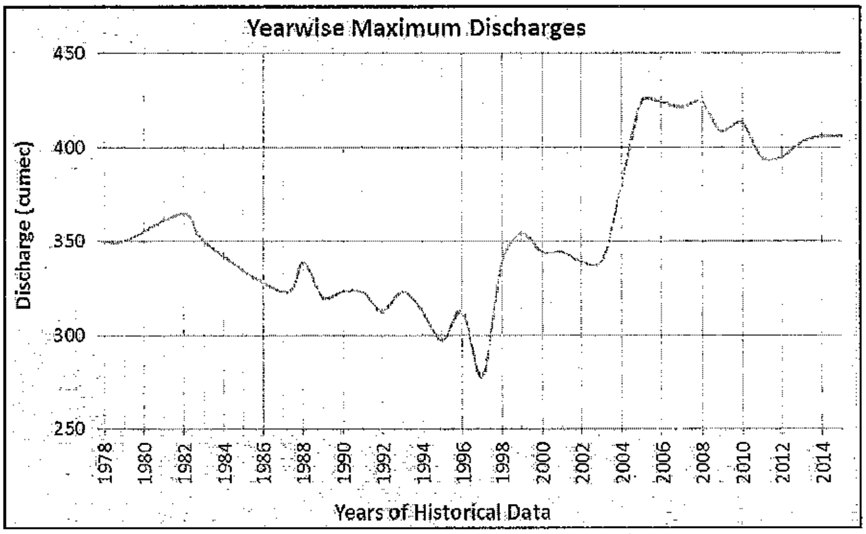


Figure 15: Year wise maximum Discharges (Complete Data Series)

The above Figure shows that year-wise maximum discharges varies between 423.9 cumec in 2005, 2006, 2008 to 277.7 cumec in 1997.

4.1.4.2. Post WAA Series (1991 – 2015)

The second series of data which have been considered is Post WAA Series, considering the available data from 1991 to 2015. The flow duration curve of BS Link-I Canal at RD 106+250 considering the post WAA data series from 1991 to 2015 is shown in Figure below analyzed 25-year data simultaneously:

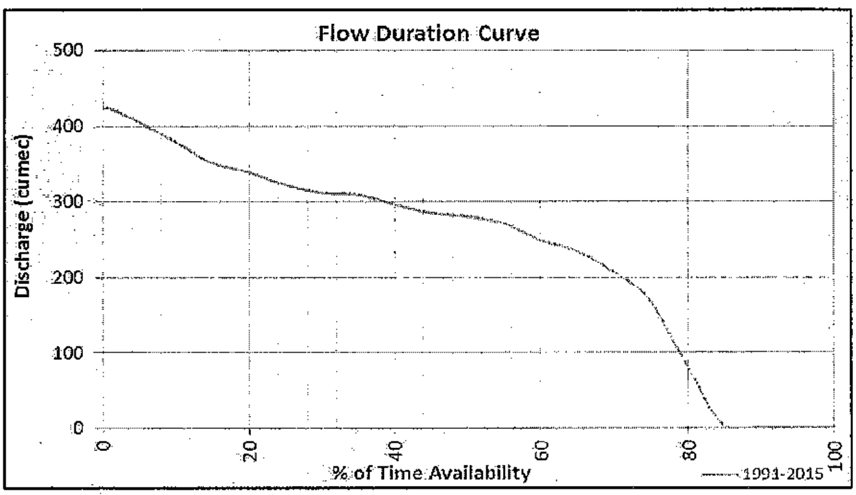


Figure 16: Flow Duration Curve (Post WAA Series)

The flow duration curve of the data series shows 406 cumec remains available for 5% of time, 339.4 cumec remains available for 20% of time, 297.3 cumec remains available for 40% of time and 249.3 cumec remains available for 60% of time.

The historical average daily flow series of BS Link-I Canal at RD 106+250 considering the post WAA data series from 1991 to 2015 is shown in Figure below analyzed 25-year data simultaneously:

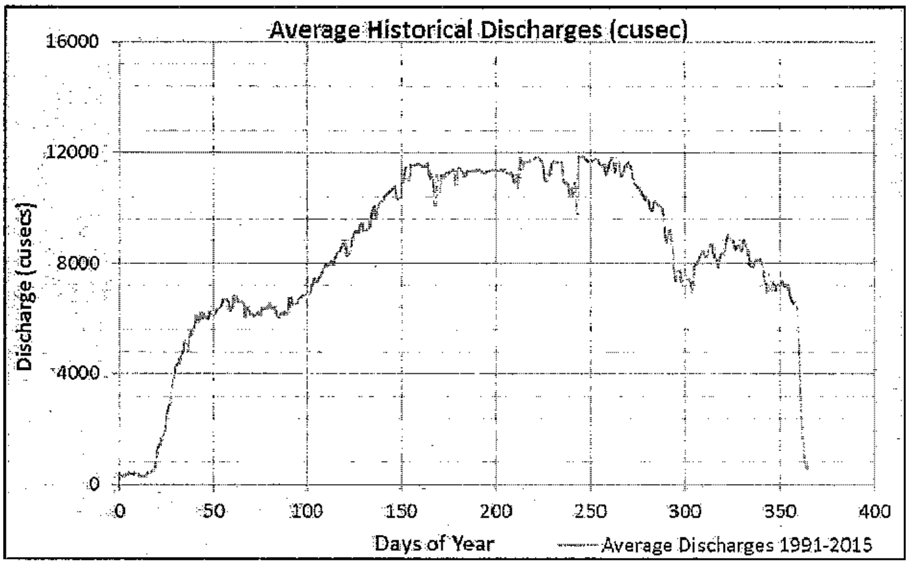


Figure 17: Average Historical Discharges in Cusec (Post WAA Series)

The historical average daily flow series of BS Link-I Canal at RD 106+250 considering the post WAA data series from 1991 to 2015 is shown in Figure below analyzed 25-year data simultaneously:

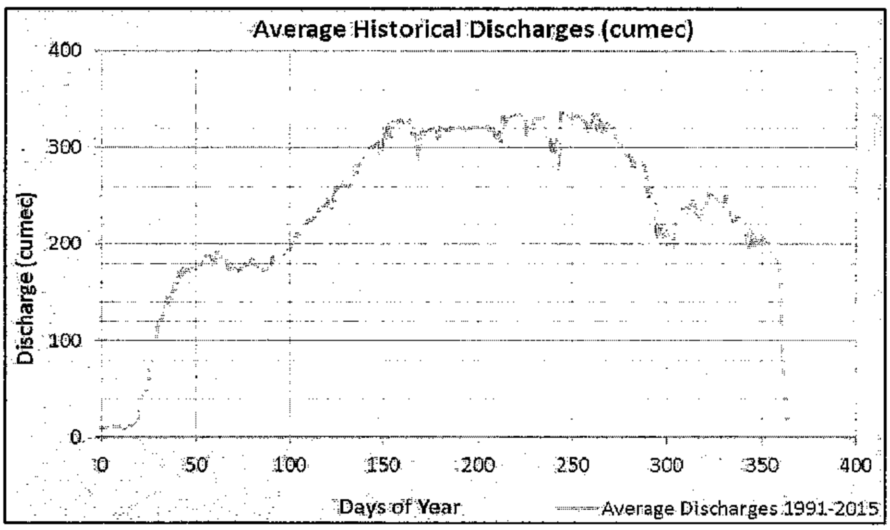


Figure 18: Average Historical Discharges in Cumec (Post WAA Series)

The year-wise maximum flow series of BS Link-I Canal at RD 106+250 considering the post WAA data series from 1991 to 2015 is shown in Figure below analyzed 25-year data simultaneously:

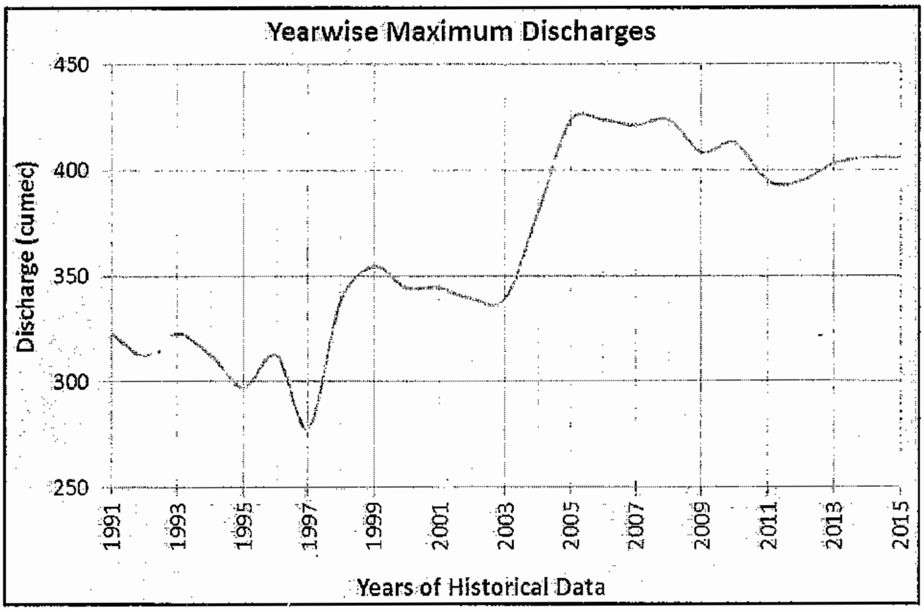


Figure 19: Year wise Maximum Discharges (Post WAA Series)

The above Figure shows that year-wise maximum discharges varies between 423.9 cumec in 2005 & 2006 to 277.7 cumec in 1997.

4.1.4.3. Post Remodeling Series (2006 – 2015)

The flow duration curve of BS Link-I Canal at RD 106+250 considering the post remodeling data series from 2006 to 2015 is shown in Figure below analyzed 10-year data simultaneously:

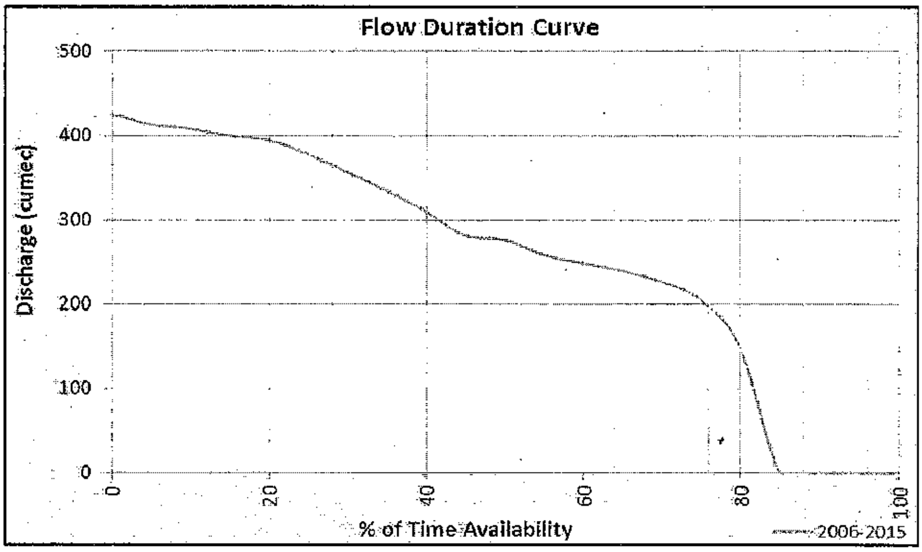


Figure 20: Flow Duration Curve (Post Remodeling Series)

The flow duration curve of the data series shows 413.7 cumec remains available for 5% of the time, 394.7 cumec remains available for 20% of the time, 309.9 cumec remains available for 40% of time and 249.2 cumec remains available for 60% of the time.

The historical average daily flow series of BS Link-I Canal at RD 106+250 considering the post remodeling data series from 2006 to 2015 is shown in Figure below in cusec analyzing 10-year data simultaneously:

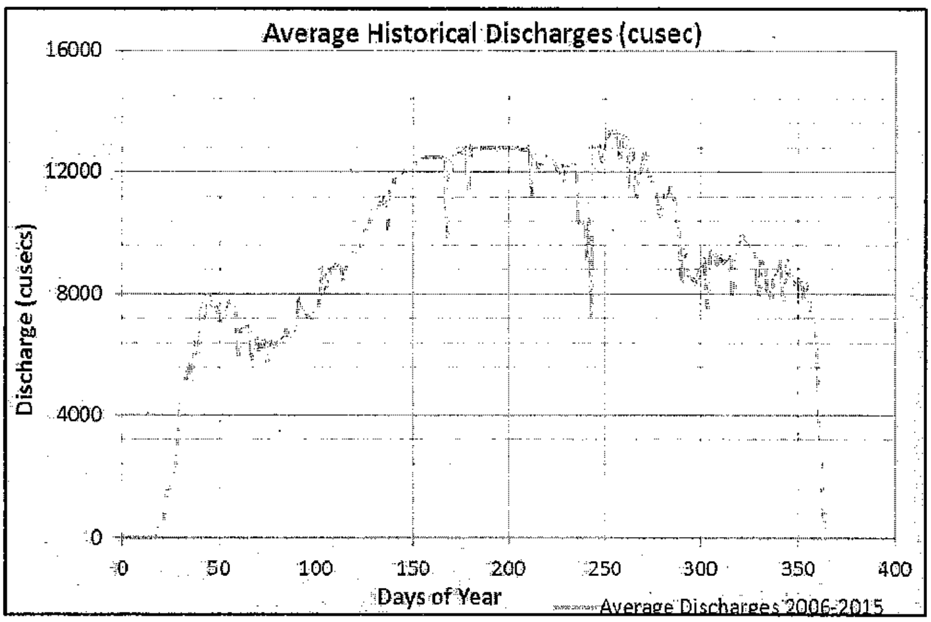


Figure 21: Average Historical Discharges in Cusec (Post Remodeling Series)

The historical average daily flow series of BS Link-I Canal at RD 106+250 considering the post remodeling data series from 2006 to 2015 is shown in Figure below in cumec analyzing 10-year data simultaneously:

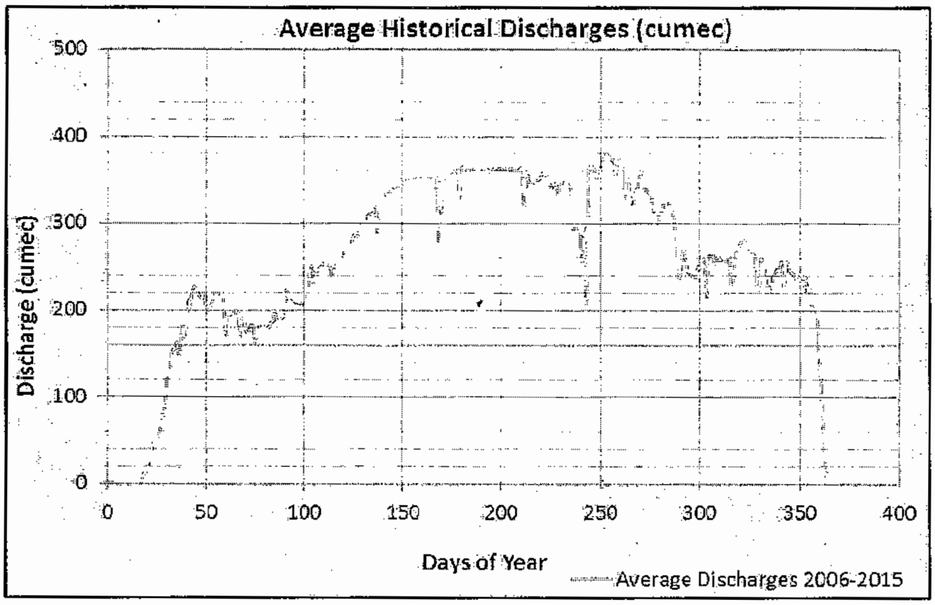


Figure 22: Average Historical Discharges in Cumec (Post Remodeling Series

The year-wise maximum flow series of BS Link-I Canal at RD 106+250) considering the post remodeling data series from 2006 to 2015 is shown in Figure below analyzing 10-year data simultaneously:

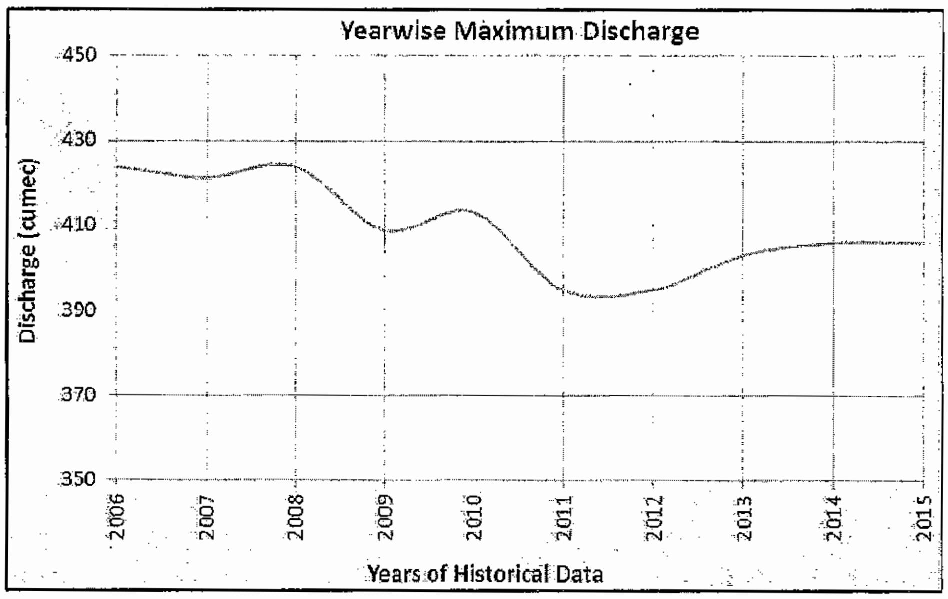


Figure 23: Year wise Maximum Discharges (Post Remodeling Series)

The above Figure shows that year-wise maximum discharges varies between 423.9 cumec in 2006, 2007, 2008 to 394.7 cumec in 2012.

4.1.4.4. Comparison of Different Data Series

The flow duration curves of BS Link-I Canal at RD 106+250 (opposite to the proposed powerhouse site) considering different data series are shown in Figure below:

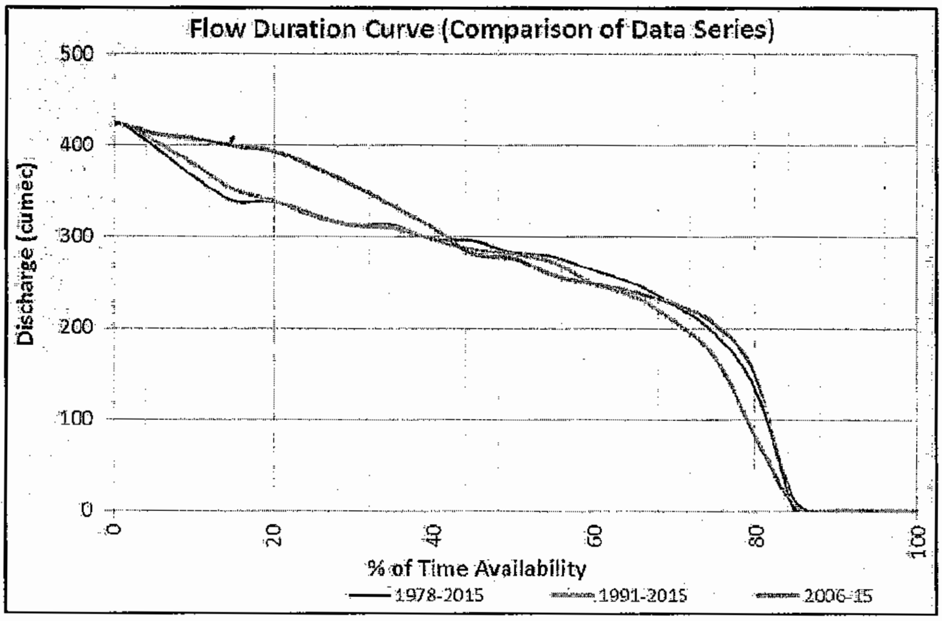


Figure 24: Flow Duration Curve (Comparison of Different Data Series)

The above Figure clearly shows that in data series 2006-15, discharges magnitudes for 0% of time to 40% of the time remain higher as evaluated in the other data series. This is the obvious reason behind remodeling of BS Link-I Canal.

The historical average daily flow series of BS Link-I Canal at RD 106+250 different data series are shown in Figure below in cusec, showing Post remodeling series with considerable higher discharges:

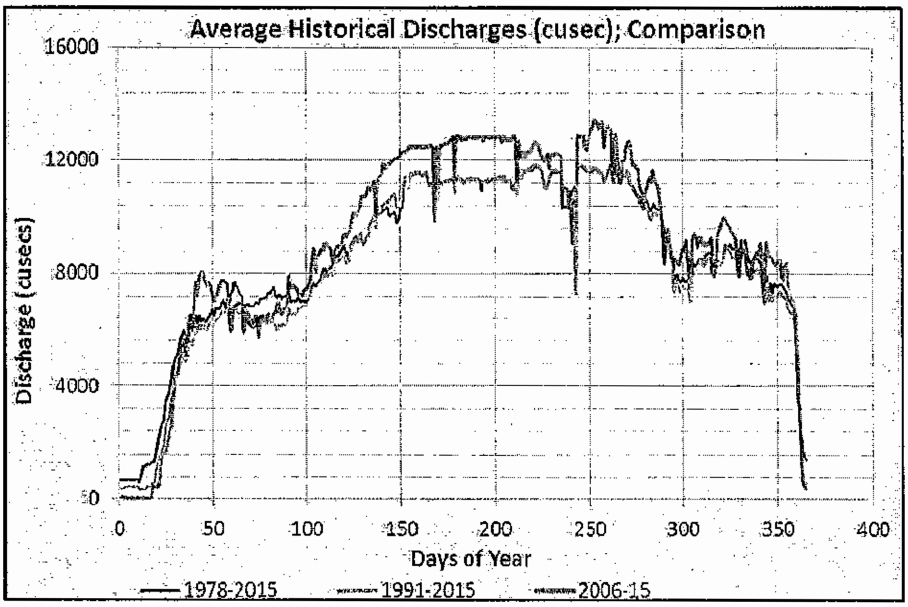


Figure 25: Average Historical Discharges (Cusec) (Comparison of Different Data Series)

The historical average daily flow series of BS Link-I Canal at RD 106+250 considering different data series are shown in Figure below in cumec:

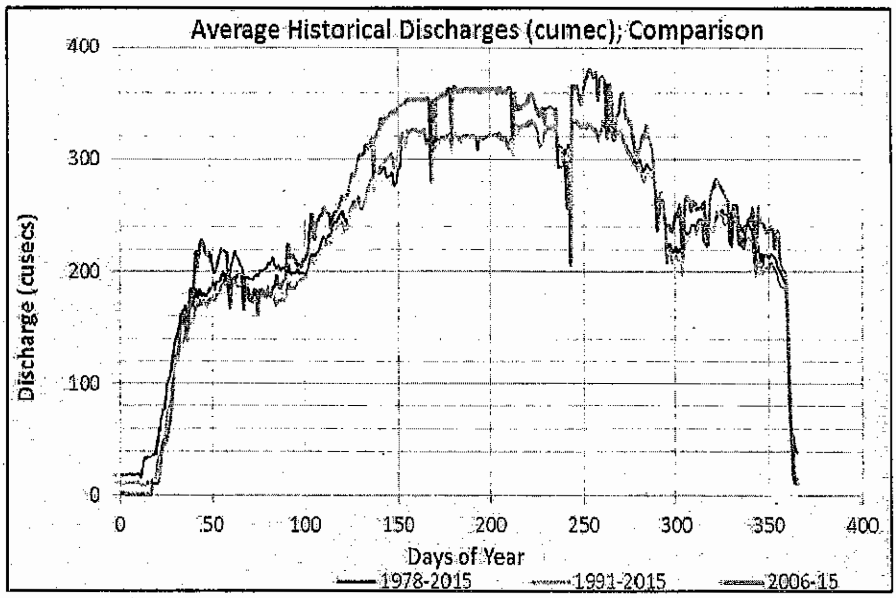


Figure 26: Average Historical Discharges (Cumec) (Comparison of Different Data Series)

The above Figure clearly shows that in data series 2006-15, discharges remains relatively higher than other data series.

4.1.5. Evaluation of Upstream Water Levels

The collected upstream water levels at RD 106+250 from 1978 to 2015 have been evaluated as follows:

- Historical Data of Upstream Water Levels
  - Post Tarbela Series (1978 – 2015)
  - Post WAA Series (1991 – 2015)
  - Post Remodeling Series (2006 - 2015)
  - Comparison of Data Series
- Maximum Designed Water Level Upstream Powerhouse

4.1.5.1. Historical Data of Upstream Water Levels

The historical discharges and hence the related upstream water levels for the period from 1978 to 2015 have been evaluated in different data series, as follows:

4.1.5.1.1. Post Tarbela Series (1978 – 2015)

The historical upstream water levels considering average daily flow series of BS Link-I Canal at RD 106+250 considering the complete data series from 1978 to 2015 is shown in Figure below analyzes 38 years' data simultaneously:

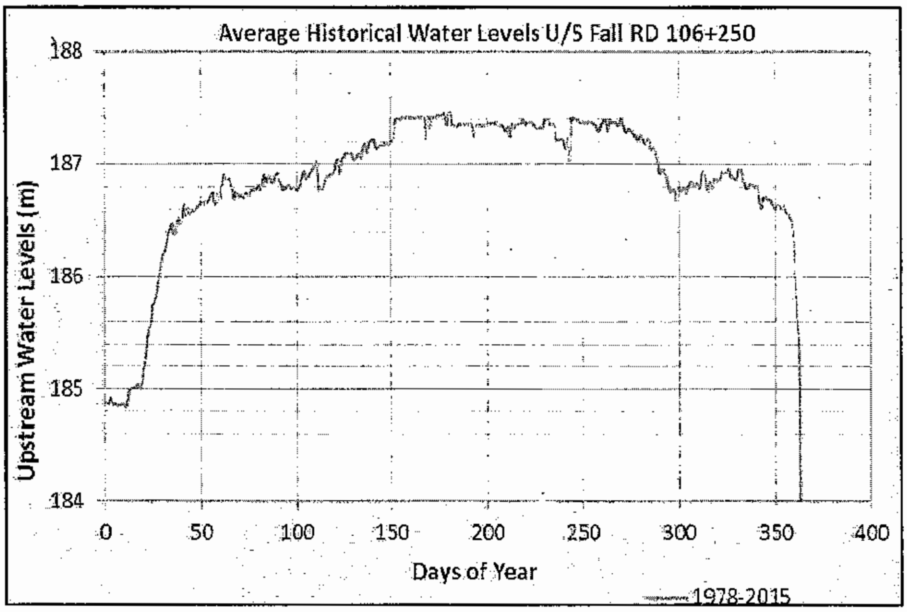


Figure 27: Average Historical Water Levels U/S Fall RD 106+250 (1978-2015)

4.1.5.1.2. Post WAA Series (1991 – 2015)

The historical upstream water levels considering average daily flow series of BS Link-I Canal at RD 106+250 considering the data series from 1991 to 2015 is shown in Figure below analyzes 25-year data simultaneously:

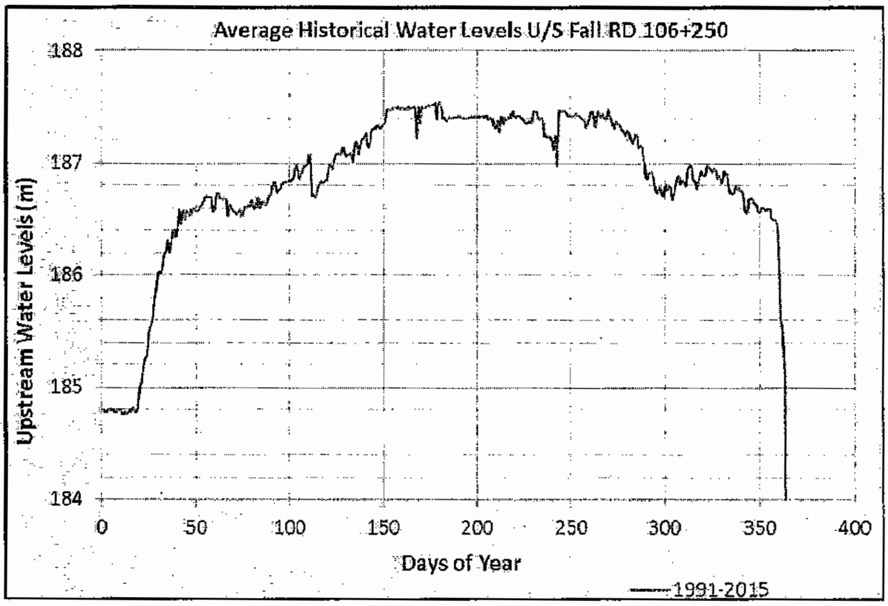


Figure 28: Average Historical Water Levels U/S Fall RD 106+250 (1991-2005)

4.1.5.1.3. Post Remodeling Series (2006 - 2015)

The historical upstream water levels considering average daily flow series of BS Link-I Canal at RD 106+250 considering the data series from 2006 to 2015 is shown in Figure below analyzed 10-year data simultaneously:

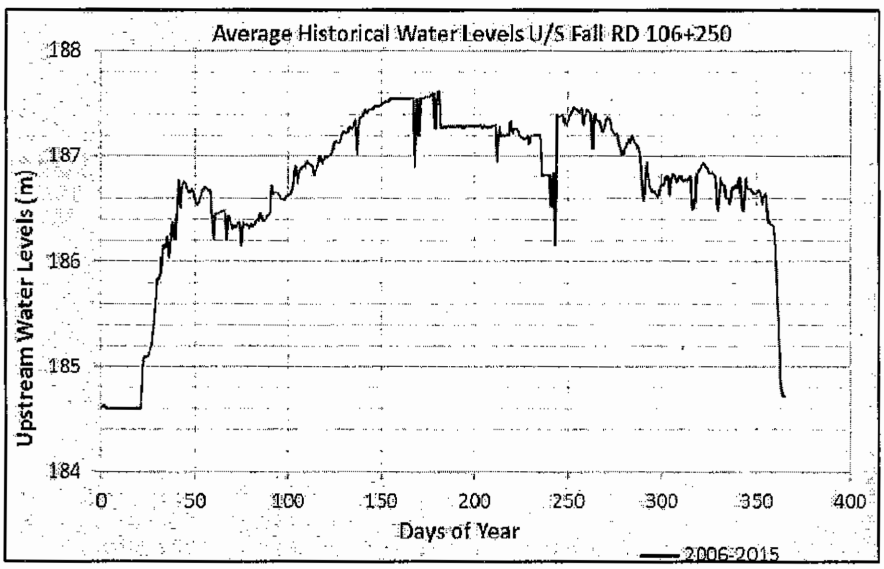


Figure 29: Average Historical Water Levels U/S Fall RD 106+250 (2006-2015)

4.1.5.1.4. Comparison of Data Series

The comparison of the different data series is shown in the Figure below:

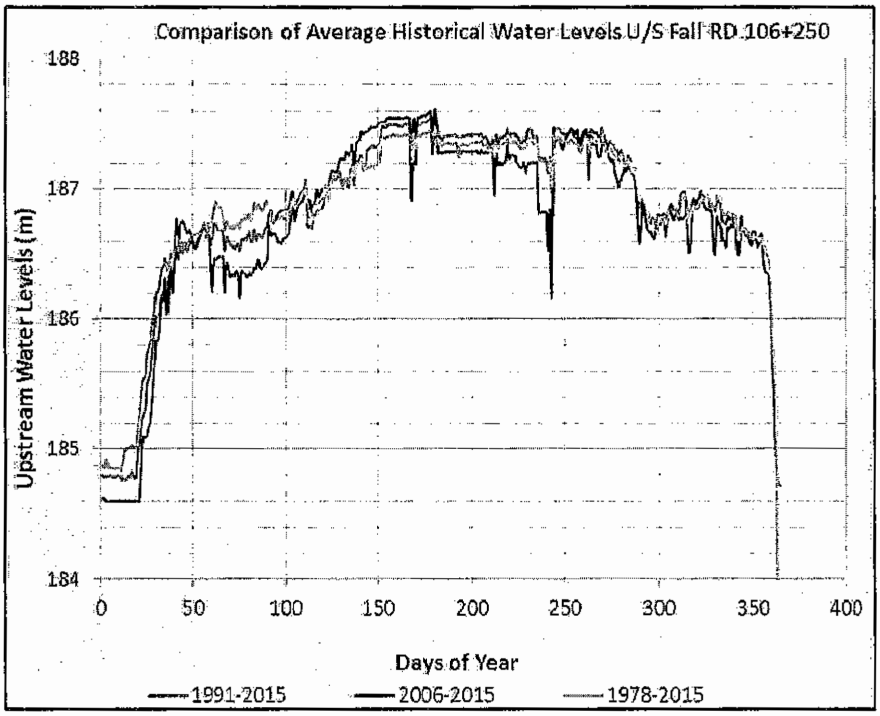


Figure 30: Comparison of Average Historical Water Levels U/S Fall RD 106+250

The comparison shows that the water levels upstream of Fall, RD 106+250 during the period post remodeling data series (2006-2015) remained at little higher elevations due to higher availability of discharges in most of the part of the year.

4.1.5.2. Maximum Designed Water Level Upstream Powerhouse

According to the revised Longitudinal Section of the canal system, maximum designed water level upstream of powerhouse will be 188.531 m (618.54 ft). Under the specific scenario, this water level will be used throughout the year as Head Water Level (HWL) upstream of powerhouse.

4.1.6. Evaluation of Downstream Water Levels

- Historical Data of Downstream Water Levels
  - Post Tarbela Series (1978 – 2015)
  - Post WAA Series (1991 – 2015)
  - Post Remodeling Series (2006 - 2015)
  - Comparison of Data Series
- Designed Water Levels Downstream Powerhouse (Tailwater Rating Curve)

4.1.6.1. Historical Data of Downstream Water Levels

The historical discharges and hence the related Downstream water levels for the period from 1978 to 2015 have been evaluated in different data series as following:

4.1.6.1.1. Post Tarbela Series (1978 – 2015)

The historical downstream water levels considering average daily flow series of BS Link-I Canal at RD 106+250 considering the complete data series from 1978 to 2015 is shown in Figure below analyzing 38 years' data simultaneously:

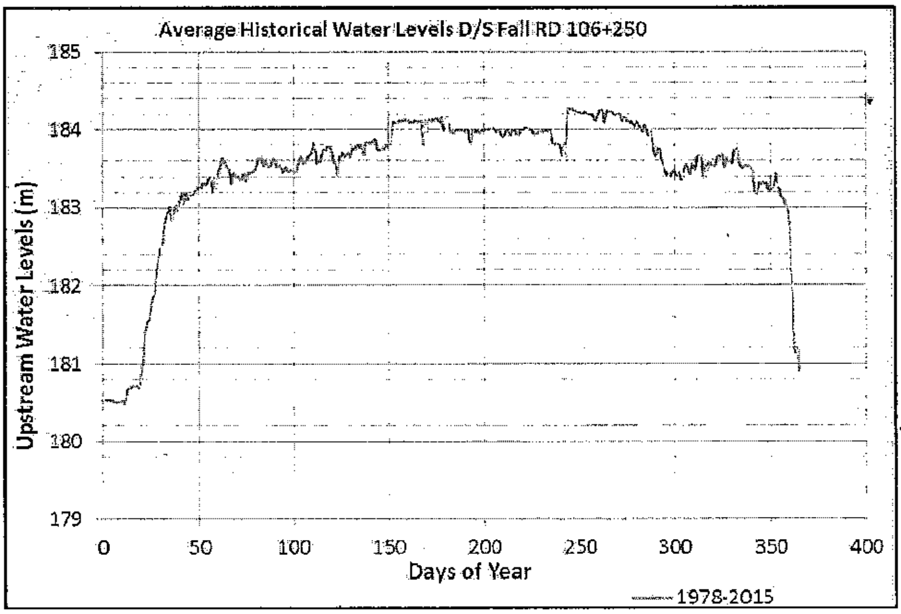


Figure 31: Average Historical Water Levels D/S Fall RD 106+250 (1978-2015)

4.1.6.1.2. Post WAA Series (1991 – 2015)

The historical downstream water levels considering average daily flow series of BS Link-I Canal at RD 106+250 considering the data series from 1991 to 2015 is shown in Figure below analyzes 25-year data simultaneously:

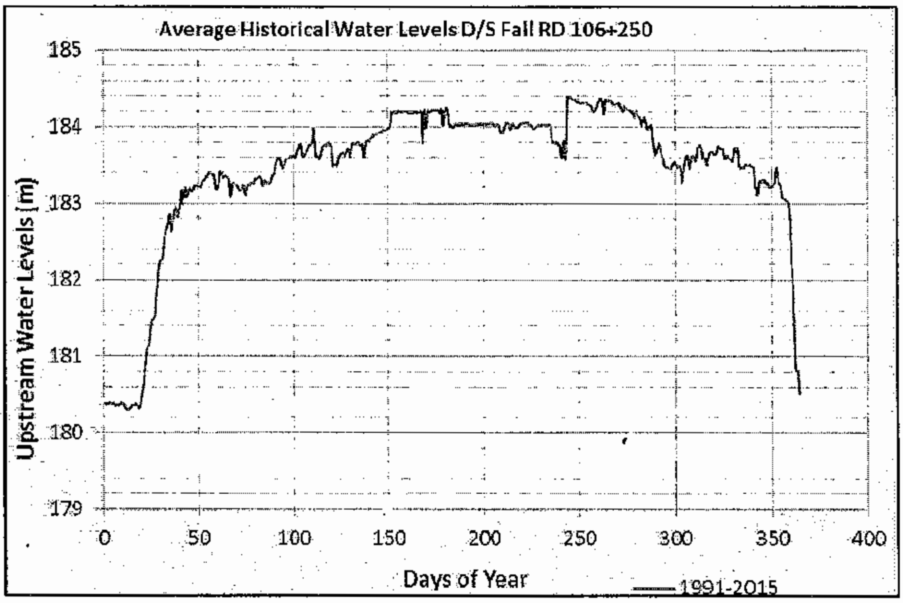


Figure 32: Average Historical Water Levels D/S Fall RD 106+250 (1991-2005)

4.1.6.1.3. Post Remodeling Series (2006 - 2015)

The historical downstream water levels considering average daily flow series of BS Link-I Canal at RD 106+250 considering the data series from 2006 to 2015 is shown in Figure below analyzes 10-year data simultaneously:

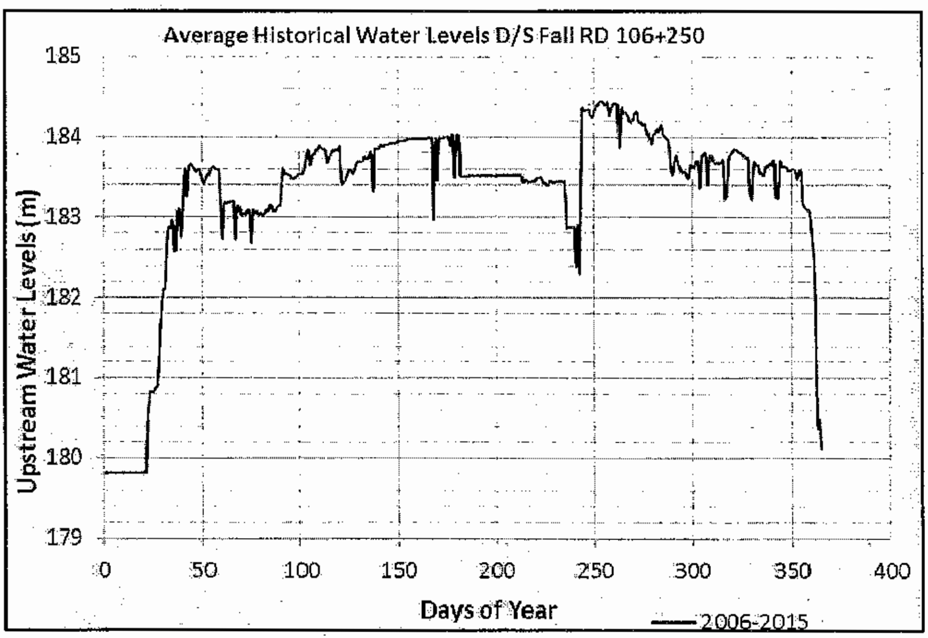


Figure 33: Average Historical Water Levels D/S Fall RD 106+250 (2006-2015)

4.1.6.1.4. Comparison of Data Series

The comparison of the different data series is shown in the Figure below:

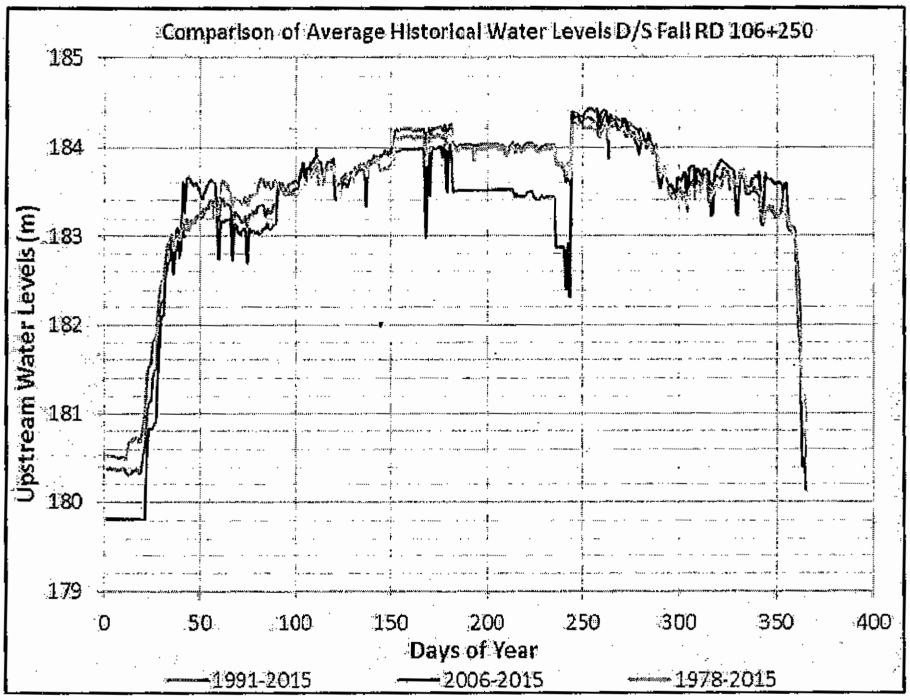


Figure 34: Comparison of Average Historical Water Levels D/S Fall RD 106+250

The comparison shows that the water levels downstream of Fall RD 106+250 during period post remodeling data series (2006-2015) remained at higher elevations in most of the part of the years.

4.1.6.2. Designed Water Levels D/S Powerhouse (Tailwater Rating Curve)

According to the revised Longitudinal Section of the canal system, designed bed level downstream of powerhouse will be 179.807 m (589.92 ft).Tailwater rating curve have been developed and produced in Figure as following:

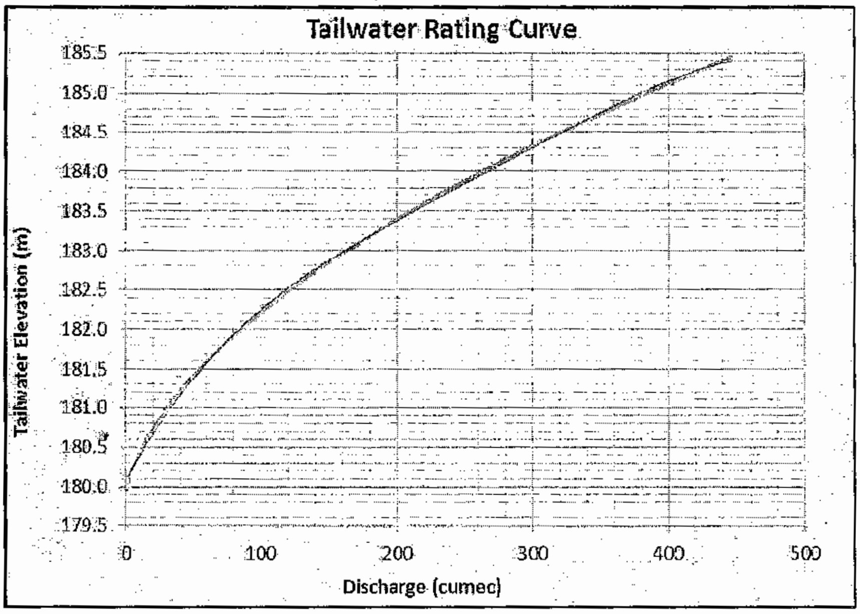


Figure 35: Tailwater Rating Curve

The above Figure will be used to compute design water levels downstream of powerhouse in the specific scenario of energy computation.

4.1.7. Selection of Design Discharge

As discussed already, out of three available data series i.e. Post Tarbela, Post WAA and Post Remodeling, more emphasis has been given on the last one being most recent and most relevant. Discharges in the canal and gross head or net head are inversely proportional to each other and net head available drastically decreased at certain limits, thus reducing the addition in power potential to small degree. Based on the careful and in depth evaluation of the concept, design discharge of Powerhouse for power production is considered as 350 cumec. 350 cumec remains available for about 31% of time, according to Post Remodeling Data Series.

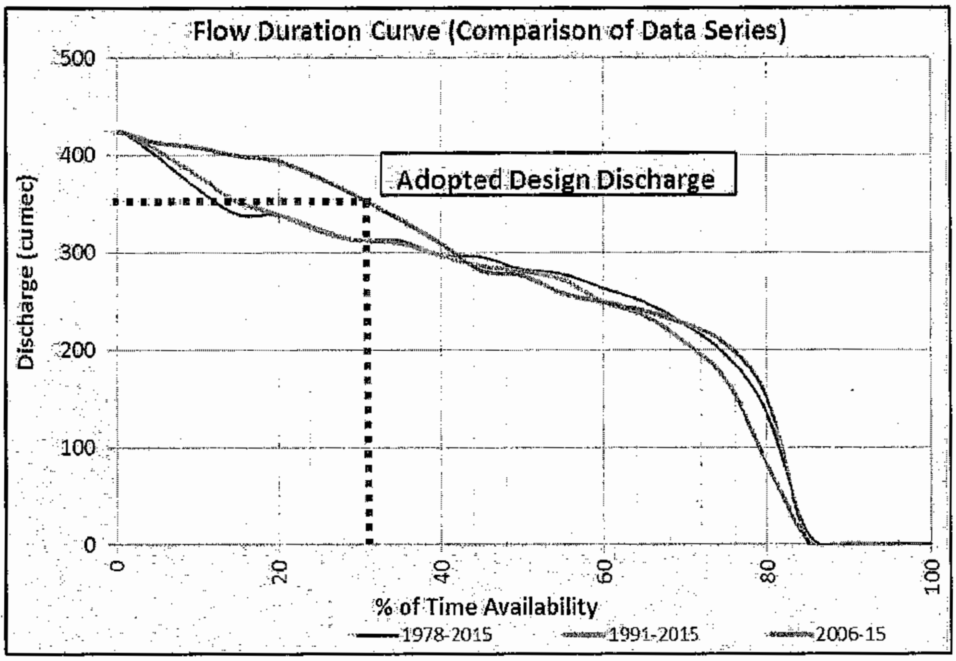


Figure 36: Availability of Design Discharge

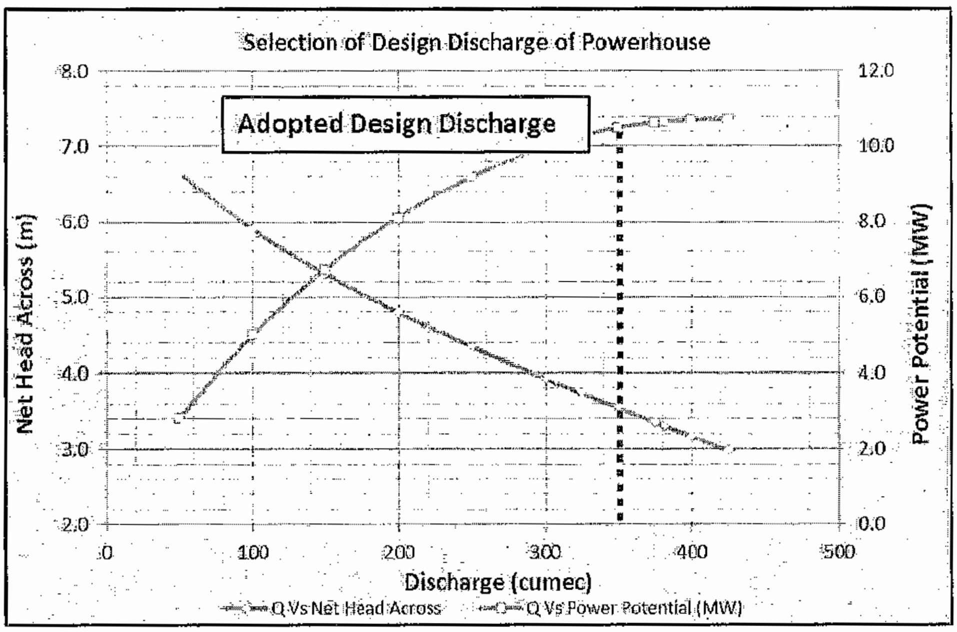


Figure 37: Selection of Design Discharge for Powerhouse

4.2. SEDIMENTATION STUDY

Balloki-Sulemanki Link Canal (BS Link) originates from Balloki Barrage on River Ravi which is located at about 65 Km southwest of Lahore. Head regulator of canal has 11 gates each 24 ft wide with a canal width of 405 ft and total length of canal from RD 0+000 to RD 266+000 is about 81 Km. Canal was constructed in 1967 with the main objective to feed the southeastern part of Punjab through supplying its water to River Sutlej just upstream of Sulemanki Barrage. After about 22 Km at RD 73+250, the canal bifurcates into two canals known as BS Link-I and BS Link-II.

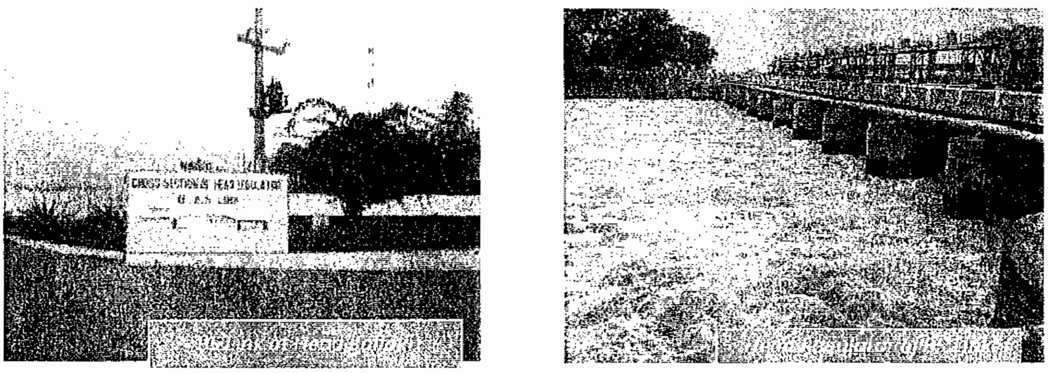


Figure 38: BS Link Canal at RD 0+000

4.2.1. Scope of Work

During the periods when the flow in the canal reduces substantially from its design discharge the headwater needs to be maintained at Full Supply Level so as to run the plant efficiently. Such heading up of water has been suspected to cause the excessive sediment deposition leading towards disturbance in the canal regime.

About 33 km long canal reach, from RD 000+000 to RD 107+000, has been selected for numerical modelling to evaluate the sedimentation behavior between the off-take of BS Link canal and Fall at RD 106+250 with various scenarios of heading-up of water at the proposed hydropower facility. Complete Sedimentation Study is presented as Appendix-D.

4.2.2. Numerical Simulation

Numerical modelling has been aimed to evaluate the sedimentation behavior between RD 0+000 and Fall at RD106+250 with various scenarios of heading-up of water at the proposed hydropower facility. In this regard keeping in view the availability of data required for numerical modelling and the computation tools available in public domain, US Army Corp's of Engineers' (USACE) tools have been considered for carrying out the modelling exercise.

Sediment load is essential to define the upstream boundary condition for simulation of the sedimentation phenomenon therefore relationship of variation of sediment load with respect to the discharge is required to be established. Studies revealed that relationship between the sediment load based on observed suspended sediment concentrations and the canal discharge is very week. This situation necessitated to use the time series of sediment load for simulation.

Time series option for sediment load is available in USACE's one dimensional program HEC RAS which is available in public domain for free of cost. This program has been stated by USACE as one of the 'Next Generation' (NEXGEN) software packages which can simulate the sedimentation in rivers and reservoirs utilizing the initial code of HEC 6 (earlier version).

Bed change calculations are based on difference of the available sediment and the transport capacity at the given section. If sediment transport capacity is greater than the available quantity of sediments to be transported, water will pick the sediment from the bed and cause scouring, otherwise the sediment in suspension would be dropped causing bed aggradations.

4.2.3. Model Inputs

Following model inputs have been worked out, analyzed and used in the model to run the simulations:

I. Canal Cross-sections

II. Flow Series

III. Sediment Load Time Series

IV. Particle Size Distribution

V. Bed Gradation

VI. Sediment Transport Function

VII. Sediment Densities

VIII. Water Temperature

IX. Fall at RD 106+250

4.2.4. Model Calibration

While working with the mobile boundary models, it is preferable to calibrate the model with the observed bed changes at distinct times. Such calibration can be achieved by adjusting the hydraulic and sediment transport parameters used in the governing equations of the model.

Since the canal geometry in the study reach was available only for limited time period and no consistent record was available, therefore, model simulations have been based on

2004 survey mainly with some input from the recent cross sections of just upstream and downstream of Fall at RD 106+250 obtained from bathymetric survey performed during the course of feasibility study and eventually could not be compared with any other observed data.

Keeping in view the given constraint, hydraulic calibration of the model has been carried out. Manning's roughness coefficient 'n' has been calibrated in the study reach to match the water surface profile corresponding to the design discharge of the canal i.e. 424.75 m3/s (15000 ft^3/s). Variation in Manning's roughness coefficient in the calibrated reach is from 0.017 to 0.024. It is important to mention that Manning's roughness coefficient variation has been made function of water depth i.e. more the water depth at any given point in the reach lesser would be the friction to the flow and vice versa.

The variation of Manning's roughness at each cross section based on flow depth is also considered for sediment simulations.

4.2.5. Simulation Scenarios

Two scenarios have been considered for simulating the sedimentation phenomenon in the current study.

4.2.5.1. Scenario-1 (Present Day Scenario)

First being the 'Present Day (PD)' scenario in which there is no intervention at RD 106+250 in terms of any construction of the hydropower facility and the water level has been kept variable according to the control imposed by the Fall at RD 106+250, for the whole simulation period.

4.2.5.2. Scenario-2 (With Project Scenario)

The second scenario formulated for the simulation incorporates the proposed hydropower facility in place at RD 106+250 which heads-up the water at canal Full Supply Level (FSL) 618.54 ft above sea level throughout the simulation period of sixty years.

4.2.6. Simulation Results

Simulation scenarios have been run in the light of above discussed parameters and conditions and the results of the two scenarios have been provided as follows:

4.2.6.1. Present Day Scenario

Model simulation for Present Day Scenario indicates the study reach in regime condition with no significant scouring or deposition trend during sixty years of simulation. Longitudinal profile of the study reach has been shown in following Figure.

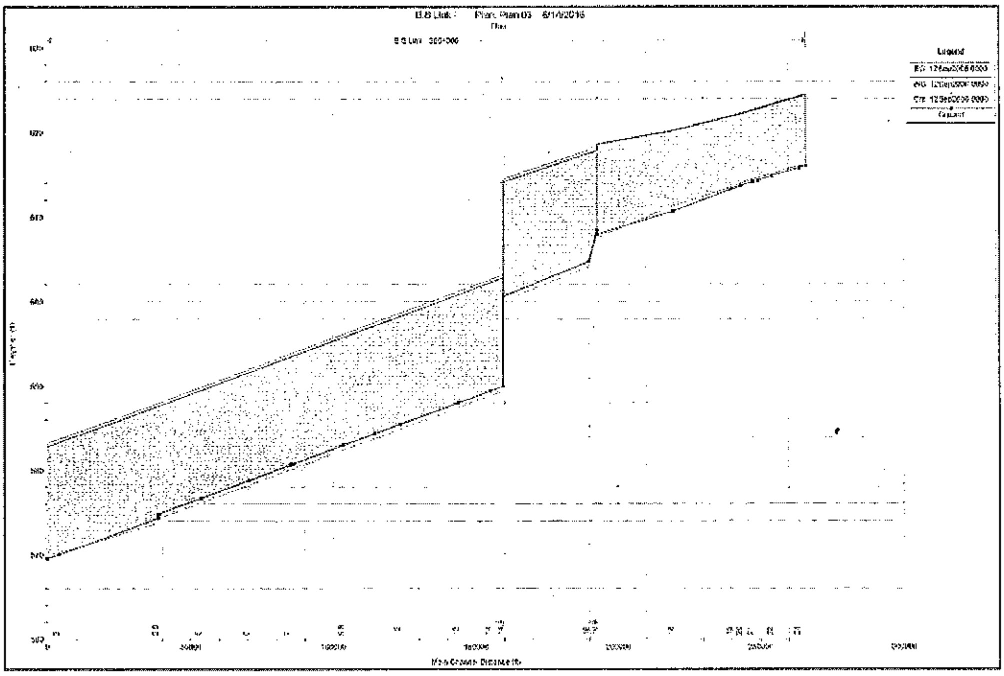


Figure 39: Sixty Years Simulation Results for Present Day Scenario

Figure indicates very minor deposition trend in upper part of the reach which is quite insignificant. However, results of the model needs to be further verified after having extensive and continuous field investigations on account of bed material gradations, channel geometry, velocity observations and sediment sampling for at least one full year.

4.2.6.2. With Project Scenario

As described above, Scenario-2 incorporates the proposed hydropower facility at RD 106+250 and affords continuous heading-up of the water at FSL during sixty-year simulation period. Results of this scenario given by HEC RAS show about 0.8 ft of sediment deposition within initial RDs of study reach. Longitudinal profile after sixty years of simulation of 'With Project Scenario' is shown in Figure below

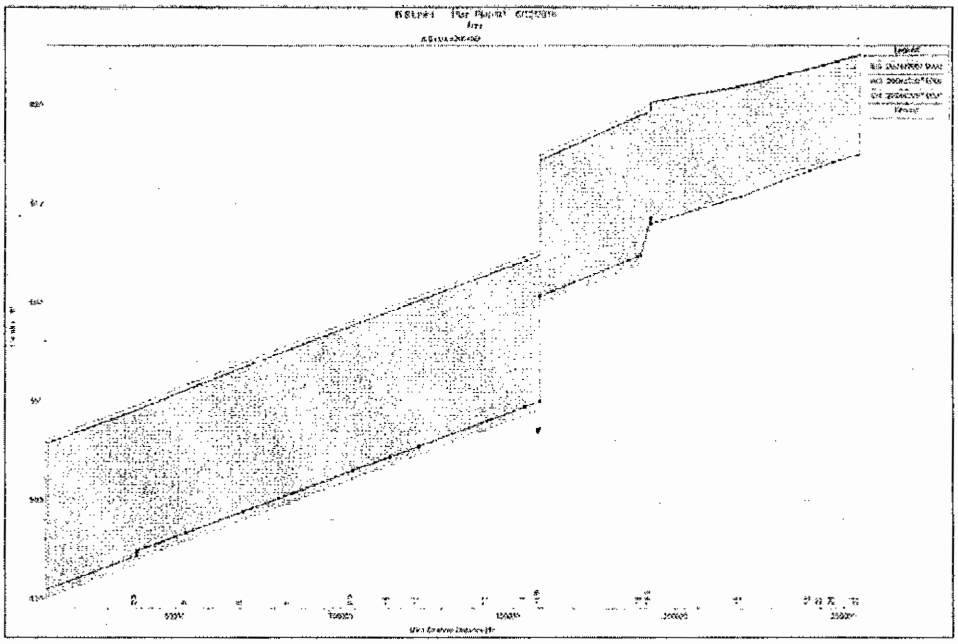


Figure 40: Sixty Years Simulation Results for with Project Scenario

The deposition is made further visible in following image by magnigying the results. However, the scour is not present upstream of RD 73+250 and from RD 73+250 to downstram. The canal is brick lines where scouring phenomenon is not existent.

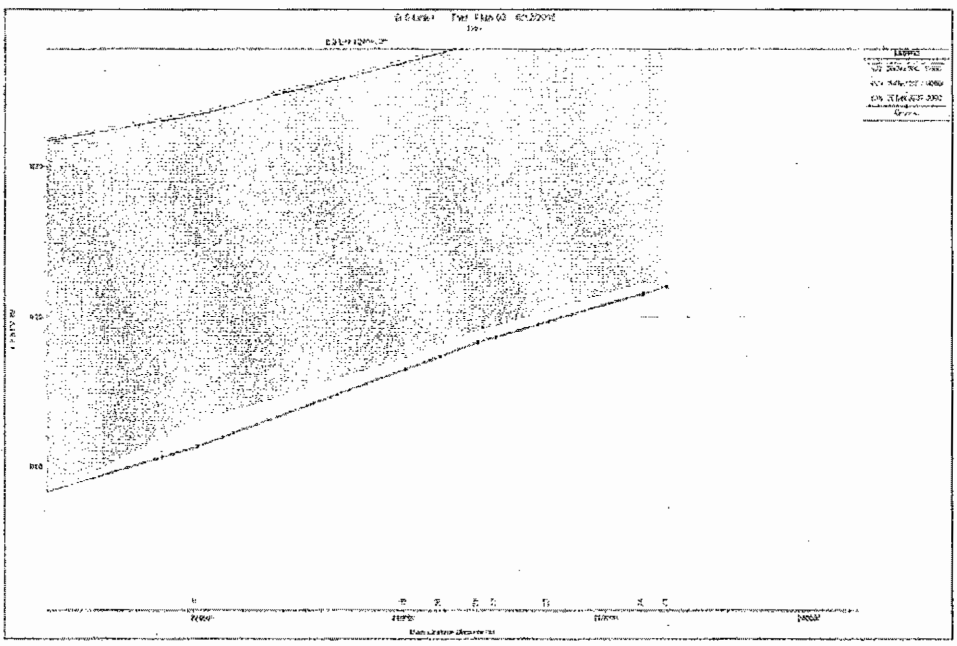


Figure 41: Magnified view of with Project Scenario

In the light of these results it can be stated that if the proposed hydropower facility would be constructed at RD 106+250, canal bed would attain its new equilibrium with average raising of bed by about 0.8 to 1 ft and the water level at full supply discharge would also be raised by the same magnitude. Since the canal is in cut therefore this situation would not lead to overbank spills and the water would be retained within the freeboard.

Raising of water level by about 1 ft by virtue of bed aggradations, calls for providing the hydro-mechanical machinery capable enough to generate more electricity at the increased head of about 1 ft after say initial fifteen to twenty years of operation.

4.2.7. Conclusion

Based on above discussions and review of the results following conclusions have been drawn;

(i) Long term daily discharge data reveals that BS Link canal flows at or above 80% of its design discharge for about 3 1 % of the time in a year (mostly during monsoon season).

(ii) More than 80% of overall sediment load enters into the canal during June to September months.

(iii) Suspended sediment concentration data collected at canal head regulator indicates reduction in percentage of coarse sand fraction during high flow season possibly due to exclusion of coarser fraction past the Balloki barrage through under-sluice operation.

(iv) Keeping in view the above conditions model's long term simulations indicates a regime condition for the Present Day Scenario.

(v) Long term simulations obtained from HEC RAS for "With Project Scenario' indicates bed aggradations of about 1 ft upstream of RD 73+250

(vi) Even after raising the bed by 1 ft for "With Project Scenario' canal would flow within the existing freeboards.

(vii) Raising of water level by 1 ft by virtue of bed aggradations provides basis to provide the hydro-mechanical machinery capable enough to generate more electricity at the increased head of 1 ft after say initial ten to twenty years of operation.

(viii) Results obtained are logically consistent with the given conditions elaborated in the text of the report.

5. LAYOUT ALTERNATIVES

5.1. Project Layout Principles

While considering different options of project layouts, following principles are applied:

I. No adverse influence on the safety and operation of the BS Link-I Canal;
II. The design flow capacity of BS Link-I Canal would not be impaired;
III. Convenient for construction;
IV. Feasible in technology, convenient for operation and management.
V. Hydraulic aspects of the curves of headrace and tailrace channels would be satisfactory;
VI. Minimum or preferably no land acquisition. The government-owned land would be preferred to the privately owned;
VII. Environment friendly and socially acceptable layout with minimum disturbance to the existing land use pattern, infrastructure and settlements;
VIII. Minimum construction period with optimum utilization of the annual canal closure period;

5.2. Considerations for Layouts

Detailed topographic survey of the area has been conducted about which details have been mentioned in Chapter 2. This survey has been used as the basis for considering different layout under the principles mentioned above.

5.2.1. Selected Layout in Previous Studies

On the project, in different periods, different studies remained under progress and the conclusions / recommendations of these studies have been described for reference as follows:

5.2.1.1. HEPO/WAPDA-GTZ Study (1984-85)

In 1984-85, HEPO-GTZ conducted a Ranking Study and a hydropower project was considered at RD 106+250 of BS Link-I Canal, ranked second in the canal Falls category. The said project was proposed at downstream of the existing Fall as submersible type of powerhouse with spillway at its top in the bed of the canal. It was further proposed that diversion canal would be constructed on right side of the existing canal through which operation of the canal would be kept in progress. The combined powerhouse & spillway was also studied but not recommended due to different foundations levels of both the structures which were considered susceptible to differential settlements. After completion of the powerhouse & spillway, existing Fall along with diversion channel was recommended to be dismantled.

However, later on, it was observed that proposed layout has following flaws / discrepancies:

- The selected type of proposal could have only specific type of turbine, more sensitive against silty water, being manufactured by only VA-Tech Germany which is not desirable at all;
- Arrangement of layout included deeper foundation of powerhouse, creating maintenance problems along with tremendous increase in dewatering cost.

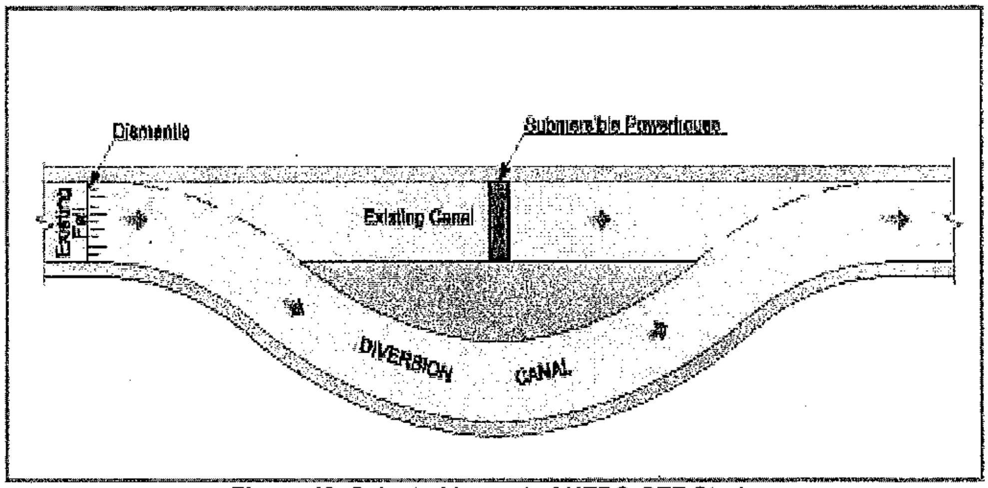


Figure 42: Selected Layout of HEPO-GTZ Study

5.2.1.2. Army Welfare Trust Study (1987)

In 1987, Army Welfare Trust Pakistan, a private developer, conducted Feasibility Study through Associated Consulting Engineer (ACE) Pakistan in association with HARZA Engineering International USA. The study recommended the powerhouse in the bypass arrangement with double regulated bulb type turbines and a sluice structure (spillway) was proposed near the powerhouse. The sluice structure was proposed with the capacity of 64% of the flows and balance flows were considered to pass through turbines.

However, later on, it was observed that proposed layout has following flaws / discrepancies:

- Spillway was proposed with design capacity of 64% of flows and rest of flows was considered through turbines which created the chances of flooding of powerhouse or breaching of canal in case of total shutdown due to what so ever reason;
- The selected type of turbines i.e. double regulated bulb type turbines was not suitable for sluice operation due to excessive vibration;
- The bottom outlets/spillway were sized such that one or more turbines are required to pass water under sluice operation, hence less generation

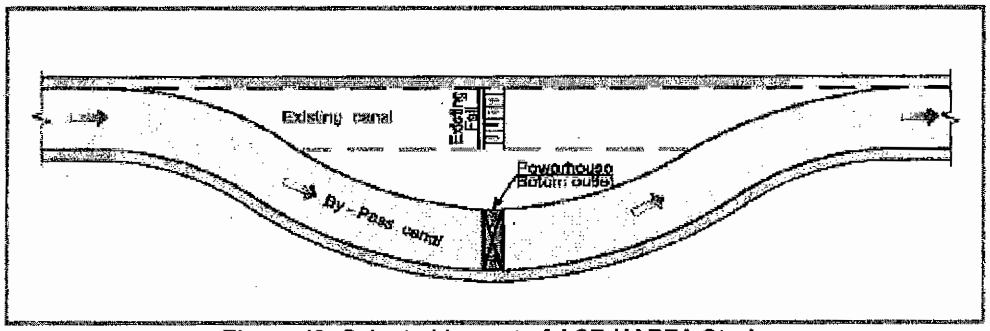


Figure 43: Selected Layout of ACE-HARZA Study

5.2.1.3. MK Power Study (1994)

MK Power Consortium, a joint venture of M/S Macro Services Pakistan and M/S Kvaerner Boving UK conducted a Feasibility Study through M/S Royds Consulting Limited, New Zealand and M/S Pakistan Engineering Services Lahore. In the study, powerhouse was proposed to be in bypass arrangement while the existing Fall at RD 106+250 was considered to be remodeled to act as spillway. The powerhouse was proposed to be equipped with three single regulated pit type turbines.

However, later on, it was observed that proposed layout has following flaws / discrepancies:

- While considering the option of remodeling of exiting Fall, the deteriorated condition of Fall was not considered properly;
- Construction of powerhouse in the bypass arrangement was considered in first phase and remodeling of Fall RD 106+250 was considered in second stage, requiring additional completion time.

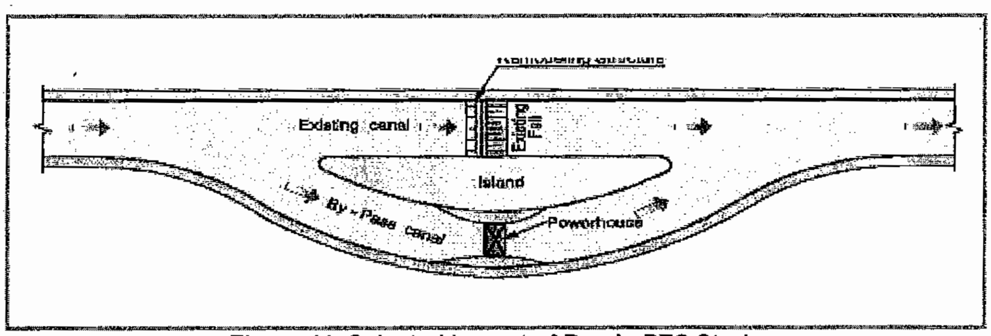


Figure 44: Selected Layout of Royds-PES Study

5.2.1.4. Olympia Chemicals Feasibility Study Report (2009)

In 2009, Olympia Chemicals conducted a Feasibility Study through M/S Technical, Engineering and Management – TEAM Consultants, Pakistan. In the study, powerhouse & spillway were proposed in the diversion arrangement on right side of BS Link-I Canal opposite Fall RD 106+250. Design discharge of powerhouse was selected as 381 cumec with three (03) number of horizontal pit type turbines.

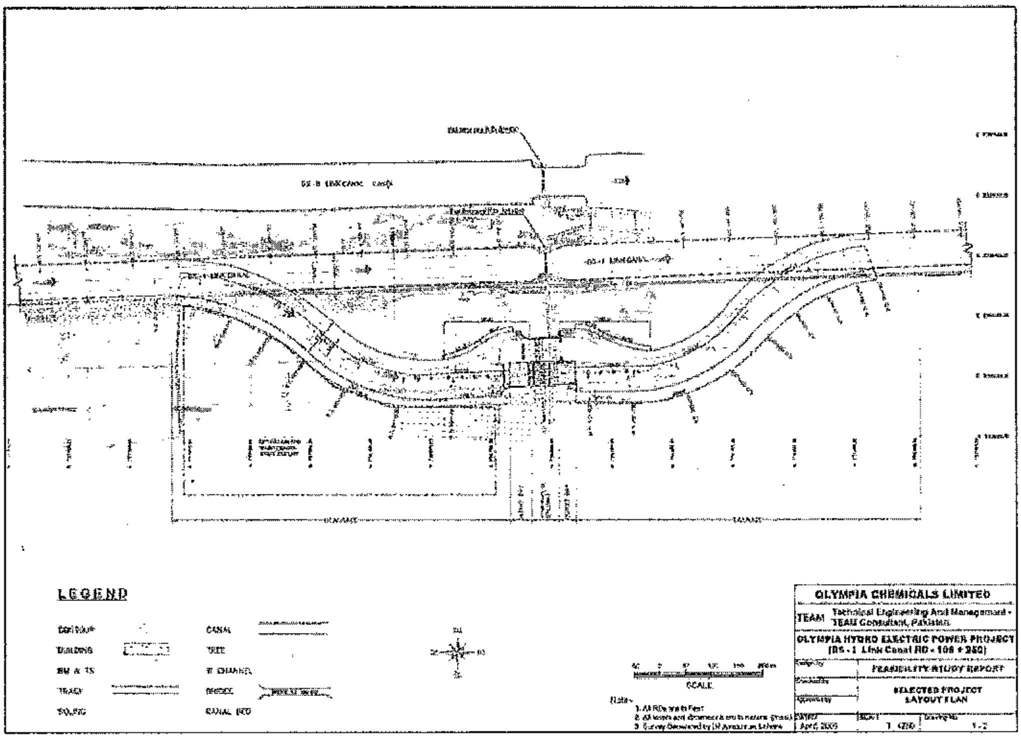


Figure 45: Selected Layout of Olympia/TEAM Study

5.2.2. Layout Studies & Selected Option

5.2.2.1. Layout Options

Considering detailed topographic survey along with available date & reports, different options are considered, evaluated and some of these have been discarded due to obvious flaws & drawbacks.

All available information, (data/reports/drawings) has been reviewed for layout planning studies. These options were put through an initial review and screening process to discard those having obvious flaws and/or major constructability issues or drawbacks. A scheme which looked promising have developed to a conceptual design stage for further consideration.

5.2.2.2. Layout Options Considered

Keeping in view the proposed site, the principles defined under serial no. 5.1 and initial evaluation of proposals, different layout options are considered. Before proceeding towards the selected options, following basic concepts have been developed:

- Based on the deteriorated condition of Fall RD 106+250, the concept of remodeling of Fall by providing gates has totally been rejected;

- BS Link-II Canal exists parallel and on the left side of the BS Link-I Canal, hence the possibility of any diversion / power canal on the left side of BS Link-I Canal is rejected;
- Chunian Disty offtakes from RD 110+767 of BS Link-I Canal from its right side. To continue the operation of Chunian Disty under all construction scenarios, the proposed project layout should not be in close proximity of offtaking point of Chunian Disty (RD 110+767);
- Powerhouse / spillway proposal situated in the existing BS Link-I Canal upstream or downstream of Fall RD 106+250 is rejected based on the following reasons:
  - BS Link-I Canal is in close proximity of BS Link-II Canal due to which deep excavation works and dewatering arrangement will require considerable additional efforts;
  - Diversion Channel has to be maintained and repaired throughout the period of constructions;
  - Start of the project will be totally dependent on construction of diversion arrangement in annual canal closure and diverting the flows towards the diversion canal before the start of construction of powerhouse / spillway. The concept can seriously delay the project. While on the other hand, powerhouse / spillway in the diversion arrangement needs no such prerequisite requirement.
- Main disadvantages associated with powerhouse / spillway in the bypass arrangement is additional cost required for permanent acquisition of land.

Keeping in view the above said basic concepts, following are the considered options:

Alternative -1	Powerhouse / Spillway in Bypass Arrangement Upstream of Fall RD 106+250
Alternative -2	Powerhouse / Spillway in Bypass Arrangement at Fall RD 106+250
Alternative -3	Powerhouse / Spillway in Bypass Arrangement D/S of Fall RD 106+250

Alternative -1 Powerhouse / Spillway in Bypass Arrangement Upstream of Fall RD 106+250

To save the interruptions in the existing & running canal system from the start time of the project along with other benefits already explained, it is planned to make powerhouse / spillway in the bypass arrangement upstream of Fall RD 106+250 at a safe distance from the existing BS Link-I Canal. After completion of construction of powerhouse & spillway in the bypass arrangement, canal flows will be diverted towards the powerhouse / spillway by means of diversion works construction in the annual canal closure. The existing Channel in between start of headrace channel and end of tailrace channel will be permanently abandoned. The headrace & tailrace channels will be of brick lined in accordance with the existing designed section of BS Link-I Canal.

The Alternative has the following advantages:

- Construction of powerhouse / spillway will be carried out in bypass arrangement without disturbing the canal operation at all;

- No relevancy with the operation of BS Link-II Canal being bypass located on right side of the BS Link-I Canal;
- No problem of maintaining diversion channel throughout the construction period;
- Powerhouse, intake bay and outlet bay foundation will be placed in cutting.

The Alternative has the following disadvantages:

- Additional cost required for permanent arrangement of land;
- Higher dewatering cost due to high elevations of flows (upstream of Fall) in existing BS Link-I Canal during construction of powerhouse / spillway.
- Involves additional work of bed excavation from end of tailrace channel to Fall RD 106+250 to maintain the same bed which is d/s of Fall RD 106+250;
- Involves additional work of dismantling of Fall RD 106+250.
- After dismantling of Fall RD 106+250, will require some passing mechanism for BS Link-I Canal in the nearby vicinity.

Alternative -2 Powerhouse / Spillway in Bypass Arrangement Opposite Fall RD 106+250

Under this scenario, it is planned to make powerhouse / spillway in the bypass arrangement opposite Fall RD 106+250 at a safe distance from the existing BS Link-I Canal. After completion of construction of powerhouse & spillway in the bypass arrangement, canal flows will be diverted towards the powerhouse / spillway by means of diversion works construction in the annual canal closure. The existing Channel in between start of headrace channel and end of tailrace channel will be permanently abandoned. The headrace & tailrace channels will be of brick lined in accordance with the existing designed section of BS Link-I Canal.

The Alternative has the following advantages:

- Construction of powerhouse / spillway will be carried out in bypass arrangement without disturbing the canal operation at all;
- No relevancy with the operation of BS Link-II Canal being bypass located on right side of the BS Link-I Canal;
- No problem of maintaining diversion channel throughout the construction period;
- Relatively lower dewatering cost due to lower elevations of flows (upstream & downstream of Fall) in comparison to Alternative-1 and relatively little higher dewatering cost due to elevations of flows (downstream of Fall) in comparison to Alternative-3 in BS Link-I Canal;
- No dismantling of Fall RD 106+250 is required in this option;
- Powerhouse, intake bay and outlet bay foundation will be placed in cutting.

The Alternative has the following disadvantages:

- Additional cost required for permanent arrangement of land.

Alternative -3 Powerhouse / Spillway in Bypass Arrangement Downstream of Fall RD 106+250

Under this scenario, it is planned to make powerhouse / spillway in the bypass arrangement downstream of Fall RD 106+250 at a safe distance from the existing BS Link-I Canal. After completion of construction of powerhouse & spillway in the bypass arrangement, canal flows will be diverted towards the powerhouse / spillway by means of diversion works construction in the annual canal closure. The existing Channel in between start of headrace channel and end of tailrace channel will be permanently abandoned. The headrace & tailrace channels will be of brick lined in accordance with the existing designed section of BS Link-I Canal.

The Alternative has the following advantages:

- Construction of powerhouse / spillway will be carried out in bypass arrangement without disturbing the canal operation at all;
- No relevancy with the operation of BS Link-II Canal being bypass located on left side of the BS Link-I Canal;
- No problem of maintaining diversion channel throughout the construction period;
- Lower dewatering cost due to lower elevations of flows (downstream of Fall) in BS Link-I Canal.
- Powerhouse, intake bay and outlet bay foundation will be placed in cutting.

The Alternative has the following disadvantages:

- Additional cost required for permanent arrangement of land;
- Involves additional work of raising of existing banks of Canal from Fall RD 106+250 to start of headrace channel;
- Involves additional work of dismantling of Fall RD 106+250.
- After dismantling of Fall RD 106+250, will require some passing mechanism for BS Link-I Canal in the nearby vicinity.

5.2.3. Selection of Final Layout

All the three (03) layouts briefly described above have been evaluated and considered in depth. After detailed evaluations and to save the interruptions in the existing & running canal system from the start time of the project (with special emphasize) along with other benefits already explained, it is selected to make powerhouse / spillway in the bypass arrangement opposite Fall RD 106+250 at a safe distance from the existing BS Link-I Canal as shown in following Figure. After completion of construction of powerhouse & spillway in the bypass arrangement, canal flows will be diverted towards the powerhouse / spillway by means of diversion works construction in the annual canal closure. The existing Channel in between start of headrace channel and end of tailrace channel will be permanently abandoned. The headrace & tailrace channels will be of brick lined in accordance with the existing designed section of BS Link-I Canal.

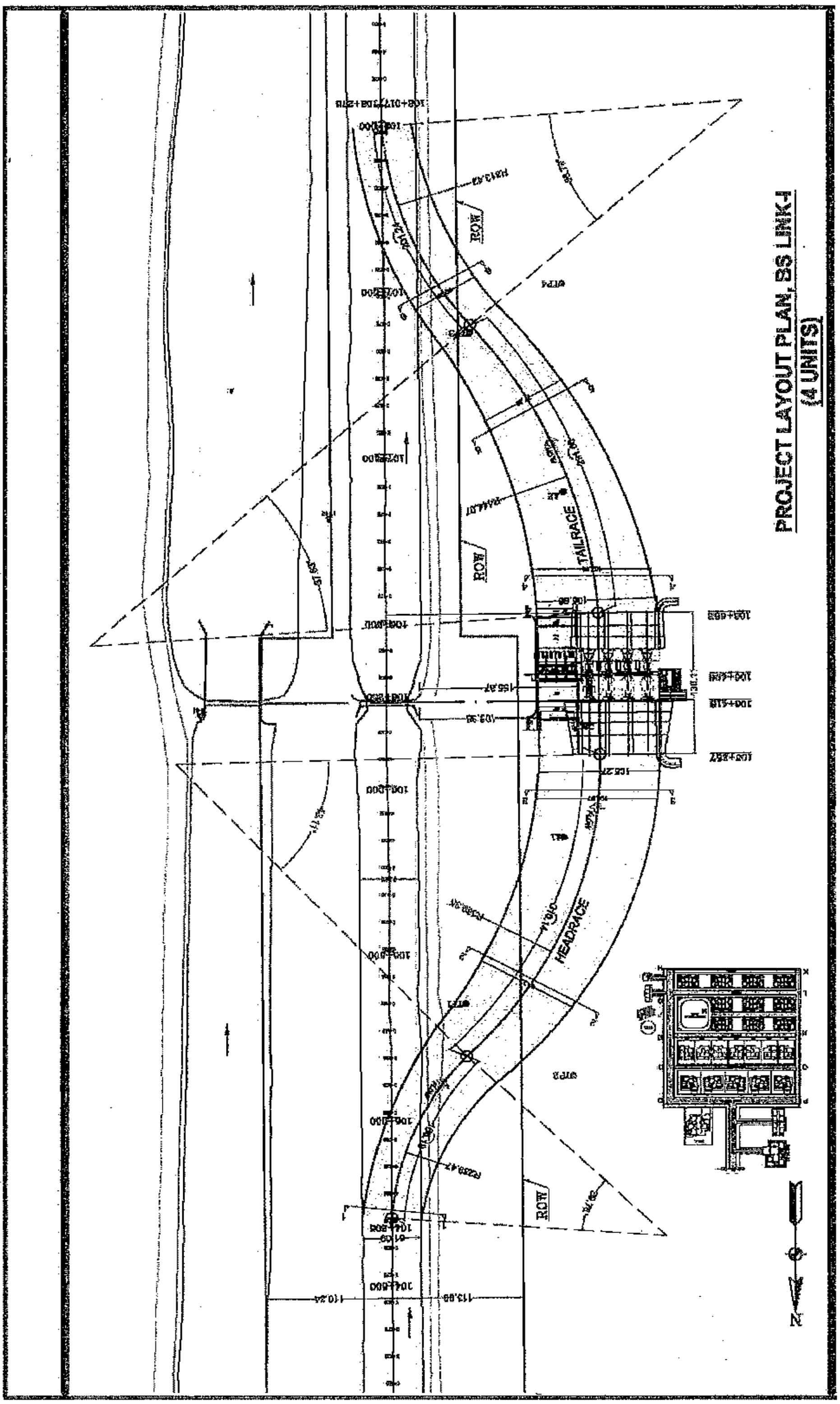


Figure 46: Selected Project Layout

6. HYDRAULIC DESIGN OF COMPONENTS

6.1. General

It is planned that the BS Link-I Canal will continue flowing without obstruction; powerhouse and spillway as an adjoining structure will be constructed on the right side of the main canal in power / bypass channel between RD 104+695 and RD 108+017 respectively. Connecting headrace and tailrace channels will be formed on the right side of the main canal with the design capacity of 424.75 cumec (15000 cusec) with respect to the approved L-section. Design discharge for the power production is selected as 350 cumec as described earlier. The project layout plan is provided in Volume II of the report.

6.2. Hydraulic Design of Headrace & Tailrace Channels

Headrace channel will start from RD 104+695 of BS Link-I Canal on right side of the existing Canal. Tailrace channel will start from RD 106+647 and rejoining the existing Canal, it ends at new RD 108+275 (Existing RD 108+017). The powerhouse and spillway will be constructed at RD 106+462 and RD 106+382 in the connecting channel while the main canal will remain in operation. Once the spillway, powerhouse and the connecting power channel will be completed, the discharges of the main canal will be diverted towards the powerhouse / spillway through the connecting power channel composed of headrace & tailrace channels. The existing BS Link-I Canal will be plugged between RD 104+695 to RD 108+017.

According to the latest approved longitudinal section of BS Link-I Canal, the designed discharge at Fall RD 106+250 is 424.75 cumec (15000 cusec) and accordingly the same capacity of headrace channel, spillway and tailrace channel have been fixed i.e. 424.75 cumec.

The hydraulic design approaches of headrace and tailrace channels have been described in the following paragraphs:

6.2.1. Hydraulic Design of Headrace Channel

At present, the BS Link-I Canal is provided with brick lining and designed on the Manning's approach with Manning's Coefficient of roughness as 0.017. The headrace and tailrace channels have been designed with the consideration of hydraulic similitude with the existing parameters of regime canal upstream and downstream of the Fall RD 106+250, stability, durability and minimum occupation of land. Headrace channel will be constructed at right side of the existing canal starting from RD 104+695 and ending at RD 106+220. The headrace channel is decided to be of having brick lining opting the existing design parameters of the respective reach. The side slope of the headrace channel is proposed as 2.0 Horizontal to 1.0 Vertical to ensure the stability of side slopes under different operational conditions. Full supply depth (FSD) is maintained as 5.486 m i.e. the same existing FSD of canal reach u/s & d/s of Fall RD 106+250. Bed width (B) of headrace channel at start (near RD 104+695) is maintained as 34.138 m however as the combined width of spillway & powerhouse is 105.27 m so the width of Headrace Channel will be smoothly increased to match the width of combined width of spillway &

powerhouse. The headrace channel will be capable to pass a maximum design discharge of 424.75 cumec. The longitudinal slope (S) proposed for the headrace is maintained as 0.000125 i.e. in accordance with the existing regime slope in the reach. The proposed hydraulic design parameters of the headrace channel are described as under:

- Design Discharge as 424.75 cumec.
- Brick lined trapezoidal section with 2.0 Horizontal to 1.0 Vertical.
- Length of Headrace canal as 464.8 m to be constructed on right side of the existing canal.
- Bed slope 1: 8000 (0.000125).
- Full supply level variation along the flow from 188.595 to 188.531 masl.
- Bed level variation along the flow from 183.108 to 183.044 masl.
- Manning's coefficient of roughness 0.017.
- Bed Width 34.138 m at start and 105.27 m at just upstream of powerhouse / spillway.
- Full Supply Depth 5.486 m.
- Height of Freeboard 1.5 m.
- Velocity of flow at start 1.72 m/s.

Proposed cross-sections of Headrace are provided in Volume II of the report.

6.2.2. Hydraulic Design of Tailrace Channel

Water passes through the spillway or releases from the powerhouse will be carried back into BS Link-I Canal through tailrace channel. Tailrace channel will be formed starting from RD 106+647 and ending at new RD 108+275 (existing RD 108+017) where it joins the existing BS Link-I Canal. The tailrace channel is proposed to be designed on Manning's theory like BS Link-I Canal with brick lining. The side slope of the lining of tailrace channel is proposed as 2.0 Horizontal to 1.0 Vertical to ensure the stability of side slopes under different operational conditions. Bed width of tailrace channel is maintained as 34.138 m at the end near RD 108+275 however as the combined width of spillway & powerhouse is 105.86 m so the width of tailrace Channel will be smoothly decreased at start matching the width of combined width of spillway & powerhouse. Full supply depth (FSD) is maintained as 5.486 m i.e. the same designed parameters of regime canal u/s & d/s of Fall RD 106+250. The tailrace channel will pass a maximum design discharge of 424.75 cumec. The longitudinal slope (S) proposed for the tailrace is maintained as 0.000125 i.e. in accordance with the existing regime slope in the reach.

Existing discharge table of BS Link-I Canal downstream of Fall RD 106+250 is attached in Appendix C. Zero R.L. of Gauge is fixed at existing designed bed level i.e. 179.817 masl (589.95 fasl). As per Approved Longitudinal Section of BS Link-I Canal d/s Fall RD 106+250, full supply level and bed level are 185.303 masl (607.95 fasl) and 179.817 masl (589.95 fasl) respectively. The tailwater rating curve has been established based of Manning's theory in accordance with the regime of BS Link-I Canal.

The proposed hydraulic design parameters of the tailrace channel are described as under:

- Design Discharge as 424.75 cumec.

- Brick lined trapezoidal section with 2.0 Horizontal to 1.0 Vertical.
- Length of tailrace channel as 496.2 m to be constructed on right side of the existing BS Link-I Canal.
- Bed slope 1: 8000 (0.000125).
- Full supply level variation along the flow from 185.294 to 185.226 masl.
- Bed level variation along the flow from 179.807 to 179.740 masl.
- Manning's coefficient of roughness 0.017.
- Bed Width 34.138 m.
- Full supply Depth 5.486 m.
- Height of Free board 1.5 m.
- Velocity 1.72 m/s.
- Maximum tailwater level as 185.294 masl.
- Tailwater level at designed discharge i.e. 350 cumec as 184.728 masl.
- Minimum tailwater level as 181.448 masl.

Proposed cross-sections of tailrace are provided in Volume II of the report. Tailwater rating curve is prepared considering the design parameters of the proposed tailrace of powerhouse. Tailwater elevations versus discharge carrying capacity of tailrace d/s of powerhouse are shown in Figure below.

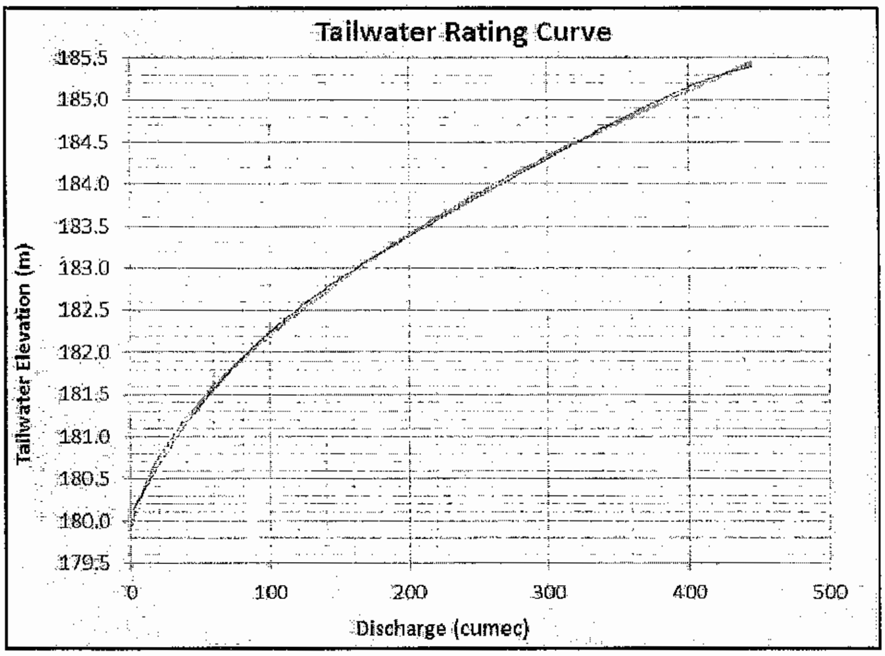


Figure 47: Tailwater Rating Curve

6.2.3. Longitudinal Section of BS Link-I Canal

The Longitudinal Sections have been prepared in FPS as well as SI systems and graphics are attached in Volume II of the report. It is evident from the Longitudinal Section that the headrace channel will be mainly in filling. However, the tailrace channel will mainly be with excavated bed levels.

6.3. Conceptual Design of Spillway

Spillway is provided along the powerhouses in the canal to pass surplus flows that can't pass through the powerhouse. Spillway is designed on the full supply discharge of the canal in that reach so that in case of shut down of powerhouse, the whole water can be passed through the spillway. In addition to provide sufficient capacity, the spillway must be hydraulically and structurally adequate and must be located so that spillway discharges do not erode or undermine the downstream toe of the structure. Energy dissipaters are required to dissipate the energy of the Falling water at the bottom of spillway.

Design of spillway for BS Link-I Hydropower Project has been prepared taking into consideration the various essential factors required for optimal performance of spillway. Outflow characteristics of the spillway are determined by discharges in the canal in the respective reach.

6.3.1. Spillway

For the BS Link-I Hydropower Project, gated broad crested type spillway has been selected. The proposed spillway is designed for 424.75 cumec which is the maximum designed discharge in the respective reach. This flow will take place over broad crested structure made of concrete. Coefficient of discharge, Cd for the broad crested spillway is adopted as 3.09 in FPS. It has four (04) bays each 7.925 m long and has three (03) piers each 0.823 m long. The spillway crest level of 184.578 meter masl has been adopted after a series of trials with higher and lower elevations. Higher crest elevation results in making the clear crest length more than 31.699 m. A number of crest widths have been studied. It has been found that a clear crest length of 31.699 meter (four bays each 7.925-meter-wide and 0.823-meter-wide piers) and broad crested shape is capable of passing the maximum design discharge. The resulted maximum surcharge level is 188.531 meter masl. Upstream chute is provided with slope of 1V to 2H. Width of the crest is provided 2.25 times head on crest to ensure the crest to behave as broad crested. Downstream chute is provided with slope of 1V to 2H. The broad crested spillway is designed according to the following weir formula:

$$q = C_O H_O^{3/2}$$

Where,

q	=	discharge per unit width (Cumec/meter)
Ho	=	total head over the weir (meter)
Co	=	coefficient of discharge

6.3.2. Stilling Basin

When water is released over the spillway, the potential energy is converted into kinetic energy at the base of spillway. This energy must be dissipated in order to prevent the possibility of severe scouring of downstream channel bed and the undermining of foundation which may cause failure of spillway and the project. For this purpose, energy dissipaters are used which perform the energy reduction by converting the hazardous laminar kinetic energy into turbulence, killing the excessive energy over a designed length.

The dissipation of energy has been achieved by means of stilling basin. In the stilling basin, the supercritical flow from the spillway is reduced to sub critical flow by a hydraulic jump. The formation of hydraulic jump in the stilling basin will lead to dissipation of excess energy. Design of stilling basin is also governed by several parameters such as:

1) Nature of foundation,
2) Approach Froude number,
3) Impact angle of flow with respect to stilling basin floor,
4) Tail water level
5) Economic Considerations.

To ensure that a stilling basin performs its function efficiently (i.e. dissipation of energy is carried out properly), basin is designed in such a way that the elevation of tail water depth in the downstream channel will not be much less than the conjugate depth elevation of jump. Otherwise sweep out of the jump from the basin takes place and as a result scouring of downstream canal bed will occur. If the conjugate depth is too low the jump will be drowned. As a result, it will lose its function as an energy dissipater.

Stilling basin has been designed as USBR Type IV basin. For design discharge, the water depth at the end of the chute is 1.04 m and conjugate depth is 5.08 m while the Froude Number before the jump is 3.76. Chute blocks of 2.072 m height, width of 1.036 at a spacing of 2.59 m have been provided at the start of stilling basin to reduce the length of jump. The stilling basin is 25.60 m long. At the end of stilling basin there is proper end sill which is followed by inverted filters. The elevation of the cistern is 179.146 masl. Conceptual drawing of plan and longitudinal section for spillway and stilling basin have been provided in Volume II of the report.

6.4. Conceptual Design of Powerhouse

The longitudinal axis of Powerhouse is parallel to the center line of BS Link-I Canal opposite RD 106+462. The Powerhouse consists of one (01) unit block with a total length of 48.6 m and one unloading /erection bay with a total length of 20.01 m. The unloading /erection bay is located at the right side of Powerhouse.

The Powerhouse in the direction of flow is composed of intake structure, Powerhouse and draft tube. The intake bed elevation is El. 171.590 m. The intake floor elevation varies from El. 183.049 m to El. 171.590 m with a 3 horizontal to 1 vertical slope for the connection to water passage of unit. The fixed trashrack is installed at intake to prevent debris from entering into water passage and turbine.

Stoplog gates operated by upstream hoist are arranged at intake with opening size of 10.01 m× 10.82m. The hoist is arranged on beam at El. 197.727 m. Powerhouse includes gallery, operating floor and superstructure. The turbine center line is at EL. 176.996m, and the access gallery runs through the whole unit blocks for the convenience of inspection and maintenance.

The operating floor is 71.74 m wide and its floor elevation is EL. 185.827 m. The width and height of Powerhouse are decided by unit layout and lifting height of equipment. Railings are provided around the top of turbine pit, and steel cover is provided on top of generator pit. Pressure oil pipe and hydraulic devices are arranged on the operating floor. One bridge crane with a span of 14.86 m is installed in the Powerhouse.

The superstructure includes columns, concrete crane girder and roof steel frame. The track top of bridge crane is at El. 196.127 m. The precast T-shape concrete crane girder is simply supported on brackets of columns.

The draft tube is 22.88 m long. Gates are provided in the draft tube, at 16.09 downstream of unit centerline, which is operated by the hydraulic cylinder on tailrace platform at El.195.139 m. Conceptual drawings of powerhouse with plan, longitudinal section and cross-sections have been provided in Volume II of the report.

6.5. Operation of Existing Irrigation System During Construction

The selected Project Layout is composed of construction of Powerhouse / Spillway in the bypass arrangement. Without interrupting the existing irrigation system, construction of powerhouse, spillway, headrace & tailrace channels will be started. However, the right side existing bank of BS Link-I Canal at start of headrace channel and at end of tailrace channel will be kept under the current status. After completion of construction of powerhouse, spillway, headrace & tailrace channels, in the annual canal closure, right banks of BS Link-I Canal at start of headrace channel and at end of tailrace channel will be removed and plug bunds will be applied in the existing canal to divert the flows towards the proposed powerhouse / spillway through headrace & tailrace channels.

7. POWER AND ENERGY OPTIMIZATION

7.1. General

Power potential and annual energy production at the proposed powerhouse site have been evaluated on daily discharge basis. Discharges from different data series have been considered and used for assessment of energy production. Available head across is computed / observed by different scenarios which will be explained in subsequent sections. Historically observed upstream & downstream gauges' record observed at existing Fall RD 106+250 of BS Link-I Canal have also been used in different scenario to determine water levels on the upstream and downstream side of proposed powerhouse.

The power potential has been computed by using the following basic formula:

$$P = \Upsilon \times Q \times H_{net} \times E_{Overall} / 1000$$

Where

P	=	Power Potential, MW
Υ	=	Unit Weight of Water, 9.81 KN /m^3
Q	=	Design Discharge, cumec
H_{net}	=	Rated Net Head Across, m
		H_{gross} – Losses in powerhouse
H_{gross}	=	Difference of Head Water Level and Tail Water Level
$E_{Overall}$	=	Overall efficiency of the Hydropower Project
	=	$E_{turbine} \times E_{gearbox} \times E_{generator}$
$E_{turbine}$	=	91%
$E_{gearbox}$	=	98.5%
$E_{generator}$	=	96%
$E_{Overall}$	=	86.06%

7.2. Selection of Turbine Type

Turbine design discharge and rated net head across are the main factors for the selection of type of turbines. Following two types of turbine have been considered:

- Horizontal Pit Type Kaplan Turbine
- Bulb Type Kaplan Turbine

Generally, Pit type turbine has the following advantages:

- Pit type turbine has an open-topped arrangement, permitting easy access to the generator for repairs and maintenance;

- ➢ The runner can be removed for maintenance without removing the generator in pit turbine unit;
- ➢ As the discharge and head across and range of the site are on the lower side, speed of the turbine becomes considerably low. To keep the generator size within reasonable limits, a speed increaser for the generator is required. This can only be utilized by selecting the pit turbine unit;
- ➢ Low cost high speed generator;

Based on the above mentioned advantages and recent experience of using Pit type turbine in four (04) low head hydropower projects in Punjab (Marala, Pakpattan, Chianwali & Deg OutFall HPPs), turbine type is selected as "Horizontal Pit Type Kaplan Turbine" for further considerations in the study

7.3. Selection of Design Discharge For Powerhouse

For selection of design discharge of the powerhouse, following basic aspects have been considered:

- ➢ Power Potential at Different Discharges;
- ➢ Availability of Selected Design Discharge.

7.3.1. Power Potential at Different Discharges

Different discharges have been considered and related gross head have been calculated by keeping head water level as constant and related tailwater levels from tail water rating curve.

Table - 13: Power Potential at Different Discharges

Different Discharges		HWL	TWL	Gross Head	Estimated Losses	Available Net Head	Overall Efficiency	Power Potential
cumec	cusec	m	m	m	m	m	%	MW
50	1766	188.531	181.401	7.129	0.473	**6.657**	86.06%	2.81
100	3531	188.531	182.203	6.327	0.420	**5.908**	86.06%	4.99
150	5297	188.531	182.841	5.690	0.377	**5.313**	86.06%	6.73
200	7063	188.531	183.387	5.143	0.341	**4.802**	86.06%	8.11
250	8829	188.531	183.875	4.656	0.309	**4.347**	86.06%	9.18
300	10594	188.531	184.318	4.212	0.279	**3.933**	86.06%	9.96
325	11477	188.531	184.527	4.003	0.265	**3.738**	86.06%	10.26
350	12360	188.531	184.728	3.802	0.252	**3.550**	86.06%	10.49
375	13243	188.531	184.923	3.608	0.252	**3.356**	86.06%	10.62
381	13455	188.531	184.969	3.562	0.252	**3.310**	86.06%	10.65
400	14126	188.531	185.111	3.419	0.252	**3.167**	86.06%	10.70
425	15009	188.531	185.294	3.237	0.252	**2.984**	86.06%	10.71

It can be seen from above mentioned table that as the discharge increases, gross head inversely decreases considerably and thus the net head also decreases. Reasonable conservative values of head losses have been considered to compute net head from gross head. It is observed that discharges above 350 cumec, increment in power potential is relatively small and hence design discharge of powerhouse is selected as 350 cumec.

7.3.2. Availability of Selected Design Discharge

Selected design discharge value (350 cumec) has been checked on flow duration curve of different data series and found as following:

Post Tarbela Data Series (1978 - 2015) = 12 %

Post WAA Data Series (1991 - 2015) = 15 %

Post Remodeling Data Series (2006 - 2015) = 31 %

Based on the most important data series i.e. Post Remodeling Data Series, it is concluded that selected design discharge will be available for about 31% time of the year.

7.4. Optimization of Turbine Size

After selection of design discharge of powerhouse as 350 cumec, for selection of number & sizes of units, a commercial software "TURBNPRO" has been used. It is based on general characteristics of typical of turbines and industry accepted design formulas. The software is commonly used on feasibility level design of different feasibility studies. Three considerations i.e. two (02) turbines, three (03) turbines and four (04) turbines have been considered to evaluate. By use of TURBNPRO, following is the used input & output data:

Table - 14: Input & Output Data of Turbnpro

Design Discharge of Powerhouse		**350**			**m^3/sec**
No. of Turbines	**No.**	**2**	**3**	**4**	**No.**
Head Water Level of Powerhouse	H1	188.536	188.536	188.536	m
Bed Level Just U/S of Powerhouse	H2	183.049	183.049	183.049	m
Maximum TWL	T1	185.303	185.303	185.303	m
Design TWL	T2	184.795	184.795	184.795	m
Minimum TWL	T3	181.442	181.096	180.896	m
Bed Level Just D/S of Powerhouse	T4	179.817	179.817	179.817	m

Design Discharge of Powerhouse		**350**			**m^3/sec**
No. of Turbines	**No.**	**2**	**3**	**4**	**No.**
Diameter Provided by Manufacturer		5.100	4.200		
Input Data for Turbn Pro-3.0					
Rated Discharge (in cumec)		175.00	116.67	87.50	m^3/sec
Net Head at Rated Discharge (in meters)		3.51	3.51	3.51	m
Site Gross Head (in meters)		7.09	7.44	7.64	m
Site Elevation (in meters)	NSL	187.00	187.00	187.00	m
Water Temperature (in degrees C)		25.00	25.00	25.00	C°
Efficiency Priority at Maximum Output		9.00	9.00	9.00	
Ratio of Rated Head to Best Eff. Head		1.00	1.00	1.00	
System Frequency		50.00	50.00	50.00	MHz
Minimum Net Head (in meters)		3.04	3.04	3.04	m
Output Data for Turbn Pro-3.0					
Output Parameters:					
No. of Solutions to Select Anyone :					
Diameter		6.707	5.477	4.766	m
Unit Speed		50	61.2	69.8	rpm
Specific Speed		774	774	764	
Centre Line Setting		4.20	4.20	4.4	m
Preliminary Output		5535	3690	2767	KW
Configuration		Pit Type ------ Kaplan			
Turbine Performance Data (Typical):					
Efficiency		95	94.9	94.8	%
Power		5.724	5.552	2.856	MW
Runner Diameter		6.707	5.477	4.766	m
Speed		50	61.2	69.8	rpm
Runner Centre Line to TWL		-5.3	-4.4	-3.9	m
Specific Speed under Rated Net Head		787.4	786.8	776.1	

Design Discharge of Powerhouse		350			m³/sec
No. of Turbines	**No.**	**2**	**3**	**4**	**No.**
Turbine Dimensional Data (Typical):					
Runner Diameter	Dia	6.707	5.477	4.766	m
Generator Enclosed in Pit:					
Inlet Width	m1	14.08	11.50	10.01	m
Inlet Height	m2	15.22	12.43	10.82	m
Pit Width (Generator Chamber Outer Width)	m3	6.04	4.93	4.29	m
Pit Length (Length from "Start of Generator Chamber" to Turbine Axis)	m4	18.11	14.79	12.87	m
Generator Chamber Inner Width (Support Width)	m5	3.76	3.07	2.67	m
Water Passage Width on Each Side of Generator Chamber		4.02	3.29	2.86	m
Draft Tube Parameters:					
Length of Draft Tube	m11	32.19	26.29	22.88	m
Draft Tube Exit Width	m12	14.08	11.50	10.01	m
Draft Tube Exit Height	m13	10.06	8.22	7.15	m
Discharge Cone Length	m14	13.41	10.95	9.53	m
Velocity at Draft tube Exit		1.23	1.23	1.22	m/sec
Setting (Water Passage)		-5.300	-4.40	-3.900	m
Different Elevations of Structure					
Selected Turbine Axis	G1	176.142	176.696	176.996	m
Selected Bottom EL. of Intake / Generator Chamber	G2	168.53	170.48	171.59	m
Selected Top EL. of Intake / Generator Chamber	G3	183.75	182.91	182.41	m
Centre EL. of Intake / Generator Chamber		176.142	176.696	176.996	m
Distance between Min TWL & DT Exit Top		0.800	0.700	0.600	
Selected Bottom EL. of Draft tube Exit	D1	170.582	172.176	173.146	m
Selected Top EL. of Draft tube Exit	D2	180.642	180.396	180.296	m
Centre EL. of Draft tube Exit	D3	175.612	176.286	176.721	m

Design Discharge of Powerhouse				**350**		**m³/sec**
No. of Turbines	**No.**		**2**	**3**	**4**	**No.**
Draft tube Portion Above Turbine Axis			4.500	3.700	3.300	
Draft tube Portion Below Turbine Axis			5.560	4.520	3.850	

All the three options about turbine numbering are considered in depth based on the following factors:

- Quantities & cost of the option;
- Weight of individual largest parts and the related design changes;
- Minimum utilizing capacity of flows;
- Maintenance Ease.

Based on the above factors, evaluation has been done carefully and concluded to proceed with four (04) number turbines.

7.5. Availability of Discharges

As described previously, different data series for daily discharges have been considered which will now be used for computation of annual energy production:

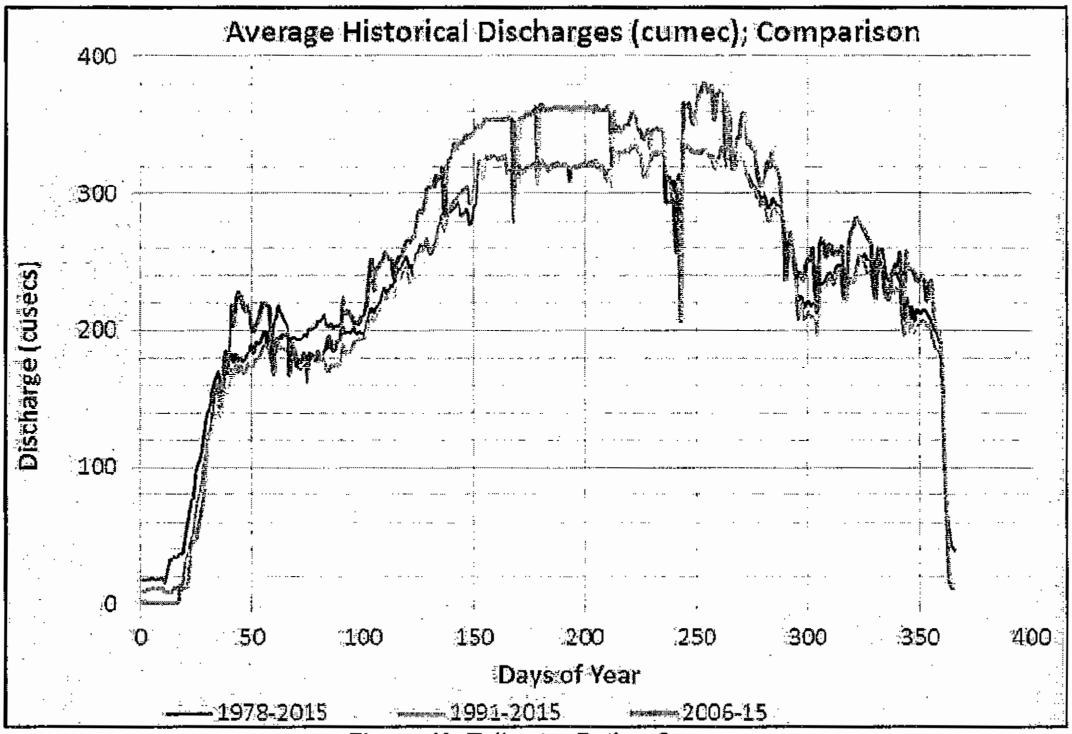


Figure 48: Tailwater Rating Curve

Average annual energy calculations will be carried out for the following data series:

- Average annual energy calculations based on post Tarbela data series;
- Average annual energy calculations based on post WAA data series;
- Average annual energy calculations based on post Remodeling data series.

7.6. Availability of Head Across

The gross head across for the proposed powerhouse depends on the difference of Head Water Level (HWL) and Tailwater Level (TWL). Broadly speaking, the tailwater level (TWL) in downstream reach of powerhouse is not controlled however, the head water Levels (HWL) in upstream reach of powerhouse can be controlled, depends on the operation of canal reach upstream of powerhouse. It is quite obvious that as higher are the head water level, more will the power & energy production.

Net Head Across, H_{net} = H_{gross} – Losses in powerhouse

Where, H_{gross} = Difference of HWL and TWL

Following scenarios have been considered for determinations of head and tail water levels:

Table - 15: Scenarios for Development of HWL & TWL

Sr. No.	Head Water Levels	Tailwater Levels
1	Maximum Designed Head Water Level	Tailwater Rating Curve
2	Maximum Designed Head Water Level	Tailwater Rating Curve
3	Maximum Designed Head Water Level	Tailwater Rating Curve
4	Post Remodeling Series	Tailwater Rating Curve

7.6.1. Head Losses in Powerhouse Structure

Following types of head losses in the powerhouse have been considered which will be subtracted from the gross head corresponding to the specific daily discharge:

A. Losses on Upstream of Powerhouse (PH):

i. Entrance Loss due to Contraction (from Headrace to Upstream Approach of PH)
ii. Slope Loss in Upstream Approach of Powerhouse (due to friction)
iii. Entrance Loss due to Contraction (from Upstream Approach to Intake Bay of PH)
iv. Trashrack Loss
v. Entrance Loss due to Vertical Contraction (at start of pressurized flow)
vi. Loss due to Misc. Uncounted Factors (max. of the above 5 number Losses)

B. Losses on Downstream of Powerhouse (PH):

vii. Exit Loss due to Expansion (from Downstream Exit of PH to tailrace)
viii. Slope Loss (from Outlet Bay to Downstream Exit of PH)
ix. Exit Loss due to Expansion (from Draft Tube to Outlet Bay)

7.6.2. Development of Scenarios

For computation of average annual energy, following scenarios will be considered:

Table - 16: Scenarios for Average Annual Energy

<table>
<tr><th>Sr. No.</th><th>Average Daily Discharges</th><th>Head Water Levels</th><th>Tailwater Levels</th><th>No. of Turbines</th></tr>
<tr><td>1</td><td rowspan="3">Post Tarbela Series</td><td rowspan="9">Maximum Designed Head Water Level</td><td rowspan="9">Tailwater Rating Curve</td><td>2</td></tr>
<tr><td>2</td><td>3</td></tr>
<tr><td>3</td><td>4</td></tr>
<tr><td>4</td><td rowspan="3">Post WAA Series</td><td>2</td></tr>
<tr><td>5</td><td>3</td></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>7</td><td rowspan="3">Post Remodeling Series</td><td>2</td></tr>
<tr><td>8</td><td>3</td></tr>
<tr><td>9</td><td>4</td></tr>
<tr><td>10</td><td rowspan="3">Post Remodeling Series</td><td rowspan="3">Post Remodeling Series</td><td rowspan="3">Tailwater Rating Curve</td><td>2</td></tr>
<tr><td>11</td><td>3</td></tr>
<tr><td>12</td><td>4</td></tr>
</table>

7.6.2.1. Scenario No. 1:

In this scenario, discharges have been considered based on "Post Tarbela Data Series" comprising of average of flows between 1978 to 2015 at Fall RD 106+250 of BS Link-I Canal with two (02) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 334.52 cumec. Head water level of powerhouse throughout the year is considered constant as the maximum designed level i.e. 188.531 masl whereas, tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 7.083 m to 3.237 m, whereas net head across limits are 7.044 m to 2.938 m. Two (02) number turbines are considered, each with design discharge 175 cumec, minimum operating discharge has been considered as 52.50 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 73.15 GWh with the plant factor of 79.61%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E. Operation of selected turbine at different discharges is shown as follows:

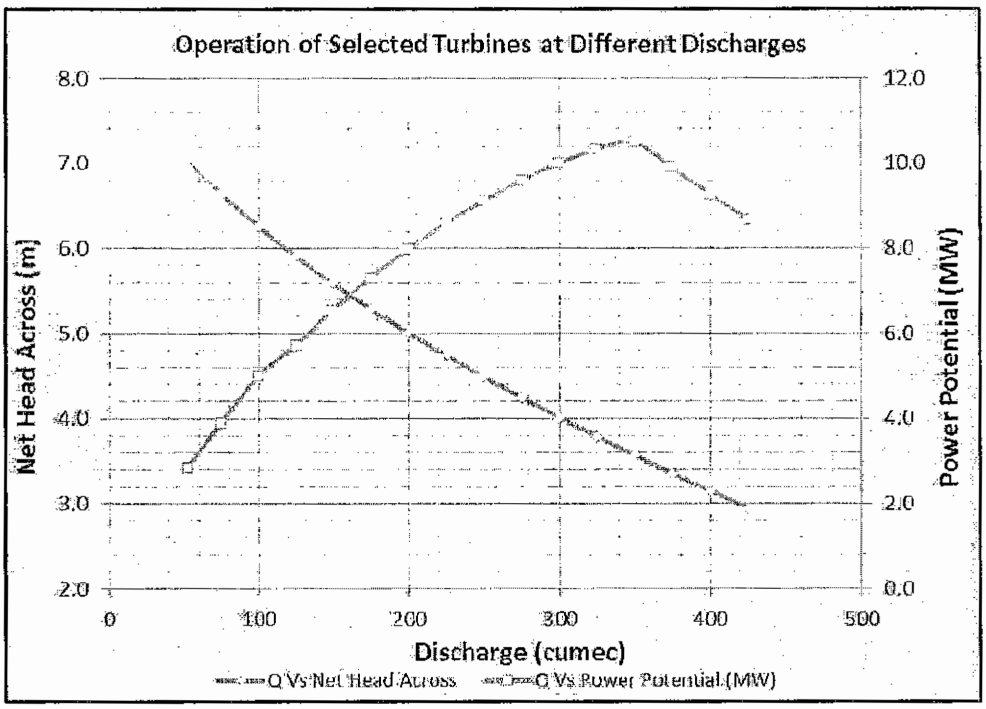


Figure 49: Turbine Operation at Different Discharges (S-1)

Annual energy production w.r.t. available daily discharges have been shown as follows:

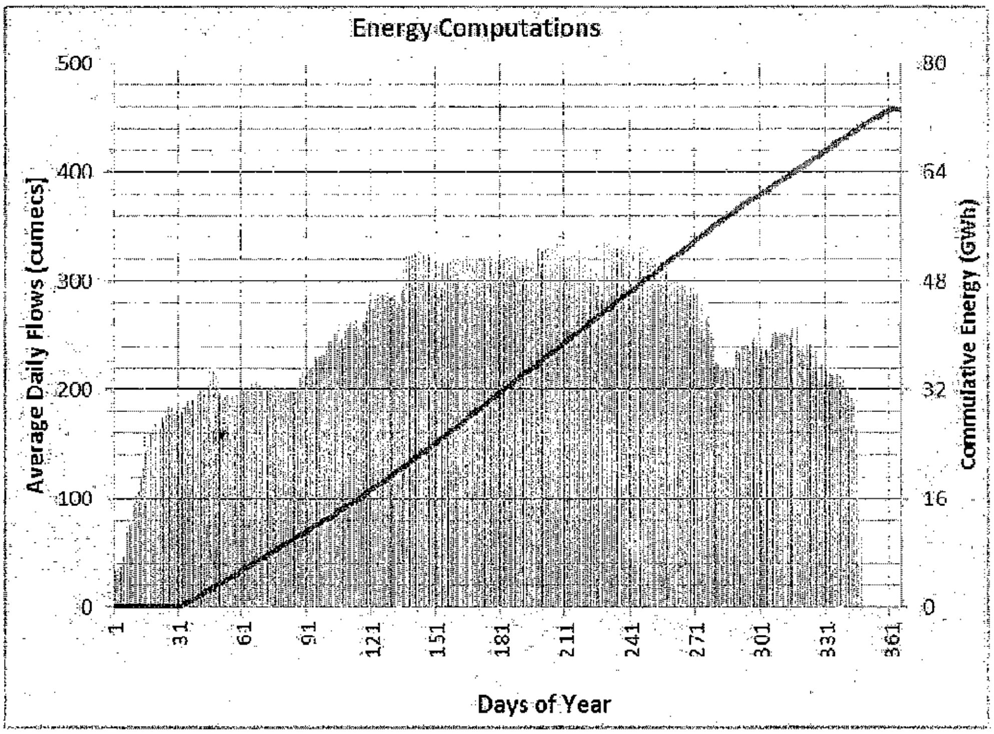


Figure 50: Average Annual Energy w.r.t Daily Discharges (S-1)

7.6.2.2. Scenario No. 2

In this scenario, discharges have been considered based on "Post Tarbela Data Series" comprising of average of flows between 1978 to 2015 at Fall RD 106+250 of BS Link-I Canal with three (03) turbines. Annual canal closure is considered according to the distributed annual canal closure program, i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 334.52 cumec. Head water level of powerhouse throughout the year is considered constant as the maximum designed level i.e. 188.531 m whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 7.433 m to 3.237 m whereas net head across limits are 7.399 m to 2.879 m. Three (03) number turbines are considered, each with design discharge 116.67 cumec, minimum operating discharge has been considered as 35.0 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 66.05 GWh with the plant factor of 71.88%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E. Operation of selected turbine at different discharges has been showed as following:

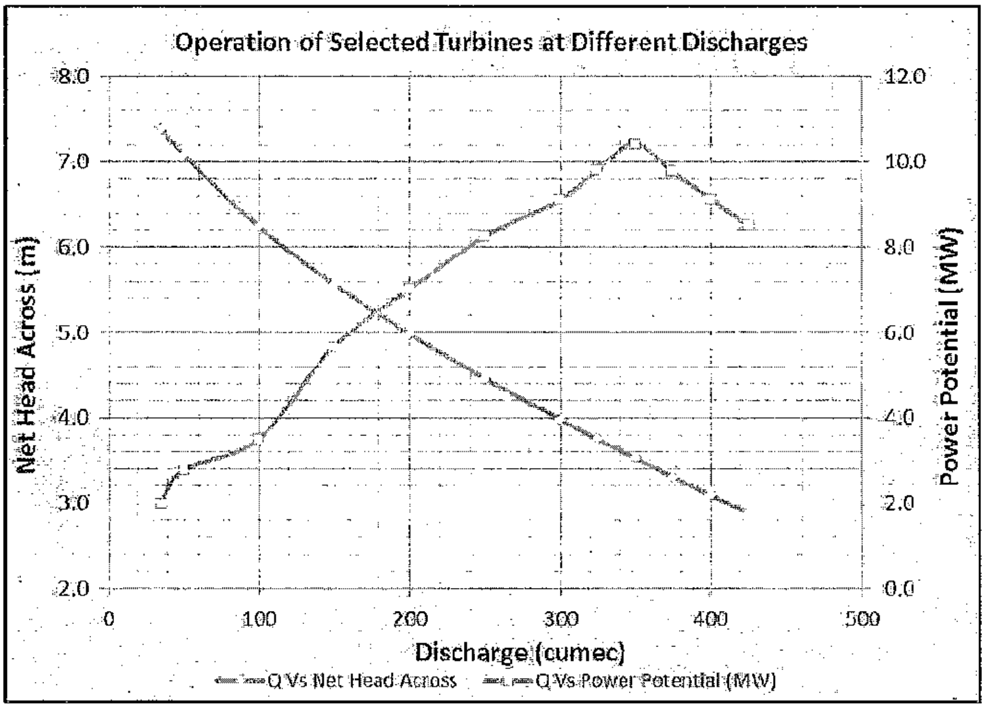


Figure 51: Turbine Operation at Different Discharges (S-2)

Annual energy production w.r.t. available daily discharges have been shown as follows:

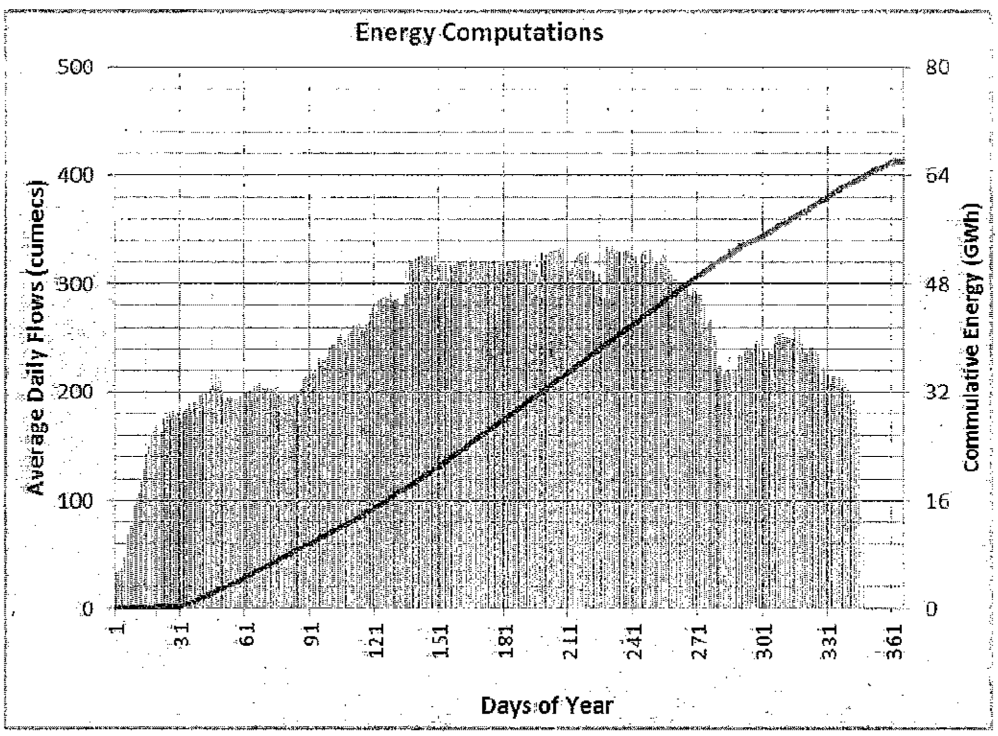


Figure 52: Average Annual Energy w.r.t Daily Discharges (S-2)

7.6.2.3. Scenario No. 3

In this scenario, discharges have been considered based on "Post Tarbela Data Series" comprising of average of flows between 1978 to 2015 at Fall RD 106+250 of BS Link-I Canal with four (04) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 334.52 cumec. Head water level of powerhouse throughout the year is considered constant as the maximum designed level i.e. 188.531 m whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 7.635 m to 3.237 m whereas net head across limits are 7.602 m to 2.799 m. Four (04) number turbines are considered, each with design discharge 87.50 cumec, minimum operating discharge has been considered as 26.25 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 65.26 GWh with the plant factor of 71.02%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E. Operation of selected turbine at different discharges has been showed as follows:

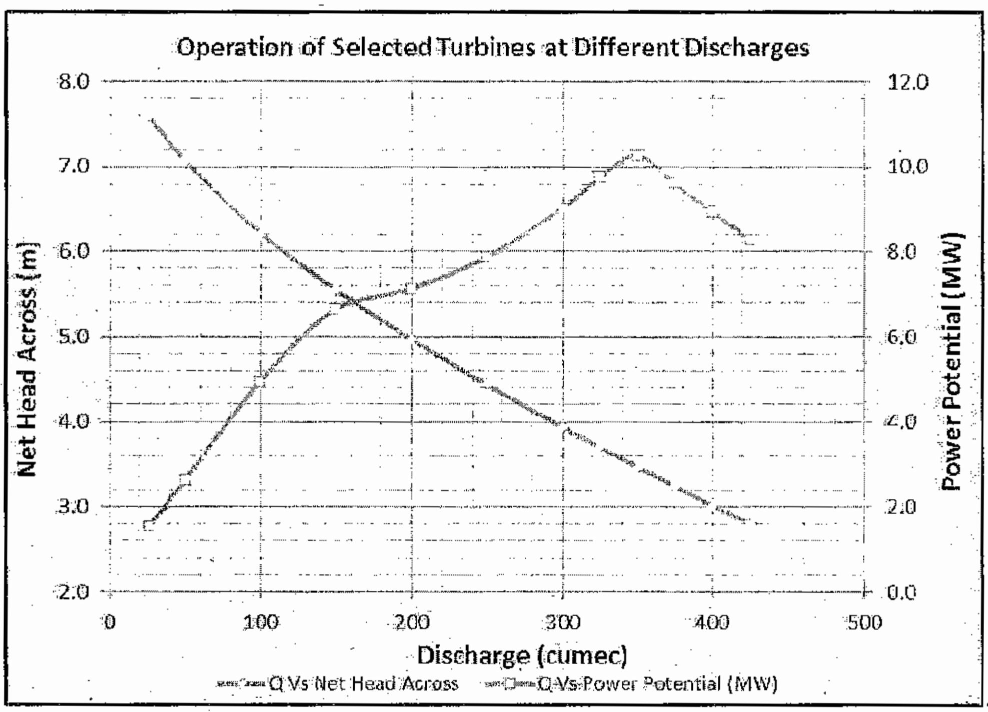


Figure 53: Turbine Operation at Different Discharges (S-3)

Annual energy production w.r.t. available daily discharges have been shown as follows:

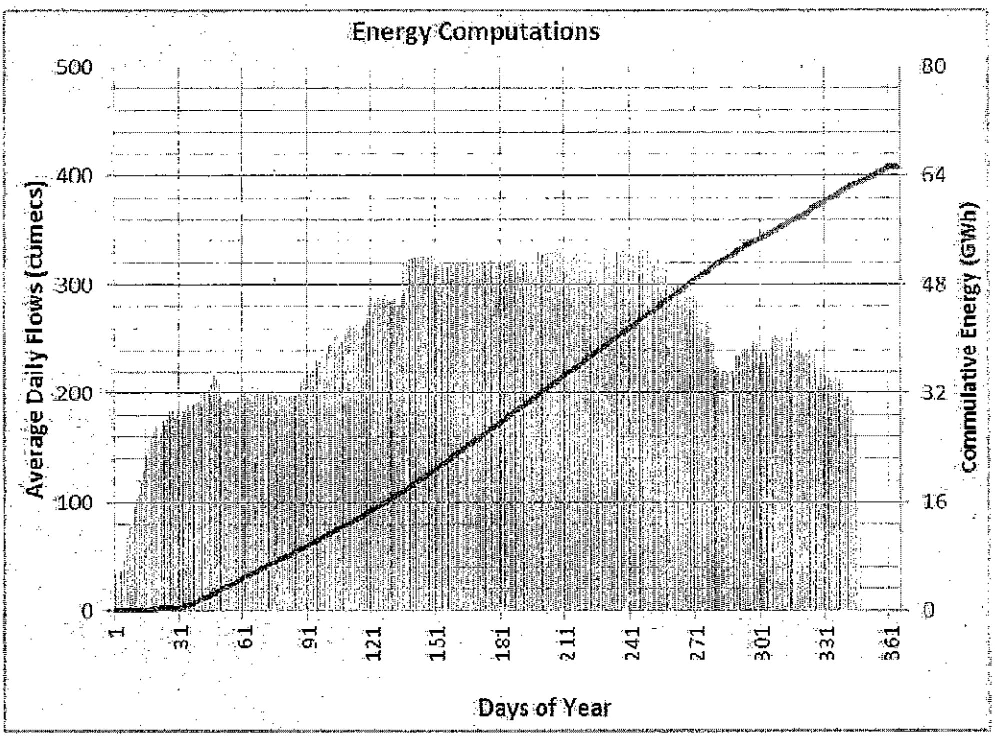


Figure 54: Average Annual Energy w.r.t Daily Discharges (S-3)

7.6.2.4. Scenario No. 4

In this scenario, discharges have been considered based on "Post WAA Data Series" comprising of average of flows between 1991 to 2015 at Fall RD 106+250 of BS Link-I Canal with two (02) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 336.24 cumec. Head water level of powerhouse throughout the year is considered constant as the maximum designed level i.e. 188.531 m whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 7.083 m to 3.237 m whereas net head across limits are 7.044 m to 2.938 m. Two (02) number turbines are considered, each with design discharge 175 cumec, minimum operating discharge has been considered as 52.50 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 71.77 GWh with the plant factor of 78.10%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E. Operation of selected turbine at different discharges has been showed as following:

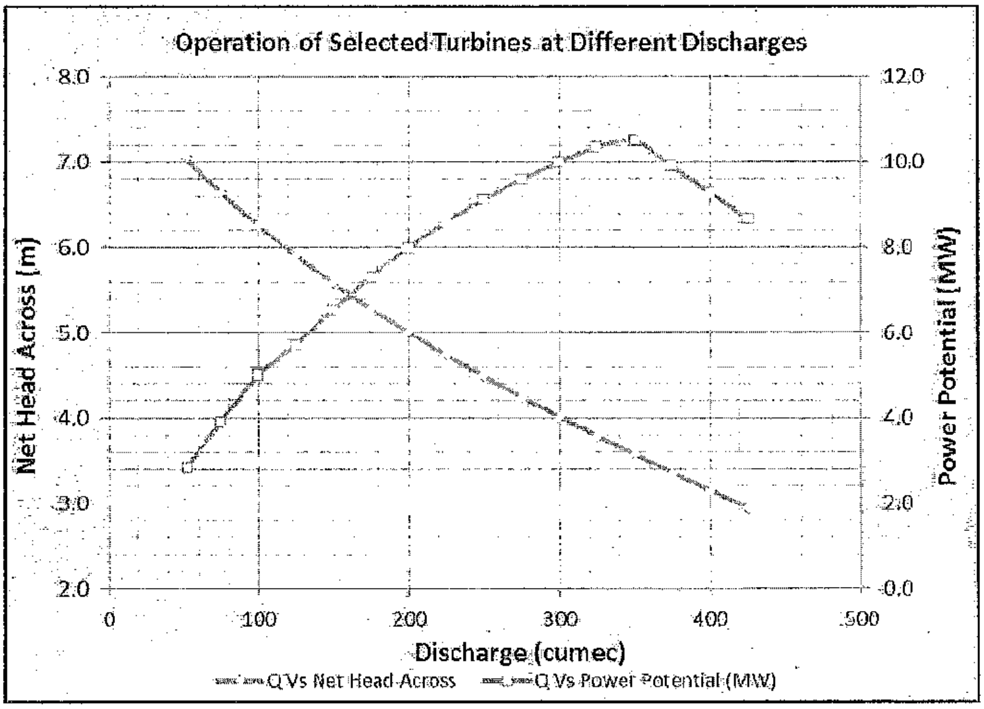


Figure 55: Turbine Operation at Different Discharges (S-4)

Annual energy production w.r.t. available daily discharges have been shown as following:

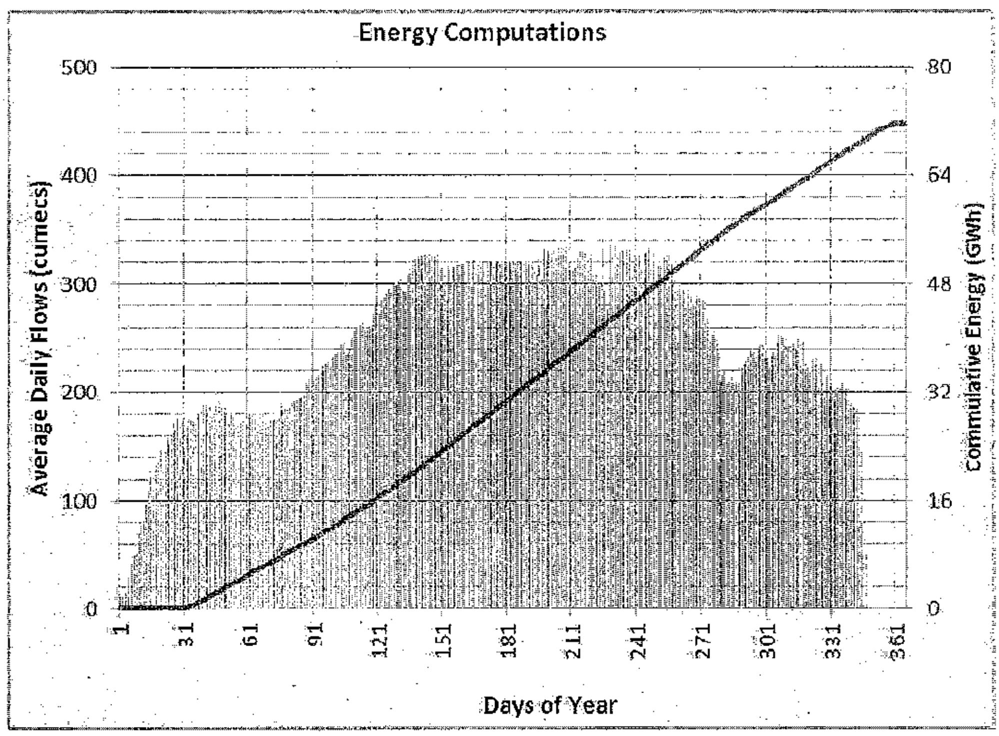


Figure 56: Average Annual Energy w.r.t Daily Discharges (S-4)

7.6.2.5. Scenario No. 5

In this scenario, discharges have been considered based on "Post WAA Data Series" comprising of average of flows between 1991 to 2015 at Fall RD 106+250 of BS Link-I Canal with three (03) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 336.24 cumec. Head water level of powerhouse throughout the year is considered constant as the maximum designed level i.e. 188.531 m whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 7.433 m to 3.237 m whereas net head across limits are 7.399 m to 2.879 m. Three (03) number turbines are considered, each with design discharge 116.67 cumec, minimum operating discharge has been considered as 35.0 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 64.58 GWh with the plant factor of 70.28%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E. Operation of selected turbine at different discharges has been showed as follows:

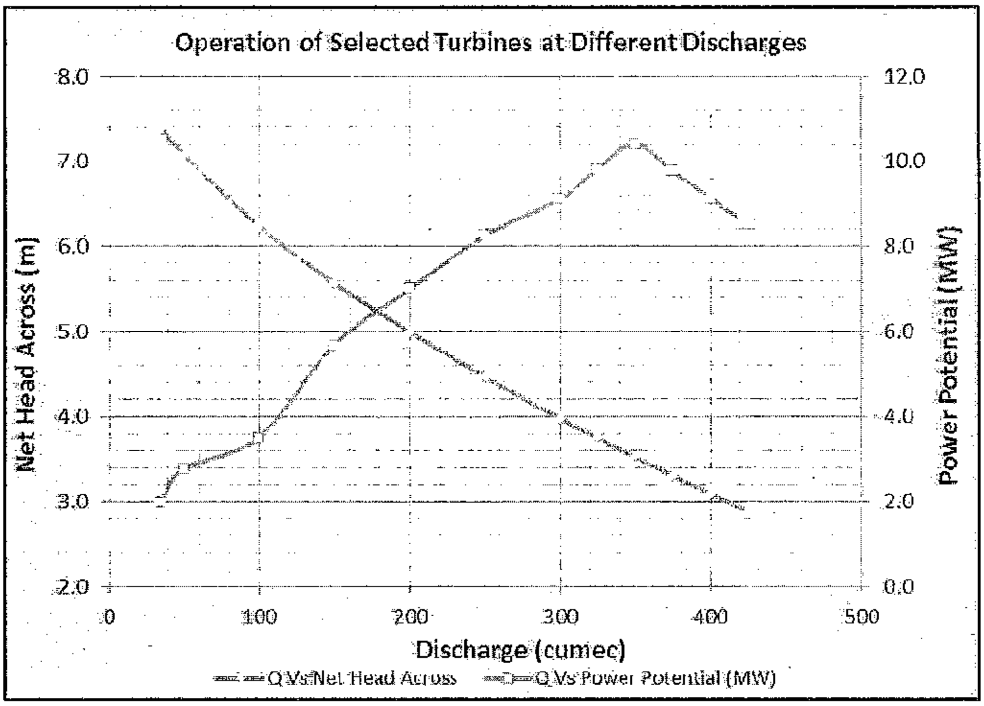


Figure 57: Turbine Operation at Different Discharges (S-5)

Annual energy production w.r.t. available daily discharges have been shown as following:

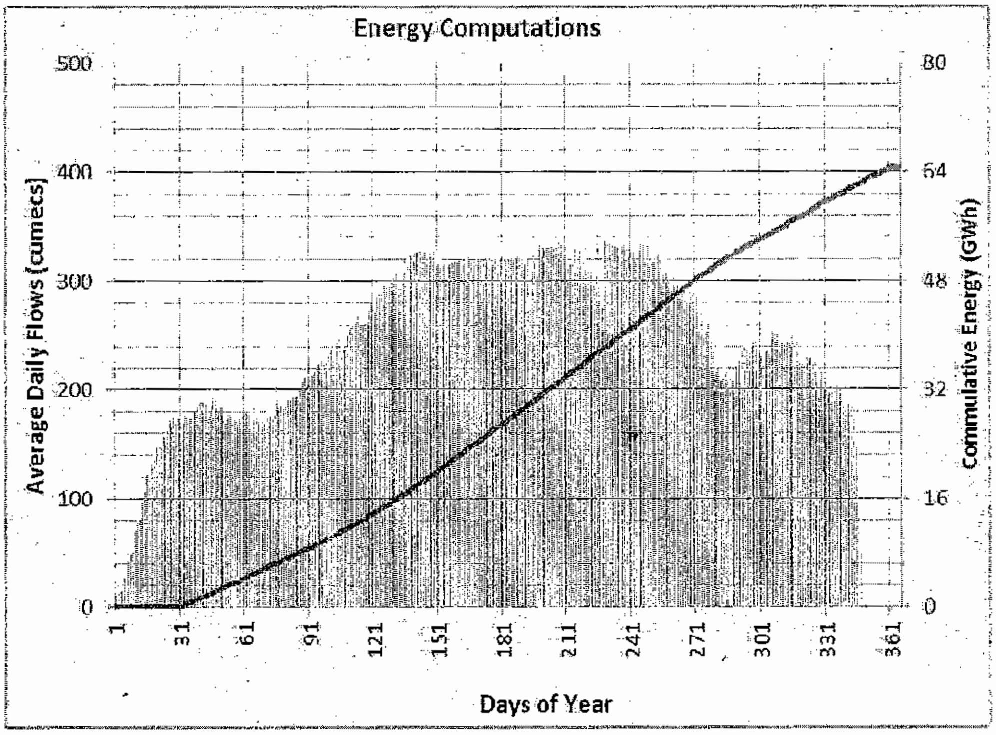


Figure 58: Average Annual Energy w.r.t Daily Discharges (S-5)

7.6.2.6. Scenario No. 6

In this scenario, discharges have been considered based on "Post WAA Data Series" comprising of average of flows between 1991 to 2015 at Fall RD 106+250 of BS Link-I Canal with four (04) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 336.24 cumec. Head water level of powerhouse throughout the year is considered constant as the maximum designed level i.e. 188.531 m whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 7.635 m to 3.237 m whereas net head across limits are 7.602 m to 2.799 m. Four (04) number turbines are considered, each with design discharge 87.5 cumec, minimum operating discharge has been considered as 26.25 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 63.68 GWh with the plant factor of 69.30%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E. Operation of selected turbine at different discharges has been showed as follows:

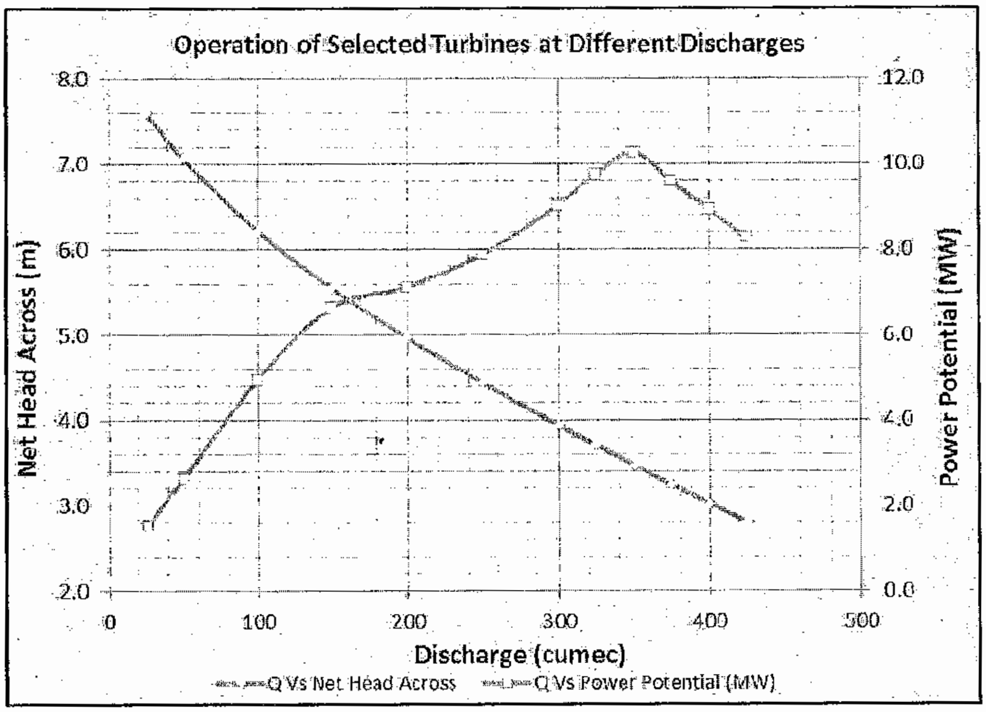


Figure 59: Turbine Operation at Different Discharges (S-6)

Annual energy production w.r.t. available daily discharges have been shown as following:

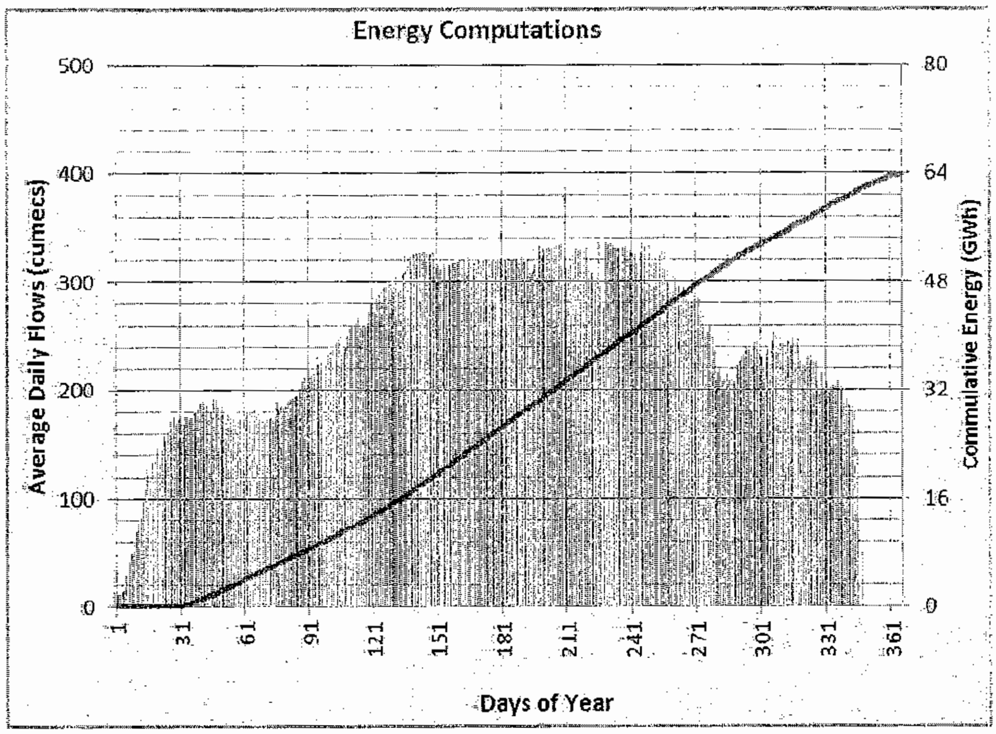


Figure 60: Average Annual Energy w.r.t Daily Discharges (S-6)

7.6.2.7. Scenario No. 7

In this scenario, discharges have been considered based on "Post Remodeling Data Series" comprising of average of flows between 2006 to 2015 at Fall RD 106+250 of BS Link-I Canal with two (02) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 380.10 cumec. Head water level of powerhouse throughout the year is considered constant as the maximum designed level i.e. 188.531m whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 7.083 m to 3.237m whereas net head across limits are 7.044 m to 2.938 m. Two (02) number turbines are considered, each with design discharge 175 cumec, minimum operating discharge has been considered as 52.50 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 74.14 GWh with the plant factor of 80.68%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E. Operation of selected turbine at different discharges has been showed as follows:

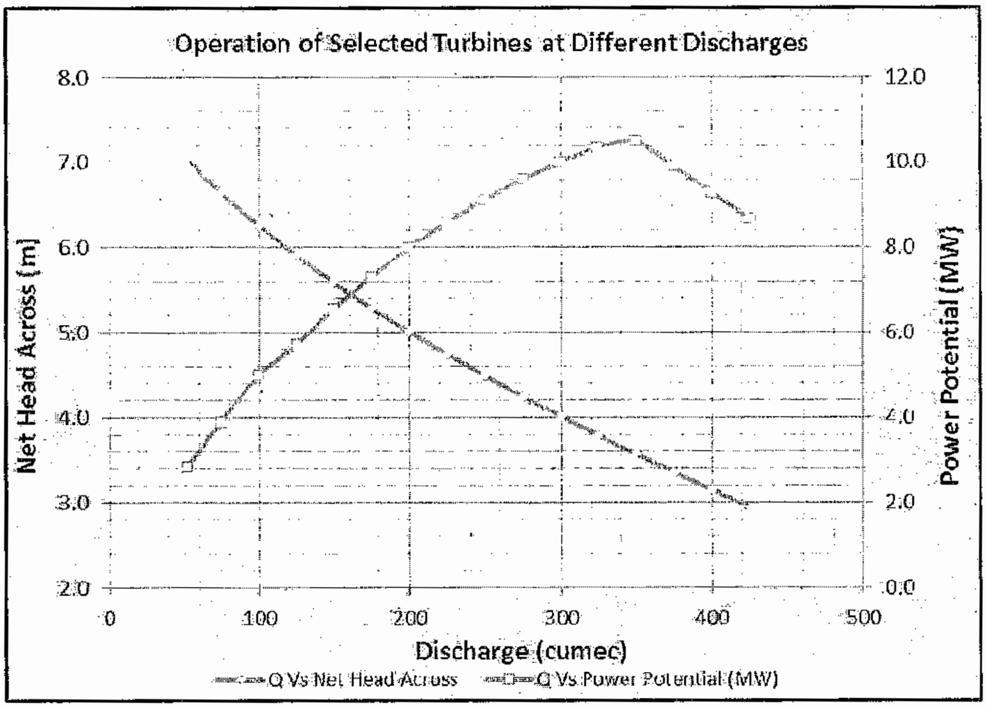


Figure 61: Turbine Operation at Different Discharges (S-7)

Annual energy production w.r.t. available daily discharges have been shown as following:

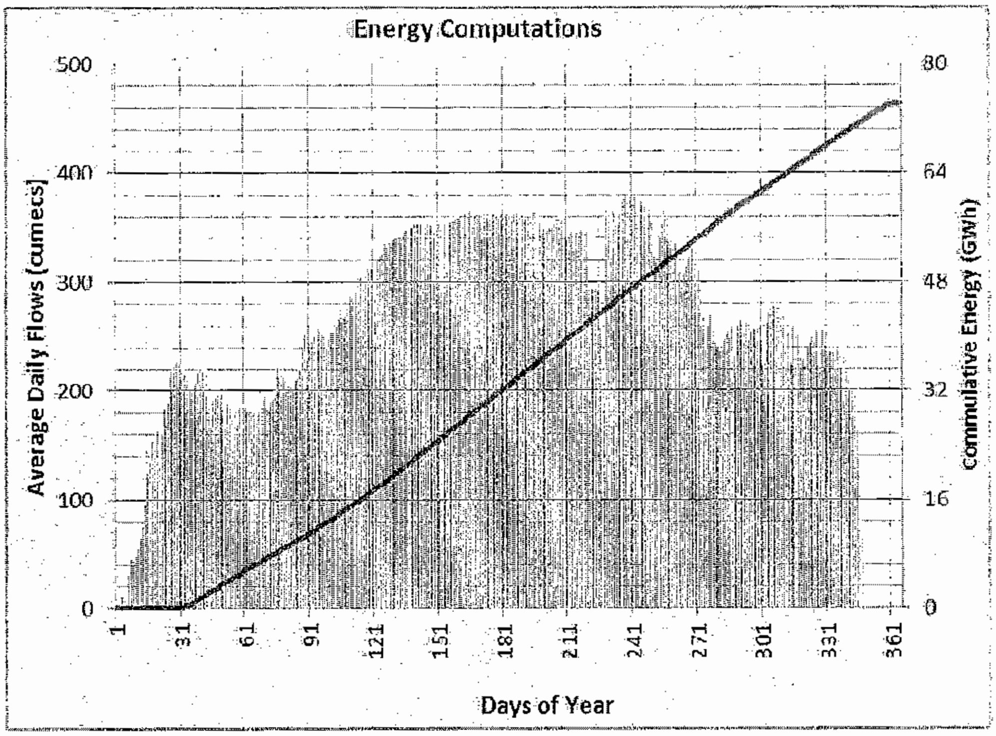


Figure 62: Average Annual Energy w.r.t Daily Discharges (S-7)

7.6.2.8. Scenario No. 8

In this scenario, discharges have been considered based on "Post Remodeling Data Series" comprising of average of flows between 2006 to 2015 at Fall RD 106+250 of BS Link-I Canal with three (03) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 380.10 cumec. Head water level of powerhouse throughout the year is considered constant as the maximum designed level i.e. 188.531 m whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 7.433 m to 3.237 m whereas net head across limits are 7.399 m to 2.879 m. Three (03) number turbines are considered, each with design discharge 116.67 cumec, minimum operating discharge has been considered as 35.0 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 68.45 GWh with the plant factor of 74.49%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E. Operation of selected turbine at different discharges has been showed as follows:

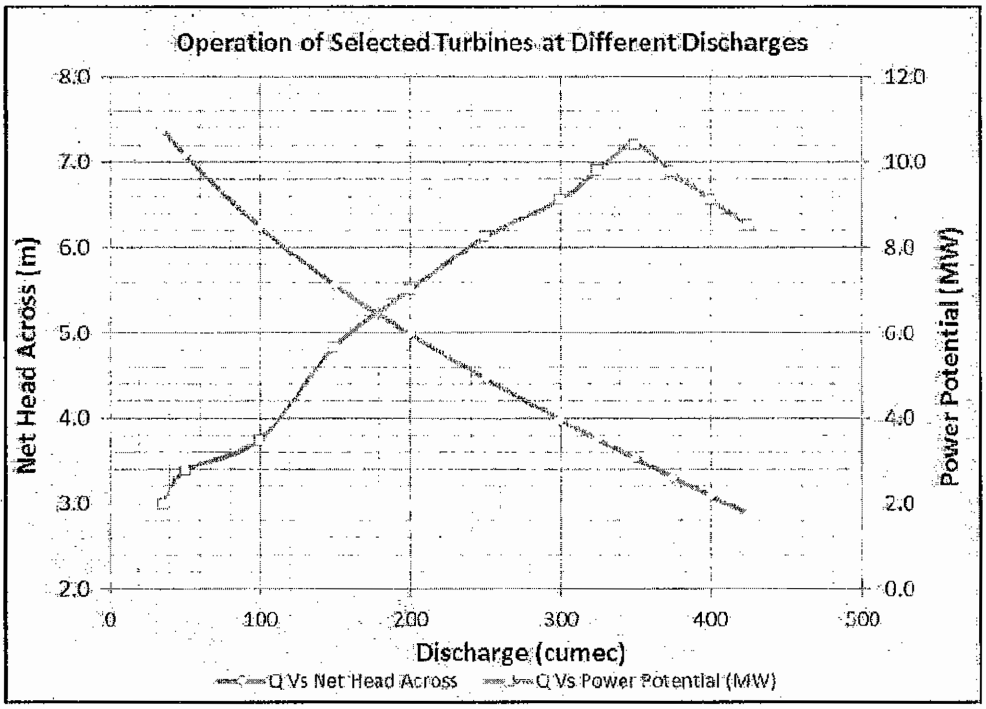


Figure 63: Turbine Operation at Different Discharges (S-8)

Annual energy production w.r.t. available daily discharges have been shown as following:

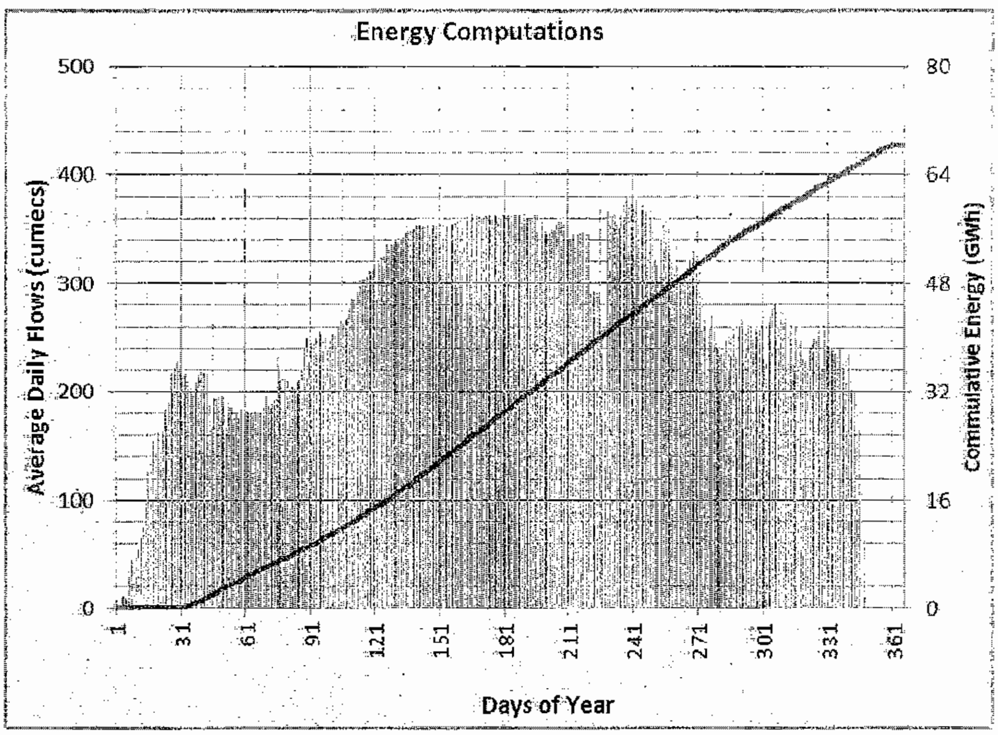


Figure 64: Average Annual Energy w.r.t Daily Discharges (S-8)

7.6.2.9. Scenario No. 9

In this scenario, discharges have been considered based on "Post Remodeling Data Series" comprising of average of flows between 2006 to 2015 at Fall RD 106+250 of BS Link-I Canal with four (04) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 380.10 cumec. Head water level of powerhouse throughout the year is considered constant as the maximum designed level i.e. 188.531 m whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 7.635 m to 3.237 m whereas net head across limits are 7.602 m to 2.799 m. Four (04) number turbines are considered, each with design discharge 87.5 cumec, minimum operating discharge has been considered as 26.25 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 67.29 GWh with the plant factor of 73.23%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E. Operation of selected turbine at different discharges has been showed as follows:

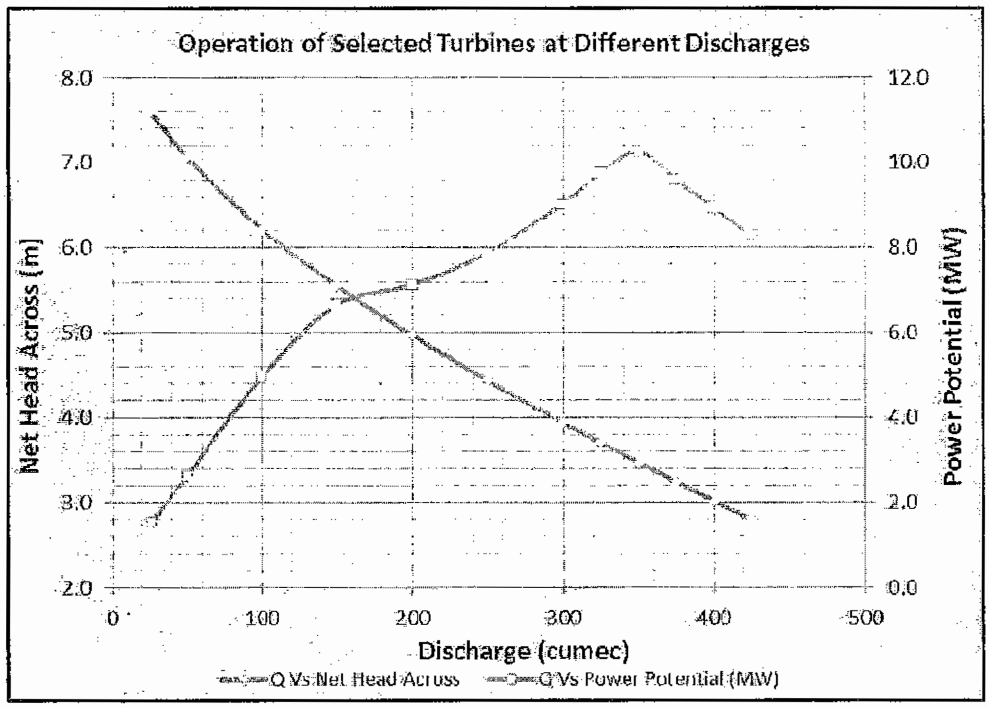


Figure 65: Turbine Operation at Different Discharges (S-9)

Annual energy production w.r.t. available daily discharges have been shown as following:

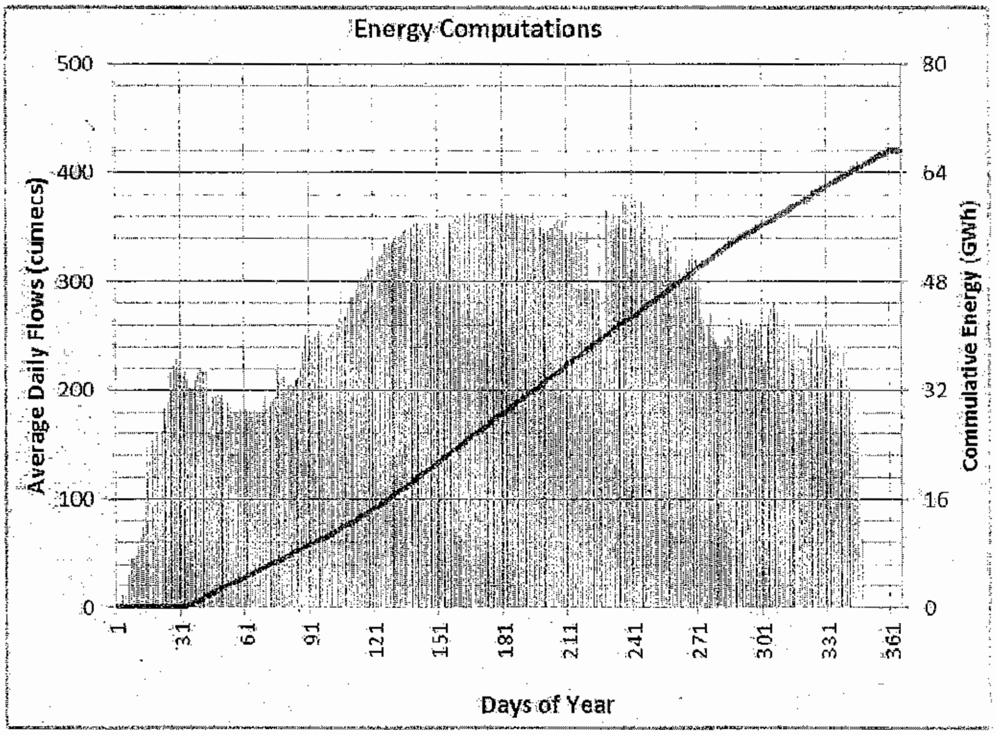


Figure 66: Average Annual Energy w.r.t Daily Discharges (S-9)

7.6.2.10. Scenario No. 10

In this scenario, discharges have been considered based on "Post Remodeling Data Series with Actual Upstream Water Levels" comprising of average of flows between 2006 to 2015 at Fall RD 106+250 of BS Link-I Canal and average water levels upstream powerhouse associated in this data series (fluctuates between 187.60 m to 184.60 m) with two (02) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 380.10 cumec. Head water level of powerhouse throughout the year is considered variable between 187.60 m to 184.60 m based on average water levels from 2006 - 2015 whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 3.67 m to 2.45 m whereas net head across limits are 3.63 m to 2.21 m. Two (02) number turbines are considered, each with design discharge 175 cumec, minimum operating discharge has been considered as 52.5 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 47.04 GWh with the plant factor of 51.19%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E.

7.6.2.11. Scenario No. 11

In this scenario, discharges have been considered based on "Post Remodeling Data Series with Actual Upstream Water Levels" comprising of average of flows between 2006 to 2015 at Fall RD 106+250 of BS Link-I Canal and average water levels upstream powerhouse associated in this data series (fluctuates between 187.60 m to 184.60 m) with three (03) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 380.10 cumec. Head water level of powerhouse throughout the year is considered variable between 187.60 m to 184.60 m based on average water levels from 2006 - 2015 whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 3.77 m to 2.45 m whereas net head across limits are 3.73 m to 2.16 m. Three (03) number turbines are considered, each with design discharge 116.67 cumec, minimum operating discharge has been considered as 35.0 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 47.05 GWh with the plant factor of 51.21%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E.

7.6.2.12. Scenario No. 12

In this scenario, discharges have been considered based on "Post Remodeling Data Series with Actual Upstream Water Levels" comprising of average of flows between 2006 to 2015 at Fall RD 106+250 of BS Link-I Canal and average water levels upstream powerhouse associated in this data series (fluctuates between 187.60 m to 184.60 m) with four (04) turbines. Annual canal closure is considered according to the distributed annual canal closure program i.e. from December 29 of preceding year to January 15 of next year. It is observed that in this data series, maximum daily discharge is 380.10 cumec. Head water level of powerhouse throughout the year is considered variable between 187.60 m to 184.60 m based on average water levels from 2006 - 2015 whereas tailwater levels have been computed according to tailwater rating curve. Accordingly, the gross head limits are 3.93 m to 2.45 m whereas net head across limits are 3.89 m to 2.10 m. Four (04) number turbines are considered, each with design discharge 87.5 cumec, minimum operating discharge has been considered as 26.25 cumec with the rated design net head of 3.55 m. The installed power potential and annual energy production have been computed as 10.49 MW and 46.41 GWh with the plant factor of 50.51%. Daily head across corresponding to the average daily discharges for the used data series have been computed and attached as Appendix E. Energy computations corresponding to the design discharge of 350 cumec with daily discharges data series under consideration have been attached as Appendix E.

7.6.3. Comparison of Developed Scenarios

All the above described scenarios have been compared as following:

Table - 17: Summary of Developed Scenarios

Sr. No.	Average Daily Discharges	Head Water Levels	Tailwater Levels	No. of Turbines	Annual Energy Production (GWh)	Plant Factor (%)
1	Post Tarbela Series	Maximum Designed Head Water Level	Tailwater Rating Curve	2	73.15	79.61
2				3	66.05	71.88
3				4	65.26	71.02
4	Post WAA Series			2	71.77	78.10
5				3	64.58	70.28
6				4	63.68	69.30
7	Post Remodeling Series			2	74.14	80.68
8				3	68.45	74.49
9				4	67.29	73.23
10	Post Remodeling Series	Post Remodeling Series	Tailwater Rating Curve	2	47.04	51.19
11				3	47.05	51.21
12				4	46.41	50.51

Above table shows that associated with post remodeling discharges, keeping maximum design water levels at upstream of the powerhouse, average annual energy production for power potential of 10.49 MW is calculated as 67.29 GWh with plant factor of 73.23%

8. STRUCTURAL DESIGN CRITERIA

8.1. General

All structures shall be designed in accordance with the following applicable design standards and Codes of Practice. In general, American standards shall be used, however where appropriate, British standards as issued by BSI may be used. Care shall be taken not to mix the use of American and British standards on any one structure. Where appropriate, local standards may be used in conjunction with American or British standards, however care shall be taken to avoid conflicts generally and particular care paid to the consistency of factors of safety and specifications of materials. British standards shall not be used for the design of highway bridges. It shall be made clear at the commencement of calculations for each structure, which standards are being adopted.

8.2. Design Standards And Codes Of Practice

8.2.1. Reinforced Concrete Design

I. "Building Code Requirements for Reinforced Concrete", ACI 318-14, American Concrete Institute.

II. Commentary, ACI 318R-14, American Concrete Institute.

III. Notes on ACI 318-14 with Design Applications, Portland Cement Association.

IV. "Building Code Requirements for Structural Plain Concrete" ACI 318.1-2002, American Concrete Institute.

V. Environmental Engineering Concrete Structures (ACI 350R-06), American Concrete Institute.

VI. BS8110 1997 Structural Use of Concrete, BSi

VII. BS5268 2005 Use of Masonry, BSi

VIII. BS5628 2006 Structural Use of Timber, BSi

IX. Concrete Manual; US Bureau of Reclamation

X. Earth Manual; US Bureau of Reclamation

XI. USACE, EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structure.

8.2.2. Steel Structure Codes

I. ASTM Designation A-615 for deformed bars.

II. ASTM Designation A-185 for welded steel wire fabric.

III. Structural Steel Works

IV. Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings" of the Manual of Steel Construction of the American Institute of Steel Construction (AISC).

V. Designation A-242 or standard strength steel meeting the requirements of ASTM Designation A-7 or A-36.

VI. BS5950 Structural Use of Steelwork, BSI

8.3. Computer softwares

For the analysis and design of hydraulic structures SAP 2000, ETABS, PROKON and GEAR computer software shall be used.

8.4. Material Strengths

The following grades of concrete and reinforcement given in Table below shall be considered in designing concrete structures.

Type of structure	6-inch dia. cylinder strength at 28 days	Steel reinforcement
Powerhouse structure	35 MPa (4061 Psi)	Grade 60 ASTM A615
Intake and outlet bays	28 MPa (4061 Psi)	Grade 60 ASTM A615
Spillway crest blocks and floors	28 MPa (4061 Psi) with top 0.3 m layer of 28 MPa (4061 Psi)	Grade 60 ASTM A615
Stilling basin appurtenants	28 MPa (4061 Psi)	Grade 60 ASTM A615
Spillway piers	28 MPa (4061 Psi)	Grade 60 ASTM A615
Road and regulation bridges	28 MPa (4061 Psi)	Grade 60 ASTM A615
Blinding concrete	10.34 MPa (1500 Psi)	Nil

- All reinforcing steel shall be deformed bars of Grade 60 having minimum yield strengths of 400 MPa 60,000 (Psi) as per ASTM A 615.
- For gates, stop logs, hoist and other structural items including superstructures, the structural mild steel designated ASTM A36, ASTM A-242 or equivalent, shall be used.
- The bricks will have a minimum crushing strength of 2,000 Psi, (13.8 MPa) when tested flat.
- Post-Tensioning cables will be used for the road and the bridges as per design of the structure

8.5. Aggregates

The concrete aggregates shall be of a quality as provided in the USBR "Concrete Manual" with the flowing maximum sizes:

- Mass concrete 75 mm
- Plain and reinforced cast-in-situ concrete 40 mm
- Precast members 25 mm

8.6. Design Loadings

Structures shall be designed to resist all dead and live loads, temperature effects, hydrostatic loads and earth pressures. The dead loads consist of the actual weight of the structure plus any permanent superimposed loads. The live loads consist of temporary imposed loads, wind, earthquake, water and loads imposed during construction. Earthquake loads are to be considered to act in a horizontal direction only, at the center of gravity of the element of the structure with the peak horizontal ground acceleration as per Pakistan Building Codes (Seismic Provision-2007). Where elements could be pre-casts, lifting forces shall be considered and lifting points and / or methods indicated.

8.6.1. Dead Loads

The dead loads consisting of self-weight of the structure and permanent superimposed loads. The unit weights of various materials for computing dead loads are given in Table below:

Material Type	Unit Weight	
	(KN/m^3)	(Lbs./ft^3)
Reinforced Concrete	24.0	150
Plain Concrete	23.0	144
Stone masonry	23.0	140
Water	9.8	62.4
Brick masonry	19.0	120
Dry earth	16.0	100
Compacted earth	18.0	120
Saturated earth	21.0	135
Steel	77.0	490
Bitumen	13.7	87
Cement	14.1	90
Timber – Hard	7.1 – 12.6	45 – 80
Timber – Soft	4.7 – 7.1	30 - 45

8.6.2. Live Loads

The live loads are for roofs, beams and floors of the power house machine hall, service bay etc. and for the structural elements of staff residential buildings. The unit loads of various components of a building for computing live loads are given in following Table:

Buildings	(KN/m²)	(lb/ft²)
Floor (Residential)	1.92	40
Roof (Residential)	0.96	20
Floor (Office)	3.83	80
Roof (Office)	2.40	50
Varandah, Balcony	4.79	100
Stairs, landings	4.80	100

For the special live loads of the electromechanical equipments , those should be incorporated when the propoer design will be completed of the propósed project

8.6.3. Wind Loads

Wind pressure will be applied to the exposed area of all structures in accordance with Building Code of Pakistan, for a maximum wind velocity of 100 mph (161 kmph) acting horizontally in any direction.

8.6.4. Earthquake Load

The earthquake loading for BS Link-I hydropower plant will be selected according to the new Building codes of Pakistan (Seismic Provision - 2007). Seismic zones and relevant peak horizontal ground acceleration for proposed site is shown in the following Table:

Hydro power plant	District	Seismic Zone	Peak Horizontal Ground Acceleration
BS Link-I	Kasur	2A	(0.08 to 0.16) g

Where "g" is the acceleration due to gravity

8.6.5. Flow Pressure

The effect of the stream flow on piers will be calculated by the formula:

P = K. V2

Where:

P = Pressure (KN/m2)

V = Velocity of flow (m/sec)

K = Constant value

Shape of the Pier	Value of K
Square-end pier	1.5
Circular or pier with semi-circular end	0.66

Triangular-end pier with angle ≤ 30°	0.50
Triangular-end pier with angle > 30° but angle ≤ 60°	0.50 – 0.70
Triangular-end pier with angle > 60° but angle ≤ 90°	0.70 – 0.90
Pier-end with equilateral arcs of circles	0.45
Pier-end with arcs intersecting at 90°	0.50

- Value of the "" V" shall be 1.4 times the maximum mean velocity of the current.
- When the water current strikes the pier at an angle, resolve the pressure into components; parallel and normal to the pier surface.

The spillway piers will be designed with the following loading cases.

Case 1: Both gates closed and water at the top of gate.

Case 2: One gate closed and the other gate wide open with water at top of closed gate.

Case 3: One gate closed and other open with bulkheads in place and water at the top of the closed gate.

8.6.6. Uplift Pressure

Uplift pressure will be assumed to correspond to full head across. Uplift will be assumed to act on hundred (100) percent of the base area. Stability of machine hall raft against floatation shall be determined without taking into account weight of turbines and other mechanical and electrical (M&E) equipment.

8.6.7. Earth Pressure

Lateral earth pressures due to backfill under static conditions will be computed by the Coulomb's Method, taking into account the effects of any soil saturation or submergence. A surcharge of two hundred or 975 kg/m2 (200 lb/sft) will be added for computing earth pressure. The dynamic lateral earth pressure during earthquake ground shaking is considered to be an earthquake load, *E*, for use in design load combinations. This dynamic earth pressure is superimposed on the preexisting static lateral earth pressure during ground shaking.

8.6.8. Special Loadings

Crane loading: Crane load must include the weight of the crane bridge, the trolley and the dynamic effect of the braking in addition to the maximum carrying capacity of the crane. The manufacturer will supply the weight of the crane bridge and the trolley and the maximum capacity of the crane hook can also be determined from the weight of the heaviest part to be lifted. Breaking load will be calculated as given below and will be 2 to 10 % of the weight of the moving mass. The braking of Crane Bridge will apply horizontal longitudinal force to the frame at the level of the rail and braking of trolley will transmit a force to the frame which acts perpendicular to the rail in flow direction. The braking load may be

$P = ma = G\ v/g\ t$

Where

P	=	Braking load (tons)
v	=	Velocity of the crane bridge or trolley (m/sec)
G	=	Weight of the moving mass (tons)
g	=	Acceleration due to gravity (m/s2)
t	=	Braking time (sec)

Short circuit torque of the generator torque: This shall also be considered while designing the generator floor. This torque has a lifting effect and is generally taken about twice the dead weight.

8.7. Factored Load Of Fully Loaded Combinations

These are indicated in the Table given below:

Condition	Factored Load or Load Effect U
Basic	U = 1.2 D+1.6L U = 1.4D
Winds	U = 1.2D+1.6L$_r$+0.8W U = 1.2D+1.6R+0.8W U = 0.9D+1.6W+1.6H U = 1.05 D+1.3W
Earthquake	U = 0.75 (1.4D+1.7L+1.87E) and include consideration of L = 0 U = 0.9 D+1.0 E
Earth Pressure	U = 1.4D+1.7L+1.7H U = 1.05 D+1.7H U = 0.9D+1.6W+1.6H U = 0.9D+E+1.6H
Fluids-normal max. water level	U = 1.4D+1.7L+1.4F U = 0.9D+1.4F
Fluids-extreme water flow (overflow)	U = 1.4D+1.7L+1.25F
Impact	Substitute (L+I) for L
Settlement, creep, shrinkage or temperature change effects	U = 0.75 (1.4D+1.4T+1.7L) U = 1.4 (D+T)

The above values are relevant to building and normal structures. For certain structures to be designed as per additional requirements of ACI-350-01A, Environmental Engineering Concrete Structures, and the values of structures in contact with water should be as follows:

Fluid = 1.7 F
Flexure-Required Strength = 1.3 U
Direct Tension-Required Strength = 1.65 U

Strength Reduction Factors based on type of loading

Kind of Strength	Strength Reduction Factor ϕ
Flexure, without axial load	0.90
Axial tension and axial tension with flexure	0.90
Axial compression and axial compression with flexure - Members with spiral reinforcement - Other Members	 0.75 0.70
Shear and torsion	0.85
Bearing on concrete	0.70
Flexure in plain concrete	0.65

8.8. Serviceability Check

Flexure, shear and compression required for the design various structural members shall be designed on Strength Design Method for the applied loading as given in Tables under article 1.7, but the safety against cracks and deflections shall be based on the allowable stresses as given in the following Table, nevertheless, the deflections and cracks shall be controlled as per ACI Code.

Allowable Stresses for Concrete

(All values in Imperial system)

Description	Allowable Stress (psi)
Modulus of elasticity ratio "n" =Es/Ec $= 29{,}000{,}000/57{,}000\sqrt{f_c'}$ For concrete strength of fc' = 3,000 psi "n" =9	
Reinforced Concrete (1:2:4) • *Flexure:* Extreme fiber stress in compression (f_c) - Normal - Exceptional - Extreme	 $0.45\, f_c'$ 1.2 of the Normal 1.33 of the Normal
Extreme fiber stress in tension in plain concrete footings and walls	$1.6\sqrt{f_c'}$
• *Shear:* Beams with no web reinforcement - Normal - Exceptional - Extreme	 $1.10\sqrt{f_c'}$ 1.2 of the Normal 1.33 of the Normal
Joists with no web reinforcement	$1.20\sqrt{f_c'}$
Members with web reinforcement	$5.0\sqrt{f_c'}$
Slabs and footings	$2.0\sqrt{f_c'}$
• *Bond:* Main bars Top bars	 $4.8\sqrt{f_c'}/d < 500$ $3.4\sqrt{f_c'}/d < 350$
• *Bearing:* On full area	 $0.25\, f_c'$

On one third area or less REINFORCEMENT - Normal - Exceptional - Extreme	0.375 f_c' 0.6fy 1.2 of the Normal 1.33 of the Normal

where:

fc' = compressive strength of concrete cylinder in 28 days (psi)
= 3,000 psi (211 kg/cm^2) (cube strength = 3,750 psi) (264 kg/cm^2)
fy = yield strength of reinforcement (psi)
= 40,000 psi (2812 kg/cm^2) (Grade 40 reinforcement in conformity with ASTM A615) d = bar diameter (in.)

8.9. Stability Criteria

Stability analysis will be carried out for structures for most severe conditions of horizontal and vertical forces. Stability criteria are aimed at ensuring the overall safety of structure against overturning and sliding in accordance with Geotechnical Design Criteria. Strength and adequacy of structural members shall satisfy the same design assumptions, with appropriate load factors applied. For structures which will be subjected to water loads, the additional hydrodynamic forces which would be caused by earthquake acceleration shall be included. Loads shall be assumed to act either singly or in combination to give the worst effect.

Stability criteria for the gravity structures are established for three general loading conditions as follows:

Normal Loads: Normal loads are those loads which have a reasonable probability of occurring simultaneously, and where the various canals, river, tail water, and ground water levels are likely to persist for extended periods of time.

Exceptional Loads: Exceptional loads are those loads in which the temporary effects of earthquake forces are combined with normal loads or high flood condition is combined with normal loads.

Extreme Loads: Extreme loads are those combinations which could occur simultaneously, but whose simultaneous occurrence would be expected only rarely, and for short duration.

8.9.1. Loading Conditions

The following cases will comprise the loading combinations:

Case 1	Construction	Dead load only
Case 2	Normal Operation	Normal headwater + highest tail water + service loads
Case 3	Inspection & Maintenance	One regulator bay empty, Otherwise as in Case 2
Case 4	Emergency	Full headwater, no tail water
Case 5	Earthquake	As in case 2 + seismic loads

8.9.2. Safety Factors

Stability safety factors for the structures shall not be less than the values shown in the following Table:

Loading Case	Overturning	Sliding	Floatation	Location of Resultant Force
Case 1	1.50	1.50	-	Middle half
Case 2	2.00	1.50	1.25	Middle third
Case 3	1.75	1.50	1.15	Middle third
Case 4	1.75	1.50	1.10	Middle half
Case 5	1.25	1.30	-	Within base

8.10. Details Of Reinforcement

All reinforcement steel shall be deformed bars of grade 60 having minimum yield strengths 400N/mm2 (60,000 Psi) respectively, conforming to ASTM A 615. The Table given below shows the designation, diameters, areas, and weights of standard bars;

Bar No.		Cross-sectional Area	Nominal Weight
SI[a]	FPS[a]	mm^2	Kg/m
10	# 3	71	0.560
13	# 4	129	0.994
16	# 5	199	1.552
19	# 6	284	2.235
22	# 7	387	3.042
25	# 8	510	3.978
29	# 9	645	5.060
32	# 10	819	6.404
36	# 11	1006	7.907
43	# 14	1452	11.380
57	# 18	2581	20.240

[a] *Bar number approximates the number of millimeters included nominal diameter of the bar. Bars are marked with this designation.*

8.10.1. Maximum and Minimum Spacing

Minimum: The clear distance between parallel bars should not be less than 1.5 times the nominal diameter of the bar nor less than 1.5 times the size of maximum coarse aggregate. Bar ϕ43 (#14) and ϕ57 (# 18) should not be spaced closer than 150 mm (6 in.) and 200 mm (8 in.), respectively, center-to-center. When parallel reinforcement is place in two layers, the clear distance between layers should not be less than 25 mm (1 in.) In horizontal layers, the bars in the upper layers should be placed directly over the bars in the lower layers. In vertical layers, a similar orientation should be used. In construction of mass reinforced concrete structures, bars in a layer should be spaced 300 mm (12 in.) center-to-center where possible to facilitate construction.

Maximum: The maximum center-to-center spacing of both primary and secondary reinforcement should not exceed 450 mm (18 in.).

8.10.2. Concrete Protection For Reinforcement

The minimum cover for reinforcement should conform to the dimensions given in the following for various concrete sections. The dimensions indicate the clear distance from the edge of reinforcement to the surface of the concrete.

Concrete Element	Minimum Concrete Cover	
	(mm)	(in.)
Formed surface in contact with foundation Unformed surface in contact with foundation Formed or screeded surface subject to cavitation or abrasion erosion, such as baffle blocks and stilling basin slabs	75 100 150	3 4 6
Formed or screened surface such as stilling basin walls, chute spillways slabs, and channel lining slabs on grade: Thickness > 24 inches Thickness > 12 inches and < 24 inches Thickness ≤ 12 inches (In accordance with ACI 318)	100 75	4 3
Beam, girder, column and wall – dry condition Beam, girder, column and pier – exposed to water and weather Slabs – not exposed (dry condition)	40 50 19	1.5 2 0.75

8.10.3. Splice and Development Length

Splicing: Bars shall be spliced only as required and it is better that splices shall be indicated on the drawings. Splices at points of maximum tensile stress should be avoided. Where such splices must be made they should be staggered. Splices may be made by lapping of bars or butt splicing. Lapped splices are made in up to and including bar ϕ36 (# 11), whereas, butt splices are made for bars larger than ϕ36 (# 11). The minimum splices / development length required shall be based on ACI-318.

8.10.4. Minimum Reinforcement (Or Temperature Reinforcement)

A minimum area of reinforcement is required to control the cracking, which occurs in the concrete due to temperature, shrinkage and creep. It enables cracking to be uniformly distributed and therefore minimizes individual crack width.

The following criteria will be used to determine the cross-section area of temperature or minimum reinforcement required in hydraulic structures. The percentages indicated are based on the gross cross-sectional area of the concrete to be reinforced. Where the thickness of the section exceeds 380 mm (15 in.), a thickness of 380 mm (15 in.) should be used in determining the temperature or minimum reinforcement. For concrete gravity structures like piers, divide walls, abutments etc. minimum temperature reinforcement may be provided with an area equivalent to ϕ29 @ 300mm (# 9 @ 12") OR ϕ19 @ 125mm (# 6 @ 5") in each face.

(Ref: Para 2-8, Engineering Manual 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures, U.S. Army Corps of Engineers).

The general equation to determine the temperature reinforcement is given by

$$As = \frac{1.8\sqrt{f_c'}}{f_y} bd$$ (In imperial units)

Where,

As = Area of steel (in2)

fc'= Compressive strength of concrete at 28 days (psi)
fy = Yield strength of concrete (psi)
b = Width of the section (in)
d = depth of the section (in)

The Table given below shows the minimum reinforcement (%age) for Grade 40 steel.

Minimum Reinforcement (%age) for Grade 60 steel

Concrete Member/Face	**Minimum Reinforcement Percentage**
SINGLE LAYER REINFORCEMENT	
Slabs not exposed to direct sun – joints spacing < 9 m (30 ft.)	0.25 %
Slabs exposed to direct sun – joints spacing < 9 m (30 ft.)	0.30 %
Slabs not exposed to direct sun – joints spacing > 9 m (30 ft.)	0.35 %
Slabs exposed to direct sun – joints spacing > 9 m (30 ft.)	0.40 %
DOUBLE LAYER REINFORCEMENT (EACH FACE)	
Face adjacent to earth - joints spacing < 9 m (30 ft.)	0.10 %
Face not adjacent to earth nor exposed to direct sun – joints spacing < 9 m (30 ft.)	0.15 %
Face not adjacent to earth but exposed to direct sun – joints spacing < 9 m (30 ft.)	0.20 %
If member exceeds 9 m (30 ft.) in any direction parallel to reinforcement, add to the above reinforcement requirement in that direction because of the increased length.	+0.05 %

The temperature reinforcement shall not be less than ϕ13 (# 4) at 230 mm (9 in.) center to center. All concrete stilling basins, glacis and floors and all concrete aprons of regulators and similar structures [with slab thickness > 380 mm (15 in.)] shall be reinforced in the exposed (top) face with ϕ19 (# 6) bars at 300 mm (12 in) center to center, both ways, placed three 75 mm (3 in.) clear from concrete face, unless otherwise designed.

Nominal reinforcement of concrete chute blocks, baffle blocks and sills for stilling basins, aprons and other portion of regulators, Falls and similar structures shall consist of ϕ19 (# 6) bars at 300 mm (12 in.) center to center, both ways.

8.10.5. Hooks and Bends

The standard dimensions and bend radii for hooks standardized by ACI code 318 are as follows:

- A 180-degree bend plus extension of at least 4 bar diameters, but not less than 2.5 inches at the free end of the bar, or
- A 90-degree bend plus an extension of at least 12 bar diameters at the free end of the bar, or
- For stirrups and tie anchorage only:
  a) For ϕ16 (# 5) bar and smaller, a 90 degree bend plus an extension of at least 6 bar diameters but not less than 75 mm (3 in.) at the free end of the bar, or
  b) For ϕ19, 22 and 25 (# 6,7,and 8 bars), a 90 degree bend plus an extension of at least 12 bar diameters at the free end of the bar, or
  c) For ϕ25 (# 8) bar and smaller, a 135 degree bend plus an extension of at least 6 bar diameters at the free end of the bar

The table shows the minimum radius for bends, as follows:

Minimum Radius of Bends

Bar Size	Min. Diameter, D
ϕ10 through ϕ25 (# 3 through 8)	6 bar diameters
ϕ29, 32 and 36 (# 9, 10, and 11)	8 bar diameters
ϕ43 and 57 (# 14 and 18)	10 bar diameters

8.11. Minimum Member Thickness

Walls with height greater than 3m (10 ft.) shall be a minimum of 300 mm (12 in.) thick and shall contain reinforcement in both ways. Walls and slabs of rigid frame construction generally will have a minimum of 300 mm (12 in.) thickness; however, normally a 500 mm (20 in.) minimum thickness shall be used.

8.12. Concrete Joints

There are four types of joints (construction, contraction, expansion and control) are generally used in concrete construction. One joint may be combination of the two or more of these types. The joints for the structures which are subjected to internal and external hydrostatic pressure (uplift), shall be provided with rubber or polyvinyl chloride (PVC) water stop of suitable sizes.

8.12.1. Construction Joints

These shall be provided where necessary for the practical placing of concrete. They shall usually, but not necessarily, be vertical or approximately horizontal. Vertical construction joints shall be kept to a practicable minimum. The reinforcement steel shall be continued across the construction joint, but reinforcement overlaps shall not be provided in the construction joint. Unless required to resist heavy shear caused by lateral loads, keys shall not be placed in construction joints. Where necessary to ensure water tightness in construction joint, water stop shall be provided. Construction joints may be used to avoid corner cracks due to settlement of fresh concrete at the sides of wall openings or at the junction of walls and slabs. For the hardened concrete surfaces where the construction joint need to be provided, the surface will be chiseled with the drilling machine to make a firm contact of the hardened surface and the newly placed concrete.

8.12.2. Contraction Joint

These shall be used to relieve tensile stresses induced in the concrete by shrinkage. Contraction joints differ from construction joints since means are used in the former case to prevent bond between the joint faces, and the reinforcement does not cross the joint face. Concrete on one side of the joint is cast first, and after the form is removed from the joint face, the joint is painted with a suitable compound to prevent bond with the concrete placed against it. Water stop shall be placed in contraction joints to provide water tightness, where necessary. Contraction joints also serve as construction joints.

8.12.3. Expansion Joints

These are used to eliminate or reduce compressive stresses that would otherwise result from thermal expansion, creep, or settlement of the concrete. Expansion joints usually are either 25 mm (1 in.) or 20 mm (3/4 in.) and the space is filled with elastic joint filler. Water stop shall be placed in expansion joints to provide water tightness, where necessary. Expansion joints also serve as construction joints to take up rotation and displacement.

8.12.4. Control Joints

These joints consist of weakened places where cracks, if any, will occur and are provided in concrete walls to prevent unsightly random cracking. Control joints will be positioned at points of reduced shear and bending moment. Reinforcement running perpendicular to the joint will be reduced by 50% at the joint, subject to stress requirements. A crack will be induced by forming a rebate of 40 mm (3/4 in.) wide and 13 mm (1/2 in.) deep on each exposed face; this rebate will be sealed with joints sealant.

8.13. Water Stops

Water stops in joints shall be of polyvinyl chloride (PVC) of type and sizes manufactured by the approved concerns. Sizes of water-stops for various types of joints will be as indicated below.

Size of Water Stop with respect of Type of Joint

	Type of Joints	Size of Water Stops
i	Construction (Water-stops to be provided only as specifically directed)	225 mm (9 in.), 2-bulbs
ii	Contraction Less than 400 mm concrete thickness 400 mm or greater concrete thickness	 225 mm (9 in.), 2-bulbs 225 mm (9 in.), 3-bulbs

Where reinforcement is continued through an expansion or contraction joint, it shall be de bonded as for a contraction joint and caps provided over the free ends to allow movement.		
iii	Expansion Less than 13 mm joint width 25 mm joint width with concrete thickness less than 400 mm. With concrete thickness 400 mm or more	 150 mm (6 in.), 3-bulbs 150 mm (6 in.), 3-bulbs 225 mm (9 in.), 3-bulbs

DESIGN CRITERIA FOR BRIDGES

8.14. Design Codes of Practice

Generally, the design code of practice of American Association of State Highway and Transportation Officials (AASHTO) will be followed. However, the following codes of practices may also be used:

i) Chief Engineer's Technical Memo No.4 (Revised) Part-I, "Design and Construction of Bridges and Culverts, Public Works Department, Government of West Pakistan, Lahore.

ii) "Code of Practice - Highway Bridge", 1967, Highway Department, Government of Pakistan.

iii) AASHTO LRFD for Bridge Construction, 3rd Edition, 2015

iv) AASHTO LRFD Bridge Design Specifications, 7th Edition, 2015/2016 Interim Revision

8.15. Computer Software

For the analysis and design of bridges SAP 2000, ETABS and GEAR computer software shall be used.

8.16. Construction Type

The principal elements of a bridge generally consist of the superstructure and substructure components described in the sections that follow.

8.16.1. Super Structure

a) For span length up to 4 m (13 ft)

Cast-in-situ reinforced concrete slab with monolithic curbs / Box Culvert

b) For span length up to 12 m (40 ft)

Cast-in-situ / Precast reinforced concrete girders and cast-in-place reinforced concrete slab with monolithic curbs.

Cast –in-situ reinforced approach slabs.

c) For span length greater than 12 m (40 ft)

Pre-stressed post tensioned reinforced concrete girders and cast-in-situ reinforced concrete slab with monolithic curbs.

Cast –in-situ reinforced approach slabs.

d) Precast / cast–in-situ reinforced concrete hand railing / G.I. pipe hand railing.

8.16.2. Substructure

The substructure supporting the village road bridge (VRB) system will be the piers founded on the gravity floors of outlet bay and stilling basin. Similarly, the supporting piers of Regulation Bridge shall emerge from the concrete slab of crest block. In case of district road bridge (DRB) choice of deep foundations may also be explored considering the geotechnical investigations. As the flow of traffic is low in that area and the bridge will be mostly used by people to pass from one side of canal to another side by walk or by bicycle that is why pier formation is suggested for the VRB.

8.17. General Features of Design

8.17.1. Geometry of Bridge Deck

Roadway Width: The width of roadway shall be the clear width measured at right angles to the longitudinal centre line of the bridge between the bottoms of the curbs. The following roadway width will generally be adopted:

Bridge classification	Traffic classification	Roadway width
Regulation bridge	Light traffic bridge	3.3 m (11 ft)
Village road bridge (VRB)	Medium traffic bridge	4.3 m (14 ft)
District road bridge (DRB)	All traffic bridge	7.3 m (24 ft)

Sidewalk and Curb: The width of the sidewalk shall be clear width, measured at right angles to the longitudinal centerline of the bridge from the extreme inside portion of the railing to the top of the curb. Where sidewalks are warranted for pedestrian traffic, the width shall not be less than 900 mm (3 ft). The face of the curb is defined as the vertical or sloping surface on the roadway side of the curb. The height of the bridge curb above the roadway shall not be less than 200 mm (8 inch) and preferably not more than 250 mm (10 inch).

Bridge classification	Roadway width	Total width
Regulation bridge	3.3 m (11 ft)	3.8 m (12.5 ft)
Village road bridge (VRB)	4.3 m (14 ft)	4.9 m (16 ft)
District road bridge (DRB)	7.3 m (24 ft)	9.75 m (32 ft)

Railing: Pre-cast / cast-in-situ reinforced concrete hand railings will be provided in VR / DR bridges, whereas G.I. Pipe hand railing shall be used in a regulation bridge. The traffic railing shall be not less than 750 mm (2.5 ft) in height measured from the top of the roadway. The minimum height of a pedestrian railing shall be 900 mm (3.0 ft) measured from the top of the walkway to the top of the upper rail member.

8.17.2. Freeboard

The free board is to be measured from the design water level up to the soffit of the girder in a Girder bridge and soffit of slab in a Slab bridge. For a regulation bridge where no boat traffic is allowed, the free board shall not be less than 700 mm (2.25 ft) from the design maximum discharge level. For a road bridge freeboard shall not be less than 1000 mm (3.3 ft) in consideration to boat inspection.

8.17.3. Roadway Drainage

The transverse drainage of the bridge roadway shall be achieved by means of a suitable camber in the roadway surface along with PVC pipes 100 mm (4 inch) diameter @ 3m center to center spacing shall be provided on the sides of the bridge adjacent to both curb lines. The following cambers shall be provided on the roadway surface over bridges:

Regulation bridge	12.5	mm
Village road bridge (VRB)	25	mm
District road bridge (DRB)	40	mm

8.17.4. Expansion Joints

To overcome the problems of expansion and contraction movements, transverse expansion joints in the superstructure of one 25 mm (1 inch) in width at intermediate supports or at the end of each span if simply supported bridges will be provided. As he suggested slab is precast monolithic, expansion or contraction joints are provided at the joint of the two precast monolithic slabs to avoid the expansion or contraction of the slab and the suggested slab is precast girders that will rest on supports, there will not be continuity of the slab so expansion and contraction joints are preferred All the expansion joints shall be filled with approved joint filler and sealer.

8.17.5. Diaphragms

In a deck girder bridge, diaphragms shall be provided between the girders at the ends of the bridge to provide lateral support. Intermediate diaphragm is provided at the center of the span exceeding 12 m (40 ft). The diaphragms are usually 200mm to 250mm (8 to 10 inches) thick with nominal reinforcement. The bottom levels of diaphragms are to be set 100 mm to 150 mm (4 to 6 inches) above the bottom of the girder.

8.17.6. Bearings

For reinforced concrete slab bridges where span length is limited up to 4 m (13 ft), no special bearings are necessary. However, to ensure separation of the slab from the seating of supporting member, the common practice is to provide either bituminous coating or a polythene sheet on the seat before casting the slab. 16 mm dia. dowel bars @ 600 mm (2 ft) centre to centre spacing shall also be provided projecting vertically from the seating as shear keys.

For reinforced concrete girder bridges for with spans up to 12 m (40 ft), fixed bearing at one end and a free bearing (for expansion) at the other shall be provided. The typical arrangements of fixed and free bearings are shown in Appendix –A.

For spans more than 12 m (40 ft), Neoprene bearing pads shall be designed as per loading.

8.17.7. Bridge Approach Gradient

Where the bridge is required to be raised above road level, maximum up-gradient towards the bridge or maximum down gradient away from the bridge shall not be greater than 5% (20H:1V).

8.17.8. Bridge Approach Slab

A bridge approach slab is used to provide a smooth and structurally sound transition from the pavement to the bridge. The area between the roadway embankment and the bridge end bent frequently receives inadequate compaction or a different degree of compaction than the roadway fill. Another cause of differential settlement between the roadway pavement and the bridge structure is subsidence of compressible original soil layers under the new approach roadway fill's weight, while the bridge is normally founded on more unyielding foundation of solid support or piling. In order to prevent pavement failure, an unacceptable differential elevation between the pavement and the bridge pavement, and excessive loading on the end bent, a bridge approach slab is constructed to span from the end bent over the roadway embankment. Bridge approach slabs will be provided both for road and regulation bridges.

8.18. Design Loading

All bridges shall be designed for the loads to which they will be subjected, such as:

- Dead load.
- Live load.
- Impact or dynamic effect of the live load.
- Wind load.
- Superimposed Load.
- Horizontal forces due to water current.
- Longitudinal forces caused by the tractive effect of vehicles or by braking of vehicles and / or those caused by restraint to movements of free bearings.
- Buoyancy.
- Earth pressure.
- Earthquake stresses.

8.18.1. Dead Loads

The dead loads on structures will be computed from the following unit weights of the materials:

Material Type	Unit Weight (kN/m³)
Reinforced Concrete	24.0
Plain Concrete	23.0
Dry earth	16.0
Compacted earth	18.0
Saturated earth	21.0
Steel	77.0

8.18.2. Superimposed Loads

Material Type	Unit Weight (kN/m³)
Stone masonry	23.0
Brick masonry	19.0
Water	9.8

8.18.3. Live Loads

The road bridge will be designed for the following live loading:

Bridge Loading

Class AA Loading: This is 700 KN (70 Tons) Army tank. The nose to tail distance between two successive tanks will not be less than 92 m (300 ft) and no other live load shall cover any part of the roadway of the bridge when tank is crossing.

Class A loading: This is a 534.5 KN (54.5 Tons) train of one truck plus two trailers with a maximum axle load of 111.20 KN (25 Kips). The nose to tail distance between successive truck units shall not be less than 18 m (60 ft).

NLC loading: This has a maximum twin wheel loading of 50.8 x 25.4 cm (20 x 10 inch). The nose to tail distance between successive truck trailer units shall not be less than 18 m (60 ft).

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Bridge Classification	Live Loads
Regulation bridge	Worst case of NLC wheeled vehicle or Class AA loading **
Village road bridge (VRB)	Worst case of NLC wheeled vehicle or Class AA loading *
District road bridge (DRB)	Worst case of NLC wheeled vehicle or Class AA loading
* NLC loading will be compared with Class A loading to accommodate the abnormally loaded vehicles carrying farm goods. ** To accommodate crane used for gate maintenance.	

Sidewalk loading: Sidewalk floors shall be designed for a live load of 5 KN/m2 (100 lb/sft) on the sidewalk area.

Curb loading: Curbs shall be designed to resist a lateral force of not less than 7.30 KN/m (500 lbs./ft.) applied at the top of the curb.

Railing loading: Railing loading shall be as per AASHTO code of practice.

8.18.4. Impact Loads

The dynamic effect caused due to vertical oscillation and periodical shifting of the live load from one wheel to another when the vehicle is moving is known as impact load. Live load stresses shall be increased for impact effect as below:

Class AA loading (tracked loading)

Live load impact – Deck = 25%
Live load impact – Girder = 10%
NLC and Class A loading (wheeled loading)

$$I = \frac{4.5}{L+6}$$

Where:

I = Impact factor < 0.3
L= Length of span (m)

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8.18.5. Wind Loads

Wind load effect is not generally significant in short span bridges; for medium spans, the design of sub-structure is affected by wind only in long spans; the super structure design is affected by wind only in long spans. For the purpose of the design, wind pressure will be applied to the exposed area of all structures in accordance with Building Codes of Pakistan, for a maximum wind velocity of hundred 161 km/hr (100) mph).

Wind load on Structure

2.40 KN/m^2, transverse

0.575 KN/m^2, longitudinal

Wind loading on live load

1.46 KN/m^2, transverse

0.584 KN/m^2, longitudinal

Both forces shall be applied simultaneously.

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8.18.6. Earthquake Load

The earthquake loading will be selected according to the New Building Codes of Pakistan (Seismic Provision - 2007), already mentioned in the report.

8.18.7. Longitudinal Loading

Provision shall be made for the effect of a longitudinal force of five percent (5%) of the live load in all lanes carrying traffic travelling in the same direction. The center of gravity of the longitudinal force shall be assumed to be located 1.83 m above the floor slab and transmitted to the sub-structure through the superstructure OR effective earthquake load shall be applied.

The longitudinal forces due to friction at the expansion bearings shall also be provided for in the design.

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8.18.8. Earth Pressure

Structures which retain fill shall be designed and proportioned to withstand earth pressures given by Coulomb's formula. A live load surcharge equal to not less than 0.6 m (2 ft) of the earth shall also be considered. Where an adequately designed RCC approach slab supported at one end by the bridge is provided, no live load surcharge need be considered, (but the appropriate loads would have to be considered in the relevant structural design). The dynamic lateral earth pressure during earthquake ground shaking is considered to be an earthquake load, *E*, for use in design load combinations. This dynamic earth pressure is superimposed on the preexisting static lateral earth pressure during ground shaking.

8.18.9. Flow Pressure

Pressure developed due to stream current on piers, columns or piles shall be considered in the design, already mentioned in the report.

8.18.10. Buoyancy

Buoyancy shall be considered as it affects the design of sub-structure.

Bed Material	Buoyancy
Homogeneous, impermeable	Nil
Coarse sand or shingle	Full

8.19. Load Combinations

The following loading conditions and combinations shall be considered in analysis and design of the various structural members of the bridge structure.

Structural Member	Loading or Combination of Loading
Railing	Dead load + Live Load
Post	Live Load
Curb	Dead load + Live Load
Sidewalk	Dead Load + Live Load
Deck slab (Girder Bridge)	Case -1 Dead Load + Live Load on side walk and railing only Case – 2 Dead Load + Live Load + Impact on roadway only.
Girder	Dead Load + Live Load + Impact
Abutment	Case – 1 Dead Load + Earth Pressure Case – 2 Dead Load + Live Load +Earth Pressure
Pier	Case – 1 Dead Load + Live Load + Impact + Flow Pressure Case – 2 Dead Load + Live Load + Impact + 30% Wind Load + Longitudinal force from Live Load + Flow Pressure

For case -2 loading, the pier shall be designed with 33% increase of allowable stress.

8.20. Distribution Of Loading

8.20.1. Distribution of Loading & Design of Concrete Slab

Effective Span Length: For simple spans, the effective span length shall be the distance between center of supports but not to exceed the clear span plus thickness of slab.

For slabs continuous over two supports and monolithic construction, clear span shall be used in calculating distribution of loads and moments.

Edge distance of wheel load: In, designing slabs the center line of the wheel load (half of axle load) shall be assumed to be 0.305 m from the face of the curb. If curbs or sidewalks are not used, the wheel load shall be assumed to be 0.305 m from the face of rail.

In designing sidewalks, slabs and supporting members, a wheel load located on the sidewalks, shall be assumed to be 0.305 m from the face of the rail. Combined stresses arising from dead load, live load and impact load for this loading shall not be greater than 150 percent of the allowable stresses.

Bending Moment: For girder bridges, with the deck slabs spanning between two main girder supports and where main reinforcement is placed perpendicular to traffic, the live load bending moment per meter width of slab shall be determined by the following formula:

$$\frac{(S+0.61)}{9.74}P \quad \text{(KN-m/m)}$$

For girder bridge deck slab, continuous over three or more supports and where reinforcement is placed perpendicular to traffic, the following formula shall be applied for both positive and negative live load bending moment (KN-m/m):

$$\frac{0.8(S+0.61)}{9.74}P$$

Where:

S = effective span as defined above (metre)

P = load on one rear wheel of truck (KN)

Main reinforcement is placed parallel to the traffic; distribution of wheel loads in the transverse direction of the slab is computed as follows:

E = 1.219 + 0.06S

In no case, shall this width of distribution exceed 2.134 m. Lane loads are distributed over a width of 2E.

Where,

E = width (in meter) of slab over which the wheel load is distributed.

Shear & Bond Stress: Slabs designed for bending moment in accordance with the foregoing shall be considered satisfactory in bond and shear.

Distribution Reinforcement: The distribution reinforcement amount shall be the percentage of the main reinforcement steel required for positive moment as given by following formula:

For main reinforcement parallel to traffic:
Percentage = 55 / S1/2, maximum = 50%
For main reinforcement perpendicular to traffic:
Percentage = 121 / S1/2, maximum = 67%
Where,
S = the effective span as defined above in meter.

Longitudinal Edge Beams: Edge beams shall be provided for all slabs having main reinforcement parallel to traffic. They shall be designed to resist a live load moment of 0.10 P S.

Where,

P = wheel load in KN & S = effective span length in metre

Cantilever Slabs: For wheel load of a truck placed on the cantilever slab, the bending moment per metre of slab shall = P.X/B (N-m)

Where,

P = Wheel load in N (newton).

X = Distance in metre from load to point of support.

B = width of slab in metre over which wheel load is distributed which is given as follows:

The distribution for each wheel load on an element parallel to the traffic is,

B = 0.35X + 0.98 (m) but shall not exceed 2.134m

Each wheel on an element perpendicular to the traffic shall be distributed over width:

B = 0.8X + 1.142 (m)

For railing load on cantilever slab, the bending moment per metre of slab = PX/B (N-m)

Where,

X = Distance in metre the post to the point of interest.

B = Effective width of slab resisting post load is equal to the following:

B = 0.8X + 1.143 (m); where no parapet is used

B = 0.8X + 1.524 (m); where parapet is used

Railing and wheel loads are not to be applied simultaneously.

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8.20.2. Distribution of Loading & Design of Concrete Girder

Position of Loads for Shear: In calculating end shears and reactions in longitudinal girders, no longitudinal distribution of wheel load shall be assumed for the wheel or axle adjacent to the end at which the stress is determined. The lateral distribution of the wheel load shall be that produced by assuming the floor to act as a simple span between girders.

Bending Moment in Longitudinal Girder: For interior girders the live load bending moment shall be determined by applying to the girder the fraction of a wheel load (both front and rear), as follows:

Interior Girders

For one traffic lane, the fraction of wheel load is S/1.981

For two or more traffic lanes, the fraction of wheel load is S/1.829

If S exceeds 1.829 m in case of one traffic lane and 3.048 m in case of two lane or more traffic lanes, then the load on each girder shall be the reaction of the wheel load, assuming the flooring between the girders to act as a simple beam.

Exterior Girders

The live load supported by exterior girders shall be the reaction of the truck wheels, under the assumption that the flooring acts as a simple beam between girders.

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8.21. Foundation Design

The foundation depth for bridge piers and abutments should be taken as

$$\text{Maximum of} \begin{cases} 4/3 \text{ x Max Scour Depth} \\ \text{Scour Depth} + 1.5 \text{ m} \end{cases}$$

For calculating the bearing capacity of deep foundations, the effective depth of foundation shall be considered to be below the design maximum scoured bed level.

9. ELECTRICAL & MECHANICAL EQUIPMENT STUDY

9.1. Turbines

Keeping in view the flow and head constraints, the plant size has been fixed using the TURBNPRO as described below and shown in following Figures. Four horizontal shaft double regulated pit type turbines each of 2.62 MW installed capacity are considered suitable. The salient features of the selected turbines are given in Table -1.

Table - 18: Turbine Parameters

Parameters	Values
Type of turbine	Horizontal shaft double regulated pit turbines
Number of units	4
Rated Turbine Discharge, (m^3/s)	87.43
Rated Head, (m)	3.516
Rated Turbine output, (KW)	2.62
Runner diameter, (m)	4.766
Unit Speed, rpm	93.75
Specific Speed	764

The turbines shall be of double regulated type. The turbine and generator will be horizontally installed and connected through the speed increase. The turbine centerline shall be set approximately 3.90 m below the minimum operating tail water level of 180.895 masl. For cavitation and vortex free operation of turbines within its operational limits, elevation of the center-line of distributor and low point of draft tube, horizontal distance from center-line of unit to the end of the draft tube, exit velocity and suction head (Hs) etc. were taken into account. The adjustable blade runner consists of runner blades, blade operating mechanism, hub and cone.

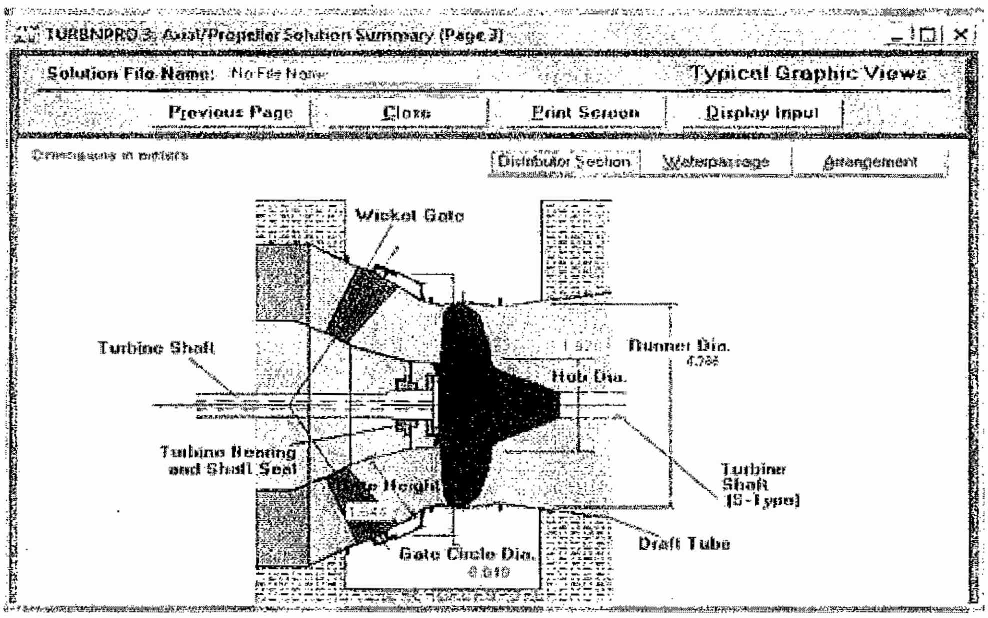


Figure 67: Turbine Sizing

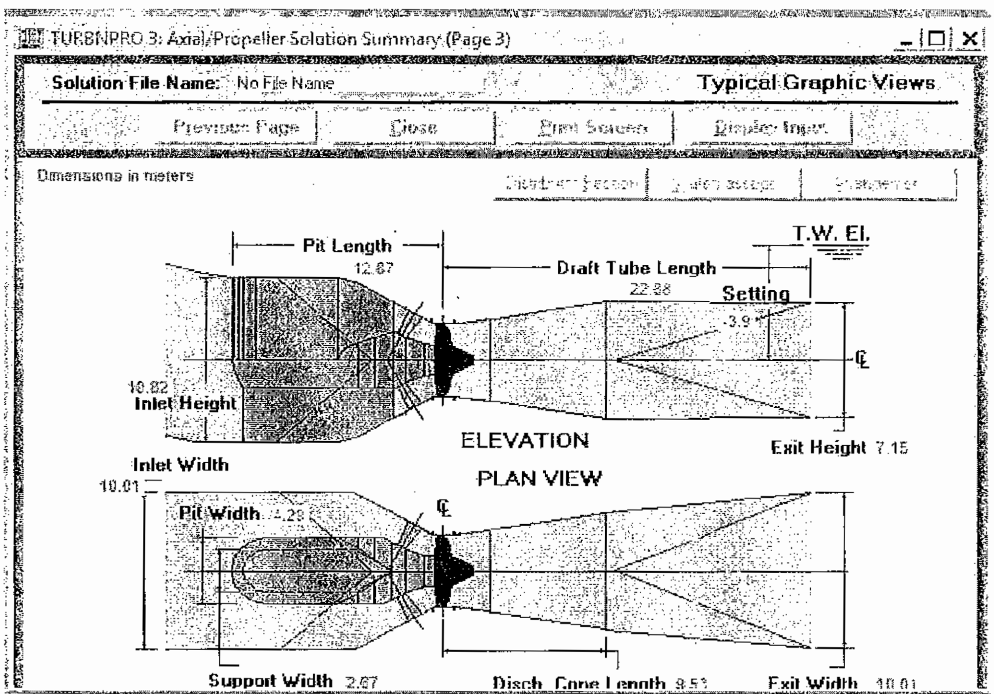


Figure 68: Water Passage Sizing

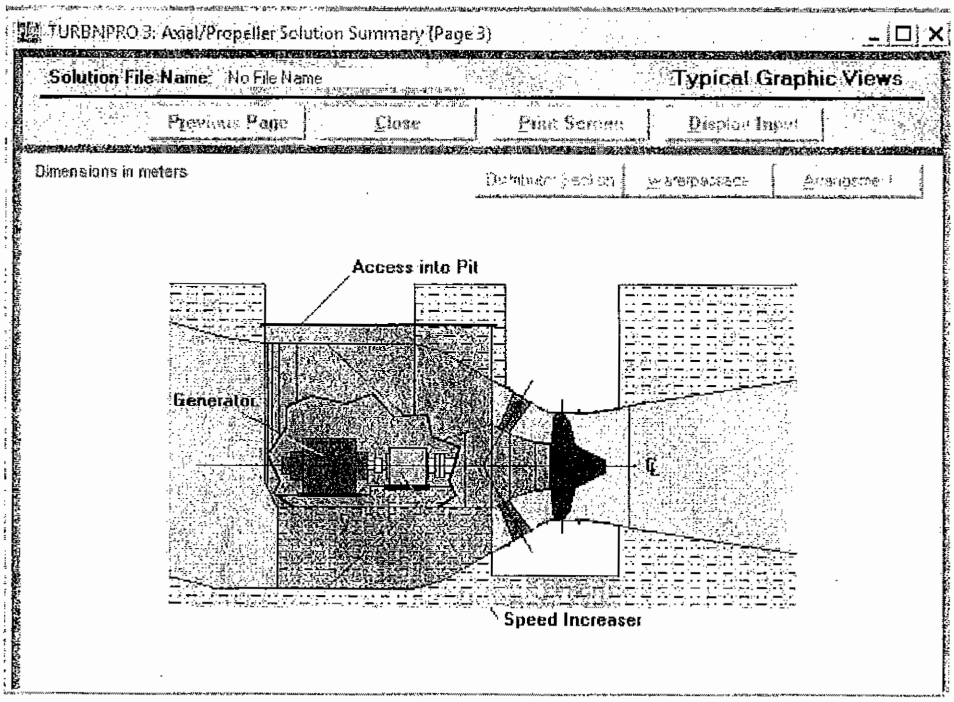


Figure 69: Schematic Arrangement of Turbine

9.2. Governors

The governing system shall include a dual digital control unit, electro-hydraulic actuator, feedback devices, pressure oil tank, oil sump tank, oil pumps, nitrogen pressure system and accessories. The governing system shall meet all requirements for the automatic control and manual control of the pit-turbine.

9.3. Auxiliary Systems

Power station has been provided with various auxiliary systems that include powerhouse crane, cooling water system, water level monitoring system, service water system, compressed air system, service air system, high pressure hydraulic oil system, lubrication and oil handling system, workshop crane, workshop equipment, dewatering and drainage system, ventilation and air conditioning system, firefighting system and emergency diesel engine generating system.

9.3.1. Powerhouse Crane

Bridge crane with an auxiliary hoist is selected to serve the entire turbine hall, lay down and maintenance areas. The span between crane rails is 14.86 m. It shall be used for the operation and maintenance of turbine and generators.

The crane shall be of double girder overhead travelling type with a main hoist installed on a trolley running on the bridge girders and shall be electrically operated. The main hoist and the trolley are capable of lifting and to move the heaviest equipment installed in the power station. The crane shall also be provided with a supplementary electrically operated hoist for handling minor parts.

9.3.2. Cooling Water System

For the turbine bearings, governor, generator and bearing cooling, cooling water system is required. The cooling water system design includes cooling water pumps, heat exchangers, valves, piping etc.

The generator cooled by a closed-circuit ventilation system through the air-water cooler, and bearing oil cooled by closed circuit with oil-water-coolers, which are mounted on the oil tank. Surface cooler elements are attached on the raw water intake passage, which release the heat produced by the generator and bearings continuously to the raw water.

9.3.3. Water Level Monitoring

Water level monitoring system installed at inlets of head / tail race channels and trash rack differential pressure sensors are required.

9.3.4. Service Water System

The service water system comprises the firefighting water and the station service water. Both systems are to be fed by A.C. driven motor pumps, and a standby D.C. motor pump, taking the water from the well.

The station service water for the power station shall be taken from the fire-fighting water tank system, treated and passed to a storage tank and distribution system for the power station building.

9.3.5. Compressed Air System

Powerhouse equipped with common compressed air supply system for all the units. The compressed air system comprises compressed air supply and storage tanks. The capacity of compressor is such that the compressed air supply required for the turbine, governor, and generator brakes can be met for 2 hours. Governor oil pressurization and maintenance requires compressed air system. An independent compressed air system is provided for Governors. This system provides compressed air to pressure tank, generator brakes, and other high pressure components of the powerhouse. The system includes air filters, compressors, after-coolers, storage tanks, valves, piping, hoses etc.

9.3.6. Service Air System

Service air system gets the air from the main compressor station, with a low pressure and is supplied to workshop, service bay, dewatering pipes, measuring devices and service air / tank.

9.3.7. High Pressure Hydraulic Oil System

A high pressure hydraulic oil system is required for control of turbine runner and distributor. The nitrogen/oil supply equipment shall be of closed loop type. Separate Oil circuits for the control of runner and distributor. Both circuits have same type of pumps and control elements. In closed loop oil system, pumps shall fulfill the functions of pressure oil supply and discharge control. Working pressure shall correspond to the differential pressure between opening and closing side of the servomotor. In case of complete power failure in the power plant, one unit shall be able to start within 10 minutes after power failure, by stored energy in Nitrogen cylinders.

9.3.8. Lubrication and Oil Handling System

A separate oil handling system is required for turbine and hydraulic governor lubrication. The system consists of storage tanks and oil treatment unit for cleaning of dirty oil. The mobile filtering unit is also required to be coupled in parallel to all oil systems, including transformers.

9.3.9. Workshop Equipment

Workshop equipment is required for the erection, assembly, dismantling and repair of turbine parts as well as other components of the power house.

9.3.10. Dewatering and Drainage System

The dewatering of the turbine and associated water passages for repair and maintenance purposes and to cater surface drainage of the powerhouse, a dewatering and drainage system is required.

The dewatering system is capable of complete dewatering of one in two hours. The dewatering and the drainage pumps shall be installed in a suitably sized pit on El. 164.012 m. The pit shall be water tight in order to prevent flooding of powerhouse in case of malfunctions of pumps. Pumps and motors can be easily accessed for maintenance.

9.3.11. Ventilation and Air Conditioning

The air conditioning system shall maintain the indoor temperature in the offices and control rooms. The air conditioning system shall be based on split type units.

The ventilation system shall be designed to provide clean fresh air and to pressurize the building so as to prevent the infiltration of uncontrolled outside air. The air exhaust system shall be provided in order to complete the fresh air circuit. The system shall include exhaust fans, ducts, louvers etc.

9.3.12. Fire Fighting System

To overcome fire hazards in the powerhouse, firefighting system is required and will be installed in power house. Firefighting system consists of fire water pumps, storage tanks, hydrants, piping, hoses etc. For lubrication, oil handling system, generators and transformers automatic carbon dioxide (CO2) extinguishing system is required. Mostly three different types of fire protection systems are used in the power stations, i.e. CO2 system, water spray system and portable fire extinguishers.

The source of water for the head tank system shall be by pumping system from the headrace channel and a suction line shall connect to pumps in the power station. The head tanks shall be set at an elevation to provide adequate pressure. Pumps shall be at a location and elevation to assure adequate suction head. The fire protection system shall be used as a reliable source of water to provide emergency backup supply for the generator bearing coolers and turbine shaft seal.

9.3.13. Emergency Diesel Engine Generating System

An emergency diesel engine generator of 100 KVA capacity is envisaged for power house, black start of turbine generator units and for general services use if power house or maintenance facility must be disconnected from the power system for any reason.

9.4. Powerhouse Complex

The powerhouse complex includes machine hall, lay down and maintenance area, dewatering gallery, cable and pipe gallery. The criteria for unit spacing is to provide sufficient space between the units for ease of maintenance. A sliding gate allows easy access for vehicles and semi-trailers required for delivery of major electrical and mechanical equipment.

9.4.1. Turbine Hall

The turbine hall extends along the entire units. It houses the turbines and generators and other electrical and mechanical equipment like generator terminals, AC/DC distribution and oil cooling units. Its floor level is at 185.827 masl with a length of 88.66 m and a width of 14.86 m (see Drawing xxx to xxx). The necessary height is defined by the hoisting requirement and the elevation of lay down and maintenance area. The stairs in the turbine area connect the floors between different levels. The turbine pits and sump areas are equipped with the necessary hoists for the handling of equipment.

Control room, switchgear, electrical and mechanical equipment area along with offices, warehouse, kitchens/lunchroom, locker and washrooms are also available in the powerhouse complex.

9.4.2. Lay Down and Maintenance Area

The lay down and maintenance area is located on one side of the powerhouse. A sliding gate of 5.0 m, width is located at one end for vehicle access to the machine hall. The lay down and maintenance area is used as a platform during erection and maintenance of turbines, generators and other electrical and mechanical equipment. Additionally, a local workshop is established below this area.

9.4.3. Facilities

Facilities such as treated water system, drainage and sewage treatment systems, oil recovery system and emergency generating system etc. are provided in the powerhouse complex.

9.5. Hydraulic Steel Structure

The term gate equipment used herein includes gates, hoists, bulkheads, stop logs and trash racks along with their embedded metalwork. The gate equipment to be provided for the power house shall only be required to stop the flow for any emergency repair or inspection of the structure and other equipment located therein. For this purpose, trash rack at intake, trash rack cleaning machine, intake stop log and draft tube stop log have been provided.

9.5.1. Trash Racks

Removable plane type trash rack set shall be provided for each intake. The trash racks shall have a rack bar spacing of 100 mm c/c to protect the turbine against trash.

The trash racks shall be of welded construction with rectangular rack bars supported on horizontal box girders. The trash racks are designed for a 5 m differential head acting across the gross area of the Trash rack. Lifting beam for handling the Trash racks, one mechanized trash rake for raking the trash rack are also provided. The lifting beam and trash rack shall be of welded construction which shall operate in the guides embedded in the concrete for removal of Trash racks.

In case of complete load rejection of power house, a servo mechanism shall be activated enabling an immediate opening of bypass weir gates (Spillway). An emergency supply diesel generator has been provided as a backup for the servo system as well as the motorized gate hoist system.

9.5.2. Trash Rack Cleaning Machine

It is necessary to clean the trash rack to maintain the required level of water upstream and downstream of the Trash rack. The trash rack cleaning machine is required to be installed upstream of the trash rack in the form of trash rack and jib grab to arrest small and big particles, respectively. The trash rack cleaner shall be equipped apart from the raking and driving mechanism with a rotating jib grab to pick up large trash pieces or wooden logs. Power supply to the trash rack cleaner shall be provided through an enclosed conductor.

The trash rack cleaner structure shall consist of a portal-type frame of welded steel shapes, end trucks supporting the long travel gears and, at the upper part service platform accommodating the control cab, electrical cubicle, hydraulic power pack, carriage operating hoist, carriage bucket operating gear and tilting apron operation. The jib grab shall be installed at convenient locations.

Adequate size crane rails, its accessories and anchors with end stops shall also be installed.

9.5.3. Intake Stop Log Equipment

For installation, maintenance, inspection and repair of turbines, it is necessary to dewater the turbines and their adjacent waterway. Intake stop logs are required to act as bulkheads for preventing entry of headrace water into the waterways when the turbines and their waterways are dewatered.

The Intake stop logs shall be vertical lift sliding gate type designed for maximum possible differential head conditions. Operation shall be performed with the help of gantry crane along with lifting beam. Four sets of Intake stop log shall be provided. The intake stop logs shall have downstream skin plates and seals, each gate being designed to close a waterway. The stop log shall be fabricated in four (4) sections. The preliminary parameters of the intake stop log equipment are given in Table 8.3:

Table - 19: Intake Stop Log Equipment

Parameters	Values
Type	Vertically sliding lift
No. of stop log	4 sets
No. of sections	4 Nos.
Size of one section	10.01 m x 2.705 m
No. of embedded parts	4 sets
Sill elevation	171.590 m
Maximum headrace water level	188.531 m

Lifting hooks shall be provided to handle the gate by a lifting beam.

9.5.4. Draft Tube Stop Log Equipment

For installation, maintenance, inspection and repair of waterway and miscellaneous embedded metalwork, it is necessary to dewater the turbines and their adjacent waterway. Draft tube stop logs are required to act as bulkheads for preventing entry of tailrace water into the waterways when the turbines and their waterways are dewatered.

Table - 20: Draft Tube Stop Log Equipment

Parameters	Values
Type	Vertically sliding lift
No. of stop log	4 sets
No. of sections	4 Nos
Width of each section	10.01 m
No. of embedded parts	4 sets
Sill elevation	173.146 m
Maximum tailwater level	185.294 m

The draft tube stop log shall be vertical sliding lift gate type. Operation shall be performed with the help of gantry crane along with lifting beam. Four (4) sets of draft tube stop logs shall be provided, each set consisting of four (4) sections of 10.01 m nominal width. The draft tube stop logs shall have downstream skin plates and seals, the stop log being designed to close a waterway of 10.01 m wide. Stop log shall be fabricated in four (4) sections. Each section being of welded steel construction 10.01 m wide.

9.6. Generators

9.6.1. Design Considerations

The three phase synchronous generators meeting the requirements of the latest edition of IEC 60034 standard and have been designed to take into consideration the operating experience gained at other similar units installed elsewhere. The design has been made for 30 years minimum operating lifetime.

The three phase synchronous generators shall be of the horizontal shaft type, with a combined thrust and guide bearing, and a guide bearing installed at the downstream side of the speed increaser shaft. The rotation shall be clockwise when viewed from the headrace.

A vertical access-shaft shall serve to facilitate inspection, maintenance and outlet for cables, generator neutral connection, cooling water pipes for the generator coolers, turbine blades adjusting oil piping etc. Generator terminals will be connected by XLPE Cable which will also pass through the vertical access shaft.

The stator insulation specifications are one of the important considerations in the generator design. Worldwide, manufacturers of form-wound machines offer Vacuum-Pressure Impregnated (VPI) insulation as an almost universal standard except for units too large for available processing equipment. That trend has not been driven so much by inherent superiority of one system over another as by economics. Resin-rich or "loaded tape" insulation is still an option for the largest sizes. Both the technologies are being used nowadays. In view of above, stator insulation will be specified to attract healthy competition from manufacturers utilizing either VPI or Resin-rich technologies i.e. the insulation will consist of either multiple layers of vacuum-pressure impregnated mica tapes or a cast resin insulation system. In either case, the coil insulation shall be applied continuously throughout the coils with equal thickness to both the slot and end-turn portions. Stator and rotor insulation will be rated for Class F although temperature rises will be limited in operation to Class B values. The coils will be protected against surface partial discharges (corona) outside the stator iron by applying a semi-conductive varnish.

The generators shall be designed to withstand all fault situations which can be experienced during operation without any displacement of its windings or mechanical damage to any of its parts or to the generator foundations, such as short circuit between two or three phases at its terminals, faulty synchronization, magnetic unbalance due to pole winding failure and runaway conditions.

The generator shall be so designed that all repair works, maintenance and inspection of the generator and turbine parts may be done with a minimum of disassembly work

The generator has been envisaged to have a state-of-the-art static excitation system with a digital Automatic Voltage Regulator (AVR). The generators have been designed for both interconnected and isolated load operations. The power generated will be dispersed through 132 kV transmission lines to the national grid.

9.6.2. Ratings

The number of units to be installed and their capacities has been determined based on the ultimate installed capacity of powerhouse. The generator main parameters estimated are given in section 9.9.1:

9.6.3. Generator Voltage Selection

The generator voltage rating has been selected based on the minimum combined cost of generators and connected equipment such as bus-bars, switchgear, cables and transformers. Experience has shown that for the generator design of a particular KVA rating to be economical, its terminal voltage should be selected from the voltage ranges indicated in Figure 9.1 for different generator ratings.

Based on the above considerations, the generator rated voltage selectable within the above ranges has been recommended for each unit size.

9.6.4. Excitation System

A Static Excitation System with a Digital Automatic Voltage Regulator is envisaged to be the state-of-art for generators. Excitation power shall be taken from the generator itself and supplied to the excitation rectifier via the excitation transformer.

The excitation transformer will be installed in a self-supported steel plate cubicle to achieve personnel safety. The excitation transformer shall be AN cooled and of dry insulated type using non-flammable Class B insulating material. Embedded temperature detectors (Pt-100) for monitoring winding temperatures will be included the excitation rectifier envisaged will be of a solid-state type with controlled silicon power Thyristors for both polarities. It will be capable of reversing its output voltage to obtain a fast response in case of load rejection and unit over speed. Each rectifier branch will consist of at least two parallel Thyristors, so that one Thyristor can be removed during operation. The remaining Thyristors will have capacity for unrestricted operation of the generating unit, and be capable of enduring a short circuit of the generator terminals from 120% of nominal field current. 100 % redundancy in excitation rectifiers is envisaged.

The rated continuous output of the excitation rectifier will correspond to not less than the excitation power required for continuous operation of the generator at rated output and power factor. The excitation rectifier will preferably be of the self-ventilated type. If forced ventilation is offered, redundancy of the cooling system must be provided to avoid the shutdown of the generator in the event of breakdown of the fan motors. The Thyristors will be protected against D.C short circuits with high-speed fuses. Blown fuses will be detected and signaled.

Two independent Thyristor trigger pulse units will be installed, one for the automatic voltage regulator, the other for manual excitation control.

The excitation system will comprise one D.C field circuit breaker. The breaker will be cubicle mounted. The circuit breaker shall be able to break the field current under the most unfavorable fault conditions, i.e., short circuit of the generator from full load or loss of synchronization, without causing damage to the breaker or adjacent equipment. The construction of the breaker shall be such as to allow easy inspection, maintenance and testing.

De-excitation during normal shutdown of the unit will be performed by opening of the field circuit breaker. Simultaneously, the AVR shall trigger all Thyristors simultaneously to fully open state, thereby providing a "freewheeling" circuit for the field current. The field suppression system will consist of voltage-dependent resistors, dimensioned to withstand the excessive field currents resulting from fault conditions. Tripping of the field circuit breaker will instantaneously put the field suppression system into operation.

An overvoltage protection against induced over voltages in the field circuit will be included. The generator is envisaged to have a state-of-the-art static excitation system with a digital Automatic Voltage Regulator (AVR). The AVR shall be equipped with fully redundant controllers with automatic and manual channels with auto-followers to track the position of the digital controller that is in control to provide bump-less, two-way transfers between controllers and manual-auto control. Part of the redundancy scheme requires redundant voltage transformers for the generator.

Over- and under-excitation limiters will be included. The under-excitation limit shall match the static and dynamic stability curves for the generator. Volts per Hertz limiter will also be included.

The AVR will include adjustable voltage droop compensation for both reactive and active load and frequency compensation adjustable in the range 0 - 5% of UN per Hz.

The AVR shall include a power swing stabilizer unit with adjustable parameters. The excitation system shall have built-in protection and supervision equipment. All fault signals shall be displayed on the AVR front panel.

The entire excitation system is foreseen to be totally self-sufficient, in that it excites the generator, provides all of the required power supplies for cooling and Thyristor control, etc. from the secondary of the excitation transformer. External power is supplied in the form of dc control voltage, field flashing source, and power supply for cubicle lighting and power sockets. The system is foreseen to have a touch screen operator interface for local control.

The equipment will provide input transducers for all generator quantities and therefore will display all unit quantities in digital format. The digital AVR will interface directly to the digital control system for the station. High-speed fuses will protect Thyristors. All other power and control circuits will use circuit breakers or mini-circuit breakers for protection and disconnection means.

9.6.5. Braking System

The generator shall be equipped with pneumatically operated disc brakes. The brake plate shall act against both sides of the brake ring attached to the upstream side of the rotor. The brake valve, pressure reducing valve and the air filter unit shall be located near the access shaft. The brake system shall be able to stop a unit from 10% speed to zero with turbine wicket gate leakage torque not exceeding 1% of the rated torque. The brake system shall be supplied with air from the plant air lines. The braking system shall be capable of operating satisfactorily with a minimum air pressure of 0.5 MPa supplied. Directly connected limit switches shall be provided on each brake to indicate brake released and brake applied positions. The brake lines shall be removable and replaceable.

Additionally, the electrical brake consisting of a short circuit disconnecting switch shall be provided. This disconnecting switch will be closed after generator circuit breaker is opened and the generator is de-excited. After this, disconnecting switch is closed the generator will be excited again until the short circuit current will reach maximum rated current. The rotating masses will be decelerated to stand still by magnetic forces.

9.7. Electrical System Design

9.7.1. Electrical Plant Concept

The electrical equipment mainly comprises the following:

- Generator & Excitation System
- 6.3 / 33 kV Switchgear (as applicable)
- 400 V Switch gear / LV Power Distribution.
- DC System including batteries, battery chargers and DC distribution.
- Generator / power plant Step-up Transformers (as applicable)
- Station Service Transformers
- Motors.
- MV Cables
- LV Cables.
- Electrical Control System.
- Electrical Protection System.
- Lighting and Small Power Services.
- Earthing and Lightning Protection System.
- Fire Detection System
- Telecommunication Equipment

For dimensioning, design and layout of the various plant components and installations, the following features and aspects have been considered:

- Ratings to safely cope with normal and fault conditions, the prevailing site conditions, avoiding any over-stressing of material and equipment

- Equipment to be of standard design, providing the highest degree of safety, reliability, availability, redundancy concepts and ease in operation
- Equipment arrangements to consider adequate space and access for transportation, installation, commissioning, operation and maintenance

The electrical plant has been designed for continuous operation in interconnected as well as isolated modes to feed 11 / 33 /132 KV network (as applicable) during normal operation. It includes facilities for safe shutdown and black start capability in case of a total electrical system blackout.

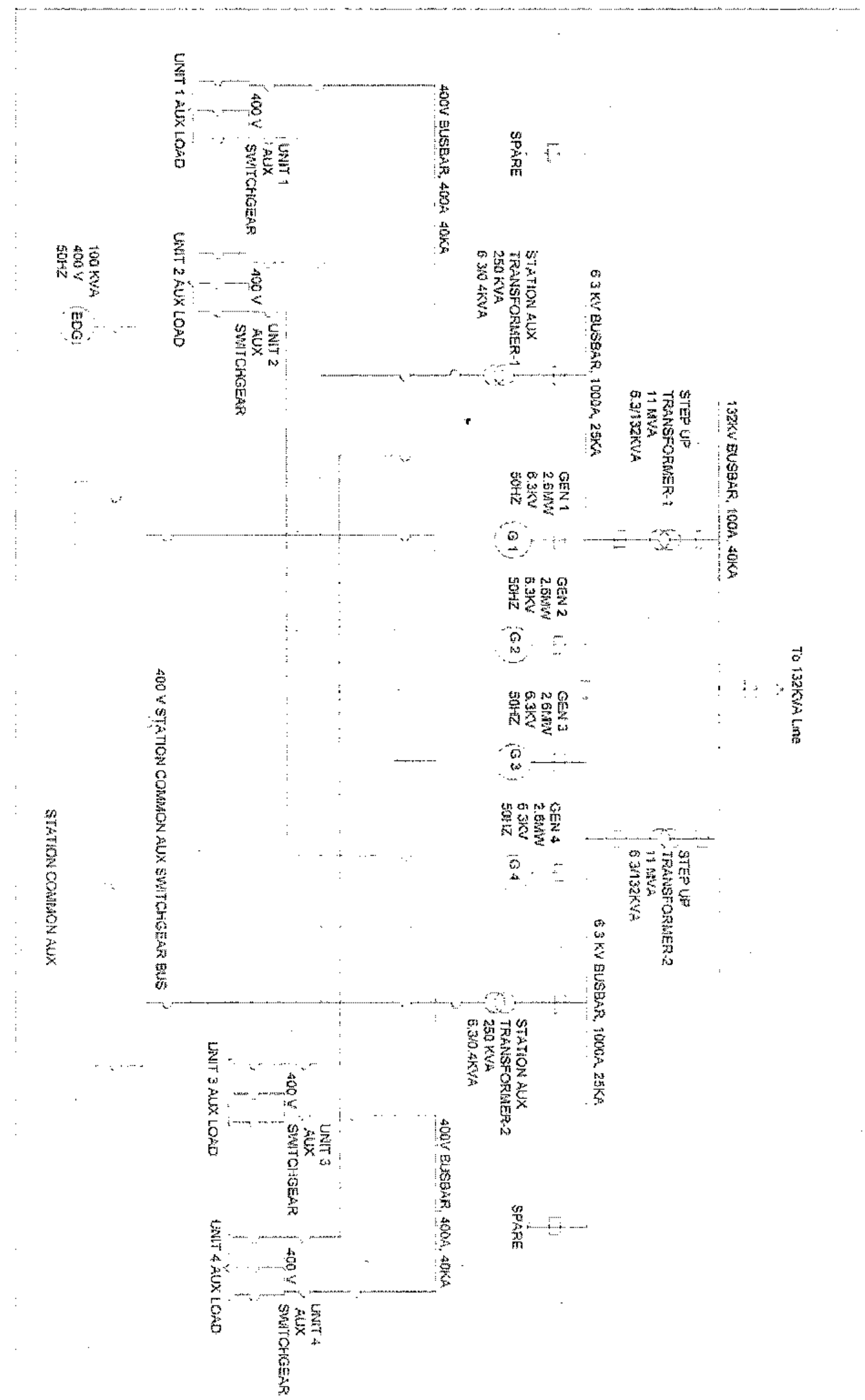
The layout, design and manufacturing of all electrical equipment comply with the latest edition of the relevant IEC standards. The main design parameters of major equipment have been worked out for each site.

Other plant systems such as lighting, small power services, lightening protection, earthing and cabling etc. have been specified based on the current practice and in accordance with relevant international standards.

9.7.2. Unit and Station Auxiliary Supply System Configuration

The electrical main connections constitute the major part of the electrical equipment in a hydro power plant having close relation to the power system, protective relaying and the selection of electrical equipment. The main connections directly affect the operation, maintenance and investment in the hydro power plant. The pre-requisites for the selection of the main connections are the reliability of the power supply to the consumer, simplicity in the design, operational flexibility, and ease of maintenance and of course, low capital and operation costs.

There are several configurations that are workable from an engineering point of view and had been used in several power plants all over the world. The selected scheme is such that it is typically used in small hydro power plants and is well proven. The unit & station auxiliary supply configuration has been selected based on the above considerations and the optimum interconnection option specific to each site.



POWER HOUSE SINGLE LINE DIAGRAM

The Unit & Station Auxiliary Supply System is depicted in Figure. The unit and station auxiliary supply system comprises of a single 6.3 KV MV switchgear with four (4) incoming feeders coming directly from the four (4) generators, two (2) feeders for the 6.3 KV / 0.4 KV station auxiliary transformers, two (2) outgoing feeder for the 6.3 KV / 132 KV station step-up transformers and two (2) spare feeders.

The low voltage side of each station auxiliary transformer is connected to its own 400 V bus section. The two 400 V bus sections are interconnected through a bus. Each of the two base sections feeds the unit, auxiliary switchgears of the four (4) units and the station common auxiliary switchgear such that each of these switchgears forms a double ended scheme.

The emergency diesel generator is connected to the station common auxiliary switchgear bus. The proposed size of emergency diesel generator for the power plant is 100 KVA. The rating of the diesel generator will be firmed up during detailed design development stage.

9.7.3. DC and Essential AC Power Supply System

The DC system foreseen in the project comprises one 110V DC Battery with two Battery Chargers. Each Battery Charger is supplied from the relevant 400 V AC Low Voltage Switchgear.

The battery will supply a main 110V DC switchboard which in turn will supply all unit and station common DC loads.

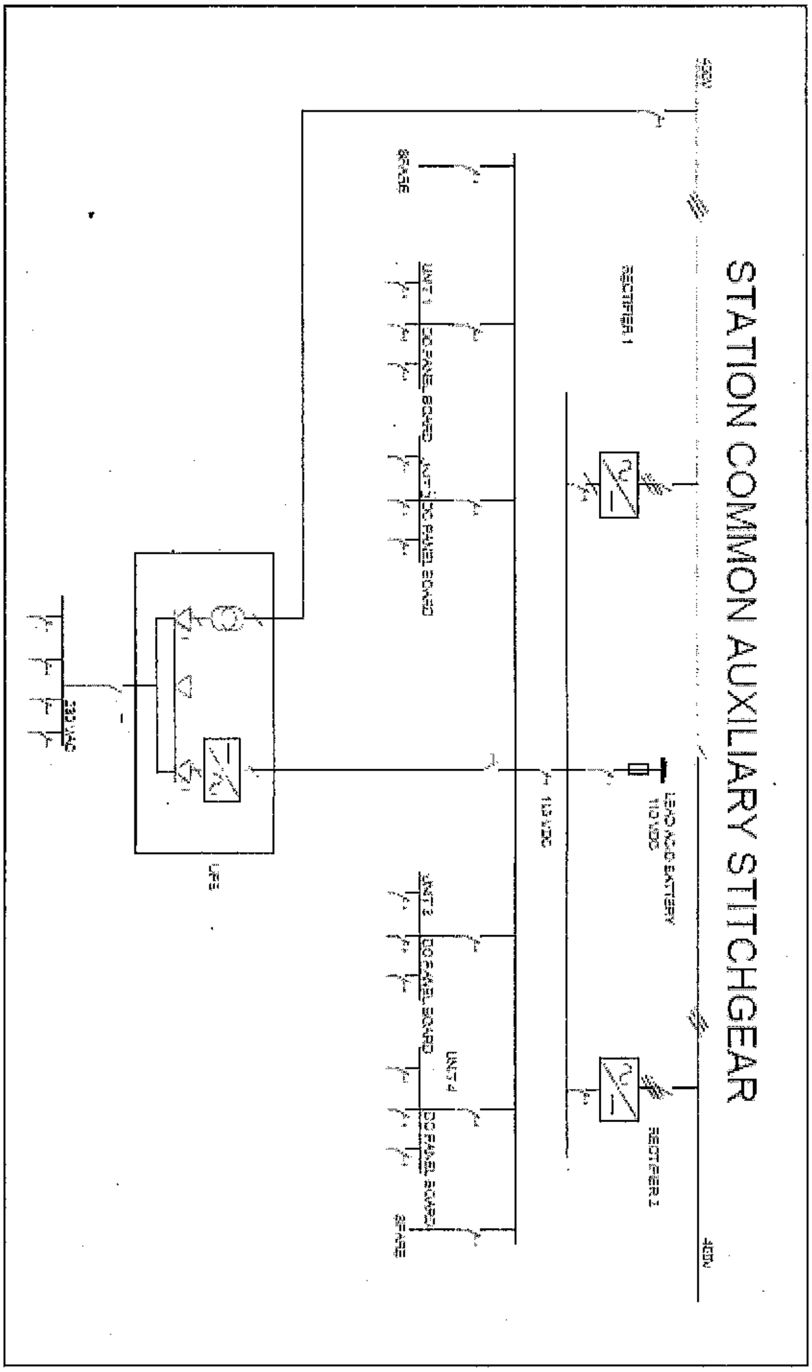
Lead acid battery having a design life of about 25 years with a guarantee period of 10 years shall be used. Maintenance free lead acid battery with solid electrolyte also may be considered. The voltage per cell has a range of 2.24 to 2.28. The battery shall be sized for 10-hour discharge.

The battery will be installed in separate ventilated rooms on wooden insulated stands and will be braced to stop movement under seismic shocks.

Fully automatic, constant voltage type, semi-conductor rectifier equipment, intended to be permanently connected across the nominal 110 V battery (lead-acid type) and DC load of the power station in the floating battery system shall be provided.

The uninterruptible power supply system (UPS) of 230 VAC, single-phase will be supplied from the 110V DC Battery/ Battery Chargers. The principal element of the UPS is the inverter. An important component of this system is a static switch. The static switch is used to select between a normal AC source and a UPS source. Normally, the load is simply taken from the UPS. But the static switch allows the system to be completely shut down without interrupting the circuits, although they would then be supplied from normal supplies. The static switch is capable of switching in less than 0.5 milliseconds. The inverter frequency is synchronized to the normal source so that switching can occur instantly.

The uninterruptible Power Supply System (UPS) shall be used for essential A.C Power to the communication and plant control system. The primary supply feed will be from the DC distribution System with the backup power being made available through a rapid acting (¼ cycle) Static Transfer Switch. (STS) should the UPS be out of service. The DC and Essential AC Single Line Diagram is shown in Figure.



DC AND AC ESSENTIOAL SINGLE LINE

9.7.4. Protection and Metering System

The electrical protection system for the generators, transformers and the MV/LV switchgears would be implemented utilizing state of the art numerical protective relays.

The general principle for the protection shall be that all parts of the installation are covered by high speed protection schemes which shall be independent to avoid common-mode failures. The protection equipment shall be complete with all relay panels, instruments, meters, interposing and auxiliary relays, control switches, interposing current and voltage transformers, transducers and all auxiliary equipment. All protections, as far as possible, shall be connected to separate current transformers, shall have separately protected voltage circuit. The DC supply for the auxiliary circuits (control and protection) shall be arranged such that auxiliary circuits are assigned to each function and branch so that only one function or one bay is affected by a fault.

Faults in the control circuit do not then influence the protection circuits and vice versa. Relays shall be in accordance with IEC 60255 and shall be suitable for use with 1 A secondary current transformer and 110/63.5 V secondary voltage transformers.

9.7.5. Telecommunication System

A public automatic branch telephone exchange (PABX) shall be installed at the power plant. The system shall comprise integrated and discrete components of a high level of reliability to guarantee a system availability of 99.9% over a fifteen year operating period. PABX shall be expandable without any interruption in service. It shall be modular in construction, to allow future expansions in subscriber trunk and tie lines.

All subscriber locations shall be equipped with a standard- single line push-button telephone set. The keypad and dialing from the telephone set shall conform to the ITU-T Q23 standard. It shall be possible to attach a hands-free unit, if required.

Normal Telephone Sets shall be general purpose instruments using the push-button facility with analogue or digital voice transmission. The telephones shall be desk/wall mounted. Executive telephone sets shall be intelligent voice terminals combining the functions of telephone loud speaking Intercom and auto-dialing.

The distribution frame for the exchange and subscriber circuits shall be of the free standing type. The connecting blocks shall be of the quick-connect type. Each of the outside cable pairs shall be protected with over-voltage and/or over-current protectors.

9.7.6. Step-up and Auxiliary Transformers

9.7.6.1. Power Plant Step-up Transformers

Each of the two (2) power plant step-up transformers shall be three phase, two-winding, oil immersed, natural oil, natural air cooled (ONAN), with the oil preservation system of the constant pressure conservator type with a flexible diaphragm to preclude direct contact of oil with air, complete with accessories, oil purification plant and spare parts, suitable for outdoor/indoor operation. The neutral point of the HV windings shall be solidly grounded.

The core of the transformer shall be of high grade, non-ageing electrical silicon steel of low hysterics' loss and high permeability.

Off-load tap changer shall be operated by means of a hand wheel with a tap position indicator. Provision shall be made for padlocking in any position. Mechanical stops shall be fitted to prevent over-running at each tap position.

All bushings shall comply with IEC60137 and shall be of concealed construction. The neutral terminals shall be provided with outdoor type bushing insulator.

Each transformer bushing shall be provided with current transformers rated as shown in the single line diagram. The final value of CT capacity shall be determined according to the burden of the connected instruments, recorders, protective relays and wiring losses.

Fire protection system shall be by the water deluge system.

9.7.6.2. Station Auxiliary Transformers

All indoor auxiliary transformers shall be dry type, three-phase units mounted in enclosures with suitable damp proof heating arrangement.

All transformers shall have a nominal ratio of 6300V/400V with a tapping range of ±10% in steps of 2.5%. Vector groups shall be Dyn11. Dry type transformers HV connection shall be by single phase XLPE cable connections.

9.7.7. MV and LV Switchgears

9.7.7.1. MV Switchgears

The switchgear assemblies shall consist of circuit breakers on mobile draw-out carriages, a single bus bar, main circuit components, control and protection equipment and indicating instruments.

The main circuit breakers shall be of indoor, trip free vacuum type. They shall be 3-phase ingle throws, mounted on the removable elements of the switchgear units, with primary and secondary disconnecting devices, electrically controlled, stored-energy operated, and necessary auxiliary switches, mechanism, accessories and appurtenances.

The switchgear panels shall be self-supporting freestanding assemblies with steel frames and formed sheet metal enclosures of dust and vermin-proof construction. The sheet metal, if of steel, shall be not less than 3 mm for barriers between the primary major section for each circuit, and of not less than 2 mm for all other covers, barriers, panels and doors. Barriers shall be provided between primary sections of adjacent units.

The control power will be derived from a battery at 110 VDC.

Each circuit breaker shall be provided with a sufficient number of auxiliary switches for operating requirements and other controls and indication. Mechanical, electrical induction, visible from in front of the switchgear, shall be provided for important equipment status.

"Local – Remote" control switch device shall be furnished for each breaker to transfer control from the switchgear to a remote location.

9.7.7.2. LV Switchgear

The equipment shall be in accordance with IEC Publication 60439 and IEC 60529.

The equipment in the switchgear assemblies shall consist of low voltage power air circuit breakers, molded case circuit breakers, buses, current transformers, potential transformers, indicating instruments, relays, control devices and associated wiring and test blocks.

The switch gears shall be self-supporting freestanding assemblies with steel frames and sheet metal enclosures of dust and vermin-proof construction. The sheet metal, if of steel, shall be not less than 2 mm for all barriers, covers, panels and doors.

Low voltage power circuit breakers shall consist of 3-pole electrically and mechanically trip-free draw out type air circuit breakers and shall be complete with inter-pole barriers for eliminating all fault communication, arc quenchers, manual and electrical stored-energy operating mechanism, mechanical position indicator, and shall be mounted on a draw out mechanism in the breaker compartment.

All molded case circuit breakers shall be manually operated, fixed type and shall have thermal and magnetic tripping devices. The electrically operated circuit breakers shall be equipped with push buttons for local control, and a "LOCAL – REMOTE" selector switch. Electrically operated circuit breakers shall be provided with a sufficient number of auxiliary switches for operating requirements and other controls, interlocks and local or remote indication.

9.7.8. Cables

The following main types of cables are foreseen:

- 6.3 kV power cables;
- 230 V/400 V power cables;
- Multi-core protection and control cables;
- Multi-core communication cables;
- Optical Fiber cables; and
- Data highway cables (special cable).

It is proposed that all cables have copper conductors with the following types of Insulation:

- Cross-linked polyethylene (XLPE) for 6.3 kV;
- XLPE for 230 V/400 V power cables;
- Polyethylene (PE) or XLPE for multi core control cables; and
- CPE (Chlorinated Polyethylene) for communication cables.

Wire sizing will follow IEC standard rules. To the extent possible, cables will be routed using ladder type cable trays. Cables will be specified to meet IEC standards with the desired options from the standards selected. In particular, conductors are to be copper, insulation is to be XLPE whenever possible, medium voltage power cables are to be copper foil shielded and terminated with proper stress relief devices, outer jackets are to be thermosetting type, color coding is to use actual insulation color (not all black with number identification).

Steel conduit or other armoring will be used on cables laid outside the powerhouse and for cables close to the mechanical plants requiring higher mechanical strength.

Special cables will be used accordance with the particular requirements as media

9.7.9. Earthing

The design of the earthing system will generally follow the main requirements outlined in the IEEE publication No.80 "Guide for Safety in Substation Grounding ".

A station earth ring will be routed around the station to connect all the installed electrical equipment to earth buses and to bond principal pieces of exposed steel to the earthing network.

Earthing of door frames, stair treads, and other incidental equipment is not intended. A system of ground plates which can be connected to by bolting will be specified for connection of principal components to the main grid system.

At the time of detailed design, earthing system calculations should be performed to determine minimum size and the quantity of conductor and earth rods to obtain the required station ground resistance (usually about 0.5 ohms). Step and touch potential calculations should be carried out to ensure that all areas are safe from electrical hazards.

9.7.10. Lighting

The lighting system shall be designed to achieve the levels of communication specified below. Lighting equipment shall have a minimum degree of protection of IP54 where required.

- Lighting fixtures within outdoor switchgear shall be arranged to allow for replacement of lamps with the switchgear in operation.
- The horizontal illumination levels in the around transformers, and buildings, shall not be less than 5 Lux.
- Fittings shall be designed for Fluorescent tube lights. Poles shall have built-in fuse boxes.
- All lighting poles shall be connected to the main earth grid.
- Main roads and access roads within 25 meters of buildings and transformers shall be provided with street light fittings at 6 m high poles.

- The outdoor lighting shall be fed via several independent circuits. Each circuit shall be controlled be a photo cell with an automatic switch.

The permanent indoor lighting shall be designed to the following mean illumination levels given in Table:

Table - 21: Mean Illumination Levels

Location	Lux	Type
Machine hall	300	High-pressure sodium vapor
Control room	300-500	Fluorescent tubes
Switchgear room	400	Fluorescent tubes
Relay local control room	300	Fluorescent tubes
Telecommunications room	300	Fluorescent tubes
Power supply/aux services room	200	Fluorescent tubes
Battery room	200	Fluorescent tubes
Office rooms (general offices)	500	Fluorescent tubes
Workshop rooms	300	Fluorescent tubes
Store rooms	200	Fluorescent tubes
Pantry	200	Fluorescent tubes
Entrances, Lavatories, General	100	Fluorescent tubes

The supply of electrical energy of the lighting system shall be realized through distribution panels.

Control room, switchgear and relay rooms, telecommunications room auxiliary supply and battery room shall be provided with emergency lights connected to the DC supply system. The emergency lights shall be automatically switched on in case of failure in the AC supply system.

The control room, relay room and local control rooms shall be provided with emergency hand lamps. The hand lamps shall be arranged in wall-mounted battery loaders located close to exit removed from the holder.

Permanent or temporary power supply for temporary lights and hand tools shall be provided at all places where gates and trash racks are located.

9.7.11. Fire Alarm and Detection System

A fire alarm system complying with the requirements of the relevant NFPA Codes shall be provided to cover the entire power plant area. Fire alarm system operation and status shall be repeated on the main fire detection and alarm panel which will be located in the central control room.

9.8. Control System Design

In line with the latest practice and trends in the hydropower plant controls, almost all the new schemes are based on distributed control philosophy now-a-days. The overall philosophy of the power plant control system is as under:

9.8.1. Control Hierarchy

Station Control Level - A computer based Station Control System (SCS) is envisaged for the supervisory control of the power plant including the generating units, Medium Voltage (6.3 kV) and the Low Voltage (400 V) switchgears.

Local Control Level - One computer based Local Control Unit (LCU) is envisaged for each generating unit, one for MV & LV switchgears / auxiliaries and headwork's / regulator gates.

Manual Control Level - Manual Control will be possible from the individual equipment's local control panels / boards.

9.8.2. Redundancy

The redundancy of the control system has been ensured such that the failure of the Station Control System will not affect the plant operation. In case of any failure of Station Control System, the control of the units will still be possible through Local Control Units of the respective units / other facilities. In case of failure of one or more LCUs, the manual operation of the Units shall still be possible through their respective local control panels.

9.8.3. Interfacing to Data Communication

All the process inputs will be brought to the respective LCUs for interfacing of the same with the SCS. All the outputs from the SCS to the process (and vice versa) will be channeled through the respective LCUs. All the LCUs and SCS will communicate with each other through data communication buses/ interface.

9.8.4. Location of the Equipment

The SCS will be located in the main control room for the generating units. The LCUs for the respective units will be located in the machine hall. The cubicles of the generator protection will be installed next to the respective LCUs. The LCU for the MV & LV switchgears / auxiliaries and headwork's / regulator gates will be installed at suitable location.

9.8.5. Power Supply

The SCS will be powered from an uninterruptible power supply (UPS) with battery backup for the SCS to operate for specific time duration. The LCUs will be supplied from the plant 110 V DC Battery / DC System.

9.8.6. Hardware

The LCUs are envisaged to be based on microprocessor controllers. The LCUs are complete with communication controllers, necessary software, signal interface equipment, redundant power supplies etc. The SCS is proposed to have two work stations each consisting of two full graphic color display monitors / LCDs with keyboard and mouse.

- One main server with disk storage system
- One front – end communication unit
- Optical disk
- One terminal server
- Printers and hard copy unit
- Necessary equipment for interfacing with data communication system
- Control desk designed for installation of the workstation with chairs will also been provided.

9.8.7. Software

The SCS software includes all Human-Machine Interface (HMI) functions such as;

- Data acquisition from all LCUs
- Control commands transfer to LCUs
- Data acquisition from and control commands transfer to the MV & LV switchgears / auxiliaries and headwork / regulator gates
- Dynamic coloring and graphic displays for unit start / stop, circuit breakers open / close etc.
- Database functions such as storage of momentary status, measurement & fault information, long-term data archival, trend analysis etc.
- Status, measurement and production reports including energy reports.

The above and other software functions will be elaborated / determined during the detailed specifications development stage.

9.9. Electrical Equipment

9.9.1. Generators

Based on the ultimate installed capacity of powerhouse, the number and sizes of units proposed to be installed along with their main parameters are indicated in Table.

Table - 22: Generator Parameters

Item	OPTION A	OPTION B	OPTION C
Unit capacity (kW)	5190	3460	2600
Number of sets	2	3	4
Turbine type	GZ1250a-WP-540	GZ1250a-WP-450	GZ1250a-WP-390
Rated head (m)	3.516	3.516	3.516
Maximum head (m)			
Minimum head (m)			
Diameter of runner (cm)	540	450	390
Rated output (kW)	5463	3680	2765
Rated discharge (m3/s)	173.03	116.68	87.43
Rated rotary speed (r/min)	68.2	88.3	93.75
Full output efficiency (%)	91.54	91.46	91.72
Peak efficiency (%)	94.2	94	94
The suction height of turbine (m)	-6	-5	-4.5
Governor type	WST-100-6.3	WST-100-6.3	WST-80-6.3
Oil pressure devices	HYZ-2.5-6.3	HYZ-2.5-6.3	HYZ-2.5-6.3
Generator type	SFWG5190-88/6250	SFWG3460-68/520	SFWG2600-64/450
		0	0
Rated capacity (kVA/kW)	5766.7/5190	3844.4/3460	2888.9/2600
Rated voltage (V)	6300	6300	6300
Rated current (A)	528.5	352.3	264.8
Rated power factor (cosϕ)	0.9	0.9	0.9
Rated rotary speed (r/min)	68.2(f=50Hz)	88.3(f=50Hz)	93.75(f=50Hz)
Insulation level	F/F	F/F	F/F
Excitation mode	Static Silicon Control Excitation system		

9.9.2. Main Equipment Design Parameters

The main design parameters of major equipment are shown in Table. These parameters are preliminary and will be refined during the detail design development stage.

Table - 23: Design parameters of 6.3 KV Switchgear

Parameters	Unit	Value
Nominal system Voltage	kV	6.3
Rated Voltage	kV	7.2
Rated Short Time Withstand Current	kA	25
Rated Continuous Current Insulation Medium	A -	1000 SF6 / Vacuum
Frequency Aux. and / or Control Voltage (DC)	Hz V	50 110

Table - 24: Design parameters of 132 KV Switchgear

Parameters	Unit	Value
Nominal system Voltage	kV	132
Rated Voltage	kV	145
Rated Short Time Withstand Current	kA	40
Rated Continuous Current Insulation Medium	A -	100 SF6 / Vacuum
Frequency Aux. and / or Control Voltage (DC)	Hz V	50 110

Table - 25: Design parameters of LV Switchgear

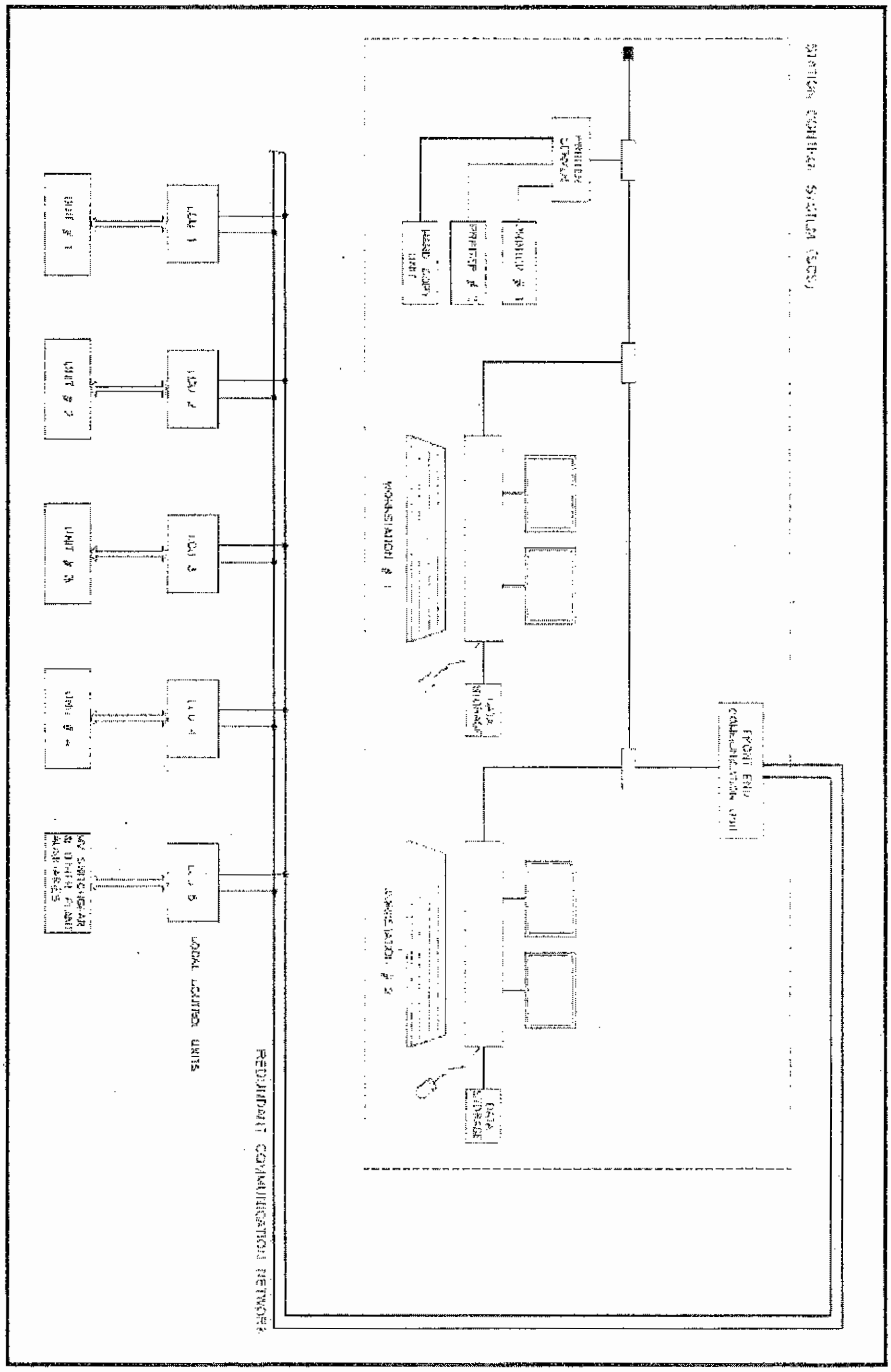
Parameters	Unit	Value
Nominal system Voltage	kV	0.4
Rated Voltage	kV	1000
Rated Short Time Withstand Current	kA	40
Rated Continuous Current Insulation Medium	A -	400 Air
Frequency Aux. and / or Control Voltage (DC)	Hz V	50 110

Table - 26: Design parameters of DC and essential AC system

Parameters	Unit	Value
DC SYSTEM Nominal System Voltage (DC)	V	110
Rated System Voltage (DC) **ESSENTIAL AC SYSTEM** Nominal Input Voltage (DC)	V V	110 110
Nominal Output Voltage (AC)	V	230

9.9.3. Control System Configuration

The proposed overall control system configuration is shown in following Figure:



CONTROL SYSTEM CONFIGRATION

9.10. Interconnection To Grid

9.10.1. Nearest 132 KV Grid Stations and Transmission Lines

A transmission line shall be installed in order to evacuate power from the power plant site to the nearest grid station, while maintaining voltage within the required limits and containing transmission losses at levels consistent with its load.

The preliminary interconnection studies for power dispersal from the power plant site were conducted based on collecting data through visits to grid station nearest to the power plant site. The information pertaining to the transmission and substation facilities obtained includes the location of nearest 132 KV substation, its distance from the power plant site, the distance of existing, if any 132 KV transmission line passing nearby etc.

The nearest 132 KV grid station from the proposed power plant site is 132 KV Chunian grid station, which is located at 7 km from power plant.

9.10.2. Interconnection Consideration

The following points have been considered in determining an optimal interconnection arrangement for each site:

- Power plant generating capacity,
- Transmission line capacity,
- Existing grid station extension limitations,
- Voltage regulation concerns,
- Environmental impact,
- Interconnection Cost
- Distance between power plant and grid connection

The power plant generators use rotating machines and thus contribute to and raise network fault levels. Although generally not an issue for generators in far flung areas, fault levels can be an impediment to the connection of generators in urban areas, as existing fault levels are often close to the rating of existing switchgear. Up-rating switchgear to allow operation with raised fault currents is generally expensive. For the power site, the fault levels at the 132 KV and 11 KV side of the grid station are considered in the interconnection study.

9.10.3. Interconnection Options

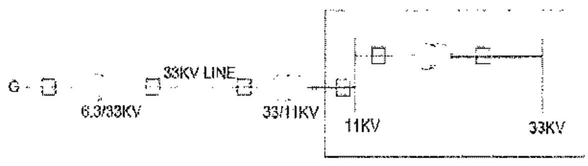
A significant aspect for any power plant is its location in relation to a primary substation.

There are less voltage control problems in making connection to the substation end of a well loaded 11 KV line feeder than to the far end of a lightly loaded 11 KV line feeding dispersed rural customers. If 11 KV connections are not feasible, then connection via 33 KV or 132 KV lines are to be made.

Two interconnection options have been considered keeping in view the power network existing in the vicinity of the power plant site. The first option is the connection of the power plant through single circuit 33 KV line to the 11 KV feeder of Chunian 132 KV grid station (Option 1) and the second option is the direct connection through double circuit of the power plant by a new transmission line at 132 KV level (Option 2) to the existing grid station.

9.10.3.1. Option 1: Interconnection Utilizing 33 KV Voltage Level

The line diagram for this option is given in Figure. The 11 KV switchgear at the relevant 132 KV substation would have to be extended to accommodate this connection. However, the switchgear ratings must not exceed with the additional in-feed from the power plant.

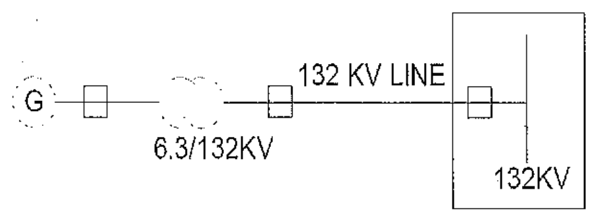


INTERCONNECTION UTILIZING 33KV VOLTAGE LEVEL

The equipment required for this option includes 11 KV switchgear and other hardware (132 KV substation side), 33 KV line including (poles, insulators, support & conductor), 33 hardware and MV switchgear (power plant + substation sides) and transformer etc.

9.10.3.2. Option 2: Interconnection at 132 KV Voltage Level

This option has enhanced transmission capacity. The existing 132 KV grid station would have to be extended to accommodate this connection. The equipment required for this option includes 132 KV equipment & hardware, 132 KV protection, 132 KV general equipment, 132 KV transmission line including (towers, insulators, supports and conductors etc.), telecom & tele-protection equipment and transformer etc.



INTERCONNECTION UTILIZING 132KV TRANSMISSION LINE

9.10.4. Recommended Interconnection Option

In case of option 2, the voltage regulation increases requiring additional higher rating hardware resulting in higher cost., but in this scenario transmission losses will be minimized as compare to option 1 so the connection of the power plant through 132 KV line to the Chunian 132 KV grid station is recommended.

9.10.5. Transmission Line Route

Various options for connecting the power station to the Chunian Grid Station initially considered. However, in view of the environmental and social impacts it was decided to route the transmission line along the road on the right of way (ROW) of the road. Being the government-owned land it does not involve any resettlement or other issues.

10. ENVIRONMENTAL STUDIES

10.1. General

The purpose of Environmental Study is to identify and assess all the physical, ecological, socio-economic and environmental significant impacts, both positive and the negative that can occur during the construction and operation of the Hydropower Project at BS Link-I at RD 106+250 along with the proposed mitigations of the adverse effects of the project on that area.

Initial Environmental Examination is an essential part of any project as the environmental & social impacts of the project on the surrounding area are the vital aspects which need to be accounted for before the start of any project.

According to the Pakistan Environmental Protection Act (PEPA) 1997 and EIA Regulations 2000, an Initial Environmental Examination (IEE) study is carried out for those hydropower projects which have less than 50 MW capacities. On the basis of this report the proponent is required to get the No Objection Certificate (NOC) from EPA Punjab.

This study covers the Environmental impacts of the proposed hydropower project, in and around the project area, comprising the environmental, physical and socio-economic aspects of the project area. The study also suggests the mitigation measures and describes the institutional arrangements and Environmental Monitoring Plan (EMP).

10.2. Methodology

10.2.1. Review of Layout Plan / Available Documents

A detailed review of the hydropower project layout plan, field visit notes, satellite imageries and GT sheets, inception report, progress reports, and pre-feasibility report was carried out in order to truly understand the proposed project and the extent of the development activities required. The review of the layout plan helped to visualize the nature and extent of the impacts related to the implementation and operation of the proposed project.

10.2.2. Environmental Baseline Survey of the Project

A team of experts have done a numbers of visits at BS Link-I HPP site and its surrounding areas in April and May 2016. These visits were carried out to gather the baselines environmental conditions data in the study area along with the study of impacts of the environment and socio-economic aspects have been done there in or around the study area. Information was mainly collected regarding impact on resettlement issues, land acquisition, agriculture (crops, animals, forest), ecology (wildlife including aquatic species like fish, and terrestrial like birds, forest trees & shrubs, etc.), infrastructure (transport network, township) and other socioeconomic aspects (cost, education, health, history, etc.).

i. Physical Environment

During site visits for collection of information regarding physical environment, various parameters were considered including:

a) Land Resources
b) Water Resources
c) Climatology
d) Air Quality
e) Noise Pollution
f) Solid Waste Management and Water Disposal activities;
g) Other infrastructures (Public & Private)

ii. Ecological Environment

Under the ecological environment the following parameters were considered:

a) Flora
b) Fauna
c) Reserved forests and wildlife sanctuaries in the study area and its vicinity
d) Endangered species (both flora and fauna), if any

iii. Social & Cultural Environment

Social and cultural environmental survey was carried out in the study area in order to assess the social and cultural baseline conditions. This survey consists of the following objectives:

- To identify poor and vulnerable groups and develop a plan/strategy so that such groups would get benefits from the project.
- To ensure adequate public/stakeholders consultation and participation
- To gather information from the local residents and the community people about the environmental and social parameters of their localities.
- Demographic characteristics of the study area.
- To identify the various effects of the project on the resources of the community and their local residents.

Social survey was carried out to collect the various information about the study area from the community people and stakeholders. Interview sessions were held at the study area to gather the socio-economic information and the physical effects on people from the project and during the project. Consultation with the different departments at or around the site area was also carried out to gather some project related and community related information, these include the Government departments and the private NGO's and various others departments from where the project related information was collected.

10.2.3. Analysis of Data

After collecting all the relevant information, including the environmental and the socio-economic baseline data from the project area, an analysis was made from the data to assess the baseline conditions and impacts of these on the project.

10.2.4. Screening of Potential Impacts and Mitigation Measures

After a thorough review of the field notes, data collected, the extent of the proposed project activities and the detailed discussions held with the stakeholders and the design team, the potential impacts of the project were assessed and measures have been proposed to mitigate the adverse impacts and to enhance the positive impacts. The potential impacts and mitigation measures were assessed covering the following aspects / phases for the environmental problems related to the project:

- Location
- Construction
- Maintenance and Operation

10.2.5. Preparation of Institutional Requirements, and Development of Environmental Monitoring Plan

Institutional capacity of the Proponent was reviewed and suggestions were made for the effective implementation of the mitigation measures and the generic monitoring requirements. As the supervision Consultants and Contractor(s) for the project are yet to be finalized, therefore, generic guidelines have been provided in this report for defining their roles and responsibilities.

ENVIRONMENTAL IMPACTS AND MITIGATION

This section highlights the potential impacts of the pre-construction, construction and post construction stages of the project on the ecological, environmental and socio-economic aspects of the area. Accordingly, proper mitigation measures are proposed for the adverse impacts of the projects on the area. It is anticipated that left bank of the BS Link I Canal HPP will face no direct impacts as the power channel of BS Link-I project is proposed on the right bank of the canal. The land available between BS-I and BS-II canals is proposed to be used for colony and offices. This land is Government property and not in use, only a couple of abandoned structures of Irrigation department are there.

There are three stages of the project which include pre-construction, during construction and operation or post construction of project and impacts for each stage are described in subsequent text.

10.3. Pre-Construction Stage

10.3.1. Physical Environment

a) Impacts on Existing Infrastructure

There is no such infrastructure available in project area which needs to be demolished before the construction of the project, so this issue is not of great significance. However, the issue of disturbing local access and canal crossing bridge will rise at later stage and will be addressed as mentioned in later paragraphs of this report.

b) Mitigation

As there is no such infrastructure present within the area of the proposed project so there will be no mitigation required at this stage except some demarcation of project boundaries and distinguishing it with barbed wire. In order to inform the local public about the project area and safeguarding project men and machinery.

10.3.2. Ecological Environment

a) Impacts on Flora

It is estimated that about 13-15 tress will be cleared for the later construction of the power channel and the power house. Other than that there is no floral presence in the project area except some bushes and herbs.

b) Mitigation

Trees replenishment cost of trees will be decided and paid to the concerned department or the other mitigation can be to plant more trees in the ratio of 1:2 in that area after the completion of the proposed project.

(1:2 means for every Fallen tree there will be 2 trees of the same species will be planted as alternate).

10.3.3. Socio-Economic Environment

a) Impacts on Community Dislocation and Resettlement

As it is seen from the proposed project site area that there is no community in or around the project area, so no dislocation or the resettlement of the community will be required in the area before the construction of the proposed project. Rather the local people and the stakeholders are very much interested and happy with this project site.

b) Mitigation

As there will be no such dislocation and the resettlement issue of the communities near the project site so no mitigation is as such required, but some privately owned land and some land of the government will be affected that will be mitigated in an amount of money or some measures are recommended as a settlement for the local community people as described below.

- The bridge over the canal may remain intact or it will be relocated nearby so that the local people may continue their daily routines and there will be no issue for the villagers on the left bank to come and cross over to the villages on the right bank of the canal.

- Other mitigation might be helpful for the residents there to open small shops or dhabba for the labors and the working staff on the project site area that not only helpful for the working men but also it will add to the bread n butter of their own to collect some revenue from this.

- Since dust, noise and social mixing may cause other environmental and social problems for this settlement so the future contractors must keep in mind some economic compensation while implementing EMP, for instance offering labor work.

c) Impacts on Affected Lands for Powerhouse

According to the proposed layout of BS Link-I HPP, the power scheme will affect about 18.12 acres of the area of the land. Some the land area that will be affected by the power scheme is privately owned and most of the area is government owned.

d) Mitigation

Project proponent will acquire the land through revenue office of Government of Punjab or directly from the land owners according to terms and conditions laid in LAA 1894. This issue will be resolved before the start of construction of the project.

e) Impacts on Affected Community Assets

It is anticipated that the access roads for the transportation of the construction materials that will be used in the construction of proposed HPP, some village roads and unpaved canal bank road will be used which are community assets.

f) Mitigation

It is foreseen that unpaved paths for the community will be improved with the construction of project roads and overall impact on the community assets will be positive.

10.4. During Construction

10.4.1. Physical Environment

10.4.1.1. Land Resources

a) Impacts Due to Soil Erosion & Contamination

Soil contamination is a phenomenon that can occur due to the mixing of the discarded materials like plastic pieces, wires, tins, bags, oil things, wood, and drums cardboard pieces into the soil. All these waste materials when added to the soil present on site during the construction of the proposed HPP It will contaminate the soil.

One of the most important soil contaminating sources is the generation of solid waste during the construction activities. It is estimated that on an average 100 laborers will be employed at construction camp, which will generate about 50 kg of solid waste for camp site @ 0.5 kg per capita per day. The major components of the worker's camp waste are garbage, putrescible waste, rubbish and small portion of ashes and residues. Immediate attention is required for such type of wastes as these are degradable and cause obnoxious odour.

b) Mitigation

Soil contamination on the site can be controlled if by practicing intelligent environmental engineering and taking reasonable measure to control it.

Soil contamination due to oil leakage, chemicals and toxic components can be minimized by providing a special storage places for these elements. Oil tanks and the toxic elements and chemicals should be placed at some distance from the main construction site on the proposed leakage proof tanks. Fire extinguishers should always be available near to these elements so that in case of emergency their services can be used by the people, instead laborers who have to control these things should be skilled and have knowledge of how to operate them in emergency.

Soil contamination by other materials like wires, tins, wood pieces, plastics and other materials can be controlled by placing separate storage tanks and drums for disposal of different things in them so that contamination can be avoided.

c) Impacts Due to Natural Drainage

Some of the loose soil that are the results of the excavation from the ground can be used for some backfilling purposes but most of the bulk of the that loose soil will remain at the place of excavation and cause dust problems due to its looseness it can blow with the air and can cause the flow problems in the natural drainage.

d) Mitigation

Excavated soil should be disposed of and used time to time so that it will make any spoil bank near the excavated area and cannot make any hindrance to the natural path of the flow and the rainwater flow. Open drains for the drainage of wastewater should be constructed, if considered necessary during the construction.

e) Impacts on Water Resources

The water requirements for the project can be divided into two main uses, i.e. water required for labor camp utilization and for construction. It is estimated that around 100 workers will be accommodated in the construction camp during construction activities, who will utilize around 4000 liters/day of water for washing, cooking and bathing purposes. This water will be extracted from groundwater and will have no conflict with the local water users and agriculture of the area.

Due to the construction activities i.e. excavation and dumping of soil, spillage of chemicals, oil, lubricants, detergents etc., and the surface water quality might get deteriorated. In addition to that, around 3,200 liters/day (3.2 $m^{3/}$day) sewage will be generated at the construction camps. If the generated sewage is not properly treated or disposed off, this may contaminate the surface and might affect the groundwater resources apart from soil contamination.

f) Mitigation

Water should be excavated from the ground sources for drinking, cooking and other purposes and it should not have any conflict with the surface water and other contamination. It is recommended that effluent from contractor's camp should be treated before discharging it. Daily sewage deposits should be done on site so that it could not make any pollution on the site for the local people nearby and the working staff and labors there.

g) Impacts on Air & Noise

A number of machinery and equipment will be in operation for the construction of the project, which includes concrete mixers, excavators, dumping trucks, road rollers, haul trucks, transport vehicles, cranes and other construction machinery.

Most of these machines use diesel engines that generate noise and exhaust emissions. The possibility of exhaust emissions increases when the old vehicles/plants are deployed during the execution. Generally, the activity generates particulate matter (PM10), smoke, dust, CO and NOx in the ambient air, which deteriorate the ambient air quality and resulting in adverse impacts on the human, livestock, agriculture, fauna and flora.

Due to the movement of trucks and other construction vehicles it causes noise and disturbance for the people living in the nearby villages and areas. Due to excavation of soil it causes dust pollution at the proposed project area that can also affects the nearby residents and can be harmful for them.

h) Mitigation

Following mitigation measures may reduce the severity of aforesaid temporary adverse impacts:

- Tuning of vehicles should be made mandatory to reduce the emissions of NOx, SOx, CO and PM10.
- Emissions from the concrete mixing plant should be controlled with appropriate control equipment (such as fabric filters or cyclone separators).
- Haul-trucks carrying, earth, sand, aggregate and other materials should be kept covered during the transportation of materials and storage at site with tarpaulin, to avoid the dust emissions.
- For the construction machinery generating noise level above the prescribed of NEQS and WHO limits. The noise level should be within the permissible limits.
- Movements of the trucks and other construction machinery causing high noise levels must be restricted at night time to avoid disturbance to the nearby locality. Truck drivers should be instructed not to play loud music at night and stop the use of horns even at day time; and

- Fugitive dust may be settled down through water sprinkling during working hours with appropriate frequency as suggested in the environment monitoring plan.

10.4.2. Ecological Environment

a) Impact on Flora

Study on impacts on flora depicts that there is no such huge damage of the trees present at the proposed project area rather than the few trees which will be Fallen down for the construction of the power channel as well as the powerhouse.

b) Mitigation

It will be decided according the mutual consent that about twice the number of trees will be planted in place of one Fallen tree or a specified amount should be paid to concerned department as the cost for the Fallen trees so that they may plant more trees after the construction of the proposed project. Instead some horticultural or floricultural based parks or sites may be established near the project site area to enhance its beauty.

c) Impact on Fauna

Impact on the fauna will be of minor and of temporary nature, although, a few rarely sighted species of avifauna are reported in the surroundings, but the project is not expected to have any significant adverse impact on them.

The proposed project will rather yield positive impact on the fauna of the study area because the fauna and especially the avifauna will be attracted to the area again due to recommended extensive plantation to improve the flora of the tract.

Other than birds, there will be rather insignificant adverse impact on other classes of wild animals including fish, wild animals, viz. mammals, reptiles, amphibians or insects; they will migrate to the adjacent safer places. It is also envisaged that local people or the Contractor labor may harass/shoot this wildlife.

Fish will not face any adverse impact regarding downstream fish catch during construction period because cofferdam will help to connect powerhouse with the main canal safely.

d) Mitigation

Hunting, shooting and other such activities which affect the fauna of the area and other environment must be avoided. Good engineering plans will make the proposed project conducive with the schedule of canal closure periods so that minimum disturbance could be envisaged during whole construction period of the project.

Adverse impact will be of temporary nature and will be more than compensated during operation stage when a sizeable tree plantation plan will be carried out along the boundaries of the power station and the portion of the main road in front of the power station area. Flowery and ornamental shrubs and plants shall be grown in the open spaces, enhancing the aesthetic value of the tract and making it more attractive for birds.

Noise control measures should be enforced during the construction phase, such as provision of heavy duty mufflers and silencers on heavy construction vehicles. Construction activities should be avoided during night, as the noise created by construction machinery becomes manifold during silence. Vehicles speed should also be controlled to avoid any incidental mortality of mammals or reptiles. There should be clear orders to the staff and labor, prohibiting hunting, shooting or harassment of wildlife.

10.4.3. Socio-Economic Environment

Impacts on the social life of the surrounding human communities is divided into two parts i.e. the construction phase and the implementation process. Following are the detailed impacts of the construction activities on the socio-economic environment shown below.

e) Impacts on Livelihood and Other Socio-Economic Status

Socio-economic impacts during the construction phase may increase the per capita income and many other allied facilities for the local residents of the communities nearby the proposed project area. They can run small business at or near the project site area to increase their livelihood as well as the males from the nearby villages can also take part in the construction phases as unskilled worker and can get the experience of the construction activities also that can help them in future for further earnings on some other projects.

There will be some impacts on the agricultural fields at the right bank of the BS Link-I Canal that are owned by some private stakeholders. That affect will be caused due to the construction of the power channel as well as the powerhouse for the proposed project.

f) Mitigation

The local community people may be hired as a skilled or semi-skilled laborers that can help in the construction of the project as well as they can get much experience from this project for their future benefits. People from other villages that are far from the proposed project site can also participate in this activity and contractor must assure that there will not be any quarrel between groups on site area.

Besides the private land owners who have agricultural fields in the way of powerhouse and power channel may be benefit with the land price or another land after the completion of the project so that they can continue to earn their livelihood.

g) Impacts on Community Health & Safety

It is observed that following health and safety issues can be seen at the site of the proposed HPP during construction phase.

- Construction activities, particularly excavation and movement of haul trucks and machinery may prove dangerous for the safety of the workers as well as for the residents who are settled on the route of contractor movements.
- Construction staff and the labors may get slip from the vertical members while working on them as well as they may get injured while working near the excavated area where there is a chance of side slope failure.
- The nearby local residents of the communities may get affected due to the contractor's activities on site as well as the windblown of sand and soil which is excavated and remained there as a loose material during construction.
- Social insecurity problems may arise for the local population of respective settlements due to the social mixing of the contractor's workers.
- Some communicable diseases, especially venereal diseases are expected to boost due to temporary settling of the contractor's labor.
- Traffic related problems are not expected to be of a significant nature because the traffic movement on the access road will not be of significant magnitude. Therefore, construction materials and machinery can be easily transported without any traffic jams.

h) Mitigation

It is recommended that a standard HSE (Health Safety & Environmental) plan must be proposed and should be duly approved by consultants and client. The social norms of the local population are respected.

i) Impacts on Other Civic Facilities

Education, health, communication, services, utilities, recreational and religious affairs are the general components of the civic life of the surrounding communities in the study area and some of them have been discussed. It is anticipated that most of these will receive positive impacts by the proposed project, therefore, no negative impact foreseen.

10.5. Operational Stage

10.5.1. Physical Environment

a) Air Resources

During the operational stage of the proposed project, powerhouse commissioning will not much affect the air quality in terms of any gas emission from powerhouse whereas the traffic volume and the frequency connected with the powerhouse working may pollute the air quality but certainly insignificant.

b) Mitigation

As gases will not emit from the powerhouse during its operational stage so there will not be any mitigation required.

c) Noise Pollution

Noise pollution may be a major problem for the residents and the local community people due to the working of the turbines. It may affect human health in terms of causing annoyance, aggression, hypertension, hearing loss, sleep disturbance and other harmful effects. Such problems may affect the person working in the powerhouse majorly and less to the local residents and the villagers far away from the powerhouse site. It is also anticipated that vehicular movement will be enhanced during project implementation phase.

d) Mitigation

The noise pollution within the power station will be maintained at less than 80 dBA and the workers will be required to wear earmuffs to minimize the effect. Noise levels outside the power house will be less than 70 dBA. Tree plantation will also be helpful to decrease the high noise impacts.

Special permanent sign boards must be fixed at appropriate distances to caution the vehicle drivers of public transport not blow horns in the Study area.

e) Impact on Water Resources

As far as the impact on water resources is concerned, proposed powerhouse location and the function will not yield any adverse effect on the water resources of the area, however the waste water from the colonies have negative impacts on the water resource and may play adverse role in the calamity of the BS Link Canal.

f) Mitigation

No mitigation needed for water resources downstream of the canal. Regarding water demand for the residents, it will be met from the groundwater so it will minimize the water conflicts. Groundwater will be utilized with the permission of the concerned departments to avoid any conflicts. It is recommended to treat the domestic wastewater from colony.

g) Impacts on Aesthetics

Aesthetics of an area play a vital role in beautifying the area and improves the working environment of an area. The proposed project site and the location of powerhouse also take part in the aesthetics of an area and not only will improve the working efficiency of the labor but also yield synergic effects on the surrounding settlements.

h) Mitigation

Since there will be no adverse impact of the project on the aesthetics, thus no mitigation required. Anyhow, in order to improve the working environment further, good housekeeping, and cleaning and efficient solid waste management system should be implemented. Moreover, it is suggested that flower pots and other techniques should be used inside the buildings to improve the working environment of the powerhouse.

10.5.2. Ecological Environment

a) Flora

Adverse effect on flora will not be observed during the operational stages of the proposed HPP. There will be insignificant impact on the vegetation in or around the site area whereas during the operational stages more trees can be planted around the power house site or at the open places as it is mentioned above of the plantation of trees after the construction of the HPP complete. This will surely induce positive impacts on the health of the local residents and community people there.

b) Mitigation

A tree plantation plan has been discussed above in the "during construction" phase where it is proposed to plant trees in the ration of 1:2 in alternative for every Fallen tree in or around the site area due to the construction of the power channel and the powerhouse. This proposed tree plantation plan will create positive impacts on the natural flora and increase the vegetation of that area.

c) Fauna

Both the flora and fauna are integral part of the ecosystem. In many ways fauna of a tract is dependent on flora for its resting, nesting and roosting activities. With the improved flora of the tract, due to extensive plantation, the fauna and especially the avifauna shall be attracted to the area, resulting in return of the wildlife, which had earlier shifted to adjoining areas and causing a positive impact. It is also envisaged that local people or the Contractor labor may harass/shoot this wildlife.

d) Mitigation

It is the responsibility of the staff working on the proposed HPP to have an accurate vision that no one will harass, shoot or kill wildlife at the site area.

e) Downstream Fishery

Some adverse impact on the downstream fishery is expected during project operation due to water striking the turbines which might trap the fish. This is considered to be insignificant.

f) Mitigation

In order to protect fish fauna stock/pond fishery along the downstream track of the canal at appropriate distances may be established so that downstream fish catch may be strengthened to supplement human diet.

10.5.3. Socio-Economic Environment

a) Impact on Soil Fertility

Fertile lands of that area will be taken from the private owners of those lands for the purpose of the construction of the power channel and powerhouse of the proposed BS Link-I HPP. In alternative some other land will be provided to the farmers at some other places or the amount relative to that of the land will be paid to them. This phenomenon should be kept in mind that such reclaimed land seldom reaches its pre-excavated fertility/productivity level mainly due to loss of pre-existed nutrients, compaction level, etc. Returning this reclaimed land and its soil to its original productivity level may take 1-3 seasons.

b) Mitigation

Since such farmland will cause to reduce the production of food and fiber for some time, hence one-time crop compensation can be considered for the next cropping season. In addition to that some additional fertilizers and compaction machinery may be provided to the farmers free of cost as soil regenerator which help the top-soils richness against physical and chemical impoverishment.

c) Other Socio-Economic Impacts

This project will mainly have positive socio-economic impacts during the operation phase. Some of the socio-economic impacts have been mentioned below:

- The socio-economic impacts like employment, health and cultural uplifts are the major and the direct benefits to the people in the study area not only during the construction phases but also after the construction of the proposed project such people can be employed as a workers and for the betterment of the aesthetics of that area during the operational stage of that project. The human resources will be developed at a local level for future development activities in the areas.

- A suitable and quick medical facility should be available for the working staff and laborers on the powerhouse during the operational phase so that in case any emergency quick medication can be provided to those people.

- Due to the implementation of the proposed HPP all the roads in the vicinity of the project area or that approaches to the project site will be widened to ease the traffic flow and to make a good aesthetic facility for the people to reach there.

- The educational and cultural aspects will undergo positive change. The social amenities i.e. roads, dispensaries, water supply etc. will raise the living standard of the people. All the job opportunity related to the project will ultimately be directed towards increased per capita income of the population in the area. It is expected that there will be no adverse impacts on the socio-economic condition of the people of the Study area.

- No additional socio-economic adverse impacts are foreseen during the operational stage of the proposed project.

d) Mitigation

No mitigation measures are required because there will not be any adverse social impact.

Environmental Management Plan (EMP)

To implement and monitor the mitigation measures EMP has been discussed in detail in Volume-3 IEE. Environmental impacts and their mitigation measures have been discussed in earlier section., the following institutions will be involved in EMP:

- Proponent of the project (the Executing Agency, EA);
- SC, as deputed by the Project Proponent;
- Project Contractor, as the executors of the Environmental Monitoring Plan (EMP) during the construction stage of the Project;
- EPA-Punjab, as observer and top monitoring agency during the construction and operation stages; and
- Representative of Irrigation Department & District Administration Kasur

10.6. Monitoring Program

10.6.1. Pre-Construction Stage

Some impacts of the proposed project are even started before the construction stage. These are given in Table below.

Table - 27: Proposed Monitoring at Pre-Construction

Parameter	Management Mechanism
Land acquisition	Confirm that all acquisition is complete before start of the project.
Tree cutting	Comply with the Project Area tree plantation plan as and when required.

10.6.2. During Construction Stage

The proposed monitoring program during the construction phase is given in Table as under:

Table - 28: Proposed Monitoring during Construction

Parameter	Location	Monitoring Mechanism/Parameters	Frequency
Dust Emissions	Near project site, access roads and	Visual checks	Daily routine monitoring

Parameter	Location	Monitoring Mechanism/Parameters	Frequency
	settlements		
Wastewater	Workers' camp	Effluent discharges from workers' camp to be tested for total coliforms, Ammonia, (BOD), (COD) and other nutrients as per NEQS	One sample quarterly
Solid Waste	Workers' camps and construction site	Waste generation, storage, collection and disposal	Fortnightly
Drinking Water	Water being used for drinking purposes by workers and nearby community	Discrete grab sampling and laboratory testing of groundwater according to WHO standards	Two samples of drinking water from the construction camp and other from nearby village on quarterly basis
Noise Levels	Project site and nearby settlements	Noise level according to WHO standards	Once prior to the start of construction and then on quarterly basis throughout the construction period
Fumes and gases	Ambient air, silencers of heavy machinery, trucks and other vehicles at project site and adjacent settlements	Pollution parameters including the SO_2, NO_2, CO, VOC and Particulate Matter according to WHO standards	Monthly monitoring
Health and Safety	Labor camps and construction sites	Medical check-ups and routine safety check-ups of the communicable diseases and accidents	Quarterly
Wildlife and Avifauna	At and around project site or in the whole study area	Illegal hunting of fauna / avifauna	Daily

10.6.3. During Operational Stage

The monitoring requirements during operational stage (post-project monitoring) including the parameters, frequencies and its sampling locations are specified in Table below.

A monitoring plan during operational stage is shown below:

Table - 29: Proposed Monitoring during Operational Stage

Parameter	Location	Monitoring Mechanism	Frequency
Potable Water Quality	One sample from workers drinking source and one from pressure/hand pump at the nearest settlement	Groundwater sampling as specified by WHO standards	Bi-annually
Wastewater	Just downstream of power station in the Canal and colony outlet	Effluents discharges as per NEQS	Bi-annually
Noise	Within Project site and around it	Noise level according to WHO standards	Bi-annually
Solid Waste	Place reserved for solid waste collection bins/ containers/open field.	Visual observation	Annually

Findings and Recommendations

The proposed hydropower station is an environmentally green project and will promote and strengthen the environmental profile of the area instead of any serious damage.

The major findings of the impacts during the construction and operational stages regarding the physical, ecological and socio-economic domains of the environment are, however, described below:

10.7. Physical Aspects

- There will not be any permanent or long term adverse environmental impact(s) on land water or air resources which may damage or limit the land use fully or partially; contaminate surface or drinking water to make them unfit for irrigation or drinking; or pollute the ambient air in terms of any stack emission;
- Construction activities may contaminate soil due to the discarded construction materials and obstruction in natural drainage due to un-attended excavated material. Generation of solid waste will be an important soil contaminating source and may yield temporary negative impact but its mitigation will be possible through good engineering and appropriate storage places will further help in managing the oil spills and other lubrication materials. Solid waste will also be properly managed by placing bins within the construction camp. If excavated material is properly disposed off then it will not block the natural rainwater drainage paths;
- Similarly impact on water and air resources will also be of temporary nature during construction period. The water requirements for the project can be divided into two main uses i.e. water required for labor camp utilization and for construction purposes.

This water will be extracted from groundwater and will have no conflict with the local water users and agriculture of the area. If the generated sewage is not properly treated or disposed of this may contaminate the surface water and may affect the groundwater resources apart from soil contamination. It is recommended that wastewater effluent from contractors' camp should be treated to remove oil/grease contaminants. Machinery in operation and other equipment may yield temporary negative impacts on the air resources. Most of these use diesel engines that generate noise and exhaust emissions. Generally, they will generate PM_{10}, smoke, dust, CO and NOx in the ambient air, which will deteriorate the air quality and resulting in temporary adverse impacts on the human health, fauna and flora. Similarly, fugitive dust due to the construction activities may also affect the local air quality. Good engineering, however, along with complying with EMP and HSE plan will solve all problems as mentioned here; and

- Transmission line connecting powerhouse with the nearest grid station at Chunian is recommended, with slight diversions from the existing route to bypass the human settlements.

10.8. Ecological Aspects

- It is expected that there will be no significant adverse impact on the trees as the area is not densely populated by trees. The site relation has been made to minimize the impact on the flora. During the operation stage, there will be positive impact on the flora due to the extensive plantation;
- It is estimated that 12-15 trees will be Fallen to clear the area for project construction. As per requirements of Forest Department, 2 to 3 times trees will be re-planted in the project site. To mitigate this minor adverse impact, a tree plantation plan is proposed in the EMP of this report which proposes re-plantation of trees and shrubs (three times the Fallen trees) in the Project Area at a total cost of Rs. 0.1 million. It also includes the maintenance of plantation for further few years' post-construction stage;
- Impact on the fauna will be of minor and of temporary nature, although, a few rarely sighted species of avifauna are reported in the surroundings, but the project is not expected to have any significant adverse impact on them. With the improved flora of the tract, due to extensive plantation, general fauna and especially the avifauna will be attracted to the area; and
- The route of transmission line will not, by and large, damage the natural resources of the area in terms of trees, general agriculture, aquatic species or natural flora.

10.9. Socio-Economic Aspects

- There will not be any population dislocation issue connected with the proposed project due to their presence away from the proposed Project Area, hence no resettlement, no damage to assets and no compensation thereof.

- The project proponent (the Executing Agency) will have to acquire about 29 acres of government and private land to be used for the construction and maintenance of the project which will, however, have to pay the cost to the relevant department or the private owner(s) before the start of construction.
- The surrounding settlements of the Study area like Kandu Khara etc may be temporarily affected due to the windblown construction material during construction period but as concerns the noise of construction activities, it will have no impact on the surrounding settlements being sufficiently far away;
- There may be some temporary adverse impacts of the presence of labor camps near the settlements in terms of the chances of fatal accidents and undesirable social mixing. Both of these impacts can be mitigated through safe traffic management plan and strict application of rules and regulations;
- Impact on the livelihood will be positive in terms of more employment opportunities, more health and education service provision as well as better availability of other civic facilities for the nearby settlements; and
- The proposed route of the transmission line will yield no special adverse impact on the underneath human settlements and/or other natural resources because both entities are not present there.

11. QUANTITIES & COST ESTIMATION

11.1. Major Quantities

After development of drawings, quantities have been worked out for the following components of work:

- Headrace & Tailrace Channel
- Spillway
- Powerhouse (including inlet bay, outlet bay, machine hall & erection bay)

Quantities have been worked out for the major works including earthwork, brick lining, dewatering, sheet piling, and stone apron & pitching for the above said components of works. For electrical and mechanical equipment and plant, the sizes and numbers as determined through the feasibility level design have been used. The details of the estimated quantities of major works including sheet piling, excavation, filling, concrete, reinforcement steel and stone apron/ pitching are summarized as following:

Table - 30: Summary of Quantities

Sr. No.	Description of item of Quantity	Quantity	Units
Headrace & Tailrace Channels:			
1	Earth filling	41,322	m^3
2	Earth Excavation	397,222	m^3
3	Brick Lining	10,567	m^3
Spillway:			
1	Earth filling	4,565	m^3
2	Earth Excavation	38,981	m^3
3	Lean	342	m^3
4	RCC	6800	m^3
5	Steel	721	Ton
Powerhouse:			
1	Earth filling	23,426	m^3
2	Earth Excavation	232,737	m^3
3	Lean	1252	m^3
4	RCC	64,058	m^3
5	Steel	4,866	Ton

11.1.1. Earthworks

Earthwork filling and excavations are required in the following components of works:

- Headrace & Tailrace Channel
- Spillway
- Powerhouse (including inlet bay, outlet bay, machine hall & erection bay)

Beside the above, earthworks will be required in the formation of plug bunds in main BS Link-I Canal at just start of headrace channel and at just end of tailrace channel to divert the canal water towards powerhouse / spillway in the bypass arrangement. The excavated material obtained from the power channel will be utilized for filling the banks of the power channel and the working platform between the power channel and BS Link-I Canal. A three-meter-wide berm in the excavation has been provided to install the dewatering wells in stages. A combination of different machinery including dozer, loader, excavator, tractor / back pusher and dump trucks are considered to be utilized for earthworks activities.

Total earthwork excavation quantities have been estimated to be 668,940 m^3. The quantity of the fill material required for bank raising comes out to be 69,314 m^3. However, for powerhouse excavation, dewatering will be carried out simultaneously with the earthworks for lowering the ground water table to achieve dry conditions during excavation.

11.1.2. Stone Apron/ Stone Pitching

Quantities of the stone apron and stone pitching in different components of works have been considered. Stone apron / pitching has to be done along the plug bunds for protection from erosion and upstream & downstream of powerhouse / spillway.

11.1.3. Plain / Reinforced Concrete

Lean, Plain and reinforced concrete will be used in the construction of the power house including inlet bay, outlet bay, machine hall & erection bay and spillway etc. The total estimated quantity of concrete comes out to be 70,858 m^3. The corresponding reinforcing steel quantity has been estimated as 5,587 m. tons.

11.1.4. Sheet Piling

Sheet piling / concrete cutoff walls will be required under the spillway to act as impervious cut offs. The total quantity of permanent sheet piling / concrete cutoff walls is duly considered.

11.1.5. Electrical and Mechanical Plant

According to the design accept, E & M quantities have been worked out. Quotations have been taken from China for major equipment.

11.2. Basis of Cost Estimates

11.2.1. Civil Works

Detailed analysis has been carried out for different major civil unit rates including the following:

- Earthwork Excavations;
- Earthwork Filling;
- Lean Concrete;
- RCC;
- Steel;
- Brick Lining.

For unit rates analysis, following rates of the area have been considered:

- Man Power
- Equipment
- Material

In the above said rates, Government taxes, contractor's overheads & profit have been duly considered.

11.2.2. E & M Works

Bids have been taken from China which has been used for E & M costing of the project. The cost of items in foreign currency have been converted into equivalent Pak rupees using a conversion rate of 1 US Dollar to 105 Pak rupees.

11.2.3. Environmental Mitigation Works

Under the subject, following costs have been considered:

- Costs for the land acquisition,
- Costs of assets to be lost,
- Development projects for project affected persons (PAP),
- Resettlement and rehabilitation;
- Environmental monitoring

Total cost for the above said aspects have been considered as 48,789,000 Pak Rs in detail in Volume-III of the report.

11.2.4. Care and Handling of Water

According to the site investigation carried out at the site, the water table is near to the natural ground surface. The excavation depths required for especially powerhouse are under the water table. For dewatering in the bypass weir and the powerhouse area, lump sum amount has been provided.

11.2.5. Earthwork Excavation and its Disposal

Unit rate for earthwork excavation and its disposal within 30 m lead have been used for power channel, power house and spillway. In addition, the unit rate for transportation of the surplus excavated earthwork up to 300 m lead has been used for costing purpose.

11.3. Cost Estimates

The detailed breakup of quantities and costs are given in Appendix F. The cost estimate includes details of civil works cost and electrical and mechanical (E & M) works cost. Base cost of Project is presented in following Table.

Table - 31: Summary of Cost Estimate

BS Link-I Hydropower Project

TOTAL COST OF PROJECT
GRAND SUMMARY

Item #	Description	Amount	Currency
1	Land Acquisition & Environment Cost	48,789,000	PKR
CIVIL WORKS			
2	Construction of Powerhouse	1,666,107,662	PKR
3	Construction of Spillway	226,768,621	PKR
4	Construction of Power Channel		
4a	Headrace Channel	107,034,679	PKR
4b	Tailrace Channel	139,930,873	PKR
Total (Civil Work)		**2,139,841,835**	
E & M Equipment			
5	Cost of E & M Equipment (4 Turbines)	1,179,570,000	PKR
Total (E & M Work)		**11,234,000**	USD
TOTAL		**3,368,200,835**	**PKR**
		32,078,103	USD

12. CONSTRUCTION METHODOLOGY PLANNING & SCHEDUING

12.1. Construction Methodology

As all the pre-requisite activities for construction will be completed, mobilization will be carried out and preparatory works will immediately be started. These comprise of construction of following:

- Access roads to disposal areas;
- Camps within the project area;
- Establishment of site offices and façilities;
- Implementation of environmental mitigation works.

After completion of the preparatory works and converting the site in the accessible and livable conditions, the main components of works will be started. Survey of the project area and related bench marked will be checked and project layout will be marked physically showing the excavation lines clearly.

Excavation of headrace & tailrace channels is not critical activity of the project but to reduce the quantum of work at the end of the project, it will be started from the start. Excavation of powerhouse from NSL in dry conditions will be started with the necessary machinery. After excavation of powerhouse deeper than ground water table, dewatering will be required at this stage to lower the water table. Detailed methodology of dewatering will be envisaged and if necessary, two (02) pumping arrangement will be carried out. Along with continuous dewatering, once the required levels are reached at the power house area, the reinforced concrete works will be started in sump pit area and raft of powerhouse. Concrete works will be kept in progress in the intake area, around generation chamber, turbine axis, draft tube area, piers and retaining walls. The powerhouse and intake substructure and superstructure will be constructed by conventional construction techniques using reinforced concrete. The draft tube liner and turbine embedded part must be available for installation during the second stage concreting. The powerhouse roof will be constructed along with the installation of the powerhouse crane which can then be used for installation of heavy plant and equipment, e.g. turbines and generators. In parallel with the installation of the turbines and generators, other electro-mechanical equipment in the powerhouse and control room will be installed. The work on the transmission line has to proceed during this period. Backfilling around the powerhouse and intake weir will be completed upon completion of the upstream and downstream retaining walls. Meanwhile when construction of powerhouse will be completed up to the bottom level of spillway, construction of spillway will also be started.

After completion of all the works of powerhouse, spillway and headrace & tailrace channels, and connection to the grid station in the canal closure, works will be constructed by which canal water will be diverted towards the proposed powerhouse / spillway. Beside closure works, general works such as landscaping, parking and permanent security fence will be completed. Wet testing of the installed plant will commence leading to the commercial operation upon successful testing.

12.2. Construction Planning

Conventional earthworks equipment and concrete batching plant will be used with the aggregate processing done at the site. The unskilled and semi-skilled labour will be recruited from the project area. Skilled labour from the adjoining districts and other parts of Pakistan will be utilized. Foreign experts and technicians will be employed for tasks relating to the installation and testing of mechanical and electrical plant and equipment.

All aspects of construction phase have been considered during the planning process including the activities required to be carried out during the annual canal closure period. A ten-hour single shift has been assumed while preparing the implementation schedule. However, there will be certain activities, which require more time and will be carried out during the late night hours, like concreting activity during the summer period. Besides this, the dewatering will have to be carried out round the clock. During the monsoon period, earthworks activity will have to be kept to a minimum and the dewatering will have to be enhanced for keeping the excavated area in almost dry conditions.

12.3. Implementation Schedule

Keeping in view the construction methodology, the quantities and the canal closure period, the construction implementation schedule has been prepared. Summary of the construction period of major works for selected option is given at the end of this section.

This schedule shows the sequence, duration and relationships between the various project activities. The schedules are divided into two distinct phases, i.e. pre-construction and construction phase.

Pre-construction phase of eighteen (18) months duration commences with the clearance of the PC-1 Form. This phase covers the project development, land acquisition, environmental mitigation works, mobilization of project implementation consultants, preparation of tender design and bid documents, tendering and bid evaluation. This phase will complete with the award of the contract to the successful bidder.

The construction phase starting in the 19th month will complete in 36 months on the successful testing and commissioning of the plant. The construction phase covers the site possession, mobilization by the contractor, issuance of construction drawings, procurement and installation of plant and equipment, construction of transmission line and connection to grid station, testing and commissioning of the plant. The critical activities are shown in red in the implementation schedule.

12.4. Phasing Of Costs

The total cost of the project is estimated to be 45.44 M.USD. The local and foreign components being in the ratio of 58% and 42% of the total cost respectively. Phasing of the project cost for the construction period of three (3) years has been done on the basis of 25% in the first year, 45% in the second year and 30% of the cost in the final year of construction as shown in Table 13.5.

Table - 32: Phasing of Costs

First Year Cost	25% of the Total Cost
2nd Year Cost	45% of the Total Cost
3rd Year Cost	30% of the Total Cost

13. ECONOMIC & FINANCIAL ANALYSIS

13.1. Project Introduction and Background

13.1.1. Energy and its Importance

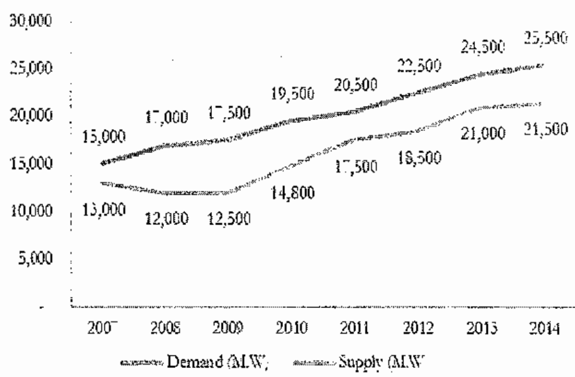
In the modern world economic development of any country is depended on the continuous supply of energy at affordable prices and this has become a global challenge. The demand for various fuel sources is changing the overall energy mix to support cost effective methods of energy generation for sustainable economic growth. The escalating demand for energy has encouraged people around the world to explore new vistas and think beyond the conventional sources of energy.

13.1.2. Objective

Financial Feasibility is part of the feasibility study being submitted to Punjab Power Development Board (PPDB) in relation to 11 MW BS Link-I Hydro Power Project. This document discusses the project rationale and the financial plan for its implementation in line with current market information available to the sponsor. It explains the financial and economic viability of the project.

13.1.3. Pakistan: Energy Profile

Pakistan is an important regional player not only because of its geo-political strategic location but also due to the fact that with a population of 180 Million it constitutes a big consumer market. Its annual GDP is USD 186 billion and GDP per capita has crossed USD 1,300 in 2012. Pakistan being rich in minerals, natural resources, fertile land and most importantly with large young work force makes right mix for growth.



Although the energy crisis is a global phenomenon however in Pakistan it is at its worst, resulting in prolonged power outages, impacting both industries and life of people at very large scale. The current energy crisis is mainly attributable to reliance on expensive thermal energy sources in spite of having huge potential for hydro energy, resulting in high electricity tariffs which are not in line with economic affordability of the local industry and people. Pakistan is currently meeting 70% of its electricity requirements from thermal sources while balance of the requirement is met from hydro and other sources. At present the electricity demand and supply deficit is more than 5000 MW in spite of very low per capita energy consumption.

The country's current energy demand far exceeds generation from its own resources, fostering dependency on imported oil that puts substantial burdens on the economy, with dire implications in the form of burgeoning oil import bill and increasing costs of power production, leading to a severe domestic shortage of electricity and gas.

13.1.4. Project Background

Government of Punjab (GoPb), realizing the urgency of the power sector's demand situation has undertaken various initiatives to overcome the current power crisis including development of Quaid-e-Azam Solar Power Park in Cholistan desert, setting up 1320 MW first coal power project in Sahiwal , 1320 MW LNG based Quadi-e-Azam Thermal Power plant .

As part of its initiatives to tap all possible avenues for power generation GOPb has given special attention to the development of small hydropower plants on the canals which is a ready resource.

Punjab Power Development Board (PPDB), Energy Department (ED), advertised eleven (11) hydropower projects in June 2015 and M/s Associated Technologies (Pvt) Ltd (ATL) was awarded Letter of Intent (LOI) for development of 11 MW hydropower project proposed on Baloki-Sulemanki (BS) Link-I Canal at RD106+250 in Mauza Kanda Kharan, Tehsil Chunian, District Kasur through a competitive bidding process.

BS Link-I Hydropower Project is located on BS Link Canal in Kasur, a city approximately 20 miles from Lahore. A Letter of Intent (LOI) for the project has been issued by the Punjab Power Development Board (PPDB) to the consortium led by Associated Technologies (Pvt) Ltd (the "Sponsors") under Punjab Power Generation Policy 2006 for developing the project on 30 years Built Operate and Transfer Basis (BOT). The Sponsors shall be responsible for arranging the finances for the development and construction of the project. Furthermore, they shall be responsible for the operation of the project for 30 years. All the power generated from this plant shall be purchased by government entity in accordance with the terms and tariff determined by the National Electric Power Regulatory Authority (NEPRA).

13.1.5. Objective of the Feasibility Report

This study gives an overview of the financial aspects of the project including capital expenditures, revenues and recurring costs that will be incurred throughout the estimated project life. Moreover, from the financial evaluation standpoint, this report examines the viability of the project and undertakes an analysis of its suitability for commercial power generation as standalone IPP. The levelized cost of electricity per unit and Project IRR has been used as key financial parameters to analyse the profitability of the project from the sponsor's point of view.

Further, this report discusses the economic rationale for undertaking the project from the government's perspective and the amount of savings and benefits expected from the project.

13.1.6. Layout of the Report

For easy reference , this report has been divided into 6 sections each containing information on a particular aspect of the project and is as follows:

Section 1: Introduction and Background

This section provides a brief preamble on the importance of energy due to the growing demand of electricity and widening gap between demand and supply of electricity in the country. This section also provides an overview of the objectives and background for the development of this Power Project.

Section 2: Power Sector Analysis

This section explains the current status of power sector in Pakistan. Moreover, this section provides a global overview of the small hydro power projects and recent developments in the region and Pakistan.

Section 3: Regulatory Framework and Incentives

The policy framework and incentive section provide an overview of Power Policy 2006 of Government of Punjab and lists out the salient features that are applicable to this project. Moreover, this section also describes the facilitations and incentives which the Government of Pakistan (GoP) has offered to small hydro power projects.

Section 4: The Project

This section gives particular facts about the project that include its background, concept, location, annual yield and generation as well as its benefits to the energy sector of Pakistan and a brief introduction to the project sponsors along with the proposed management and transaction structure.

Section 5: Project Cost and Financing Plan

This section identifies the estimated costs for setting up this power project, with respect to capital outlay for project implementation. The project cost has been further divided into various project components. It also looks at the funding requirements and proposes the financing plan to finance the capital costs.

Section 6: Tariff and Financial Analysis

This section describes the determination of tariff for sale of electricity and the basis for determination of tariff, including detail of different components contributing to the levelized cost of tariff.

Section 7: Financial and Economic Analysis

In conclusion, Project's Financial and Economic appraisal /valuation have been discussed in this section along with a sensitivity analysis.

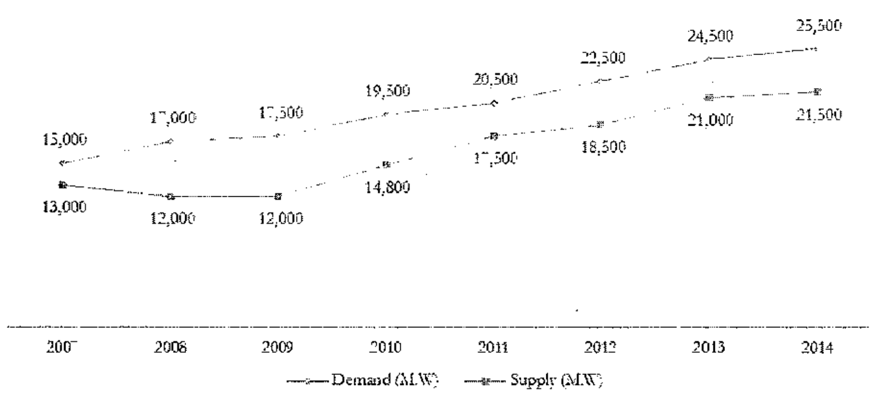
13.2. Power Sector in Pakistan & Overview of Small Hydropower Sector

13.2.1. Overview of Power Sector

Pakistan has an installed electricity generation capacity of 21,813 MW which has produced 91,960 GWh of electricity in the last fiscal year at an average load factor of 48% only. Due to growing population and rapid increase in energy demand, the country is facing a shortfall of about 5,000 MW; therefore, to fulfill the increasing energy demand of the country, a budget of USD 1.4 Billion has been allocated for the development of power generation and up-gradation of transmission and distribution networks.

Pakistan's energy constraints have become more pronounced in the past 10 years, as energy supply has failed to meet the demand emanating from both residential and industrial consumers. The demand-supply mismatch has affected millions of domestic consumers, industries, and the overall economy.

Source of Electricity	Total (M.W)
IPPs	7,584
Thermal	6,831
Hydel	6,664
Nuclear	462
Others	272
Total Installed Generation Capacity	**21,813**



Pakistan has a history of successfully tapping into the private sector through the IPP program in the thermal segment. About a third of the installed power generation capacity in Pakistan has been developed by the private sector. However, the bulk of future generation has been planned through hydro and coal fuel sources which have previously seen little participation from the private sector. In the recent years, Pakistan has managed to attract USD 8.9 Billion of private investment in 38 power projects.

In order to tackle with this situation government has shifted its focus from liquid fuel based thermal power generation to coal based power generation along with development of large hydro projects and alternate renewable resources .

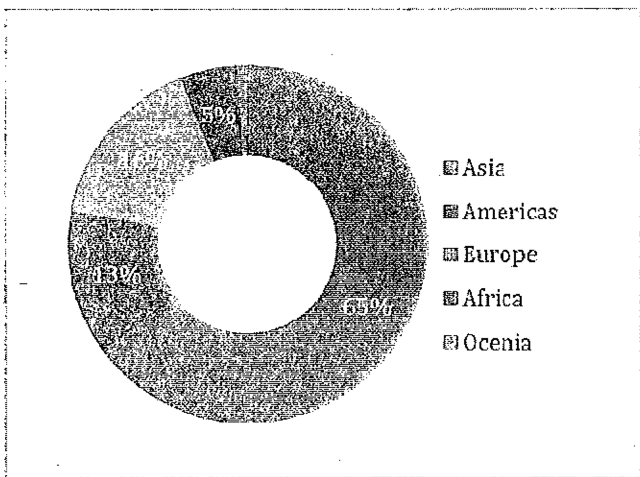
13.2.2. Small Hydro Power – Global Perspective

Many countries including several small island states rely on diesel for electricity generation. Soon they will be impacted by increasing petroleum prices and growing trade deficits. The switch to renewable energy, including small hydropower, may provide greater energy independence and economic stability, as well as contributing to climate change mitigation. Even in countries that are fully electrified, small hydropower may contribute to achieve renewable energy targets, energy diversification and energy independence.

Small hydropower is a well-developed small-scale renewable energy technology, which can contribute to the improvement of electricity access in rural areas and be part of the solution for socially inclusive sustainable industrial development as per the mandate of the United Nations Industrial Development Organization (UNIDO).

Currently, small hydropower plants with a capacity of 10 MW, exist in 148 countries or territories worldwide. Four other countries have been identified with resource potential.

The findings of WSHPDR 2013 shows that small hydropower potential globally is approximated at almost 173 GW. More than half of the world's known hydropower potential is located in Asia, around one third can be found in Europe and the Americas. The installed small hydropower capacity (up to 10 MW) is estimated to be 75 GW . Following is the Global distribution of small hydropower resource potential (up to a capacity of 10 MW)



13.2.3. Challenges for Small Hydro Project

In general Following are the key challenges for the development of small hydro power projects.

- Small size indeed in itself is a biggest challenge as small size of the projects doesn't attract investors particularly institutional investor, contractors and lenders.
- Lack of availability of discharge data.
- Lack of availability of qualitative geological and sedimentation data.
- Lack of availability of manpower for small hydropower plants planning and design.
- Long project development and construction period.
- Lack of involvement of local people.
- Lack of awareness and legal tools with state government to regulate minimum flows in the streams.

13.2.4. Small Hydropower Developments in India

India has developed small hydropower on its existing irrigation dams and irrigation canal falls. From 1997 to 2008, about 500 MW have been developed on these existing facilities and have been the first choice for development by IPPs. As per the latest data as of March 2016, small hydro projects with aggregate capacity 4,000 MW have been developed.

In India water is a state government subject, and hence development of hydropower is the responsibility of state governments. However, Central government advises the state governments on the hydropower matters and plays the role of an overall river basin planner and arbitrator.

Following are the key initiatives which have been taken by the majority of the states to develop the hydro power projects.

- In order to make the small hydropower projects cost effective and reliable, 31 supporting documents (standards, guidelines and manuals) covering the entire range of small hydropower activities have been developed by the Indian Institute of Technology (IIT).
- Key states have announced policies for setting up commercial small hydropower projects through private sector participation. The facilities available in the States include wheeling of power produced, banking, buy-back of power and facility for third party sale.
- More than 6,500 MW capacity small hydropower sites have been allotted to private sector for their development.

- Power banking (a concept of utilizing the electricity from the grid by the independent Power Producer for its use from one season rainy period) to other seasons i.e. dry period) is permitted by many for a period of one year but in some cases only for six to eight months.

- Buy back of small hydropower is generally based on the guidelines issued by the Central Electricity Regulatory Commission (CERC), with variations given by the State Electricity Regulatory Commissions (SERCs) of many states.

- Some states provide other concessions such as lease of land, exemption from electricity duty and entry tax on power generation equipment

- Some, States do not levy any water charges while some levy it as a percentage of electricity tariffs.

13.2.5. Small Hydropower Progress in Pakistan

Pakistan is blessed with a hydropower potential of more than 50,000 MW. However, only 12 per cent of total hydropower potential has been harnessed so far. The total installed capacity of the hydropower stations in the country is approximately 6,595 MW, out of which 3,767 MW is in Khyber-Pakhtunkhwa, 1,698 MW in Punjab, 1,036 MW in Azad Jammu and Kashmir and 93 MW in the Northern Areas.

Water and Power Development Authority (WAPDA) owns and manages hydropower sector in Pakistan. It is also the largest electric power producer in Pakistan owning more than 55 per cent of total electric power generation and serving 88 per cent of Pakistan's electricity consumers. However , private sector i.e. Independent Power Plants (IPPs) are also showing their presence in Pakistan , mainly in run of the river projects and these IPPs are expected to increase their share gradually and are likely to have significant share in hydropower by 2025.

Following table summarizes the potential of Small hydro projects in each province

Province	*Capacity*
Gilgit Baltistan	*764*
KPK	*564*
Azad Jammu Kashmir	*337*
Punjab	*409*
Sindh	*191*
Baluchistan	-
Total	*2,265*

Like India, water is a provincial subject in Pakistan and provinces are solely responsible for the development of small hydro power projects. However majority of the concessions and security package guarantees required to make the projects bankable are to be provided by the federal government.

Following are key incentives announced by the federal/provincial governments

- Comprehensive security package .
- Fiscal concessions for the hydropower projects.
- Guaranteed purchase of all the electricity produced.
- Provision of upfront tariff for small hydropower projects up to 25 MW.
- Resource risk guarantee.
- Attractive returns for equity investors
- Provision of severing guarantee for the payment obligation of the purchased electricity.
- State Bank of Pakistan (SBP) has introduced a special financing scheme for small renewable projects to provide low cost debt funding.

Small Hydropower has witnessed very small contribution in the power sector as compared to the overall potential available. Following are the key challenges to development of hydropower sector in Pakistan.

- Long gestation period
- Small/micro hydropower schemes are generally constructed in remote off-grid areas with poor infrastructure;
- Lack of trained local staff for operation and maintenance;
- Restricted optimal usage due to off-grid nature;
- Lower interest by private sector due to lacking proper tariff structure and reliance of provincial governments on the federal government/agencies to provide required guarantees and support in implementation.
- Difficult socio-economic conditions and generally weak implementation and coordination capacity.

13.3. Regulatory Framework

Pakistan has been facing an unprecedented shortfall in the electricity for last one decade which has jeopardized the economic growth and has affected the life of people at large scale. In order to combat the energy crisis, Government of Punjab introduced the Power Policy 2006, further updated in 2009. The policy aims to tap all the available avenues for the power generation. After the 18th amendment in the constitution of Pakistan, provinces can undertake and initiate project of any size at their own. The Power Policy provides the basic parameters, incentives and roadmap for the power projects therefore it is imperative to have a review of the power policy.

13.3.1. Objectives of the Power Policy 2006

The main objectives of this Policy are:-

- To provide adequate power generation capacity at the least cost.
- To encourage and ensure exploitation of indigenous fuel (oil/gas/coal/biomass) and hydel resources for development of thermal or hydel Power Generation projects in the Punjab Province. Utilization of wind and solar energy for power generation shall be encouraged.
- To promote indigenization.
- To encourage the local engineering industry to form joint ventures with foreign companies for participation in the development of the Power Generation projects.
- To protect the environment.

13.3.2. Scope of the Policy

The Power Generation Policy covers the development and implementation of power generation projects in:

- The private sector;
- The public sector; and
- Through public-private partnerships

13.3.3. Regulatory Environment

The objective of the current power regulatory environment is to promote fair competition in the electricity industry. To protect the rights of consumers as well as the producers and sellers of electricity, the Government of Pakistan has enacted the Regulation of Generation, Transmission and Distribution of Interests of the Electric Power Act (XL of 1997) (NEPRA Act). The NEPRA Act extends to Consumers and the whole of Pakistan. Under the NEPRA Act, the National Electric Power Companies Regulatory Authority (NEPRA) has been established with various powers and functions.

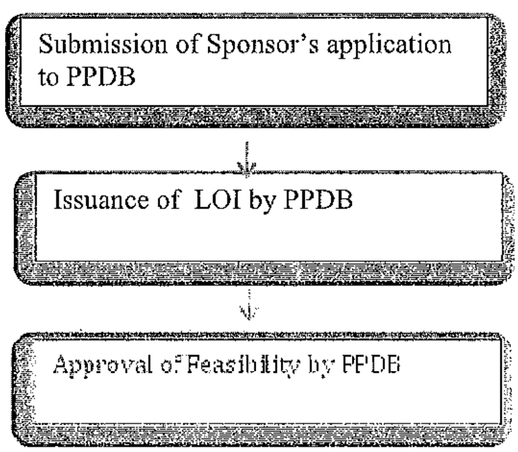
Powers and functions of NEPRA

NEPRA is the regulator of the industry and is exclusively responsible for the following:

- Regulating the provision of electric power services;
- Granting licenses for generation, transmission and distribution of electric power;
- Prescribing procedures and standards for investment programs by generation, transmission and distribution companies;
- Prescribing and enforcing performance standards for generation, transmission and distribution companies;

- Establishing a uniform system of accounts for generation, transmission and distribution companies;
- Prescribing fees including fees for grant of licenses and renewal thereof;
- Prescribing fines for contravention of the provision of this Act;
- Performing any other function which is incidental or consequential to any of the aforesaid functions;
- Determining tariff, rates, charges and other terms and conditions for supply of electric power services by the generation, transmission and distribution companies and Reviewing the organizational structures of generation, transmission and distribution companies to avoid any adverse effect on the operation of electric power services and for continuous and efficient supply of such services;
- Encouraging uniform industry standards and code of conduct for generation, transmission and distribution companies;
- Giving advice to public sector projects;
- Submitting reports to the Federal Government with respect to the activities of generation, transmission and distribution companies; and
- Performing any other function which is incidental or consequential to any of the aforesaid functions.

13.3.4. Project Development Process & Institutional Arrangement



Issuance of Generation License & Tariff Approval by NEPRA

↓

Issuance of LOS by PPDB on Approval of Tariff

↓

Signing of Energy Purchase Agreement with CPPA

↓

Signing of Implementation Agreement with GoP

↓

Signing of Financing Agreements with Banks

13.3.5. Incentives for the Project

Government of Pakistan (GOP) granted following incentives to Power Projects.

Regulatory Incentives — A Snapshot	
Incentive	*Status*
Custom Duty Exemption (Plant Machinery, Equipment)	*Yes*
Tax Exemption (Income and Sales Tax)	*Yes*
Exemption from payment of Zakat on Dividends	*Yes*
Private sector Participation (IPP, Grid Spillover, Captive)	*Yes*
Repatriation of Equity along with dividends	*Allowed*
Local and Foreign Financing	*Allowed*
Issuance of Corporate Registered Bonds & Shares	*Allowed*
Guaranteed Market	*Yes*
Grid Connection	*Yes*
Net Metering, Net Billing, Wheeling & Banking	*YES*
Resource Risk Coverage	*YES*
Security Package	*Yes*
Land & Site Access	*Yes*
Negotiated Tariff or Upfront Tariff	*Yes*
Carbon Credits	*Yes*
Collection & Dissemination of Data	*Yes*
Accelerated Depreciation of 90%	*Allowed*
Allocation of network investment cost	*Yes*

13.3.6. Specific Incentives for Grid connected Power Projects

Specific incentives are provided under the Policy to independent power producers (IPPs) selling all generated electricity to the grid. They are as follows:-

13.3.6.1. Security Package

The power purchaser shall enter into a specific Energy Purchase Agreement (EPA), based on a standard model agreement, with the power producer. The Government of Pakistan shall also enter into an Implementation Agreement (IA) which will guarantee the payment obligation of the public sector power purchaser for power sales extending over the term of the EPA.

13.3.6.2. Land and Site Access

The provincial government shall facilitate investors in acquiring land or rights-of-way (RoWs) for project development, as well as providing site access on a case-to-case basis by leasing, acquisition of RoW, and/or construction of road linkages. However, the primary responsibility for acquiring land and site access will rest with the project sponsors.

13.3.6.3. Allocation of Network Investment Costs

The construction of transmission lines for evacuation of power from any IPP shall be the responsibility of the NTDC, KESC or a DISCO (depending on the location and supply voltage of the project). The NTDC shall bear all expenses associated with power balancing on the grid to accommodate priority dispatch and variability on account of the power project, and ensure that these expenditures are made in a timely fashion.

13.3.6.4. Guaranteed Market: Mandatory Purchase of Electricity

It shall be mandatory for the CPPA to purchase all electricity offered to them by the Power Plant. An EPA contract will be concluded between the Project Company and the CPPA. After the CPPA ceases to exist, neither distributors nor transmission companies will have the right to reject, in part or in entirety, any contract signed.

Power Producers shall be allowed to enter into direct sales contracts with eligible customers. In this case, electricity sale prices will not require prior approval by NEPRA; additionally, the EPA will be between the SPC and the end-use customer and no sovereign guarantee will be provided.

13.3.6.5. Wheeling

Power producers shall also be allowed to enter into direct sales contracts with end users. Under this arrangement, they would be allowed to sell all or a part of the power generated by them directly to their private customers and the rest to the utility for general distribution. For direct sales, they shall be required to pay "wheeling" charges for the use of the transmission and/or distribution grid network employed to transport power from the plant to the purchaser. In practical terms, the IPP shall inject electricity into the grid system at one point and would be entitled to receive the same amount at any other location upon payment of a corresponding wheeling charge, to be determined by NEPRA. This wheeling charge will reflect the cost of providing and maintaining the transmission interconnection, including the energy losses suffered en route, calculated on a utility-wide basis by NEPRA.

13.4. The Project

13.4.1. Project Overview

The broader and the main objective of the project is to shorten the energy crisis of the country by utilizing the available energy resources of the country. The idea is to install small hydro projects on the canal falls and barrages to generate cheap and environment friendly electricity to add power in the national grid of the country.

The project envisages setting up a 10.5 MW Hydro Power Project under "IPP" structure for a special purpose. Consultants and advisors have been hired for the smooth progress of this project by the Sponsors. The project is envisioned to be completed through an EPC contract for which the EPC Contractor will also be providing the O&M services at least in the initial years of operation.

The plant will despatch generated electricity to the grid through transmission lines in accordance with technical parameters and specifications approved by the LESCO/NTDC . The power generated by the project is proposed to be sold to National Transmission and Dispatch Company (NTDC) through Central Power Purchasing Authority (CPPA).

The project time for construction to commercial generation of electricity, has been estimated to be 36 months, provided there are no unforeseen delays during project implementation.

13.4.2. Project Location

The proposed BS Link-I HPP has a generation capacity of about 10.5 MW. Balloki-Sulemanki Link canal off-takes from left bank side of Balloki Barrage on river Ravi and connects Sutlej River upstream of Sulemanki Barrage. The proposed powerhouse of the project will be constructed on the right-bank of the canal at RD 106+250 utilizing the existing available head of 3.55 m (10.64 ft.). It is located near the town of Chunian District Kasur of Punjab Province. The upstream limit of the project is constrained by the Fall at RD 73+250 while downstream limits are controlled by the Chunian Distributary which is off-taking from right bank of BS-I link at RD 110+667. From Balloki Headwork to RD 73+250, the canal bed is unlined. However, at RD 73+250 the canal is bifurcated in two segments known as BS Link- I & BS Link-II canals and the canal bed of BS Link-I is brick-lined from that RD so on.

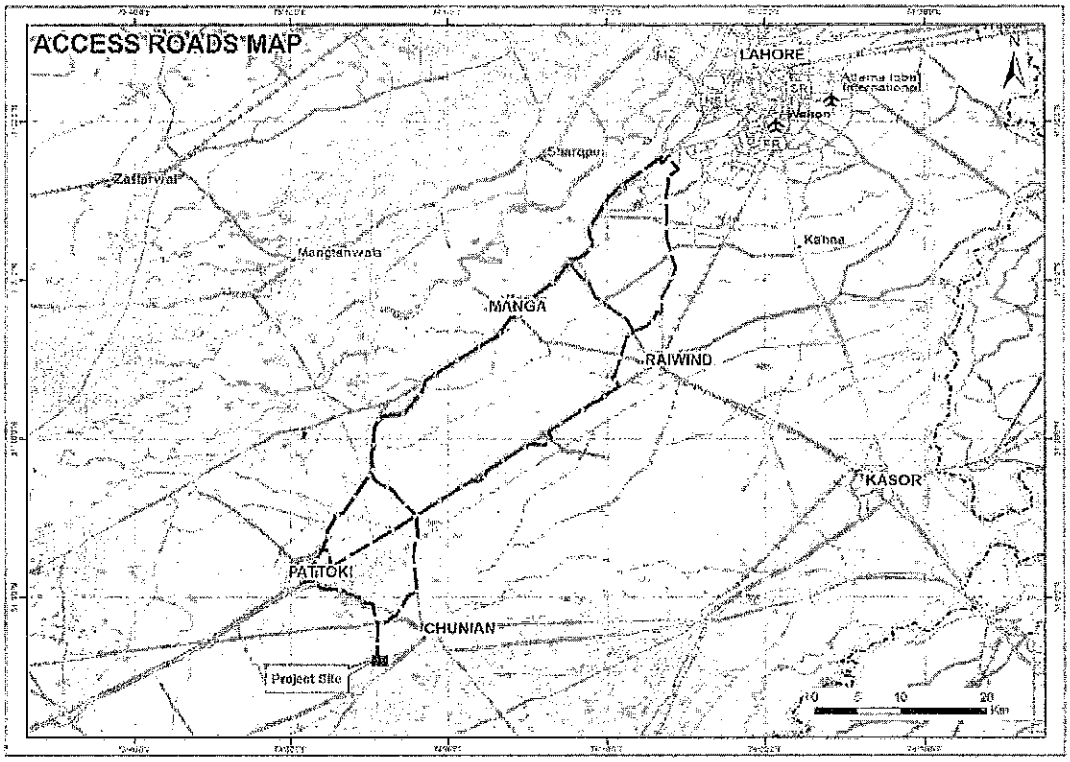


Figure 70: Location Map BS Link-I Hydro Power Project

13.4.3. Description of the Project Area

BS Link-I HPP area is located in Tehsil Chunian, District Kasur, Punjab. The Project area is located at about 90 Km from Lahore. The general climatic condition of the area is five seasons semi-arid. Monsoons and western disturbances are the two main factors that affect the weather of the region; otherwise, continental air prevails for rest of the seasons.

The land is generally fertile and irrigated. The project site is located within the Punjab plain which is the upper part of the Indus Basin with thick alluvial deposits. The sediments comprise soil materials falling in the range of sand, silt and clay. These are generally devoid of grain sizes bigger than sand i.e. pebbles cobbles, gravels and stones etc. No rock outcrop is located in the near vicinity of the project site.

13.4.4. Project Technology & Technical Parameters

The proposed technology for the project is Horizontal Pit Type Kaplan (4 units) each with 2.62 MW capacity. Following are the key technical parameters of the project.

Project Name	BS Link -I Hydro Power Project
Location	Kandu Khara, Tehsil Chunian, District Kasur
Design Discharge	350 m^3/s
Rated Head	3.55 m
Installed Capacity	10.49 MW (4x 2.62 MW)
Net Annual Plant Energy	66.61 GWh
Plant Factor	73.23%
Turbine Type	Horizontal Pit Type Kaplan (4 units)
Runner Diameter	4.766 m
Power Channel Top Width	41.124 m
Power Channel Bottom Width	34.138 m
Headrace Channel Length	464.8 m
Tailrace Channel Length	496.2 m
Design discharge for spillway	425 m^3/s
Powerhouse Dimensions	48.6 m x 88.66 m x 29.637 m
Length of Transmission Line	7km (to Chunian Grid Station)

13.4.5. Project Sponsor

Associated Technologies (Pvt) Limited is the lead sponsor of the Project. ATL has been involved in the development of power projects for last 10 years. ATL in association with its partner has been involved in the development of the projects like

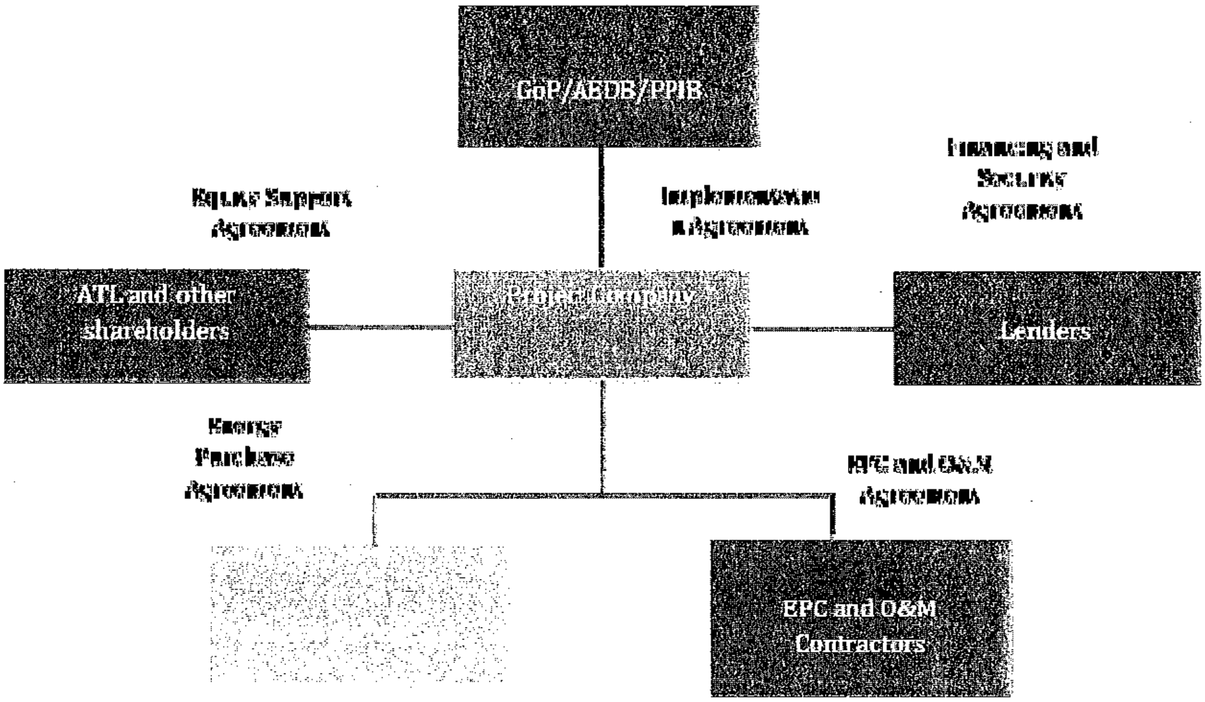
- 720 MW Karot Hydro Power Project
- 545 MW Kaigah Hydro Power Project
- 24 MW Kaigah Hydro Power Project
- 81 MW Malakand Hydro Power Project

In addition to the power sector, ATL is also involved in the telecommunication and real estate businesses. It's working with the almost all the key players in telecom industry.

13.4.6. Transaction Structure

The project shall be undertaken under IPP structure under a special purpose project company. ATL and other shareholders of the project company shall inject the required equity into the project company, amounting to 20% of the project cost in accordance with terms agreed with the lenders, and financing for the remaining 80% of the Project Cost shall come from the banks in the form of commercial debt. The construction of the Project and its Operations shall be undertaken by the EPC and O&M contractor against payments made by the Project Company.

Revenue earned from the tariff payments against electricity supplied, as per energy purchase agreement, shall serve to cover the costs of O&M, Insurance, and Debt Servicing and Sponsor's return .

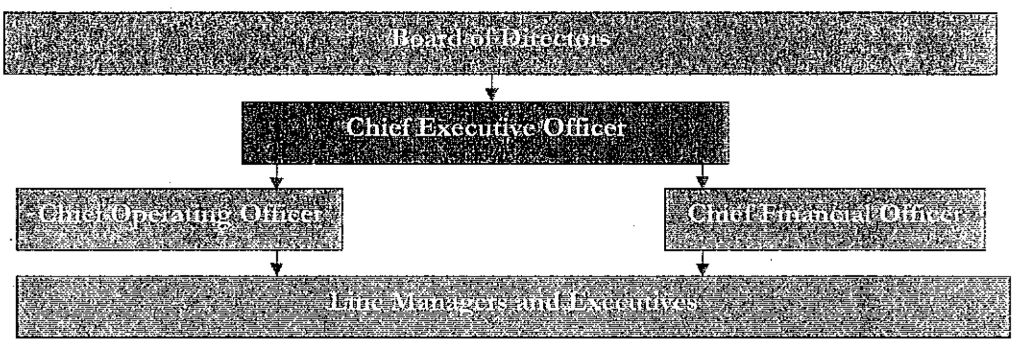


13.4.7. Project Management

As per the corporate style of management, Board of Directors shall oversee the management of the company.

Top management of the company shall include Chief Executive Officer, Chief Operating Officer, and Chief Financial Officer, followed by line managers and assistant managers in each line. The following layout shows the proposed management structure of the project company.

Cooperative Structure of the Project Company



13.4.8. Power Generation

The monthly energy generation from the project is depicted in the table below:

Month	Mean Monthly Benchmark Flow (m^3/Second)	Monthly Net Generation (Gwh)	Annual Net Generation (GWh)
January	24.49	0	66.61
February	196.5	4.24	
March	184.54	4.80	
April	234.64	5.24	
May	312.44	6.95	
June	350.02	7.15	
July	360.72	7.30	
August	329.84	7.17	
September	359.08	7.01	
October	281.12	6.34	
November	258.30	5.70	
December	198.1	4.71	

13.5. Project Cost and Financing

13.5.1. Project Cost

The estimate of the capital cost of the Project has been prepared to cover the civil works, electrical and mechanical works, temporary works, and engineering and development costs. The EPC cost estimates for Civil and E&M Works are based on estimated BoQs whereas the Non-EPC Costs, Financial Fee & Charges , Insurance During Construction are estimated based on best international practices and in line with costs that finalized for all other similar projects in Pakistan. A provision for the import duties/taxes has been accounted for in line with concession available to the power sector.Total project cost is estimated at USD 45.44 Million which is equivalent to PKR 4.772 billion. Following is the summary project cost.

Project Cost	PKR	USD
Civil Works	*2,139,841,835*	*20,379,446*
Electrical & Mechanical Equipment	*1,179,570,000*	*11,234,000*
Design & Engineering	*99,582,355*	*948,403*
Erection & Commissioning	*58,978,500*	*561,700*
Freight & Inland Transportation	*47,182,800*	*449,360*
EPC Cost	**3,525,155,491**	**33,572,909**
Taxes/Import Duty	*70,774,200*	*674,040*
Insurance During Construction	*26,438,666*	*251,797*
Non EPC Costs	*387,767,104*	*3,693,020*
Financial Fee & Charges	*126,467,064*	*1,204,448*
Interest During Construction	*635,546,901*	*6,052,828*
Total Cost	4,772,149,426	45,449,042

13.5.1.1. EPC Cost

It is envisaged that the project shall be executed under a turnkey/EPC arrangement with a reputable contractor. An EPC arrangement is critical as it caters many risks which are inherent in multiple/split contract arrangements with different contractors. Further lenders are more comfortable with EPC arrangement from risk mitigation perspective. The EPC cost includes the cost of plant design , construction, procurement of electrical and mechanical equipment , transportation and installation/erection of the plant. A brief description of these costs is given here under.

a) Civil Works

The Civil Works required for the project mainly include construction of Power House, Power Channels and Spillways. The estimated cost of the required civil works is USD 20.379 Million equivalent to PKR 2.139 Billion.

b) Electrical & Mechanical Equipment

This cost head includes cost of all the electrical and mechanical equipment required for the power plant including 4 sets of turbines, generators, governors and Balance of the Plant/equipment. Total cost of E&M equipment is estimated at USD 11.234 Million equivalent to PKR 1.179 Billion.

c) Design & Engineering

A detailed design of the project shall be undertaken by the EPC contractor on the basis of which construction of the project shall be undertaken. Further, on the basis of project design specifications of the Electrical & Mechanical equipment shall be customized. Estimated cost for the design is USD 948,403 equivalent to PKR 99.582 Million.

d) Erection & Commissioning

The erection and commissioning cost of the project is estimated at 5% of the E&M cost which is 561,700 equivalent to PKR 58.978 Million.

e) Freight & Inland Transportation

This includes the cost sea freight from foreign country port to Karachi seaport, seaport handling as well as inland transportation from seaport to project site. it is estimated at 4% of the E&M equipment cost i.e. USD 449,360 or PKR 47.18 Million.

f) Grid Connectivity Cost

Nearest grid to the project for the power connectivity is Chunian Grid Station and is approximately 7 kms away from the project location . We have not catered any costs related to the project connectivity with the grid because under the policy power evacuation from the project and connectivity of the project with Grid is responsibility of the power purchaser.

13.5.1.2. Import Taxes/Duties

Import duty charges for the M&E plant are estimated at 5% of the total E&M equipment cost. Further 1 % of E&M cost is considered as Sindh Infrastructure Development Surcharge in the project cost. Total value of the import duties/taxes is USD 674,040 equivalent to PKR 70.774 Million.

13.5.1.3. Non-EPC Cost

In addition to the work to be done by the EPC Contractor, there are other works/items that are essential part of the project. Including the cost of land, supervision, Costs related to all such items are included in Non EPC Costs. Non-EPC costs basically include cost of fixed assets including computers, vehicles, furniture and fixtures required for the project. Table below depicts the details of these costs.

Non EPC Costs	PKR	USD
Land & Environmental Costs	*48,789,000*	*464,657*
Supervision Cost	*113,400,000*	*1,080,000*
Owner's Cost During Construction	*113,400,000*	*1,080,000*
Legal Fees	*31,500,000*	*300,000*
Project Development & Other Costs	*80,678,104*	*768,363*
Total	**387,767,104**	**3,693,020**

13.5.1.4. Pre-COD Insurance

It covers the cost of insurance of the project during the construction phase and up-to the COD. This is estimated at 0.75% of EPC Costs i.e. PKR 26.438 Million or USD 251,797. Pre-COD insurance cost covers the insurance cost of the Project Company's assets during construction as well as the cost incurred prior to COD. Insurance cost during construction will be adjusted and trued up as per actual upon COD.

13.5.1.5. Interest During Construction

Interest during construction involves cost of financial charges on debt to be incurred during the construction period. Construction period of the project is assumed at a period of 3 years, during which the total cost of interest during construction is calculated to be USD 6.052 Million equivalent to PKR 635.5 Million.

13.5.1.6. Financial Fees and Charges

As the project is to be financed through a combination of debt and equity therefore some costs shall be incurred for the arrangement of debt and other financing facilities. A total of USD 1.204 Million equivalent to PKR 126.4 Million is estimated on this account.

Financial charges include the costs related to the debt financing of the Project. These include the upfront arrangement fee, security trustee fee, lenders' monitoring fee, commitment fee, and opening and retirement charges on letters of credit. These costs will be incurred up to COD. In addition to above fees, all charges, fees on account of Lender's consultant (technical, legal and insurance etc.) have been included in this cost item. A total of USD 1.204 Million equivalent to PKR 126.4 Million is estimated on this account.

13.5.2. Financing Plan

The project will be financed with a debt equity combination of 80:20. Following is the proposed financing structure that shall be finalized at the time of financial close.

Project Financing		PKR	USD
Equity	20%	954,429,885	9,089,808
Debt	80%	3,817,719,540	36,359,234
Total		4,772,149,426	45,449,042

13.5.2.1. Equity Financing

Associated Technologies (Private) Limited and other shareholders/sponsors of the project company shall contribute the total required equity for the project in proportion to their respective shareholding in the project company.

13.5.2.2. Debt Financing

The project is expected to get a loan of USD 36.359 Million equivalent to PKR 3.817 billion from the local banks although option for the foreign bank loan is also there. Following are the key assumptions of the loan arrangement considered in this report.

Loan Amount	PKR 3,817,719,540
Loan Period	13 years
Grace Period	3 years
Repayment Period	10 years
Installment Frequency	4 per year /quarterly
KIBOR/Base Rate	6.73%
Spread/Margin	3.5%

On the basis of the above mentioned assumptions following is the debt repayment schedule of the loan.

Year	Opening Balance	Installment	Principle	Interest	Closing Balance
1	3,817,719,540	614,239,803	232,415,535	381,824,268	3,585,304,005
2	3,585,304,005	614,239,803	257,119,406	357,120,397	3,328,184,599
3	3,328,184,599	614,239,803	284,449,097	329,790,706	3,043,735,502
4	3,043,735,502	614,239,803	314,683,710	299,556,093	2,729,051,791
5	2,729,051,791	614,239,803	348,132,016	266,107,787	2,380,919,775
6	2,380,919,775	614,239,803	385,135,603	229,104,200	1,995,784,172
7	1,995,784,172	614,239,803	426,072,369	188,167,434	1,569,711,804
8	1,569,711,804	614,239,803	471,360,378	142,879,425	1,098,351,426
9	1,098,351,426	614,239,803	521,462,132	92,777,671	576,889,293
10	576,889,293	614,239,803	576,889,293	37,350,510	0

13.6. Project Tariff

NEPRA determines the yearly tariff of the project over the concession period . The basic principle for the tariff determination is to allocate all the yearly costs to be incurred by the project including Local and Foreign O&M, Insurance, Return on Equity, Redemption of equity investment, Principal and Markup payment of the project loan, water use charges on per Kwh basis. The CPPA, Power Purchaser, shall purchase the energy from the project on the basis of the tariff approved by the NEPRA.

The tariff for the project in this report has been calculated on the cost plus basis, however NEPRA has determined the upfront tariff for small hydropower projects upto 25 MW and sponsors may decide to opt the upfront tariff. Following are the tariff components of the tariff.

13.6.1. Energy Component

This component of the tariff is payable by the project power purchaser only to for the number of units actually dispatched to the Purchaser. It has following sub components.

13.6.1.1. Water Use Charges

The project shall pay the water use charges PKR 0.15 /per Kwh of the energy sold to the purchaser as per the policy.

13.6.1.2. Variable Operations and Maintenance Costs

These include cost of Operations and Maintenance (O & M) of the project during the tenure of 30 years which includes lube, oils, spares and other repair costs. These costs are further segregated into local & foreign costs . Variable O&M Costs is taken as 25% of the total annual O&M cost assumed for the project. A breakdown of the variable costs in local and foreign component is as follow.

	% of O&M Cost	PKR
Variable O&M Local	*10%*	*7,050,311*
Variable O&M Foreign	*15%*	*10,575,466*
Total	*25%*	*17,625,777*

13.6.2. Energy Component

This component is payable by the project power purchaser for the number of units (KWh) actually dispatched plus any energy which is not produced or dispatched for the reason other than non-availability of the plant. It has following sub components.

13.6.2.1. Fixed Operation and Maintenance Costs

These costs include salaries, rents, leases, operator's fee, utilities and other miscellaneous costs for the project. These costs constitute 75% of the annual O&M costs Following is the breakup of the operational costs into local and Foreign Costs.

	% of O&M Cost	PKR
Fixed O&M Local	*55%*	*38,776,710*
Fixed O&M Foreign	*20%*	*14,100,622*
Total O&M	75%	52,877,332

13.6.2.2. Insurance

The Project shall obtain the insurances for the operation period. The estimated annual insurance cost is 1.35% of the EPC Cost i.e. USD 453,234.28 equivalent to PKR 47.58 Million.

13.6.2.3. Return on Equity

Return on equity for the project has been assumed at 20% per annum as mentioned in the upfront tariff as announced by National Electric Power Regulatory Authority for Small Hydro Power Projects in Pakistan. After the 10th year of the operation, redemption of the equity investment by the sponsors has been catered in line with the tariff precedence by the NEPRA as the project would be transferred to the government at no cost.

13.6.2.4. Principal Payments

This component includes repayment of principal portion of loan. Total repayment of loan shall be made over a period of 10 years. Quarterly principal repayment of the loan has been catered to under this portion of the tariff.

13.6.2.5. Mark-up Payments

Loan for the project has been obtained at a Mark-up of KIBOR + 3.5 %, where KIBOR is assumed at 6.73%. This component includes annual mark-up cost of the loan to be repaid over the tenure of the loan.

13.6.2.6. Tariff Indexations

In order to cater the macroeconomic changes over the tariff period i.e. from determination of the tariff till the end of concession period, there is a comprehensive tariff indexation mechanism followed by the NEPRA . This indexation mechanism ensures that project tariff component are adjusted to the key economic variables impacting the project cash flows. Following is the summary of the benchmarks for the indexation of each tariff component.

Tariff Component	Indexation	
Variable O&M -Local -Foreign	CPI (General US CPI and PKR/US$	
Fixed O&M -Local -Foreign	CPI (General US CPI and PKR/US$	
Insurance	PKR/US$	
Return on Equity	PKR/US$	
Debt Servicing	Foreign Debt	Local Debt
-Principal	PKR/ US$	-
-Interest	3 months US LIBOR & PKR/ US$	3 months KIBOR

13.6.3. Project Tariff

Tariff for this project has been calculated by taking into account concession period of 30 years from the date of commercial operation. Given below is annual and levelized tariff for the project.

PROJECT TARIFF

	Energy Charge (Rs / kWh)				Capacity Charge (Rs / kWh)							Total Tariff	
	WUC	V-O&M L	V-O&M-F	Total	F-O&M-L	F-O&M -F	Insurance	Principle	Interest	ROE	Total	PKR / kWh	US¢ / kWh
1	0.15	0.11	0.16	0.41	0.58	0.21	0.71	3.49	5.73	3.99	14.71	15.13	14.41
2	0.15	0.11	0.16	0.41	0.58	0.21	0.71	3.86	5.36	3.99	14.71	15.13	14.41
3	0.15	0.11	0.16	0.41	0.58	0.21	0.71	4.27	4.95	3.99	14.71	15.13	14.41
4	0.15	0.11	0.16	0.41	0.58	0.21	0.71	4.72	4.50	3.99	14.71	15.13	14.41
5	0.15	0.11	0.16	0.41	0.58	0.21	0.71	5.23	3.99	3.99	14.71	15.13	14.41
6	0.15	0.11	0.16	0.41	0.58	0.21	0.71	5.78	3.44	3.99	14.71	15.13	14.41
7	0.15	0.11	0.16	0.41	0.58	0.21	0.71	6.40	2.82	3.99	14.71	15.13	14.41
8	0.15	0.11	0.16	0.41	0.58	0.21	0.71	7.08	2.14	3.99	14.71	15.13	14.41
9	0.15	0.11	0.16	0.41	0.58	0.21	0.71	7.83	1.39	3.99	14.71	15.13	14.41
10	0.15	0.11	0.16	0.41	0.58	0.21	0.71	8.66	0.56	3.99	14.71	15.13	14.41
11	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
12	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
13	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
14	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
15	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
16	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
17	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
18	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
19	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
20	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
21	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
22	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
23	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
24	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
25	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
26	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
27	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
28	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
29	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
30	0.15	0.11	0.16	0.41	0.58	0.21	0.71			4.09	5.60	6.02	5.73
Levelized Tariff												11.96	11.39

13.7. Financial & Economic Analysis

This is a private public partnership (PPP) project under the Build Operate and Transfer (BOT) mode in which private sector shall be responsible for development, construction and operation of the plant and project shall be financed from a combination of debt and equity whereas government shall provide significant concessions to the project to make it profitable and financially attractive for the investors. Therefore, it is important to discuss the financial viability of the project from the investor's perspective and also equally important is to determine the economic viability of the project from the government's perspective.

13.7.1. Financial Analysis

There is total cash outlay of approximately PKR 4.77 Billion over three years of construction period out of which 20% of the project cost shall be financed from the debt whereas remaining 80% from the debt.

The project shall generate its revenue from sale of the power to the power purchaser over the 30 years of operation at the yearly tariff determined (and subsequently indexed) by NEPRA .The project shall incur costs on its operations, insurance and debt servicing . The income of the project company shall be exempted from the tax under the law. The balance amount shall be paid to the investor as dividend.

Financial viability of the project has been determined using free cash flow technique over 33 years of cash flows i.e. 3 years of construction and 30 years of operation and following project viability parameters have been analyzed during this exercise

13.7.1.1. Project IRR

Internal rate of return (IRR) is a metric used in capital budgeting measuring the profitability of potential investments. Internal rate of return is a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. In theory, any project with an IRR greater than its cost of capital is a profitable one and should be undertaken by the investor.

The IRR of BS Link Hydropower project is 12.6% whereas the weighted cost of capital (WACC) is 10.4%. As the project IRR is higher than the WACC therefore project is financially viable for investment .

13.7.1.2. Project NPV

NPV parameter is used in capital budgeting to analyze the profitability of a project. Net Present Value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows. Generally, an investment with a positive NPV is considered profitable and one with a negative NPV will result in a net loss.

The NPV of the BS Link Hydropower project is calculated at PKR 606 Million using a discount rate of 10.4% i.e. WACC . The positive NPV means project is profitable for the investor and would yield excess cash than investor's required rate of return.

13.7.1.3. Pay Back Period

The payback period is the time required to recover the investment and starts from the final cash outflow of the investment. The payback period of any project is an important determinant of its financial viability. Normally, all else equal, the projects with shorter payback are preferred.

The payback period of the project is 5.5 years which is very reasonable keeping in view the nature of the project and 30 years of concession period.

13.7.2. Sensitivity Analysis

Sensitivity analysis, also referred to as what-if analysis, is a technique to predict the outcome of a decision given a certain range of variables. By creating a given set of variables, the analyst can determine how changes in one variable impact the outcome. All the variables whose impact can be eventually passed through are not critical however the change in the variables which cannot be pass through affect the financial viability of the project. For the BS Link project changes in economic variables like inflation, currency and interest rate fluctuation are fully pass through however there are some factors which are internal to the project who have significant impact on the project and it is important to analyze the impact of such factors. Two very important factors are Project cost escalation and Energy production and their impact on Project IRR and NPV has been discussed hereunder.

13.7.2.1. Generation Sensitivity

For the base case the project generation is assumed at 160,300,000 kWh per annum. The effect on the Project IRR and NPV of the project for every 5%, 10%,15 and 20 % reduction form the base case generation is shown in the below table:

% Decrease in Energy	NPV	IRR
Base Energy (0%)	*606*	*12.60%*
5%	*337*	*11.64%*
10%	*67*	*10.65%*
15%	*(203)*	*9.63%*
20%	*(473)*	*8.57%*

It is important to note that hydrological risk is pass through risk factor under the power policy 2006 and these results are only applicable if there is lesser generation because of the unavailability of the plant for energy generation in spite of the water availability .

13.7.2.2. Increase in Project Cost

The project cost is approved by the NEPRA and some adjustments are allowed in the project cost as pass through costs in the tariff. However, in case there are some additional costs which are not in category of the allowed cost and no adjustment is approved by the NEPRA such costs are not passed through the tariff. Following table depicts the impact of increase in nonadjustable project costs on the Project IRR and NPV.

% Increase in Project Cost	NPV	IRR
(Base Cost)0%	606	12.60%
5%	410	11.83%
10%	214	11.12%
15%	17	10.46%
20%	(179)	9.85%

13.7.3. Economic Analysis

Pakistan is currently suffering from the worst energy crisis and pro longed spells of loading shedding have severely affected the economic growth of the country. A large number of our factories are unable to meet their production and revenue targets because of load shedding . Our factories are losing business and reputation in national and international markets for not meeting the promised schedule of deliveries. The recent blow to our export is largely attributed to absence of gas and electricity supplies. This situation has forced lot of industrial units either to shut down or shift to diesel generators , an inefficient and expensive option, thereby compromising their cost efficiency .

13.7.3.1. Comparison of cost of energy from BS Link , Diesel and RFO

This section compares the cost of energy generation from BS Link project with cost of same generation from Diesel and RFO over 30 years . Although hydro power projects have life of more than 50 years and unlike Diesel and RFO plants, hydro projects are transferred to government at the end of 30 year at no cost. Therefore generation from BS Link would almost cost 1 PKR per Kwh after 30 years onward. However, in our cost comparison analysis we are not considering cost free generation after 30 years and the resultant savings/benefits that would accrue to the government. The purpose of this analysis is to quantify the net saving from the project over the 30 year concession period only.

The prices of per Kwh from diesel and RFO based generation are assumed at 16.32 cents and 11.9 cents respectively for next 30 years as mentioned in NEPRA's State of Industry Report 2015. It is pertinent to mention that per Kwh generation cost of Diesel and RFO have been lesser in 2015 as compared to the cost of previous years because of lower oil prices in the international market from USD 100 per barrel in 2013 to USD 45 per barrel in 2015.

It is evident from the table below that total payments by the government for the energy purchase from the BS Link -I Project over the 30 years shall be USD 172 million whereas the same amount of energy purchased from a Diesel plant would cost USD 326 Million and USD 238 Million for RFO based generation. Thereby resulting in net savings of USD 154 million and USD 63 million as compared to the diesel and RFO based generation over 30 years respectively.

Year	Generation (Kwh)	Tariff (Cents)	Cost of BS Link Generation	Cost of Diesel Generation	Cost of RFO Generation
1	66,619,876	14.41	9,599,280	10,874,902	7,956,317
2	66,619,876	14.41	9,599,280	10,874,902	7,956,317
3	66,619,876	14.41	9,599,280	10,874,902	7,956,317
4	66,619,876	14.41	9,599,280	10,874,902	7,956,317
5	66,619,876	14.41	9,599,280	10,874,902	7,956,317
6	66,619,876	14.41	9,599,280	10,874,902	7,956,317
7	66,619,876	14.41	9,599,280	10,874,902	7,956,317
8	66,619,876	14.41	9,599,280	10,874,902	7,956,317
9	66,619,876	14.41	9,599,280	10,874,902	7,956,317
10	66,619,876	14.41	9,599,280	10,874,902	7,956,317
11	66,619,876	5.73	3,817,124	10,874,902	7,956,317
12	66,619,876	5.73	3,817,124	10,874,902	7,956,317
13	66,619,876	5.73	3,817,124	10,874,902	7,956,317
14	66,619,876	5.73	3,817,124	10,874,902	7,956,317
15	66,619,876	5.73	3,817,124	10,874,902	7,956,317
16	66,619,876	5.73	3,817,124	10,874,902	7,956,317
17	66,619,876	5.73	3,817,124	10,874,902	7,956,317
18	66,619,876	5.73	3,817,124	10,874,902	7,956,317
19	66,619,876	5.73	3,817,124	10,874,902	7,956,317
20	66,619,876	5.73	3,817,124	10,874,902	7,956,317
21	66,619,876	5.73	3,817,124	10,874,902	7,956,317
22	66,619,876	5.73	3,817,124	10,874,902	7,956,317
23	66,619,876	5.73	3,817,124	10,874,902	7,956,317
24	66,619,876	5.73	3,817,124	10,874,902	7,956,317
25	66,619,876	5.73	3,817,124	10,874,902	7,956,317
26	66,619,876	5.73	3,817,124	10,874,902	7,956,317
27	66,619,876	5.73	3,817,124	10,874,902	7,956,317
28	66,619,876	5.73	3,817,124	10,874,902	7,956,317
29	66,619,876	5.73	3,817,124	10,874,902	7,956,317
30	66,619,876	5.73	3,817,124	10,874,902	7,956,317
	Total		172,335,284	326,247,052	238,689,500

13.7.3.2. CDM Benefits

The Clean Development Mechanism (CDM) was initiated under Kyoto Protocol of the United Nation Framework Convention on Climate Change (UNFCCC) in order to explore cost effective option to mitigate impacts of climate change. This puts obligations on governments and companies of industrialized countries (developed nations) to reduce their emission providing opportunity to reach their quantified emission limitation by financing emission reduction projects in developing countries which makes Pakistan eligible to benefit from it.

The BS Link-I Hydropower Project is also an opportunity which will result into GHG emission reduction and will provide an additional source of revenue in shape of carbon credits. The analysis reveals that after registration with UNFCCC, the Project generating net energy of 66.16 GWh has the capability of reducing approximately 33,309 Metric Tons of Carbon per year which could result in additional revenue of US$ 166,545 per year (@ US$ 5 per Metric Ton approx) for the period of at least 10 years or three terms of 7 years.

13.7.3.3. Foreign Exchange Savings

Construction of Hydropower projects requires lesser foreign exchange as only E&M equipment is required to be imported which is 40%-50% of the project cost whereas major cost is of civil works . However , for any other project based on alternate technology i.e. thermal, wind and solar, imported component is 75-80% and requires more foreign exchange.

Further during the operation phase there is minimum requirement of foreign exchange whereas diesel and RFO based plant rely heavily on the imported fuel . This project shall save hundreds of millions of foreign exchange on account of lesser consumption of fuel.

14. CONCLUSION

The study shows that the hydropower project at BS Link-I Canal at RD 106+250 is technically and financially feasible.

The power project would have a design discharge of 350 cumec, which would have a probability of equaling or exceeding 31% of the time based on remodeling data series 2006-2015. The rated net head is 3.55 m. It will have an installed capacity of 10.49 MW with four units, each of 2.62 MW. Four (04) Kaplan pit type horizontal turbines would have a rated discharge of 87.50 cumec each which will produce an average annual energy of 67.29 GWh. Its plant factor would be 73.23%.

The power station is proposed to be connected to nearest NTDC grid at 132 KV Chunian Substation which is 7 km away from the Project site.

The environmental study shows that the project Falls under category B of the criteria fixed by Pakistan Environmental Protection Agency (PEPA) regulation (2000). According to these guidelines a category 'B' project is likely to have minimal or no adverse environmental impact which can be easily mitigated.

The total cost of the project is Rs. 4,772,149,426 i.e. 45.44 MUSD. The cost includes provision for detailed engineering and administration/ supervision of the project.

The economic and financial analyses for implementation have been carried out for a project life of 30 years. The cost per MW of installed capacity is 4.33 MUSD which is in line with the current cost of low head hydropower stations.

The Project is clean in terms of emission of greenhouse gases being utilizing renewable and infinite source of energy. BS Link-I hydropower project is appropriate for execution as all the major economic and financial indicators are positive and sound. The project, being the low head in the plain area of Punjab, will contribute to the energy production of the country. It will specially yield a positive impact in the area in terms of raising the standard of living of the local people as a sizeable number of unskilled and skilled labour force will be employed during construction and implementation phase. Improved social environments in terms of the presence of parks, banks, shops or other social amenities will further help in the socioeconomic uplift of the area.

2017

11 MW BS LINK-I HYDROPOWER PROJECT AT RD 106+250

Feasibility Study

VOLUME-3 INITIAL ENVIROMENTAL EXAMINATION

Integral
INGENIEROS CONSULTORES

ASSOCIATED TECHNOLOGIES (PVT) LIMITED
142-D Model Town, Lahore, Pakistan

ENVIRONMENT PROTECTION DEPARTMENT

Government of the Punjab
National Hockey Stadium, Lahore.

NO. DD (EIA)/EPA/F-400(IEE)/1412/2016/695
Dated: 23/12/2016

To

Mr. Ali Nawaz Khan,
Project Director (Hydro Power),
11-MW BS Link-I Hydropower Project,
142-D, Model Town,
Lahore.

Subject: **DECISION OF EPA PUNJAB FOR THE PROJET "CONSTRUCTION OF 11-MW BS LINK-I HYDROPOWER PROJECT, MOUZA KANDHU KHARA, TEHSIL CHUNIAN DISTRICT KASUR"**

1.	Description of Project:	Construction of 11-MW BS Link-I Hydropower Project.
2.	Location of Project:	Mouza Kandhu Khara, Tehsil Chunian District Kasur.
3.	Date of filing of IEE:	21.06.2016

4. EPA Punjab has reviewed the Initial Environmental Examination Report (IEE) and considered Site Inspection Report received from District Officer (Environment), Kasur vide letter No. 607/DOE/EPA/PN dated 08.08.2016. EPA Punjab has also considered the recommendations of **Committee of Experts** (Meeting dated 07.09.2016), recommendations of **EA Committee** (Meeting dated 14.12.2016) and other relevant record.

5. **Environmental Protection Agency, Punjab accords approval for construction / installation of your aforesaid project subject to the following conditions:**

i. The proponent shall ensure compliance of Punjab Environmental Quality Standards (PEQS).
ii. Mitigation Measures suggested in the IEE report and Environmental Management Plan (EMP) shall be strictly adhered to minimize any negative impacts on soil, ground water, air and biological resources of the project area.
iii. Monitoring shall be carried out during the entire period of the project activities. Monitoring reports of the whole operation shall be submitted to EPA, Punjab on quarterly basis.
iv. Camping sites shall be located at suitable distance away from any settlement to avoid disturbance to the local people. Sewage generated from camping sites shall be treated in septic tanks.
v. The proponent shall take measures to control dust.
vi. The area around the project site shall be kept clean.
vii. The proponent shall ensure efficient health and first aid treatment facilities for protection of workers.
viii. The proponent shall plant at least 10000 trees of minimum height 6-7 feet in consultation with the District Officer (Environment) under intimation to this office.
ix. The proponent shall do proper landscaping after completion of the project.
x. The construction material shall be piled / stored in such a way that it shall not destroy the flora / environment of the locality.
xi. The proponent shall care about noise issues during construction and operation stage of the project.
xii. The objections / complaints of the locals / stakeholders (if any) shall be redressed on priority basis.
xiii. The proponent shall provide compensation to the inhabitants in case of loss of agricultural land, crop, property, etc. in accordance with the rates that are agreed upon. All conflicting issues regarding compensation, etc. shall be settled amicably before the start of the project activities.
xiv. The proponent shall obtain NOC / clearance from all other concerned departments before commencement of work.
xv. The proponent shall appoint Environmental Manager (having relevant qualification and experience) for the project and shall convey his name along with his complete Mailing Address and Phone Numbers.

P.T.O.

xvi. Arrangements shall be made for safe disposal of solid and hazardous waste. The solid waste shall be retained within the unit boundary / premises and shall be disposed off in an environmental friendly way at a suitable disposal facility.

xvii. The proponent shall ensure that strict and efficient health and safety measures are in place for protection of the workers in case of any environmental emergency and these measures are backed by a comprehensive emergency response system.

xviii. At least 90% unskilled and to the extent possible skilled jobs shall be given to locals after providing them proper training.

xix. The proponent shall ensure all necessary measures for the protection of sensitive / protected areas in the vicinity.

xx. The proponent shall prepare a Community Development Plan and implement it for the benefit of communities of the project area.

xxi. The proponent shall provide a copy of IEE Report and this letter to the contractors for its implementation letter and spirit.

xxii. The proponent shall restore the environment of the area after completion of the project and Environmental Audit Report of actual versus Perceived / Assessed imports to EPA Punjab after completion of construction.

xxiii. The proponent shall follow the SOPs regarding dengue larvae eradication and shall ensure removal of stagnant water on daily basis.

xxiv. This approval can be withdrawn at anytime without any prior notice if deem necessary in the public / national interest.

6. The proponent shall be liable for correctness, exhaustiveness and validity of information supplied to this department by the environmental consultant.

7. The proponent shall be liable for compliance of Regulations 13, 14, 18 and 19 of IEE/EIA Regulations, 2000, regarding approval, confirmation of compliance, entry, inspections and monitoring.

8. This approval is accorded only for the construction phase of the project. The proponent shall apply for confirmation of compliance under Regulation 14 of IEE / EIA Regulation, 2000 by submitting Environmental Management Plan for operational phase along with compliance status report of the Environmental Approval of the construction phase of the project.

9. Any change in the approved project shall be communicated to EPA, Punjab and shall be commenced after obtaining the approval.

10. This approval shall be treated as null and void if all or any of the conditions mentioned above, is/are not complied with. This approval does not absolve the proponent of the duty to obtain any other approval or consent that may be required under any law in force and is subjudice to legal proceedings in any legal fora / court.

11. This approval shall be valid (for commencement of construction) for a period of three years from the date of issue under Regulation 17 of IEE / EIA Regulations, 2000.

ASSISTANT DIRECTOR (EIA)
for Director General, EPA, Punjab
Ph: # 042-99232282

NO. & DATE EVEN.

A copy is forwarded to the District Officer (Environment), Kasur w.r.t. his letter No. 607/DOE/EPA/PN dated 08.08.2016. He is requested to ensure compliance of the conditions mentioned in the Environmental Approval and to furnish compliance status report accordingly.

ASSISTANT DIRECTOR (EIA)
for Director General, EPA, Punjab

INITIAL ENVIRONMENT EXAMINATION

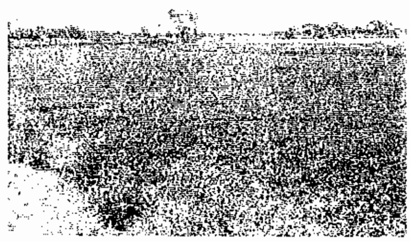
Miss Sara Asif

Mr. Ali Nawaz Khan

Mr. Hamza Tariq

Mr. Tayyab Rafique

Mr. Tayyab Siddique



Project Consultants : M/s INTEGRAL, S.A.
(Carrera 46 NO. 52-36, PISO 11, Medellin, Colombia)

Project Sponsor : M/s ASSOCIATED TECHNOLOGIES PVT. LTD
(142-D Model Town, Lahore)

BS Link-I HPP IEE Report

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
Aps	Affected persons
ATL	Associated Technologies (Pvt) Limited
BOD	Biochemical Oxygen Demand
CEA	Country Environmental Analysis
CO	Carbon Mono Oxide
COD	Chemical Oxygen Demand
dBA	Decibel (sound level filter of A-scale)
ED	Energy Department.
EIA	Environmental Impact Assessment
EMP	Environmental Monitoring Plan
EPA	Environment Protection Agency (Federal)
EPC	Engineering Procurement and Construction
EPD	Environment Protection Department
ESIC	Environment and Social Impact Cell
Ft	foot / feet (3.28 ft = 1 m)
GoP	Government of Pakistan
Ha	Hectare
HSE	Heath, Safety and Environment
IEE	Initial Environmental Examination
IPD	Irrigation and Power Department, Government of the Punjab
IUCN	International Union for the Conservation of Nature
KESC	Karachi Electric Supply Corporation
kV	Kilo-Volt
LAA	Land Acquisition Act, 1894 (amended)
LAA	Land Acquisition Act, 1894
LAC	Land Acquisition Collector
LESCO	Lahore Electricity Supply Corporation
LPG	Liquefied Petroleum Gas
Marla	Smallest unit of land measurement: 1 marla = 272.25 ft_2 (= 25.31 m_2)
MW	Mega Watt
NEQs	National Environmental Quality Standards
NGOs	Non-Government Organizations
NOC	No Objection Certification
NPO	Non- Project Option
OSHA	Occupational Safety and Health Administration, 1970
PAPs	Project Affected Persons

PEPA	Pakistan Environmental Protection Act, 1997
PEPCO	Pakistan Electric Power Company
PMD	Pakistan Meteorological Department
PPDB	Punjab Power Development Board
PPB	Parts Per Billion
PPM	Parts Per Million
PPIB	Private Power Infrastructure Board
RCC	Reinforced Cement Concrete
RD	Reduced Distance
RMB	Right Marginal Bund
ROW	Right of Way
Rs.	Pakistani rupees (currency)
SC	Supervisory Consultants
SRP	Short Resettlement Plan
TDS	Total Dissolved Solids
TL	Transmission line
TSS	Total Suspended Solids
WAPDA	Water & Power Development Authority
WHO	World Health Organization

EXECUTIVE SUMMARY

1. INTRODUCTION

BS Link-I HPP is proposed on Balloki-Sulemanki link canal at RD 106+250 on the right bank of the canal. This project is beneficial for the power generation of the country and will reduce the prevailing power shortage in the country.The Initial Environment study (IEE) of the project is carried out in order to assess the physical, socioeconomic, environmental and ecological aspects of the area. This study also assesses their impacts, both positive and negative on the proposed hydropower project and propose the mitigation measures for the adverse impacts in before, during and after the construction of the proposed hydropower project, if any. Environmental Guidelines/Requirements of Pakistan Environmental Protection Act (PEPA), 1997 and Asian Development Bank (ADB) Guidelines, have been kept in mind during the study.

2. DESCRIPTION OF THE PROJECT

According to Pak-EPA Regulations, 2000 for IEE/EIA, the hydropower project falls in Schedule-I of Category-B "Energy" having a capacity less than 50 MW. The proposed project site is located on the right bank of the BS Link canal in Mauza Kanda Kharan, Tehsil Chunian, District Kasur. The total power scheme will acquire around 29 acres of the area, including the power channel, power house, maintenance area and will produce 10.49 MW of electricity. Power channel will be constructed on the right bank of the main canal and the water from the main canal is diverted into the power channel and will direct to the powerhouse for the generation of electricity. The estimated time for the proposed project is around 36 months and the total cost involved in the project is 45.44 MUSD.

The nearest grid station is the 132 KV Chunian grid station and the transmission lines of the proposed project will connect to this grid station.

3. METHODOLOGY

Following methodology was adopted to carry out the IEE study of the site area.

i. Desk Studies

ii. Delineation of the study area

iii. Collection of the baseline data, that involves

   a. Physical environment, including environmental monitoring, sampling and testing

   b. Ecological environment, including visual observations and secondary sources.

   c. Socioeconomic environment using socioeconomic survey, etc.

iv. Impact assessment, mitigation, and remedial measures and evaluation using checklist and matrices.

v. Development of environmental monitoring plan and Institutional requirements.

4. DESCRIPTION OF ENVIRONMENT & BASELINE CONDITION

Baseline conditions of the project site area are given below:

5. PHYSICAL ENVIRONMENT

Environment monitoring parameters like the ground water and the surface water samples were collected from the project site area and tested. The results of these parameters showed that all the parameters of the ground water sample are within the limits of WHO drinking water guidelines. Similarly, chemical contents of the surface water are also within the recommended safe limits. BS Link canal surface water is the best fit for the irrigation purposes of the nearby fields, but it cannot be used for drinking water purposes. The surface water results indicate that all the parameters of the surface water are within the safe limits of NEQS. BOD is within the prescribed limits of NEQS which shows that the industrial waste material and other domestic material quantity within the water is in low content, their higher content will increase the BOD from the safe limits and will adversely affect the aquatic life in the canal. The ambient air can be classified as moderate because of almost no vehicular movement. No other major point and non-point sources could be identified at the site, except house chimneys emitting smoke due to the combustion of wood for cooking purposes and non-point sources like limited agricultural runoff. All noise values in the area were within permissible limits, i.e. below 70 dB (A).

6. ECOLOGICAL ENVIRONMENT

Natural flora and fauna are essential part of the ecosystem and live together. Since the main part of the study area shows the features of flowing water environs, so agriculturally (thus ecologically) rich alluvial soils and conducive climatic conditions represent a fertile account of eco-environs of the area.

The study area is enriched with natural flora and is covered with vegetation which is the part of the fertile land of the central Punjab, thus natural flora comprise rich profile of all types of vegetation, viz. wood, shrub and grass. The canal is surrounded by vegetation and crops and it is although best suited for the soil conditions there. The feed quality and the raising of the crops is rapid in raining season and reduces when there is less rainfall in the area. Different types of trees have been spotted at the study area which includes tahli (Dalbergia sisso), sufaida (Euclyptus camalulensis), pipal (Ficus religiosa), jamun (Black plump), amrood (Guava) and beri (Ziziphus mauritiana). The dominant weeds & herbs that are most commonly found near the study are thamayan, ajwain, herbal, peelak, berm/dandi and dophali/booti.

Natural fauna also play an important role in the ecological sector of the study area. The common and the dominant wildlife mammals along with the insects, butterflies and vectors are present there. Freshwater fish in various types are also found there.

None of the floral or faunal species recorded as endangered, rare or protected under the legislation of Pakistan and applicable international environmental agreements as well as listed in the Red Book of Pakistan and IUCN registers.

7. SOCIOECONOMIC ENVIRONMENT

A Survey of the study area indicated that no resettlement and relocation is required in or around the project site area as no community is present at or nearby the project area. The information collected from some respondents showed that the area is agriculturally rich which included cereal crops, vegetables, fodder / forage and fruit trees.

The non-Government Organization does not found near the project site area, but different NGO's like Edhi center in Pattoki, Shahjahan Trust in Chunian and Sunnat-e-Mustafa Welfare Trust in Chunian are working for the people but they are at some distance from the study area.

General account of the study area shows that the nearby villages have education facilities and there are primary, middle and high schools in the nearby villages. Medical facilities are also available, including 2-3 private and the government hospitals along with hakeems and private doctors in the villages nearby.

Load shedding problems are extreme in the study area as they are facing a load shedding problem with an interval of 1.5 hours daily. There are electricity problems and gas problems and they use LPG in their daily routines for the cooking and other purposes. One police Chowki at RD 115 on the left bank of the canal, one union council in Sadda at RD 95 and one rescue office 4 km from the Bhairwaal village is also working there for the people.

8. ENVIRONMENTAL IMPACTS & MITIGATION

According to the Pak-EPA regulation 2000, this project lies in the Schedule-I, category B of the energy sector and according to this regulation project lies in this category have less impact on the environment and have mitigation measures which can be mitigated in a short term duration.

There will be adverse impacts of the construction of the power channel at the right bank of the BS Link canal due to the excavation of the land that acquire an area of around 29 acres. This is mitigated by proper consensus with the private land owners and stakeholders of the field land that would be the part of power channel construction.

The ecological baseline of the project site area shows that around 13-15 trees will be cleared for the construction of the power channel and power house and this impact will be mitigated by planting around double trees in that area after the completion of the construction of the project. It is also assessed that proposed route of the transmission line will not significantly cause a mass cutting of trees.

Analysis of the anticipated communities dislocation and resettlement shows that the proposed project have not any impacts on the community dislocation and no resettlement plan is required in that area as no community is present in or around the project site area. The proposed project will need to acquire an area of around 29 acres for the construction of powerhouse and power channel and this will not affect any community and the people living there. Cost of acquired land is to be paid to the government or to the private owner(s) as per LAA, 1894.

Regarding an impact on the general social circle of the community, this project will become the cause of the positive impact on the study area as well as in the surroundings in terms of raising the status of the local people because before and during the low and the peak construction phases, local people will be hired as a laborer and some of them may prolong their jobs during the implementation phase. Improved social environment in terms of the presence of parks, bank or some other facilities will further help in the socioeconomic uplift of the area.

During the construction phase of the project some problems may arise for the residents living in the nearby villages. There can be problem of noise due to the working of the machinery or the windblown from the construction material like sand and excavated soil that can cause problems to the local residents. Besides, there can be traffic problems because during the construction there will be movement of heavy machinery and traffic, which can be a problem for the local residents.

9. INSTITUTIONAL PROBLEMS & ENVIRONMENT MONITORING PLAN

Relevant components of EMP which have been discussed in the report are Institutional requirements, Management activities (auditing, etc.), Training, Monitoring program, Public disclosures and Environ management and monitoring cost.

10. PUBLIC CONSULTATION DISCLOSURE

The main objective of the consultation with the stakeholders and the public is to aware them with the project activities and the impacts of the project on the socioeconomic, physical, ecological and environmental conditions and its mitigation measures before, during and after the construction of the proposed project. A summary of public consultation is given below:

- Most of the people were inclined to help the government in terms of providing paid services.
- The majority thinks that the proposed project will bring prosperity in their area.
- Some showed apprehensions about the consequences of social mixing and the chances of accidents due to transportation of construction material.
- People of the surrounding settlements have nothing against the proposed project.
- Some business persons have apprehensions that they may not be able to get the same status of their business as that of today if their business is dislocated.

Public disclosure is the outcome of all such activities where the public is involved at least in the information sharing process, if at all their participation in decision making is not possible. This is an integral part of that process when Proponent applies for an NOC to the EPA. The organizational structure of the power scheme has been proposed.

11. FINDINGS & RECOMMENDATIONS

a) PHYSICAL ENVIRONMENT

- There will not be any adverse or long term environmental impacts on the land, water and air resources which may damage or limit the land use fully or partially; contaminate surface or drinking water to make them unfit for irrigation or drinking; or pollute the ambient air in terms of any stack emission. Construction activities may contaminate the soil due to the discarded material, toxic chemicals and other miscellaneous materials are involved in the construction activities besides solid waste from the construction will also contaminate the soil, but their mitigations are also present that will be possible through good engineering practice and by placing the storage racks or bins for the storage of these materials. It is noted that if excavated material is properly disposed off that will not block the natural rainwater drainage paths.

- Transmission lines will connect the powerhouse through 132 KV Chunian grid station that will not cause any harm to the surroundings and will not be having any adverse impacts on the nearby villages and communities.

b) ECOLOGICAL ENVRIRONMENT

- The project site area is not densely populated as there is a sparse number of trees present in or around the project site area. As it is surveyed that 13-15 trees will be clear for the power channel and powerhouse construction and double trees will be planted after the completion of the project. The area is enriched in vegetation and crop fields which may get affected by the project construction, but also the mitigation measures are considered for this cause. During the operation stage, there will be a positive impact on the flora due to the extensive plantation.

- Fauna and avifauna will also get attracted to the study area during the implementation stage of the project because during the plantation phase of trees they may get affected but there will be little or no impacts on the fauna and the avifauna. The route of transmission line will not, by and large, damage the natural resources of the area in terms of trees, general agriculture, aquatic species or natural flora.

c) SOCIOECONOMIC ENVIRONMENT

- There will not be any community dislocation and resettlement from the construction of the proposed project. The project proponents have to acquire around 29 acres of the land on the right bank of the BS Link canal for the powerhouse and power channel construction purpose and the compensation for the land is required before the commencement of the construction activities.

- The surrounding settlements and the nearby villages like Kandu Khara, Bairwaaal, Bukankee, Pink Dhos and Nizamabad may get affected during the construction phase by the windblown of the sand and the excavated soil, but this impact is temporary and will be mitigated after the construction of the project completed. Besides, noise pollution may not be a problem for these nearby areas as they are far away from the project site area, but there may be some temporary adverse impacts of the presence of labor camps near the settlement in terms of the chances of fatal accidents and undesirable social mixing. Both of these impacts can be mitigated through the safe traffic management plan and strict application of rules and regulations. Impact on the livelihood will be positive in terms of more employment opportunities, more health and education service provision as well as better availability of other civic facilities.

- The proposed route of the transmission lines will cause no special impacts on the underneath settlement as well as the natural resources. Minor losses to the assets of the community may be compensated easily without any legal problem.

12. CONCLUSION

Based on the survey of the study area and the initial environmental examination of the project site area, it is concluded that the proposed project at RD 106+250 will not have any adverse impacts on the physical, ecological, socioeconomic and the environment of the study area and small impacts should be mitigated at the end. Besides, the proposed project is an environmentally green project as there is no fuel usage is required and no pollution would be generated thereafter.

Keeping in view the ADB guidelines, the IEE suggests that no further EIA is needed because no significant adverse physical, ecological and social environmental impact is identified. There is no dislocation is required for the people and no resettlement is needed in this area. The proposed project is beneficial not only for the residents living there, but it also will add electricity to the national grid of the country that will help to shortage the energy crisis of the country.

Transmission lnes route will not affect any settlement and the natural resources of the area rather it this project will work for the aesthetics of the area and in future there will be recreational points and parks for the people. According to the conversation with the local residents there, they are very much in favor of this project and they are well aware by the project construction and activities.

1. INTRODUCTION

In order to facilitate the private investors in setting up the hydropower schemes in accordance with Government policy, Punjab Power Development Board (PPDB), Energy Department (ED), Punjab advertised eleven (11) hydropower projects in the year 2015. Consequently, through proper selection procedure, M/s Associated Technologies (Pvt.) Ltd (ATL) was entrusted with the task of development of a hydropower scheme proposed on Balloki-Sulemanki (BS) Link-I Canal at RD 106+250 in Mauza Kanda Kharan, Tehsil Chunian, District Kasur. M/s Integral, SA worked as the Project consultants for the proposed BS Link-I HPP. A Letter of Interest (LOI) was issued in favour of ATL in March, 2016.

BS Link-I Hydropower Project will possess a power capacity of about 11 MW which will be added to the national grid through 132 KV transmission line to Chunian grid station under LESCO. This study evaluates the potential environmental and social impacts of the proposed project and suggests mitigation or remedial measures for the adverse. This stand-alone document is prepared to be a part of the Feasibility Study Report (FSR) of BS Link-I Hydropower Project as a separate volume.

This section elaborates the background, nature and location of the project as well as the scope, extent, methodology, limitations and approach to conduct the Initial Environmental Examination (IEE).

1.1. Background

Today the energy crisis in Pakistan is more than the demand of the electricity. The gap between the demand and supply of the electricity is widening. Government of Punjab through its attached departments is working to overcome the energy crisis in Pakistan and meet the energy demand by utilizing the available hydel power potential at barrages and canal falls to generate clean and cheap electricity.

BS Link-I HPP was first identified during a comprehensive study conducted by WAPDA/GTZ in 1985. A number of hydropower project sites were identified along existing canal falls and barrages in the existing irrigation system of Pakistan (WAPDA\GTZ Ranking 1985 and Inventory 1992). A feasibility study of the project was performed in 2009 which has been reviewed thoroughly.

1.2. Objective of the Project

The broader and the main objective of the project is to shorten the energy crisis of the country by utilizing the available energy resources of the country. The idea is to install small hydel projects on the canal falls and barrages to generate cheap and environment friendly electricity to add power in the national grid of the country.

1.3. Nature, Size and Location of the Project

The proposed BS Link-I HPP has a generation capacity of about 11 MW. Balloki-Sulemanki Link canal off-takes from Balloki Barrage on river Ravi and connects Sutlej River upstream of Sulemanki Barrage. The proposed powerhouse of the project will be constructed on the right-bank of the canal at RD 106+250 utilizing the existing available head. It is located near the town of Chunian District Kasur of Punjab Province. The upstream limit of the project is constrained by the Fall at RD 73+250 while downstream limits are controlled by the Chunian Distributary which is off-taking from right bank of BS-I link at RD 110+667.

A detailed location map of the proposed project area is shown in the figure below.

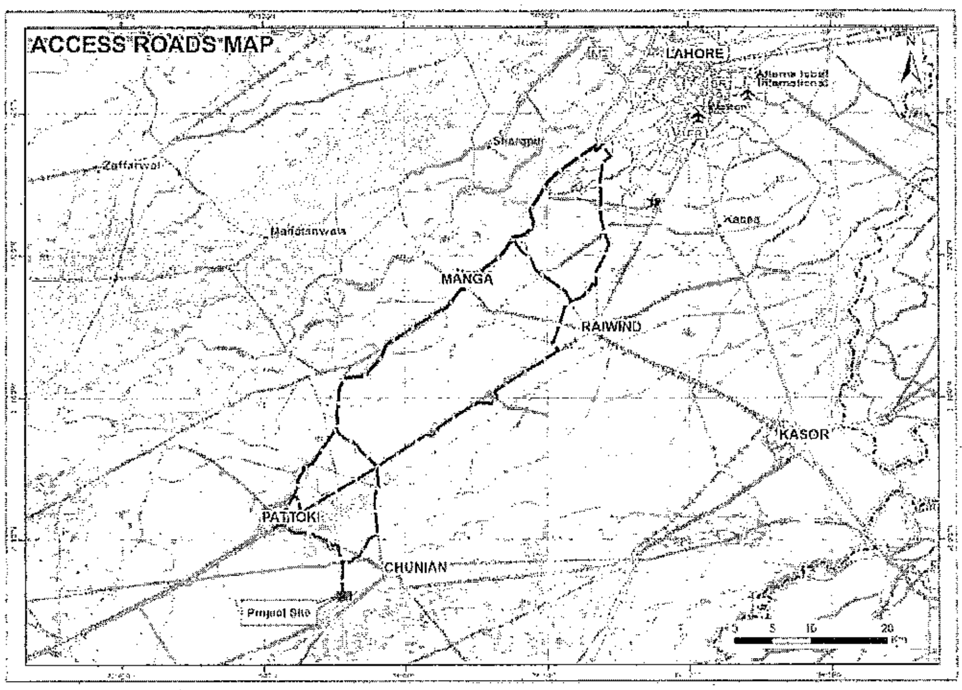


Figure 1: Location Map of the BS Link-I Hydropower Project

1.4. Purpose of the Report

The purpose of this IEE report is to identify and assess all the physical, ecological, socio-economic and environmental significant impacts, both positive and the negative that can occur during the construction and operation of the Hydropower Project at BS Link-I at RD 106+250 along with the proposed mitigations of the adverse effects of the project on that area.

Initial Environmental Examination is an essential part of any project as the environmental & social impacts of the project on the surrounding area are the vital aspects which need to be accounted for before the start of any project.

1.5. Extent of Study

According to the Pakistan Environmental Protection Act (PEPA) 1997 and EIA Regulations 2000, an Initial Environmental Examination (IEE) study is carried out for those hydropower projects which have less than 50 MW capacities. On the basis of this report the proponent is required to get the No Objection Certificate (NOC) from EPA Punjab.

This study covers the Environmental impacts of the proposed hydropower project, in and around the project area, comprising the environmental, physical and socio-economic aspects of the project area. The study also suggests the mitigation measures and describes the institutional arrangements and Environmental Monitoring Plan (EMP).

1.6. Delineation of the Study area

Before proceeding the environmental analysis of the study area it is advisable to delineate the proposed project site area. Most of the construction activities included in the project are limited to in or around the power house and power channel site. But there are some other requirements during the construction of the proposed project. There are areas where the construction related activities can extend further because of the following purposes:

- Establishment of construction camps for the labor and the other staff members
- Storage and transportation of construction materials
- Erection of transmission line from powerhouse to the nearest suitable substation along the ROW of government structures (road, canal, railway, etc.)

The project activities including construction and operation may have various direct and indirect impacts on the physical, environmental, ecological and socio-economic resources of the project area. In direct impact, primary and the secondary impacts are included. The primary impacts are basically related to the on-ground things like impacts on local residents, their relocation from that area and the impacts on their lands containing crops and vegetation are also included in the primary impacts on the study area. Whereas indirect impacts are the impacts on the environmental, socio-economical resources and the physicals system of the project area by the pollution, noise, toxic chemicals, wastewater, fugitive, dust and consumption of natural resources etc.

1.6.1. Powerhouse

To check the direct and indirect environmental impacts on the study area, the proposed powerhouse site options were considered as mentioned below.

- From RD 104+000 to RD 108+000 along the BS Link-I Canal.
- 150 meters (500 ft) in width at left bank from RD 104+000 to RD 106+250 and on the right bank from RD 106+250 to RD 108+000.

1.6.2. Transmission Line

The transmission line of the proposed power station will start from the proposed powerhouse location to the Chunian grid station which is located at about 7-km from the BS Link-I canal having route through villages.

1.6.3. Headrace & Tailrace Channel

Headrace channel will start from RD 104+695 of BS Link-I Canal on right side of the existing Canal. Tailrace channel will start from RD 106+647 and rejoining the existing Canal, it ends at new RD 108+275 (Existing RD 108+017).

1.7. Approach Adopted to Conduct the Study

1.7.1. Review of Layout Plan / Available Documents

A detailed review of the hydropower project layout plan, field visit notes, satellite imageries and GT sheets, inception report, progress reports, and pre-feasibility report was carried out in order to truly understand the proposed project and the extent of the development activities required. The review of the layout plan helped to visualize the nature and extent of the impacts related to the implementation and operation of the proposed project.

1.7.2. Environmental Baseline Survey of the Project

A team of experts have done a numbers of visits at BS Link-I HPP site and its surrounding areas in April and May 2016. These visits were carried out to gather the baselines environmental conditions data in the study area along with the study of impacts of the environment and socio-economic aspects have been done there in or around the study area. Information was mainly collected regarding impact on resettlement issues, land acquisition, agriculture (crops, animals, forest), ecology (wildlife including aquatic species like fish, and terrestrial like birds, forest trees & shrubs, etc.), infrastructure (transport network, township) and other socioeconomic aspects (cost, education, health, history, etc).

i. Physical Environment

During site visits for collection of information regarding physical environment, various parameters were considered including:

a) Land Resources
b) Water Resources
c) Climatology
d) Air Quality
e) Noise Pollution
f) Solid Waste Management and Water Disposal activities;
g) Other infrastructures (Public & Private)

ii. Ecological Environment

Under the ecological environment the following parameters was considered:

a) Flora
b) Fauna
c) Reserved forests and wildlife sanctuaries in the study area and its vicinity
d) Endangered species (both flora and fauna), if any

iii. Social & Cultural Environment

Social and cultural environmental survey was carried out in the study area in order to assess the social and cultural baseline conditions. This survey consists of the following objectives:

- To identify poor and vulnerable groups and develop a plan/strategy so that such groups would get benefits from the project.
- To ensure adequate public/stakeholders consultation and participation
- To gather information from the local residents and the community people about the environmental and social parameters of their localities.
- Demographic characteristics of the study area.
- To identify the various effects of the project on the resources of the community and their local residents.

Social survey was carried out to collect the various information about the study area from the community people and stakeholders. Interview sessions were held at the study area to gather the socio-economic information and the physical effects on people from the project and during the project. Consultation with the different departments at or around the site area was also carried out to gather some project related and community related information, these include the Government departments and the private NGO's and various others departments from where the project related information was collected.

1.7.3. Analysis of Data

After collecting all the relevant information including the environmental and the socio-economic baseline data from the project area, an analysis was made from the data to assess the baseline conditions and impacts of these on the project.

1.7.4. Screening of Potential Environmental Impacts and Mitigation Measures

After a thorough review of the field notes, data collected, extent of the proposed project activities and the detailed discussions held with the stakeholders and the design team, the potential impacts of the project were assessed and measures have been proposed to mitigate the adverse impacts and to enhance the positive impacts. The potential impacts and mitigation measures were assessed covering the following aspects / phases for the environmental problems related to the project:

- Location
- Construction
- Maintenance and Operation

1.7.5. Preparation of Institutional Requirements and Development of Environmental Monitoring Plan

Institutional capacity of the Proponent was reviewed and suggestions were made for the effective implementation of the mitigation measures and the generic monitoring requirements. As the supervision Consultants and Contractor(s) for the project are yet to be finalized, therefore, generic guidelines have been provided in this report for defining their roles and responsibilities.

2. DESCRIPTION OF THE PROJECT

2.1. Type and Category of Project

According to Pak-EPA Regulations, 2000 for IEE/EIA, the hydropower project falls in Schedule-I of Category-B "Energy" having a capacity less than 50 MW.

According to these regulations the category B project is likely to have minimal or no adverse environmental impacts and can be mitigated easily. On further discussion it is suggested that beyond the Initial Environmental Examination (IEE) of the project area no other Environmental Impact Assessment (EIA) is further required for such project.

2.2. Need of the Project

The increased energy crisis in Pakistan has created much difference between the demand and the supply of the power in Pakistan. There is a huge difference between demand and supply, so in order to reduce such difference and to adequately increase the power capacity of the country, Government of Pakistan has proposed such small projects on the canal falls from where the maximum power can be generated that will be an addition in the national grid of the country. BS Link-I HPP will also play its role as it will generate 11 MW of electricity and help to increase the power supply of the country.

2.3. Project Location

BS Link canal takes off from Balloki Barrage and from RD 73+000 it is bifurcated into two branches known as BS Link-I and BS Link-II canals. On the RD 106+250, there is a 3.242 m canal fall, which is the exact location of the proposed BS Link-I HPP shown in the general location map and location plan in **Exhibit-A**. The Site is located in Tehsil Chunian, District Kasur, Punjab, Pakistan having following coordinates.

Table - 1: Project Site Coordinates

Site	Latitude	Longitude
BS Link Structure at RD 106	30°56'23.29"N	73°55'26.46"E

The site is about 90 Km away from Lahore and can be accessed easily via National Highway up to Pattoki town then 7 Km on Pattoki-Chunian road and after that along the bank of BS Link-I canal up to the site is again about 7 Km. The location map of the BS Link-I is shown in **Exhibit-A** of IEE.

Figure 2 National Highway up to Pattoki

Figure 3 Along Pattoki-Chunian Road

Figure 4 Along the right bank of BS Link-I Canal

2.4. Salient Features of the Project

Table - 2: Salient Features of BS Link-I HPP

Location of the Project	Plant Factor
Located 7 km from south of Chunian, and 90 km south of Lahore	73%
Head Race Canal	**Tail Race Canal**
Top Width = 41.124 m Bed Width = 34.138 m Side Slopes = 1 V : 0.5 H	Top Width =41.124 m Bed Width = 34.138 m Side Slopes = 1 V : 0.5 H
Power House	
Length = 48.6 m Width = 88.66 m Total Height = 29.637 m	
Hydro Mechanical Equipment	
No. of Units = 4 No. Installed Capacity =10.49 MW Energy Potential = 67.29 GWh Type of Turbine =Hz. Pit Type Kaplan Runner Diameter = 4.766 m Unit Speed =69.8 rpm Rated Discharge =87.50 cumec each Rated Head = 3.55 m	
Spillway	
Design Discharge =425 cumec No. of Gates = 4 No. Type of Gates = Radial Gates	

The proposed BS Link-I HPP is spread over an area of about 29 acres. The total installed capacity of BS Link-I HPP will be 11 MW. A permanent power channel will be constructed on the right bank of the canal that will divert water from main canal to the power house and then from powerhouse, water will re-enter into the main canal through a tail race channel. The salient features of BS Link-I HPP are described in table above.

2.4.1. Cost Estimates of the Project

The cost estimate includes details of civil works cost and electrical and mechanical (E & M) works cost. Base cost of Project is presented in following Table.

BS Link-I Hydropower Project

TOTAL COST OF PROJECT
GRAND SUMMARY

Item #	Description	Amount	Currency
1	Land Acquisition & Environment Cost	48,789,000	PKR
CIVIL WORKS			
2	Construction of Powerhouse	1,666,107,662	PKR
3	Construction of Spillway	226,768,621	PKR
4	Construction of Power Channel		
4a	Headrace Channel	107,034,679	PKR
4b	Tailrace Channel	139,930,873	PKR
	Total (Civil Work)	**2,139,841,835**	
E & M Equipment			
5	Cost of E & M Equipment (4 Turbines)	11,234,000	PKR
	Total (E & M Work)	**11,234,000**	USD
	TOTAL	**2,199,864,835**	**PKR**
		20,951,094	USD

BS LINK HYDROPOWER PROJECT
PRELIMINARY WORK SCHEDULE

Page 1 of 2

ID	Task Name	Duration	Start	Finish
1	**BS LINK HYDRO POWER PROJECT**	1025 days	Mon 2/22/16	Sat 1/19/19
2	**LOI STAGE**	134 days	Mon 2/22/16	Wed 7/6/16
3	**ISSUANCE OF LOI**	1 day	Tue 3/1/16	Tue 3/1/16
4	**PREPARATION OF FEASIBILITY STUDY**	134 days	Mon 2/22/16	Wed 7/6/16
5	**Data Collection**	14 days	Mon 2/22/16	Sun 3/6/16
6	Technical Data Collection from PFCB / Punjab Irrigation Department / PMIU	7 days	Mon 2/22/16	Sun 2/28/16
7	Digitization of Discharges / Gauges etc	7 days	Mon 2/29/16	Sun 3/6/16
8	**Hydrological Analysis**	21 days	Mon 3/7/16	Mon 3/28/16
9	Development & Evaluation of Daily Flow Patterns in Last at least 3 Decades considering different measuring points of BS-I & BS-II	10 days	Mon 3/7/16	Wed 3/16/16
10	Evaluation of Approved L-Sections of BS-I & BS-II	2 days	Thu 3/17/16	Fri 3/18/16
11	Development of Flow Duration Curve based on Historical Data	2 days	Thu 3/17/16	Fri 3/18/16
12	Development of Average Daily Flows for Energy Computations	2 days	Thu 3/17/16	Fri 3/18/16
13	Selection of Design Flow of Powerhouse	2 days	Sat 3/19/16	Sun 3/20/16
14	Selection of Design Flow for Spillway	2 days	Sat 3/19/16	Sun 3/20/16
15	Report Writing on Hydrological Studies	7 days	Mon 3/21/16	Mon 3/28/16
16	**Consideration of Different Layouts & Selection of Final Layout**	7 days	Tue 3/29/16	Mon 4/4/16
17	Consideration of Different Layouts & Selection of Final Layout	7 days	Tue 3/29/16	Mon 4/4/16
18	**Geotech Investigations**	52 days	Fri 3/18/16	Tue 5/10/16
19	Selection of Sub-Contractor for Geotech Investigations	7 days	Fri 3/18/16	Fri 3/25/16
20	Contract Agreement with Geotech Sub-Contractor	3 days	Sat 3/26/16	Mon 3/28/16
21	Mobilization of Geo-Tech Sub-Contractor to Site	7 days	Tue 3/29/16	Mon 4/4/16
22	Geotech Investigation at Site	21 days	Tue 4/5/16	Mon 4/25/16
23	Preparation of Report on Geotech Investigation	14 days	Tue 4/26/16	Tue 5/10/16
24	**Sizing of Powerhouse (Selection of type & no. of Turbines)**	6 days	Tue 4/5/16	Sun 4/10/16
25	Consideration of Different Options	3 days	Tue 4/5/16	Thu 4/7/16
26	Report Writing on Sizing of Powerhouse	3 days	Fri 4/8/16	Sun 4/10/16
27	**Design of Hydraulic Structures (Conceptual Design)**	65 days	Tue 4/5/16	Thu 6/9/16
28	Design of Headrace Channel	1 day	Tue 4/5/16	Tue 4/5/16
29	Design of Tailrace Channel & Development of Tail rating Curve	1 day	Tue 4/5/16	Tue 4/5/16
30	Design of Spillway	7 days	Wed 5/11/16	Tue 5/17/16
31	Finalization of Hydraulic Parameters for Powerhouse	1 day	Wed 4/6/16	Wed 4/6/16
32	Sizing (Civil) of Powerhouse (partial information requires from Manufacturer)	20 days	Wed 5/11/16	Mon 5/30/16
33	Report Writing and Development of Drawings	10 days	Tue 5/31/16	Thu 6/9/16
34	**Development of Revised L-Section of BS-I (for NoC for Punjab Irrigation Department)**	3 days	Fri 6/10/16	Sun 6/12/16
35	**Power & Energy Studies**	10 days	Fri 6/10/16	Sun 6/19/16
36	Head Loss Calculations	3 days	Fri 6/10/16	Sun 6/12/16
37	Assessment of Power Potential	1 day	Mon 6/13/16	Mon 6/13/16
38	Energy Calculations	3 days	Tue 6/14/16	Thu 6/16/16
39	Report Writing	3 days	Fri 6/17/16	Sun 6/19/16
40	**Electrical & Mechnical Studies**	7 days	Mon 6/20/16	Sun 6/26/16
41	**Environment & Resettlement Studies**	20 days	Tue 4/5/16	Sun 4/24/16

Project: BS Link Hydropower Project
Date: 16-02-2016

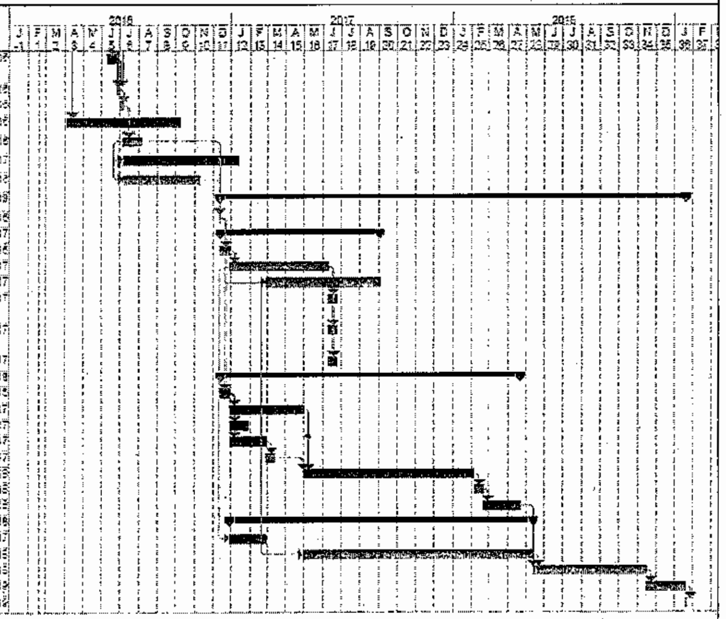
Task | Critical Task | Milestone | Summary | Rolled Up Task | Rolled Up Critical Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Progress | Deadline

Note: Preliminary Work Schedule Without Time Optimization between Civil Construction, E & M Equipment Manufacturing & Installation.

Page 2 of 2

BS LINK HYDROPOWER PROJECT
PRELIMINARY WORK SCHEDULE

ID	Task Name	Duration	Start	Finish
42	Computation of Quantities & Cost (based on Conceptual Design)	14 days	Fri 6/10/16	Thu 6/23/16
43	Conclusions & Recommendations	3 days	Mon 6/27/16	Wed 6/29/16
44	Finalization & Submission of Feasibility Study	7 days	Thu 6/30/16	Wed 7/6/16
45	ACQUIRATION OF PRIVATE LAND	160 days	Tue 4/5/16	Fri 10/7/16
46	NOC FROM PUNJAB IRRIGATION DEPARTMENT	33 days	Thu 7/7/16	Fri 8/5/16
47	APPLICATION FOR FEASIBILITY LEVEL TARRIF	160 days	Thu 7/7/16	Thu 1/12/17
48	PHYSICAL MODEL STUDY (IF REQUIRED)	100 days	Thu 7/7/16	Tue 11/8/16
49	LOS STAGE	747 days	Tue 12/13/16	Sat 1/19/19
50	ISSUANCE OF LOS	1 day	Tue 12/13/16	Tue 12/13/16
51	DETAILED DESIGN	234 days	Wed 12/14/16	Sat 9/2/17
52	Preparation of Design Criteria	14 days	Wed 12/14/16	Wed 12/28/16
53	Detailed Design of Project	160 days	Thu 12/29/16	Fri 6/9/17
54	Construction Drawings	160 days	Tue 2/28/17	Sat 9/2/17
55	Preparation of Standard Documents (Technical Specifications, Civil)	14 days	Sat 8/12/17	Fri 8/25/17
58	Preparation of Standard Documents (Quality Assurance Manual, Civil)	14 days	Sat 8/12/17	Fri 8/25/17
57	Work Schedule of Project	14 days	Sat 8/12/17	Fri 8/25/17
58	DESIGN & PROCUREMENTS FOR E & M EQUIPMENTS	479 days	Wed 12/14/16	Sat 4/21/18
59	Finalization of Scope of Work	14 days	Wed 12/14/16	Wed 12/28/16
60	Design of E & M Equipment	120 days	Thu 12/29/16	Sat 4/29/17
61	Standard Quality Documents	30 days	Thu 12/29/16	Fri 1/27/17
62	Selection of Manufacturers	60 days	Thu 12/29/16	Mon 2/27/17
63	Ordering for Manufacturers	14 days	Tue 2/28/17	Mon 3/13/17
64	Manufacturing of E & M Equipment	270 days	Sun 4/30/17	Sun 2/4/18
65	Pre-Shipment Tests	14 days	Tue 2/6/18	Mon 2/19/18
66	Transportation through Land, Sea, to Site	60 days	Tue 2/20/18	Sat 4/21/18
67	CIVIL CONSTRUCTION	495 days	Thu 12/29/16	Sun 5/13/18
68	Selection of Sub-Contractor	60 days	Thu 12/29/16	Mon 2/27/17
69	Construction Works on Different Components	365 days	Sun 4/30/17	Sun 5/13/18
70	E & M INSTALLATION	180 days	Mon 5/14/18	Wed 11/14/18
71	PRE-COMMISSIONING TESTS	60 days	Thu 11/15/18	Fri 1/18/19
72	COMERCIAL OPERATION DATE (COD)	1 day	Sat 1/19/19	Sat 1/19/19



Project: BS Link Hydropower Project
Date: 15-02-2016

Task; Critical Task; Milestone; Summary; Rolled Up Task; Rolled Up Critical Task; Rolled Up Milestone; Rolled Up Progress; Split; External Tasks; Project Summary; Group By Summary; Inactive Milestone; Inactive Summary; Manual Task; Duration-only; Manual Summary Rollup; Manual Summary; Start-only; Finish-only; External Tasks; External Milestone; Progress; Deadline

Note: Preliminary Work Schedule Without Time Optimization between Civil Construction, E & M Equipment Manufacturing & Installation.

2.4.2. Solid Waste

Solid waste generation is an unavoidable phenomenon during the construction of any project. Some of the excavated soil will be used as landfill during the project whereas other solid wastes include toxic components, plastic bags, disposable material, tins, cans, miscellaneous items, organic waste from a common zone, waste from offices and colonies developed for staff and the sewage waste.

2.5. Construction Aspects

2.5.1. Powerhouse Ownership & Contractor's Arrangements

The project proponent i.e. Associated Technologies (Pvt) Ltd will make arrangements for the execution of the proposed project after the completion of the feasibility study of the proposed HPP. The proponents will start the tendering process of the project for the competitive bidding to select the potential contractors based on the pre-formulated selection criteria. If the proposed project is awarded to some contractor on Engineering, Procurement and Construction (EPC) basis then the EPC based contractor will be responsible for the design, construction and the operation of the proposed HPP and its other related works. Proponents should ensure that its selection criteria for contractors should include health, safety and environment aspects of the project. The proponents should have their own HSE criteria for selection of the sub-contractors for the project.

2.5.2. Work Force

Various skilled and unskilled labors will be engaged during the construction of the project. During the construction phase of the project it is expected that around 150 to 200 skilled labors will be engaged on the constructions activities and other related activities of the project.

2.5.3. Construction Material

Steel, cement, brick, stones as well as other material will be used. The structure will consist of Reinforced Cement Concrete (RCC) using mainly steel, cement, sand, aggregate for construction purposes.

2.5.4. Project Completion Time

The estimated completion time for the construction of the proposed project is about 36 months.

2.6. Analysis of Alternatives

Different alternatives considered for the project which include the no project option and powerhouse location alternatives as described below:

Powerhouse is placed in the power channel at RD 106+250 on the right band of the BS Link-I Canal keeping in view the socio-economic aspects of the area. Keeping in view the socio-economic and other aspects of the project area the following alternatives were suggested during the IEE study of the project.

2.6.1. No Project Option

The current total power generation capacity of Pakistan is 19,855 MW and the electricity demand (as of April 2010) is 14,500 MW and PEPCO is merely generating 10,000 MW, resulting in load shedding of almost 6 to 8 hours a day in urban centers of Pakistan and even more in the rural areas. This gap between demand and supply of the electricity is increasing day by day causing a great economic loss to the country apart from the human who are suffering from the great electricity outages.

Government of Pakistan is working hard to reduce this short fall and the energy crisis of the country by introducing different power generating projects which include thermal, hydel, coals, nuclear and renewable power generation to minimize the gap between demand and supply of power to the country.

Keeping in view the above discussion, No Project Option (NPO) does not seem realistic option in order to pull out country from the major energy crisis and to enhance the economy of the country by resolving this core issue.

2.6.2. Powerhouse Location Alternatives

Keeping in view the socio-environmental aspects, the following alternatives of the powerhouse location were suggested and analyzed:

a) **Option – 1:** Propose diversion power channel at right bank of the canal at RD 106+250 and make powerhouse in the channel and spillway in the main canal.

b) **Option – 2:** Propose both powerhouse and spillway to be constructed in the main canal at RD 106+250.

c) **Option – 3:** Propose power channel at right bank of the canal at RD 106+250 and make powerhouse and spillway in the power channel.

All these options are further depicted in detail in **Exhibit-A**

Option – 1: Propose diversion power channel at right bank of the canal at RD 106+250 and make powerhouse in the channel and spillway in the main canal

i. Keeping in view the apprehensions discussed above, similar question arises for this proposition i.e. dependency on canal closures. Location map is shown in **Exhibit-A** as **Layout option-01.**

Option – 2: Propose both powerhouse and spillway to be constructed in the main canal at RD 106+250.

Information collected for this proposed powerhouse location in the main canal. It is observed that if the powerhouse and the spillway of the project are to be constructed into the main canal then there can be following problems which we have to be faced during the construction

i. Water will have to be diverted from main canal to the diversion channel for construction and we will have to wait for the canal closure period to make that diversion channel operational.

ii. Annual closure period of canal is a short period in a year meant for canal maintenance when the flow of the canal is stopped. It is not possible to construct powerhouse and spillway during one canal closure so another closure period will be required after the construction of project components to revert the water back from diversion to main original course.

iii. Cost of the project may increase as the construction duration is very much dependent on the canal closures. So this option has been discarded by project proponents due to more uncertainty developed by the canal closure phenomenon.

Location map is shown in **Exhibit-A** as **Layout option-02.**

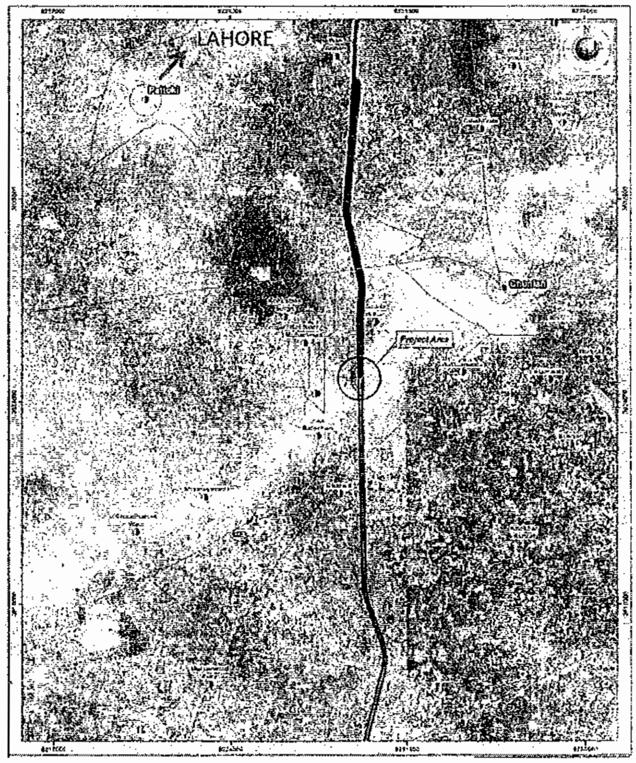
Option – 3: Propose diversion power channel at right bank of the canal at RD 106+250 and make powerhouse and spillway there

i. This option appears to be more feasible and more economical as compared to the other two options mentioned above. In this option, powerhouse and the spillway construction can be started anytime of the year independently and construction activities will have to be planned such that the completion of headrace, tailrace channels and powerhouse is instantly followed by a canal closure so this scheme can be make operational.

ii. By doing this, the dependency on canal closures is reduced by 50% which makes this option rather attractive.

Location map is shown in **Exhibit-A** as **Layout option-03.**

Selected project layout is presented in **Exhibit-A**



Project Location Map

Satellite Image map of the Project

3. ENVIRONMENTAL STANDARDS AND GUIDELINES

There are number of national and international standards and guidelines which can be used for the proposed project and can be beneficial both for the community and the project. These guidelines and standards are described below:

3.1. Regulatory Requirements and Application Standards

3.1.1. The National Guidelines

The national guidelines and legislations related to the environment of the project area which are considered necessary for the proposed BS Link-I HPP are as follows:

- National Forest Policy covers natural renewable resources of Pakistan including forests, rangelands, watersheds, wildlife, biodiversity and their habitats; the main objective of the policy is to foster the Renewable Natural Resources (RNR) of Pakistan.
- Pakistan National Environmental Policy 2005, which provides a framework for addressing environmental issues of Pakistan particularly pollution of fresh water sources, air pollution lack of proper waste management, deforestation, loss of biodiversity, desertification, natural disaster and climate change.
- The other provincial and departmental applicable laws and regulation include The ForestAct1, 1927 and Provincial Wild Life Act 1974, etc.
- Land Acquisition Act (LAA), 1894 is the main law regulating land acquisition for public purpose in Pakistan. The LAA and its implementation rules require that following impacts identification and valuation, land and crops are compensated in cash at market rate totitled landowners and registered land tenants/users, respectively. The LAA mandatesthat land valuation is to be based on the latest 3-5 years average registered land sale rates though, recently, the median rate over the past 1 year, or even current rates, wereapplied in some cases. Due to widespread land under-valuation by the RevenueDepartment, current market rates are now frequently applied, plus 15% Compulsory Acquisition Surcharge as provided in the LAA.
- PEPA, 1997, which empowers the Pak-EPA to delegate power to the provincial Environmental protection Agencies (EPAs), identifies the categories of projects to which the IEE/EIA provisions will apply, develop guidelines for conducting IEE and EIAs andprocedures for their submissions, review and approval, develop environmental emissionstandards for parameters such as air and noise, etc. as the project falls under jurisdiction of EPA-Punjab, so Proponent will submit the report for review and approval and getapproval from EPA-Punjab.
- The PEPA, 1997 makes it mandatory for the project Proponent to carry out an IEE or
- Environmental Impact Assessment (EIA) of the development projects depending upon the nature of the project, which includes magnitude and type of development and capital outlay. Pakistan Environmental Protection Agency has categorized various development projects under Regulations 2000 into schedule–I, for IEE, and schedule–II for EIA studies, as the project lies in schedule–I, so IEE study will be conducted.

- The National Environmental Quality Standards (NEQS) 2000, which specify the maximum allowable concentrations of pollutants in municipal and liquid industrialef fluents, maximum allowable concentrations of pollutants in gaseous emissions from industrial sources, etc. The compliance standards and guidelines considered for the proposed project are NEQS and World Health Organization (WHO) in addition to PEPA1997.

3.2. Legal and Institutional Framework

3.2.1. General

The legislation of Pakistan contains many laws in the form of Acts, and ordinances which have direct or indirect relevance and implications in the layout, design, construction and operation of the BS Link-I Hydropower Project. The main national and international instruments of environmental legislation, which have bearing on the project, are discussed in this chapter. The prevailing operational manuals and guidelines of the World Bank, the Asian Development Bank and other donors and financial institutions are also considered. Pakistan is signatory to various international conventions for pollution control and biodiversity, which are also mentioned.

3.2.2. Environment Regulatory Authorities

The development of statutory and other instruments for environmental protection has steadily gained priority in Pakistan since late 1970s. The Pakistan Environmental Protection Ordinance (PEPO 1983) was the first legislation designed specifically for the protection of the environment. The promulgation of this ordinance was followed in 1984 by the creation of Pakistan Environmental Protection Council (PEPC) headed by the Chief Executive of the country as the highest inter-ministerial and multi- stakeholder's decision making body and establishment of the Pakistan Environmental Protection Agency (EPA), the federal level government institution dealing with environmental issues. The Ministry of Environment, Local Government and Rural Development is responsible for policy making and planning in respect of environmental aspects at national level.

3.2.2.1. Pakistan Environmental Protection Council

The Pakistan Environmental Protection Council (PEPC) is the highest inter-ministerial statutory body in the country headed by the Chief Executive for formulation of national environmental policy, enforcement of PEPA 1997, approval of the National Environmental Quality Standards (NEQS), incorporation of environmental considerations into national development plans and policies and to provide guidelines for the protection and conservation of biodiversity in general and for the conservation of renewable and non-renewable resources.

Table - 3: National Environmental Quality Standards (NEQS) For Municipal and Liquid Industrial Effluents

(Mg/l, unless otherwise defined)

Sr. No.	Parameter	Existing Standards	Revised Standards		
			Into Inland Waters	Into Sewage Treatment	Into Sea
1	Temperature/ Temperature increase*	40° C	≤ 3° C	≥ 3° C	≥ 3° C
2	pH value	6 - 10	6 - 9	6 - 9	6 – 9
3	5-days Biochemical Oxygen Demand (BOD) at 20°C. (1)	80	80	250	80**
4	Chemical Oxygen Demand (COD) (1)	150	150	400	150
5	Total Suspended Solids	150	200	400	200
6	Total Dissolved Solids	3500	3500	3500	3500
7	Grease and Oil	10	10	10	10
8	Phenolic Compounds (as phenol)	0.1	0.1	0.3	0.3
9	Chloride (as Cl)	1000	1000	1000	SC
10	Fluoride (as F)	20	10	10	10
11	Cyanide (as QN) total	2	1	1	1
12	An-Ionic Detergents (as MBAS) (2)	20	20	20	20
13	Sulphate (SO_4)	600	600	1000	SC
14	Sulphide (S)	1.0	1	1	1
15	Ammonia (NH_3)	40	40	40	40
16	Pesticides, Herbicides, Fungicides and Insecticides (3)	0.15	0.15	0.15	0.15
17	Cadmium (4)	0.1	0.1	0.1	0.1
18	Chromium (trivalent & hexavalent) (4)	1.0	1	1	1
19	Copper (4)	1.0	1	1	1
20	Lead (4)	0.5	0.5	0.5	0.5
21	Mercury (4)	0.01	0.01	0.01	0.01
22	Selenium (4)	0.5	0.5	0.5	0.5
23	Nickel (4)	1.0	1	1	1

24	Silver (4)	1.0	1	1	1
25	Total Toxic Metals	2.0	2	2	2
26	Zinc	5.0	5	5	5
27	Arsenic (4)	1.0	1	1	1
28	Barium (4)	1.5	1.5	1.5	1.5
29	Iron	2.0	8	8	8
30	Manganese	1.5	1.5	1.5	1.5
31	Boron (4)	6.0	6	6	6
32	Chlorine	1.0	1	1	1

1. Summing minimum dilution 1:10 on discharge, lower ratio would attract progressively stringent standards to be determined by the Federal Environmental Protection Agency. By 1:10 dilution means for example, that for each one cubic meter of treated effluent the recipient water body should have 10 cubic meter of water for dilution of this effluent.
2. Modified Benzene Alkyl Sulphate; assuming surfactant as bio-degradable.
3. Pesticides. Herbicides, fungicides, and insecticides.
4. Subject to total toxic metals discharge.
5. Applicable only when and where sewage treatment is operational and BOD5=80 mg/l is achieved by the sewer treatment system.
6. Provided discharge is not at shore and not within 10 miles of mangrove or other important estuaries.

SC Discharge concentration at or below Sea concentration.

* The effluent should not result in temperature increase of more that 3°C at the edge of the zone where initial mixing and dilution take place. In case zone is not defined, use 100 meters from the point of discharge.

Note: Dilution of gaseous emissions and liquid effluents to bring them to the NEQS limiting value is not permissible through excess air mixing/blowing into the gaseous emissions or through fresh water mixing with the effluent before discharge into environment.

** The value of BOD and COD is 200 and 400 respectively

Table - 4: National Environmental Quality Standards (NEQS) For Industrial Gaseous Emission (Mg / NM3, unless otherwise defined)

Sr. No.	Parameter	Source of Emission	Existing Standards	Revised Standards
1	Smoke (1)	Smoke opacity not to exceed	40% or 2 (Ringlemann scale)	40%
2	Particulate Matter (2)	Boilers and furnaces:		
		(i) Oil fired. (ii) Coal fired. (iii) Cement Kilns. Grinding, crushing, clinker coolers and related processes, metallurgical processes, converter blast furnaces and cupolas	300 500 200 500	300 500 200 500
3	Hydrogen Chloride (3)	Any.	400	400
4	Chlorine (3)	Any.	150	150
5	Hydrogen fluoride (3)	Any.	150	150
6	Hydrogen Sulphide (3)	Any.	10	10
7	Sulphur Oxides	Sulphuric acid plant Others.	400	5000 1700
8	Carbon monoxide (3)	Any.	800	800
9	Lead (3)	Any.	50	50
10	Mercury (3)	Any.	10	10
11	Cadmium (3)	Any.	20	20
12	Arsenic (3)	Any.	20	20
13	Cooper (3)	Any.	50	50
14	Antimony (3)	Any.	20	20
15	Zinc (3)	Any	200	200
16	Oxides of Nitrogens	Nitric acid manufacturing Unit Gas fired. Oil fired Coal fired	400 400	3000 400 600 1200

1. Based on the assumption that the size of the particulates is 10 micron or more.
2. In respect of emissions of sulphur dioxide and nitrogen oxides, the power plants operating on oil or coal as fuel shall, in addition to national Environmental Quality Standards (NEQS) specified above, comply with the following standard.

Table - 5: National Environmental Quality Standards (NEQS)

Sulphur Dioxide and Nitrogen Oxide Ambient Air Requirements (NEQS)

A. SULPHUR DIOXIDE Sulphur Dioxide Background Levels (µg/m³)				
		Standards		
Background Air Quality (SO_2 Basic)	Annual Average (µg/m³)	Max. In 24 Hour Interval (µg/m³)	Criterion I Max. SO_2 Emission (Tons/day/Plant)	Criterion II Max. Allowable Ground Level Increment To Ambient (One year average, µg/m³)
Unpolluted Moderately Polluted*	< 50	< 200	500	50
Low	50	200	500	50
High	100	400	100	10
Very Polluted**	> 100	> 400	100	10
* For intermediate values between 50 and 100 µg/m³) liner interpolations should be used ** No project with sulphur dioxide emissions will be recommended				

3.2.2.2. Ministry of Environment, Local Government and Rural Development

The Ministry of Environment, Local Government and Rural Development is the main federal level government organization responsible for protection of the environment and resource conservation and is headed by a federal minister. The Ministry works in collaboration with the PEPC and the federal and provincial Environment Protection Agencies (EPA).

3.2.2.3. Environmental Protection Agency (EPA)

The EPA is headed by a Director General and has wide ranging functions as given in PEPA 1997. These include preparation and co-ordination of national environmental policy for approval by PEPC, administering and implementing PEPA 1997 and preparation, revision or establishment of NEQS. The EPA issued regulations regarding the environmental assessment procedures known as Review of IEE and EIA Regulations, 2000 in order to give a firm legal status to the IEE and EIA. The jurisdiction of the EPA is applicable to the following projects:

- On federal land
- Military projects
- Involving trans-country impacts, and
- Bearing trans-province impacts.

3.2.2.4. Provincial Level Institutions

Each provincial government has its own provincial EPAs and EPDs, which are the provincial level counterparts of the EPA. The provincial EPAs are formed by the respective provincial governments headed by a Director General who exercises powers delegated to him by the concerned provincial government. A separate EPA for the Northern Areas at Gilgit has also been established. The IEE and EIA reports pertaining to projects falling within the different provincial boundaries and the Northern Areas are submitted to the relevant provincial EPA and Northern Areas EPA for approval. In present case, EPA Punjab is the relevant authority.

3.2.3. National Conservation Strategy (NCS)

The Pakistan National Conservation Strategy (NCS) is the principal policy document for environmental issues in the country which was developed and approved by the Government of Pakistan on 1st March 1992. The NCS works on a ten-year planning and implementation cycle. It deals with fourteen core areas, as follows:

i. maintaining soils in cropland

ii. increasing irrigation efficiency

iii. protecting watersheds

iv. supporting forestry and plantations

v. restoring rangelands and improving livestock

vi. protecting water bodies and sustaining fisheries

vii. conserving biodiversity

viii. increasing energy efficiency

ix. developing and deploying material and energy renewables

x. preventing and abating pollution

xi. managing urban wastes

xii. supporting institutions for common resources

xiii. integrating population and environmental programmes

xiv. preserving the cultural heritage

3.3. Environmental Legislation

3.3.1. Environmental Protection Act, 1997

The Pakistan Environmental Protection Act, 1997 is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The act is applicable to almost all environmental parameters such as air, water, soil, and noise pollution, as well as to the handling of hazardous wastes. The Act provides the framework for protection and conservation of species, wildlife habitats and biodiversity, conservation of renewable resources, establishment of standards for the quality of the ambient air, water and land, establishment of Environmental Tribunals, appointment of Environmental Magistrates, IEE and EIA approval. Penalties have been prescribed for those contravene the Act. The key features of the Act have a direct bearing on the proposed project requirement for an Initial Environmental Examination and Environmental Impact Assessment for development projects. The Environmental Protection Agency (EPA) has delegated the power of review and approval of environmental assessments to the provincial environmental protection agencies. The proposed BS Link-I Hydropower Project is located in the Punjab province under the jurisdiction of the EPA Punjab.

The following are the key features of the Act that have a direct bearing on the project area:

- Section 11 (Prohibition of Certain Discharges or Emissions) states that "Subject to the provisions of this Act and the rules and regulations made thereunder, no person shall discharge or emit, or allow the discharge or emission of, any effluent or waste or air pollutant or noise in an amount, concentration or level which is in excess of the National Environmental Quality Standards (NEQS)".
- Section 12-I (Initial Environmental Examination and Environmental Impact Assessment) requires that "No proponent of a project shall commence construction or operation unless he has filed with the Federal Agency an IEE or, where the project is likely to cause an adverse environmental effect, an EIA, and has obtained from the Federal Agency approval in respect thereof."
- Section 12-2b (Review of IEE and EIA): The Federal Agency shall review the Environmental Impact Assessment report and accord its approval subject to such conditions as it may deem fit to impose, or require that the Environmental Impact Assessment be re-submitted after such modifications as may be stipulated or rejected, the project as being contrary to environmental objectives.
- Section 14 (Handling of Hazardous Substances) requires that "Subject to the provisions of this Act, no person shall generate, collect, consign, transport, treat, dispose-off, store, handle, or import any hazardous substance except (a) under a license issued by the Federal Agency and in such manner as may be prescribed; or (b) in accordance with the provisions of any other law for the time being in force, or of any international treaty, convention, protocol, code, standard, agreement, or other Instrument to which Pakistan is a party." Enforcement of this clause requires the EPA to issue regulations regarding licensing procedures and to define 'hazardous substance.

- Section 15 (Regulation of Motor Vehicles): Subject to provision of this clause of the Act and the rules and regulations made thereunder, no person shall operate a motor vehicle from which air pollutants or noise are being emitted in an amount, concentration or level which is in excess of the NEQS, or where the applicable standards established under clause (g) of subsection (1) of Section-6 of the Act.
- Section 17 (Penalties): Whoever contravenes or fails to comply with the provisions of section 11, 12, 13, or section 16 or any order issued there under shall be punishable with fine which may extend to one million rupees, and in the case of a continuing contravention or failure, with an additional fine which may extend to one hundred thousand rupees for every day during which such contravention or failure continues: Provided that if contravention of the provisions of section 11 also constitutes contravention of the provisions of section 15, such contravention shall be punishable under sub-section (2) only.
- Section 18 (Offences by Bodies Corporate): Where any contravention of this Act has been committed by a body corporate, and it is proved that such offence has been committed with the consent or connivance or, is attributed to any negligence on the part of, any director, partner, manager, secretary or other officer of the body corporate, such director, partner, manager, secretary or other officer of the body corporate, shall be deemed guilty of such contravention along with the body corporate and shall be punished accordingly.

3.3.2. EPA, IEE and EIA Regulations 2000

The EPA prepared the regulations during 2000 for "Review of IEE and EIA" under the powers conferred upon it by the PEPA. These regulations categorize development projects for IEE and EIA into three schedules: Schedules I and II and III. Projects are classified on the basis of expected degree and magnitude of environmental impacts and are included in different schedules. The projects listed in Schedule-I include those where the range of environmental issues is comparatively narrow and the issues can be understood and managed through less extensive analysis. Schedule-I projects require an IEE to be conducted, rather than a full-fledged EIA, provided that the project is not located in an environmentally sensitive area.

The projects listed in Schedule-II are generally major projects and have the potential to affect a large number of people in addition to significant adverse environmental impacts. The impacts of projects included in Schedule-II may be irreversible and could lead to significant changes in land use and the social, physical and biological environment. Dams and reservoirs with a maximum storage volume greater than 50 Mm^3 or a surface area greater than 8 km^2 fall under Schedule-II of the IEE-EIA Regulations, 2000.

3.3.3. National Environmental Quality Standards 2000

The National Environmental Quality Standards (NEQS) were first promulgated in 1993 and have been amended in 1995 and 2000. The following standards are specified therein:

- Maximum allowable concentration of pollutants (32 parameters) in municipal and liquid industrial effluents discharged to inland waters, sewage treatment facilities, and the sea (three separate sets of numbers)
- Maximum allowable concentration of pollutants (16 parameters) in gaseous emissions from industrial sources
- Maximum allowable concentration of pollutants (2 parameters) in gaseous emissions from vehicle exhaust and noise emission from vehicles.

The standards apply to liquid effluents from the construction sites, dam area, powerhouse site and residential areas and to wastewater discharges from workers and other construction camps, and to project vehicles, especially heavy construction vehicles.

The prevailing NEQS for liquid effluents discharged to inland surface waters and gaseous emission from industrial sources will be applicable to the gaseous emissions and liquid effluents discharged to the environment from the project.

3.3.4. Land Acquisition Act 1894

This Act is the primary law for acquisition of land and built-up properties for public interest in Pakistan and also sets out the procedure and rules for acquisition and compensating the owners, as well as for compensating owners for damage caused to their properties, crops and trees by a project but it lacks the mechanism to address the complex issues of resettlement. It comprises 55 sections dealing with area notifications, surveys, acquisition, compensation, appointment awards, disputes resolution, penalties and exemptions. The latest revisions and amendments including Land Acquisition Rules were made in 1983. Presently, the Land Acquisition Act 1894 is applicable throughout Pakistan. The valuation of land for compensation is governed by sections 23 and 24 of the Act, which include the following provisions:

- Market value of the land at the time of notification of Section 6
- Damage sustained by the person interested by taking of any standing crops or trees
- Damage sustained by the person at the time of Collector's taking possession of land
- Damage sustained by the person at the time of acquisition of land injuriously affecting his other property, movable or immovable.

For the BS Link-I Hydropower Project compensation for acquisition of land for project operations and hearing of complaints will be carried out primarily in the light of this Act, supported by other measures (to be decided in the particular circumstances to suit the requirements). However, in case a need arises, this Act will be used for this purpose, supported by other measures as warranted. In the project area mostly land ownership belongs to the community, people living in villages have ownership rights on the local lands.

3.3.5. Project Implementation and Resettlement of Affected Persons Ordinance 2000

The Government has proclaimed an ordinance entitled "Project Implementation and Resettlement of the Affected Persons Ordinance 2001", later referred to as the "Resettlement Ordinance". This ordinance will be used to safeguard the interests of persons and groups involuntarily displaced from the existing places to new resettlement areas. This ordinance establishes that the resettlement of the involuntarily displaced persons is done as a matter of right and not by way of charity or any such sentiment, also the PAP will be accepted as special groups, who in the interest of the project have accepted and undergone involuntary displacement.

3.3.6. Antiquities Act 1975

The Antiquities Act of 1975 ensures the protection of the cultural resources of Pakistan. All the archaeological sites, artefacts, historical carvings, historical monuments, temples, shrines, old graveyards etc. come under the cultural property. The Act is designed to protect "antiquities" from destruction, theft, negligence, unlawful excavation, trade and export. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area which is of archaeological significance. Under this Act, it is understood that all project proponents are obliged to:

- Ensure that no activity is undertaken in the proximity of a protected areas without permission of the competent authority
- In case any antiquities have been found or reported in any project area it will be the responsibility of the proponent to report to the department of Archaeology, Government of Pakistan.

3.3.7. Pakistan Water and Power Development Authority Act 1958

The Act provides for the unified and coordinated development of the water and power resources of Pakistan. This Act authorizes WAPDA to develop water and power resources in the country through construction and operation of water storages and power houses, and erecting electrical transmission lines with powers and obligations of a licensee under the Telegraphy Act of 1910. This act also establishes policy for land acquisition and compensation, as well as the degree of liability of WAPDA for damages sustained by landowners or others.

3.3.8. The Telegraphy Act 1910

This act was promulgated for the installation of telegraph poles and lines. This Act makes provision of installing poles and towers without acquiring any land. However, provision is also made for temporary acquisition of land during the construction period. As such, compensation is made for the loss of crops for a specific period.

3.3.9. Labour Laws

Labour laws in Pakistan are governed by several legislative tools. However, the principal labour rights are provided by the constitution of Pakistan. The following articles enforce key labour rights:

- Article 11 of the constitution prohibits all forms of slavery, forced labour and child labour
- Article 17 provides for a fundamental right to exercise the freedom of association and the right to form union
- Article 18 prescribes the right of its citizen to enter upon any lawful profession or occupation and to conduct any lawful trade or business
- Article 25 lays down the right to equality before the law and prohibition of discrimination on the grounds of sex alone
- Article 37 (e) makes provisions for securing just and human conditions of work, ensuring that children and women are not employed in vacations unsuited to their age or sex, and for maternity benefits for women employment.

In addition to constitutional rights, Act and Ordinances have been enforced for limiting working hours, minimum working age, and conditions of employment.

3.3.10. Penal Code 1860

The Pakistan Penal Code deals with offences where public or private property and/or human lives are affected due to the intentional or accidental misconduct of an individual or body of people. In the context of the environment, the Penal Code empowers local authorities to control noise, toxic emissions and disposal of effluents (NEQS enforced by EPAs supersede the application of this legislation to industries and municipalities).

3.3.11. Local Government Ordinance 2001

This Act empowers the Government of Pakistan and provincial governments to enforce laws for land use; conservation of natural vegetation; air, water, and land pollution; disposal of solid waste and wastewater effluents; and public health and safety, including some provisions for environmental protection.

3.3.12. Regulations of Mines and Oil Fields and Mineral Development Act, 1948

This Act provides regulatory procedures for the quarrying and mining of construction material on public as well as private lands.

3.3.13. Motor Vehicle Ordinance 1965

The Motor Vehicles Ordinance of 1965 of Punjab was extended to the whole of Pakistan in 1978. The ordinance deals with the powers of the Motor Vehicle Licensing Authorities and empowers other related agencies to regulate traffic rules, vehicle speed and weight limits, and vehicle use, to erect traffic signs, and to prescribe special duties of drivers in case of accidents. It also prescribes powers of police officers to check and penalize traffic offenders. At the same time, the ordinance also empowers the regional transport authority to operate as a quasi-judicial body at district level to monitor road transport, licensing requirements, and compensations for deaths or injuries to passengers on public carriers.

3.3.14. Factories Act, 1934

The clauses relevant to the project are those which concern health, safety and welfare of workers, disposal of solid wastes and effluents, and damage to private and public property. The Factories Act also provides regulations for handling and disposal of toxic and hazardous materials. As construction activity is classified as 'industry', these regulations will be applicable to the project construction contractor.

3.3.15. Highways Safety Ordinance 2000

This ordinance includes provisions for licensing and registration of vehicles and construction equipment; maintenance of road vehicles; traffic control offences, penalties and procedures; and the establishment of a police force for motorways and national highways to regulate and control the traffic as well as keep the highways clear of encroachments.

3.3.16. Explosive Act, 1884

Under the Explosives Act, the project contractors are bound by regulations on licensing, handling, transportation, storage and using explosives during quarrying, blasting, and other purposes.

3.3.17. Wild Life Act 1975

The Wild Life Act is an Act to amend and consolidate the law relating to protection, preservation, conservation and management of wildlife in the country.

3.3.18. The Forest Act, 1927 and later Amendments

This Act establishes the right of the Government to designate areas for reserved forest, village forest and protected forest, and may acquire such areas for prohibiting or restricting the public use of the resources or other activities. There are a few orchards and other trees, but no forests in the primary or secondary impact zone of the BS Link-I Hydropower Project area.

3.3.19. Protection of Trees and Brushwood Act, 1949

This Act prohibits cutting or lopping of trees along roads and canals planted by the Forest Department, without permission of the Forest Department.

3.3.20. The Local Government Ordinance, 2001

Section 93 of this Ordinance pertains to environmental pollution, under which the local councils are authorized to restrict causing pollution to air, water or land. They may also initiate schemes for improving the environment. The Local Councils of the project area have been consulted for their views on the project interventions, and mitigation being proposed for the likely impacts.

3.3.21. Draft National Forest Policy 2001

A draft of the National Forest Policy was prepared in 2001 which is also applicable to the Punjab. It emphasizes the sustainable use of natural resources with community participation and recommends that timber harvesting be used for poverty alleviation. It also aims to rehabilitate the environment.

3.4. Environmental Assessment Procedures

The EPA has published a set of environmental procedures and guidelines for carrying out environmental assessments and the environmental management of different types of development projects. The guidelines that are relevant to the BS Link-I Hydropower Project are listed below, followed by comments on their relevance to the proposed project.

3.4.1. Policy and Procedures for Filing, Review and Approval of Environmental Assessments

These guidelines define the policy context and the administrative procedures that will govern the environmental assessment process, from the project pre-feasibility stage to the approval of the environmental report.

3.4.2. Guidelines for the Preparation and Review of Environmental Reports

These guidelines on preparation of environmental reports address project proponents, and specify:

- The nature of the information to be included in environmental reports
- The minimum qualifications of the IEE/EIA consultant
- The need to incorporate suitable mitigation measures into every stage of project implementation
- The need to specify monitoring procedures
- The terms of reference for the reports are to be prepared by the project proponents themselves. The reports must contain baseline data on the project area, a detailed assessment thereof, and mitigation measures.

3.4.3. Guidelines for Public Consultation

The guidelines deal with possible approaches to public consultation and techniques for designing an effective programme of consultation that reaches out to all major stakeholders and ensures the incorporation of their concerns in impact assessment.

3.4.4. Guidelines for Sensitive and Critical Areas

The guidelines identify officially notified protected areas in Pakistan, including critical ecosystems, archaeological sites, etc., and present checklists for environmental assessment procedures to be carried out inside or near such sites. Environmentally sensitive areas include, among others, archaeological sites, biosphere reserves and natural parks, and wildlife sanctuaries and preserves.

The guidelines state that the approach recommended in the document should extend to areas near such sensitive and critical sites, although the term 'vicinity' is not explicitly defined. Since there are no other sensitive areas within or near the project area, these guidelines will not apply.

3.4.5. Sectoral Guidelines: Major Sewerage Schemes

This guideline identifies and explains issues that should be addressed for a sewage collection, transportation, treatment, and disposal system. The guidelines primarily address the issues associated with domestic sewage but are applicable to the BS Link-I Hydropower Project. The guidelines should be consulted during planning and designing the disposal of sewage from the contractors' camps, offices and colonies at the project site.

3.4.6. Solid Waste Management Policy

This policy was promulgated by PEPA in collaboration with JICA in 2000, which aims to facilitate control on waste by providing the principles of good waste management and reducing waste at source. The guidelines should be consulted during planning and designing the disposal of solid waste from contractors' camps, offices and colonies.

3.4.7. Punjab Province

As the project site falls into the province of Punjab. At the Provincial level, Punjab holds all the required administrative powers regarding land acquisition, resettlement and rehabilitation of displaced people of any development project. For the BS Link-I Hydropower Project various government departments at Federal, Provincial and District level will interact and collaborate for implementation of the project. One of the prerequisites which will require immediate action relates to the handling of environmental issues. The construction of the BS Link-I Hydropower Project will require that all land and immovable assets located within project boundary will need to be acquired. The project area is mainly covered within the administrative jurisdiction of District Administration of District Kasur, in the Punjab Province.

The Land Acquisition Act of 1894 with its amendments will need to be applied for acquisition of the land. Other land based assets will be acquired according to the rules and regulations applicable for acquiring such assets.

The bureaucratic machinery of the Province is headed by a Chief Secretary who coordinates and supervises functions of various Departments headed by Departmental Secretaries. In the Punjab, the person in charge of the Planning & Development Department is the Additional Chief Secretary who reports to the Chief Secretary. All the Secretaries of different Departments are assisted by Additional Secretaries, Deputy Secretaries, Section Officers and other staff. The Departments may have attached Departments and autonomous or semi-autonomous bodies to look after various functions.

Since 2001, a system of elected District Governments has been introduced in the Punjab. The Province is divided into 36 districts. The Districts are headed by a Zilla Nazim (District Nazim) assisted by a District Coordination Officer (DCO), who is in charge of the District bureaucracy. In a District the functions are devolved further to the Tehsil, Town and Union

Council Governments as a part of the local Government system. Each District has an elected Zilla Council, elected Tehsil, Town and Union Councils who look after various activities at their respective levels. At District level a District Police Officer looks after the Law and Order and he reports to the Zilla Nazim. Each District has a Public Safety Commission which addresses public complaints against the Police. There is a Provincial Police Officer who is in charge of the police system at the provincial level.

3.5. Major Items of Pakistan Environmental Legislation

(Source: Pakistan Environmental Assessment *Procedures, Pakistan EPA, Islamabad)*

SECTOR	LEGISLATION
Environmental Protection	- The Pakistan Penal Code (1860) - Pakistan Environmental Protection Act, No. XXXIV of 1997
Land Use	- The Punjab Development of Damaged Areas Act (1952) - The Punjab Soil Reclamation Act (1852) - The West Pakistan Agricultural Pests Ordinance (1959) and Rules (1960) - The Islamabad (Prevention of Landscape) Ordinance (1966) - The Punjab Development Cities Act (1976) - The Balochistan, NWFP, Punjab and Sindh Local Government Ordinance(s) (1979/80) - The NWFP Salinity Control and Reclamation Act (1988)
Water Quality and Resources	- The Pakistan Penal Code (1860) - The Canal and Drainage Act (1873) - The Balochistan, NWFP, Punjab and Sindh Local Government Ordinance(s) (1979/80) - On Farm Water Management and Water Users' Associations Ordinance (1981) - Indus River Water Apportionment Accord (1991) - Statutory Notification S.R.R. 742 (1993)
Air Quality	- The Pakistan Penal Code (1860) - The Motor Vehicles Ordinance (1965) and Rules (1969) - The Balochistan, NWFP, Punjab and Sindh Local Government Ordinance(s) (1979/80) - Statutory Notification S.R.R. 742 (1993) - Statutory Notification S.R.R. 1023 (1995)
Noise	- The Motor Vehicles Ordinance (1965) and Rules (1969)
Toxic or Hazardous	- The Pakistan Penal Code (1860)

Substances	- The Explosives Act (1884) - The Agricultural Pesticides Ordinance (1971) and Rules (1973)
Solid Waste and Effluents	- The Balochistan, NWFP, Punjab and Sindh Local Government Ordinance(s) (1979/80) - Pakistan Environmental Protection Act, No. XXXIV of 1997
Marine and Fisheries	- The West Pakistan Fisheries Ordinance (1961) - The NWFP Fisheries Rules (1976)
Forest Conservation	- The Punjab Forest (sale of timber) Act (1913) - The Forests Act (1927). - The NWFP Hazara Forest Act (1936) - The West Pakistan Firewood and Charcoal (Restrictions) Act 1964 - The Punjab Plantation and Maintenance of Trees Act (1974) - The Cutting of Trees (Prohibition) Act (1975) - The NWFP Management of Protected Forests Rules (1975) - The Balochistan, NWFP, Punjab and Sindh Local Government Ordinance(s) (1979/80) - The NWFP (Conservation and Exploitation of Certain Forests in Hazara Division) Ordinance (1980) - The NWFP Forest Development Corporation Ordinance (1980) - The Protection of Trees and Brushwood Act of 1949
Parks and Wildlife Conservation Protection	- The West Pakistan Ordinance (1959) - The Punjab Wildlife (Protection, Preservation, Conservation and Management) Act (1974) and Rules (1974) - The NWFP Wildlife (Protection, Preservation, Conservation and Management) Act (1975) and Rules (1976) - Northern Areas Wildlife Preservation Act (1975) - The Pakistan Plant Quarantine Act (1976) - Islamabad Wildlife (Protection, Preservation, Conservation and Management) Ordinance (1979/80) - The Balochistan, NWFP, Punjab and Sindh Local Government Ordinance(s) (1979/80) - Export and Control Order (1982)
Mineral Development	- The Regulation of Mines and Oil-Fields and Mineral Development (Government Control) Act (1948)
Cultural Environment	- The Antiquities Act (1975) - The Punjab Special Premises (Prevention) Ordinance (1985)

Livestock	- West Pakistan Goats (Restriction) Ordinance (1959) - The Grazing of Cattle in Protected Forests (Range Lands) Rules (1978) - Pakistan Animal Quarantine (Import and Export of Animals and Animal Products) Ordinance (1979/80) - The Balochistan, NWFP, Punjab and Sindh Local Government Ordinance(s) (1979/80)
Resettlement	- Land Acquisition Act 1894 - Project Implementation and Resettlement Ordinance - The Telegraphy Act (1910) - The West Pakistan Water & Power Act (1958) - The Electricity Act IX (1910)
Public Health and Safety	- The Pakistan Penal Code (1860) - The Public Health (Emergency Provisions) Ordinance (1944) - The Balochistan, NWFP, Punjab and Sindh Local Government Ordinance(s) (1979/80) - The West Pakistan Epidemic Diseases Act (1979/80)

3.6. International Policies and Guidelines for Project Financing

Due consideration has been given to current and future compliance of the Project with applicable environmental and social guidelines and safeguard policies that reflect international good practice. International funding agencies, such as the World Bank and its private sector investment arm, the International Finance Corporation, have well developed guidelines for conducting Environmental Impact Assessments (EIA). International guidance and regulations considered relevant to this project include:

- World Bank OP 4.00 Environmental and Social Safeguard Policies.
- International Finance Corporation Policy and Performance Standards on Social and Environmental Sustainability, 2006
- Equator Principles, 2006
- International Finance Corporation: OP 3.37 Safety of Dams 1996
- International Standards Organization (ISO), ISO 14001
- Environmental Management Systems – Specification with guidance for use, 1996
- World Commission on Dams
- International Treaties.

3.6.1. Operational Policies of the World Bank

The World Bank's relevant Operational Policies (OP) and Bank Procedures (BP) which have been consulted are briefly discussed below:

- Operational Policy (OP) 4.01 (Environmental Assessment): Operational Policy (OP) 4.01 lays down the procedure and guidelines for conducting Environmental Assessment (EA) including the aspects to be considered in the EA, public consultation and information disclosure procedures. It also provides environmental screening guidelines for placing projects into various categories such as A, B, C & F
- Annex-A (Definitions): This Annex defines some terms that are frequently used in Environmental Assessment (EA) reports
- Annex-B (Content of an Environmental Assessment for a Category-A Project): This Annex provides the contents of an Environmental Assessment Report for a Category-A project. It is also stated that the order of items in a report may differ from the given format. The present report is prepared in accordance with Annex B
- Annex-C (Environmental Management Plan): This document describes the contents of an Environmental Management Plan, and also discusses its main components such as mitigation, monitoring, and institutional measures including capacity development and training, as well as the implementation schedule and costing of the suggested measures. The present report has attempted to fulfil recommendations of this Annex.
- Operational Policy (OP) 4.04 (Natural Habitats): This OP explains the Bank's precautionary approach to natural resource management to ensure opportunities for environmentally sustainable development, and supports the protection, maintenance, and rehabilitation of natural habitats and their functions. Since there are no habitats of wildlife in natural or semi-natural state within or near the project area, this OP will not apply
- Operational Policy (OP) 4.10 (Indigenous Peoples): This OP describes the Bank's policy of ensuring that any development project must fully respect the dignity, human rights, economies, and cultures of Indigenous Peoples. There are no distinct, vulnerable, social and cultural groups in the project area which could qualify as "indigenous" according to this Policy, so no Social Assessment, or preparation of an Indigenous Peoples Plan is required
- Operational Policy Plan (OPN) 11.03 (Management of Cultural Property in Bank Financed Projects): This OPN deals with the Bank's policy on cultural properties including site structures and remains of archaeological, historical, religious and aesthetic values. There are no cultural or archaeological resources in the vicinity of the Project, hence this OPN is not triggered
- Operational Policy (OP) 4.12 (Involuntary Resettlement): This document provides the Bank's guidelines relating to involuntary resettlement of population dislocated by the Project. The Bank recommends that involuntary resettlement should be avoided. Where resettlement is unavoidable, it should be handled as a sustainable development project. The affected persons should be engaged in meaningful consultation, properly compensated and resettled. The document also identifies the need for a Resettlement Plan, an abbreviated Resettlement Plan or otherwise.

A Resettlement Action Plan will be prepared as a separate document, describing various categories of people affected, their entitlement framework for compensation, to address cases of loss of income, and relocation of shelters.

3.6.2. The World Bank Guidelines for Project Financing

The principal World Bank publications which contain environmental guidelines and are relevant to the project are listed below:

- Pollution Prevention and Abatement Handbook: Towards Cleaner Production (World Bank, 1997)
- Environmental Assessment Sourcebook, Volume I: Policies, Procedures, and Cross-Sectoral Issues,(World Bank, 1991)
- Environmental Assessment Sourcebook, Volume II: Sectoral Guidelines. Technical Paper 140. (World Bank, 1991)
- Operational Directive (OD) 4.01: Environmental Assessment (World Bank, 1991).

The World Bank "Environmental Assessment Sourcebook" covers environmental issues relating to development in most sectors. It contains special sections on dams and reservoirs and on irrigation and drainage. Apart from providing information on the Bank's policies and procedures it gives general information on potential environmental impacts. Updates are issued from time to time. The Sourcebook is particularly useful if financial support is required from the World Bank. The World Bank Operational Directive (OD 4.01) on Environmental Assessment describes the Bank's policy and procedures in respect of EIA at regional, sectoral and project levels.

In addition to these documents there are several other World Bank operational policies and directives, such as those on environmental assessment, natural habitat, involuntary settlement and cultural property that provide guidelines for environmental assessment.

3.6.3. Asian Development Bank's Guidelines

The Asian Development Bank (ADB) could be a potential funding institution for the proposed project. The environmental assessment requirements of the ADB are clearly laid out in their Environmental Assessment Guidelines of 2003 and available on the ADB website. Under the ADB classification system any dam or reservoir is classified as a Category A, as is any project requiring relocation of people which is not applicable to BS Link-I HPP. Category A requires a full EIA to be carried out and the formats for reporting are clearly given in Appendix 2 of the 2003 ADB Guideline. The section headings for an EIA report are given and for a Summary EIA report maximum page lengths for each section are prescribed. The ADB also produce sector guidelines for environmental assessment and rapid environmental assessment checklists, including one for hydropower.

3.6.4. Equator Principles 2006

The Equator Principles are a voluntary set of guidelines for managing environmental and social issues in project finance lending, developed by leading financial institutions. The Equator Principles apply globally to development projects in all industry sectors with a capital cost of USD 10 M or more; most apply to projects in non-OECD or OECD countries not designated as high-income.

The Equator Principles, developed in close consultation with IFC, are a series of ten principles relating to the environmental and social assessment and management of development projects under consideration for finance. They require commercial banks to categorize the risk of a project in accordance with the environmental and social screening criteria of the IFC which determine the type of environmental assessment required. Both Category A and B projects require a Social and Environmental Assessment to determine the social and environmental impacts and risks of a proposed project in its area of influence. The Equator Principles established a list of issues to be addressed as part of the EIA and require consideration of IFC Safeguard Policies for projects located in low to middle income countries. Host country laws and regulations must be applied, in addition to the guidelines established in the World Bank Pollution Prevention and Abatement Handbook, and IFC environmental, health and safety guidelines.

As part of the environmental and social assessment process, a project is required to consult in a structured and culturally appropriate way with project affected groups, including indigenous peoples and local NGOs, or projects with significant adverse impacts on affected communities, the consultation process must ensure free, prior and informed consultation for the entire project process. The concerns of communities need to be adequately incorporated into the project. Appropriate procedures to receive and address concerns or grievances must be established.

Action Plans are required which draw on the conclusions of the assessment describe and prioritize measures for managing impacts and risks. An independent expert review is required for Category A projects and as appropriate for Category B projects. The Equator Principles incorporate covenants to comply with relevant legislation, comply with the Action Plans, provide regular reporting, and decommission facilities according to an agreed upon plan. Independent environmental or social advisors may be appointed for monitoring and reporting.

The Equator Principles require the Social and Environmental Action report to address:

- Assessment of the baseline environmental and social conditions
- Requirements under host country laws and regulations, applicable international treaties and agreements
- Sustainable development and use of renewable natural resources
- Protection of human health, cultural properties, and biodiversity, including endangered species nd sensitive ecosystems
- Use of dangerous substances
- Major hazards
- Occupational health and safety and other labour-related issues
- Fire prevention and life safety

- Socio-economic impacts
- Land acquisition and land use
- Involuntary resettlement
- Impacts on affected communities, indigenous peoples and communities
- Cumulative impacts of existing projects, the proposed project, and anticipated future projects
- Consultation and participation of affected parties in the design, review and implementation of the project
- Consideration of feasible environmentally and socially preferable alternatives
- Efficient production, delivery and use of energy
- Pollution prevention and waste minimization, pollution controls (liquid effluents and air emissions) and solid and chemical waste management.

The Equator Principles are based on the environmental and social standards of the IFC and reflect in Bank Safeguard Policies and Operative Procedures.

3.6.5. IFC Performance Standards

The International Finance Corporation (IFC) in its project review processes integrates environmental and social components, e.g. in assessment and action plan development. IFC broadens the definition of social impact assessment from identification and mitigation of adverse impacts to include a sustainable development component. Thus, impacts and opportunities that enhance the well-being of people living and working in the direct area of influence are encouraged. The IFC's 2003 Good Practice Note for Addressing the Social Dimensions of Private Sector Project provides guidance for identifying and assessing project-related social issues. The socio-economic chapter will reflect this guidance.

In April 2006, IFC published its Policy and Performance Standards on Social and Environmental Sustainability. There are eight performance standards addressing:

- Social and environmental assessment and management systems
- Labour and working conditions
- Pollution prevention and abatement
- Community health, safety and security
- Land acquisition and involuntary resettlement
- Biodiversity conservation and sustainable nature resource management
- Indigenous peoples
- Cultural heritage.

3.6.6. World Commission on Dams

The World Commission on Dams (WCD) was set up in 1998 by the World Bank and the World Conservation Union (IUCN).

The mandate of the commission is to conduct an independent review of the development effectiveness of large dams, to assess alternatives and to develop practical guidelines for decision-making.

The key recommendations of WCD include:

- Before a decision is taken to build a new dam, outstanding social and environmental issues from existing dams should be addressed, and the benefits from existing projects should be maximized
- All stakeholders should have the opportunity for informed participation in decision-making processes related to large dams through stakeholder forums. Public acceptance of all key decisions should be demonstrated. Decisions affecting indigenous peoples should be taken with their free, prior and informed consent
- The project should provide entitlements to affected people to improve their livelihoods and ensure that they receive the priority share of project benefits (beyond compensation for their losses). Affected people include communities living downstream of dams and those affected by dam-related infrastructure such as transmission lines and irrigation canals
- Affected people should be able to negotiate mutually agreed and legally enforceable agreements to ensure the implementation of mitigation, resettlement and development entitlements
- The project should be selected based on a basin-wide assessment of the river ecosystem and an attempt to avoid significant impacts on threatened and endangered species
- The project should provide for the release of environmental flows to help maintain downstream ecosystems.

3.7. International Treaties and Conventions

Pakistan is a signatory to a number of international environment related treaties, conventions, declarations and protocols, such as the Rio Declaration 1992, the Convention on Conservation of Migratory Species of Wild Animals, the Ramsar Convention 1971, etc., which have to be checked for their relevance to a project. In view of the low sensitivity of the project area with no habitats of wildlife, and the limited interventions of the project, no international convention or treaty is likely to be violated. The following are the relevant international treaties and conventions to which Pakistan is a party:

- Convention on Conservation of Migratory Species of Wild Animals 1979
- International Plant Protection Convention, 1951

- Convention on Wetlands of International importance especially as Waterfowl Habitat, Ramsar, 1971 and its amending protocol, Paris, 1982
- Convention concerning the Protection of World Culture and Natural Heritage (World Heritage Convention), 1972
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Washington, 1973
- Vienna Convention for the Protection of the Ozone Layer, Montreal, 1987
- Convention on Biological Diversity, Rio de Janeiro, 1992
- United Nations Framework Convention on Climate Change, Rio de Janeiro, 1992.

Table - 6: Major International Conventions and Treaties Signed By Pakistan

Sr. No.	Treaty / Convention	Brief Description
1	The Convention on Biological Diversity	Pakistan signed this convention in 1992. The objective of this convention is the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including those by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies and by appropriate funding.
2	The Convention on Conservation of Migratory Species of Wild Animals – 1979	The Convention on the Conservation of Migratory Species of Wild Animals (CMS), 1979, requires countries to take action to avoid endangering migratory species. The term "migratory species" refers to the species of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries. The parties are also required to promote or co-operate with other countries in matters of research on migratory species.
3	The Convention on Wetlands of International Importance, Ramsar 1971	Pakistan is a signatory to the said Convention. The principal obligations of contracting parties to the Convention are: • To designate wetlands for the List of Wetlands of International Importance. • To formulate and implement planning so as to promote wise use of wetlands, to carry out EIA before transformations of wetlands, and to make national wetland inventories. • To establish nature reserves on wetlands and provide adequately for their wardening and through management to increase waterfowl populations on appropriate wetlands. • To train personnel competent in wetland research, management and wardening. • To promote conservation of wetlands by combining far-sighted national policies with coordinated international action, to consult with other contracting parties about implementing obligations arising from the Convention, especially about shared wetlands and water system.

		• To promote wetland conservation concerns with development aid agencies. • To encourage research and exchange of data. So far 9 sites in Pakistan have been declared as wetlands of International Importance or Ramsar Sites (WWF – Pak 2000). None of these wetlands is located within or in close vicinity of the project area.
4	Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) – 1973	This convention came into effect in March 1973 at Washington. In all 130 countries are signatory to this convention with Pakistan signing the convention in 1976. The convention requires the signatories to impose strict regulation (including penalization, confiscation of the specimen etc.) regarding trade of all species threatened with extinction or that may become so, in order not to endanger further their survival.
5	IUCN Red List 2000	The red list is published by IUCN and includes those species that are under potential threat of extinction. These species have been categorized as: • Endangered: species that are seen to be facing a very high risk of extinction in the wild in the near future, reduction of 50% or more either in the last 10 years or over the last three generations, survive only in small numbers, or have very small populations. • Vulnerable in Decline: species that are seen to be facing a risk of extinction in the wild, having apparent reductions of 20% or more in the last 10 years or three generations. • Vulnerable: species that are seen to be facing a high risk of extinction in the wild, but not necessarily experiencing recent reductions in population size. • Lower Risk: species that are seen to be facing a risk of extinction that is lesser in extent that for any of the above categories. • Data Deficient: species that may be at risk of extinction in the wild but at the present time there is insufficient information available to make a firm decision about its status.

4. DESCRIPTION OF ENVIRONMENTAL BASELINE

This section of the document briefly describes the baseline conditions of the project which include physical, socio-economical and the ecological information of the project area. The data is collected from the different sources like coordination with Govt. departments, interaction with local community and on-site data gathering. All the information provided and site conditions described in document contain data at and around RD 106+250 of BS Link-I canal.

4.1. Physical Environment

Physical environmental conditions of the project area include topography of land, soil conditions, climate of the area, air & water quality, noise and pollution at the area, basic hydrology, geology and seismicity of the area, water resources conditions, transmission lines and other related aspects. The same are described in the sub-sections below.

4.1.1. Topography

The project area is predominantly flat terrain. There are earthen heaps of soil that are basically spoil banks on both banks of the project site which were formed during the construction of the canal. The whole length of the canal is in cutting profile. The entire land of the project area is arable with mild to steep slope towards the south east and cultivation on both left and right bank is practiced extensively.

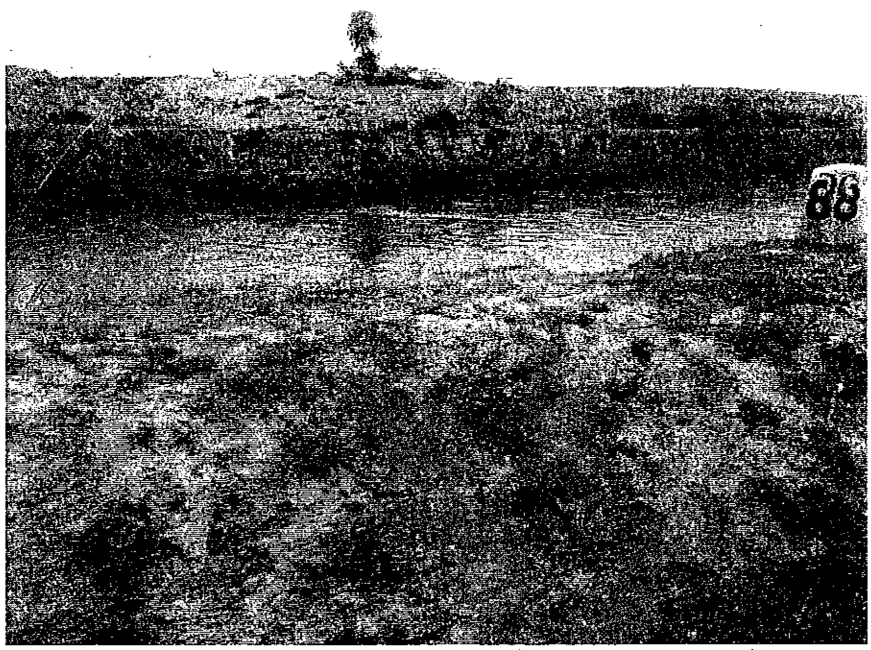


Figure 5 :Spoil Banks along the Canal

Figure 6: General Terrain & Topography

4.1.2. General Soil Condition

The soil conditions of the project area vary from course to fine grained soil, medium to dense sand and small traces of silt and clays. This soil has a tendency to act as a permeable medium to some extent and the water table in this region is at a shallow depth and can be beneficial for the crops in this region. Hard soils heaps are present alongside the canal for which local people have coined the term "Paharon Wali Naher", i.e. Canal with hills.

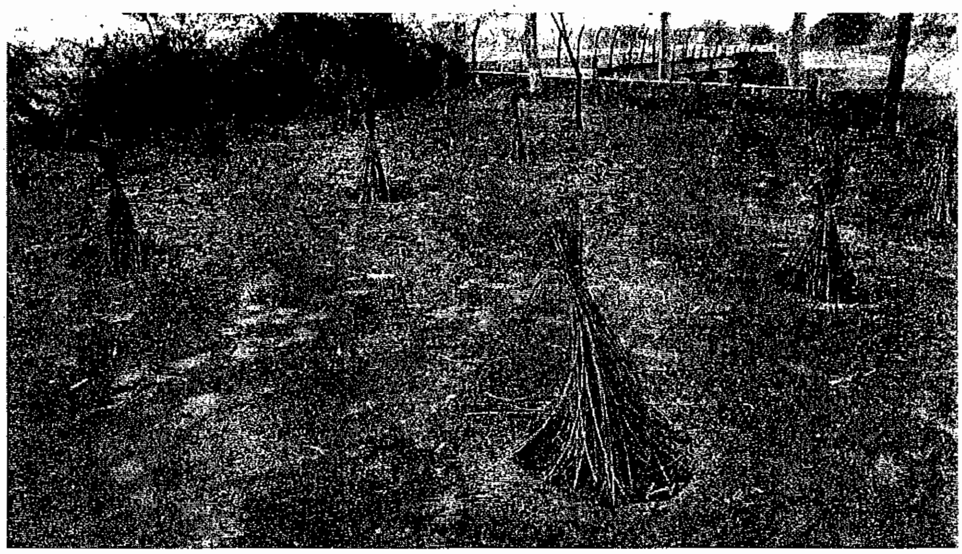


Figure 7: At RD 106+250

4.1.3. Climate of the Area

The study area is featured with a variety of weather changes throughout the year. The summer is hot, humid and sunny with the exception of Monsoon rains, whereas winters are short and usually dry. The transition in between witnesses the spring and autumn as well.

It is extreme hot during the months of May, June and July and the monsoon prevails from late June to August when there is heavy rainfall throughout the Province of the Punjab.

Rainfall in this study area is low to moderate with the growing season that extends from 180-300 days per year in which a wide variety of crops are grown by the farmers locally.

Lahore weather station is the nearest weather station to the project site which is controlled and maintained by Pakistan Meteorological Department (PMD).

From the Lahore weather station which is located at 31°35′ N and 74°24′ E fairly representative and authentic climate parameters of the project site which can be helpful to determine the exact climatic conditions at the study area. These parameters are shown in the table below.

Table - 7: Climatic Parameters of Lahore Weather Station (1971-2010/2014)

Month	Average Daily Temp. (oC)			Relative Humidity (%)			Wind (knots)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
January	7.4	19.2	13.3	51.5	86.0	68.75	0.5	1.5	1.
February	10.4	22.3	16.35	44.8	79.9	62.35	1	2.8	1.9
March	15.3	27.3	21.3	40.2	74.4	57.3	1.3	3.5	2.4
April	20.6	34.2	27.4	27.2	60.1	43.65	1.6	3.6	2.6
May	25	38.8	31.9	24.5	52.7	38.6	1.7	3	2.35
June	27.4	39.4	33.4	33.2	61.2	47.2	1.8	3	2.4
July	27.1	35.8	31.45	57	80.5	68.75	1.6	2.8	2.2
August	26.9	34.9	30.9	62.3	84.6	73.45	0.9	2.3	1.6
September	25.1	34.8	29.95	52.5	81.4	66.95	0.7	2.1	1.4
October	19.4	32.4	25.9	42.6	79.1	60.85	0.4	1.2	0.8
November	13.3	27.5	20.4	47.8	82.5	65.15	0.4	0.6	0.5
December	8.6	21.9	15.25	52.7	85.3	69	0.4	0.7	0.55

Source: Pakistan Meteorological Department (PMD)

Month	Atmospheric Pressure (hPa/gPm)						Precipitation (mm)
	Station Level			Sea Level			
	Min	Max	Mean	Min	Max	Mean	Mean
January	990.9	992.6	991.75	1016	1018.5	1017.25	23.2
February	988.4	990.2	989.3	1013.1	1015.7	1014.4	35.3
March	985.3	987.3	986.3	1009.5	1012.1	1010.8	36
April	980.9	983.3	982.1	1004.5	1007.7	1006.1	21.6
May	976	978.8	977.4	999.1	1002.6	1000.85	22.4
June	971.8	975	973.4	994.9	998.6	996.75	55.1

July	972	974.6	973.3	995.3	998.3	996.8	190.9
August	974.4	977.5	975.95	997.8	1000.5	999.15	179.4
September	978.8	981.4	980.1	1002.3	1005.4	1003.85	60.4
October	984.8	987.1	985.95	1008.7	1011.6	1010.15	15.3
November	988.8	990.9	989.85	1013.2	1016.2	1014.7	6.8
December	991	992.9	991.95	1016	1018.8	1017.4	9.8

Source: Pakistan Meteorological Department (PMD)

Year	Mean Annual Temperature		
	Annual Min Temp	Annual Max Temp	Mean Annual Temp.
2010	20.1	30.8	25.5
2011	19.5	29.9	24.7
2012	18.4	30.3	24.4
2013	17.9	30.0	24.0
2014	17.9	29.8	23.8

Source: Pakistan Meteorological Department (PMD)

4.1.4. Summary of Climate

This table shows clearly that the mean average daily temperature in the month of January has the min value i.e. 13.3°C which means the coldest climate in that region is in the month of January whereas the mean average daily temperature in the month of June is the highest which is 33.4°C which shows that June is the hottest month there. Besides the maximum rainfall is in the month of August which is recorded as 212.1mm and relative humidity is min in the month of May i.e. 38.5% that rises to a maximum value of 73.7% in August.

Moreover, the climatic data obtained using "Meteonorm" is also presented below for reference.

BS Link 1,
Location name

30.94	73.924
Latitude [°N]	Longitude [°E]
186	IV, 3
Altitude [m a.s.l.]	Climate region

Standard	Standard	Perez
Radiation model	Temperature model	Tilt radiation model
2000–2009	1991–2010	
Temperature period	Radiation period	

Additional information

Uncertainty of yearly values: Gh = 7%, Bn = 14%, Ta = 1.1 °C
Trend of Gh / decade: -12.0%
Variability of Gh / year: 4.6%
Radiation interpolation locations: Lahore (1981-1990, 78 km), Lahore (78 km), Multan (252 km), Multan (252 km), Islamabad (307 km), New Delhi (410 km) (Share of satellite data: 41%)
Temperature interpolation locations: LAHORE (CIV/MIL) (78 km), Amritsar (118 km), PATIALA (252 km), HISSAR (283 km)

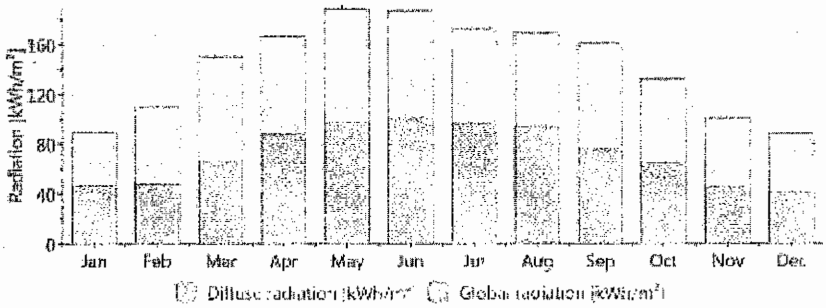
Month	G_Gh	G_Dh	Ta	FF
	[W/m2]	[W/m2]	[°C]	[m/s]
January	120	63	11.2	1.4
February	163	71	15.6	1.9
March	202	89	21.1	2.0
April	231	123	26.9	2.3
May	254	131	32.1	2.7
June	260	141	32.4	2.6
July	232	130	30.7	2.3
August	227	127	30.2	1.9
September	223	105	29.4	1.7
October	177	87	24.7	1.3
November	140	63	18.3	1.2
December	116	55	13.1	1.2
Year	196	99	23.7	1.9

Ta: Air temperature
FF: Wind speed
G_Gh: Mean irradiance of global radiation horizontal
G_Dh: Mean irradiance of diffuse radiation horizontal

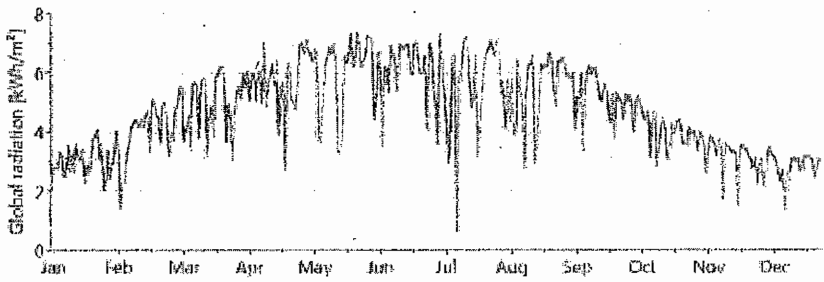
meteonorm

meteonorm V7.1.6.26237 1/3

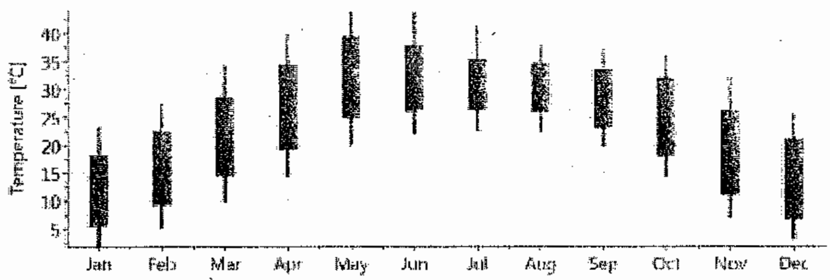
Monthly radiation



Daily global radiation



Monthly temperature



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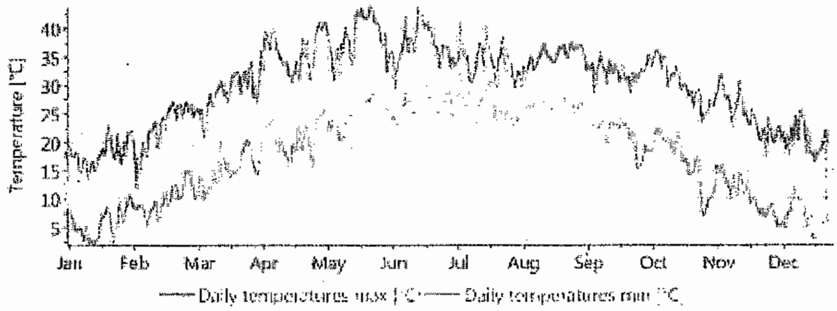
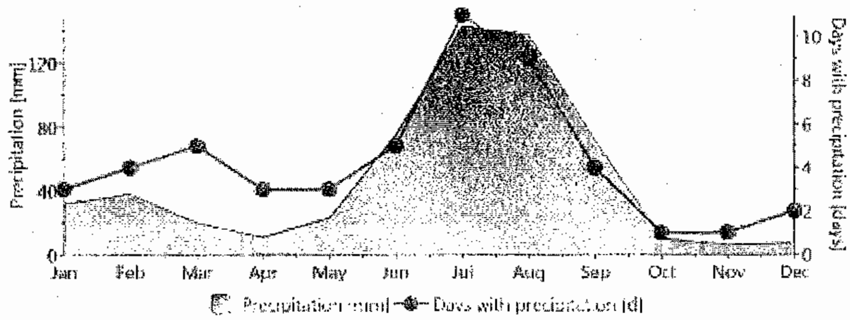
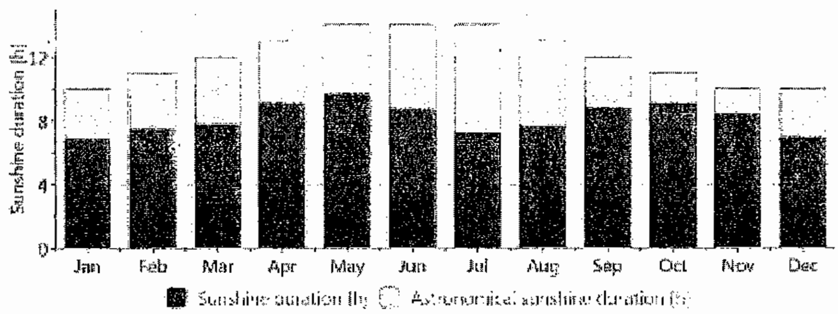
Daily temperature



Precipitation



Sunshine duration



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4.1.5. Geology & Seismicity of area

The low to the moderate seismicity level is recorded at the Punjab Province plains which is the upper part of the Indus Basin and in which the faulting in the basement rocks is covered with the thick alluvial deposits of soil. The basement high, depicted by outcrops of basement rocks near Sargodha, Chiniot, and Shahkot and extending from Sargodha to Faisalabad and further south-east towards the Indian Border shows a concentration of earthquakes with magnitude up to 5.5 on the Richter scale. The moderate earthquake at the project site can produce high ground shaking with the peak ground acceleration of 0.16g to 0.24g and the site area is considered to be in the 2A zone where the moderate earthquakes hit the ground mostly.

4.1.6. Water Resources

4.1.6.1. Hydrology

a) Environmental Monitoring, Sampling & Testing

To analyze the quality of water at the project area different water samples have been collected from different locations.

Sample #1: Ground water sample from the hand pump at RD 104+050

Sample #2: Ground water sample from the hand pump at RD 33+400 (near BS Link-II)

Sample #3 Surface water sample collected from canal at RD 105+000

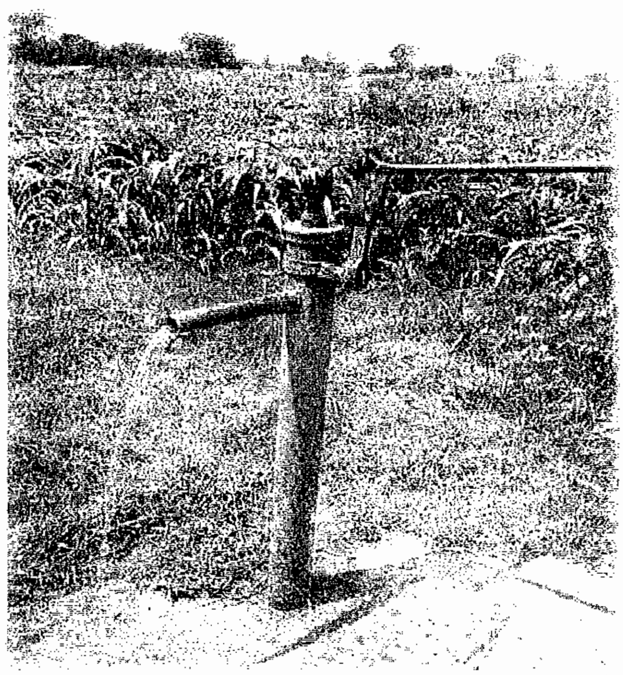

Figure 8: Hand pump near the site area

b) Ground Water

The main source of water at the project area is ground water which is pumped out by using the hand pumps installed at various locations while the other main source of water in that area is by using tube wells which is use for the drinking as well as the agricultural purposes. The laboratory test results of ground water are shown in table below.

Table - 8: Results of Chemical Analysis of Ground Water

SOLUTION ENVIRONMENTAL & ANALYTICAL LABORATORY

GROUND WATER ANALYSIS REPORT

Client Name: Associated Technologies (Pvt.) Ltd **Sample Location:** 142-D, Model Town, Lahore
Sampling Point: Tap Water (Hand Pump) RD-104+50 **Nature of Sample:** Ground Water
Sampling Date: 24-05-2016 **Completion Date:** 28-05-2016
Sampling By: Client **Reference No.:** SEAL/ATPL/16/01 GW
Results:

Sr. No.	Parameter	Unit	Result	WHO maximum allowable guideline value
1	Temperature	°C	24.0	----
2	pH	--	7.48	6.5-8.5
3	Total Dissolved Solids (TDS)	mg/l	424	1000
4	Total Suspended Solids (TSS)	mg/l	BDL	----
5	Chloride	mg/l	102	250
6	Fluoride	mg/l	0.2	1.5
7	Taste	Object./unobj.	Unobject.	Unobject
8	Odour	Object./unobj.	Unobject.	Unobject
9	Colour	TCU	0	15
10	Iron	mg/l	0.02	0.3
11	Sodium	mg/l	62	200
12	Nitrate (as NO_3^-)	mg/l	6.2	50
13	Nitrite (as NO_2^-)	mg/l	BDL	3
14	Ammonia	mg/l	0	1.5
15	Hydrogen Sulphide (H_2S)	mg/l	BDL	0.05
16	Sulphate	mg/l	80	250
17	Lead	mg/l	BDL	0.10
18	Total Hardness as $CaCO_3$	mg/l	128	500
19	Turbidity	NTU	0	5
20	Zinc	mg/l	0.24	3
21	Manganese	mg/l	BDL	0.1
22	Benzene	mg/l	BDL	10-120

BDL (Below Detection Limits)

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SOLUTION ENVIRONMENTAL & ANALYTICAL LABORATORY

Client Name:	Associated Technologies (Pvt.) Ltd	**Sample Location:**	142-D, Model Town, Lahore
Sampling Point:	Tap Water (Hand Pump) RD-104+50	**Nature of Sample:**	Ground Water
Sampling Date:	24-05-2016	**Completion Date:**	28-05-2016
Sampling By:	Client	**Reference No.:**	SEAL/ATPL/16/01 GW

Sr. No.	Parameter	Unit	Result	WHO maximum allowable guideline value
23	Aluminum	mg/l	BDL	0.2
24	Molybdenum	mg/l	BDL	0.070
25	Chromium	mg/l	0.01	0.050
26	Cadmium	mg/l	BDL	0.003
27	Boron	mg/l	BDL	0.300
28	Barium	mg/l	BDL	0.700
29	Antimony	mg/l	BDL	0.005
30	Arsenic	mg/l	BDL	0.010
31	Cyanide	mg/l	BDL	0.070
32	Mercury	mg/l	BDL	0.001
33	Nickel	mg/l	BDL	0.020
34	Total Coliform	Number/100ml	0	0/100 ml
35	E.Coli	Number/100ml	0	0/100 ml

BDL (Below Detection Limits)

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- The report is not valid for any negotiation

Sample Analyzed By Awais Shafique

Signature: Awais

Name of Chief Chemist with Seal SHABNAM SHAHZAD Chief Chemist

Signature of Chief Chemist For Noreen

Date: 28-05-2016

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SOLUTION ENVIRONMENTAL & ANALYTICAL LABORATORY

GROUND WATER ANALYSIS REPORT

Client Name:	Associated Technologies (Pvt.) Ltd	**Sample Location:**	142-D, Model Town, Lahore
Sampling Point:	Tap Water (Hand Pump) RD-531+400	**Nature of Sample:**	Ground Water
Sampling Date:	24-05-2016	**Completion Date:**	28-05-2016
Sampling By:	Client	**Reference No.:**	SEAL/ATPL/16/02 GW

Results:

Sr. No.	Parameter	Unit	Result	WHO maximum allowable guideline value
1	Temperature	°C	23.0	----
2	pH	--	7.32	6.5-8.5
3	Total Dissolved Solids (TDS)	mg/l	368	1000
4	Total Suspended Solids (TSS)	mg/l	BDL	---
5	Chloride	mg/l	76	250
6	Fluoride	mg/l	0.18	1.5
7	Taste	Object./unobj.	Unobject.	Unobject.
8	Odour	Object./unobj.	Unobject.	Unobject.
9	Colour	TCU	0	15
10	Iron	mg/l	0.02	0.3
11	Sodium	mg/l	52	200
12	Nitrate (as NO_3)	mg/l	6.5	50
13	Nitrite (as NO_2)	mg/l	BDL	3
14	Ammonia	mg/l	0	1.5
15	Hydrogen Sulphide (H_2S)	mg/l	BDL	0.05
16	Sulphate	mg/l	58	250
17	Lead	mg/l	BDL	0.10
18	Total Hardness as $CaCO_3$	mg/l	124	500
19	Turbidity	NTU	0	5
20	Zinc	mg/l	0.12	3
21	Manganese	mg/l	BDL	0.1
22	Benzene	mg/l	BDL	10-120

BDL (Below Detection Limits)

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SOLUTION ENVIRONMENTAL & ANALYTICAL LABORATORY

Client Name:	Associated Technologies (Pvt.) Ltd	**Sample Location:**	142-D, Model Town, Lahore
Sampling Point:	Tap Water (Hand Pump) RD-331+400	**Nature of Sample:**	Ground Water
Sampling Date:	24-05-2016	**Completion Date:**	28-05-2016
Sampling By:	Client	**Reference No.:**	SEAL/ATPL/16/02 GW

Sr. No.	Parameter	Unit	Result	WHO maximum allowable guideline value
23	Aluminum	mg/l	BDL	0.2
24	Molybdenum	mg/l	BDL	0.070
25	Chromium	mg/l	0.01	0.050
26	Cadmium	mg/l	BDL	0.003
27	Boron	mg/l	BDL	0.300
28	Barium	mg/l	BDL	0.700
29	Antimony	mg/l	BDL	0.005
30	Arsenic	mg/l	BDL	0.010
31	Cyanide	mg/l	BDL	0.070
32	Mercury	mg/l	BDL	0.001
33	Nickel	mg/l	BDL	0.020
34	Total Coliform	Number/100ml	0	0/100 ml
35	E.Coli	Number/100ml	0	0/100 ml

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Sample Analyzed By: Awais Shafique

Signature: Awais

Name of Chief Chemist with Seal: SHABNAM SHAHZAD

Signature of Chief Chemist: For Chief Chemist

Date: 28-05-2016

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c) Surface Water

The BS LINK I canal is the major source of surface water at the project area. The laboratory test results of surface water are shown in table below.

Table - 9: Results of Chemical Analysis of Surface Water

SOLUTION ENVIRONMENTAL & ANALYTICAL LABORATORY

SURFACE WATER ANALYSIS REPORT

Client Name:	Associated Technologies (Pvt.) Ltd	**Sample Location:**	142-D, Model Town, Lahore
Sampling Point:	Balloki-Sulemanki Canal RD-105+000	**Nature of Sample:**	Surface Water
Sampling Date:	24-05-2016	**Completion Date:**	28-05-2016
Sampling By:	Client	**Reference No.:**	SEAL/ATPL/16/001 SW

Results:

Sr. No.	Parameters	Unit	NEQS	Result
1	Temperature	°C	40	[illegible]
2	pH	---	6-9	6.76
3	Chemical Oxygen Demand (COD)	mg/l	150	26
4	Biochemical Oxygen Demand (BOD_5)	mg/l	80	14
5	Total Dissolved Solids (TDS)	mg/l	3500	398
6	Total Suspended Solids (TSS)	mg/l	200	32
7	Oil & Grease	mg/l	[illegible]	BDL
8	Chromium (Hexa & Trivalent)	mg/l	[illegible]	0.28
9	Sulphate (SO_4^{2-})	mg/l	600	89
10	Iron (Fe^{2+})	mg/l	8	[illegible]
11	Chlorine (Cl_2) Free	mg/l	1.0	BDL
12	Fluoride (F^-)	mg/l	20	[illegible]
13	Chloride	mg/l	1000	142
14	Ammonia (NH_3)	mg/l	40	[illegible]
15	Cadmium	mg/l	0.1	BDL
16	Lead	mg/l	0.5	0.06
17	Arsenic	mg/l	1.0	0.03
18	Copper	mg/l	1.0	0.35
19	Barium	mg/l	1.5	BDL
20	Selenium	mg/l	0.5	BDL
21	Silver	mg/l	1.0	BDL
22	Pesticides	mg/l	0.15	BDL
23	Manganese	mg/l	1.5	BDL

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SOLUTION ENVIRONMENTAL & ANALYTICAL LABORATORY

Client Name:	Associated Technologies (Pvt.) Ltd	**Sample Location:**	142-D, Model Town, Lahore
Sampling Point:	Balloki-Sulemanki Canal RD-105+000	**Nature of Sample:**	Surface Water
Sampling Date:	24-05-2016	**Completion Date:**	28-05-2016
Sampling By:	Client	**Reference No.:**	SEAL/ATPL/16/001 SW

Sr. No.	Parameters	Unit	NEQS	Result
24	Zinc	mg/l	5.0	1.2
25	Nickel	mg/l	1.0	BDL
26	Boron	mg/l	6.0	BDL
27	Mercury	mg/l	0.01	BDL
28	Total Toxic Metals	mg/l	2.0	0.37
29	**Sulphide (S^{-2})**	mg/l	1.0	BDL
30	An Ionic Detergent as MBAS	mg/l	20	BDL
31	Phenolic Compounds	mg/l	0.1	BDL
32	Cyanide	mg/l	2.0	BDL

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- The report is not valid for court

Sample Analyzed By: Awais Shafique

Signature of analyst: for [signature]

SHABNAM SHAHZAD

Chief Chemist with Seal: Chief Chemist

Signature of Chief Chemist: for [signature]

Date: 28-05-2016

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The test results of surface water show that chemical contents are within the safe limits. Temperature is higher than the normal limits profile suggests that this source of water is fit for irrigation use but may not be used as drinking water source downstream of the canal.

d) Wastewater

Wastewater enters the BS Link-I at different locations from domestic and industrial sewage sources and pollutes the canal water and increases its turbidity and its looks greyish black and becomes foamy when it strikes with the stones present in the canal or when there is a fall in canal. This same polluted water is transferred to the downstream of the canal and used by the local communities present there that may can cause serious health issues to the people. Results of chemical analysis of this wastewater are shown in table below.

Figure 9: Foamy Canal water in Low Flow

Table - 10: Results of Chemical Analysis of Wastewater

Sr. No.	Parameter	Units	NEQS Limiting Value	Lab Test Results	
				WW1	Status
1	pH	---	9-Jun	8.7	Normal
2	Temperature, °C	°C	=<3°C	17	Higher
3	Biochemical Oxygen Demand (BOD5) 20°C	mg/l	80	92	Higher
4	Chemical Oxygen Demand (COD)	mg/l	150	146	Normal
5	Total Suspended Solids (TSS)	mg/l	200	106	Normal
6	Total Dissolves Solids (TDS)	mg/l	3500	374	Normal
7	Grease & Oil	mg/l	10	2.2	Normal
8	Phenolic Compound as Phenols	mg/l	0.1	N.D.	Normal
9	Chloride as Cl-	mg/l	1000	433	Normal
10	Fluoride as F-	mg/l	10	1.3	Normal
11	Cyanide total as CN-	mg/l	0.1	N.D.	Normal
12	An-Ionic Detergents as MBAs	mg/l	20	5.2	Normal
13	Sulphide as SO42-	mg/l	600	101	Normal

14	Sulphide as S-	mg/l	1	0.06	Normal
15	Ammonia as NH3	mg/l	40	3.3	Normal
16	Pesticides	mg/l	0.15	N.D.	Normal
17	Cadmium	mg/l	0.1	N.D.	Normal
18	Chromium trivalent and hexavalent	mg/l	1	N.D.	Normal
19	Copper	mg/l	1	0.09	Normal
20	Lead	mg/l	0.5	N.D.	Normal
21	Mercury	mg/l	0.01	N.D.	Normal
22	Selenium	mg/l	0.5	N.D.	Normal
23	Nickel	mg/l	1	N.D.	Normal
24	Sliver	mg/l	1	N.D.	Normal
25	Total toxic metals	mg/l	2	1.1	Normal
26	Zinc	mg/l	5	0.03	Normal
27	Arsenic	mg/l	1	0.06	Normal
28	Barium	mg/l	1.5	N.D.	Normal
29	Iron	mg/l	8	2.11	Normal
30	Manganese	mg/l	1.5	N.D.	Normal
31	Boron	mg/l	6	N.D.	Normal
32	Chlorine	mg/l	1	N.D.	Normal

The wastewater results indicated that all the parameters except temperature and BOD is within the NEQS limits. Higher BOD is mainly due to the discharge of untreated Industrial and domestic wastewater which may adversely affect the aquatic life.

4.1.7. Air Quality of the Study area

The air quality of the study area is generally good and without considerable pollution. Difference in air pressure due to temperature variations cause windy conditions as prevailing in the region. A brick kiln is operational at in Kandu Khara village at about 3 Km from site. Similar brick kilns are present far away from the project area in Chunian Cantt and Pattoki. Also there is no industrial work being carried there because no industry is present near the project area except the Chunian Sugar Mill which is about 12-14 km from the project area and Abdullah Sugar Mills which is almost 15 km from the study area.

4.1.8. Noise Level

As the sources of noise pollution at the study area can be because of traffic, industries or some other sources but these sources are far from the project area as explained in the above section so the level of noise is relatively less as compared to the areas where brick kilns, heavy traffic and industries are present.

4.1.9. Solid Waste

Solid wastes include the waste from the humans, sewage waste, household wastes and garbage etc. There are no such arrangements for the special disposal of these wastes near the villages and areas of the project site. People mostly throw garbage or human and animal waste in the open area and somehow the part of this waste may be reused as manure to the agricultural field and animal waste can be used as fuel by the local people.

4.1.10. Wastewater Discharge

There is no such sewerage system is present near or at the project area. The community wastewater discharge is handled and reduced by using the soakage pits and by throwing to the open fields.

4.1.11. Physical Infrastructure

a) Powerhouse

Right Bank of the Canal: On the right bank of the canal some important and significant physical features are present which are as follows:

- Spoil Bank
- Farmer's crops
- Kandu khara village
- Hand pump at RD 104+040
- Brick kiln at RD 94+000'

Left Bank of the Canal: On the left bank of the canal some important and significant physical features are present which are as follows:

- Dera Abdul Qayum
- Hand pump near BS Link II at RD 33+400
- Spoil Bank
- BS Link-II Canal
- Quarters of Baildaar

b) Transmission Line

The area around HPP is presently served by 132 KV and 66 KV transmission line network. Consumers in the area are supplied from Chunian 132 KV grid station through 11kV feeders controlled by Chunian Operation Division of LESCO

Existing 132 KV grid station in LESCO area have been studied for interconnection with the planned HPP on BS-1 link canal at RD 106+250. For the selection of suitable grid station, distance and load of surrounding grid stations are shown below:

Table - 11: Data of Grid station near HPP Site

Name of Grid Station	Primary Voltage	Load On GS (MW)	Distance (Km)
Chunian	132KV	20	7
Pattoki	132KV	50	15
Jamber	132KV	100	30
Habibabad	132KV	30	30
Bhaipheru	132KV	50	40

Chunian is the nearest GS and most suitable for the interconnection with the planned HPP as all the power transmitted to this grid station will be absorbed by the local electric load. Moreover, power supply of Chunian will become reliable. Due to small distance of Chunian GS to the HEPP, capital cost Transmission line, power losses and route environment impact will be minimum.

4.2. Ecological Environment

Natural Flora and fauna are the major parts of the ecological system and plays their vital role. Besides that, the study area shows the features of the flowing canal, crops, alluvial soil deposits and climatic conditions represents the ecological environment of the study area. Following is the brief discussion of flora and fauna at the study area:

4.2.1. Natural Flora

The canal is surrounded by vegetation and crops and it is although best suited for the soil conditions there. The feed quality and the raising of the crops is rapid in raining season and reduces when there is less rainfall in the area. About 20-30% of the study area is less cultivated to almost barren because of the presence of the spoil banks and the area far from the study area is more and richly cultivated.

Figure 10: Vegetable Plantation

Figure 11: Sugarcane Field

The privately owned land is used to cultivate various crops like sugarcane, maize and wheat also vegetables of various kinds are grown long the banks of the canal.

a) Forest, Trees & other Vegetation

The study area is surrounded by sparse number of tress, abundant vegetation and crops but the forest is not actually there at or near the project area. Different types of trees have been spotted at the study area which includes tahli (Dalbergia sisso), sufaida (Euclyptus camalulensis), pipal (Ficus religiosa), jamun (Black plump), amrood (Guava) and beri (Ziziphus mauritiana).

Figure 12: Various Trees in Project Area

b) Herbs & Weeds

The dominant weeds & herbs that are most commonly found near the study are thamayan, ajwain, herbal, peelak, berm/dandi and dophali/booti. Despite of the presence of good number of herbaceous species, no commercial activity is seen in the study area because farmers are inclined towards cultivating grain crops for growing population.

c) Endangered Floral Species

No rare plant species is encountered in study area that is, endangered or declared protected under National, Provincial or Local Government definitions as well as International agreements/protocols ratified by Government of Pakistan. But Bohr, Kikar (Acacia nilotica) and Shisham (Dalbergia sisso) trees are in declining trend in the Study area due to viral attacks.

4.2.2. Natural Fauna

As we get the information about the natural fauna at the study area we get to about the different species comprising of mammals, insects, butterflies, fresh water fish and birds etc. Livestock and poultry are the major businesses that are mostly managed and run domestically by the people there. Some natural faunas that are commonly found at the study area are described below

d) Wildlife-Mammals

The common and the dominant wildlife mammals that are found mostly at the study area are Canius aurous (Asiatic jackal), Petaurista petaurista (Common squirrel), Mus Muscullus (Common house mouse), Rattus rattus (Common rat). Other than that dogs, cows, goats, buffalos, camels and common cats are also there in a large amount.

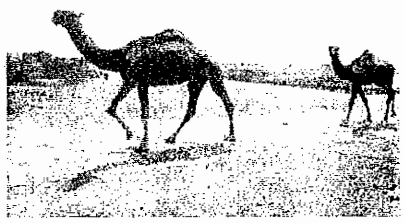


Figure 13: Squirrel & Domestic Camels

e) Insects, Butterflies and Vectors

Commonly found insects at the study area comprised of different species of caterpillars, beetles, bugs and other insects. Pets are also there that are present of some crops but their damage to the crops is not so major according to the famers there. Termite can do a lot of damage to the wheat crops when the climate is dry according to the statement by local people at the study area.

Among vectors, house flies, mosquitoes, bed bugs, lice and snails are commonly found which spread diseases like cholera, typhoid, and gastro-enteritis and malaria fever. Natural bee hives also exist in big trees and the bees collect nectar of wild flowers from surroundings but their production is limited because wild flowers are not abundant.

f) **Fresh Water Fish**

Many types of fish are found near the study area because of the presence of fish farms on left bank of the adjacent BS Link-II Canal and also some fish catch is available in the canal. Mainly in-farm grown types are Gulfaam (Cyprinus Carpio), Chigaari, Sole, Rahu (Labeo Rohita), Malee (Schizothorax plagicstomus), Thaila (Orechrombus Mossambeca), and Maraca. These are also transported to different areas of cities were people enjoy them in the months when they are preferable to eat. Fish is not commercially exploited here in the form of stock or pond fishery because of three main reasons, viz. commercial value of land is high, secondly running water carries carnivore fishes whose contact may destroy farm fish-stock, and thirdly Study Area is practically isolated and far-flung from the main markets of the towns.

Figure 14: Fish Ponds on the Right Bank of BS-II

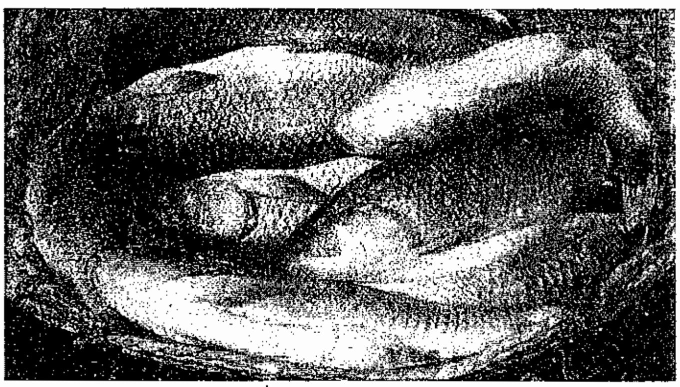


Figure 15: Rahu (Labeo Rohata) Fish of the Farm

g) **Endangered Faunal Species**

None of the faunal species has been recorded in the study area that is endangered, rare or protected under the legislation of Pakistan and applicable international environmental agreements as well as listed in the Red Book of Pakistan and International Union for the Conservation of Nature (IUCN) registers.

4.2.3. Socio-Economic Environment

In this section information is collected from the local community and respondents about their occupation, civic facilities available to them, educational and health facilities, NGO's working for the betterment of their lives, rescue facilities, union council of the area, their agricultural statuses and livestock business, impacts of the project on people, their awareness about the project and how it will be beneficial for them in near future.

Information which is described here covers the baseline of the statements about the project and the study area and the focus is made on the socio-economic situation of the entire project area.

4.2.3.1. Specific Socio-Economic Profile of the Project Area

At the Project area most of the land is occupied by the Irrigation and Power Department of Government of the Punjab, Pakistan but some land that may be involve in the making of the headrace channel and powerhouse is owned by private owner and there are a few settlements accordingly. An SRP is made between the private owner and the clients so that the project will not get delayed in any caser. Following is the given information collected from the study area as a whole. Major settlements near Project area are far enough so that there is absolutely no adverse impact of the project is foreseen.

Table - 12: Data of Settlements near HPP Site

Serial	Settlement/Village	Distance from Project Area	Approximate Population	Adverse Impact of Project
1	Kandu Khara	2 Km	3200	None
2	Bahairawal	3.9 Km	580	None
3	Bukanki	5.8 Km	500	None
4	Pind Ghaus	3.8 Km	1800	None

a) General Socio-Economic Profile

Following are the general socio-economic information which has been collected from the study area.

i. Marital Status

It was observed at the site area that almost 50-53% of the correspondents are in the relation of marriage and their age ranges between 15-65 years and they are the only ones who earn bread and butter for their families. As the total population in the nearby villages is around 6080 people so, according to this around 1611 are the married couples General trend was observed to marry once and raise a family.

ii. Languages

Different languages have been found to be spoken by the people there. These languages include Urdu, Punjabi and Saraiki but the dominant one is Punjabi that most people understand there.

iii. Occupation of the Residents

Mostly people there works on their on agricultural fields as farmers, others do work as a labor in the areas nearby. Some people so livestock farming and known as charhaway. The total employment description of the living residents in all the nearby villages in shown in table below.

Table - 13: Employment status of the people in villages nearby

Sr. #	Total Population	Government jobs	Private Jobs	Agriculture	Livestock / Farmers	Total
1	6080	21	15	651	1301	1988

iv. Casts & Religion

Various castes live together in harmony and according to the information collected, most of the people belong to Bhatti clan and the second most abundant caste is Machhi. However, there is significant presence of Wattoo, Burberry, Khokhar, Araein and Shah in the descending order of their population there.

Almost all the residents of the project area or nearby area are Muslim except one Sikh family which migrated to Chunian. Only one house comprising of 10-12 members near project area belong to Christianity.

Table - 14: Caste and families status in the villages

Castes	Families	%age
Bhatti	*35*	*27*
Machi	*28*	*22*
Watto	*20*	*15*
Burberry	*12*	*9*
Khokhar	*10*	*8*
Araein	*25*	*19*
Total	**130**	**100**

v. Educational Status/Literacy Rate

People of the area are willing to educate their children, however, there are not much facilities available beyond high school for boys and primary schools for girls. For further studies, some of boys have to go to Pattoki, Chunian, Kasur or even Lahore for higher studies.

Average literacy rate at the study area is about 18-20% because the educational institutions are far from the area as explained above so the children are limited to attend primary schools and they don't go for higher education because of the lack of institutions.

Table - 15: Schools in nearby Areas

Schools					
Government			Private		
Primary	Middle	High	Primary	Middle	High
Kandu-Khara (RD 106 right)					
1 (Girls)	-	-	1 (Girls)	-	-
1 (Boys)	-	-	1 (Boys)	-	-
Nizampura (RD 106 right)					
-	-	1 (Boys)		-	-
-	-	1 (Girls)	-	-	-
Bairwal (RD 106 + 2km)					
1 (Girls)	-	-	-	-	-
1 (Boys)	-	-	-	-	-

vi. Health & Medical Facilities and diseases

According to the survey of the site area no major diseases are found frequently in the residents of that area except the hepatitis and waterborne diseases that may the results of the sources mixed with drinking water in that area.

Table - 16: Health Facilities in nearby Areas

Health Facilities										
Hospitals	Clinics									
	Pind Ghos		Kanda Khara		Baitwaal		Bukankee		Tutanwala	
	Hakeem	Doctor	Hakeem	Doctor	Hakeem	Doctor	Hakeem	Doctor	Hakeem	Doctor
2-3 Govt/Private Hospitals are near the Chunian District	1	3	-	1	-	1	-	1	-	-
	-	-	-	-	-	-	-	-	-	-

Around out of 6080 populations of the villages nearby the project site area, 180 people, including men, women and children are facing serious hepatitis and waterborne disease problems and because of lack of hospital and clinic facilities they are deprived of any kind of treatment for these diseases and they have to travel to the big cities for the treatment. These areas are lacking the health and medical facilities & only 2-3 Government/Private hospitals are there near the Chunian district and some private clinics are also there in different villages comprising of Hakeem and Doctors.

vii. Civic Facilities

A brief discussion of the civic facility availabile at the project site area is given as below.

b) Public Facilities

Electricity is available at the study area but there is a lot of load shedding from which people are suffering. According to local respondents the interval of load shedding varies from 8 to 12 hours and they are facing a lot of trouble because of that. Besides no Banking facility is available at or near the project site area and the people have to move a lot to get this facility. There is no gas facility available and the people have to use woods and gas cylinders to overcome their kitchen needs and to heat up their houses in the winter.

Various NGO's are also working there near to the project site area in which Edhi Centre is located in Pattoki region and Shahjahan Trust and Sunnat-e-Mustafa Welfare Trust is working for the needs and the betterment of the people in Chunian district.

People have the facility of Police Chowki which is located at RD 115+000 near the project site area to maintain law & order because there are incidents of quarrel between the different castes over petty issues.

One Union Council office of the area is also there at RD 95+000 in Sadda and one Rescue office is working for the area residents and the nearby areas at about 4km from the Bairwaal Village.

Table - 17: Public Facilities in nearby Areas

Load Shedding	NGO's	Weeds/Herbs	Police Chowki	Union Council	Rescue Office
Timings of load shedding are mostly with 1.5 hours interval	Edhi Centre Pattoki	Thamayan	1 Police Chowki is there at RD 115 near the Site	1 Union Council is also there at RD 95 in Sadda	1 rescue office is there 4km from Bairwaal Pind
		Ajwain			
	Shahjahan Trust Chunian	Herbal			
		Peelak			
	Sunnat-e-Mustafa welfare Trust	Berm/Dandi			
		Dophali/Booti			

c) Private Facilities

Other than the Public facilities as there is no gas available so privately LPG gas cylinders are available in the area that are in use by rickshaw transport, in houses for making of food and for lightening. Courier service is available to site and telephonic communication is easily available too besides Chingchi rickshaws is commonly used there because other transports cannot make their way to the villages. Buffalo cart and donkey carts of the local people are also there.

d) Housing Condition

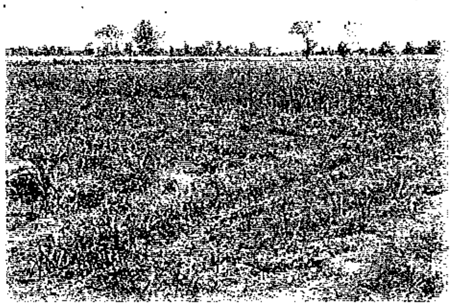
As it is a fact that the hosing condition is dependent on the living condition of the people and the population. From the survey of that area the housing condition is not so good people living in mud houses. There are almost 18-22% mud houses 25-30% semi brick houses and just 17-18% brick made houses. Roads are unpaved and the pathway is not so comfortable.

e) Agriculture – Crops, Vegetables, Fodder and Fruit Trees

According to the agricultural zone of the command area at the project site, crop yields never sustained on plain and flat terrain for more than 2.5 years without fertilizer and manuring. So same is the case with local agriculture there.

Study area is filled with the green agricultural products and the wheat, maize and the sugarcane are the major crops of that area besides animal fodder is also been cultivated there Maize and millets are mainly grown for the livestock purposes.

Mainly vegetables are also grown at the site area but mostly that are used for domestic use only. Commonly Pear, onion, round gourd, carrot, melon and bitter cucumber are grown there.



There are no commercial fruits orchards but local people have planted some fruits trees for their own domestic purposes in which guava, strawberry, banana, apricot, peach and aloobukhara are mostly common.

f) Livestock & Poultry

Livestock and poultry business play an important role in the income of the local residents there because livestock and poultry is the second major income source of the people. They not only reared cows and buffalos to get milk for domestic use but they also sold that milk to earn bread n butter for their family.

g) Women Status

Gender survey is also carried out to get information of the females and the males social roles in various activities. According to the survey it is found out that females face resistance in gaining and achieving access to the various activities and development of the society. Females are working as a farming lady and housewives and some are elderly women. It is suggested that women should take part in household activities in which cooking foods, taking care of children, cleanliness, caring for elderly people and of other family members is included. They can also take part in farming activities like cultivation and harvesting of the crops and other processes but they are not considered valuable entity by the male members and they are not paid for their work. So this gender discrimination should be eradicated from the backward areas and this is only possible by gaining education.

h) Conflict Resolution

General trend in the area to resolve any conflicts is the "Panchayat". It is considered a preferable method to resolve such conflicts in villages in which a group of elderly & respected people of those areas who sit together to resolve anyone's issue and every local person pays attention to them and their decision is considered binding by everyone. So such issues are also present in the study area and the method to resolve such conflicts is same as described above.

i) Religious, Archaeological, Historical or Recreational Treasurers

There are no such archeological or historical treasurers there and there is no such historical and recreational parks in the nearby areas except Chhanga Manga Forest Park which is not reachable easily by local people. There are open places at the study area where small children and youth spend their free time to play some healthy games to make them physically fit.

j) Cultural Values & Tradition

People there have strong cultural and human based connections between them. They care for each other and live in a joint family and raise their voices for every problem to anyone. They respect their elders very much and standby each other through every thick n thin. They take part in everyone's happiness and sorrows and they prefer to live like a family.

Their cultural traditions are almost same as of the people living in major cities. Males mostly wear shalwar qameez some elderly person also make use of dhoti whereas in females shalwar qameez is mostly common. Females also observe veils and dopatta. The influence of religion at the study area is also strong and they practice Islamic culture and religion strongly.

k) Socioeconomic Profile of Transmission Lines

Keeping in view the social setup of the COI of the TL route, an effort was made during the baseline survey to get information related to the demographic features, i.e., ethnicity/tribal setup, size of households, gender composition, and literacy status. Information is gathered from primary and secondary sources such as DCRs and other published material.

The main occupations in the COI are agriculture which includes cultivation of lands, rearing of livestock, sowing and harvesting of grain crops and producing poultry and other allied subsidiary occupations. Main crops of the area are rice, wheat and sugarcane. Women and children work at home and also perform light chores and farming work like helping in sowing and harvesting of crops and animal grazing to assist their male members. The major castes of the Study Area are Jatt, Rajput and Awan.

Socio-economic condition of the people is good due to reason that majority of the people have naturally endowed fertile agriculture land aided by an efficient irrigation system and the settled farmers gain agricultural productivity thus generating good revenue.

Health facilities are not so good here like other segments of the district. Private and state health facilities are available only up to the municipal boundaries and the villagers have to travel Warburton, Nankana and Sheikhupura to get better and advanced health facilities.

Education facilities are comparatively good along the COI. Primary schools for males and females exist in every village while high schools are only present in Warburton city. People have to leave their native places for the sake of attaining higher studies.

l) Roads, Railways & Harbors

The nearest paved road to the project site area is the main Pattoki-Chunian road which linked the Pattoki city to the Chunian city and the railway lines are passing through the Pattoki city and the main railway station is the Pattoki railway station which is around 21 km from the project site area. There is no such harbors in Kasur District near the project site area

m) Aesthetic Values

Proposed project site area have no such aesthetic values rather the project after completion will contribute in the aesthetics of the area. There will be parks for the people where they enjoy their time besides, there will be recreational points that will also help to increase the aesthetics of that area

n) Awareness & Acceptance of the project

Most of the residents of the study area are aware of the project and they showed positive response about the project that if there will be any project here that would be beneficial for them because they expect a reduction in load-shedding, creation of jobs for local people, improvement of infrastructure and availability of health and education with the development of the project.

5. ANTICIPATED ENVIRONMENTAL IMPACTS & MITIGATION MEASURES

This section highlights the potential impacts of the pre-construction, construction and post construction stages of the project on the ecological, environmental and socio-economic aspects of the area. Accordingly, proper mitigation measures are proposed for the adverse impacts of the projects on the area. It is anticipated that left bank of the BS Link I Canal HPP will face no direct impacts as the power channel of BS Link-I project is proposed on the right bank of the canal. The land available between BS-I and BS-II canals is proposed to be used for colony and offices. This land is Government property and not in use, only a couple of abandoned structures of Irrigation department are there.

There are three stages of the project which include pre-construction, during construction and operation or post construction of project and impacts for each stage are described in subsequent text.

5.1. Pre-Construction Stage

5.1.1. Physical Environment

a) Impacts on Existing Infrastructure

There is no such infrastructure available in project area which needs to be demolished before the construction of the project, so this issue is not of great significance. However, the issue of disturbing local access and canal crossing bridge will rise at later stage and will be addressed as mentioned in later paragraphs of this report.

b) Mitigation

As there is no such infrastructure present within the area of the proposed project so there will be no mitigation required at this stage except some demarcation of project boundaries and distinguishing it with barbed wire. In order to inform the local public about the project area and safeguarding project men and machinery.

5.1.2. Ecological Environment

a) Impacts on Flora

It is estimated that about 13-15 tress will be cleared for the later construction of the power channel and the power house. Other than that there is no floral presence in the project area except some bushes and herbs.

b) Mitigation

Trees replenishment cost of trees will be decided and paid to the concerned department or the other mitigation can be to plant more trees in the ratio of 1:2 in that area after the completion of the proposed project.

(1:2 means for every fallen tree there will be 2 trees of the same species will be planted as alternate).

5.1.3. Socio-Economic Environment

a) Impacts on Community Dislocation and Resettlement

As it is seen from the proposed project site area that there is no community in or around the project area, so no dislocation or the resettlement of the community will be required in the area before the construction of the proposed project. Rather the local people and the stakeholders are very much interested and happy with this project site.

b) Mitigation

As there will be no such dislocation and the resettlement issue of the communities near the project site so no mitigation is as such required, but some privately owned land and some land of the government will be affected that will be mitigated in an amount of money or some measures are recommended as a settlement for the local community people as described below.

- The bridge over the canal may remain intact or it will be relocated nearby so that the local people may continue their daily routines and there will be no issue for the villagers on the left bank to come and cross over to the villages on the right bank of the canal.
- Other mitigation might be helpful for the residents there to open small shops or dhabba for the labors and the working staff on the project site area that not only helpful for the working men but also it will add to the bread n butter of their own to collect some revenue from this.
- Since dust, noise and social mixing may cause other environmental and social problems for this settlement so the future contractors must keep in mind some economic compensation while implementing EMP, for instance offering labor work.

c) Impacts on Affected Lands for Powerhouse

According to the proposed layout of BS Link-I HPP, the power scheme will affect about 18.12 acres of the area of the land. Some the land area that will be affected by the power scheme is privately owned and most of the area is government owned.

d) Mitigation

Project proponent will acquire the land through revenue office of Government of Punjab or directly from the land owners according to terms and conditions laid in LAA 1894. This issue will be resolved before the start of construction of the project.

e) Impacts on Affected Community Assets

It is anticipated that the access roads for the transportation of the construction materials that will be used in the construction of proposed HPP, some village roads and unpaved canal bank road will be used which are community asset.

f) Mitigation

It is foreseen that unpaved paths for the community will be improved with the construction of project roads and overall impact on the community assets will be positive.

5.2. During Construction

5.2.1. Physical Environment

5.2.1.1. Land Resources

a) Impacts Due to Soil Erosion & Contamination

Soil contamination is a phenomenon that can occur due to the mixing of the discarded materials like plastic pieces, wires, tins, bags, oil things, wood, and drums cardboard pieces into the soil. All these waste materials when added to the soil present on site during the construction of the proposed HPP It will contaminate the soil.

One of the most important soil contaminating sources is the generation of solid waste during the construction activities. It is estimated that on an average 100 laborers will be employed at construction camp, which will generate about 50 kg of solid waste for camp site @ 0.5 kg per capita per day. The major components of the worker's camp waste are garbage, putrescible waste, rubbish and small portion of ashes and residues. Immediate attention is required for such type of wastes as these are degradable and cause obnoxious odour.

b) Mitigation

Soil contamination on the site can be controlled if by practicing intelligent environmental engineering and taking reasonable measure to control it.

Soil contamination due to oil leakage, chemicals and toxic components can be minimized by providing a special storage places for these elements. Oil tanks and the toxic elements and chemicals should be placed at some distance from the main construction site on the proposed leakage proof tanks. Fire extinguishers should always be available near to these elements so that in case of emergency their services can be used by the people, instead laborers who have to control these things should be skilled and have knowledge of how to operate them in emergency.

Soil contamination by other materials like wires, tins, wood pieces, plastics and other materials can be controlled by placing separate storage tanks and drums for disposal of different things in them so that contamination can be avoided.

c) Impacts Due to Natural Drainage

Some of the loose soil that are the results of the excavation from the ground can be used for some backfilling purposes but most of the bulk of the that loose soil will remain at the place of excavation and cause dust problems due to its looseness it can blow with the air and can cause the flow problems in the natural drainage.

d) Mitigation

Excavated soil should be disposed of and used time to time so that it will make any spoil bank near the excavated area and cannot make any hindrance to the natural path of the flow and the rainwater flow. Open drains for the drainage of wastewater should be constructed, if considered necessary during the construction.

e) Impacts on Water Resources

The water requirements for the project can be divided into two main uses, i.e. water required for labor camp utilization and for construction. It is estimated that around 100 workers will be accommodated in the construction camp during construction activities, who will utilize around 4000 liters/day of water for washing, cooking and bathing purposes. This water will be extracted from groundwater and will have no conflict with the local water users and agriculture of the area.

Due to the construction activities i.e. excavation and dumping of soil, spillage of chemicals, oil, lubricants, detergents etc., and the surface water quality might get deteriorated. In addition to that, around 3,200 liters/day (3.2 $m^{3/}$day) sewage will be generated at the construction camps. If the generated sewage is not properly treated or disposed off, this may contaminate the surface and might affect the groundwater resources apart from soil contamination.

f) Mitigation

Water should be excavated from the ground sources for drinking, cooking and other purposes and it should not have any conflict with the surface water and other contamination. It is recommended that effluent from contractor's camp should be treated before discharging it. Daily sewage deposits should be done on site so that it could not make any pollution on the site for the local people nearby and the working staff and labors there.

g) Impacts on Air & Noise

A number of machinery and equipment will be in operation for the construction of the project, which includes concrete mixers, excavators, dumping trucks, road rollers, haul trucks, transport vehicles, cranes and other construction machinery.

Most of these machines use diesel engines that generate noise and exhaust emissions. The possibility of exhaust emissions increases when the old vehicles/plants are deployed during the execution. Generally, the activity generates particulate matter (PM10), smoke, dust, CO and NOx in the ambient air, which deteriorate the ambient air quality and resulting in adverse impacts on the human, livestock, agriculture, fauna and flora.

Due to the movement of trucks and other construction vehicles it causes noise and disturbance for the people living in the nearby villages and areas. Due to excavation of soil it causes dust pollution at the proposed project area that can also affects the nearby residents and can be harmful for them.

h) Mitigation

Following mitigation measures may reduce the severity of aforesaid temporary adverse impacts:

- Tuning of vehicles should be made mandatory to reduce the emissions of NOx, SOx, CO and PM10.

- Emissions from the concrete mixing plant should be controlled with appropriate control equipment (such as fabric filters or cyclone separators).

- Haul-trucks carrying, earth, sand, aggregate and other materials should be kept covered during the transportation of materials and storage at site with tarpaulin, to avoid the dust emissions.

- For the construction machinery generating noise level above the prescribed of NEQS and WHO limits. The noise level should be within the permissible limits.

- Movements of the trucks and other construction machinery causing high noise levels must be restricted at night time to avoid disturbance to the nearby locality. Truck drivers should be instructed not to play loud music at night and stop the use of horns even at day time; and

- Fugitive dust may be settled down through water sprinkling during working hours with appropriate frequency as suggested in the environment monitoring plan.

5.2.2. Ecological Environment

a) Impact on Flora

Study on impacts on flora depicts that there is no such huge damage of the trees present at the proposed project area rather than the few trees which will be fallen down for the construction of the power channel as well as the powerhouse.

b) Mitigation

It will be decided according the mutual consent that about twice the number of trees will be planted in place of one fallen tree or a specified amount should be paid to concerned department as the cost for the fallen trees so that they may plant more trees after the construction of the proposed project. Instead some horticultural or floricultural based parks or sites may be established near the project site area to enhance its beauty.

c) Impact on Fauna

Impact on the fauna will be of minor and of temporary nature, although, a few rarely sighted species of avifauna are reported in the surroundings, but the project is not expected to have any significant adverse impact on them.

The proposed project will rather yield positive impact on the fauna of the study area because the fauna and especially the avifauna will be attracted to the area again due to recommended extensive plantation to improve the flora of the tract.

Other than birds, there will be rather insignificant adverse impact on other classes of wild animals including fish, wild animals, viz. mammals, reptiles, amphibians or insects; they will migrate to the adjacent safer places. It is also envisaged that local people or the Contractor labor may harass/shoot this wildlife.

Fish will not face any adverse impact regarding downstream fish catch during construction period because cofferdam will help to connect powerhouse with the main canal safely.

d) Mitigation

Hunting, shooting and other such activities which affect the fauna of the area and other environment must be avoided. Good engineering plans will make the proposed project conducive with the schedule of canal closure periods so that minimum disturbance could be envisaged during whole construction period of the project.

Adverse impact will be of temporary nature and will be more than compensated during operation stage when a sizeable tree plantation plan will be carried out along the boundaries of the power station and the portion of the main road in front of the power station area. Flowery and ornamental shrubs and plants shall be grown in the open spaces, enhancing the aesthetic value of the tract and making it more attractive for birds.

Noise control measures should be enforced during the construction phase, such as provision of heavy duty mufflers and silencers on heavy construction vehicles. Construction activities should be avoided during night, as the noise created by construction machinery becomes manifold during silence. Vehicles speed should also be controlled to avoid any incidental mortality of mammals or reptiles. There should be clear orders to the staff and labor, prohibiting hunting, shooting or harassment of wildlife.

5.2.3. Socio-Economic Environment

Impacts on the social life of the surrounding human communities is divided into two parts i.e. the construction phase and the implementation process. Following are the detailed impacts of the construction activities on the socio-economic environment shown below.

e) Impacts on Livelihood and Other Socio-Economic Status

Socio-economic impacts during the construction phase may increase the per capita income and many other allied facilities for the local residents of the communities nearby the proposed project area. They can run small business at or near the project site area to increase their livelihood as well as the males from the nearby villages can also take part in the construction phases as unskilled worker and can get the experience of the construction activities also that can help them in future for further earnings on some other projects.

There will be some impacts on the agricultural fields at the right bank of the BS Link-I Canal that are owned by some private stakeholders. That affect will be caused due to the construction of the power channel as well as the powerhouse for the proposed project.

f) Mitigation

The local community people may be hired as a skilled or semi-skilled laborers that can help in the construction of the project as well as they can get much experience from this project for their future benefits. People from other villages that are far from the proposed project site can also participate in this activity and contractor must assure that there will not be any quarrel between groups on site area.

Besides the private land owners who have agricultural fields in the way of powerhouse and power channel may be benefit with the land price or another land after the completion of the project so that they can continue to earn their livelihood.

g) Impacts on Community Health & Safety

It is observed that following health and safety issues can be seen at the site of the proposed HPP during construction phase.

- Construction activities, particularly excavation and movement of haul trucks and machinery may prove dangerous for the safety of the workers as well as for the residents who are settled on the route of contractor movements.
- Construction staff and the labors may get slip from the vertical members while working on them as well as they may get injured while working near the excavated area where there is a chance of side slope failure.
- The nearby local residents of the communities may get affected due to the contractor's activities on site as well as the windblown of sand and soil which is excavated and remained there as a loose material during construction.
- Social insecurity problems may arise for the local population of respective settlements due to the social mixing of the contractor's workers.
- Some communicable diseases, especially venereal diseases are expected to boost due to temporary settling of the contractor's labor.
- Traffic related problems are not expected to be of a significant nature because the traffic movement on the access road will not be of significant magnitude. Therefore, construction materials and machinery can be easily transported without any traffic jams.

h) Mitigation

It is recommended that a standard HSE (Health Safety & Environmental) plan must be proposed and should be duly approved by consultants and client. The social norms of the local population are respected.

i) Impacts on Other Civic Facilities

Education, health, communication, services, utilities, recreation and religious affairs are the general components of the civic life of the surrounding communities in the study area and some of them have been discussed. It is anticipated that most of these will receive positive impacts by the proposed project, therefore, no negative impact foreseen.

5.3. Operational Stage

5.3.1. Physical Environment

a) Air Resources

During the operational stage of the proposed project, powerhouse commissioning will not much affect the air quality in terms of any gas emission from powerhouse whereas the traffic volume and the frequency connected with the powerhouse working may pollute the air quality but certainly insignificant.

b) Mitigation

As gases will not emit from the powerhouse during its operational stage so there will not be any mitigation required.

c) Noise Pollution

Noise pollution may be a major problem for the residents and the local community people due to the working of the turbines. It may affect human health in terms of causing annoyance, aggression, hypertension, hearing loss, sleep disturbance and other harmful effects. Such problems may affect to the person working in the powerhouse majorly and less to the local residents and the villagers far away from the powerhouse site. It is also anticipated that vehicular movement will be enhanced during project implementation phase.

d) Mitigation

The noise pollution within the power station will be maintained at less than 80 dBA and the workers will be required to wear ear muffs to minimize the effect. Noise levels outside the power house will be less than 70 dBA. Tree plantation will also be helpful to decrease the high noise impacts.

Special permanent sign boards must be fixed at appropriate distances to caution the vehicle drivers of public transport not blow horns in the Study area.

e) Impact on Water Resources

As far as the impact on water resources is concerned, proposed powerhouse location and the function will not yield any adverse effect on the water resources of the area, however the wastewater from the colonies have negative impacts on the water resource and may play adverse role in the calamity of the BS Link Canal.

f) Mitigation

No mitigation needed for water resources downstream of the canal. Regarding water demand for the residents, it will be met from the groundwater so it will minimize the water conflicts. Groundwater will be utilized with the permission of the concerned departments to avoid any conflicts. It is recommended to treat the domestic wastewater from colony.

g) Impacts on Aesthetics

Aesthetics of an area play a vital role in beautifying the area and improves the working environment of an area. The proposed project site and the location of powerhouse also take part in the aesthetics of an area and not only will improve the working efficiency of the labor but also yield synergic effects on the surrounding settlements.

h) Mitigation

Since there will be no adverse impact of the project on the aesthetics, thus no mitigation required. Anyhow, in order to improve the working environment further, good housekeeping, and cleaning and efficient solid waste management system should be implemented. Moreover, it is suggested that flower pots and other techniques should be used inside the buildings to improve the working environment of the powerhouse.

5.3.2. Ecological Environment

a) Flora

Adverse effect on flora will not be observed during the operational stages of the proposed HPP. There will be insignificant impact on the vegetation in or around the site area whereas during the operational stages more trees can be planted around the power house site or at the open places as it is mentioned above of the plantation of trees after the construction of the HPP complete. This will surely induce positive impacts on the health of the local residents and community people there.

b) Mitigation

A tree plantation plan has been discussed above in the "during construction" phase where it is proposed to plant trees in the ration of 1:2 in alternative for every fallen tree in or around the site area due to the construction of the power channel and the powerhouse. This proposed tree plantation plan will create positive impacts on the natural flora and increase the vegetation of that area.

c) Fauna

Both the flora and fauna are integral part of the ecosystem. In many ways fauna of a tract is dependent on flora for its resting, nesting and roosting activities. With the improved flora of the tract, due to extensive plantation, the fauna and especially the avifauna shall be attracted to the area, resulting in return of the wildlife, which had earlier shifted to adjoining areas and causing a positive impact. It is also envisaged that local people or the Contractor labor may harass/shoot this wildlife.

d) Mitigation

It is the responsibility of the staff working on the proposed HPP to have an accurate vision that no one will harass, shoot or kill wildlife at the site area.

e) Downstream Fishery

Some adverse impact on the downstream fishery is expected during project operation due to water striking the turbines which might trap the fish. This is considered to be insignificant.

f) Mitigation

In order to protect fish fauna stock/pond fishery along the downstream track of the canal at appropriate distances may be established so that downstream fish catch may be strengthened to supplement human diet.

5.3.3. Socio-Economic Environment

a) Impact on Soil Fertility

Fertile lands of that area will be taken from the private owners of those lands for the purpose of the construction of the power channel and powerhouse of the proposed BS Link-I HPP. In alternative some other land will be provided to the farmers at some other places or the amount relative to that of the land will be paid to them. This phenomenon should be kept in mind that such reclaimed land seldom reaches its pre-excavated fertility/productivity level mainly due to loss of pre-existed nutrients, compaction level, etc. Returning this reclaimed land and its soil to its original productivity level may take 1-3 seasons.

b) Mitigation

Since such farmland will cause to reduce the production of food and fiber for some time, hence one-time crop compensation can be considered for the next cropping season. In addition to that some additional fertilizers and compaction machinery may be provided to the farmers free of cost as soil regenerator which help the top-soils richness against physical and chemical impoverishment.

c) Other Socio-Economic Impacts

This project will mainly have positive socio-economic impacts during the operation phase. Some of the socio-economic impacts have been mentioned below:

- The socio-economic impacts like employment, health and cultural uplifts are the major and the direct benefits to the people in the study area. not only during the construction phases but also after the construction of the proposed project such people can be employed as a workers and for the betterment of the aesthetics of that area during the operational stage of that project. The human resources will be developed at a local level for future development activities in the areas.

- A suitable and quick medical facility should be available for the working staff and laborers on the powerhouse during the operational phase so that in case any emergency quick medication can be provided to those people.

- Due to the implementation of the proposed HPP all the roads in the vicinity of the project area or that approaches to the project site will be widened to ease the traffic flow and to make a good aesthetic facility for the people to reach there.
- The educational and cultural aspects will undergo positive change. The social amenities i.e. roads, dispensaries, water supply etc. will raise the living standard of the people. All the job opportunity related to the project will ultimately be directed towards increased per capita income of the population in the area. It is expected that there will be no adverse impacts on the socio-economic condition of the people of the Study area.
- No additional socio-economic adverse impacts are foreseen during the operational stage of the proposed project.

d) Mitigation

No mitigation measures are required because there will not be any adverse social impact.

6. ENVIRONMENTAL MONITORING PLAN AND INSTITUTIONAL REQUIREMENTS

1. The main objectives of the environmental monitoring plan (EMP) and institutional requirements are:

- To ensure that all necessary corrective actions are carried out in time to counter any adverse environmental impact;
- To ensure the regular monitoring of those factors which may affect the safety of the environment under a systematic monitoring approach;
- Define the responsibilities of the project proponents, contractors, construction, supervision consultants and environmental monitors;
- Provide a procedure for timely action in the face of unanticipated environmental situation; and
- Identify training, requirements at various levels.

2. The EMP comprises six main components:

1) Institutional requirements
2) Management activities (auditing, etc.)
3) Training
4) Monitoring program
5) Environ management and monitoring cost
6) Public disclosures

3. They are briefly discussed below:

6.1. Institutional Requirements

4. Environmental impacts and their mitigation measures have been discussed in detail in Chapter -5. To implement and monitor the mitigation measures, the following institutions will be involved:

- Proponent of the project (the Executing Agency, EA);
- SC, as deputed by the Project Proponent;
- Project Contractor, as the executors of the Environmental Monitoring Plan (EMP) during the construction stage of the Project;
- EPA-Punjab, as observer and top monitoring agency during the construction and operation stages; and
- Representative of Irrigation Department & District Administration Kasur

6.1.1. Roles and Responsibilities

5. Roles and responsibilities of various institutions are briefly described below:

a. Project Proponent

6. The project Proponent (ATL) will be responsible for ensuring the overall implementation of the EMP during the construction as well as operational stages of the project. Proponent will depute the Supervisory Consultants.

b. Supervisory Consultants

7. SC will be responsible for assisting the Proponent for the implementation of EMP through the Contractor(s). SC will also submit progress reports to the Proponent for the implementation of EMP by the Contractor.

8. The major role of the SC, i.e., supervising the project activities in general and the environment related issues in particular, is as under:

- Coordinating as required with regulatory agencies including EPA-Punjab as well as regional agencies;
- Ensuring that the terms of reference of Contractor(s), adequately cover the environmental and social issues to comply with the local laws;
- Ensuring that the Contractor develops and adopts environmental implementation plans that are consistent with the EMP;
- Supervising the project's Contractor and ensuring that all the contractual obligations related to design and construction, as well as environmental and social compliances are met;
- Ensuring that day-to-day construction activities are carried out in an environmentally sound and sustainable manner;
- Determine the timing and exact locations of air, noise and water quality monitoring;
- Undertake critically important routine visual monitoring of construction, waste disposal and overall environmental management practices by the Contractor;
- Devise solutions to the environmental issues as they arise particularly related with dust, noise levels and other impacts that are in some instances unavoidable. Good construction supervision requires that every effort be made to minimize these impacts; and
- As referred earlier, ensuring the implementation of the EMP by the Contractor will be the sole responsibility of the Proponent and Supervisory Consultant.

c. The Project Contractor

9. The contractor is responsible for execution of construction activities as well as for environmental protection through his environmental field staff. The contractor is subjected to environmental protection liabilities under environmental laws of the country, project IEE provisions and under their contract with ED. The contractor is also responsible for communicating with his crew and to train them in all aspects of the environ management.

d. **Environment Protection Agency (EPA), Punjab**

10. EPA does not involve itself into the project matters except to award NOC for project implementations as well as to respond on the public complaints. Its Act 1997 is the main document which defines the environment protection standards. Every IEE/EIA is prepared by keeping in view the Pak-EPA guidelines in letter and spirit.

6.2. Management Activities

6.2.1. Internal Auditing

11. The internal environmental audit will be carried out by SC. The primary aim of auditing is to assess compliance and effectiveness of the EMP as well as the degree of success of the environmental and social objectives, and also to assess the effectiveness of the corrective actions. Audit will also suggest remedial measures to overcome the environmental and social problems.

6.2.2. External Auditing

12. The external environmental audit will be carried out by EPA-Punjab in order to check the compliance and implementation of the EMP. EPA-Punjab will check the various parameters with reference to the guidelines provided by PEPA, 1997 and the standards specified by NEQS.

6.3. Training and Capacity Building

13. To enhance the capacity of the Proponent/EA as well as the Contractor, training will be imparted related to the environmental and social issues of the project, implementation of mitigation measures and the monitoring protocols and reporting mechanism.

14. Project will ensure in-house training for the project staff, Contractor, and the Supervisory staff of the Proponent/EA and the Consultants through the provision of one-day basic training and one-day advanced training, covering environmental and social aspects of the development projects in general, and implementation requirements with emphasis on the roles and responsibilities of the Proponent/EA and the Contractor staff while executing the environmental monitoring plan in particular. The training protocols will include the following aspects:

- Procedures for monitoring the air quality parameters and measures to be adopted for avoiding or minimizing air pollution, particularly from the concrete batching plant, haul-trucks, etc.;
- Procedures for monitoring water quality parameters and measures to be adopted for avoiding or minimizing water pollution, particularly from the wastewater effluent generated from the workshops, machinery washing yards, and other obnoxious chemicals;

- Safe waste disposal practices;
- Safe noise levels from the construction machinery etc.;
- Safety measures against hazards for workforce and the local communities arising from the construction activities; and
- Use of safety gadgets by the workforce.

6.4. Monitoring Program

6.4.1. Pre-Construction Stage

15. Some impacts of the proposed project are even started before the construction stage. These are given in Table below.

Table - 18: Proposed Monitoring at Pre-Construction

Parameter	Management Mechanism
Land acquisition	Confirm that all acquisition is complete before start of the project.
Tree cutting	Comply with the Project Area tree plantation plan as and when required.

6.4.2. During Construction Stage

16. The proposed monitoring program during the construction phase is given in Table as under:

Table - 19: Proposed Monitoring during Construction

Parameter	Location	Monitoring Mechanism/Parameters	Frequency
Dust Emissions	Near project site, access roads and settlements	Visual checks	Daily routine monitoring
Wastewater	Workers' camp	Effluent discharges from workers' camp to be tested for total coliforms, Ammonia, (BOD), (COD) and other nutrients as per NEQS	One sample quarterly
Solid Waste	Workers' camps and construction site	Waste generation, storage, collection and disposal	Fortnightly
Drinking Water	Water being used for drinking purposes by workers and nearby	Discrete grab sampling and laboratory testing of groundwater according to	Two samples of drinking water from the construction camp and other from nearby village

Parameter	Location	Monitoring Mechanism/Parameters	Frequency
	community	WHO standards	on quarterly basis
Noise Levels	Project site and nearby settlements	Noise level according to WHO standards	Once prior to the start of construction and then on quarterly basis throughout the construction period
Fumes and gases	Ambient air, silencers of heavy machinery, trucks and other vehicles at project site and adjacent settlements	Pollution parameters including the SO_2, NO_2, CO, VOC and Particulate Matter according to WHO standards	Monthly monitoring
Health and Safety	Labor camps and construction sites	Medical check-ups and routine safety check-ups of the communicable diseases and accidents	Quarterly
Wildlife and Avifauna	At and around project site or in the whole study area	Illegal hunting of fauna / avifauna	Daily

6.4.3. During Operational Stage

17. The monitoring requirements during operational stage (post-project monitoring) including the parameters, frequencies and its sampling locations are specified in Table below.

18. A monitoring plan during operational stage is shown below:

Table - 20: Proposed Monitoring during Operational Stage

Parameter	Location	Monitoring Mechanism	Frequency
Potable Water Quality	One sample from workers drinking source and one from pressure/hand pump at the nearest settlement	Groundwater sampling as specified by WHO standards	Bi-annually
Wastewater	Just downstream of power station in the Canal and colony outlet	Effluents discharges as per NEQS	Bi-annually
Noise	Within Project site and around it	Noise level according to WHO standards	Bi-annually
Solid Waste	Place reserved for solid waste collection bins/ containers/open field.	Visual observation	Annually

6.5. Management Plans

6.5.1. Tree Plantation Plan

19. Perimeter of the proposed power scheme is about 3,920 m which must be decorated with woody trees and/or ornamental shrubs. They may be raised along the boundary of the Project Area and portion of the main road in front of the power station. To enhance the aesthetic beauty, grassy plots may be planted around the building and other selected sites within and around the Project Area.

20. Total cost to be incurred on Project Area is about Rs.0.06 million which includes their basic cost and the maintenance for the following four years. Tree and shrub species recommended for plantation are given in Tables as under:

Table - 21: Proposed Trees & Shrubs to be Planted

Trees		Shrubs	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Shisham (sisso)	Dalbergia Sisso	Kaner	Nerium oleander
Kiker	Accia nilotica	Jastropha	Jastropha curcas
Neem	Azadirachata indica	Peela Tecoma	Tecoma stans
Siris or Shirin	Albizzia lebbek	Bathu	Chaenopodium album
Sufaida	Eucalyptus cmldulnsis		

6.5.2. Restoration and Rehabilitation Plan

21. After completion of the construction work all the disturbed sites will be restored to the conditions at the commencement of the project or better than that. The area will be planted with indigenous vegetation and all the access roads will be broken in the strategic places so that it can no longer be used. All the concrete will be broken and dispose of according to the waste disposal plan. The fences will be removed, the borrow areas leveled and the top soil restored separately after the construction.

6.6. Environmental Monitoring Cost

22. Implementation of the recommendations of the IEE at the construction stage is the sole responsibility of the Contractor and the monitoring activities will be carried out by the SC. Cost for environmental monitoring will be a part of the contract document with the Contractor. It must be noted that environmental cost will not be a separate entity because all of its components will be addressed in the bidding document under various heads of account. For instance, tree plantation will be a part of landscaping; infrastructure repair will be covered under rehabilitation work, etc.

23. The lump-sum estimated cost of the implementation of Environmental Monitoring before and 1-2 years after the completion of Project period has been worked out to Rs. 48.8 million.

Table - 22: Cost Estimate

Sr. No.	Description	Area	Units	Ownership status		Avg. Unit Rate (Rs.)		Total Cost (Mil Rs.)			Remarks
				State	Private	Permanent	Temporary	State	Private	Total	
A	**Land Acquisition**							8000000	28992000	36,992,000	
1	*Main Canal Bank Area*	6	Acres	6		1000000		6000000		6000000	Permanent
2	*Powerhouse & other structures*	18.12	Acres		18.12	1600000			28992000	28992000	Center of canal
3	*Land for PAPs Resettlement*	0	Acres							0	Not applicable
4	*Land for Transmission Line*	0	Acres							0	Not applicable
5	*Land for Project Colony*	2	Acres	2		1000000		2000000		2000000	Not applicable
B	**Cost of Assets to be Lost**							60000	887000	947,000	
B1	**Demolished Infrastructure**										
1	*House*	0	Number							0	Not applicable
2	*Animal Shed & relocation*	0	Number							0	PAP's livelihood
3	*Electric Poles*	0	Number							0	Functional
4	*Hand Pump*	1	Number		1	7000			7000	7000	Domestic & Functional
B2	**Damaged Crops**										
1	*Land lease / acre / annum for gain crops*	22	Acres		22	40000			880000	880000	PAP's livelihood (for 3 years)
2	*Land lease / acre / annum for vegies*	0	Acres							0	Not applicable
B3	**Fallen Trees**										
1	*Replenishment cost of fallen trees***	15	Number	15		4000		60000		60000	Replacement cost
2	*Replenishment for removing big old trees****		Number							0	Not applicable
B4	**Other Damages**										
1	*Nil*		NA							0	Not applicable
2	*Nil*		NA							0	Not applicable
C	**Development Projects for PAPS**								2,300,000	2,300,000	
1	*Women social development scheme*	1	Number			200000			200000	200000	Not applicable
2	*Water filtration plant*	1	Number			400000			400000	400000	Not applicable
3	*Basic health unit*	1	Number			500000			500000	500000	Not applicable
4	*Small development schemes*	1	Number			1200000			1200000	1200000	Social upgradation
D	**Resettlement & Rehabilitation**										
1	*Transitional Period Allowance*	0	Household							0	For 6 months
2	*Transportation Charges*	0	Household							0	One time
E	**Environment Monitoring Cost**							Frequency		8550000	
1	*Environment Testing (water, air etc)*		NA			600000		3		1800000	Construction stage
2	*Environment Auditing*		NA			400000		4		1600000	Construction stage
3	*Environmental Training*		NA			200000		2		400000	Construction stage
4	*Solid Waste Management*		NA			500000		5		2500000	Construction stage
5	*Tree Plantation (Not replacement of cut trees)*		NA			400000		5		2000000	Post-construction
6	*Social cost (meetings, visits etc)*		NA			50000		5		250000	Pre-construction
F	**Contingencies**										
1	*Miscellaneous*		Lump sum			1000000					Not applicable
2	*Adjustments*		Lump sum			200000					Not applicable
	Grand Total									48,789,000	

7. FINDINGS AND RECOMMENDATIONS

The proposed hydropower station is an environmentally green project and will promote and strengthen the environmental profile of the area instead of any serious damage.

The major findings of the impacts during the construction and operational stages regarding the physical, ecological and socio-economic domains of the environment are, however, described below:

7.1. Physical Aspects

- There will not be any permanent or long term adverse environmental impact(s) on land water or air resources which may damage or limit the land use fully or partially; contaminate surface or drinking water to make them unfit for irrigation or drinking; or pollute the ambient air in terms of any stack emission;
- Construction activities may contaminate soil due to the discarded construction materials and obstruction in natural drainage due to un-attended excavated material. Generation of solid waste will be an important soil contaminating source and may yield temporary negative impact but its mitigation will be possible through good engineering and appropriate storage places will further help in managing the oil spills and other lubrication materials. Solid waste will also be properly managed by placing bins within the construction camp. If excavated material is properly disposed off then it will not block the natural rainwater drainage paths;
- Similarly impact on water and air resources will also be of temporary nature during construction period. The water requirements for the project can be divided into two main uses i.e. water required for labor camp utilization and for construction purposes. This water will be extracted from groundwater and will have no conflict with the local water users and agriculture of the area. If the generated sewage is not properly treated or disposed of this may contaminate the surface water and may affect the groundwater resources apart from soil contamination. It is recommended that wastewater effluent from contractors' camp should be treated to remove oil/grease contaminants. Machinery in operation and other equipment may yield temporary negative impacts on the air resources. Most of these use diesel engines that generate noise and exhaust emissions. Generally, they will generate PM_{10}, smoke, dust, CO and NOx in the ambient air, which will deteriorate the air quality and resulting in temporary adverse impacts on the human health, fauna and flora. Similarly, fugitive dust due to the construction activities may also affect the local air quality. Good engineering, however, along with complying with EMP and HSE plan will solve all problems as mentioned here; and

- Transmission line connecting powerhouse with the nearest grid station at Chunian is recommended, with slight diversions from the existing route to bypass the human settlements.

7.2. Ecological Aspects

- It is expected that there will be no significant adverse impact on the trees as the area is not densely populated by trees. The site relation has been made to minimize the impact on the flora. During the operation stage, there will be positive impact on the flora due to the extensive plantation;
- It is estimated that 12-15 trees will be fallen to clear the area for project construction. As per requirements of Forest Department, 2 to 3 times trees will be re-planted in the project site. To mitigate this minor adverse impact, a tree plantation plan is proposed in the EMP of this report which proposes re-plantation of trees and shrubs (three times the fallen trees) in the Project Area at a total cost of Rs. 0.102 million. It also includes the maintenance of plantation for further few years' post-construction stage;
- Impact on the fauna will be of minor and of temporary nature, although, a few rarely sighted species of avifauna are reported in the surroundings, but the project is not expected to have any significant adverse impact on them. With the improved flora of the tract, due to extensive plantation, general fauna and especially the avifauna will be attracted to the area; and
- The route of transmission line will not, by and large, damage the natural resources of the area in terms of trees, general agriculture, aquatic species or natural flora.

7.3. Socio-Economic Aspects

- There will not be any population dislocation issue connected with the proposed project due to their presence away from the proposed Project Area, hence no resettlement, no damage to assets and no compensation thereof.
- The project proponent (the Executing Agency) will have to acquire about 29 acres of government and private land to be used for the construction and maintenance of the project which will, however, have to pay the cost to the relevant department or the private owner(s) before the start of construction.
- The surrounding settlements of the Study area like Kandu Khara etc may be temporarily affected due to the windblown construction material during construction period but as concerns the noise of construction activities, it will have no impact on the surrounding settlements being sufficiently far away;
- There may be some temporary adverse impacts of the presence of labor camps near the settlements in terms of the chances of fatal accidents and undesirable social mixing. Both of these impacts can be mitigated through safe traffic management plan and strict application of rules and regulations;

- Impact on the livelihood will be positive in terms of more employment opportunities, more health and education service provision as well as better availability of other civic facilities for the nearby settlements; and
- The proposed route of the transmission line will yield no special adverse impact on the underneath human settlements and/or other natural resources because both entities are not present there.

8. CONCLUSION

Base on the overall assessment of the construction of the BS Link-I hydropower project at RD 106+250, it is concluded that the proposed project have no adverse impacts on the physical, ecological, socioeconomic and the environmental conditions of the study area. Besides, the following project is environmentally green project as no fuel consumption or gas usage is required int this project and the population is neglible. It will keep the environment green and clean and will put some aesthetic in the study area.

Transmission lines of the project will connect to the 132 KV Chunian grid station and will not cause any adverse impacts on the beneath residence and the local residents as well as the natural resource of the area.

Keeping in view the ADB guidelines, the IEE suggests that no further EIA is neededbecause no significant adverse physical, ecological and social environmental impact is identified. Though there is no dislocation of the persons is involved in this project.